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By Robert Chambers

VESTIGES

OF

THE NATURAL HISTORY

OF

CREATION.

[illegible]

LONDON:
JOHN CHURCHILL, PRINCES STREET, SOHO.
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Reprint of Sixth Edition.

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ERRATUM.

Page 56, last line—*for* " four," *read* " fore."

THE BODIES OF SPACE,

THEIR ARRANGEMENTS AND FORMATION.

It is familiar knowledge that the earth which we inhabit is a globe of somewhat less than 8000 miles in diameter, being one of a series of eleven which revolve at different distances around the sun, and some of which have satellites in like manner revolving around them. The sun, planets, and satellites, with the less intelligible orbs termed comets, are comprehensively called the solar system; and if we take as the uttermost bounds of this system the orbit of Uranus (though the comets actually have a wider range), we shall find that it occupies a portion of space not less than three thousand six hundred millions of miles in diameter. The mind fails to form an exact notion of a portion of space so immense; but some faint idea of it may be obtained from the fact, that, if the swiftest race-horse ever known had begun to traverse it, at full speed, at the time of the birth of Moses, he would as yet have accomplished only half his journey.

It has long been concluded amongst astronomers, that the stars, though they appear to our eyes only as brilliant points, are all to be considered as suns, representing so many solar systems, each bearing a general resemblance to our own. The stars have a brilliancy and apparent magnitude which we may safely presume to be in proportion to their actual size and the distance at which they are placed from us. Attempts have been made to ascertain the distance in some instances by calculations founded on parallax; that is, the change of relative situation produced on a heavenly object by our planet passing from one part of its orbit to another exactly opposite; it being previously understood that if, upon this base of nearly two hundred millions of miles, an angle of so much as one second, or the 3600th part of a degree, could be raised, the distance might be assumed in that instance as not less than 19,200,000 millions of miles! In the case of the most brilliant star, Sirius, even this minute parallax could not be found; from which, of course, it was to be inferred that the distance of that star is something beyond the vast distance which has been stated. In some others, on which the experiment has been tried, no sensible parallax could be detected; from which the same inference was to be made in their case. We seemed thus to be left in a hopeless state of ignorance regarding the measurements of the sidereal universe, as if it were such a question as man was not destined ever to answer; but at length, in our own time, responses came from several points almost at once. By Professor Henderson, it was ascertained that the star *a* of the constellation of the Centaur, the third in brightness in our heavens, but in reality a double star, and believed for various reasons to be among those nearest to us, had a parallax of a full second, from which it was inferred that the distance was the vast sum of miles which has been stated. Afterwards, Bessel assigned a parallax of thirty one hundredths of a second to the double star 61 Cygni, placing it at a distance nearly 670,000 times that of the sun.(1) Such are but the first steps we take in imagination amongst the hosts of orbs by which we are surrounded. If we suppose that similar intervals exist between all the stars, we shall readily see that the space occupied by even the comparatively small number visible to the naked eye must be vast beyond all powers of human conception.

The number visible to the eye is about three thousand; but when a telescope of small power is directed to the heavens, a great number more come into view, and the number is ever increased in proportion to the increased power of the instrument. In one place, where they are more thickly sown than elsewhere, Sir William Herschel reckoned that fifty thousand passed over a field of view two degrees in breadth in a single hour. It was first surmised by the ancient philosopher, Democritus, that the faintly white zone which spans the sky under the name of the Milky Way, might be only a dense collection of stars too remote to be distinguished. This conjecture has been verified by the instruments of modern astronomers, and some speculations of a most remarkable kind have been formed in connexion with it. By the joint labours of the two Herschels, the sky has been "gauged" in all directions by the telescope, so as to ascertain the conditions of different parts with respect to the frequency of stars. The result has been a conviction that, as the planets are parts of solar systems, so are solar systems parts of what may be called Astral Systems—that is, systems composed of a multitude of stars, bearing a certain relation to each other. The astral system to which we belong, is conceived to be of an oblong, flattish form, with a space wholly or comparatively vacant in the centre, while the extremity in one direction parts into two. The stars are most thickly sown in the outer parts of this vast ring, and these constitute the Milky Way. Our sun is believed to be placed in the southern portion of the ring, near its inner edge, so that we are presented with many more stars, and see the Milky Way much more clearly, in that direction, than towards the north, in which line our eye has to traverse the vacant central space. Nor is this all. A motion of our solar system with respect to the stars, first suggested by Sir William Herschel, in 1783, has since been verified by the exact calculations of M. Argelander, late director of the Observatory at Abo. The sun is proceeding towards a point in the constellation Hercules. It is, therefore, receding from the inner edge of the ring. Motions of this kind, through such vast regions of space, must be long in producing any change sensible to the inhabitants of our planet, and it is not easy to grasp their general character; but grounds have nevertheless been found for supposing that not only our sun, but the other suns of the system, pursue a wavy course round the ring, *from west to east*, crossing and recrossing the middle of the annular circle. "Some stars will depart more, others less, from either side of the circumference of equilibrium, according to the places in which they are situated, and according to the direction and the velocity with which they are put in motion. Our sun is probably one of those which depart furthest from it, and descend furthest into the empty space within the ring."(²) According to this view, a time may come when we shall be much more in the thick of the stars of our astral system than we are now, and have of course much more brilliant nocturnal skies; but it may be countless ages before the eyes which are to see this added resplendence shall exist.

The evidence of the existence of other astral systems is much more decided than might be expected, when we consider that the nearest of them must needs be placed at a mighty interval beyond our own. The elder Herschel, directing his wonderful tube towards the *sides* of our system, where stars are planted most rarely, and raising the powers of the instrument to the required pitch, was enabled with awe-struck mind to see suspended in the vast empyrean astral systems, or, as he called them, firmaments, resembling our own. Like light cloudlets to a certain power of the telescope, they resolved themselves, under a greater power, into stars, though these generally seemed no larger than the finest particles of diamond dust. The general forms of these systems (*nebulæ*) are various. So also are the distances, as proved by the different degrees of telescopic power necessary to bring them into view. The furthest observed by the astronomer were estimated by him as thirty-five thousand times more remote than Sirius, supposing its distance to be about twenty millions of millions of miles.

More recently, the Earl of Rosse has brought his superb instruments to bear upon these distant objects, and thus revealed them in more wondrous forms than before. Many which Herschel saw only as filmy matter, spread in patches over the sky, are now found to be vast aggregations of stars. Many which to the elder philosopher seemed round and well defined, are seen by his successor to have branches starting out in different directions—filaments, as he calls them,—the language applicable to the smallest of objects examined in our hands, being thus found applicable to the promontories of those great continents, each atom of which may be said to be millions of miles removed from another.

Such is the universe, as developed to the perceptions of the modern philosopher—different indeed from that of our forefathers, who did not know the bounds even of this little world, and beheld in the sun, moon, and stars only a set of menial lights ordained, usefully or not, to attend it. And to such contemplations are we raised by modern science, if we choose to leave for them the strifes and self-seekings of our social scene. Thinking of such acquisitions of knowledge, one cannot but go warmly along with the living Herschel when he speaks of the discoveries of Struve, Bessel, and Henderson, as among the fairest flowers of civilization. They surely justify, as he says, "the vast expenditure of time and talent which have led up to them," and show that "there are yet behind not only secrets of nature which shall increase the wealth and power of man, but TRUTHS which shall ennoble the age and the country in which they are divulged, and by dilating the intellect, re-act on the moral character of mankind." ([3])

Where our perceptive faculties are baffled, we dream; where they compass their object, we inquire after cause. Such is a law of our minds, which cannot have been bestowed upon us without being designed for a good end. And, indeed, it is by experience placed beyond all doubt, that to yield to this impulse is to use a direct means of improving our condition on earth, and to advance in the scale of moral as well as intellectual being. Nor are we left to doubt that extensions of knowledge, either in simple fact or in cause and relation, are not to be estimated by their immediate and apparent effects; for both are there often good results of the most tangible kind where no such thing was expected—as from Napier's discovery of the logarithms, or, to take an opposite instance, from Smith's ascertainment of the supra-position of rocks—and it is utterly impossible in any way to reckon the benefits which light confers upon mind wherever it is allowed to enter. Assuming, then, the legitimacy of such inquiries, and yet holding by the reverence which Created owes to Creating, we may without fear yield to the instinct which sends us to ask after cause with regard to this vast and beauteous scene. How has it been that these orby myriads have taken the places in which we find them? To what authorship are we to ascribe the whole?

In philosophising, the prime difficulty is to bring down the mind to sufficiently simple conceptions. Many can soar and mystify, and come to nothing; to few is it given to find truth where it usually lies, amongst the things most familiar. The ideas which the ancients formed of the movements of the heavenly bodies were lofty, but utterly false. It was reserved for the geometers of the last two centuries, by pursuing truth on more solid grounds, to establish the simplicity which is now known to extend through the physical constitution of the universe. It has been fully ascertained that the planets have obtained their forms, keep their places with regard to the sun and to each other, and pursue all their various motions, in obedience to certain laws which are to be every day seen acting on the humblest scale in our very presence. Thus, the earth is a globe for the same reason that a dew-drop is so. It is slightly flattened at the poles, as a consequence of rotation on an axis when in a soft state, for the same reason that a mass of clay whirled rapidly round will become of a similar shape. The sun and earth are mutually attracted in proportion to their respective masses, and inversely as the square of the distance, which is a law prevailing with not less certainty upon two rose leaves floating on the summer lake into which they have fallen. The revolution of the planet or satellite in an orbit round a central mass is, again, the result of a composition of two opposite forces—one of them this attraction of gravity in its proper proportions, the other a primitive motion of the one mass away from the other in a straight line; and this phenomenon is exemplified when we see a stone which has been thrown from a boy's hand, brought in a curve to the ground. All these marvels rest on mathematical calculations of the nicest exactness, insomuch that, taking one as an example, astronomers have computed ten years beforehand, the time at which the planet Jupiter would pass our meridian, and the predicted time was *correct within half a second.*

Since Newton stated the laws of gravity and of the planetary motions, there have been some important additions to his philosophy. It has been shown, that certain perturbations in the planetary movements, which appeared to him as denoting a necessary end to the system, observe periods, and are only further proofs of the stability of the whole arrangement. It has also been discovered that the laws of motion extend beyond the solar system. Amongst the serene orbs, which seem so still to our ordinary perceptions, we now know that there is no such thing as rest. Stars are ascertained to have proper motions, of the same nature with that found in our own sun. Many are seen to be, in reality, double or triple—that is, composed of a plurality of suns, which perform regular revolutionary motions around each other in ellipses. The periods of some of these movements and revolutions are of such brevity, that their elements are already in the book of the astronomer; others are seen to be of such vastness, that the times which have determinated the youth and death of our oldest empires, would be, in the comparison, but as a little spoke in some enormous wheel. Yet of all of them no doubt can be entertained that they depend upon those simple physical laws which preside over every particle of tangible matter in our own sphere.

Here it is right to advert to some general features of the solar system, most of which have also been discovered since the days of Newton. It is, in the first place, remarkable, that the planets all move nearly *in one plane*, corresponding with the centre of the sun's body. Next, it is not less worthy of attention, that the motion of the sun on its axis, those of the planets around the sun, and the satellites around their primaries,(4) and the motions of all on their axes, are in one direction—namely, from west to east. Had all these matters been left to accident, the chances against the uniformity would have been, though calculable, inconceivably great.

Of the forty-three motions ascertained in the early part of this century, it was found by Laplace, that the adverse chances were as upwards of *four millions of millions* to *one*. It is thus powerfully impressed on us that the uniformity of the motions, as well as their general adjustment to one plane, must have been a consequence of a single cause acting throughout the whole system.

Some of the other relations of the bodies are not less remarkable. It is, perhaps, of little consequence that the larger planets are towards the outside of the system, since there is an absence of regularity in the gradation in this respect. In the series of comparative densities we find an approach to a regular gradation: they stand thus in decimals, the Earth being considered as 1—Mercury, 2·95; Venus, ·99; Earth 1; Mars, ·79; Jupiter, ·23; Saturn, ·11; Uranus, ·26; the last being the only very decided violation of the rule. Then the distances are curiously relative. It has been found that, if we place the following line of numbers,—

0	3	6	12	24	48	96	192

and add 4 to each, we shall have a series denoting the respective distances of the planets from the sun. It will stand thus—

4	7	10	16	28	52	100	196
Merc.	Venus.	Earth.	Mars.		Jupiter.	Saturn.	Uranus.

It will be observed that the first row of figures goes on from the second on the left hand in a succession of duplications, or multiplications by 2. Surely there is here a most surprising proof of unity in the solar system. It was remarked, when this relation was first detected, that there was the want of a planet corresponding to 28; the difficulty was afterwards considered as overcome, by the discovery of four small planets revolving at nearly one mean distance from the sun, between Mars and Jupiter.(5) The distances bear an equally interesting mathematical relation to the times of the revolutions round the sun. With respect to any two planets, *the squares of the times of revolutions are to each other in the same proportion as the cubes of their mean distances*,—a most surprising result, for the discovery of which the world was indebted to the illustrious Kepler. Sir John Herschel truly observes—"When we contemplate the constituents of the planetary system from the point of view which this relation affords us, it is no longer mere analogy which strikes us, no longer a general resemblance among them, as individuals independent of each other, and circulating about the sun, each according to its own peculiar nature, and connected with it by its own peculiar tie. The resemblance is now perceived to be a true *family likeness*; they are bound up in one chain—interwoven in one web of mutual relation and harmonious agreement, subjected to one pervading influence, which extends from the centre to the furthest limits of that great system, of which all of them, the Earth included, must henceforth be regarded as members." ([6])

The tendency of all the later discoveries has been to deepen the conviction arising from the first, that the physical affairs of the universe are under the regulation of laws; the forms, the distances, the movements, the inter-dependencies of the bodies of space, are determined in this, and in no other more arbitrary manner. And what does a law imply? It is an arrangement in which we see invariable uniformity and self-consistency. In the case of these physical laws, we can bring it to mathematical elements, and see that *numbers*, in the expression of space or of time, form, as it were, its basis. We thus trace in law, Intelligence—often we can see that it has a beneficial object, still more strongly speaking of *mind* as concerned in it. There cannot, however, be an *inherent intelligence* in these laws; we cannot conceive of mind actually working in the agglomeration of a dew-drop or the orbitual revolution of the moon. The intelligence appears *external to the laws*; something of which the laws are but as the expression of the Will and Power. If this be admitted, the laws cannot be regarded as primary or independent causes of the phenomena of the physical world. We come, in short, to a Being beyond nature—its author, its God;—infinite,—inconceivable, it may be, and yet one whom these very laws present to us with attributes showing that our nature is in some way a faint and far-cast shadow of His, while all the gentlest and beautifullest of our emotions lead us to believe that we are as children in his care, and as vessels in his hand. We must consequently understand—and this is for the reader's special attention—that when we speak of natural law, we only speak of the *mode* in which the Divine Power is exercised. It is but another phrase for the *action* of the ever present and sustaining God.

Viewing Nature in this light, the pursuit of science is but the seeking of a deeper acquaintance with the Infinite. The endeavour to explain any events in her history, however grand or mysterious these may be, is only to sit like a child at a mother's knee, and fondly ask of the things which passed before we were born. In modesty and reverence, in the spirit of the love of truth, and that craving of an innate helplessness which seems as if it could never be satisfied till it knew all, we may even inquire if there be any trace of the origin of that arrangement of the universe which is presented to our notice.

In this inquiry, we start with the clear fact of the orbs being determined in their forms by law. That law necessarily infers a previous form of matter, one in which the molecules were separately moveable—fluid or gasiform—just as the law by which the dew-drop is spherified, implies that the constituent particles were in such a condition before it took effect. We thus see the Will which constitutes law acting in a non-material manner in that portion of what we are accustomed to call Creation. In the places and relations of the orbs, there is equal proof, though of a less popularly tangible kind, that law was concerned. The work was done by the will of God, expressed in the form of the law of gravitation. When we come to consider the motions, and regard them as necessarily containing results of *an impulse*, we are apt to suppose some immediate and more direct application of divine power necessary; but this cannot stand a second consideration. We see the motions inextricably wrought up in relation with the magnitudes, as well as the arrangements; a totally different mode of their origin is therefore inconceivable. Having, moreover, in gravitation a general source of motion, and knowing in what various ways a motive power may be applied,—see, for a familiar example, the wheels of a clock revolving under the influence of a weight,—all difficulty in supposing an actual origin of a natural kind for the motions of the heavenly bodies vanishes, however obscure our notions may remain as to the process concerned in the case. Thus everything leads us to the belief that there was a previous form of matter, the alteration of which into the present was brought about in the manner of, though certainly not by any self-dependent efficacy in, Natural Law.

At this point we might rest, for in the general conclusion that the orbs were formed and arranged in such a manner, enough has been gained for the present object. It is worth while, however, to touch slightly on the ideas which have passed through certain great minds with respect to the births of these bodies.

The first idea of what has been called the nebular cosmogony arose with Sir William Herschel, in consequence of the observations which he made regarding a class of heavenly bodies, to which the appellation of *nebulæ* had been applied, in reference to their cloud-like appearance. Some of these bodies were ascertained, by a high telescopic power, to be only astral systems like our own, placed at such a vast distance, that the individuality of the stars composing them was lost to ordinary perceptions. Others resisted the highest telescopic power which the astronomer applied, and, from various considerations, he came to regard them as masses of diffused luminous matter. In these he further discovered a variety of appearances, marking what seemed a gradation of characters, as if they had been in various degrees of condensation ; and hence he was led to surmise that they were solar systems in the process of being formed out of a previous condition of matter. Laplace now stepped forward to show that, if such a luminous matter existed, and if nuclei were established in it, these might become centres of aggregation for the neighbouring diffused matter ; on such centres a rotatory motion would be established, wherever, as was the most likely case, there was any obliquity in the lines of direction in which the opposing currents met each other: this motion would increase as the agglomeration proceeded: at certain intervals, the centrifugal force acting in the exterior of the rotating mass would overcome the agglomerating force, and a series of rings would thus be left apart, each possessing the motion proper to itself at the crisis of separation. These, again, could only continue in their annular form if uniform in constitution. There being many chances against this, they would probably break up, and be agglomerated into either one or several masses, which would then become representatives of the primary mass, and perhaps give rise to a similar progeny of inferior masses. All this Laplace showed to be possible under the physical laws of the universe, and he conceived that such might be the actual history of all such systems as ours, the four small planets between Mars and Jupiter being an example of a ring which agglomerated into distinct parts, and the rings of Saturn instances of satellites which have not yet attained, if they ever will attain, the ultimate form assigned to such bodies in general.

This hypothesis, it will be observed, only comes to the point at which we must needs arrive under a consideration of the "web of relation" traceable in the constituents of the solar system—namely, that they have had a common origin in a soft and diffused form of matter. Such a form of matter may now, as is alleged, be no longer actually seen in the heavens; and yet there may remain good reasons for believing that it once existed. One of these will afterwards be presented in the facts connected with the density of the planets and the internal heat of the earth. As another, I may point to the curious phenomenon called the zodiacal light, an oblate luminosity surrounding the sun, and very conspicuous in the twilights of tropical climes; a remnant, as has been supposed, of the diffused solar atmosphere of the nebular cosmogony. There is even a support to the hypothesis in what would seem at first to be an anomaly and an objection—the existence of the many binary and ternary solar systems. It may be supposed that, at a certain point in the confluence of the matter of these regions of space, the solar nuclei would become involved in a common revolutionary motion, linked inextricably with each other, though it might be at sufficient distances to allow of each body having afterwards its attendant planets. Such a phenomenon is occasionally realized to us on the surface of a river flowing between irregular banks. There we not only see single dimples rotating and passing onward, results of that obliquity in the meeting of currents which is thought to have set solar systems in motion, but often two or more of these dynamic microcosms will come within a range of mutual influence, and go on wheeling around each other. These fantastic eddies, which the musing poet will sometimes watch abstractedly for an hour, little thinking of the laws which produce and connect them, form an illustration of the mechanism of binary and ternary stars, and bring an unexpected aid to a hypothesis of the history of the heavenly spaces.

A remarkable approximation has also been made to what may be called an experimental verification of this cosmogony, by a living professor, M. Plateau, of Ghent. Divested of technical terms, the experiment was nearly as follows:—Placing a mixture of water and alcohol in a glass box, and therein a small quantity of olive oil of density precisely equal to the mixture, we have in the latter *a liquid mass relieved from the operation of gravity*, and free to take the exterior form given by the forces which may act upon it. In point of fact, the oil, by virtue of the law of molecular attraction, instantly takes a globular form. A vertical axis being introduced through the box, with a small disc upon it, so arranged that its centre is coincident with the centre of the globe of oil, we turn the axis at a slow rate, and thus set the oil-sphere in rotation. "We then presently see the sphere *flatten at its poles* and *swell out at its equator*, and thus realize on a small scale an effect which is admitted to have taken place in the planets." The spherifying forces are of different natures, that of molecular attraction in the case of the oil, and of universal attraction in that of the planet; but the results are analogous, if not identical. Quickening the rotation makes the figure more oblately spheroidal. When it comes to be so quick as two or three turns in a second, "the liquid sphere first takes rapidly its maximum of flattening, then becomes hollow above and below around the axis of rotation, stretching out continually in a horizontal direction, and finally, abandoning the disc, is *transformed into a perfectly regular ring*." At first, this remains connected with the disc by a thin pellicle of oil; which, however, on the disc being stopped, breaks and disappears, and the ring then becomes completely disengaged. The only observable difference between this ring and that of Saturn, is that it is rounded, instead of being flattened; but this is accounted for by the learned professor in a satisfactory way.

A little after the stoppage of the rotatory motion of the disc, the ring of oil, losing its own motion, gathers once more into a sphere. If, however, a smaller disc be used, and its rotation continued after the separation of the ring, rotatory motion and centrifugal force will be generated in the alcoholic fluid, and the oil-ring, thus prevented from returning into the globular form, divides itself into *several isolated masses, each of which immediately takes the globular form.* These "are almost always seen to assume, at the instant of their formation, *a movement of rotation upon themselves*,—a movement which constantly takes place *in the same direction as that of the ring*. Moreover, as the ring, at the instant of its rupture, had still a remainder of velocity, the spheres to which it has given birth tend to fly off at a tangent; but, as on the other hand, the disc, turning in the alcoholic fluid, has impressed on this a movement of rotation, the spheres are especially carried along by this last movement, and revolve for some time round the disc. Those which revolve at the same time upon themselves, consequently then present the curious spectacle of *planets revolving at the same time upon themselves and in their orbits*. Finally—besides three or four large spheres into which the ring resolves itself, there are almost always produced one or two very small ones, which may thus be compared to satellites. The experiment presents, as we see, an image in miniature of the formation of the planets, according to the hypothesis of Laplace, by the rupture of the cosmical rings attributable to the condensation of the solar atmosphere." (7) It must of course be admitted that the process of the experiment was of a reverse kind, and attended, as far as M. Plateau's description informs us, by slightly various effects; but the general reflection which it gives of Laplace's cosmogony is certainly such as to confer upon that hypothesis a strong probability.

To conclude this section of the history. What we see is —a boundless multitude of bodies with vast empty spaces between. We know of certain motions amongst these bodies; of other and grander translations we are only beginning to get some knowledge. Beside this idea of locality and movement, we have the equally certain one of a former soft and more diffused state of the materials of these bodies; also a tolerably clear one as to gravitation having been the determining cause of both locality and movement. To no other conclusion, as it appears to me, can these various ideas lead, than to that of universal space being formerly occupied with gasiform matter; this, however, of irregular constitution, so that gravitation caused it to break up and gather into patches, producing at once the relative localities of astral and solar systems, and the movements which they have since observed, in themselves and with regard to each other, from the daily spinning of single bodies on ideal axles, to the mazy dances of vast families of orbs, which come to periods only in millions of years. How grand, yet how simple the whole of this process—for a God only to conceive and do, and yet for man, after all, to trace out and ponder upon. Oh, truly must we be in some way immediate to the august Father, who can *think* all this, and so come into his presence and council, albeit only to fall prostrate and mutely adore!

CONSTITUENT MATERIALS OF THE EARTH,

AND OF THE OTHER BODIES OF SPACE.

The orbs being all inextricably connected in the manner which has been described, are we also to presume that the constitution of the whole is uniform?—that is to say, do the whole consist of the same chemical elements?

What are elements? This is a term applied by the chemist to a limited number of substances, (fifty-five are ascertained,) which, in their combinations, form all the matters present in and about our globe. They are called elements, or simple substances, because it has hitherto been found impossible to reduce them into others, wherefore they are presumed to be the primary bases of all matters. It has, indeed, been surmised that these so-called elements are only modifications of a primordial form of matter, brought about under certain conditions; but if this should prove to be the case, it would little affect the present speculations. Analogy would lead us to conclude that the modifications of the primordial matter, forming our so-called elements, are as universal, or as liable to take place everywhere, as are the laws of gravitation and centrifugal force. It therefore appears likely that the gases, the metals, the earths, and other simple substances, (besides whatever more of which we have no acquaintance,) exist under proper conditions, as well in the astral system which is thirty-five thousand times more distant than Sirius, as within the bounds of our own solar system or our own globe.

Matter, whether it consists of about fifty-five ingredients, or only one, is liable to infinite varieties of condition under different influences. As a familiar illustration, water, when subjected to a temperature under 32° Fahrenheit, becomes ice; raise the temperature to 212°, and it becomes steam, occupying a vast deal more space than it formerly did. The gases, when subjected to pressure, become liquids; for example, carbonic acid gas, when subjected to weight equal to a column of water 1230 feet high, at a temperature of 32°, takes this form: the other gases require various amounts of pressure for this transformation, but all appear to be liable to it when the pressure proper in each case is administered. Heat is a power greatly concerned in regulating the volume and other conditions of matter. The chemist will probably yet tell us what additional amount of heat would be required to vaporize all the water of our globe; how much more to disengage the oxygen which is diffused in nearly a proportion of one-half throughout its solids; and, finally, how much more would be required to cause the whole to become vaporiform, which we may consider as equivalent to its being restored to its supposed original nebulous state. He may calculate with equal certainty, what would be the effect of a considerable diminution of the earth's temperature—what changes would take place in each of its component substances, and how much the whole would shrink in bulk.

The earth and all its various substances have at present a certain volume in consequence of the temperature which actually exists. If, then, we admit that its matter and that of the associate planets was at one time diffused throughout the whole space now circumscribed by the orbit of Uranus, it follows, after what we know of the power of heat, that the nebulous form of matter was attended by the condition of a very high temperature. The nebulous matter of space, previously to the formation of stellar and planetary bodies, must have been a universal Fire Mist, an idea which we can scarcely comprehend. The formation of systems out of this matter implies a change of some kind with regard to the condition of the heat. Had this power continued to act with its full original repulsive energy, the process of agglomeration by attraction could not have gone on. We do not know enough of the laws of heat to enable us to surmise how the necessary change in this respect was brought about; but we can trace some of the steps and consequences of the process. Uranus would be formed at the time when the heat of our system's matter was at the greatest, Saturn at the next, and so on. Now this tallies with the exceeding diffuseness of the matter of those elder planets, Saturn being not more dense or heavy than the substance cork. It may be that a sufficiency of heat still remains in those planets to make up for their distance from the sun, and the consequent smallness of the heat which they derive from his rays. And it may equally be, since Mercury is nearly thrice the density of the earth, that its matter exists under a degree of cold for which that planet's large enjoyment of the sun's rays is no more than a compensation. Thus there may be upon the whole a nearly equal experience of heat amongst all these children of the sun. Where, meanwhile, is the heat once diffused through the system, over and above what remains in the planets? May we not rationally presume it to have gone to constitute that luminous envelope of the sun, in which his warmth-giving power is now held to reside? It may have simply been reserved to constitute, at the last, a means of sustaining the many operations of which the planets were destined to be the theatre.

The tendency of the preceding considerations is to impress the notion that our globe is a specimen of all the similarly-placed bodies of space, as respects its constituent matter and the physical and chemical laws governing it, with only this qualification, that there are *possibly* shades of variation with respect to the component materials, and *undoubtedly* with respect to the conditions under which the laws operate, and consequently the effects which they produce. Thus, there may be substances here which are not in some of the other bodies, and substances here solid may be elsewhere liquid or vaporiform. We are the more entitled to draw such conclusions, seeing that there is nothing at all singular or special in the astronomical situation of the earth. It takes its place third in a series of planets, which series is only one of numberless other systems forming one group. It is strikingly—if such an expression may be used—a member of a democracy. Hence, we cannot suppose that there is any peculiarity about it which does not attach to multitudes of other bodies; in fact, to all that are analogous to it in respect of cosmical arrangements.

It therefore becomes a point of great interest—what are the materials of this specimen? What is the constitutional character of this object, which may be said to be a sample, presented to our immediate observation, of those crowds of worlds which seem to us as the particles of the desert sand-cloud in number, and to whose diffusion there are no conceivable local limits?

The solids, liquids, and aeriform fluids of our globe are all, as has been stated, reducible into fifty-five substances hitherto called elementary. Of these, forty are well-characterized metals, twelve non-metallic bodies, and the remaining three solid substances of intermediate character, which form a connecting link between the two great groups. Among the non-metallic elements, four—viz., oxygen, hydrogen, nitrogen, and chlorine, are permanently gaseous; bromine is fluid at common temperatures; and the remainder (with the exception of fluorine, which has never been isolated, and whose physical characters are consequently unknown) are solid.

The body oxygen is considered as by far the most abundant substance in our globe. It constitutes a fifth part of our atmosphere, eight-ninths of the weight of water, and a large proportion of every kind of rock in the crust of the earth. Hydrogen, which forms the remaining part of water, and enters into some mineral substance, is perhaps next. Nitrogen, of which the atmosphere is four-fifths composed, must be considered as an abundant substance. The metal silicium, which unites with oxygen in nearly equal parts to form silica, the basis of about a half of the rocks in the earth's crust, is, of course, an important ingredient. Aluminium, the metallic basis of alumina, a material which enters largely into many rocks, is another abundant elementary substance. So, also, is carbon, a small ingredient in the atmosphere, but the chief constituent of animal and vegetable substances, and of all fossils which ever were in the latter condition, amongst which coal takes a conspicuous place. The familiarly-known metals, as iron, tin, lead, silver, gold, are elements of comparatively small magnitude in that exterior part of the earth's body which we are able to investigate.

It is remarkable of the elementary substances that they generally exist in combination. Thus, oxygen and nitrogen, though in mixture they form the aerial envelope of the globe, are never found separate in nature. Carbon is pure only in the diamond. And the metallic bases of the earths, though the chemist can disengage them, may well be supposed unlikely to remain long uncombined, seeing that contact with moisture makes them burn. Combination and re-combination are principles largely pervading nature. There are few rocks, for example, that are not composed of at least two varieties of matter, each of which is again a compound of elementary substances. What is still more wonderful with respect to this principle of combination, all the elementary substances observe certain mathematical proportions in their unions. When in the gaseous state, one volume of them unites with one, two, three, or more volumes of another, any extra quantity being sure to be left over, if such there should be. Combinations by weight are also governed by fixed and unchanging laws, of the greatest beauty and simplicity. It has hence been surmised that matter is composed of infinitely minute particles or atoms, each of which belonging to any one substance can only associate with a certain number of the atoms of any other. There are also strange predilections amongst substances for each other's company. One will remain combined in solution with another, till a third is added, when it will abandon the former and attach itself to the latter. A fourth being added, the third will perhaps leave the first, and join the new comer.

Such is an outline of the information which chemistry gives us regarding the constituent materials of our globe, and their combinations. How infinitely is the knowledge increased in interest, when we consider the probability of such being the materials of the whole of the bodies of space, and the laws under which these everywhere combine, subject only to local and accidental variations!

In considering the cosmogenic arrangements of our globe, our attention is called in a special degree to the moon.

In Laplace's hypothesis, satellites are considered as masses thrown off from their primaries, exactly as the primaries had previously been from the sun. The orbit of any satellite is also to be regarded as marking the bounds of the mass of the primary at the time when that satellite was thrown off; its speed likewise denotes the rapidity of the rotatory motion of the primary at that particular juncture. For example, the outermost of the four satellites of Jupiter revolves round his body at the distance of 1,180,582 miles; hence, according to the hypothesis, the planet was once about 3,675,501 miles in circumference, instead of being, as now, only 89,170 miles in diameter. This large mass would take rather more than sixteen days six hours and a half (the present revolutionary period of the outermost satellite) to rotate on its axis. The innermost satellite would be formed when the planet was reduced to a circumference of 309,075 miles, and rotated in about forty-two hours and a half.

From similar inferences, it would result that the mass of the earth, at a certain point of time after it was thrown off from the sun, was no less than 482,000 miles in diameter, being sixty times what it has since shrunk to. At that time, the mass must have taken rather more than twenty-nine and a half days to rotate, (being the revolutionary period of the moon,) instead of, as now, rather less than twenty-four hours.

The time intervening between the formation of the moon, and the earth's diminution to its present size, was probably like one of those vast sums in which astronomy deals so largely, but which the mind altogether fails to grasp.

The observation made upon the surface of the moon by telescopes tends strongly to support the hypothesis as to all the bodies of space being composed of similar matters subject to certain variations. It does not appear that our satellite is provided with an atmosphere of the kind found upon earth; neither is there any appearance of water upon the surface. Yet that surface is, like the face of our globe, marked by inequalities and the appearance of volcanic operations. These inequalities and volcanic operations are upon a scale far greater than any which now exist upon the earth's surface. The mountains are, in many instances, equal in height to nearly the highest of our Andes. They are generally of extreme steepness, and sharp of outline, peculiarities which might be looked for in a planet deficient in meteoric agencies such as those which operate so powerfully in wearing down ruggedness on the surface of our earth. The volcanic operations are on a stupendous scale. They are the cause of the bright spots of the moon, while the want of them is what distinguishes the duller portions, usually but erroneously called *seas*. In some parts, bright volcanic matter, besides covering one large patch, radiates out in long streams, which appear studded with subordinate *foci* of the same kind of energy. A large portion of the surface is covered with circular eminences, called Ring Mountains, of various diameters, from a quarter of a mile to several hundred miles, and in some places as close together as the circles on the surface of a boiling pot, which they in no small degree resemble. Some even intrude upon and obliterate portions of the neighbouring circles, thus leading to the idea of *date*, or a succession of events on the moon's surface. Generally, in the centre, there is a mount, which appears to be connected, in the way of cause, with the annular eminence, beyond which again vast boulder-like masses are in some instances seen scattered. What, however, most strikes the senses of an observer, is the vast profundity of some of the pits between the ring and the inner mount; in one case, this is reckoned to be not less than 22,000 feet, or twice the height of Ætna.

These characteristics of the moon forbid the idea that it can be at present a theatre of life like the earth, and almost seem to declare that it never can become so. But it is far from unlikely that the elements which seem wanting may be only in combinations different from those which exist here, and may yet be developed as we here find them. Seas may yet fill the profound hollows of the surface; an atmosphere may spread over the whole. Should these events take place, meteorological phenomena, and all the phenomena of organic life, will commence, and the moon, like the earth, will become a green and inhabited world. ([8])

It is unavoidably held as a strong proof in favour of any hypothesis, when all the relative phenomena are in harmony with it. This is eminently the case with the Laplacian cosmogony, for here the associated facts cannot be explained on any other supposition. We have seen reason to believe that the primary condition of matter was that of a diffused mass, in which the component molecules were kept apart through the efficacy of heat; that portions of this matter agglomerated into suns, which threw off planets; that these planets were at first very much diffused, but gradually contracted by cooling to their present dimensions. Now, as to our own globe, there is a remarkably distinct memorial of the supposed high temperature of the materials, in the store of heat which still exists in the interior. The immediate surface of the earth, be it observed, exhibits only the temperature which might be expected to be imparted to such materials by the heat of the sun. There is a point a very short way down, but varying in different climes, where all effect from the sun's rays ceases. Then commences a temperature from an entirely different cause, one which evidently has its source in the interior of the earth, and which regularly increases as we descend to greater and greater depths, the rate of increment being, in general, about one degree Fahrenheit for every fifty feet; and of this high temperature there are other evidences in the phenomena of volcanoes and thermal springs, as well as in what is ascertained with regard to the density of the entire mass of the earth. This approximates five and a half times the weight of water; but the actual weight of the principal solid substances composing the outer crust is as two and a half times the weight of water; and this, we know, if the globe were solid and cold, should increase greatly towards the centre, water acquiring the density of quicksilver at 362 miles below the surface, and other things in proportion, and these densities becoming much greater at greater depths; so that the entire mass of a cool globe should be of a gravity infinitely exceeding five and a half times the weight of water. The only alternative supposition is, that the central materials are greatly expanded or diffused by some means; and by what means could they be so expanded but by heat? Indeed, the existence of this central heat, a residuum of that which kept all matter in a vaporiform chaos at first, is amongst the most solid discoveries of modern science,([9]) and the support which it gives to the nebular hypothesis is highly important. We shall hereafter see what have been supposed by some to be traces of an operation of this heat upon the surface of the earth in very remote times; an effect, however, which has long passed entirely away.

THE EARTH FORMED—GEOLOGICAL CHANGES.

In our version of the romance of nature, we now descend from the consideration of orb-filled space and the character of the universal elements, to trace the history of our own globe. We shall see that it falls into connexion in an interesting manner with the primary order of things indicated by Laplace's Hypothesis.

The nature of the materials of the externe or crust of our globe, is known to a greater depth than might be supposed, in consequence of the relation of position of its various masses. Confused as these at first appear, an order of arrangement, connected with time, has been detected in them by the labours of modern geologists. It is found that a certain kind of rock, below which there is never, in ordinary circumstances, any other kind, is of crystaline character. Sometimes elevated in naked mountain masses, sometimes found only at great depths below other rocks of a different kind, *Granite* (for such is its name) appears as the basis rock of the earth's crust; the form into which the once fluid matter of our planet was primarily resolved, although, in many instances, subjected, under heat, to new movements at times long subsequent. The crystals of granite are of distinct substances—quartz, felspar, mica, and hornblende (each of which is, again, a combination of a certain number of the simple or elementary substances): two of these, sometimes three, associated in various proportions, compose the rock, which thus appears in many varieties, passing under different names.

Where granite does not appear upon the surface, or else some other igneous rock, such as will presently be adverted to, we find that great flooring overlaid with rocks of a different character and history—namely, what are called *Aqueous* or *Sedimentary Rocks.* These are in the form of strata or beds, and have evidently been for the most part produced as a sediment of sand, clay, or other materials, at the bottom of seas, the matter being hardened by heat and pressure after its deposition. Whence the materials of these rocks? With some peculiar exceptions, each group of them has been derived from the substance of such rocks as were previously in existence, the earliest from the original granite, and so on in succession; and this, by means or processes which continue in operation at the present day. That is to say, the atmosphere, by the chemical action of its materials, and the vapours with which it is charged, wears down whatever rocks are exposed to it; rivers carry the particles into the sea, the sea also erodes the rocks against which it impinges, and strews the matter along its bottom; thus are sediments laid down, to be in time formed into rocks. Many of the earliest or lowest strata are obviously composed of material but slightly changed from the original granite; such are all the rocks bearing the name of *Gneiss.* Others present the component materials in different combinations; as, for instance, where, with clay derived from the felspar and the addition of mica, *Micaceous Schist* has been formed. Sometimes the quartz forms a sedimentary rock by itself. For such elections of materials, as they may be called, we see natural means of accounting, when we reflect that the lighter particles of any substance suspended in moving water are liable to be carried most rapidly, and to the greatest distance.(10) It is also to be remarked of all these early rocks, that they have evidently been subjected to an extraordinary degree of heat, insomuch that they generally have acquired a new crystaline texture, are strangely waved and contorted, and often cannot be distinguished from the underlying granite, the adjacent parts of which may sometimes be detected as having been placed there after the deposition of the aqueous rocks. Now the lowest stratified rocks are sometimes found lying in a nearly horizontal position, as they would be originally formed; but more generally they are tilted up in high inclinations, with the broken edges directed towards granitic mountains; indicating that the rise of these mountains from below was the cause of the change of position in the stratified rocks. Thus the earliest strata were in their turn exposed to the wearing influences of sea and atmosphere, and the materials appropriated to form new rocks. And, precisely as might be expected, these new rocks are laid down *unconformably* to the old; that is, their verges rest at an angle against the sides of the senior formation. These new rocks are again, in their turn, broken up and placed in high inclinations by new and similar upbursts of igneous rock; so as to become liable, of course, to similar disintegration. Such a repetition of wearings down and raisings up, implying frequent changes of land and sea, has been in reality the history of our globe since it took its present shape. A granitic crust, containing vast and profound oceans, as is proved by the extent and thickness of the earliest strata, was the infant condition of the earth. Points of unconformableness in the overlying aqueous rocks, connected with protrusions of granites, and other similar presentments of the internal igneous mass, such as trap and basalt, mark the conclusions of subsequent sections in this grand tale. Dates, such as chronologists never dreamed of—compared with which those of Egypt's dynasties are as the latter to a child's reckoning of its birthdays—have thus been presented to the now living generation, in connexion with the history of our planet.

The aqueous rocks, taken in their details, are a vast number. Geologists, however, group them in *formations* or *systems*, partly with reference to their lithological characters and the breaks in stratific arrangement above described, and partly with regard to an entirely different class of particulars. It is now time to say that, from an early portion of the sedimentary rock series to its close, the mineral masses are found to enclose remains of the organic beings (plants and animals) which flourished upon earth during the time when the various strata were forming; and these organisms, or such parts of them as were of sufficient solidity, have, in many instances, been preserved with the utmost fidelity, although for the most part converted into the substance of the enclosing mineral. Now, as we pass along through the series of strata, we find a cessation of certain specific forms of plants and animals, while others come into view; at some points, the change is almost complete—at others, it is very considerable. Such demarcations are taken into account by geologists in the grouping of the rock series. They speak of a *Palæozoic Period*, comprehending a large early section, terminating at a point where the specific forms are for the first time almost wholly changed; a *Secondary Period*, and a *Tertiary Period*,—these also giving groups of species all but distinct. Under each period are reckoned certain *systems*, more or less organically distinct, and these we shall now proceed to treat separately.

LOWER AND UPPER SILURIAN FORMATIONS—FIRST FORMS OF LIFE.

THE first leaves of the Stone Book have been damaged by fire. It is acknowledged by all geologists that the rocks of what has been called the *Gneiss and Mica Slate System*, were, subsequently to their deposition, exposed to so high a temperature, that, though organic remains had been entombed in them, we should have had no chance of seeing these preserved.(11) If it be a fact, therefore, that no distinct traces of plants and animals are presented in these rocks, it is no conclusive proof that such did not then exist. But no such fact can be said to have been ascertained. Certain fragments resembling the cases of infusoria (shelled animalcules) have been observed.(12) A few patches of limestone (primary limestone) indicate organic life as having been present where they were formed;(13) and a similar inference has been drawn from certain experiments of M. Braconnot, in which he detected *ammoniacal products* from masses of this formation. From analogy, moreover, seeing that all other sedimentary formations contain remains of living beings—it appears, *à priori*, unlikely that this should be, any otherwise than apparently, devoid of them. (14) However all this may be, it is certain that the next formation—the *Silurian*—is the first in which we find incontestable monuments of the early life of our planet.

The Silurian System is so named, because a district in western England, where it is largely presented at the surface, and where it was first thoroughly examined, was that occupied in the time of the Romans by a people called the Silures. It is in reality developed much more extensively in Scandinavia and Russia, as well as other parts of the world. With us it is a series of clayey and arenaceous beds, of hard consistence; but the characters are different in other countries.

And what were the vessels of the mystery of life upon our earth in the era of the Silurian formation, as far as these rocks can inform us?

One would imagine that, if our present amount of geological knowledge had come to us by some sudden revelation, it would have been with a kind of awe that its first recipients would have waited for this portion of it. But had they done so, they would quickly have had to admit that nature is simpler than man's wit would make her, for, behold, the interrogation only brings before us the unpretending forms of a few humble sea-plants, certain zoophytes and polypiaria, and a variety of shelled marine animals!

To descend to particulars—*Fucoids*, or markings produced by fuci, a tribe of sea-plants, appear in the Lower Silurians of Russia, below any ascertained animal remains, thus supporting the obvious conclusion that vegetation must have started fully as early as animal life, since the one thing is necessary to the support of the other. In America, the same vegetable remains are presented in the very first ascertained fossiliferous strata; but in England they are not as yet found quite so early. In the Lower Silurians of Sweden, not only are there distinct impressions of such plants, but Professor Forchhammer speaks of courses of true coal, composed, as he thinks, of sea-weed, and gives an opinion that the alum-slate of that country owes its combustible character to the carbon, sulphur, and potash, derived from marine vegetation. ([15])

Of the animals, the first we are called upon to notice are *Polypiaria*,—the creatures to which we are indebted for those vast coral reefs by which the course of the mariner is so often obstructed in tropical seas,—beings thus productive of great results, and yet in themselves extremely humble, as is partly indicated by the composite form in which they exist. Next to them may be ranked certain humble animals (*graptolites*) allied to the sea-pens of modern seas, a family usually inhabiting mud and slimy sediment in deep water. We come to creatures comparatively well organized, and yet still within the lowest division of the Animal Kingdom, when we speak of *Crinoidea*, which might be described as a lowly kind of star-fish, fixed on the top of a flexible stalk arising from the sea-bottom. Numberless calcareous plates enter into the composition of the stalk, body, and multitudinous tentacula or arms of the crinoid, forming altogether a wonderful example of the elaborateness of pattern on which nature sometimes works; and yet it is a very humble animal,—only, indeed, a stomach of one aperture, with arms wherewith to supply itself with food. The echinodermata, however, to which order it belongs, are the destructives of their grade; and thus soon, it therefore appears, were animals set up as a police over the rest, to effect the great providential object of controlling the numbers of living beings.

We have spoken of the Animal Kingdom and one of its divisions. It may be well here to state that these divisions have a reference to the grade and general character of the animals. An animal is said to be low, when its organization is of a simple kind, subservient to a comparatively narrow range of functions, and suited to a comparatively narrow field of existence,—if, like the polypes, for instance, and crinoids, it be fixed in situation, and consist mainly of an alimentary receptacle, with means of filling that with food. Elevation is marked in the scale, by an animal ceasing to be compound (which is the case of the coralline polypes), assuming a power of locomotion, having sex assigned to separate individuals, exchanging a multiplicity of parts serving one end (as the many pairs of feet in the centipede) for a smaller number; attaining, in short, at once a more complex and more concentrated organization. On such grounds, the animal kingdom may be primarily divided into *Vertebrated* and *Invertebrated*; animals with a back-bone and the superior nervous system which that structure implies, and animals devoid of that structure and possessing a humbler nervous system. In the latter are placed, first, the rayed animals (*Radiata*); then, on one higher platform, the *Articulata* or jointed animals, as crustacea, insects, spiders,—and the *Mollusca*, or pulpy animals, of which oysters, cowries, and cuttle-fish are examples. To all these, the *Vertebrata* are as a great and beautiful superstructure upon a rustic basement, in the four great classes of ascending rank—Fishes, Reptiles, Birds, Mammalia.

To resume our view of the Lower Silurian fossils:—Of Articulata, we have first a few examples of its lowest class, the *Annelides* or sea worms,—a group ill adapted for preservation; otherwise, they might have been seen in greater abundance. Some which were found in a building stone at Lampeter, far down in the Lower Silurians, lie in a long coil, as they might be supposed to have laid themselves down to die upon the sea-bottom; they are considered as allied to the nereis of the present seas. But by far the most conspicuous articulate of the early rocks is a member of the class *Crustacea.*

This is the *Trilobite*, a marine animal to which the woodlouse makes the nearest approach in general form, but marked by two groovings along the length of the body, so as to present a tri-lobed form; hence the name. The animal of our present seas most resembling it, is the limulus, or king-crab. It is surprising how many species and even genera of the trilobite lived in the Silurian seas, and in what quantities their remains are found in various parts of the earth. The means of locomotion possessed by the animal are not known; but from its form we must suppose it to have lived at the bottom of the sea, having its eyes directed upwards and sideways. The latter organs presenting facets such as are seen upon similar animals of our era, we may be said to have a proof furnished to us by this humble creature, "that the water of those oceans and the supernatant atmosphere, was as transparent a medium at that time as it is at the present day, and that therefore no material permanent alteration can have resulted in either during the thousands of years which have elapsed since the creation of the animal world on this earth." ([16]). The trilobites stand low in the crustacea, nor were any higher animals of that order (such as crabs, lobsters, &c.,) yet in existence.

Of the division *Mollusca*, the predominant form in point of numbers was the bivalve order *Brachiopoda*, which is now but slenderly represented upon earth. So numerous are the specimens in the Silurian rocks, that an eminent geologist calls this emphatically the Age of Brachiopods. ([17]) The animal is a humble one, having two shells, not connected by a hinge, as is usual in superior bivalves, but kept together by a bundle of fibres. Its destiny is to remain fixed at the bottom of deep seas, and live upon nutritive particles, which it collects by means of two spiral-shaped arms, extending from the margin of its mouth, and from which the order has received its name. The superior abundance of life in the depths of the ocean, far from land, may be inferred, as a fact of this period, from the comparative number of the brachiopod fossils.

Of univalves, which, generally speaking, rank above the bivalves, there are remains of all the three classes. The first and humblest, *Pteropoda*, most of which are naked, and therefore incapable of preservation in the fossil state, appear only in a few slight conical shells, indicating an animal allied to the genus Criseis, still common in the Mediterranean. Of the next, *Gasteropoda*, there are many fossil species. There are also representatives of the last class, *Cephalopoda*, amongst which are now found some of the highest of the invertebrate animals, as the nautilus, cuttle-fish, and poulp. The cephalopods (orthoceratites, &c.,) pursuing a free-swimming life, and highly organized for the catching and destroying of the weaker marine animals, were the lords of the organic world in their day.

Such are the organisms of the Lower Silurian era, the first age of organization upon earth of which any very distinct memories have been left to us. There was as yet no fish nor any other kind of vertebrated animal, nor any creature which lived upon dry land. The zoology of the Upper Silurians is only different in as far as it presents, for the most part, new species of the same families, and a greater abundance of specimens; one rock (Wenlock limestone) is a mere mass of the remains of corals, crinoids, and trilobites, held together by shale, and gives us, in England, a few obscure traces of fish. It is most remarkable how uniform has been the Fauna of the earth in those primitive ages. Silurian rocks have now been examined in England, Russia, Germany, and North America, with great care; also in South America, the southern part of Africa, and even at the Falkland islands, the very antipodes of Britain; yet in no place has any essential difference of fossils been detected. Brachiopods, orthoceratites, trilobites, are almost everywhere characteristic fossils. In the Alleghany mountains, in the hills of Herefordshire, on the slopes of the Ural chain, which divides Europe from Asia, we have remains of the same animal tribes. ([18]) There are differences of species—that is to say, the fossils of different regions present certain minor peculiarities—but even this is only partial, and does not materially interfere with the general fact that there has been a remarkable uniformity of life in the primeval seas. In the present era, it is hardly necessary to say, the case is very different. Even seas so near as the Red Sea and Mediterranean, present wholly different genera of mollusks. It has been thought that there might be a cause for the greater uniformity of life in those ages, in the greater uniformity of temperature, resulting from the as yet unspent heat of the surface, arising from the internal incandescence; but perhaps the more probable cause was simply the comparative newness of life upon earth, and its little experience of those external agencies by which it is liable to be affected, and which, we shall see reason to believe, have operated in producing the many shades of variation which now mark the organic kingdoms.

DEVONIAN ERA.—FISHES ABUNDANT.

We now advance to a new chapter in this marvellous history —that of the *Devonian* era. The term Devonian System is applied to an important and conspicuous group of strata, overlying the Silurian, and largely developed—first in the South of Devonshire (whence the name), and in Cornwall, South Wales, Herefordshire, Shropshire, and Worcestershire; also in Scotland, the valley of the Rhine, Russia, and the western states of America; besides, in all probability, many parts of the world as yet unexplored. In Scotland, the great Grampian elevation, composed of granite and gneissic rock, is skirted by a dense formation of conglomerate and red sandstone, extending in a sweep from Dunbarton to Stonehaven, and so on to Morayshire, Ross, and Caithness. This passes by the general name of the Old Red Sandstone, which was at first used as an appellative for the system; but it has latterly been abandoned, as redness is not found to be a prevailing peculiarity of the strata in other countries. In Russia, a surface as large as the whole of Great Britain is occupied by this formation. It reaches a thickness of ten thousand feet in England.

The general forms of life prevalent in the Silurian era are continued in the Devonian, with the remarkable addition of a large development of the humblest vertebrate class—Fishes. There is here, as there was in the Silurians, an abundance of zoophytes, corallines, crinoids, crustaceans, and mollusks, but mostly presenting those inferior variations which naturalists regard as constituting distinct species: speaking strictly, out of about eight hundred so-called species of the Silurian epoch, one hundred pass into the Devonian formation, where, however, they gradually disappear, while new ones as gradually take their place. For such changes of species, adopting this word in the sense usually attached to it, geologists suggest causes in physical changes, as the rise of a sea-bottom by gradual filling up, or the intrusion of a new mineral material into the ocean, or one of a more decisive kind proceeding from such revolutions as are indicated by unconformableness in the strata. But on this point much obscurity at present rests, for, as our survey is extended into other countries, it is found that extensive changes of species occur without any apparent dependence on at least some of these causes; so that, in these instances, some other explanation remains to be sought for.

Corallines (favosites, cyathophylla, stromatopora) are amongst those genera which pass from the Silurians to the Devonians; they are so abundant, as in some places to constitute entire strata, (Devonshire marbles.) The crinoids and trilobites are also continued as families throughout this era. Of the latter we have a new species (brontes), marked by several new features, including a set of claws resembling those of the common lobster, and the whole length of which is judged to have been not less than four feet. Some of the new brachiopods are of very peculiar shape; amongst the gasteropods are some which approach existing forms. The lordly cephalopoda continue to be largely represented, but in a considerable change of form; for while the chief animals of this class in the Silurians (orthoceratites) had a simple, straight, or slightly curved shell, those new to the present era (as clymenia) had one forming a complete spiral.

The most remarkable circumstance connected with the Devonian formation, is its presenting us with fish. A few faint traces of this class had, as we have seen, been presented in the Upper Silurians of our own country, though, it may be remarked, wanting in the corresponding rocks of Russia. We are now to see such memorials of them in the Devonian formation as show that the seas of that era had in many places swarmed with such inhabitants. M. Agassiz, of Neufchatel, to whom the investigation of the subject has chiefly been committed, has ascertained upwards of a hundred species of Devonian fish, to which number it is to be expected that many additions will yet be made.

The predominating fishes of this system, and the only ones which (as far as fossils show) existed for some ages, are arranged by M. Agassiz in two orders, with a regard to their external covering, which that naturalist holds to be, in fishes, a reflection of the internal organization. Both orders, it is to be remarked at the very first, are manifestly of an inferior character to the two other orders which afterwards came into existence, and still are the principal fishes of our seas, these being covered by true scales, and respectively named ctenoid and cycloid, from the forms of that part of their organization. The two orders of early fish are covered with integuments considerably different in character; the one (*placoids*) with irregular enamelled plates, the other (*ganoids*) with regular enamelled scales, the first being not placed over each other, as scales are, but laid edge to edge, in the manner of a pavement. These characters, according to M. Agassiz, were accompanied by a rudimentary or cartilaginous skeleton, while the ctenoids and cycloids possess an osseous structure.

The *cephalaspis* has a longish tail-like body inserted within the cusp of a large crescent-shaped head, somewhat like a saddler's cutting-knife. The body is covered with strong plates of bone, enamelled, and the head was protected on the upper side with one large plate, as with a buckler—hence the name, implying *buckler-head.* A range of small fins conveys the idea of its having been as weak in motion as it is strong in structure. In the *coccosteus*, the outline of the body is of the form of a short thick coffin, rounded, covered with strong bony plates, and terminating in a long tail, which seems to have been the sole organ of motion. While the tail establishes this creature among the vertebrata and the fishes, its teeth, chiselled, as it were, out of the solid bone of the jaw, like the nippers of a lobster, suggest its propinquity to the invertebrate part of creation. The *pterichthys* has also strong bony plates over its body, arranged much like those of a tortoise, and has a long tail; but its most remarkable feature, and that which has suggested its name, is a pair of narrow wing-like appendages attached to the shoulders, which the creature is supposed to have erected for its defence when attacked by an enemy.

A group of ganoids seem to have been the police of their day, possessing a powerful development of sharp conical teeth situated on the margin of the jaws. One genus, the *holoptychius*, introduced near the close of the Old Red era, and passing up into the next, presents a flat oval form, measuring in one specimen thirty inches by twelve, with a covering of strong plates, wavily grooved and overlapping each other, the head forming only a slight rounded projection from the general figure. We here find another early and startling example, in addition to the brontes, of animals which may be called *large*. In the strata of this formation at Dörpat, there are gigantic bones, which were at first thought to belong to reptiles, but have since been ascertained to be remains of fishes, leading to the conjecture that the animals to which they appertained could not be less than thirty-six feet long ([19]).

M. Agassiz has lately announced nine genera of sharks of the division *Cestraceon* in the Devonians of Russia. It is in this voracious family that we see the placoids represented in modern seas; the ganoids are all but unrepresented in our time. Of both classes, one invariable peculiarity has attracted much attention. "In all recent fish, with the exception of the shark family, the sturgeon, and the bony pike, the vertebral column terminates at the point where the caudal fin is given off, and this fin is expanded above and below the body, forming what is called a *homocercal* tail. In all those, without exception, which have been found in strata of the Palæozoic period, [placoids and ganoids,] the caudal fin is *heterocercal*, being formed of two unequal branches, the upper one expanded immediately from the vertebral column, while the lower one is given off at a point some distance from the extremity." [20] Now it is a remarkable fact, that this one-sided tail is a peculiarity in the more perfect fishes (as the salmon) at a certain stage in their embryonic history; as is also the inferior position of the mouth, peculiar to the early fishes. More than this: in the earlier periods of embryonic life, there is no vertebral column. This organ is represented in embryos by a gelatinous cord, called the dorsal cord, which in maturity disappears as the vertebræ are formed upon it. M. Agassiz has satisfied himself that this was the nature of the organization of the early fishes, as it is that of the sturgeon of the present seas. It is not premature to remark how broadly these facts hint at the parity of law affecting the progress of general creation, and the progress of an individual fœtus of one of the more perfect animals.[21] Another feature of the placoids, bringing them down towards the level of an inferior portion of the animal kingdom, is the distinct marks which the dermal plates bear, in many specimens, of processes for muscular attachments. This suggests a peculiarity of articulate animals, and powerfully hints that the cartilaginous skeleton had not been, as in higher vertebrata, the grand support of the frame, and the basis of its strength.

An eminent geologist is of opinion that the species of this era vary locally, as far as might be expected from what we see of the distribution of animal life in the present times. Nevertheless, throughout the distant parts of the earth where Devonian strata are found, the general characters of animals and also vegetable life are nearly the same. It is further observed, that whatever particular family is continued with little change through a succession of strata, is also amongst those most widely extended over the world. It is the opinion of M. Brongniart, who has distinguished himself by his investigation of vegetable fossils, that the fuci of these early seas indicate a higher temperature than now prevails at many of the places where they are found. He regards this as a proof of the more equable diffusion of a tropical climate in ancient times, and distinctly attributes it to the action of the internal heat of the earth. The early animals are not so uniform over large geographical areas as the plants. M. Agassiz surmises, from an examination of the fishes of the ancient seas, that the ocean did not at first contain much salt, but gradually acquired its present infusion of that material; a theory, it may be remarked, which derives support from the suggestion, that the salt of the sea has been mainly brought thither, in the course of time, by rivers, washing it in particles out of the land, in common with other detritus, while it is obvious that rain does not restore it.([22]) It is easy to suppose a comparative absence of salt in the early ocean affecting animal and vegetable marine life in different ways and degrees.

As yet—overlooking possible exceptions of a narrow and dubious kind ([23])—we meet with no traces of land plants: remains of terrestrial animals have not even been suspected. This exclusively marine character of the flora and fauna of the early ages is usually thought to betoken the non-existence of dry land. But there are reasons apart from the fossil history for believing that great masses had been exposed to the atmosphere in those ages. The earliest strata give token of vast disintegration. In our time, this process is usually seen taking place chiefly in the atmosphere, and at the point where land and water meet; in a much less activity below the surface of the ocean. It would thus appear likely that there was dry land in the eras of the earliest stratified formations, though, from whatever cause, it bore no vegetation and sustained no animals, or was only a scene of life in certain rare and favourably situated places. The ages of mountains, from which this inference is derived, form one of the most curious as well as trustworthy chapters in geological science. It is as certain that the Grampian mountains of Scotland are older than the Alps and Apennines, as it is that civilization had visited Italy, and had enabled her to subdue the world, while Scotland was the residence of "roving barbarians." The Pyrenees, Carpathians, and other ranges of continental

Europe, are all younger than the Grampians, or even the insignificant Mendip Hills of southern England. Stratification tells this tale as plainly as Livy tells the history of the Roman republic. It tells us—to use the words of Professor Phillips—that at the time when the Grampians sent streams and detritus to straits where now the valleys of the Forth and Clyde meet, the greater part of Europe was a wide ocean.

CARBONIGENOUS ERA.

COMMENCEMENT OF LAND PLANTS.

The next group of rocks is called the *Carboniferous Formation*, from the remarkable feature of its numerous interspersed beds of coal. It commences with the beds of the *mountain limestone*, which, in some situations, as in Derbyshire and Ireland, are of great thickness, being alternated with chert, (a siliceous sandstone,) sandstones, shales, and beds of coal, generally of the harder and less bituminous kind, (*anthracite*,) the whole being covered in some places by the millstone grit, a siliceous conglomerate, composed of the detritus of the earliest formation. The mountain limestone, attaining in England to a depth of eight hundred yards, greatly exceeds in volume any of the primary limestone beds, and shows an enormous addition of power to the causes connected with animal life, by which this substance is supposed to have been produced. In fact, distinct remains of corals, crinoidea, and shells, are so abundant in it, as to compose three-fourths of the mass in some parts.

Above the mountain limestone commence the more conspicuous *coal beds*, alternating with sandstones, shales, beds of limestone, and ironstone. Coal is altogether composed of the matter of a terrestrial vegetation, transmuted by putrefaction of a peculiar kind, beneath the surface of water and in the absence of air. Some estuary shells have been found in it, but few of pelagic origin, and no remains of those zoophytes and crinoidea so abundant in the mountain limestone and other rocks. Coal beds exist in Europe, Asia, and America, and have hitherto been esteemed as the most valuable of mineral productions, from the important services which the substance renders in manufactures and in domestic economy. It is to be remarked, that there are some local variations in the arrangement of coal beds. In France, they rest immediately on the granite and other primary rocks, the intermediate strata not having been found at those places. In other countries, traces of coal are found in the Devonian formation. These last circumstances may only show that different parts of the earth's surface did not all witness the same events of a certain fixed series exactly at the same time.

Some features of the condition of the earth during the deposition of the carboniferous group, are made out with a clearness which must satisfy most minds. First we are told of a time when carbonate of lime was formed in vast abundance along the shores and islands of the ocean, accompanied by an unusually large population of corals and encrinites; while in some parts of the earth there were pieces of dry land covered with a luxuriant vegetation. Next we have a comparatively brief period of volcanic disturbance, (when the conglomerate was formed.) Then the causes favourable to the so abundant production of limestone, and the large population of marine radiata, decline, and we find the masses of dry land increase in number and extent, and begin to bear an amount of forest vegetation, far exceeding that of the most sheltered tropical spots of the present surface. The climate, even in the latitude of Baffin's Bay, was torrid; and the atmosphere has been supposed by some to have contained a larger charge of carbonic acid gas (the material of vegetation) than it now does. The forests or thickets of the period included no plants specifically the same with those now known upon earth. They mainly consisted of gigantic vegetables, many of which are not represented by any existing types, while others are akin to kinds which, in temperate climes at least, are now only found in small and lowly forms. That these forests grew upon a Polynesia, or multitude of small islands, is considered probable, from similar vegetation being now found in such situations within the tropics.

With regard to the circumstances under which the masses of vegetable matter were transformed into successive coal strata, geologists are divided. From examples seen at the present day, at the mouths of such rivers as the Mississippi, which traverse extensive sylvan regions, and from other circumstances to be adverted to, it is held likely by some that the vegetable matter, the rubbish of decayed forests, was carried by rivers into estuaries, and there accumulated in vast natural rafts, until it sunk to the bottom, where an overlay of sand or mud would prepare it for becoming a stratum of coal. Others conceive that the vegetation first passed into the condition of a peat moss, that a subsidence then exposed it to be overrun by the sea, and covered with a layer of sand or mud; that a subsequent uprise made the mud dry land, and fitted it to bear a new forest, which afterwards, like its predecessors, became a bed of peat; that, in short, by repetitions of this process, the alternate layers of coal, sandstone, and shale, constituting the carboniferous group, were formed. It is favourable to this last view that marine fossils are rarely found in the body of the coal itself, though abundant in the shale layers above and below it; also that in several places erect stems of trees are found with their roots still fixed in the shale beds, and crossing the sandstone beds at almost right angles, showing that these, at least, had not been drifted from their original situations. On the other hand, it is not easy to admit such repeated risings and sinkings of surface as would be required, on this hypothesis, to form a series of coal strata. Perhaps we may most safely rest at present with the supposition that coal has been formed under both classes of circumstances, though in the latter only as an exception to the former.

The plants of the carbonigenous period have been investigated with great care by several able naturalists, and above eight hundred species have been ascertained. The living plants of our own era are at least 80,000, and it is difficult to suppose the flora of that remote age to have been so much more limited. It must, however, be observed, that there are many conceivable circumstances to account for the non-preservation or transmission of many of the plants of this era. The numerous fungi, and other lowly forms, could scarcely have left clear memorials of themselves in the rocks, or in the masses of coal; and it has even been ascertained by experiment, that some of the highest forms of vegetation perish with surprising quickness in water. If we might assume, nevertheless, that the plants actually ascertained, form in any degree a representation of the flora of this period, they would imply that the early terrestrial botany of our globe was greatly less varied than the present, and composed chiefly of plants of comparatively simple form and structure. ([24])

In the ranks of the vegetable kingdom, the lowest place is taken by plants of cellular tissue, and which have no flowers, (*cryptogamia*,) as sea-weeds, lichens, mosses, fungi, ferns. Above these stand plants with vascular tissue, and bearing flowers, in which again there are two great subdivisions; first, plants having one seed-lobe, (*monocotyledons*,) and in which the new matter is added within, (endogenous—the cane and palm are examples;) second, plants having two seed-lobes, (*dicotyledons*,) and in which the new matter is added on the outside under the bark, (exogenous—the pine, elm, oak, and all the British forest-trees are examples;) these subdivisions also ranking in the order in which they are here stated. Now it is found that the predominant plants of the coal era are of the cellular and cryptogamic kind, while the dicotyledons are comparatively rare. There is, indeed, one exogenous family, which occurs in considerable numbers, and, perhaps, figured more conspicuously in the living woods than in the dead coal beds—namely, the conifers; but this, again, is held as the lowest family of its class. That many trees of higher families now existed, seems unlikely, when we learn that such trees occur in considerable numbers in subsequent formations, showing that there was nothing positively to forbid their being preserved in the coal measures, if they had then existed.

The master-form or type of the era was the *fern*, or breckan, of which about one hundred and thirty species have been ascertained as entering into the composition of coal. The ferns are plants which thrive best in warm, shaded, and moist situations. In tropical countries, where these conditions abound, there are many more species than in temperate climes, and some of these are arborescent, or of a tree-like size and luxuriance. ([25]) The ferns of the coal strata have been of this magnitude, and that without regard to the regions of the earth where they are found. In the coal of Baffin's Bay, of Newcastle, and of the torrid zone, alike, are the fossil ferns arborescent, showing that, in that era, the present tropical temperature, or one even higher, existed in very high latitudes.

In the swamps and ditches of England there grows a plant called the horse-tail, (*equisetum*,) having a succulent, erect, jointed stem, with slender leaves, and a scaly catkin at the top. A second large section of the plants of the carboniferous era were of this kind, (*equisetaceæ*,) but, like the ferns, reaching the magnitudes of trees. While existing equiseta rarely exceed three feet in height, and the stems are generally under half an inch in diameter, their kindred, entombed in the coal beds, seem to have been generally fourteen or fifteen feet high, with stems from six inches to a foot in thickness. It is to be remarked that plants of this kind (forming two genera, the most abundant of which is the *calamites*) are only represented on the present surface by plants of the same *family:* the *species* which flourished at this era gradually lessen in number as we advance upwards in the series of rocks, and disappear before we arrive at the tertiary formation.

The club-moss family (*lycopodiaceæ*) are other plants of the present surface, usually seen in a lowly and creeping form in temperate latitudes, but presenting species which rise to a greater magnitude within the tropics. Many specimens of this family are found in the coal beds; it is thought they have contributed more to the substance of the coal than any other family. But, like the ferns and equisetaceæ, they rise to a prodigious magnitude. The *lepidodrendon* (so the fossil genus is called, from the scaly exterior) has probably been from sixty-five to eighty feet in height, having at the base a diameter of about three feet, while the leaves measured twenty inches in length. In the forests of the coal era, the lepidodendra would enjoy the rank of firs in our forests, affording shade to the only less stately ferns and calamites. The internal structure of the stem, and the character of the seed-vessels, show them to have been a link between single-lobed and double-lobed plants—a fact worthy of note, as it favours the idea of a progress in vegetable creation, in the line of an improved organization. It is also curious to find a missing link of so much importance in a genus of plants which has long ceased to have a living place upon earth.

The other leading plants of the coal era are without representatives on the present surface, and their characters are in general less clearly ascertained. Amongst the most remarkable are—the *sigillaria*, of which large stems are very abundant, showing that the interior has been soft, and the exterior fluted, with separate leaves inserted in vertical rows along the flutings—and the *stigmaria*, a plant apparently calculated to flourish in marshes, or pools, having a short, thick, fleshy stem, with a dome-shaped top, from which sprung branches of from twenty to thirty feet long. Amongst monocotyledons were some palms, (*flabellaria* and *nœggerathia*,) besides a few not distinctly assignable to any class.

The conifers of the coal are comparatively rare, and are only as yet found in isolated cases, and in sandstone beds. One discovered in the Craigleith quarry, near Edinburgh, consisted of a stem about two feet thick, and forty-seven feet in length. Others were afterwards found, both in the same situation, and at Newcastle. Leaves and fruit being wanting, an ingenious mode of detecting the nature of these trees was devised by some naturalists residing in the northern capital.([26]) Taking thin polished cross slices of the stem, and subjecting them to the microscope, they detected the structure of the wood to be that of a cone-bearing tree, by the presence of certain "reticulations" which distinguish that family, in addition to the usual radiating and concentric lines. That particular tree was concluded to be an araucaria, a species now found in Norfolk Island, in the South Sea, and in a few other remote situations. The conifers of this era may be said to form the dawn of dicotyledonous trees, to which, it has already been noticed, the lepidodendra are a link from the monocotyledons. The concentric rings of the Craigleith and other conifers of this era have been mentioned. It is interesting to find in these a record of the changing seasons of those early ages, when as yet there were no human beings to observe time or tide. The rings are clearly traced; but it is observed that they are more slightly marked than is the case with their family at the present day, as if the changes of temperature had been within a narrower range.

Such (if we are to be allowed to rest with positive evidence) was the vegetation of the carbonigenous era, composed of forms low in the botanical scale, mostly flowerless and fruitless, but luxuriant and abundant beyond what the most favoured spots on earth can now show. The rigidity of the leaves of its plants, and the absence of fleshy fruits and farinaceous seeds, unfitted it to afford nutriment to animals; and, monotonous in its forms, and destitute of brilliant colouring, its sward probably unenlivened by any of the smaller flowering herbs, its shades uncheered by the music of birds, it must have been a sombre scene to a human visitant. But neither man nor any other animals were then in existence to look for such uses or such beauties in this vegetation. It was serving other and equally important ends, clearing perhaps the atmosphere of matter noxious to animal life, and certainly storing up mineral masses which were in long subsequent ages to prove of the greatest service to the human race, even to the extent of favouring the progress of its civilization.

Traces of land plants previous to the Carboniferous era are isolated at the best, and, till we know more about them, they cannot be allowed greatly to affect our views of the botanical history of the globe. Geologists speak of a fern leaf in the Silurians of Wales; in those of America, a plant apparently allied to the lepidodendron; in the American lower Devonian, some allied to ferns. These phenomena, if fully established, would not interfere with general deductions from the mass of early land vegetation found in the coal era. There might be patches of vegetation long before the time of the great coal flora; and from such pieces of land might those early specimens have been wafted.

The Carboniferous formation exhibits a scanty zoology compared with either those which go before, or those which come after. The mountain limestone, indeed, deposited at the commencement of it, abounds unusually in polypiaria, crinoidea, and mollusca; but when we ascend to the coal-beds themselves, the case is altered. We have then only a limited variety of shell mollusks, with fragments of a few species of fishes, and these are rarely or never found in the coal seams, but in the shales alternating with them. Among the fishes, the conspicuous form is the Sauroid family, which receives its name in consequence of a character of teeth, scales, and even osteology, resembling that of the Sauria, and evidently leading on to that section of reptiles. ([27]) One of the most noted species is the *Megalichthys Hibbertii*, discovered by Dr. Hibbert Ware, in a limestone bed at Burdiehouse, near Edinburgh, and of which other specimens have been found in the coal measures of Yorkshire, and low coal shales of Newcastle. The enormous size of the animal is inferred from teeth belonging to it, not less than four inches long. At this point we find the first traces of land animals, in the fossil remains of terrestrial insects ([28]) and the foot-prints of reptiles, the first in England, the latter in America. ([29])

Coal strata are nearly confined to the group termed the carboniferous formation. Thin beds are not unknown afterwards, but they occur only as a rare exception. It is therefore thought that the most important of the conditions which allowed of so abundant a terrestrial vegetation—whatever these were—had ceased about the time when this formation was completed.

The termination of the carboniferous formation is marked in some regions by symptoms of great disturbance. Coal-beds generally lie in basins, as if following the curve of the bottom of seas. There is no such basin which is not broken up into pieces, some of which have been tossed up on edge, others allowed to sink, causing the ends of strata to be in some instances many yards, and in a few, several hundred feet, removed from the corresponding ends of neighbouring fragments. These are held to be results of volcanic movements below, the operation of which is further seen in numerous upbursts and intrusions of fire-born rock, (trap.) That these disturbances took place about the close of the formation, and not later, is shown in the fact of the next higher group of strata being comparatively undisturbed. Other symptoms of this time of violence are seen in the beds of conglomerate which occur amongst the first strata above the coal. These, as usual, consist of fragments of the elder rocks, more or less worn from being tumbled about in agitated water, and laid down in a mud paste, afterwards hardened. ([30]) It is to be admitted for strict truth, that in some parts of Europe the carboniferous formation is followed by superior deposits, without the appearance of such disturbances between their respective periods; but such cases apparently are exceptive.

PERMIAN ERA.—FIRST TRACES OF REPTILES.

In this subordinate manner, may be noticed a short series of strata, following, whether conformably or otherwise, upon the carboniferous formation, and to which a general name has been applied, from its being unusually well developed in the portion of Russia which formed the ancient kingdom of Permia. This sub-formation—comprehending in ascending order a group of sandstones, called with us the *Lower New Red Sandstones*, and amongst the Germans *Rothe-todte-liegende* ([31])—a thick calcareous bed called with us the *Magnesian Limestone*, by the Germans *Zechstein*,—and some other strata—is, in respect of fossils, a continuation of the carboniferous system. With it, however, ends a range of animal forms which first appeared in the Silurians, and passed, with the changes which have been indicated, through the Devonian and Carbonigenous eras.

The total number of specific forms, which had been diminishing in the carbonigenous era, is in this still further reduced; one recent author says, from about a thousand to a hundred and sixty-six, of which only eighteen are common to the inferior strata. (32) It appears as if, while some new species continued to present themselves, the animal kingdom were now generally undergoing a decay, for even specimens of particular families are less abundant than formerly. Instead, for example, of the hundred species of corals of the carboniferous formation, there were now only fifteen, and of these but three or four abundant. Of the numerous crinoidea of the past, but one now remained, and this is rarely found. The trilobite has now vanished, to appear no more. For hundreds of brachiopods, there were now only thirty, ten of them old. The cephalopods almost disappear at the very commencement of the Permian era.

It cannot at present be determined whether this diminution of fossils is owing to an actual reduction of the amount of life in the ancient seas, or only to some such simple cause as the occurrence of deposits which were not favourable to the preservation of animal remains. It may even be that the principal cemeteries of the age have not yet been hit upon by research; for certainly this is neither the most extensively nor the most rigidly examined of the various formations, and we are made the more suspicious by finding that, at this part of the rock series, several important fossiliferous strata are present in one region and not in others. It has been ascertained, however, by Permian researches, that extensive changes of specific forms in the ancient seas were not, as has been supposed, necessarily and essentially connected with great physical disturbances; for both do we find that the unconformability of strata or memorials of disturbance between the carboniferous and Permian do not affect the fossils, and that a conformable succession of strata over the Permian is attended by a great—usually called a complete—change of species. At this termination of the Permian, modern geologists close what they call the Palæozoic Period, on a supposition that an ancient creation had now passed away, to give place to one entirely new. And this view is eagerly embraced by those who argue for repeated interferences of creative power. But not only is such a notion discountenanced by the nature of the subsequent organisms, an advance to higher species of particular classes, and to a new class the next in the animal scale, but it is utterly overthrown by the recent discovery of plants in the higher formations, (Trias of France and certain Liassic beds in the Alps,) identical with carboniferous species. Where such changes of fossils occur, the more reasonable supposition is, that notwithstanding conformableness of strata, a local suspension of deposits for a considerable time is indicated,—a time during which the usual changes of species were proceeding, probably at their usual rate, and which was sufficient to present something like a complete change of forms when the deposits were re-commenced. ([33])

In the Permian formation, besides the principal orders of animals which previously existed, we have the first undoubted traces of another, succeeding fish in the animal scale, namely, *Reptiles.*

This is a most important event in our history, for it gives us, for the first time, a class of vertebrate animals capable of breathing the atmosphere and walking upon the land. We shall presently see that it was a class destined for a long succession of ages to flourish over the soil, in many various and some most formidable shapes, and without any superiors to keep them in check. As yet, but a few bones of reptiles have been discovered in the Zechstein of Thuringia in Upper Saxony, and in quarries near Bristol. By Professor Owen, who has carefully examined them, they are said to be of the lacertilian or lizard order (specifically called by him, palæosaurs, thecodonts, monitors, &c.), but for the most part of gigantic size, and differing from modern lizards in very remarkable characters of the vertebræ, teeth, and dermal plates. To them, as to all the reptiles of this and several subsequent great periods, belonged a fish-like form of the vertebral column, in as far as its component bones were biconcave, or shaped like a double egg-cup, a peculiarity regarded by this eminent anatomist as probably fitting the animal for partially marine habits. And that the full importance of this peculiarity of the early reptiles may be appreciated, the reader must be made aware that modern reptiles have a ball-and-socket form of the vertebræ—that is, a convexity at the one side fitting into the hollow of the adjacent bone; but this form only when they are mature animals, for in the embryotic state of the crocodile and of the frog the form has been ascertained to be biconcave, which gradually changes as the animal approaches perfection. The teeth of the thecodonts and palæosaurs were fixed in distinct sockets, like those of the modern crocodiles. In this respect, they were superior to the modern varanians, the nearest living tribes, which have the teeth imbedded in comparatively shallow cavities along the bottom of a groove in the jaw.

ERA OF THE TRIAS AND OOLITE.

REPTILES ABUNDANT.—FIRST TRACES OF BIRDS AND MAMMALIA.

Geologists now apply the term Secondary Formation (once of wider application) to those intervening between the end of the Permian or close of what they call the Palæozoic Period, and the termination of the Chalk Series, afterwards to be described, at which place there is another and almost total change of specific forms. The first of these formations is called with us the *Upper New Red Sandstone;* it consists, in England, of only a group of strata of that kind, surmounted by some variegated marls. But on the Continent, below a stratum equivalent to these marls, there is one of limestone, bearing the name of the *Muschelkalk*, and full of shells. The system is there called *Trias*, on account of its thus consisting of a triple group of strata.

TRIAS.

The organic relics of this system are most abundant in the Muschelkalk. There we are presented with a great number of crinoids and shells, all differing in specific character from their predecessors of the same orders. The crinoid called, from its elegant lily-like shape, Encrinites Moniliformis, is a conspicuous fossil. The brachiopods, here almost extinct, are replaced by ostraceæ of various genera—a change from the animals of deep to those of shallow seas. The univalve mollusks also indicate a condition of the sea advancing towards that which exists near the present shores. In the new forms of cephalopoda were some marking their advanced character by their non-possession of a shell or stony skeleton. In this case, the existence of the animal is only betrayed by its horny mandible, constituting the fossils called *rhyncholites*.

We find in this system further traces, but still obscure and local, of the reptilian class. Before proceeding to speak of them, it is necessary to remark that the ingredients and arrangements of rocks, with fossil remains, do not form the sole materials of the history compiled by the geologist. He is equally contented when he can find an intelligible fact told by what may be called a writing of nature upon these stone tablets. So low as the bottom of the carboniferous system, slabs are found marked over a great extent of surface with that peculiar corrugation or wrinkling which the receding tide leaves upon a sandy beach when the sea is but slightly agitated; and not only are these ripple-marks, as they are called, found on the surfaces, but casts of them appear on the under sides of slabs lying above. The phenomena suggest the time when the sand, ultimately formed into these stone slabs, was part of the beach of a sea of the carbonigenous era; when, left wavy by one tide, it was covered over with a thin layer of fresh sand by the next, and so on, precisely as such circumstances might be expected to take place at the present day. Sandstone surfaces, ripple-marked, present themselves throughout the subsequent formations: in those of the New Red, at more than one place in England, they further bear impressions of rain-drops which have fallen upon them—the rain, of course, of the inconceivably remote age in which the sandstones were formed. In the Greensill sandstone, near Shrewsbury, it has even been possible to tell from what direction the shower came which impressed the sandy surface, the rims of the marks being somewhat raised on one side, exactly as might be expected from a slanting shower falling at this day upon one of our beaches. These facts have the same kind of interest as the season rings of the Craigleith conifers, speaking of the identity of the familiar processes of nature in those early ages with those of our own.

Hearing of memorials of this kind will prepare the reader to learn that the earliest intelligence we have respecting land-walking animals consists, in great part, of their mere footsteps, impressed on the wet sand or mud, which afterwards became rock. Let no one undervalue such testimony. The fidelity of an impression from a foot, as certifying by what or whose foot the impression was made, is acknowledged in judicial procedure; and often has this kind of evidence fixed the opinion of judge and jury, when every other has failed.

So much being premised, we proceed to examine the Triassic reptiles. In the lower beds of the upper new red sandstone, near Shrewsbury, we are introduced to a new lacertilian, presenting some remarkable characters, and named the *Rhynchosaurus*. From the few fragments of the animal which have been discovered, it would appear to have had a toothless head, resembling that of a bird, and enclosed in a bony sheath; also a hinder toe directed backwards, in which feature we also see an assimilation to the next higher vertebrate class. Footmarks, impressed in the way which has been described, and attributed to this animal, confirm the appearances presented by the extraordinary arrangement of its locomotive organs.

In the same beds occur a few bones, and a great number of footsteps, which Professor Owen has fixed as the double memorials of a group of animals, to which he has given (from the structure of their teeth) the name of Labyrinthodonts, and which he classes with the *Batrachia*,—that order of reptiles to which the frog and toad belong. Those who are accustomed to regard this as a group of generally small and insignificant animals, will be surprised to learn that the labyrinthodonts were of the size of a large hog. Their footmarks, discovered alike in America and the elder continent, "bear a singular resemblance to the impression that would be made by the palm and expanded fingers and thumb of the human hand." But it is evident that the four extremities of the animal had been, like those of the kangaroo and some other genera, much smaller than the hinder, some specimens of which measure eight inches by five. These batrachia present affinities to the fish class in their biconcave vertebræ and the formation and arrangement of the teeth. Their nostrils being also, like those of the Sauria, placed near the extremity of the head, indicate a partially marine habitat, such an arrangement being required to enable the animal to breathe while nearly altogether sunk in the water.

Quarries of the red sandstone of this system also present an abundance of footmarks attributed to tortoises, thus pointing to the contemporaneous existence of a third order of reptiles, the *Chelonia.* The first examples were discovered by the Rev. Dr. Duncan in the quarry of Corncockle Muir, Dumfriesshire, where the slabs incline at an angle of thirty-eight degrees, and the footmarks are distinctly traced up and down the slope, as if, when the surfaces were those of a beach—at, however, a lower inclination—the animal had had occasion to pass only in that direction, in its daily visits to the sea. Some slabs similarly impressed, in the Stourton quarries, Cheshire, are further marked with a shower of rain which we know to have fallen *afterwards*, for its little hollows are impressed in the footmarks also, though more slightly than on the rest of the surface, the comparative hardness of a trodden place having apparently prevented so deep an impression being made.

It is in the celebrated *Muschelkalk* that, for the first time, we find examples of a group of reptiles which have excited more attention than perhaps any other fossil animals. The same group, it may be remarked, occurs in the English lias and subsequent formations; but the mere fact of writing in England should not make us postpone to that place an order of beings which we find earlier in another portion of what, geologically, may be regarded as but one great zoological province. These animals, called collectively *Enaliosauria*, or *Marine Saurians*, abounded throughout a long period of the earth's history, while mammalian life was yet hardly developed; but they disappeared in what we shall have to speak of as the Cretaceous Era. The *Ichthyosaur*, of which ten species have been distinguished, was an animal of marine habits and great bulk, (reaching about thirty feet in length,) in which to the form of the fish there were united, in a remarkable way, characters of animals higher in the scale. A body, framed upon a purely piscine vertebral column, containing a huge voracious stomach, and terminating in a vertically expanded tail, in which respect it also preserved the fish character, was furnished with the head of a crocodile, and four fins approximating to the character of the paddles of the whale, but composed of a greater number of bones, and thus showing an affinity to the fins of fishes. Over all was a skin resembling that of the cetaceous animals. Nor should it be omitted that the sternum or breast-bone presents a structure resembling that of the ornithorhynchus or duck-rat of Australia. The vast jaws of this animal, having a stretch of seven feet; its eye resting in a socket eighteen inches in diameter, and defended by an apparatus of bony plates, like that of a bird of prey; the powerful range of teeth, and the position of the breathing apertures near the extremity of the snout; all speak to the naturalist of ferocious habits like those of the modern crocodile, to which the ichthyosaur may be considered as a link from the predaceous fish. A curious light has been thrown upon these habits by the pellets voided by the animal, which have been found in great quantities in a fossilized state, and bear the name of *coprolites*. In these we find fragments not only of fish, but of reptiles, arguing that the animal must have been a destructive creature both to its own class and to that below it.

The genus next in importance is the *Plesiosaurus*, so called as being near to the saurian character. This animal was under eighteen feet long, and altogether a feebler creature than the Ichthyosaur, which seems to have made it a prey. Yet it was itself one of the destructive potentates of the early seas. A body, generally fish-like, though framed on vertebræ presenting less concave ends, and which terminated in a short tail, serving only as a rudder, was furnished with a long neck and small head, together with four slender paddles, more cetacean than those of the Ichthyosaur. Moving, like that animal, quickly in the water, by means of the special organs designed for the purpose, the Plesiosaur would have a further advantage in its long, flexible, serpent-like neck; but the small size of the head, though there we find the same superior arrangement of teeth seen in the thecodonts, must have rendered it a much less formidable creature than that last described. Professor Owen regards it as fitted to live near shores and to ascend estuaries.

The attention of the geologists of the United States has been called to certain footmarks in the sandstones of the valley of Connecticut, indicative, as they think, of birds of the orders *Grallatores* (waders) and *Rasores* (scrapers.) "The footsteps appear in regular succession on the continuous track of an animal, in the act of walking or running, with the right and left foot always in their relative places. The distance of the intervals between each footstep on the same track is occasionally varied, but to no greater amount than may be explained by the bird having altered its pace. Many tracks of different individuals and different species are often found crossing each other, and crowded, like impressions of feet upon the shores of a muddy stream, where ducks and geese resort." ([34]) Some of these prints indicate small animals, but others denote birds of what would now be an unusually large size, one having a foot fifteen inches in length, and a stride of from four to six feet. There are anomalies in the forms of some of the feet; but their being the vestiges of birds has for some years been generally admitted. There is, however, some uncertainty regarding the date of the rocks which present these memorials, for the phenomena of superposition only denote their being between the carboniferous and cretaceous formations, and an exact place is assigned them, merely upon the strength of the discovery that they present fish of certain genera never found above the Triassic series. Along with distinctly ornithic footmarks are those of the Labyrinthodont. Altogether, above thirty species of Triassic birds are made out from these vestiges by American geologists.

OOLITE.

The chronicles of this period consist of a series of beds, mostly calcareous, taking their general name (*Oolite system*) from a conspicuous member of them—the oolite—a limestone composed of an aggregation of small round grains or spherules, and so called from its fancied resemblance to a cluster of eggs, or the roe of a fish. This texture of stone is novel and striking. It is supposed to be of chemical origin, each spherule being an aggregation of particles round a central nucleus. The oolite system is largely developed in England, France, Westphalia, and Northern Italy; it appears in Northern India and Africa, and patches of it exist in Scotland, and in the vale of the Mississippi. It may of course be yet discovered in many other parts of the world.

The series, as shown in the neighbourhood of Bath, is (beginning with the lowest) as follows: 1. Lias, a set of strata variously composed of limestone, clay, marl, and shale, clay being predominant; 2. Lower oolitic formation, including, besides the great oolitic bed of central England, fullers'-earth beds, forest marble, and cornbrash; 3. Middle oolitic formation, composed of two sub-groups, the Oxford clay and coral rag, the latter being a mere layer of the works of the coral polype; 4. Upper oolitic formation, including what are called Kimmeridge clay and Portland oolite. In Yorkshire there is an additional group above the lias, and in Sutherlandshire there is another group above that again. In the wealds (moorlands) of Kent and Sussex, there is, in like manner, above the fourth of the Bath series, another additional group, to which the name of the *Wealden* has been given, from its topographical situation, and which, composed of sandstones and clays, is subdivided into Purbeck beds, Hastings sand, and Weald clay.

There are no particular appearances of disturbance between the close of the Trias, and the beginning of the Lias and Oolite system, as far as has been observed in England. Yet there is a great change in the materials of the rocks of the two formations, showing that, while the bottoms of the seas of the one period had been chiefly arenaceous, those of the other were chiefly clayey and limy. And there is an equal difference between the two periods in respect of both botany and zoology. While the Permian and Triassic systems, with the single exception of the Muschelkalk, show comparatively scanty traces of life, those in the lias and oolite are extremely abundant, particularly in the department of animals, and more particularly still of sea mollusca. The distinguishing characters of the zoology appear to be uniform over a great space. "In the equivalent deposits in the Himalayan Mountains, at Fernando Po, in the region north of the Cape of Good Hope, and in the Run of Cutch, and other parts of Hindostan, fossils have been discovered, which, as far as English naturalists who have seen them can determine, are undistinguishable from certain oolite and lias fossils of Europe. ([35])

The dry land of this age presented cycadeæ, "a beautiful class of plants between the palms and conifers, having a tall, straight trunk, terminating in a magnificent crown of foliage." ([36]) There were tree ferns, but in smaller proportion than in former ages; also equisetaceæ, lilia, and coniferæ. The vegetation was generally analogous to that of the Cape of Good Hope and Australia, which seems to argue a climate between the tropical and temperate. It was, however, sufficiently luxuriant, in some instances, to produce thin seams of coal, for there are such in the oolite formation of both Yorkshire and Sutherland. The sea, as for ages before, contained algæ, of which, however, only a few species have been preserved to our day.

The lower marine animals present themselves in great abundance, and in some interesting varieties of form. Corals, absent in the lias, reappear in the oolite in quantity sufficient, at some places, as we have seen, to constitute entire strata. The crinoids are also numerous, and amongst these are new genera showing an advance of organization from those of preceding systems. The *pentacrinite*, instead of a round, has a five-angled stalk, with an increased profusion of tentacula; it had also the superior character of a power to float about, and attach itself where it pleased. To this fossil of the lias succeed others of the same family in the oolite—*comatula* and *ophiura*—which are entirely free-swimming, thus supporting the general appearances of an advance of animal characters as we proceed from lower to higher formations. Here also appear other examples of the order to which the crinoidea belong (*echinodermata*); namely, the *echinus*, or sea-urchin, and the *goniaster*, which last is regarded as a link between the echinus and star-fish.

Among the crustaceans of the oolite, a conspicuous place is due to the *limulus*, or king-crab, of which several species occur in this formation. This animal is remarkable as the genus of our time to which the trilobite makes the nearest approach; and the appearance of the limulus at the time when the trilobite vanishes, (the carbonigenous era,) is spoken of by a distinguished geologist as "one of those beautiful links in natural history, of which the strata forming the earth's crust have afforded so many proofs." ([37]) Here also we have, in the *eryon*, an early example of the highest crustacean order, (decapoda,) and one to which the modern lobster and cray-fish belong. Insects resembling the dragon-fly have been found in the oolite.

The deeper oolitic seas were occupied by various species of terebratula, a brachiopodous mollusk remarkable as having lived in one form or another from the earliest to the present time. In the shallower seas were other bivalves. There was also abundance of all the univalve classes, Pteropoda, Gasteropoda, and Cephalopoda. Of the last we see an advance of characters in the ammonites and belemnites, which now appear in many varieties. The belemnite, which belonged to the higher order of the class, those having only two branchiæ, calls for some particular notice. It is an elongated, conical shell, terminating in a point, and having, at the larger end, a cavity for the residence of the animal, with a series of air-chambers below. The animal, placed in the upper cavity, could raise or depress itself in the water at pleasure by a pneumatic operation upon the air tube pervading its shell. Its tentacula, sent abroad over the summit of the shell, searched the sea for prey. The creature had an ink bag with which it could muddle the water around it, to protect itself from more powerful animals, and strange to say, this has been found so well preserved, that an artist has used it in one instance as a pigment, wherewith to delineate the belemnite itself.

There are many fishes, some of which (*acrodus*, *psammodus*, &c.) are presumed, from remains of their palatal bones, to have been of the gigantic cartilaginous class, (*placoidean*,) now represented by such as the cestraceon. It has been considered by Professor Owen as worthy of notice, that, the cestraceon being an inhabitant of the Australian seas, we have, in both the botany and ichthyology of this period, an analogy to that Continent. The pycnodontes, (thick toothed,) and lepidoides, (having thick scales,) are other families described by M. Agassiz as extensively prevalent.

In the English lias there is a vast abundance of the enaliosauria which we have seen commence in the foreign Muschelkalk, and, in addition to these, specimens of *Pterosauria* or *Winged Saurians*, a type of being, the most new, perhaps, of all which the geological record has presented to us. The Pterodactyls, as the animals of this order have been called, were saurians of small size compared with their associates, being not larger than a modern cormorant; but the marvel in their case consists in bat-like wings extended upon the fore-finger, by which the animal was enabled to pursue its way in the air. This order became extinct in the time of the chalk formation. The only existing animal of which it may even remind us is the *draco volans* or flying lizard, which has a membrane by which to support itself in leaping from tree to tree.

In the proper oolite, there is added an enaliosaurian (the *Pliosaur*) in which there is a very close approach made to the crocodilian order, but upon a scale of enormous magnitude, the animal having apparently been as large as the existing whales. Here, too, we find the true *crocodilia* largely developed, and five genera have been described, (*Teleosaurus*, *Steneosaurus*, *Cetiosaurus*, &c.) The two first are like crocodiles of our own time in all respects, except a somewhat greater bulk, and certain peculiarities, indicating more aquatic habits. The last derives its name from the approximation to the whale tribes seen in the form of its vertebræ. In this group there is a genus presenting ball-and-socket vertebræ, and thus proving its advanced character; but, strange to say, the concavity is in this case directed backwards, instead of forwards, which is the universal arrangement in similar cases, in our era.

The first glimpse of the highest class of the vertebrate sub-kingdom—*Mammalia*—is obtained from the Stonesfield slate, where there have been found several specimens of the lower jaw-bone of a quadruped evidently insectivorous, and inferred, from peculiarities of structure, to have belonged to the marsupial family, (pouched animals.) ([38]) It may be observed, although no specimens of so high a class of animals as mammalia are found earlier, such may nevertheless have existed: the defect may be in our not having found them; but, other things considered, the probability is that heretofore there were no mammifers. It is an interesting circumstance that the first mammifers found should have belonged to the marsupialia, when the place of that order in the scale of creation is considered. In the imperfect structure of their brain, deficient in the organs connecting the two hemispheres—and in the mode of gestation, which is only in small part uterine—this family is usually regarded as only a little advanced above the character of the bird.

The highest part of the oolitic formation presents some phenomena of an unusual and interesting character, which demand special notice. Immediately above the upper oolitic group in Buckinghamshire, in the vicinity of Weymouth, and other situations, there is a thin stratum, usually called by workmen the *dirt-bed*, which appears, from incontestable evidence, to have been a soil formed, like soils of the present day, in the course of time, upon a surface which had previously been the bottom of the sea. The dirt-bed contains exuviæ of tropical trees, accumulated through time, as the forest shed its honours on the spot where it grew, and became itself decayed. Near Weymouth there is a piece of this stratum, in which stumps of trees remain rooted, mostly erect or slightly inclined, and from one to three feet high; while trunks of the same forest, also silicified, lie imbedded on the surface of the soil in which they grew.

Above this bed lie those which have been called the Wealden, from their full development in the Weald of Sussex; and these as incontestably argue that the dry land forming the dirt-bed had next afterwards become the area of brackish estuaries or lakes partially connected with the sea; for the Wealden strata contain exuviæ of fresh-water tribes, besides those of the great saurians and chelonia. The area of this estuary comprehends the whole south-east province of England. A geologist thus confidently narrates the subsequent events: "Much calcareous matter was first deposited [in this estuary], and in it were entombed myriads of shells, apparently analogous to those of the vivipara. Then came a thick envelope of sand, sometimes interstratified with mud; and, finally, muddy matter prevailed. The solid surface beneath the waters would appear to have suffered a long continued and gradual depression, which was as gradually filled, or nearly so, with transported matter; in the end, however, after a depression of several hundred feet, the sea again entered upon the area, not suddenly or violently—for the Wealden rocks pass gradually into the superincumbent cretaceous series—but so quietly, that the mud containing the remains of terrestrial and fresh-water creatures was tranquilly covered up by sands replete with marine exuviæ." ([39]) A subsequent depression of the same area, to the depth of at least three hundred fathoms, is believed to have taken place, to admit of the deposition of the cretaceous beds lying above.

From the scattered way in which remains of the larger terrestrial animals occur in the Wealden, and the intermixture of pebbles of the special appearance of those worn in rivers, it is also inferred that the estuary which once covered the south-east part of England was the mouth of a river of that far-descending class of which the Mississippi and Amazon are examples. What part of the earth's surface presented the dry land through which that and other similar rivers flowed, no one can tell. It has been surmised, that the particular one here spoken of may have flowed from a point not nearer than the site of the present Newfoundland. Professor Phillips has suggested, from the analogy of the mineral composition, that anciently elevated coal strata may have composed the dry land from which the sandy matters of these strata were washed. Such a deposit as the Wealden almost necessarily implies a local, not a general condition; yet it has been thought that similar strata and remains exist in the Pays de Bray, near Beauvais. This leads to the supposition that there may have been, in that age, a series of river-receiving estuaries along the border of some such great ocean as the Atlantic, of which that of modern Sussex is only an example.

The zoology of the Wealden is chiefly remarkable for the additions which it makes to the list of reptiles presented in previous formations. Besides some new crocodilia (*Suchosaurus* and *Goniopholis*), and several chelonia (*Tetrosternon*, etc.), we have here the principal constituents of a group, which Professor Owen has described as a distinct order, under the name of *Dinosauria*, the remaining form being the *Megalosaurus* of the oolite. These were terrestrial crocodile-like animals, with some features of organization recalling the lacertilia, and also such a massive and stately form of the extremities, as to remind us of the large land pachyderms. The animal last named, from twenty-five to thirty feet long, with an enormous muzzle furnished with strong teeth, must have been by far the most formidable land creature of its age. The very opposite habits of the *Iguanodon*, an equally huge herbivorous reptile, lead me to suspect an error in the classification: but—passing from this—its size and stately limbs are such as equally to excite our surprise. From the scapula or blade-bone of the remaining genus, the *Hylæosaurus*, the approximation of the whole of the dinosaurs to the mammalian type of structure has been inferred.

The imagination eagerly aspires to picture the world of the Oolitic Era, when there were scarcely any living creatures of more exalted character than reptiles. There were then vast tracts of dry land, as now; their surface bore a luxuriant vegetation of no mean kind. The meteoric agencies, the rise and fall of tides, were common phenomena of that time, as of the present. Day after day, through long drawn ages, the sun passed on his course. Night after night, the sparkling garniture of the sky looked down on this green world. But a being of superhuman intelligence, coming to examine our globe, would have seen all this existing only for fishes and still humbler creatures in the sea, and for reptiles, insects, and perhaps a few birds, and still fewer opossums, upon land. He would have beheld the tyrant sauria pursuing their carnivorous instincts upon the wave, upon the shore, and even in the air; huge turtles creeping along the muddy coasts; still more huge megalosaurs traversing the plain; frog-like animals of the bulk of modern boars, croaking in the marshes; and with all this, the air filled with multitudes of insects. But no flocks would have met his eye upon the mountains, no herds quietly roaming in the valleys. He would encounter no tiger or elephant in the jungle. None of the smaller mammalian quadrupeds, as the dog, the genet, the hedgehog, the hare, the mole, would have presented themselves. And not only were no human beings to be seen, but our supernatural visitant would know that this scene must lie spread out in perfect capability for their reception, during ages upon ages, before such beings were to exist; the stream flowing and glittering in the sun, but not to cheer the eye of man; the season passing, but not to yield its fruit to him; the whole jocund earth spread out in unenjoyed beauty, as yet unwitting of the glory and the gloom which human impulses were to bring upon it. How strange to reflect on the contemplations of the supposed visitant. What a vast void! What a stretch of time before there was to be even a commencement to its proper filling! And yet the certainty that in good time, in the ripeness of the plans of the mighty Author, the higher animals were to come, and among the last the Creature of

Creatures—who, in his infinity of device, was to turn it all to his use—the historical being of the world! It has been supposed by some geologists, that there was a special adaptation of the earth at this time to its predominating tenants, as if it presented only low muddy coasts and marshes fit for the residence of reptiles. And it has been thought that this state of the earth is what led to the existence of so many reptiles. But all such speculations rest on insecure grounds. When we consider that the Age of Reptiles, as it has been called, is interposed between an age of fishes and an age of mammals, reptiles being also intermediate to these in the animal scale, we cannot but surmise that the fact depends on some organic law, rather than upon one in physical geography. An observation of some importance to this question is made by Mr. Darwin in his Journal. Describing the Galapagos islands in the Pacific Ocean, where turtles and lizards replace the herbivorous mammalia, and are the predominating forms of life, he says—" The geologist, on hearing this, will probably refer back his mind to the secondary epochs, when lizards, some herbivorous, some carnivorous, and of dimensions comparable only with our existing whales, swarmed on the land and in the sea. It is, therefore, worthy of his observation, that this archipelago, instead of possessing a humid climate and rank vegetation, cannot be considered otherwise than extremely arid, and, for an equatorial region, remarkably temperate."

CRETACEOUS ERA.

The record of this period consists of a series of strata, in which chalk beds make a conspicuous appearance, and which is therefore called the *Cretaceous System* or formation. In England, a long stripe, extending from Yorkshire to Kent, presents the cretaceous beds upon the surface, generally lying conformably upon the oolite, and in many instances rising into bold escarpments towards the west. The celebrated cliffs of Dover are of this formation. It extends into Northern France, and thence north-westward into Germany, whence it is traced into Scandinavia and Russia. The same system exists in North America, and probably in other parts of the earth not yet geologically investigated. Being a marine deposit, it establishes that seas existed at the time of its formation on the tracts occupied by it, while some of its organic remains prove that, in the neighbourhood of those seas, there were tracts of dry land.

The cretaceous formation in England presents beds chiefly sandy in the lowest part, chiefly clayey in the middle, and chiefly of chalk in the upper part, the chalk beds being never absent, which some of the lower are in several places. In the vale of the Mississippi, again, the true chalk is wholly, or all but wholly absent. In the south of England, the lower beds are (reckoning from the lowest upwards), 1. *Shankland* or *greensand*, "a triple alternation of sands and sandstones with clay;" 2. *Galt*, "a stiff blue or black clay, abounding in shells, which frequently possess a pearly lustre;" 3. *Hard* chalk; 4. Chalk with flints; these two last being generally white, but in some districts red, and in others yellow. The whole are, in England, about 1200 feet thick, showing the considerable depths of the ocean in which the deposits were made.

Chalk is a carbonate of lime, and the manner of its production in such vast quantities was long a subject of speculation among geologists. Some light seemed to be thrown upon the subject a few years ago, when it was observed, that the detritus of coral reefs in the present tropical seas gave a powder, undistinguishable, when dried, from ordinary chalk. It then appeared likely that the chalk beds were the detritus of the corals which lived in the oceans of that era. Mr. Darwin, who made some curious inquiries on this point, further suggested, that the matter might have intermediately passed through the bodies of worms and fish, such as feed on the corals of the present day, and in whose stomachs he has found impure chalk. This, however, cannot be a full explanation of the production of chalk, if we admit some more recent discoveries of Professor Ehrenberg. That master of microscopic investigation announces, that chalk is composed partly of "inorganic particles of irregular elliptical structure and granular slaty disposition," and partly of shells of inconceivable minuteness, "varying from the one-twelfth to the two hundred and eighty-eighth part of a line"—a cubic inch of the substance containing above ten millions of them! The chalk of the north of Europe contains, he says, a large proportion of the inorganic matter; that of the south, a larger proportion of the organic matter, being in some instances almost entirely composed of it. He has been able to classify many of these creatures, some of them being allied to the nautili, nummuli, cyprides, &c. The shells of some are calcareous, of others siliceous. M. Ehrenberg has likewise detected microscopic sea-plants in the chalk.

The distinctive feature of the uppermost chalk beds in England is the presence of flint nodules. These are generally disposed in layers parallel to each other. It was readily presumed by geologists that these masses were formed by a chemical aggregation of particles of silica, originally held in solution in the mass of the chalk. But whence the silica in a substance so different from it? Ehrenberg suggests that it is composed of the siliceous coverings of a portion of the microscopic creatures, whose shells he has in other instances detected in their original condition. It is remarkable that the chalk *with* flint abounds in the north of Europe; that *without* flints in the south; while in the northern chalk siliceous animalcules are wanting, and in the southern present in great quantities. The conclusion seems natural, that in the one case the siliceous exuviæ have been left in their original form; in the other, dissolved chemically, and aggregated on the common principle of chemical affinity into nodules of flint, probably concentrating, in every instance, upon a piece of decaying organic matter, as has been the case with the nodules of ironstone in the earlier rocks, and the spherules of the oolite.

What is more remarkable, M. Ehrenberg has ascertained that at least fifty-seven species of the microscopic animals of the chalk, being infusoria and calcareous-shelled polythalamia, are still found living in various parts of the earth. These species are the most abundant in the rock. Singly they are the most unimportant of all animals, but in the mass, forming as they do such enormous strata over a large part of the earth's surface, they have an importance greatly exceeding that of the largest and noblest of the beasts of the field. Moreover, these species have a peculiar interest, as the only specific types of that early age which have survived to the present day. While the specific features of all higher animals have been again and again changed since that period, these humble creatures have preserved the characters they then possessed—shall we say, through a continuing uniformity in the conditions under which they have lived, while all other animals have been exposed to circumstances productive of change?

All the ordinary and more observable orders of the inhabitants of the sea, except the cetacea, have been found in the cretaceous formation — zoophytes, radiaria, mollusks, crustacea (in great variety of species), and fishes in smaller variety. Down to this period, the placoid and ganoid fishes had, as far as we have evidence, flourished alone; now they decline, and we begin to find in their place fishes of two orders of superior organization, those which predominate in the present creation. These are osseous in internal structure, with corneous scales. The enaliosaurians disappear in this formation, while the land reptiles, so numerous in the two preceding periods, become much diminished in numbers. Of the latter, one of the most remarkable was the mosæsaurus, which seems to have held an intermediate place between the monitor and iguana, and to have been about twenty-five feet long, with a tail calculated to assist it powerfully in swimming.

Fuci abounded in the cretaceous seas, and confervæ are found enclosed in flints. Of terrestrial vegetation, as of terrestrial animals, the specimens in the European area are comparatively rare, rendering it probable that there was little dry land near. The remains are chiefly of ferns, conifers, and cycadeæ, but in the two former cases we have only cones and leaves. There have been discovered many pieces of wood containing holes drilled by the teredo, and thus showing that they had been long drifted about in the ocean before being entombed at the bottom.

The series in America corresponding to this, entitled the Ferruginous Sand formation, presents fossils generally identical with those of Europe, not excepting the fragments of drilled wood; showing that, in this, as in earlier ages, there was a parity of conditions for animal life over a vast tract of the earth's surface. To European reptiles, the American formation adds a gigantic one, styled the Saurodon, from the lizard-like character of its teeth.

We have seen that footsteps of birds have been announced from America, in the new red sandstone. Some similar isolated phenomena occur in the subsequent formations. In the slate of Glaris, in Switzerland, corresponding to the English galt, in the chalk formation, the remains of a bird have been found. From a chalk bed, near Maidstone, have likewise been extracted some remains of a bird, supposed to have been of the long-winged swimmer family, and equal in size to the albatross.

ERA OF THE TERTIARY FORMATION—MAMMALIA ABUNDANT.

The chalk-beds are the highest which extend over a considerable space; but in hollows of these beds, comparatively limited in extent, there have been formed series of strata—clays, limestones, marls, alternating—to which the name of the *Tertiary Formation* has been applied. London and Paris alike rest on basins of this formation, and another such basin extends from near Winchester, under Southampton, and reappears in the Isle of Wight. A stripe of it extends along the east coast of North America, from Massachusetts to Florida. It is also found in Sicily and Italy, insensibly blended with formations still in progress. Though comparatively a local formation, it is not of the less importance as a record of the condition of the earth during a certain period.

The hollows filled by the tertiary formation must be considered as the beds of estuaries and gulfs, left at the conclusion of the cretaceous period. We have seen that an estuary, either by the drifting up of its mouth, or a change of level in that quarter, may be supposed to have become an inland sheet of water, and that, by another change of the reverse kind, it may be supposed to have become an estuary again. Such changes the Paris basin appears to have undergone oftener than once, for, first, we have there a fresh-water formation of clay and limestone beds ; then, a marine-limestone formation ;

next, a second fresh-water formation, in which the material of the celebrated *plaster of Paris* (gypsum) is included; then a second marine formation of sandy and limy beds; and finally, a third series of fresh-water strata. Such alternations occur in other examples of the tertiary formation likewise.

The end of the Secondary Formation, which we have just seen take place, presents in some respects a remarkable resemblance to the close of what is called the Palæozoic period in the Permian strata. Looking broadly at the specific forms of the next higher strata, they appear to have undergone a total change. Again do we now witness a difference of the shelly cephalopoda. There is also a gradual reduction and finally a disappearance of the specific forms of gasteropods, formerly abundant. It has heretofore been a belief of geologists, that at this point, as at the former, there was an entire renewal of life upon our planet; but several considerations forbid such a conclusion in the second as well as in the first instance. First, the specific forms are not wholly changed, for a few do pass into the next higher strata. Second, there is, in the higher formation, an apparent following of *an order applicable to the whole palæontological history, as something under one law*, seeing that birds and mammalia, the next classes in the vertebrate scale, are then added. In the words of Sir R. Murchison, who believes that a true geological passage may be found between the two formations, the upper secondary rocks—judging from many of their generic forms—"seem to have prepared the way for the sequence of the tertiary strata." For these reasons, the idea of an entire renovation of life at this time—what is commonly called a new creation—is not now maintained anywhere with confidence. The more rational explanation of the appearances is one suggested by actual facts observed in the strata; that the final cretaceous beds were deposited in seas more than usually deep, and which were therefore no proper habitat for the animals previously existing; that an interval of time afterwards took place, which is not represented by any strata which have been discovered; and that, by the time the tertiary formation commenced, the usual modifying influences having never ceased, the fauna had undergone such an amount of change as naturalists are accustomed to describe (their language being wholly arbitrary) as a renewal of species.

It is in perfect harmony with this view, that from the commencement of the Tertiaries, and as we ascend in the series, we find more and more specific forms identical with those still existing upon earth, as if we had now reached the dawn of the present state of the zoology of our planet. By the study of the shells alone, Mr. Lyell has formed a division of the whole term into four sub-periods, to which he has given names with reference to the proportions which they respectively present of surviving species—first, eocene; second, miocene; third, older pliocene; fourth, newer pliocene. ([40]) This division, however, is to be regarded as not safely applicable to the Tertiaries generally, except as a convenient means of indicating various portions of the series.

The eocene period presents, in three continental groups, 1238 species of shells, of which forty-two, or 3·5 per cent. yet flourish unchanged. Some of these are remarkable enough; but they all sink into insignificance beside the mammalian remains which the lower eocene deposits of the Paris basin present to us, showing that the land had now become the theatre of an extensive creation of the highest class of animals. Cuvier ascertained about fifty species of these, all of them long since extinct. About four-fifths are of the order *Pachydermata*, thick-skinned animals, to which our modern elephant, rhinoceros, horse, and pig belong. Nearly the whole of these, however, belong to a family which is now confined to South America and Sumatra, namely, the tapirs,—an animal of squat figure, and possessing a short proboscis, an inhabitant of the woods, and an herbivore, but of unsocial habits. It is curious to find that a family now so limited in its range, had formerly been distributed over France, England, and other parts of the earth. Naturalists have conferred the names, Palæotherium, Lophiodon, Coryphodon, &c., upon the ancient extinct tapirs, which seem chiefly to differ from modern species in a few peculiarities of the constitution of the teeth, and in having three, instead of four toes upon the fore feet. One British specimen seems to have been about a third larger than the modern animal.

Another section of the Paris eocene remains have served to reconstruct a family to which the general name *Anoplotherium* has been given, from a regard to its deficiency of all offensive or defensive weapons. These are the first examples of bi-hooved animals as yet discovered upon earth; they were strictly herbivorous, and make a slight approach to the cervine or deer tribes. The common anoplothere was about the size of an ass, but less elevated from the ground, and with a tail of above three feet in length; it is supposed to have been of aquatic habits, and an expert swimmer and diver, but also given to browsing upon land. Associated with these we find the first example (chœropotamus) of an animal approaching to the hog tribe, being nearest to the peccary of South America.

We learn from the remainder of the Paris fossils, and from others found in the eocene, that the earth now possessed fresh-water reptiles; serpents of the size of the boa; natatorial, wading, and rapacious birds; rodents (dormouse and squirrel); species allied to the racoon, the genet, and fox; also bats and monkeys. Lastly, the oldest tertiaries of America present us with the *Zeuglodon*, a herbivorous whale resembling the dugong, having a stinted development of the extremities, but an enormous tail, and reaching altogether the length of a hundred feet.

In the miocene sub-period, the shells give eighteen per cent. of existing species, showing a considerable advance from the preceding era with regard to the inhabitants of the sea. The advance in land animals is less marked, but yet considerable. The predominating forms are still pachyderms, and the tapiroid animals continue to be conspicuous. Here occur remains of the *Dinotherium*, a creature said to exhibit an affinity to the cetacea in the form of its head, and to the tapir in the character of its teeth. It is most distinguished by its huge size, being not less than eighteen feet long; it had a mole-like form of the shoulder-blade, conferring the power of digging for food, and a couple of tusks turning down from the lower jaw, by which it could have attached itself, like the walrus, to a shore or bank, while its body floated in the water. Dr. Buckland considers this and some similar miocene animals, as adapted to a semi-aquatic life, in a region where lakes abounded. Besides the tapirs, we have in this era animals allied to the glutton, the bear, the dog, the horse, the hog, and lastly, several felinæ (creatures of which the lion is the type); all of which are new forms, as far as we know. There was also an abundance of marine mammalia, seals, dolphins, lamantins, walruses, and whales.

The shells of the older pliocene give from thirty-five to fifty; those of the newer, from ninety to ninety-five per cent. of existing species. The pachydermata of the preceding era now disappear; but others enter upon the scene—elephantoid animals, the hippopotamus, rhinoceros, and horse. All of these bear a striking resemblance to pachyderms of the same families still existing. We have, in the mastodon and mammoth, which succeed each other in the strata, elephants variously distinguished from the present by peculiarities in their dentition, and hence considered as of different species, though this is a purely arbitrary distinction. What is remarkable of these ancient animals is their having lived in countries so far beyond the present range of their family, namely, throughout the whole temperate region of Asia and Europe, (England not being excepted,) and even so far north as the seventieth degree of latitude. The mammoth also inhabited North America. Its chief external peculiarity was a pair of long curved tusks extending forwards and upwards from the upper jaw. The numerous remains of the animal in the most superficial strata, and the discovery (in 1801) of a specimen with its flesh and hide entire in a mass of ice at the mouth of the Lena in Siberia, show that it must have lived down to comparatively modern times.

The pliocene gives many other new families. From remains which have been found, however fragmentary in many cases, there cannot be a doubt that all the principal mammalian forms, except the highest and a few others, now existed throughout the earth, and in species which only differed from those now living in slight peculiarities, chiefly of dentition. Bears, badgers, hyænas, and feline animals; moles and other insectivores; otters and weasels; the wolf and dog, then roamed for prey as now; besides an extinct felina, the machairodus, possessing teeth like curved saws. England had beavers and bears, little different from living species; only, one of the former family was of huge bulk. We also had the hippopotamus and rhinoceros. Oxen, deer, camels, etc., inhabited the great zoological province with which we are connected; and monkeys and apes passed far beyond the tropical regions to which they are now confined. In India, besides the pachyderms of the European eocene, there were ruminants in abundance (including an extraordinary one, of huge bulk, named the Sivatherium), carnivores, rodents, and insectivores. Here also were monkeys, of unusual bulk; but the most wonderful animal as yet discovered in this region was a tortoise, not distinguishable in any point of structure from a land species now living, but reaching the surprising length of eighteen feet. The discoveries among the tertiaries of South America have been of a not less interesting character, in as far as they equally show an approach to the existing zoological characters of that region. Dr. Lund, a Danish naturalist, presents us with a monkey, indicating the features of the platyrrhine or New World group; and the edentate order, which is still more peculiar to that region, is there preceded by examples of vast size. In the megatherium, megalonyx, scelidotherium, and mylodon, we have a family of sloths, of elephantine magnitude, which lived by breaking down and eating trees. The toxodon surprises us not less, being an equally huge member of the rodent order,—that order which now includes most of the smallest quadrupeds.(41)

One remarkable circumstance connected with the tertiary formation remains to be noticed,—the prevalence of volcanic action at that era. In Auvergne, in Catalonia, near Venice, and in the vicinity of Rome and Naples, lavas exactly resembling the produce of existing volcanoes are associated and intermixed with the lacustrine as well as marine tertiaries. The superficies of tertiaries in England is disturbed by two great swells, forming what are called anticlinal axes, one of which divides the London from the Hampshire basin, while the other passes through the Isle of Wight, both throwing the strata down at a violent inclination towards the north, as if the subterranean disturbing force had *waved* forward in that direction. The Pyrenees, too, and Alps, have both undergone elevation since the deposition of the tertiaries; and in Sicily there are mountains which have risen three thousand feet since the deposition of some of the most recent of these rocks. The general effect of these operations was of course to extend the land surface, and to increase the variety of its features, thus improving the natural drainage, and generally adapting the earth for the reception of higher classes of animals.

ERA OF THE SUPERFICIAL FORMATIONS

EXISTING SPECIFIC FORMS ABUNDANT.

We have now completed our survey of the series of stratified rocks, and traced in their fossils the progress of organic creation down to a time which seems not long antecedent to the appearance of man. There are, nevertheless, memorials of still another era or space of time which it is all but certain did also precede that event.

The first that calls for notice is the phenomenon to which geologists have applied the term denudation. Great hitches and slips are detected in superficial strata,—such as, if left in their original state, must have caused considerable inequalities on the face of the country; yet all is found as smooth—the joinings are all as much reduced to a common level—as if some gigantic artificial force had been used for the purpose. Again, a great valley has been scooped out in the midst of sedimentary strata, leaving the edges of these facing each other from the opposite sides, with perhaps here and there an isolated mass starting up to the height of the two sides, being composed of matter which has resisted the agency by which the adjoining matter was removed. Here, it is thought, we see incontestable traces of the operation of moving water. The second fact we are called to notice is, that over the rock formations of all eras, in various parts of the globe, but confined in general to situations not very elevated, there is a layer of stiff clay, mostly of a blue colour, mingled with fragments of rock of all sizes, travel-worn, and otherwise, and to which geologists give the name of Diluvium, as being apparently the produce of some vast flood, or of the sea thrown into an unusual agitation. It seems to indicate that, at the time when it was laid down, much of the present dry land was under the ocean—a supposition which we shall see supported by other evidence. The included masses of rock have been carefully inspected in many places, and traced to particular parent beds at considerable distances. Connected with these phenomena are certain rock surfaces on the slopes of hills and elsewhere, which exhibit groovings and scratchings, such as we might suppose would be produced by a quantity of loose blocks hurried along over them by a flood. Another associated phenomenon is that called *crag and tail*, which exists in many places,—namely, a rocky mountain, or lesser elevation, presenting on one side the naked rock in a more or less abrupt form, and on the other a gentle slope; the sites of Windsor, Edinburgh, and Stirling, with their respective castles, are specimens of crag and tail. Finally, I may advert to certain long ridges of clay and gravel which arrest the attention of travellers on the surface of Sweden and Finland, and which are also found in the United States, where, indeed, the whole of these phenomena have been observed over a large surface, as well as in Europe. It is very remarkable that the direction from which the diluvial blocks have generally come, the lines of the grooved rock surfaces, the direction of the crag and tail eminences, and that of the clay and gravel ridges—phenomena, be it observed, extending over the northern parts of both Europe and America—*are all from the north and north-west towards the south-east.* We thus acquire the idea of a powerful current moving in a direction from north-west to south-east, carrying, besides mud, masses of rock which furrowed the solid surfaces as they passed along, abrading the north-west faces of many hills, but leaving the slopes in the opposite direction uninjured, and in some instances forming long ridges of detritus along the surface. These are curious considerations; and it has become a question of much interest, by what means, and under what circumstances, such a current was produced. But in the present state of our knowledge, all that can be legitimately inferred from the diluvium is, that many portions of the northern nations of Europe and America were then under the sea, and that a strong current set over them.

Connected with the Diluvium is the history of *Ossiferous Caverns*, of which specimens singly exist at Kirkdale in Yorkshire, Gailenreuth in Franconia, and other places. They occur in the calcareous strata, as the great caverns generally do, but have in all instances been naturally closed up till the recent period of their discovery. The floors are covered with what appears to be a bed of the diluvial clay, over which rests a crust of stalagmite, the result of the droppings from the roof since the time when the clay bed was laid down. In the instances above specified, and several others, there have been found, under the clay bed, assemblages of the bones of animals, of many various kinds. At Kirkdale, for example, the remains of twenty-four species were ascertained—namely, pigeon, lark, raven, duck, and partridge; mouse, water-rat, rabbit, hare, hippopotamus, rhinoceros, elephant, weasel, fox, wolf, deer (three species), ox, horse, bear, tiger, hyena. From many of the bones of the gentler of these animals being found in a broken state, it is supposed that the cave was a haunt of hyenas and other predaceous creatures, by which the smaller ones were here consumed. This must have been at a time antecedent to the floodings which produced the diluvium, since the bones are covered by a bed of that formation. It is impossible not to see here a very natural series of incidents. First, the cave is frequented by wild beasts, who make it a kind of charnel-house. Then, submerged in the current which has been spoken of, it receives a clay flooring from the waters containing that matter in suspension. Finally, raised from the water, but with no mouth to the open air, it remains unintruded on for a long series of ages, during which the clay flooring receives a new calcareous covering, from the droppings of the roof.

Our attention is next drawn to the erratic blocks or boulders, which in many parts of the earth are thickly strewn over the surface, particularly in the north of Europe. Some of these blocks are many tons in weight, yet are clearly ascertained to have belonged originally to situations at a great distance. Fragments, for example, of the granite of Shap Fell are found in every direction around to the distance of fifty miles, one piece being placed high upon Criffel Mountain, on the opposite side of the Solway estuary; so also are fragments of the Alps found far up the slopes of the Jura. There are even blocks on the east coast of England, supposed to have travelled from Norway. The only rational conjecture which can be formed as to the transport of such masses from so great a distance, is one which presumes them to have been carried and dropped by icebergs, while seas existed upon the space between their original and final sites. Icebergs do even now carry off such masses from the polar coasts, which, falling when the retaining ice melts, must take up situations at the bottom of the sea, similar to those in which we find the erratic blocks of the present dry land.

While the diluvium and erratic blocks clearly suppose a part at least of the present land to have at one time been sunk to a considerable depth in the sea, there is another set of appearances which as manifestly show the steps by which the land was made afterwards to re-emerge from that element. These consist of *terraces*, which have been detected near, and at some distance inland from, the coast lines of Scandinavia, Britain, America, and other regions; being evidently ancient beaches, or platforms, on which the margin of the sea at one time rested. They have been observed at different heights above the present sea-level, from twenty to above twelve hundred feet; and in many places they are seen rising above each other in succession, to the number of three, four, and even more. The smooth flatness of these terraces, with generally a slight inclination towards the sea, the sandy composition of many of them, and, in some instances, the preservation of marine shells in the ground, identify them perfectly with existing sea-beaches, notwithstanding the cuts and scoopings which have at frequent intervals been effected in them by water-courses. The irresistible inference from the phenomena is, that the highest was first the coast line; then an elevation took place, and the second highest became so, the first being now raised into the air and thrown inland. Then, upon another elevation, the sea began to form, at its new point of contact with the land, the third highest beach, and so on down to the platform nearest to the present sea-beach. Phenomena of this kind become comparatively familiar to us, when we hear of evidence that the last sixty feet of the elevation of Sweden, and the last eighty-five of that of Chili, have taken place since man first dwelt in those countries; nay, that the elevation of the former country goes on at this time at the rate of about forty-five inches in a century, and that a thousand miles of the Chilian coast rose four feet in one night, under the influence of a powerful earthquake, so lately as 1822. Subterranean forces, of the kind then exemplified in Chili, supply a ready explanation of the whole phenomena, though some other operating causes have been suggested. In an inquiry on this point, it becomes of consequence to learn some particulars respecting the levels. Taking a particular beach, it is generally observed that the level continues the same along a considerable number of miles, and nothing like breaks or hitches has as yet been detected in any case. A second and a third beach are also observed to be exactly parallel to the first. These facts would seem to indicate quiet elevating movements, uniform over a large tract. It must, however, be remarked that the raised beaches at one part of a coast rarely coincide with those at another part forty or fifty miles off. We might suppose this to indicate a limit in that extent of the uniformity of the elevating cause; but it would be rash to conclude positively that such is the case. In the present sea, as is well known, there are different levels at different places, owing to the operation of peculiar local causes, as currents, evaporation, and the influx of large rivers into narrow-mouthed estuaries. The differences of level in the ancient beaches might be occasioned by some such causes. But, whatever doubt may rest on this minor point, enough has been ascertained to settle the main one, that we have in these platforms indubitable monuments of an elevation of the land from the sea, and the concluding great event of the geological history.

The idea of such a deep immersion of the land unavoidably suggests some considerations as to the effect which it might have upon terrestrial animal life. Some, regarding it as a complete submersion, argue that terrestrial life would be, on such an occasion, extensively, if not universally, destroyed. Nor was the idea of its universal destruction the less plausible, when it was believed that the present land animals are an entirely new set of species, introduced since the conclusion of the Tertiary Formation. It must now be owned that there are insurmountable objections to such hypothesis. First, it is not true that the specific forms of the tertiary epoch have all of them disappeared. There are several—for example, a badger of the Miocene—which are not in the slightest degree distinguished from living species. Many reptiles, now living in India, have been proved to be coëval with the Himalayan Anoplothere, Mastodon, and Hippopotamus. Second, the specific distinctions alleged in a great number of cases between tertiary and existing animals are extremely slight, and such as we have no fixed principle by which to be assured that they mark new species, in the sense of a new creation. Finally, the tertiary animals of America indicate an approximation to the character of existing animals in that region, and tertiary animals of the other great continent, equally approximate to those at present occupying it; showing that the demarcations of the present great zoological provinces had been already marked out, and have never been obliterated. There is therefore enough to justify us in believing that no entire submergence of the earth took place at the time of the Diluvium, though how nearly it might approach completeness we cannot say.

There are some other superficial formations, of less consequence on the present occasion than the diluvium—namely, lacustrine deposits, or filled-up lakes; alluvium, or the deposits of rivers beside their margins; deltas, the deposits made by great ones at their efflux into the sea; peat mosses;

and the vegetable soil. The animal remains found in these generally testify to a zoology on the verge of that now prevailing, or melting into it, there being included many species which still exist. In a lacustrine deposit at Market-Weighton, in the Vale of York, there have been found bones of the elephant, rhinoceros, bison, wolf, horse, felis, deer, birds, all or nearly all presenting peculiarities different from existing species, associated with thirteen species of land and fresh-water shells, " exactly identical with types now living in the vicinity." In similar deposits in North America, are remains of the mammoth, mastodon, buffalo, and other animals of extinct and living types. In short, these superficial deposits show precisely such remains as might be expected from a time at which the present forms of the animal world had been generally assumed, but yet so far remote in chronology as to allow of the dropping of many species, through familiar causes—perhaps we should only say the obliteration of many peculiarities called specific—in the interval. Still, however, several of the most important living species have left no record of themselves in any formation beyond what are, comparatively speaking, modern. Such are the sheep and goat, and such, above all, is our own species. We thus learn that, compared with many humbler animals, man is a being, as it were, of yesterday.

GENERAL CONSIDERATIONS

RESPECTING

THE ORIGIN OF THE ANIMATED TRIBES.

Thus concludes the wondrous section of the earth's history which is told by geology. It takes up our globe at the period when its original incandescent state had nearly ceased; conducts it through what we have every reason to believe were vast spaces of time, in the course of which many superficial changes took place, and vegetable and animal life was gradually evolved ; and drops it just at the point when man was apparently about to enter on the scene. The compilation of such a history, from materials of so extraordinary a character, and the powerful nature of the evidence which these materials afford, are calculated to excite our admiration, and the result must be allowed to exalt the dignity of science, as a product of man's industry and his reason.

It is now to be remarked, that the whole series of operations displayed in inorganic geology is concluded upon as having taken place under the agency of natural laws. Those movements of subterranean force which thrust up mountain ranges and upheaved continents, stand in inextricable connection, on the one hand, with the volcanoes which are yet belching forth lavas and shaking large tracts of ground, as, on the other, with the primitive incandescent state of the earth.

Those forces which disintegrated the early rocks and of the detritus formed new beds at the bottoms of seas, are still seen at work to the same effect in every part of the globe. To bring these truths the more clearly before us, it is possible to make a substance resembling basalt in a furnace; limestone and sandstone have both been formed from suitable materials in appropriate receptacles; the phenomena of cleavage have, with the aid of electricity, been similated on a small scale, and by the same agent crystals are formed. In short, the remark which was made regarding the indifference of the cosmical laws to the scale on which they operated, is to be repeated regarding the geological. A common furnace will sometimes exemplify the operation of laws which have been concerned in the production of a Giant's Causeway; and in a sloping ploughed field after rain, we may often observe, at the lower end of a furrow, a handful of washed and neatly deposited mud or sand, capable of serving as an illustration of the way in which Nature has produced the deltas of the Nile and Ganges. In the ripple-mark on sandy beaches of the present day, we see Nature's exact repetition of the operations by which she impressed similar features on the sandstones of the carbonigenous era. Even such marks as wind-slanted rain would in our day produce on tide-deserted sands, have been read upon tablets of the ancient strata. It is the same Nature working every where and in all time, causing the wind to blow and the rain to fall, and the tide to ebb and flow, inconceivable ages before the birth of our race, as now. So also we learn from the conifers of those old ages, that there were winter and summer upon earth, before any of us lived to liken the one to all that is genial in our own nature, or to say that the other breathed no airs so unkind as man's ingratitude. Let no one suppose there is any necessary disrespect for the Creator in thus tracing his laws in their minute and familiar operations. There is in reality no true great and small, grand and familiar, in nature. Such only appear, when we thrust ourselves in as a point from which to start in judging. Let us pass, if possible, beyond immediate impressions, and see all in relation to Cause, and we shall chastenedly admit that the whole is alike worshipful.

We have, then, in this history, a planet formed, and a long and complicated series of superficial changes effected upon it, all through the efficacy of simply natural laws, which we can see at work at this day in numberless familiar ways. But mixed up with these geognostic changes, and apparently as a final object connected with the formation of the globe itself, there is another set of phenomena presented in the course of our history—the coming into existence, namely, of a long suite of living things, vegetable and animal, terminating in the families which we still see occupying the surface. The question arises—In what manner has this set of phenomena originated? Can we touch at and rest for a moment on the possibility of plants and animals having likewise been produced in the way of natural law; thus assigning but one class of causes for everything revealed to our sensual observation; or are we at once to reject this idea, and remain content, either to suppose that creative power here acted in a different way, or to believe unexaminingly that the inquiry is one beyond our powers?

Taking the last part of the question first, I would reply, that I am extremely loath to imagine that there is anything in nature which we should, for any reason, refrain from examining. If we can infer aught from the past history of science, it is, that the whole of nature is a legitimate field for the exercise of our intellectual faculties; that there is a connexion between this knowledge and our well-being; and that if we can judge from things once despaired of by our inquiring reason, but now made clear and simple, there is none of Nature's mysteries which we may not hopefully attempt to penetrate. To remain idly content to *presume* a various class of immediate causes for organic nature, seems to me, on this ground, equally objectionable.

Granting, then, that the inquiry should be entered upon, it may be right to insist, in the first place, upon certain general considerations, which, supposing we enter upon it in a scientific spirit, appear to throw the balance of likelihood on the side of ordinary natural causes. The production of the organic world is, we see, mixed up with the production of the physical. It is mixed in the sense of actual connexion and dependence, and it is mixed in regard to time, for the one class of phenomena commenced whenever the other had arrived at a point which favoured or admitted of it; life, as it were, *pressed in* whenever and wherever there were suitable conditions, and, once it had commenced, the two classes of phenomena went on, hand in hand, together. It is surely very unlikely, *à priori*, that in such a complex mass of phenomena there should have been *two totally distinct modes of the exercise of the divine power.* Were such the case, it would form a most extraordinary, and to philosophic consideration ought to be a most startling exception, from what we otherwise observe of the character of the divine procedure in the universe. Further, let us consider the comparative character of the two classes of phenomena, for comparison may of course be legitimate where the natural system is not admitted. The absurdities into which we should thus be led must strike every reflecting mind. The Eternal Sovereign arranges a solar or an astral system by dispositions imparted primordially to matter; he causes, by the same majestic means, vast oceans to form and continents to rise, and all the grand meteoric agencies to proceed in ceaseless alternation, so as to fit the earth for a residence of organic beings. But when, in the course of these operations, fuci and corals are to be for the first time placed in those oceans, a particular interference of the divine power is required: in the belief of the ignorant, the very hand of Deity is necessary; in that of the sage—as sages are amongst us—only a "creative fiat" is demanded; but, in either way, special attention to the object, such as a human being has to pay in the progress of his affairs, is presumed. And not only on this one occasion, but all along the stretch of geological time, this special attention is needed whenever a new family of organisms is to be introduced: a new fiat for fishes, another for reptiles, a third for birds; nay, taking up the present views of geologists as to species, such an event as the commencement of a certain cephalopod, one with a few new nodulosities and corrugations upon its shell, would, on this theory, require the particular care of that same Almighty who willed at once the whole means by which infinity was replenished with its worlds!

I have here contemplated the question as one remaining to be settled by science. We must not, however, overlook that the decision is exposed to great prejudice, in consequence of our minds being prepossessed by a more or less distinct conclusion in favour of organic creation by some kind of special exercise of divine power. This is the idea which first rose in the human family, being that which the unassisted mind is apt to form out of the appearances presented to it; precisely as, with regard to the heavenly motions, the geocentric theory was that which the appearances first suggested, and therefore was first embraced by man. This idea of the organic creation has rested almost undisturbed to the present day, because, till a recent period, science came little near it, and means for testing its soundness scarcely existed. It is different now, when, besides the cosmical arrangements being seen to have been brought about under natural law, the same influence is traced through the whole series of geognostic changes since the beginning of our planet's existence. But yet, this knowledge being recent, the ancient idea of the creation of organisms continues to have that hold upon our minds which early impressions and long-continued habits tend to give to even the most unphilosophical convictions. It is necessary to keep this in view, if we would enter upon the inquiry in a philosophical spirit, and with the pure desire to arrive only at such a conclusion as the balance of evidence may justify.

In intimate connexion with the ancient idea, is the supposition found resting in many minds, that to presume a creation of living beings by the intervention of law, is equivalent to superseding the whole doctrine of the divine authorship of organic nature. Were this true, it would form a most important objection to the law theory; but I think it is not only not true, but the reverse of the truth. As formerly stated, the whole idea of law relates only to the mode in which the Deity is pleased to manifest his power in the natural world.

It leaves the absolute fact of his authorship of and supremacy over nature, precisely where it was; and only tells us that, instead of dealing with the natural world as a human being traffics with his own affairs, adjusting each circumstance to a relation with other circumstances as they emerge, he has originally conceived, and since sustained arrangements fitted to serve in a general sufficiency for all contingencies; himself, of course, necessarily living in all such arrangements, as the only means by which they could be, even for a moment, upheld. Were the question to be settled upon a consideration of the respective moral merits of the two theories, I would say that the latter is greatly the preferable, as it implies a far grander view of the divine power and dignity than the other. For one thing, it places the leading divine attribute of foresight in a much more sublime position. "If," says Dr. Buckland, contemplating the possible establishment of this doctrine—"if the properties adopted by the elements at the moment of their creation adapted them beforehand to the infinity of complicated useful purposes which they have already answered, and may have still further to answer, under many dispensations of the material world, such an aboriginal constitution, *so far from superseding an intelligent agent, would only exalt our conceptions of the consummate skill and power that could comprehend such an infinity of future uses under future systems, in the original groundwork of his creation.*"

It is also to be observed, though almost needlessly, that any objection of this kind would lie equally well against other doctrines which the enlightened part of mankind have long admitted. The whole purport of science is to ascertain *law*; it has, in the course of time, transferred one set of phenomena after another out of the region of marvel into that of law, thus showing a true divine regulation in them. Suppose, then, that there be a balance of probability from actual evidence in favour of an organic creation by law, we should only, in so settling the matter, be concluding upon one department of the great system of things, as we have been concluding upon others throughout all the ages of philosophy.

To return to a consideration of the positive arguments for an organic creation by law, we have seen that this stands in harmony with our conclusions as to the cosmical arrangements, and also those regarding the geognostic changes. We are now to observe that it consorts equally well with what we know of the actual history of organic beings upon the earth. These came not at once, as they might have been expected to do if produced by some special act, or even some special interposition of will, on the part of the Deity. They came in a long-extending succession, in the order, as we shall afterwards see more convincingly, of progressive organization; grade following grade, till, from a humble starting-point in both kingdoms, the highest forms were realized. Time, we see, was an element in the evolution of Being, as it is in the reproduction of an individual at the present day. At the beginning of geological investigation, it was thought that some immediate external conditions ruled the appearance of particular classes of animals at particular times: as that the absence of dry land was the cause of the late commencement of terrestrial animals; that there being for a long time only reptilian land vertebrata was owing to an overcharge of the atmosphere with carbonic acid—the store from which came the chief material of the abundant vegetation of the carbonigenous age; and so forth. But it is now seen that the progress of the animal world was, in its main features, independent of such circumstances. There *was* dry land unreckonable ages before there were any land animals. The sea abounded in invertebrate animals before there were any fish, though the conditions required for the existence of both are the same. The oolitic continents where only reptiles roamed could have equally supported mammalia, for which the atmosphere was then fully fitted, even upon the admission of the carbonic acid theory, as the coal was by that time formed; yet mammalia came not. It was also a dream at the dawn of true geology, that fresh creations of animals were connected with great physical revolutions of the surface; as if, at particular times, all had perished in storms of volcanic violence, and been replaced with a wholly new fauna. But this idea is likewise passing away.

It is now seen that changes in specific forms took place quietly in the course of time, while no volcanic disturbances are traceable. In short, it is always becoming more and more clear that organic progress—both the specific changes in classes formerly existing, and the accession of new and higher classes—depended, not by any means wholly or immediately upon external circumstances, but in great part upon time. All this looks very unlike either special working or special willing on the part of the Creator, but, on the contrary, very like the simply natural procedure of things in the world of our own day.

There are some other facts in the history of fossils, which it is difficult to reconcile with the idea of special creative effort, but which perfectly harmonize with that of a creation through the medium or in the manner of law. It is admitted, for instance, that "the differences which exist between extinct faunas and the animals now living are *so much greater in proportion as these faunas are most ancient.*" Passing downward in the formations and backward in time, we first find species identical with the present; next, only genera; afterwards, only families or orders. These are the words of naturalists; but the truth simply is, that in early formations, animals resembled the present in broad general characters; afterwards, they resembled them in characters more particular; finally, they become identical. Always as we advance, the total mass of the animal creation puts on more and more of the appearances which it now bears. It may be asked if this does not seem to imply that the present system of things is essentially connected with the past; in which case, if the present is a natural system, we have an additional proof that the past was a natural system also. So also it is admitted that, however nearly the specific forms may experience an entire change from one formation to another, there are always resemblances and approximations between each two which are adjacent to each other. "If," says M. Pictet, an opponent of the views here advocated, "we compare two successive creations of one and the same epoch, such as the faunas of the five divisions of the cretaceous formation, we cannot fail to be struck with *the intimate connexion they* *have with each other.* The greater part of the genera are the same: a great part of the species are very closely allied and easily confounded. [Referring to two of these sub-formations,] is it probable that the albian fauna had been completely annihilated, and then, by a new and independent creation, replaced by a fauna altogether new, and *so similar to it?* I am aware that these facts may be referred to the general plan of creation [that is, a supposed plan, according to which the divine power had operated in its special successive creative operations]; but is the mind entirely satisfied with this explanation?" I cannot but echo the last question. Can we be content to assume—for, after all, it is assumption—that a series of miraculous creations was invariably to be in the manner of a piecing on and blending from one to another, when we have the alternative of presuming (grant it were to be left to presumption alone) that these connexions are only memorials of a natural law presiding over the development of the whole organic creation, and making it one and not many things? I can only wonder that a man learned in the subject can see such a difficulty as he has here stated, and find it more easily passed over than the bare fact that certain mammalia have not changed for three thousand years,—for such is the only difficulty he states on the other side.

It must further be recollected that we are not only to account for the origination of organic being upon this little planet, third of a series which is but one of hundreds of thousands of series, the whole of which again form but one portion of an apparently infinite globe-peopled space, where all seems analogous. We have to suppose, that every one of these numberless globes is either a theatre of organic being, or in the way of becoming so. This is a conclusion which every addition to our knowledge makes only the more irresistible. Is it conceivable, as a fitting mode of exercise for creative intelligence, that it should be constantly paying a special attention to the creation of species, as they may be required in each situation throughout those worlds, at particular times? Is such an idea accordant with our general conception of the dignity, not to speak of the power, of the

Great Author? Yet such is the notion which we must form, if we adhere to the doctrine of special exercise. Let us see, on the other hand, how the doctrine of a creation in the manner of law agrees with this expanded view of the organic world.

Unprepared as most men may be for such an announcement, there can be no doubt that we are able, in this limited sphere, to form some satisfactory conclusions as to the plants and animals of those other spheres which move at such immense distances from us. Suppose that the first persons of an early nation who made a ship and ventured to sea in it, observed, as they sailed along, a set of objects which they had never before seen—namely, a fleet of other ships—would they not have been justified in supposing that those ships were occupied, like their own, by human beings, possessing hands to row and steer, eyes to watch the signs of the weather, intelligence to guide them from one place to another—in short, beings in all respects like themselves, or only showing such differences as they knew to be producible by difference of climate and habits of life? Precisely in this manner we can speculate on the inhabitants of remote spheres. We see that matter has originally been diffused in one mass, of which the spheres are portions. Consequently, inorganic matter must be presumed to be everywhere the same, although probably with differences in the proportions of ingredients in different globes, and also some difference of conditions. Out of a certain number of the elements of inorganic matter are composed organic bodies, both vegetable and animal: such must be the rule in Jupiter and in Sirius, as it is here. We, therefore, are all but certain that herbaceous and ligneous fibre, that flesh and blood, are the constituents of the organic beings of all those spheres which are as yet seats of life. Gravitation we see to be an all-pervading principle: therefore there must be a relation between the spheres and their respective organic occupants, by virtue of which they are fixed, as far as necessary, on the surface. Such a relation, of course, involves details as to the density and elasticity of structure, as well as size of the organic tenants, in proportion to the gravity of the respective planets—peculiarities, however, which may quite well consist with the idea of a universality of certain types, such as we see exemplified upon earth. We come to comparatively matter of detail, when we advert to heat and light; yet it is important to consider that these are universal agents, and that, as they bear marked relations to organic life and structure on earth, they may be presumed to do so in other spheres also. The considerations as to light are particularly interesting, for, on our globe, the structure of one important organ, almost universally distributed in the animal kingdom, is in direct and precise relation to it. Where there is light there will be eyes, and these, in other spheres, will be the same in all respects as the eyes of tellurian animals, with only such differences as may be necessary to accord with minor peculiarities of condition and of situation. It is but a small stretch of the argument to suppose that, one conspicuous organ of a large portion of our animal kingdom being thus universal, a parity in all the other organs—species for species, class for class, kingdom for kingdom—is highly likely, and that thus the inhabitants of all the other globes of space bear not only a general, but a particular resemblance to those of our own.

It must be obvious, that, if organic beings are thus universally distributed, the idea of their having all come into existence through the immediate agency of laws everywhere applicable, is strictly conformable to the principle laid down for our own limited sphere. As a set of laws produced all orbs, their motions and geognostic arrangements, so a set of laws overspread them all with life. The whole productive or creative arrangements thus appear in unity.

PARTICULAR CONSIDERATIONS

RESPECTING

THE ORIGIN OF THE ANIMATED TRIBES.

It being thus shown that there is a general probability in favour of organic creation as a natural event, it becomes necessary to inquire whether this idea be supported or contradicted by special facts connected with the constitution of organic bodies

Here the patrons of opposite views appear at first sight to have an advantage. "Yes," they say, "it may appear that the bodies of space have been formed and arranged in the manner of natural law; it may be admitted that all the geognostic phenomena have had a similar history; but when you come to treat of life and organization, you find yourself in a totally different field. These are *mysteries*, in the consideration of which physical laws fail you, and you are forced to make reference to causes of a different order. Before the origin of life upon our planet could be supposed to have taken place as a simply natural phenomenon, it would be necessary to show that it can be produced at this moment out of inorganic elements. But this cannot be shown; and we must therefore conclude that a special interference of deity was required at the commencement of every species."

It is nevertheless true, that much of this is mere assumption, contrary to the actual state, and much more contrary to the tendency, of science.

First, with regard to the constituents of organic bodies, it is found that they are merely a selection of the simple substances which form the inorganic or non-vitalized world. Carbon, oxygen, hydrogen, and nitrogen, are the chief. The first combinations of these in animals are into what are called *proximate principles*, as albumen, fibrin, etc., out of which the animal body is composed. Now, so far from there being anything peculiar or mysterious in these combinations, it is acknowledged that they are simply chemical. "It is now certain," says Dr. Daubeny, of Oxford, "that the same simple laws of composition pervade the whole creation; and that if the organic chemist only takes the requisite precautions to avoid resolving into their ultimate elements the proximate principles upon which he operates, the result of his analysis will show that they are combined precisely according to the same plan as the elements of mineral bodies are known to be."(42) A particular fact is here worthy of attention: "The conversion of fecula into sugar, as one of the ordinary processes of vegetable economy, is effected by the production of a secretion termed *diastase*, which occasions both the rupture of the starch vesicles, and the change of their contained gum into sugar. This diastase may be separately obtained by the chemist, and it acts as effectually in his laboratory as in the vegetable organization. He can also imitate its effects by other chemical agents." (43) The same writer elsewhere adds, "No reasonable ground has yet been adduced for supposing that, if we had the power of bringing together the elements of any organic compound, in their requisite states and proportions, the result would be any other than that which is found in the living body. Every fresh discovery," he says, "is tending to break down the barrier between the two classes of organic and inorganic bodies, as far as regards their chemical combination."(44)

It is much to know the elements of organic bodies, and that the first combinations of these are simply chemical. The powers by which these combinations take place are next to be inquired into. The predominant idea hitherto has been, that the vital affinities are of a totally distinct nature, depending upon a mystic something, to which the term *vital principle* was applied. But this idea is now on the decline. Admitting the vital affinities, as powers superseding and counteracting ordinary chemical affinities, it is seen that the idea of a distinct inscrutable principle on which they depend, is "both unsupported by evidence and useless in the explanation of facts."(45) It is becoming evident that living structures result from the action of a multitude of natural forces in combination—"gravity, cohesion, elasticity, the agency of the imponderables, and all other powers which operate both on masses and atoms." Professor Draper, of New York, in making this statement, says—"It is astonishing that in our days the ancient system which excludes all connexion with natural philosophy and chemistry, and depends on the fictitious aid of a visionary force, should continue to exist; a system which at the outset ought to have broken down by the most common considerations, such as those connected with the mechanical principles involved in the bony skeleton, the optical principles in the construction of the eye, or the hydraulic action of the valves of the heart."(46)

So much for the combinations concerned in living bodies; but how shall we hope to see their *forms* brought under any relation to physical laws? On this point we have some illustrations in the phenomena attending the production of crystals, a class of bodies which has been said to stand between the inorganic and the organic. From the agency which has been employed by Mr. Crosse in making crystals formerly supposed to be of Nature's production alone, it is now incontestable that crystallization is dependent on electric agency, the special forms being the result of the peculiar nature of the constituent substance and the conditions under which the imponderable is applied. Here are obviously natural means of producing forms almost as various as those of living beings, and equally determinate and regular. A certain community of cause in the two instances is indicated by the surprising resemblance which some examples of crystallization bear to vegetable forms. In some, the mimicry is beautiful and complete; for example, in the well-known one called the *Arbor Dianæ*. An amalgam of four parts of silver and two of mercury being dissolved in nitric acid, and water equal to thirty weights of the metals being added, a small piece of soft amalgam of silver, suspended in the solution, quickly gathers to itself the particles of the silver of the amalgam, which form upon it a *crystallization precisely resembling a shrub*. Vegetable figures are also presented in some of the most ordinary appearances of the electric fluid. In the marks caused by positive electricity, or which it leaves in its passage, we see the ramifications of a tree, as well as of its individual leaves; those of the negative, recal the bulbous or the spreading root, according as they are clumped or divergent. These phenomena seem to indicate that the electric energies have had something to do in determining the forms of plants. That they are intimately connected with vegetable life is indubitable, for germination will not proceed in water charged with negative electricity, while water charged positively greatly favours it; and a garden sensibly increases in luxuriance when a number of conducting rods are made to terminate in branches over its beds. With regard to the resemblance of the ramifications of the branches and leaves of plants to the traces of the positive electricity, and that of the roots to the negative, it is a circumstance calling for especial remark, that the atmosphere, particularly its lower strata, is generally charged positively, while the earth is always charged negatively. The correspondence here is curious. A plant thus appears as a thing formed on the basis of a natural electrical operation—*the brush* realized. We can thus suppose the various forms of plants as, immediately, the result of a law in electricity, variously affecting them according to their organic character, or respective germinal constituents. In the poplar, the brush is unusually vertical, and little divergent; the reverse in the beech: in the palm, a pencil has proceeded straight up for a certain distance, radiates there, and turns outwards and downwards; and so on. We can here see at least traces of secondary means by which the Almighty Deviser might establish all the vegetable forms with which the earth is overspread. (47)

We turn to the minutiæ of organic structure and embryology, as affording us some further illustrations of an instructive kind. It is now ascertained by microscopic research, that the basis of all vegetable and animal substances consists of nucleated cells; that is, cells having granules within them. Nutriment is converted into these before being assimilated by the system. The tissues are formed from them. The ovum destined to become a new creature, is originally only a cell with a contained granule. We see it acting this reproductive part in the simplest manner in the cryptogamic plants. "The parent cell, arrived at maturity by the exercise of its organic functions, bursts, and liberates its contained granules. These, at once thrown upon their own resources, and entirely dependent for their nutrition on the surrounding elements, develop themselves into new cells, which repeat the life of their original. Amongst the higher tribes of the cryptogamia, the reproductive cell does not burst, but the first cells of the new structure are developed within it, and these gradually extend, by a similar process of multiplication, into that primary leaf-like expansion which is the first formed structure in all plants." (48) *Here the little cell becomes directly a plant, the full formed living being.* It is also worthy of remark that, in the sponges, (an animal form,) a gemmule detached from the body of the parent, and trusting for sustentation only to the fluid into which it has been cast, becomes, without further process, the new creature. Further, it has been recently discovered by means of the microscope, that there is, as far as can be judged, a perfect resemblance between the ovum of the mammal tribes, during that early stage when it is passing through the oviduct, and the young of the infusory animalcules. One of the most remarkable of these, the *volvox globator*, can hardly be distinguished from the germ which, after passing through a long fœtal progress, becomes a complete mammifer, an animal of the highest class. It has even been found that both are alike provided with those *cilia*, which, producing an appearance of revolving motion, is partly the cause of the name given to this animalcule. These resemblances are the more entitled to notice, that they were made by various observers, distant from each other at the time. (49) It has likewise been noticed that the globules of the blood are reproduced by the expansion of contained granules; they are, in short, *distinct organisms multiplied by the same fissiparous generation.* So that all animated nature may be said to be based on this mode of origin; *the fundamental form of organic being is a cell, having new cells forming within itself*, by which it is in time discharged, and which are again followed by others and others, in endless succession. It is of course obvious that, if these cells could be produced by any process from inorganic elements, we should be entitled to say that the fact of a transit from the inorganic into the organic had been witnessed in that instance; the possibility of the commencement of animated creation by the ordinary laws of nature might be considered as established. Now it was announced some years ago by Prevost and Dumas, that *globules could be produced in albumen by electricity.* If, therefore, these globules be identical with the cells which are now held to be reproductive, it might be said that the production of albumen by artificial means is the only step in the process wanting. This has not yet been effected; but it is known to be only a chemical process, the mode of which may be any day discovered in the laboratory. (50)

Admitting, however, all these views regarding life and organization, the advocates of *interference* have still to say that a transition from the inorganic to the organic, such as we must suppose to have taken place in the early geological ages, is no ordinary cognizable fact of the present time upon earth: structure, form, life, are never seen to be imparted to the insensate elements; the production of the humblest plant or animacule, otherwise than as a repetition of some parental form, is not one of the possibilities of science; if, then, we trace back the generations of organisms to the Silurian or any earlier epoch, and acknowledge the world of that time to have been one in which the present order of natural events was prevalent, we necessarily can see no natural origin for species, and a miraculous one must be admitted.

Here we have undoubtedly the strongest of the arguments usually adduced against a natural origin of life. Yet it is one which may easily be replied to. In the first place, there is no reason to suppose that, although life had been imparted by natural means after the first cooling of the surface to a suitable temperature, it would have continued thereafter to be capable of being imparted in like manner. The great work of the peopling of this globe with living species is mainly a fact accomplished: the highest known species came as a crowning effect thousands of years ago. The work being thus, to all appearance, finished, we are not necessarily to expect that the origination of life and of species should be conspicuously exemplified in the present day. We are rather to expect that the vital phenomena presented to our eyes should mainly, if not entirely, be limited to a regular and unvarying succession of races by the ordinary means of generation. This, however, is no more an argument against a time when phenomena of the first kind prevailed, than it would be a proof against the fact of a mature man having once been a growing youth, that he is now seen growing no longer. We might consider the primitive production of species either as one phenomenon of the nature of the development of an individual embryo, and that phenomenon as past, just as the individual creation is perfected at birth, or as expressly and wholly a consequence of conditions, which being temporary, the results were temporary also. From the occupation of all the great geographical provinces with a more or less full suite of the forms of life, a new development may have hardly any chance of being now drawn forth, and none of being advanced to any extent, even though the same life-creating laws be still in force. Or the operations of these laws might be observant of times, and those of rare occurrence, so that hundreds of human generations may pass without an opportunity of witnessing such effects. However it may actually have been, assuredly the most rigid disproof of primitive creation as a fact of our time could be no conclusive argument against a natural creation at a time when the earth was vacant of all organic tenantry, if for such a creation any positive arguments can be adduced.

Secondly, it is far from being certain that the primitive imparting of life and form to inorganic elements is not a fact of our times. Such a doctrine is not generally received in the scientific world; but the reasons for rejecting it may at least admit of criticism. The leading one is, that, in a great number of instances where the superficial observers of former times assumed a non-generative origin for life, (as in the celebrated case in Virgil's fourth Georgic,) either the direct contrary has been ascertained, or exhaustive experiments have left no alternative from the conclusion that ordinary generation did take place, albeit in a manner which escapes observation. Finding that an erroneous assumption has been formed in many cases, modern inquirers have not hesitated to assume that there can be no case in which generation is not concerned; which is certainly far from being allowable. There are several persons eminent in science who profess at least to find great difficulties in accepting the doctrine of invariable generation. Dr. Allen Thomson, one of the professors in the Edinburgh University, has stated several considerations arising from analogical reasoning, which appear to him to throw the balance of evidence in favour of the primitive production of infusoria, the vegetation called mould, and the like. One seems to be of great force; namely, that the animalcules, which are supposed (altogether hypothetically) to be produced by ova, are afterwards found increasing their numbers, not by that mode at all, but by division of their bodies. If it be the nature of these creatures to propagate in this splitting or fissiparous manner, how could they be communicated to a vegetable infusion?([51]) It has been shown by the opponents of this theory, that when a vegetable infusion is debarred from the contact of the atmosphere, by being closely sealed up or covered with a layer of oil, or only receives oxygen which has passed through sulphuric acid, whereby all animal admixtures have been destroyed, no animalcules are produced; but can we be sure, in such circumstances, that we have not set aside some other simple condition requisite for a *non-ex-ovo* generation? Who can tell what effect such exclusion of air or such mode of admitting oxygen may have upon the operation of the imponderables in the case? To this I do not believe that any satisfactory answer could be given.

Perhaps the fashionable doctrine is in nothing placed in greater difficulties than it is with regard to the entozoa, or creatures which live within the bodies of others. These animals do, and apparently can, live nowhere else than in the interior of other living bodies, where they generally take up their abode in the viscera, but also sometimes in the chambers of the eye, the interior of the brain, the serous sacs, and other places having no communication from without. Some are viviparous, others oviparous. Of the latter it cannot reasonably be supposed that the ova ever pass through the medium of the air, or through the blood-vessels, for they are too heavy for the one transit, and too large for the other. Of the former, it cannot be conceived how they pass into young animals—certainly not by communication from the parent, for it has often been found that entozoa do not appear in certain generations of a human family, and some of peculiar and noted character have only appeared at rare intervals, and in very extraordinary circumstances. A candid view of the less popular doctrine, as to the origin of this humble form of life, is taken by a distinguished living naturalist. "To explain the beginning of these worms within the human body, on the common doctrine that all created beings proceed from their likes, or a primordial egg, is so difficult, that the moderns have been driven to speculate, as our fathers did, on their spontaneous birth; but they have received the hypothesis with some modification. Thus it is not from putrefaction or fermentation that the entozoa are born, for both of these processes are rather fatal to their existence, but from the aggregation and fit apposition of matter which is already organized, or has been thrown from organized surfaces. * * Their origin in this manner is not more wonderful or more inexplicable than that of many of the inferior animals from sections of themselves. * * Particles of matter fitted by digestion, and their transmission through a living body, for immediate assimilation with it, or flakes of lymph detached from surfaces already organized, seem neither to exceed nor fall below that simplicity of structure which favours this wonderful development; and the supposition that, like morsels of a planaria, they may also, when retained in contact with living parts, and in other favourable circumstances, continue to live and be gradually changed into creatures of analogous conformation, is surely not so absurd as to be brought into comparison with the Metamorphoses of Ovid. * * We think the hypothesis is also supported in some degree by the fact, that the origin of the entozoa is favoured by all causes which tend to disturb the equality between the secerning and absorbent systems."(52) Here particles of organized matter are suggested as the germinal original of distinct and fully organized animals, many of which have a highly developed reproductive system. How near such particles must be to the inorganic form of matter may be judged from what has been said within the last few pages.

While these appear as good general arguments for primitive life-production as a common occurrence in nature, there is a series of facts which goes a far way to prove that such occurrences must have taken place in comparatively modern times. The pig, in its domestic state, is subject to the attacks of a hydatid, from which the wild animal is free; hence the disease called measles in pork. The domestication of the pig is of course an event subsequent to the origin of man; indeed, comparatively speaking, a recent event. Whence, then, the first progenitor of this hydatid? So also there is a tinea which attacks dressed wool, but never touches it in its unwashed state. A particular insect disdains all food but chocolate, and the larva of the *oinopota cellaris* lives nowhere but in wine and beer, all of these being articles manufactured by man. There is likewise a fish called the *pymelodes cyclopum*, which is only found in subterranean cavities connected with certain specimens of the volcanic formation in South America, dating from a time posterior to the arrangements of the earth for our species. Whence the first pymelodes cyclopum? To have produced all these various animals, there must have been means in force at a time long subsequent to that at which the production of life by miracle is assumed to have taken place. And what is this but to connect the ancient events, assumed to have come by miracle, with the modern cases of doubted primitive generation? Does it not tend to show that the ancient and modern events are of one character, both alike results of a silent immutable energy imparted to nature by her Divine Author, and in the working of which there is no regard to great or small?

Seeing such reasons for believing the general dictum of the philosophical world on primitive generation to be inconclusive, we may be prepared to review without surprise or incredulity the well-known experiments of Mr. Crosse, which seemed to result in the production of a small species of insect in considerable numbers. This gentleman was pursuing some experiments in crystallization, causing a powerful voltaic battery to operate upon a saturated solution of silicate of potash, when the insects unexpectedly made their appearance. He afterwards tried nitrate of copper, which is a deadly poison, and from that fluid also did live insects emerge. Discouraged by the reception of his experiments, Mr. Crosse soon discontinued them; but they were some years after pursued by Mr. Weekes, of Sandwich, with precisely the same results. This gentleman, besides trying the first of the above substances, employed ferro-cyanate of potassium, on account of its containing a larger proportion of carbon, the principal element of organic bodies; and from this substance the insects were produced *in increased numbers.* A few weeks sufficed for this experiment, with the powerful battery of Mr. Crosse: but the first attempts of Mr. Weekes required about eleven months, a ground of presumption in itself that the electricity was chiefly concerned in the phenomenon. The changes undergone by the fluid operated upon, were in both cases remarkable, and nearly alike. In Mr. Weekes's apparatus, the silicate of potash became first turbid, then of a milky appearance; round the negative wire of the battery, dipped into the fluid, there gathered a quantity of *gelatinous matter*. From this Mr. Weekes observed one of the insects in the very act of emerging, immediately after which it ascended to the surface of the fluid, and sought concealment in an obscure corner of the apparatus. The insects produced by both experimentalists seem to have been the same, a species of acarus, minute and semi-transparent, and furnished with long bristles, which can only be seen by the aid of the microscope. It is worthy of remark, that some of these insects, soon after their existence had commenced, were found to be likely to extend their species. They were sometimes observed to go back to the fluid to feed, and occasionally they devoured each other. ([53])

The reception of novelties in science must ever be regulated very much by the amount of kindred or relative phenomena which the public mind already possesses and acknowledges, to which the new can be assimilated. A novelty, however true, if there be no received truths with which it can be shown in harmonious relation, has little chance of a favourable hearing. In fact, as has been often observed, there is a measure of incredulity from our ignorance as well as from our knowledge, and if the most distinguished philosopher three hundred years ago had ventured to develop any striking new fact which only could harmonize with the as yet unknown Copernican solar system, we cannot doubt that it would have been universally scoffed at in the scientific world, such as it then was, or, at the best, interpreted in a thousand wrong ways in conformity with ideas already familiar. The experiments above described, finding a public mind which had never discovered a fact or conceived an idea at all analogous, were of course ungraciously received. It was held to be impious even to surmise that animals could have been formed through any instrumentality of an apparatus devised by human skill. The more likely account of the phenomena was said to be, that the insects were only developed from ova, resting either in the fluid, or in the wooden frame on which the experiments took place. On these objections the following remarks may be made. The supposition of impiety arises from an entire misconception of what is implied by an aboriginal creation of insects. The experimentalist could never be considered as the author of the existence of these creatures, except by the most unreasoning ignorance. The utmost that can be claimed for, or imputed to him is, that he arranged the natural conditions under which the true creative energy—that flowing from the primordial appointment of the Divine Author of all things—was pleased to work in that instance. On the hypothesis here brought forward, the *acarus Crossii* was a type of being ordained from the beginning, and destined to be realized under certain physical conditions. When a human hand brought these conditions into the proper arrangement, it did an act akin to hundreds of familiar ones which we execute every day, and which are followed by natural results; but it did nothing more. The production of the insect, if it did take place as assumed, was as clearly an act of the Almighty himself, as if he had fashioned it with hands. For the presumption that an act of aboriginal creation did take place, there is this to be said, that, in Mr. Weekes's experiment, every care that ingenuity could devise was taken to exclude the possibility of a development of the insects from ova. The wood of the frame was baked in a powerful heat; a bell-shaped glass covered the apparatus, and from this the atmosphere was excluded by the fumes constantly rising from the liquid, for the emission of which there was an aperture so arranged at the top of the glass, that only these fumes could pass. The water was distilled, and the substance of the silicate had been subjected to white heat. Thus every source of fallacy seemed to be shut up. In such circumstances, a candid mind, which sees nothing either impious or unphilosophical in the idea of a new creation, will be disposed to think that there is less difficulty in believing in such a creation having actually taken place, than in believing that, in two instances, separated in place and time, exactly the same insects should have chanced to arise from concealed ova.([54])

HYPOTHESIS OF THE DEVELOPMENT

OF THE

VEGETABLE AND ANIMAL KINGDOMS.

We have now seen arguments, of both a general and particular kind, for the simply natural origin of life upon our planet. But, whatever force may be allowed to these arguments, no attempt has as yet been made to show how, even if life originated in its first and humblest forms in this manner, it passed on, otherwise than by a series of interferences, through that double series of higher forms terminating in the dicotyledons and mammalia, which we have seen rising throughout the geological ages, and leaving the earth occupied by its present organisms.

In now proposing to make such an attempt, I deem it necessary, for the sake of simplicity, to confine attention mainly to the animal kingdom, the vegetable department of nature, which starts from a common, or at least, contiguous basis, being sure to fall into any system which may be found applicable to the other.

It has already been intimated that the succession of animals throughout the geological eras is generally conformable to the gradation of forms in the animal scale, taking these in broad masses, and allowing for such imperfections in the series as geology itself at once leads us to expect, and partly accounts for. We have seen that, overlooking an era with doubtful vestiges of life, there was first one in which only sea plants and invertebrate marine animals flourished; afterwards one presenting the meaner (cartilaginous) fishes; and that higher (osseous) fishes, reptiles, birds, and mammals, came at long intervals throughout the subsequent ages. Even when we pass into details, we find the succession to be in so many instances conformable to the gradation of the special groups of animals, that no doubt can remain that such is the case in all. Thus, for example, there is, between the silurians and the oolite, a clear advance from humble to more highly organized cephalopoda and echinodermata. In the same time, the trilobite is exchanged for the superior but connected form, limulus, and the brachiopoda sink beneath the new and superior class of bivalves, the lamellibranchiata. We see, in an order of fishes of the carbonigenous era, an approximation to the reptile class. By-and-by, come ichthyosauri, half-fish half-crocodile; afterwards, a succession of forms ending in true crocodiles. Some difficulties have, indeed, been brought forward; but they are, on a just view of the sciences concerned, of no real importance, and I only deem them worthy of notice in a subordinate place.(55)

Leaving for a future section the particulars of the animal scale, which will there lend us further illustration, it may now be observed that, while the external features of the various creatures are so different, there has been traced, throughout large groups of them, a *fundamental unity of organization*, as implying, with respect to these groups, that all were constructed upon one plan, though in a series of improvements and variations giving rise to the special forms, and bearing reference to the conditions in which each animal lives. Starting from the primitive germ, which, as we have seen, is the representative of a particular order of full-grown animals, we find all others to be merely advances from that type, with the extension of endowments and modification of forms which are required in each particular case; each form, also, retaining a strong affinity to that which precedes it, and tending to impress its own features on that which succeeds.

This principle is partly matter of familiar observation. It is obvious to all, that an ordinary mammalian quadruped has a strong analogy of form to the human being; its head, its forelegs, its hinder extremities, have each their representative parts in our frame. But the ordinary observer is surprised to learn how much further the principle is carried. For example, the hind leg of the horse looks very different from one of our limbs, in as far as it seems to have a knee presented backwards, and possesses no toes. In reality, the part of the horse corresponding to our knee is high up near the body of the animal, and the hock corresponds to our heel. It has toes, moreover; but they are sunk in the hollow of a hoof, which serves as a shield to that part. The horse, the dog, and many other quadrupeds, may be said to walk upon their toes (hence called digitigrade): others, as the bear and badger, present the whole foot to the ground, as man does (hence called plantigrade). Thus, too, the wing of the bird contains bones representing those of our arm, though modified for so different a purpose. The paddles of the whale tribes and seals are other curious modifications of a member substantially the same. The bat, again, has the bones of its *hand* developed to an unusual extent, so as to become a frame for the membrane by which it flies: in the extinct pterodactyle, the same purpose was chiefly served by a development of the forefinger alone. The fundamental resemblance which lurks below various appearances is often startling. Thus, the giraffe, with its long neck, has, in that part, no more bones than are to be found in the neck of the elephant or pig, which hardly seem to have any neck at all. The cervical vertebræ are but seven in every one of the mammalian animals. Sometimes, an organ appears entirely wanting in one family, as feet in the serpent tribes, a pelvic region in the whale, the wing in the bird called the apteryx; and yet it is not truly wanting. Usually, some rudiment of it appears, as if nature had been willing to give it, but had kept it back from a complete development, as knowing it to be not needed in that instance. On this ground, the notion of a much ridiculed philosopher of the last century, respecting a human tail, may be said to be not quite without foundation. Between the fifth and sixth week, a tail exists in the human embryo; it then goes back; but still in the mature subject its elements are seen clumped up in the bone at the bottom of the spine, the *os coccygis.*

Unity of organization becomes the more remarkable when we observe that the corresponding organs of animals, while preserving a resemblance, are sometimes put to different uses. For example, the ribs become, in the serpent, organs of locomotion, and the snout is extended, in the elephant, into an instrument serving all the usual purposes of an arm and hand.

It is equally remarkable, that there should be, in the original plan of the animal structure, a double set of organs, one or other of which is selected for development according to the needs of the particular animal. Thus, there are in the plan both gills and lungs, two wholly distinct kinds of respiratory apparatus, the one being designed for a watery and the other for an atmospheric medium. The mammalia, as creatures destined to breathe the air, are furnished with lungs; but, at an early stage of the fœtal progress, this is not the case. They have at that time a branchial apparatus. Afterwards, this goes back, and the lungs are developed from a different portion of the organism. Lungs, on the other hand, are possessed by certain fishes in a rudimental form; it is the well-known air-bladder of those fishes, which are understood to profit by it, as an additional means of floating. So, also, the baleen of the whale and the teeth of the land mammifer are different organs. The whale, in embryo, shows the rudiments of teeth; but, not being wanted, they are not developed, and baleen is brought forward instead.

But the most remarkable circumstance attending the law of unity of organization is, that an organ will sometimes be seen developed to a certain extent, but wholly without use.

This organ will, perhaps, be seen serving a purpose in a particular family of animals; but we advance into an adjoining or kindred family, and there find a rudiment of the same organ, which, owing to the different conditions of this new set of creatures, is of no kind of service. Thus, some of the serpent tribes possess rudimentary limbs. In other instances, a portion of organization necessary in one sex is also presented in the other, where it is not necessary. For example, the mammæ of the human female, by whom these organs are obviously required, also exist in the male, who has no occasion for them. It might be supposed that in this case there was a regard to uniformity for mere appearance' sake; but that no such principle is concerned, appears from a much more remarkable instance connected with the marsupial animals. The female of that tribe has a process of bone advancing from the pubes for the support of her pouch; and this also appears in the male marsupial, who has no pouch, and requires none.

The same law of unity presides over the vegetable kingdom. Amongst phanerogamous plants, a certain number of organs are always present, either in a developed or rudimentary state; and those which are rudimentary can be developed by cultivation. The flowers which bear stamens on one stalk and pistils on another, can be caused to produce both, or to become perfect flowers, by having a sufficiency of nourishment supplied to them. So, also, where a special function is required for particular circumstances, nature provides for it, not by a new organ, but by a modification of a common one. Thus, for instance, some plants destined to live in arid situations, require to have a store of water which they may slowly absorb. The need is arranged for by a cup-like expansion round the stalk, in which water remains after a shower. Now the *pitcher*, as this is called, is not a new organ, but simply the metamorphosis of a leaf.

It is thus proved, with regard to the constituent beings of large sections of the animal kingdom, that they are bound up in a fundamental unity, however various in degree of endowment and in the purposes which they serve in the world. They may be said to stand in a connexion analogous to that in which the planets are placed by the third law of Kepler. And the inference with regard to their origin is the same. Precisely as it is impossible to suppose a distinct exertion or fiat of Almighty Power for the formation of the earth, wrought up as it is in a complex dynamical connexion, first with Venus on the one hand and Mars on the other, and secondly with all the other members of the system, so is it impossible to conceive the same power using particular means for the production of a particular animal species, an individualized fraction, as it now appears, in a vast system which would not be complete without it, and into whose adjacent parts it melts by the finest shadings. Supposing, for a moment, that each species had been distinct in its origin, these shadings would have been unnecessary; and there would at least have been a strong probability against a unity of organization being adopted as part of the plan. In that case, abortive or rudimentary organs must have been considered as a kind of blemish—the thing of all others most irreconcilable with that idea of perfection which a general view of nature irresistibly attributes to its author. If, on the other hand, we admit that the animal kingdom took its rise in a general law, we see in the shadings and the organic unity something not only harmonious with, but essential to the system. Rudimentary organs, too, appear but as harmless peculiarities of development, and interesting evidences of the manner in which the Divine Author has been pleased to work.

It must be easy to see how this class of facts bears on the great question. Organisms we *know* to have been produced, not at once, but in the course of a vast series of ages; here we now see that they are not a group of individually entire things accidentally associated, but parts of great masses, nicely connected, and integral in their respective totalities. Time, and a succession of forms in gradation and affinity, become elements in the idea of organic creation. It must be seen that the whole phenomena thus pass into strong analogy with those attending the production of individual organisms. But it becomes something more than analogy when we have learned the facts attending the *embryonic development* of animals. First surmised by the illustrious Harvey, afterwards illustrated by Hunter in his wondrous collection at the Royal College of Surgeons, finally advanced to mature conclusions by Tiedemann, St. Hilaire, and Serres, embryonic development is now a science. Its primary positions are—1. that the embryos of all animals are not distinguishably different from each other; and, 2. that those of all animals pass through a series of phases of development, each of which is the type or analogue of the permanent configuration of tribes inferior to it in the scale. With regard to the latter proposition, it is to be remarked that, while it is generally true of the whole forms of animal being, it is more particularly true of departments of the organization, as the nutritive system, the vascular system, the nervous system, &c., each of which is destined for a peculiar degree of development in different groups of animals, according to their needs. Speaking, however, roundly, it is undoubted, respecting nearly all animals, that they pass in embryo through phases resembling the general as well as the particular characters of others of lower grade. For example, the comatula, a free-swimming star-fish, is, at one stage of its early progress, a crinoid—that is, a star-fish fixed upon a stalk at the bottom of the sea. It advances from the form of one of the lower to that of one of the higher echinodermata. The animals of its first form were, as we have seen, among the most abundant in the earliest fossiliferous rocks: they began to decline in the New Red Sandstone era, and they were succeeded in the Oolitic age by animals *of the form of the mature comatula.* Thus, too, the insect, standing near the head of the articulated animals, is, in the larva state, an annelid or worm, the annelides being the lowest in the same class. The higher crustacea, as the crab and lobster, at their escape from the ovum, resemble the perfect animal of the inferior order entomostraca, and pass through the forms of transition which characterize the intermediate tribes of crustacea. The salmon, a highly organized fish, exhibits, in its early stages, as has been remarked, the gelatinous dorsal cord, the heterocercal tail, and inferior position of the mouth, which mark the mature example of the cartilaginous fishes. The frog, again, for some time after its birth, is a fish with external gills, and other organs fitting it for an aquatic life, all of which are changed as it advances to maturity and becomes a land animal. The mammifer only passes through still more stages, according to its higher place in the scale. Nor is man himself exempt from this law. His first form is that which is permanent in the animalcule. His organization gradually passes through conditions generally resembling a worm, a fish, a reptile, a bird, and the lower mammalia, before it attains its specific maturity. At one of the last stages of his fœtal career, he exhibits an intermaxillary bone, which is characteristic of the perfect ape; this is suppressed, and he may then be said to take leave of the simial type, and become a true human creature. Even as we shall find, the varieties of his race are represented in the progressive development of an individual of the highest, before we see the adult Caucasian, the highest point yet attained in the animal scale.

To come to particular points of the organization. The brain of man, which exceeds that of all other animals in complexity of organization and fulness of development, is, at one early period, only "a simple fold of nervous matter, with difficulty distinguishable into three parts, while a little tail-like prolongation towards the higher parts, and which had been the first to appear, is the only representation of a spinal marrow. Now, in this state it perfectly resembles the brain of an adult fish, thus assuming *in transitu* the form that in the fish is permanent. In a short time, however, the structure is become more complex, the parts more distinct, and the spinal marrow better marked; it is now the brain of a reptile. The change continues; by a singular motion, certain parts (*corpora quadrigemina*) which had hitherto appeared on the upper surface, now pass towards the lower; the former is their permanent situation in fishes and reptiles, the latter in birds and mammalia. This is another advance in the scale, but more remains yet to be done. The complication of the organ increases; cavities termed *ventricles* are formed, which do not exist in fishes, reptiles, or birds; curiously organized parts, such as the corpora striata, are added; it is now the brain of the mammalia. Its last and final change alone seems wanting, that which shall render it the brain of MAN. ([56]) And this change in time takes place.

So also with the heart. This organ, in the mammalia, consists of four cavities, but in the reptiles of only three, and in fishes of two only, while in the articulated animals it is merely a prolonged tube. Now in the mammal fœtus, at a certain early stage, the organ has the form of a prolonged tube; and a human being may be said to have then the heart of an insect. Subsequently, it is shortened and widened, and becomes divided by a contraction into two parts, a ventricle and an auricle; it is now the heart of a fish. A subdivision of the auricle afterwards makes a triple-chambered form, as in the heart of the reptile tribes; lastly, the ventricle being also subdivided, it becomes a full mammal heart.

We have now to remember that, corresponding generally to these progressive forms in the development of individuals, has been the succession of animal forms in the course of time. Our earth bore crinoidea before it bore the higher echinodermata. It presented crinoidea, annelides, and mollusca, before it bore fishes, and when fishes came, the first forms were those cartilaginous types which correspond with the early fœtal condition of higher orders. Afterwards there were reptiles, then mammifers, and finally, as we know, came man. Was it, then, too much to say that, when we learned the facts of embryonic development, we should see *something more than analogy* between the progress of species upon the earth and the production of an individual organism?

The tendency of all the illustrations is undoubtedly to make us look to *development* as the principle which has been immediately and mainly concerned in the peopling of this globe, a process extending over a vast space of time, but which is nevertheless connected in character with the briefer process by which an individual being is evoked from a simple germ. What mystery is there here—and how shall I proceed to enunciate the conception which I have ventured to form of what may prove to be its proper solution! It is an idea by no means calculated to impress by its greatness, or to puzzle by its profoundness. It is as much marked by simplicity as perhaps any other of those which have explained the great secrets of nature. But here, again, it may be said, lies one of its strongest claims to our faith.

My proposition is that the several series of animated beings, from the simplest and oldest up to the highest and most recent, are the results, *first*, of an inherent impulse in the forms of life to advance, in definite times, by generation, through grades of organization terminating in the highest dicotyledons and vertebrata, these grades being few in number, and generally marked by intervals of organic character which we find to be a practical difficulty in ascertaining affinities; *second*, of another inherent impulse connected with the vital forces, tending, in the course of generations, to modify organic structures in accordance with external circumstances, as food, the nature of the habitat, and the meteoric agencies, these being the "adaptations" of the natural theologian. We may contemplate these phenomena as ordained to take place in every situation, and at every time, where and when the requisite materials and conditions are presented—in other orbs as well as in this—in any geographical area of this globe which may at any time arise—observing only the variations due to difference of materials and of conditions. The nucleated vesicle is the fundamental form of all organization, the meeting-point between the inorganic and the organic—the end of the mineral and beginning of the vegetable and animal kingdoms, which thence start in different directions, but in a general parallelism and analogy. This nucleated vesicle is itself a type of mature and independent being, as well as the starting point of the fœtal progress of every higher individual in creation, both animal and vegetable. We have seen that it is a form of being which there is some reason to believe electric agency will produce—though not perhaps usher into full life—in albumen, one of those component materials of animal bodies, in whose combinations it is believed there is no chemical peculiarity forbidding their being any day realized in the laboratory. Remembering these things, it seems, after all, an obvious idea that *a chemico-electric operation, by which germinal vesicles were produced*, was the first phenomenon in organic creation, and that the second was *an advance of these through a succession of higher grades, and a variety of modifications*, in accordance with laws of the same absolute nature as those by which the Almighty rules the physical department of nature.

Leaving the first of these supposed processes to rest upon the arguments which have been adduced with regard to a possible transition from the inorganic to the organic, as a natural fact, we have two things to be accounted for—first, *grade;* and, second, *external peculiarities.* We have to convince ourselves, both that a fish may advance to be a reptile, and a reptile to be a bird—being a distinct step onward in complexity of organization—and that particular organs are capable of being modified, so as to suit external conditions,—for example, the bill of a bird to the picking up of food in shallow waters, or the throat of the fœtal marsupial to the reception of the mother's milk without a danger of choking.

With regard to grade, it may be admitted at once that, in Nature's government, there is no observable appearance of such promotions. But it may be asked, if, supposing such events to be within the scope of nature, we are necessarily to expect to see them take place, or even to hear of them having been recorded. To settle this question, let us first inquire into the proportion of the number of these grades to the space of time believed to be represented in the fossiliferous series of rocks. Mr. Lyell tells us that the space between our sun and some of the remote star-clusters, of which the distance to Sirius (not less than nineteen millions of millions of miles) is but a fraction, may no more than compare with the space of time which has probably elapsed since the origin of the coralline limestone over which the Niagara is precipitated at the Falls. Now, the number of grades of what may be called the first degree (transitions from class to class) passed through by the vertebrata since their origin in the Devonian rocks is, at the utmost, *three*. Such a leap in organic progress has, therefore, only taken place *once in many millions of millions of years*. If such be the case, all chance of such grade transitions being witnessed within the four thousand years of historical humanity vanishes. As to the possible occurrence of such unusual events in the midst of a series which appear fixed and regular, let us call forward an illustration from the *Ninth Bridgewater Treatise* of Mr. Babbage. The reader is requested to suppose himself seated before the calculating machine, and observing it. It is moved by a weight, and there is a wheel which revolves through a small angle round its axis, at short intervals, presenting to the eye successively, a series of numbers engraved on its divided circumference.

Let the figures thus seen be the series, 1, 2, 3, 4, 5, &c., of natural numbers, each of which exceeds its immediate antecedent by unity.

"Now, reader," says Mr. Babbage, "Let me ask you how long you will have counted before you are firmly convinced that the engine has been so adjusted, that it will continue, while its motion is maintained, to produce the same series of natural numbers? Some minds are so constituted, that after passing the first hundred terms, they will be satisfied that they are acquainted with the law. After seeing five hundred terms few will doubt, and after the fifty thousandth term the propensity to believe that the succeeding term will be fifty thousand and one, will be almost irresistible. That term *will* be fifty thousand and one; and the same regular succession will continue; the five millionth and the fifty millionth term will still appear in their expected order, and one unbroken chain of natural numbers will pass before your eyes, from *one* up to *one hundred million*.

"True to the vast induction which has been made, the next succeeding term will be one hundred million and one; but the next number presented by the rim of the wheel, instead of being one hundred million and two, is one hundred million *ten thousand* and two. The whole series from the commencement being thus,—

1
2
3
4
5
. . .
. . . .
. . . . .
. . . . . .
99,999,999
100,000,000
regularly as far as 100,000,001
100,010,002 the law changes.
100,030,003
100,060,004
100,100,005
100,150,006
100,210,007
100,280,008
... ...
... ...

"The law which seemed at first to govern this series failed at the hundred million and second term. This term is larger than we expected by 10,000. The next term is larger than was anticipated by 30,000, and the excess of each term above what we had expected forms the following table:—

10,000
30,000
60,000
100,000
150,000
. . . . . .
. . . . . .

being, in fact, the series of *triangular numbers*,([57]) each multiplied by 10,000.

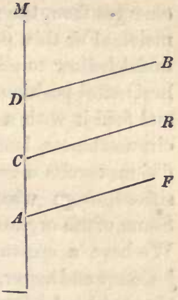
"If we now continue to observe the numbers presented by the wheel, we shall find, that for a hundred, or even for a thousand terms, they continue to follow the new law relating to the triangular numbers; but after watching them for 2761 terms, we find that this law fails in the case of the 2762nd term.

"If we continue to observe, we shall discover another law then coming into action, which also is dependent, but in a different manner, on triangular numbers. This will continue through about 1430 terms, when a new law is again introduced which extends over about 950 terms, and this, too, like all its predecessors, fails, and gives place to other laws, which appear at different intervals.

"Now it must be observed that *the law that each number presented by the engine is greater by unity than the preceding number*, which law the observer had deduced from an induction of a hundred million instances, *was not the true law that regulated its action*, and that the occurrence of the number 100,010,002 at the 100,000,002nd term was *as necessary a consequence of the original adjustment, and might have been as fully foreknown at the commencement, as was the regular succession of any one of the intermediate numbers to its immediate antecedent.* The same remark applies to the next apparent deviation from the new law, which was founded on an induction of 2761 terms, and also to the succeeding law, with this limitation only—that whilst their consecutive introduction at various definite intervals, is a necessary consequence of the mechanical structure of the engine, our knowledge of analysis does not enable us to predict the periods themselves at which the more distant laws will be introduced."

It is not difficult to apply the philosophy of this passage to the question under consideration. Let us remember that the gestation of a single organism is the work of but a few days, weeks, or months; but the gestation (so to speak) of a whole creation is a matter involving the enormous spaces of time which have been described. Suppose that an ephemeron, hovering over a pool for its one April day of life, were capable of observing the fry of the frog in the water below. In its aged afternoon, having seen no change upon them for such a long time, it would be little qualified to conceive that the external branchiæ of these creatures were to decay, and be replaced by internal lungs, that feet were to be developed, the tail erased, and the animal then to become a denizen of the land. Precisely such may be our difficulty in conceiving that plants and animals are capable of advancing by generation to a higher type of being. Granting that, during the whole time which we call the historical era, there have been no movements of this kind, nor even any of the less rare transitions in which only specific modifications are concerned, we know the historical era to be only an infinitesimal portion of the entire age of our globe. We do not know what may have happened during the ages which preceded its commencement, as we do not know what may happen in ages yet in the distant future. All, therefore, that we can properly infer from the apparent fixity of organic forms is, that such is the ordinary procedure of nature in the time immediately passing before our eyes. Mr. Babbage's illustration enables us to understand how this ordinary procedure may be subordinate to a higher law which in proper season interrupts and changes it.

It has been seen that, in the reproduction of the higher animals, the new being passes through stages in which it is successively fish-like and reptile-like. But the resemblance is not to the adult fish or the adult reptile, but to the fish and reptile at a certain point in their fœtal progress; this holds true with regard to the vascular, nervous, and other systems alike. It seems as if gestation consisted of two distinct and independent stages—one devoted to the development of the new being through the conditions of the inferior types, or, rather through the corresponding *first stages of their development*; another perfecting and bringing the new being to a healthy maturity, on the basis of the point of development reached. This may be illustrated by a simple diagram.([58]) The fœtus of all the four classes may be supposed to advance in an identical condition to the point A. The fish there diverges and passes along a line apart, and peculiar to itself, to its mature state at F. The reptile, bird, and mammal, go on together to C, where the reptile diverges in like manner, and advances by itself to R. The bird diverges at D, and goes on to B. Here it is apparent that the only thing required for an advance from one grade to another in the generative process is that, for example, the fish embryo should not diverge at A, but go on to C before it diverges, in which case the progeny will be, not a fish, but a reptile. To protract the *straightforward part of the gestation over a small space* is all that is necessary.



Now we may never see an example of the working of the actual law which is supposed to be capable of producing such an advance of grade; but something approaching to it in effect has been observed. Sex is fully ascertained to be a matter of development. All beings are, at one stage of the embryotic progress, female; a certain number of them are afterwards *advanced* to be of the more powerful sex. From this it will be understood that no absolute distinction exists; all such are merely apparent. The ingenious Huber first made us aware of an instance, in a humble department of the animal world, of arrangements being made by the animals themselves for adjusting the law of development to the production of a particular sex. Amongst bees, as amongst several other insect tribes, there is in each community but one true female, the queen bee, the workers being false females or neuters; that is to say, sex is carried on in them to a point intermediate between the female and male, where it is attended by sterility. The preparatory states of the queen bee occupy sixteen days; those of the neuters, twenty; and those of males, twenty-four. Now it is a fact, settled by innumerable observations and experiments, that the bees can so modify a larva, which otherwise would result in a worker, that, when the perfect insect emerges from the pupa, it is found to be a queen or true female. For this purpose they enlarge its cell, make a pyramidal hollow to allow of its assuming a vertical instead of a horizontal position, keep it warmer than other larvæ are kept, and feed it with a peculiar kind of food. From these simple circumstances, leading to a *shortening* of the embryotic condition, results a creature different in form, and also in dispositions, from what would have otherwise been produced. Some of the organs possessed by the worker are here wanting, We have a creature "destined to enjoy love, to burn with jealousy and anger, to be incited to vengeance, and to pass her time without labour," instead of one "zealous for the good of the community, a defender of the public rights, enjoying an immunity from the stimulus of sexual appetite and the pains of parturition; laborious, industrious, patient, ingenious, skilful; incessantly engaged in the nurture of the young, in collecting honey and pollen, in elaborating wax, in constructing cells and the like!—paying the most respectful and assiduous attention to objects which, had its ovaries been developed, it would have hated and pursued with the most vindictive fury till it had destroyed them!"(59) All these changes may be produced by a mere modification of the embryotic progress, which is within the power of the adult animals to effect. By the arrangements made and the food given, the embryo becomes sooner fit for being ushered forth in its imago or perfect state. Development may be said to be thus arrested at a particular stage—that early one at which the female sex is complete. In the other circumstances, it is allowed to go on four days longer, and a stage is then reached between the two sexes, which in this species is destined to be the perfect condition of a large portion of the community. Four days more make it a perfect male. It may be observed that there is, from the period of oviposition, a destined distinction between the sexes of the young bees. The queen lays the whole of the eggs which are designed to become workers, before she begins to lay those which become males.

But the condition of her reproductive system evidently governs the matter of sex, for it is remarked that when her impregnation is delayed beyond the twenty-eighth day of her entire existence, she lays only eggs which become males.

We have here, it will be admitted, a most remarkable illustration of the principle of development, although in an operation limited to the production of sex only. Let it not be said that the phenomena concerned in the generation of bees may be very different from those concerned in the reproduction of the higher animals. There is a unity throughout nature which makes the one case an instructive reflection of the other. (60)

We shall now see an instance of development operating within the production of what approaches to the character of variety of species. It is fully established that a human family, tribe, or nation, is liable, in the course of generations, to be either advanced from a mean form to a higher one, or degraded from a higher to a lower, by the influence of the physical conditions in which it lives. The coarse features, and other structural peculiarities of the negro race only continue while these people live amidst the circumstances usually associated with barbarism. In a more temperate clime, and higher social state, the face and figure become greatly refined. The few African nations which possess any civilization exhibit forms approaching the European; and when the same people in the United States of America have enjoyed a within-door life for several generations, they assimilate to the whites amongst whom they live. On the other hand, there are authentic instances of a people originally well-formed and good-looking, being brought, by imperfect diet and a variety of physical hardships, to a meaner form. It is remarkable that prominence of the jaws, a recession and diminution of the cranium, and an elongation and attenuation of the limbs, are peculiarities always produced by these miserable conditions, for they indicate an unequivocal retrogression towards the type of the lower animals. Thus we see nature alike willing to go back and to go forward. Both effects are simply the result of the operation of the law of development in the generative system.

Let us trace this law also in the production of certain classes of monstrosities. A human fœtus is often left with one of the most important parts of its frame imperfectly developed; the heart, for instance, goes no further than the three-chambered form, so that it is the heart of a reptile. There are even instances of this organ being left in the two-chambered or fish-form. Here we have apparently a realization of the converse of advance of grade, so far, at least, as one organ is concerned. Seeing a complete specific retrogression in one point, how easy it is to suppose a simply natural process, reversing the phenomenon, and making a fish mother develop a reptile heart, or a reptile mother develop a mammal one. It is no great boldness to surmise that a super-adequacy of force in the measure of this under-adequacy (and the one thing seems as natural an occurrence as the other) would suffice in a natatorial bird to give it as a progeny the ornithorhynchus, or might give the progeny of an ornithorhynchus the mouth and feet of a true mammalian, and thus complete at two stages a passage from one class to another.

Perhaps, with the bulk of men, even those devoted to science, the great difficulty is, after all, in conceiving the particulars of such a process as would be required to advance a fish into a reptile. And yet no difficulty could well be less substantial, seeing that the metamorphosis of the tadpole into the frog—a phenomenon presented to our observation in countless instances every spring—is, in part at least, as thoroughly a transmutation of the fish organization into that of the reptile, as the supposable change of sauroid fishes into saurian reptiles could ever be. It is different, as being only a process in ordinary generation; but it realizes, *as far as the necessary organic changes are concerned*, the hypothetic view of an advance of one grade of animal forms into another. There is another fact connected with the reproduction of the batrachian order of reptiles, that, when the young are enclosed in a dark box sunk in a river, with holes through which the water may flow, the animals grow, but never undergo their destined change:

they became gigantic tadpoles, and the reptile characters are not developed. Here the progeny of a reptile literally becomes a fish, and transition of species is thoroughly realized, although in retrogression. And this is an instance in which the whole animal is concerned. Now surely no one will deny that that which we see nature *undo* she is able to *do*, and might be seen *doing*, if the proper occasion were to occur, or were the requisite attendant conditions realized.

So much with regard to grade. Let us now consider the principle of *modifiability*—that part of the hypothesis to which we are to look for an account of the external variations and adaptation of animals.

Here we are directly opposed by the prevalent doctrine among naturalists, that species is intransible, and has so continued during all the time that scientific observation has existed. There is a certain volubility, they admit, in organisms, throughout successive generations, and for this variability external conditions may account; but such variations show a disposition to give way, when the original conditions are resumed, or when the changed individual is mingled in alliance with the original stock. There is therefore a fixed and immutable character which we call *species*, and which can only be traced to an origin differing as an event from the procedure of nature in our own time. I trust to be able to show that this doctrine is in such a condition with regard to facts, and has of late been obliged by facts to make so many shifts in its assumptions, that it is not entitled to the respect usually assigned to it.

The doctrine theoretically attaches the term species to every organism which manifests the same peculiarities throughout a series of generations. Practically, without waiting to watch successive generations, or where, from the extinction of the organism, this may be impossible, naturalists give the appellation to every organism which presents a plurality of individuals similarly marked. Very small peculiarities suffice. A particular spot on the wing of a butterfly constitutes it a distinct species. The Golden Plover of Australia was so reckoned, and got the name of Xanthocheilus, from only having a small portion of yellow in the commissure of its bill. At the same time, in palæontology, such a peculiarity as an extra-plication in the enamel of a fossil pachiderm's tooth, is sufficient to obtain a specific name for that animal, and constitute its origin a separate miracle. With equal facility, naturalists of this predominant order make up groups of species into genera, and groups of genera into families and tribes.

Suppose the doctrine were to be taken according to the practice, we should possess a fact speaking strongly against fixity of species. It has been pointed out by an eminent botanist that, amongst recent fossil plants, are poplars, pines, birches, and hornbeams, like those now existing, but not the same. Thus one species has replaced another in even comparatively recent times. It may be asked, if the same change of species has not been going on since. The vague descriptions of ancient botanists forbid our speaking confidently of the intermediate ages. But look to the present time. In districts examined narrowly at no distant day, new species are continually being found by new investigators. It will be said, that these additions are owing to the acuteness of modern observers. But this is begging the whole question. "We do not know," says our author, "that we are entitled to assert that botanists were so mole-eyed thirty years ago, that their quick-sighted successors have been able to add twenty-five per cent. to the number of ascertained species growing at their own doors." ([61]) Grant, then, that the peculiar plants in question really are species, the probability undoubtedly is, that they are *new* species, true examples of that very phenomenon which the superstition of science would hold to be a supernatural event.

Still take the doctrine according to the practice, and let us see how it stands with regard to certain facts recently ascertained. Amidst all the dogmatism which has been indulged in on this subject, the assumed distinction of species has given way in numberless instances, both in the vegetable and animal kingdoms. In botany, the wider distinction of *genus*, and even that of whole *tribes*, has proved in some cases fallacious. According to Dr. Lindley, "So entirely in the simplest forms of Thallogens [an assemblage embracing sea-weeds, fungi, and lichens] is all trace of series missing, that in some of them their reproductive matter has been regarded by certain writers as altogether of an ambiguous nature. In their opinion, it is even uncertain whether this matter will reproduce its like, and whether it is not a mere representation of the vital principle of vegetation, capable of being called into action either as a Fungus, an Alga, or a Lichen, according to the particular conditions of heat, light, moisture, and medium, in which it is placed; producing Fungi upon dead or putrid organic beings; Lichens upon living vegetables, earth, or stones; and Algæ where water is the medium in which they are developed. Kützing endeavours to maintain the following propositions connected with this subject:—1st, the formation of organic matter can only take place by means of the previously dissolved elements of other organic principles; 2nd, simple globules, such as Cryptococcus, Palmella, and Protococcus, can give birth to different formations, according to the influence of light, air, and temperature; 3rd, we must regard all the forms of lower algæ as vegetations of a very simple structure, and distinguish them from each other, notwithstanding that in certain circumstances they may raise themselves to vegetations of a higher form; for, in other circumstances, they can exist and multiply independently; 4th, the same formation may be produced by primitive formations of altogether different kinds." "It has been said," adds Dr. Lindley, "that Algæ are aquatics, while Lichens and Fungi are terrestrial; but *Fungi will develop in water, when they assume the form of Algæ*."(62) Undoubtedly, eight so-called genera of fungi are now set down as only variations of one plant (Telephora sulphurea), arising from peculiar conditions of culture.

Even in higher departments of the vegetable kingdom, the revolutions have been very remarkable. Six so-called species of pine are wound up into one in a recent memoir on the Coniferæ. The cowslip, primrose, oxlip, and polyanthus, which were always regarded as distinct species, are now found to be producible from one set of seeds, under various conditions; they are radically one plant. So also "the clove, pink, and carnation are only varieties of a flower growing among the ruins of some of our old castles, the Dianthus caryophyllus." The artichoke of the garden and the cardoon (a kind of thistle) of the South American wild, are held as distinct species in all botanical works; yet the artichoke, in neglect, degenerates into the cardoon. (63) The ranunculus aquatilis and the ranunculus hederaceus are, in like manner, set down as distinct species; but behold the secret of their difference! While the former plant remains in the water, its leaves are all finely cut and have their divisions hairy; but when the stems reach the surface, the leaves developed in the atmosphere are widened, rounded, and simply lobed. *Should the seeds of this water plant fall upon a soil merely moist without being inundated*, the result is the ranunculus hederaceus—the presumed distinct species—with short stalks, and none of the leaves divided into hairy cut work! (64) To come to a more familiar instance. It is now fully ascertained that the various bread-forming grains, wheat, barley, oats, rye, are resolvable into one. If wheat be sown in June, and mown down so as not to be allowed to come to ear till the next season, the product will be found to consist partly of rye or some other of the cereals. Oats have in like manner been transformed into rye, barley, and even wheat. Till a recent period, this phenomenon was doubted; but it has been tested by experiment, and reported on by so many credible persons, that it can no longer be rejected. And it appears that poorness of soil has the same effect as mowing down. One observer states that, in a field of wheat near Lucerne, he saw ears resembling barley, but with grains similar to rye, *growing from the same stem with ears of wheat.* (65) Dr. Lindley, who publishes these facts, acknowledges there being no theoretical improbability in such transformations, seeing that, "in orchidaceous plants, forms just as different as wheat, barley, rye, and oats, have been proved by the most rigorous evidence to be accidental variations of one common form, brought about no one knows how, but before our eyes, and rendered permanent by equally mysterious agency." It is more than probable that the greater number of what may be called the domesticated plants, are unsuspected variations of others, which, growing wild, are recognised as different species. One noted instance of such transition has been detected within the last few years, in our different kinds of cabbage, savoy, brocoli, and cauliflower. They are all common descendants of a plant which is sometimes found growing wild upon our sea-shores, the brassica oleracea—a transition which no one can appreciate till he has compared the tough slender stem and small glaucous leaf of the original, with the stout fleshy stem and large succulent leaves, sometimes gathered into a *heart* several feet in circumference, which he will find in the most familiar of the cabbages.

What respect, it may be asked, can we attach to the doctrine of intransibility of species, when we find its adherents wrong in so many instances? Admit their explanation, that a mere mistake has been made in calling that species which was only variety, what guarantee can we have for the fixity of any so-called species, when it has given way in such instances? What *is* species, if it cannot be fixed upon such a vast assemblage as the Thallogens, or even the progeny of the Telephora sulphurea? Apart from all theorising about the absolute characters of *species*, do not these facts show a transibility and intercommunion of forms totally at variance with those general opinions as to fixity which now reign in the scientific world?

In the animal kingdom, we have fewer illustrations of modifiability or transition; but they tend to exactly the same effect. We shall here pass over the succession of forms which appears in common infusions. Neither shall we enter into the particulars of a late curious investigation by a Danish naturalist, which results in showing *alternative forms* in the succession of certain animals low in the scale, including the medusa; that is, as it were, A giving birth to B, B to C, and C to A again.(66) Such matters are as yet obscure, however highly they may promise in time to illustrate this question. Let us rather look to departments of this kingdom which come broadly under the observation of naturalists. In the mollusca there occurs a modifiability of a most remarkable nature. Fresh-water species of these, exposed to brackish water, assume, where able to survive the change, characters in the exterior form of the shell proper to their marine congeners, and involving differences from the original animal *much greater than is usually sufficient with naturalists to constitute a distinction of species, if not of tribe or family.* Many years ago, Pennant remarked the singular modification of stomach which the common trout appears to have undergone in the lakes of the county of Galway, in consequence of feeding on shell-fish. The integument has become as thick as the gizzard of a bird, manifestly in consequence of an effort of nature to accommodate herself to the peculiar food of the animal. So also, when a common gull was fed upon corn, the parietes of the stomach were found, on examination after death, to be thickened.(67) The peculiar forms of the mandibles of birds are grounds of specific distinction; yet it is now ascertained that these are variable under particular conditions as to food. It has been tried with confined birds; and even in a wild state there occur individuals strangely modified in this respect, the magpie, woodpecker, and rook, having all been found with the crossed mandibles of the loxia.(68) Look also at the changes from the wild animals to those domesticated ones which are known to be descended from them. "When the eggs of the wild goose," says Professor Low, "are taken, and the young are supplied with food in unlimited quantity, the result is remarkable. The intestines, and with them the abdomen, become so much enlarged, that the animal nearly loses the power of flight, and the powerful muscles which enabled him in a wild state to take such flights, become feeble from disease, and his long wings are rendered unserviceable. The beautiful bird that outstripped the flight of the eagle, is now a captive without a chain." Another change is the transition from grey to white plumage. In the domestication of the pig, the author last quoted admits that there are reductions of the number of teeth, and variations of the number of the dorsal, lumbar, sacral, and caudal vertebræ, producing differences greater than what are usually regarded as sufficient to constitute species. But the most striking observations on this subject are those of M. Roulin, made during a residence of several years in Columbia, relative to the races which had been introduced there in a domesticated state by the early voyagers, and allowed to run wild during the three centuries which have since elapsed. As an example, the hog: "Wandering all day in the woods, this animal has lost nearly all marks of servitude; its ears have become erect, its head broadened, and raised at the upper part, and its colour has been rendered permanent." It has, in short, returned to a strict resemblance to the wild boar of France. The cow, also, from the cessation of the practice of milking, has lost the abundant flow of milk which is found in her species in Europe: to get milk from her at all, it is necessary that her calf should be left with her. M. Roulin arrived at the following conclusions: that animals naturalized in new countries undergo durable changes, bringing their organization into accordance with the climates in which they are destined to live; and that habits of independence soon make the domestic species resume the characters of the wild species from which they have sprung. We have here, it will be owned, equal proof that the tuskless hog of our farm-yards is the same animal which roams the forest in formidable state and armature, as that the wild boar is the same with the domestic pig.

It is difficult, after what we have now seen, to regard the idea of species or specific distinction as descriptive of a fact in nature; it must be held as merely representing certain appearances presented, perhaps transiently, to our notice. The history of the question seems to be this. Naturalists, starting with a limited fund of observation,—mainly, indeed, consisting of the remark which the most superficial observation supplies, that like usually produces like,—lay it down as an axiom that species is a determinate thing. In a little time, certain modifiabilities are observed. To maintain the axiom intact, these are called varieties. Afterwards, much greater variabilities are witnessed, even to the dissolution of genera among the cryptogams and cereals, and the community of algæ and fungi—water and land plants. Still, to keep the axiom whole, these are held in doubt, or relegated to a place in the elastic region of the varieties. Such is the stage which we have now attained. But this is a process the reverse of philosophical: it is to start with a theory, and then make facts succumb to it. Were the process reversed and the facts taken first, we should see that a great modifiability exists in organic nature, especially in the humbler departments of the two kingdoms. And seeing that this modifiability presents itself within the scope of a very limited experience, it might safely be inferred that something much greater would be detected if our range of experience were extended, especially since the world presents us with results which can only be naturally accounted for in this manner. It is here a fact to be specially remarked, that the greatest variability, the most striking instances of transition or intercommunion of forms, are offered in the lower grades of being. In these departments of nature, generation is rapid and abundant in comparison with the reproduction of the higher forms. What requires perhaps a century in the one case (say a series of three generations) will be accomplished in a day in the other. Nothing, therefore, seems more natural than that phenomena connected with the reproduction of the higher animals should require a much longer time to be evolved than those connected with the lower. The time may be, in the one case, such as to fall within our range of observation (and this range, as far as scientific accuracy is concerned, is but a day), while in the other case it may be, and indeed, on a just comparison, we should expect it to be, beyond even the whole space of what is called the historical era. Such is precisely the point to which the present theory would lead us. We see that permanency of specific distinctions in the higher organisms would sink, as it has done in so many of the lower, *if we had as long a time to observe their reproductive history as would, in embryology, be equivalent to the space of time during which we have observed the humbler creatures.* We see this persistency and think it fixed, exactly as men have hitherto seen the solar position in the universe. We advance among the stars at the rate of two millions of millions of miles a year; but astronomers tell us that it would take ninety millions of years to enable us to pass through the whole, even at this rapid rate. Well, therefore, might the unassisted eye and unexamining intellect presume the place of the solar system to be fixed, for it is evident that no human tradition could record changes indicating the translation. Yet we do pass on to Hercules, although forty centuries failed to remark the circumstance. So may specific distinctions in the higher animals have been changed in the course of the vast periods which geology shows to have elapsed since the commencement of organization upon earth, although, during that inappreciable segment of the great cycle which has passed since man woke to the mysteries of nature, no single transition of the kind might have been observed. The whole case reminds us greatly of the objection which stood against the earth's motion from the days of Aristarchus downwards, that there ought in that case to be an observable parallax. As there was no observable parallax, *because* the earth's orbit is an insignificant space in comparison with the distance of the stars, so is our observation of animal changes insufficient to show transitions of species in the higher grades of the kingdom, because it is a mere span in comparison with the vast ages actually concerned in the phenomenon.

A similar principle of explanation applies to the alleged tendency of *variety* to be obliterated. While it is only to be expected that a single animal showing an originality of form will fail to impress it on its posterity, if it be absorbed in alliance with animals possessing no such peculiarities, there is no reason to believe that a variety uniting with a creature like itself will not have descendants of its own character. We judge on this question in the midst of a fully-peopled world; but we must cast back our minds to a time when it was only in the course of being filled with living things. We must think of a time when, for example, over large portions of the surface mountain tracts were rising, perhaps beside low and marshy grounds, or when forests began to spread over extensive regions. Here a new field of existence is presented.

The fecundity of nature has ordained that her creatures shall ever be pressing upon the verge of the local means of subsistence. A colonizing principle accordingly comes into play. On such an occasion, it might be that individual wading birds began to advance into dry grounds and woods, elected to the new life perhaps by some of those varieties of appetency which occur in all tribes; thus exposing themselves to new influences, and ceasing to experience those formerly operating, until, by slow degrees, in the course of a vast space of time, the characters of the pheasant tribes were evoked.(69) Here, it will be at once perceived, re-absorption of peculiarities was not likely to occur, for the field of colonization, so to speak, was sufficiently wide to allow of the new families wandering farther and farther away from the original grounds and the ancestral tribes, while return was prevented by the full population continually pressing behind. Altogether, this presents a very different view of varieties from that which is commonly presented, when we see a single peculiar individual standing in the midst of, and necessarily allying itself to, the original stock. The process of variation as a consequence of changed conditions and appetencies being left unchecked, and that for a vast space of time, we obtain at length creatures fixedly peculiar; that is, however, merely creatures which appear so, because there is no replacing them in the former conditions in this densely-peopled globe, and, though there were, the retrogression to the anterior forms would require a space of time beyond the range of human observation.

It may now be remarked, that, in this hypothetic variability, the possibility of re-union may, and in all probability does, depend upon the degree of similarity which still exists in the different individuals, supposing them to be members of the same *stirps* or line of being, for I believe that no others are capable of intermixture. As has been remarked by a venerable naturalist—"Many bulbous roots that have been increased during a long succession of years by offsets, become absolutely incapable of bearing seed; and it is not more strange that plants which in different soils and climates have diverged from the original form of the first created individual, should refuse to bear seed by the one which has departed most widely, and yet produce it readily by another, which still agrees with it in some important points." ([70]) Admit this, and the grand basis of specific distinction, the possibility of intermixture, can no longer be laid hold of. Plants and animals of one line are only to be expected to unite, which, being of one grade of organization, are also sufficiently near to each other in those peculiarities liable to modification from external causes, on which the so-called distinctions of species are grounded.

The illustrations of our hypothesis are now closed. We have seen that, even judging from short spaces of time, there is a great and incontestable modifiability of organic forms,—so great as to have absorbed the presumed distinctions of species in many noted instances. We have seen that this modifiability, by some hidden law, immediately obeys external conditions. It has also been seen that, though no transition from grade to grade was ever observed to take place, the means and mode by which it could naturally happen are not concealed from us; they are pictured before our eyes in the metamorphosis of the tadpole, and even practically exemplified in a narrow degree in the natural history of the bee. It has been shown that no organism is independent, but all stand in a web of intimate relation, undeniably indicating that their origin is one connected phenomenon. It has been seen that the higher animals, when their organization is examined, are only improvements upon the lower—advanced forms of the same beings; and the same holds good regarding plants. In conformity, too, with this gradation of forms, is the succession of the actual animals throughout the geological ages;—a fact most important—not merely one calling *to be explained*, as is at the utmost allowed by men of science of the present day, but one which *helps to explain*,—a piece of actual tangible evidence, and bearing wholly, when taken in connexion with proofs of other kinds, in favour of the natural origin of species. Surely when, in addition to all this, we learn that life is believed by many men of science to spring occasionally, even now, from inorganic elements—

when we find that, moreover, it is generally admitted by that class of men to be in itself a simply natural phenomenon, we cannot but say that at least VESTIGES have been seen of the natural ordinances or arrangements, by which the Almighty Father caused this globe (and probably others within our ken) to be overspread with the many creatures whose perfection is his praise. Rigid proof is not, indeed, attained; but we have all the evidence which is attainable in the case. It is evidence from various quarters, all perfectly homogeneous; it harmonizes with everything else which science tells us of the history of the universe; it supplants a mean with an exalted idea of the Deity, and has nothing opposed to it but the prejudices formed in the nonage of our race. For these reasons, I must, till disproof is offered, regard the theory of Progressive Development as the true explanation of the origin of organic nature. The simplest and most primitive types of being, under a law to which that of like production is subordinate, gave birth to a type superior to it in compositeness of organization and endowment of faculties; this again produced the next higher, and so on to the highest. There has been, in short, a universal gestation of nature, analogous to that of the individual being, and attended as little by circumstances of a startling or miraculous kind as the silent advance of an ordinary mother from one week to another of her pregnancy. We see but the chronicle of one or two great areas, within which the development has reached the highest forms. In some others, as Australia and the islands of the Pacific, development has not yet passed through the whole of its stages, because, owing to the comparatively late uprise of the land, the terrestrial portion of the development was there commenced more recently. It would commence and proceed in any new appropriate area, on this or any other sphere, exactly as it commenced upon our area in the time of the earliest fossiliferous rocks, whichever these are. Nay, it starts every hour with common infusions, and in similar humble theatres, and would there proceed through all the subsequent stages, granting suitable space and conditions. Thus simple—after ages of marvelling—is Organic

Creation, while yet the whole phenomena are, in another point of view, wonders of the highest kind, being the undoubted results of ordinances arguing the highest attributes of foresight, skill, and goodness on the part of their Divine Author.

Early in this century, M. Lamarck, one of the most distinguished of modern naturalists, suggested that the gradation of animals depended upon some general law which it was important for us to discover. So far he was right; but the theory which he consequently formed with regard to the causes of the varieties of animated being was so far from being adequate to account for the facts, that it has had scarcely a single adherent. What M. Lamarck chiefly grounded upon was the well-known physiological fact, that use or exercise strengthens and enlarges an organ, while disuse equally atrophies it. He conceived that, an animal being brought into new circumstances, and called upon to accommodate itself to these, the exertions which it consequently made to that effect caused the rise of new parts: on the contrary, when new circumstances left certain existing parts unused, these parts gradually ceased to exist. Something analogous was, he thought, produced in vegetables, by changes in their nutrition, in their absorptions and transpirations, and in the quantity of caloric, light, air, and moisture which they received. This principle, with time, he deemed sufficient to have produced the advance from the monad to the mammal. His illustrations were chiefly of the following nature. The bird which is attracted to the water by the necessity of seeking there its food, wishes to move about on the surface of the flood, and for this purpose strikes out its toes. Through the consequent repeated separations of the toes, the skin uniting them at the roots is extended and at length becomes webbed. In like manner, the shore bird which has no desire to swim, but has to approach the water for food, is constantly subject to sink in the mud. The bird, disliking this, exerts all its efforts to lengthen its legs; the result is, that, by continual habit for many generations, the legs of this order do at length become long and bare, as we see them. The error of the theory is in giving this adaptive principle too much to do. What undoubtedly is effectual in modifying the exterior peculiarities of animals was obviously insufficient to account for the great grades of organization. In the present day, we have superior light from geology and physiology, and hence arises my suggestion of a process analogous to ordinary gestation for advancing organic life through its grades in the course of a long but definite space of time, with only a recourse to external conditions as a means of producing the exterior characters. It must nevertheless be acknowledged that the germ of this natural view of the history of the world is presented in the work of Lamarck.

But the idea that any of the lower animals have been concerned in any way with the origin of man—is not this degrading? Degrading is a term expressive of a notion of the human mind, and the human mind is liable to prejudices which prevent its notions from being invariably correct. Were we acquainted for the first time with the circumstances attending the production of an individual of our race, we might equally think them degrading, and be eager to deny them, and exclude them from the admitted truths of nature. Knowing this fact familiarly and beyond contradiction, a healthy and natural mind finds no difficulty in regarding it complacently. So also, on becoming aware of the genetic history of our species, we might expect a rational and well-ordered mind to receive the idea with submission, as a view of the manner in which Divine Providence has been pleased in this instance to work. One source of the prejudice here to be contended with rests in our associations with the word ancestry. From seeing our immediate seniors possessed of venerable qualities, we naturally incline to venerate an ancestry; we presume its constituent elements to be something superior to ourselves. When called upon, therefore, to place any of the inferior orders of Being in this relation, a shock unavoidably follows. But here the error lies in transferring our idea of the qualities of a sire or grandsire to a collective ancestry. The elder people of the earth are in reality its children, and we are its true senate. The feeling due to early generations is the half-pitying benevolence which we daily bestow upon childhood. It follows that the still earlier generations antecedent to the perfection of the human type, ought to be regarded with an extension of this same feeling—the modification of it which humane natures daily exemplify in their treatment of the inferior animals. Our children, it may be said, are the representatives of the first simple and impulsive men of the earth: the lower animals represent the earlier pre-human stages of life. The right conception of the case is, that in these stages we are not to look for what is venerable, but, on the contrary, for what is humble and elementary. We are to expect but the *primitiæ* of man's masterful life—something not even ascending to the dignity of "the infant mewling in its nurse's arms." If thus prepared, we should experience no shock on hearing that the human form was preceded genealogically by others of humbler aspect,—no more than we are on learning that every individual amongst us passes through the characters of the invertebrate, fish, and reptile, before he is permitted to breathe the breath of life. A deep moral principle seems involved in the history of the origin of man. He is the undoubted chief of all creatures, and as such may well have a character and destiny in some respects peculiar and far exalted above the rest; but it appears that his relation to them is, after all, one of kindred. Along with his authority over them, he bears from nature an obligation to abstain from wantonly injuring them, and as far as possible to cherish and protect them. Good men feel this duty, as if it were a command from a source above themselves. It seems to them, that if the helplessness of childhood calls for kind and gentle treatment, much more does the essentially weaker character of the dumb creature. And if the innocence of infancy is touching, still more so is the even more harmless character which (overlooking carnivorous instincts implanted in certain families for a wise purpose) attaches to the lower animals. It is common, under the influence of prejudice, to do gross injustice to the characters of these denizens of nature's common. We do not sufficiently reflect on their respectable qualities. Yet we must go to the dog for a type of the virtue of fidelity, and to the bee for that of industry. The parental affection of many animals is not below, if it is not considerably above, that of human mothers. Man nowhere exemplifies the virtue of patience in the practical perfection in which we see it in the horse and many other creatures which become the slaves of his convenience. Nowhere does he display that perfect moderation in wants. Alas for man's boasted superiority—in how many respects does it fail beside the unassuming merits of the mere commonalty of nature!

AFFINITIES AND GEOGRAPHICAL DISTRIBUTION OF ORGANISMS.

All truth being self-consistent, we might expect that this view of the history of organic nature, if sound, would accord with a just classification of plants and animals, supposing such to exist. It is certainly very desirable that our theory could have been subjected to this test; but it cannot be, for naturalists are as yet only struggling towards true classifications in both kingdoms. It becomes necessary, nevertheless, that we should make some inquiry into that *order* which has long been alleged to exist in animated nature, as, if any such thing truly exist, it either must agree with a genealogical system, or become its condemnation.

The result of my own investigations is, that there is an order in animated nature, but that it has hitherto been much misunderstood both by those who incline to a theory of development and others. The former naturally took hold of the idea of gradations, because it generally accorded with the notion of development. They pointed to that "chain of being," or series of ascending forms, which had long been supposed to extend between the animalcule and the human being. It was on the other hand successfully shown that beings did not form "a single and continuous series;" that it was "impossible to place all living animals in such an order that we may always pass from one species to another by following a decrease in perfection." "On the one hand, there are classes of animals so insulated, that nothing connects them with others." "On the other, there are types of organization which are absolutely indivisible, and of which the most perfect beings are superior to the mean of another type, while the most imperfect are inferior to it." All this is true: it remained unanswered by the advocates of the development theory; and such was the position of the question when the earlier editions of the present work made their appearance. But the error actually lay in the original idea of a chain of being. The animal kingdom (and, by consideration of parity, we may presume the vegetable also) consists of a *plurality of series* going on side by side with each other, but not all to the same point in the scale. No wonder, accordingly, that some appear insulated, or that the highest of some types are superior to the meanest of others, while the most imperfect appear inferior. Nor is this merely a hypothetical view of the animal kingdom. It is clearly pointed to by some of the most interesting discoveries in embryology. It is supported by several important considerations regarding the general characters of particular series. It likewise harmonizes with that order of fossils, which I have ventured to describe as not something calling in itself for explanation, but a fact which we may look to as one of the means of explaining something else—the whole history of organization upon earth. Finally, such reformation as this new view calls for in our classifications, is accordant in its general demands with all those recently effected by the greatest naturalists, by which external and comparatively accidental characters are overlooked, and only the more essential affinities regarded. If it goes beyond the march of living naturalists, it goes in the direction in which they are going, and over ground, to which I believe they must quickly come, whether they adopt a genealogical view of the organic world or not.

The divisions of the animal kingdom, as we find it in Cuvier, are partly into *grades*, with a regard to dignity of organization—first into Vertebrata (having an internal skeleton) and Invertebrata, and afterwards into such divisions as these of the vertebrata, namely, Mammalia, Birds, Reptiles, Fishes. In these grades are comprehended animals of very various character,—animals which only agree in this particular of a community of grade or rank. But other divisions in the common classifications are into groups or *series* of animals closely allied to each other in form and of one general character,—as, for example, the cephalopoda, the echinodermata, the crustacea. The one kind of division may be said to be transverse, the other longitudinal. Such a diversity gives rise to a suspicion that there is something wrong, something out of accordance with nature. And so it is. The true fundamental divisions are entirely of the latter kind—longitudinal; there only do we find persistence of characters; the other so-called divisions are only the marks of stages which the true divisions, the *Stirpes* of being, have reached in their respective courses. It is nevertheless necessary, in the meantime, to keep the existing classification in view, and to use its language, in order that my own views may be intelligible.

Cuvier divided the Invertebrata into three great masses, the Radiata, the Articulata, and Mollusca. Of these the two last appear as co-ordinate, though distinct from each other; while the Radiata, again, may, excepting one class, be considered as forming a kind of basis for the whole kingdom.

The Radiata are all of them animals of exceedingly simple structure, mostly inhabitants of the waters, many of them propagating not by ova, but by division of their bodies, or by the throwing out of little bud-like excrescences. In this lower region are comprehended the Infusory animalcules, Internal Parasites (*Entozoa*), Sponges, Polyps, Sea-nettles (*Acalephæ*), and some other obscure classes. Some of these appear to be distinct and independent series, which advance no further; such, in particular, are the internal parasites, which necessarily do not pass to any higher grade, because they have no sphere for further development. Others form the roots, as it were, of higher families.

There are two admitted methods of investigating the affinities of beings. One is to observe the connexion between the forms of the mature organisms; another is to examine the embryotic progress, and watch the succession of forms there presented. It has for some time been ascertained that no animal, in the course of its development, passes through the forms of all the animals meaner than itself. For example, the sea-nettle is at one time like the monad, an infusory animalcule, and then like the polyp; the mollusk is successively like the monad and polyp, but never like the sea-nettle. The articulate animal, again, is never like the polyp or sea-nettle, but proceeds at once from the monad form to that of the worm. This Professor Owen calls being "obedient to the law of unity of organization only in its monad stage."(71) The fact has been held as a difficulty in the way of the doctrine of unity; but perhaps it is only one of the same nature with that intimated regarding the assumed scale of being. I see animals classed by their affinities in distinct lines, or series, which I regard as stirpes or races. I would therefore expect the unity of organization to be liable to some such limitation as Mr. Owen points out. Is it not, in reality, that each stirps has a unity of organization for itself, or, in other words, that there is such a unity only as far as each particular series of animals is concerned? These breaks in unity and the breaks in the chain of being are but one thing: they are only disturbances to our preconceived ideas, not to a true view of nature drawn from its realities.

I shall not attempt to place all these obscure animals in genealogical series. The state of zoological science demands that such an effort should be postponed for several years to come. Let us limit our attention to one class, the Echinodermata, or star-fishes, which are perhaps improperly ranked with other Radiata, seeing that their character is so much superior. In general highly organized, and enjoying free movement at the bottom of the sea, these animals are signally destructive. Admitted to be in their lower forms intimately allied to the Polyps, they probably start in some portion of that extensive order. In their own class, however, as far as traceable backwards, they commence with the encrinus or stone-lily, a group of animals of which we have seen many varieties flourishing in the early seas, but which are now nearly extinct. The creature consisted of a stomach and arms, surrounded by long tentacles or arms, placed upon the top of a stalk fixed to the sea-bottom, the whole being composed of numberless minute calcareous plates, connected by gelatinous substance. In more advanced forms of the same order, (as the comatula and the extinct marsupite), the body and arms desert the stalk, and betake themselves to a free-swimming life; but, as has been elsewhere mentioned, the young comatula lives for a time as an encrinus; that is, upon a stalk. Seeing that the same animal, in an earlier embryotic stage, represents a polypidom, we conclude that in the polypiaria is the origin of the echinodermatous line: it is first the polypidom, then the encrinus, then the free-swimming comatula, or feather star, the last being one of the most graceful animals in existence. In the higher genera of the latter family, the tentacles are shortened and reduced in number. In the *Ophiuræ*, there are only five long and simple rays projecting from the central body. Afterwards, in the *Asteriadæ*, or true star-fishes, the central part dilates step by step, until it fills up the interstices between the rays, and the form becomes a pentagonal disk. From this there is a clear passage to the *Echinus* or sea urchin, which is merely a spheroidal animal in a calcareous case, through which numberless spines or tentacles project, for locomotion and the collection of food. This form again becomes elongated into the cylindrical soft-bodied *Holothuria*, with a circle of tentacles at the oral extremity; thence the transition is easy to the genus *Fistularidæ*, animals externally worm-like, and possessing the rudiment of a heart, with red blood in the arteries, so that, in this last echinoderm, we may be said to have come nearly, if not fully abreast with, the annelides, and to be approximating to some of the humbler fishes.([72]) The reader cannot fail to have been struck by the great number of forms passed through in this line, in comparison with any other, before leaving the radiate sub-kingdom; but, in reality, the echinodermata, though of radiated form, are much superior to the rest of that division in their organization, which is, if not complicated in the usual sense of naturalists, full of extremely curious minute work. Their whole destiny seems to be of a high kind, for in the stone record their line of forms stands parallel with others in which the whole of the three lowest sub-kingdoms are passed through. Polypiarian animals and encrinites appear in the Silurian and many subsequent formations; at the commencement of the carbonigenous era, the latter are so abundant that we walk over large tracts of country, where the rocks beneath our feet are almost wholly composed of their remains. The Asteriadæ appear in the upper Silurians, and are but faintly seen until the Lias, when they become conspicuous. In the Oolite, the Echinidæ make their appearance. These are the last which we could expect to be preserved in rocks, as the higher families possess no hard parts; otherwise, we might perhaps have seen the succession of this class of fossils continued into the holothuriæ and fistularidæ. It cannot fail to be noticed how well the progression of forms agrees with the order of their appearance in the geological ages.

The ground is now cleared for the two grand series of invertebrate animals, and first of the ARTICULATA. These are generally describable as animals "composed of a succession of rings, formed by the skin or outward integument, which from its hardness constitutes a kind of external skeleton;" one class, however, the Annelides, have no hard investment. The pedigree of the Articulata is very brief. The embryo in most classes passes at once from the monad to the worm form, and then the articulate character is assumed. It can therefore scarcely be said that the radiate sub-kingdom comes before the articulate, though the one is lower in organization than the other. There is indeed reason to believe that the great classes of the Articulata are distinct stirpes, the commencement of each of which is little more than a step from the inorganic form of matter. This may seem inconsistent with the maxim *Natura per saltum nihil agit;* but maxims must be obedient to facts, not facts to maxims, and we may deem that a leap which in reality is none.

The necessity of taking liberal views of the procedure of nature in the development of the organic world, is impressed upon us by a character found in the very first order of the articulata to which our attention is called. That the *Annelides* (worms) are the humblest of the articulate animals there is now no doubt; yet, unlike their superiors, almost all of them have *red blood*, a feature of the highest sub-kingdom. Four leading forms in this class are described. Of the *Tubicolidæ*, or those inhabiting tubes, the serpula is an example. It forms for its habitation, usually upon some sea-immersed stone, an irregularly twisted calcareous tube, out of which it presents, floating in the water, a fan-like branchial apparatus of beautiful colours. The second order, *Suctoria*, is represented by the well-known leech; the third by the earth-worm; the fourth by the sea-mouse (aphrodita). In all of these groups, we see distinct advances in organization, and this is traceable in some in an interesting conformity with changes of scene and mode of life, from fixed situations to free movement in the sea, from thence to the shore, and thence again to the land. From the Nais, a simple marine worm which at the recess of tide burrows in the sand, there is a clear passage to the common earth-worm, which adopts a similar retreat on land, and comes to the surface when rain is falling. The fourth order, *Dorsibranchiata*, so called because of gill tufts ranged along the back, have an equally clear affinity, implying ancestral relationship to certain land animals, which, however, naturalists at present regard as an independent class. The nereis, a well known dorsibranchiate, is an animal of great length, composed of a consecutive series of rings, each having a couple of processes at each side, which are used as oars for propelling the body through the water. One species is four feet long, and consists of several hundred segments. By conversion of the water-breathing apparatus into one fitted for aerial respiration, an increase of firmness and density to the external integument, and the development of a couple of limbs for each ring of the body, we see the nereis, as it were, transmuted into the

Myriapod.(73) Here, however, there may be more than one line of passage; for the two great families of the myriapods, the Julidæ and Scolopendridæ, are diverse in character, the former being vegetable feeders, the latter carnivorous, and it appears as a rule in the genetic system, that true carnivores are always apart. Confining our view to the Scolopendridæ, we see a remarkable continuity of character and habits transmitted to them from the presumed marine ancestor, (nereis,) allowing for the altered medium of existence. The scolopendra is an animal furnished with powerful destructive organs; and, living under stones and the bark of trees, and in fissures generally, it is his custom to wind insidiously along, and dart upon any little animal which comes in his way. Of the nereides, on the other hand, we are told that they "usually live in the excavations of littoral rocks, in the hollows of sponges, in the interstices of the radicles of thalassiophytes, under stones, and in general in all bodies which present fissures more or less profound . . . They all appear to feed upon animal substances. . . M. Bosc tells us they live upon polypi and small worms, on which they throw themselves, by darting the anterior part of their body, which they have first contracted."

The next articulate class demanding attention is the *Crustacea*, animals in which the annular sections are covered with a calcareous shell, and provided with jointed limbs, the respiratory apparatus being branchial; all are aquatic, except some of the higher genera, which occasionally adventure upon the land. They are in two great groups, entomostraca and malacostraca, the former being the simpler, and exclusively marine. Emmerich considers the Trilobites which figure so conspicuously in the early rocks, as between the two divisions, but most nearly allied to the first; whence it would appear that the crustacea which make so early an appearance in the rock series, are humble animals, only preceded in their own sub-kingdom by a group, which, from their slight forms, might be ill-adapted for preservation in strata exposed after deposition to a high temperature. The geological history of the crustacea tallies in other points with their gradation. In the triassic epoch come the Macruri, which prevail to the present time; afterwards, in the tertiary era, come the Brachyura. These are the fossil orders which have been best studied, and it is M. Agassiz who remarks "they succeed each other in the series of formations in the order of their organic gradation." The same naturalist remarks "the intimate analogy between these different types and the phases of the embryonic development of the crustacea, which MM. Rathke and Erdl have afforded us the means of becoming acquainted with." As elsewhere remarked, the young of the decapoda are of the entomostracous form, and thus denote a passage of the one from the other.

In one family of the crustacea, there is a striking illustration of what I regard as the true history of species. This is the family to which the well-known hermit-crab belong (Paguri,) distributed extensively in the tropical American islands, and upon our own coasts. Animals of this kind live in molluscan shells deserted by their proper tenants. They select one at the first for their residence, and afterwards, as they increase in size, they remove to larger ones. With the hind part of the body inserted in the hollow shell, they present the head and feet outwards. They move about in the shallow water, upon the shore, and even upon dry land, with great freedom, dragging their adopted mansion after them. A very slight examination of these animals shows that they are adapted by special peculiarities for this kind of life. In the common British hermit crab, the third and fourth pairs of locomotive limbs are of small size, being buried wholly within the shell, where they are applied to the columellar fold, as a means of fastening the animal in the recess. Farther in, and also employed in fastening the body to the shell, is the caudal part, with two holders developed for this express purpose, and as rough as a file. The hold is still further secured in some species by rows of suckers along the abdomen. Add to all this, that, for want of room at the mouth of the shell, only one of the pincer claws is well developed, usually the right, while only the two front pairs of feet are used for locomotion, and we see that, whether we take these crabs as a species, a genus, or a family, their ordinary form—that thing which naturalists regard as immutable, and as originally the effect of a special creative effort—is in direct relation to the existence and forms of turbinate shells formerly possessed by a different class of animals,—which must therefore have existed before the hermit crabs. Now mark the credulity to which the adherents of immutability must here be reduced. They must believe that the Creator, having a particular regard to the fact of molluscan shells lying useless on the shore, formed, by special care or fiat, a family of crabs to occupy them. They must believe that the roughness of the caudal appendages, the development of suckers along the abdomen, the reduction of the two hind pairs of limbs, and the left pincer claw, were all subjects for this special care, and were beyond the power of what an eminent geologist calls "vulgar nature." Surely the *Deus ex machinâ* was never more remarkably exemplified. See, on the other hand, how these facts are accounted for on the development theory. According to this new light, the hermit crabs are simply a portion of some greater section of the crustacean class. Their peculiarities are modifications from the parent form, brought about in the course of generations, in consequence of an appetency which had led these creatures to seek a kind of shelter in turbinate shells. They are as truly creatures of the Great God, as if they had been made in the manner of a human artist modelling a figure. But the *means* were inherent natural forces in the constitution of the original tribe, tending, in generation, to accommodate organic form to physical circumstances.

The next class in general rank is the *Insecta*, a wonderfully varied group, yet all agreeing in having thirteen segments and three pairs of legs; all, moreover, respiring by means of tracheæ or tubes permeating the body,—an arrangement having reference to their peculiar mode of locomotion, which, in the majority of species, is by flight through the air. The fact of the greater number of insect genera passing, in their larva state, through the annelidan or myriapodous form, points to these classes as their genetic origin; yet this is a point on which the benefit of further investigation is desirable. In the case of the *Arachnida* (mites and spiders), the highest articulate class, no humbler form is traceable in the embryo; it is therefore impossible to assign them any pedigree. Can it be possible that the arachnida, or these with the insecta, have sprung almost or wholly at once from inorganic elements under the proper electric influences? On this subject, we are quite unprepared to make any positive affirmation; but it certainly is remarkable that in no department of the animal kingdom, besides the infusoria and entozoa, have there been more frequent appearances of an aboriginal commencement of life than in the insecta. The acarus so often produced from certain solutions, where ova were rigidly excluded, is a lowly member of the arachnida.

We now come to the MOLLUSCA, a portion of the animal kingdom, the importance of which, in point of numbers and the part they play in creation, none but students of zoology could fully appreciate. The infinite variety of bivalve and univalve shells presented upon our own coasts and brought from all parts of the world, will convey some idea of the multitude of forms comprehended under this sub-kingdom. The whole mass is after all resolvable into three divisions; one of them comprising headless mollusks in bivalve shells; the other two, headed mollusks in univalve shells (some, however, of all the three divisions being naked). The whole sub-kingdom appear to have a very brief genesis in the radiata, the only preceding forms in embryo being the infusorial and polypian. Here, too, as in the Articulata, we find that we must start at a point very near the fountain-head of organic existence.

In the headless division, naturalists place three sub-divisions, called by them classes, in the following rank, according to ascending grade of organization—Tunicata, Brachiopoda, and Lamellibranchiata. The two latter are the shell-fish of popular observation, headless, and mostly sessile, or destined to spend their lives in fixed positions. The *Tunicata* are similar in all essential respects, except in being of humbler organization, and inclosed, not in shells, but in a cartilaginous or coriaceous integument; whence their name. It thus appears that the *Brachiopoda*, which are the predominant fossils of the Lower Silurian era, are *the first animals we meet with in this line, having parts capable of commemorating their existence.* While the Brachiopoda are generally inhabitants of deep seas, the *Lamellibranchiata*, among which are included the oyster, muscle, and other testacea, affect the beds of shallow seas, whence they spread in a variety of genera, towards shores, the mouths of rivers, and into fresh water. The Lamellibranchiates are higher than the preceding class; they are the first bivalves which possess a true hinge. It is also remarkable that, with the decline of the brachiopods, at an early point in the secondary formation, rises the lamellibranchiate class. There is here, therefore, an improvement in organization, an advance in habitat landward, and a succession of existence in the geological ages, all in harmonious connection. Nor is this all. The lamellibranchiata are again divisible into monomyaria and dimyaria, the former having one adductor muscle, and the latter two; the former, moreover, being intermediate between the brachiopods and dimyaria in respect of non-symmetrical form. *Now the monomyaria succeed the brachiopods as an abundant and predominating form, and are succeeded again, in that respect, by the dimyaria.* This beautiful harmony between the fossil history of the acephalous mollusks and their order in progressive organization is expressly declared by M. Agassiz.

The three highest molluscan classes, univalved, possessing heads, and with hardly an exception destined for independent locomotion, stand apart from the bivalve orders; generally superior in organization, as beseems their higher destiny, but not on that account to be held as an advanced form in the same genealogy. The lowest univalve class—called *Pteropoda*, from their mode of progression by a couple of wing-like membranes projecting from the neck—may be described as marine slugs, generally of small size, many of them naked, others protected by a very delicate shell, which swim through the ocean in vast multitudes; one species (clio) being in such abundance in the circumpolar ocean as to form the chief food of the whale. Professor Edward Forbes expresses his opinion that the larva of the pteropod will yet most likely be found to resemble an ascidian polype; inferring a very brief descent from the starting-point of life in its class.

The *Gasteropoda*—a class of many families and genera, including limpets, whelks, cowries, snails, etc.—have comparatively a high organization, the nervous system more concentrated, the nutritive more elaborate, but yet are of sluggish habits, usually moving by alternate contractions and expansions of a fleshy disk placed upon their stomachs; hence the name of the class. Many of the gasteropods are naked, others possessed of but slender protection. A large proportion are vegetable feeders, the marine species battening upon sea-weed, the terrestrial species upon herbage and fruit; the rest are flesh-eaters, but the general character of the Gasteropoda as a class is harmless, like that of the herbivorous mammalia. A clear gradation of forms passes through some of the families, from the simple cone of the limpet to the spiral of the snail. The descent of the class appears to be from some families of the preceding; for "they all," says a minute observer of nature,(74) "commence life under the same form, both of shell and animal; namely, a very simple spiral, helicoid shell, and an animal furnished with two ciliated wings or lobes, by which it can swim freely through the fluid in which it is contained. At this stage of the animal's existence, it corresponds to the permanent state of a Pteropod."

In the univalve mollusks, as in the bivalves, it clearly appears that the humblest families are destined to a fixed place in the depths of the ocean. As we advance through the higher groups, we find, in parallel steps with an improvement in the organs of animal life (for example, the splitting of the sexes into different individuals), an advance in the sphere of existence, to a life on the surface of the ocean, to fresh water, and even to dry land. The humble *Helicidæ* (snails) a family of the Gasteropoda, are the first animals which we encounter as adventuring upon the firm surface of the globe. And it is interesting to remark, in this progression, the requisite change in the mode of respiration—namely, from branchiæ, the apparatus necessary in aquatic life, to a vascular air-sac, the first form of lungs—the proper breathing organ of terrestrial animals.

In the peculiarly destructive *Cephalopoda*, we recognise the highest organization of which the molluscan form appears capable; it includes the orthoceratites, ammonites, belemnites, etc. of the rock systems, and the nautilus and cuttlefish of the present era. Their descent is probably from the carnivorous families of the pteropoda; for "the nucleus of their shells," says the naturalist last quoted, "is a spiral univalve, similar in form to the undeveloped shells above alluded to [those of the embryo gasteropods]; and it is yet to be seen whether all cephalopoda do not commence their existence under a spiral-shelled pteropodous form." It has also been remarked, that "the shells of two species [of pteropoda] afford indications of a transition towards the cephalopoda; one resembling in its straight conical form the belemnite and many other extinct genera of that class, and the other having a partially formed chamber at the lower closed extremity; and similar evidence is afforded by their internal structure."(75) This genealogy, if it shall be affirmed, will afford an important illustration of the geological history, because it will show that *cephalopoda might be expected to make their appearance as early in the rock series as any other mollusks possessing parts equally fitted to commemorate their existence.* These animals are to be supposed as an ultimate form, reached, not through the medium of all the lower molluscan orders, but only of one, and with respect to that one, it so happens that, though possessing hard parts of such delicacy as to have little chance of preservation, relics of it have been discovered as far down as any cephalopodous remains.(76) This contemporaneity of the cephalopoda with the gasteropods and brachiopods, it may be remarked, would be in harmony with what we know of the economy of nature with respect to the destructive animals. They seem to bear a relation to those upon which they are destined to prey, and to be a necessary accompaniment to them. Hence they would require to be upon a different genetic line—which actually appears, in every advance of the animal kingdom, to be the case—and developed contemporaneously with the weaker tribes, the fertility of which would otherwise produce complete anarchy. Granting, then, this pedigree for the cephalopoda, it would be no anomaly in our theory, although remains of inferior mollusks should never be found lower down in any part of the earth.

The cephalopods, though so highly organized in comparison with the gasteropods, do not advance, like these, to land forms, with apparatus for aerial respiration. They are, as a class, restricted to a pelagic life, admitting of occasional appearances on the surface of the ocean. Their respiratory system is accordingly branchiate, yet with marks of grade which are worthy of observation. It is, in the words of Professor Owen, a law determining animal rank, that "increased number [of parts] irrespective of correlative structure, in an organ of the animal body, is ever a mark of its inferiority." By this test, the nautilus, with its four branchiæ, sinks below the belemnite and the cuttle-fish with only two; and such is the basis of a division of the cephalopoda. In the whole of this order, however, there is a remarkable advance of the nervous system, though only to the effect of enabling the animal to supply itself with food by conquest over the inferior tribes. The nervous centres, which in lower mollusca were only protected by coverings which also served to cover the rest of the body, now become of sufficient importance to have a special protection, in the form of cartilaginous plates, which naturalists interpret as the rudiment of an internal skeleton. In this way, the cephalopoda approach the borders of the vertebrate sub-kingdom.

This remarkable class of animals affords in its details some evidences in favour of the development theory. The humble form of a straight or slightly curved shell prevails in the earlier ages. Curved shells increase afterwards. There are also tolerably distinct appearances of a transition of forms in the genera of clymenia, goniatite, and ceratite, which make their appearance in this succession in the rock formations.

The dibranchiate belemnites commence in the oolitic epoch, ushering in the sepiæ, the highest of all the cephalopodous orders, and which have since continued to exist.

It is worthy of remark that, in the succession of rocks, the forms of the cephalopoda change much more abruptly than appears to be the case with other less organized mollusca; that is, there are more decided as well as more frequent examples of what geologists call change of species in this class than in others. This is only one of the many proofs of *law* in these phenomena. On the theory of interferences, why should there be entire renewals of some sets of animals and not of others? On the theory of law, we only see each line of organic being undergoing the modifications appropriate to its special constitution, in connexion with the efficacy upon that constitution of external conditions.

When we consider the Invertebrate animals in this arrangement, the advances made in portions of the Animal Kingdom before the end of the Silurian era, appear in a very different light from what they do while we entertain the erroneous notion that there is but one chain of being. The annexed tabular view will make this readily and abundantly plain. Those animals which, though hypothetically concerned in the genealogy, are not actually found in a fossil state, but for whose non-appearance as fossils reasons are given, are expressed in italics.

Lower Silurian			Sub Silurian
Cephalopoda	Pteropoda	*Polype*	*Infusoria*
Gasteropoda	Pteropoda	*Polype*	*Infusoria*
Brachiopoda	Tunicata	*Bryozoa*	*Infusoria*
Trilobites			*Vibrio*
Annelides			*Vibrio*
Crinoidea			
Graptolites			
Coralifera			*Infusoria*

In looking among the animals of one class for the point of connexion by which it is joined to the next above, we must not invariably expect to find what we are wanting in the highest species, for these are often the heads of branches. On the contrary, it appears, in many instances, in the lower species. And this is the more worthy of being pointed out, as the supposition of something different has supplied many of the stumbling blocks of the development theory. In all the classes, for instance, which have terrestrial as well as marine species, the nexus to the next grade of being is among the latter, which are invariably the inferior. And thus it is that no transition of the kind here under our attention—that is, none of the greater grade transitions—takes place out of the aquatic medium which I have regarded as analogous to that of all individual embryos.

We now proceed into the Vertebrata, of which the fishes compose the lowest class. Here, with a skeleton, we have red blood and a double chambered heart; but the blood is still cold, and the respiratory system is by branchiæ, the animals being wholly designed for aquatic existence.

Of the transitions or transmutations implied by the development theory, the greatest, or most violent, are those few which took place in the passage from the invertebrate animals to fishes, from fishes to reptiles, and from these to the higher classes. This we might expect, as at such points the phenomenon had nothing to do with external circumstances, but wholly depended on the internal development force,—each stage being one of that limited number of periods, into which the long enduring gestation of nature was divided. Here, accordingly, we shall always find the affinities less distinct than elsewhere; and yet at all of them some connexions are visible, leaving the general fact of the transition indubitable.

Between the invertebrate animals and the fishes, the junction is tolerably clear at one point. This is where the cephalopodous mollusks connect with such fishes as the myxine, or hag, and the lamprey. These fishes are worm-like in shape, with only a rudimental skeleton in the form of a horny or gelatinous cord. They have a suctorial leech-like mouth, with numerous small teeth, by which they fasten upon living animals for sustenance. The affinity to the cephalopods is fully admitted. It is seen in the nature of the skeleton, so like that of the belemnite, in the character of the investing skin which ejects a copious secretion whenever the animal considers itself in danger, in the power of respiring through the gill apertures without any dependence for that function on the mouth, and in the eight free filaments seen in some species extending forward from around the mouth,—"representing," as Professor Owen remarks, "the eight ordinary arms of the Cephalopoda Dibranchiata, but arrested in their development by reason of the preponderating size of the caudal extremity of the body, which now [that is, in the fish] forms the sole organ of locomotion." The lancelot, one of this family, is so extremely humble in organization, that Pallas mistook it for a limax (a gasteropodous mollusk), and it has only of late been finally established among the fishes. Some difficulty has been experienced in seeing true affinity between the bag-like figure of the mollusk and the cylindrical elongated form of the fish; but it has been suggested that the mollusk is, as it were, the fish doubled in or inverted upon itself: hence the end of the alimentary canal so near to the mouth. The inversion reversed or undone, makes the fish. These appearances of propinquity are most arresting. If they do not indicate genealogical connexion, how should we account for them? On any other supposition, how should such peculiarities of organization be seen exactly at this point in the animal scale? The fishes here spoken of are not discovered in a fossil state. For this their want of hard parts unfitted them; but they are classed with the Chondroptergii, or cartilaginous fishes, which, we have seen, are amongst the first found in the ascending series of rocks. The affinity and the geological succession, are therefore in perfect harmony. It is here important to remark the progress from entirely soft animals, to an order bearing cartilaginous plates to protect a rudimental brain; from these, again, to an order having a skull and vertebral column of cartilage; a series of advances entirely conformable to phenomena seen in individual development. Nor is it to be overlooked that the presumed progeny exhibit, in their voracious character, and the functions they serve in nature, a perfect family likeness to their ancestry. The cartilaginous fishes were the chief police for keeping down the redundant life of the Devonian and Carboniferous seas, as the cephalopoda had been during the Lower and partly also during the Upper Silurian eras.

The approach made by the annelides to some of the humbler forms of fish indicates another passage from the invertebrate into the vertebrate animals; and this passage may have taken place in the Upper Silurian or Devonian era, for annelides are ascertained to have previously existed. Perhaps some of the less destructive of the early cartilagines—the Lepidoids were such an inoffensive family—have had such an origin.

It might be suggested, as an inquiry worthy of the attention of zoologists, whether the echinodermal line has not given rise to the more recently developed fish families,—those which enter upon the field in the cretaceous era. If the fistularidæ make, as appears, so near an approximation to the lowest bearers of the vertebratal type, it is not easy to see how any preconceived ideas regarding the order of sub-kingdoms to be passed through should stand in the way, especially after so many traces of similar irregularity. The geological history of the animals in question is favourable to the conjecture, for the echinoderms are amongst the most conspicuous and important forms antecedent to the chalk era. Looking, indeed, at the enormous abundance of crinoidea in the carboniferous rocks, one can hardly avoid the idea that this peculiar form was destined for some important ultimate history. It might be suggested that the orders by which the fish class is thus entered are those placed by Cuvier at the bottom of the osseous fishes, the *Lophobranchii* and *Plectognathi*, which indicate their nearness to the invertebrate type by many features attaching to some or all of them, as imperfection and slow hardening of the skeleton, deficiency of ribs and fins, low and embryotic forms of mouth, dentition, and gills; the Lophobranchi, moreover, hatching their young in a pouch below the tail, after the manner of a family of animals equally low in the mammalia.

In the present state of this inquiry, it is impossible to give an entire genealogical tree of Being. Much must remain obscure and unindicated. Even of what is set forth, some parts must be held liable to correction under better light. Enough, however, is done for the present object, if such fragments of the great composite chain be shown, as afford proof that there is such a thing in nature, and that the idea of genetic succession of advancing forms is in harmony with it. In the Fishes, we have one of the obscurer portions of the animal kingdom. The classifications of Cuvier and Agassiz are neither of them admitted to be *natural*; it is therefore not to be expected that any general student should be able to display the class in all its genetic relations, however confident he may be, from what he sees elsewhere, that such relations exist. We find, however, three advances made to its lower confines from the invertebrata—namely, by the cephalopodous mollusks, by the annulose animals (annelides), and by the echinodermata. And we see advances made in its upper confines to the next higher class, the REPTILIA, which succeed it in the strata and chronology of the earth, as in organization.

It is also sufficiently clear, that the succession of fishes upon our globe was in conformity with the embryonic development of the individual fish of a high order. This has been denied; but against all inferior authorities that of M. Agassiz must on such a point be held incontestable. He expressly affirms it as proved "that *the embryo of a fish during its development, the class of living fishes in its numerous families, and the fish type in its planetary history, in every respect go through analogous phases.*" The want of substantial vertebræ in the Devonian fishes is found in the last gradation of the class of fishes, among the Cyclostomes. He has reason to think that the internal case for the brain in the Devonian fishes was cartilaginous. So it is in the sturgeon; so it is in all embryos. Certain arrangements of the fins, as well as the heterocercal tail, and the inferior position of the mouth, complete these curious and most convincing analogies.

The Reptiles to the cold blood of the fish add a higher circulatory organization, as also lungs for aerial respiration; all of them (for exceptions are only apparent) are oviparous. Amidst the confusions of existing classifications, it is possible to trace three leading divisions, of which the tortoise, the lizard, and the frog are the several representatives,—namely, the Chelonia, the Sauria, and the Batrachia. Cuvier makes a fourth order of the serpents; but Merrem and other naturalists have shown, I think successfully, that these are but a reduction from the lacertine portion of the sauria.

The Chelonia are remarkable for the box-like case in which most of them are inclosed,—a peculiar development of the ribs of the animal, and which forms an admirable means of passive defence. They are animals of inert faculties, but great tenacity of life, and, generally speaking, the most harmless of all the reptiles, many of them feeding exclusively on vegetable substances. Destitute of teeth, they exhibit, like the birds, only a horny armature of the jaws, and even this is, in one genus, replaced by skin only.

The Chelonia are for the most part tropical animals, being seldom seen beyond the 20th degree of latitude. Within that range, however, the marine species are remarkable for the long voyages they annually undertake, for the purpose of depositing their eggs. It is also found, from our stony records, that the Chelonia were much more widely diffused over the earth in the ages of the oolite and tertiary than they are now.

The marine chelonia—Turtles (*Chelones*)—demand the first notice. In this group we find the largest existing specimens of the order; some of them reach six and even seven feet in length, and weigh seven or eight hundred pounds. All of them have extremities modified into paddles, for marine progression, with the toes enveloped in the membrane, and a very slight development of claws; but there is a natural division of the chelones in respect of habits and even of organization. One sub-group, amongst which is the common Green

Turtle, so well known for its palatable qualities, is composed of species altogether herbivorous and of gregarious and innocent habits. These animals may be seen in herds at the bottom of the sea, quietly browsing on the weeds growing there. Sometimes they enter the mouths of large rivers, and are occasionally seen to make their way ashore, apparently in search of food. Their plates are discoidal, laid edge towards edge, with intervals of cartilage, by which their bodies have a certain flexibility. Another sub-group comprises turtles of carnivorous habits, active, and when attacked, fierce; examples are seen in the Loggerhead Turtle, which has the plates arranged as above, and the Hawksbill, in which they are imbricated, or laid edge over edge; the latter being the animal which furnishes the arts with the elegant substance called Tortoise-shell. Finally, there is a genus, also of carnivorous habits,—the Sphargis or Coriaceous Turtle,—in which the exterior is not composed of shell, but of a leathery skin, having seven tuberculated ridges passing lengthwise along the back. These carnivorous genera have a more powerful form of mouth than the rest, and in some the claws are more marked. Thus armed, the Loggerhead, for example, will defend itself from a man with courage and ferocity, will snap a walking-cane in twain with one effort of its jaws, and not let go anything it has seized until its own life is extinct. These genera live upon mollusca, crustacea, and fishes; and even the young crocodiles are liable to the attacks of the loggerhead. The progression of all the turtles in their proper element is rapid. M. Audubon says—"The Green and Hawkbilled, in particular, remind you by their celerity, and the ease of their motions, of the progress of a bird in the air."

In all the remaining chelonia, the paddle form of the extremities is exchanged for legs and feet, the latter furnished with claws.

The River Tortoises (*Tryonices*), conspicuous tenants of the Ganges and Euphrates, the Niger and Nile, the Mississippi and Ohio, are next in size to the Turtles, some being three feet long. With an imperfect development of the osseous case, they are enveloped in a soft skin, which has caused them to be often denominated Soft Tortoises. The feet are palmated for swimming, and the toes exhibit three claws. These animals are of fierce and energetic character, living upon fishes and reptiles, and not scrupling to attack the young alligators. They dart out their head at their prey with inconceivable rapidity, and tear it with their sharp-edged beaks and claws, after the manner of the predaceous birds.

The *Emydes*, sometimes called Fresh-water Tortoises, sometimes Marsh Tortoises, are of many various species, haunting lakes, marshes, and small rivers in Asia, Africa, Australia, but more particularly America, where the proper habitat is most largely presented. They have shelly cases, which in youth exhibit the imperfect closing peculiar to the turtles, but afterwards become complete. Certain species can, by flexures in the case, close in their head, tails, and feet, so as to set enemies at defiance. The feet are palmated, and provided with five claws before and four behind. A remarkable rapidity of movement distinguishes this family, which devours not only aquatic worms, insects, mollusks, and small reptiles, but carrion. Among the emydes are species, such as Cestudo Carolina and Emys Muhlenburgii, which tend to a land life, and have the feet less palmated than the rest. There are also genera, Pyxis and Kinyxis, the one belonging to the Old World, the other to the New, which are regarded as connecting links between the emydes and land tortoises.

Several aquatic genera of remarkable forms are not yet settled in any definite place in our systems. One of these, the Emysaura Serpentina, which has a large head and a crocodilian tail, lives in the North American rivers, feeding on fish and small birds. Another, Chelys Fimbriata, or Matamata, with hardly any tail, has a large neck and snouted head, in which the mouth opens crosswise; it belongs exclusively to the rivers of Guiana. Mr. Swainson makes of these genera a group, to which he gives the name of Chelydrida.

Last are the Land Tortoises (*Testudines*), in which, with a perfect osseous case, there are extremities formed entirely for land progression, terminating in rounded callous stumps, with indistinct unguiculate toes. These animals are found in tropical regions all over the earth. Generally they are of small size; but in the Galapoagos islands Mr. Darwin found them several feet in length, and we know that in the tertiary era there were species in India of colossal proportions. The greater number of the land tortoises are vegetable feeders, and similar in disposition to the herbivorous turtles. A small group of species, already adverted to, stand apart, as exhibiting immediate affinities to the emydes.

Seeing the various characters of the Chelonia, and keeping in view the principles of the genealogical system, we have good reason for believing that two or more stirpes exist in this order of animals. The herbivorous species of sea and land undoubtedly form portions of one family, the transition from the one to the other being attended by little besides a slight conversion of the extremities, a maturing of the development of the osseous case, and that reduction of bulk which is everywhere seen in terrestrial advances from marine originals. Another stirps, perhaps starting in the coriaceous turtle, involves the Tryonices, or Soft Tortoises, which may be regarded as having merely passed from a marine to a fluviatile life, as has been done in many other instances. The Emydes, for which an original may be found in some of the other carnivorous turtles, constitute another line terminating in certain land species. On the chelydes it would perhaps be premature to speculate. In our investigations in this order, it is highly instructive to mark the improvement in the filling up of the interstices of the osseous frame as we advance from the marine and fluviatile species. These interstices are seen in the youth of the emydes and land tortoises, but as age advances they are obliterated. But what is in them a youthful and transient character, is permanent in the former animals, marking clearly their precedence in the genealogical scale.

No better word than Sauria seems attainable for the greatly varied order which next occurs, a combination of all the loricate and squamate reptiles. The crocodile, the lizard, and serpent, will suggest the principal forms to those least acquainted with zoology. They are extensively distributed over the earth, but chiefly in warm climates, and, being for the most part disliked by man, they are usually seen to decline as the human population advances. Of the three great reptilian orders, they may be considered the most carnivorous and destructive, though few are of great strength. In the time of the secondary formation, it was different. Vast saurians then traversed both sea and land, the undoubted masters of the animal world. Now, excepting in the crocodile family, and a few of the serpents, bulk and strength have alike departed from the order.

The *Crocodilia* form a distinct and well marked family, comprehending the several genera of the common Crocodile, distributed in Africa, India, and America, the Alligators and Caimans of North America, and the Gavial, peculiar to India. All of these are well known to be animals of large size, living in rivers, fierce and carnivorous, and serving a useful end in devouring the dead animals which are usually floated in great quantities down the large continental streams. Their exterior presents " distinct series of bones of moderate size, embedded, as it were, in the substance of the skin, and covered externally with a thick cuticle;" hence the term *loricata*, or mailed, which has been applied to them. The head is large, with an enormous gape, and some arrangements in respect of teeth, nostrils, and gullet, which appear admirably adapted for an animal requiring to catch its prey in the water. The origin of this reptilian family is to be sought amongst the great aquatic saurians of the secondary formation; the ichthyosaur, in particular, whose head is entirely crocodilian, while its general organization is fish-like. Afterwards, connecting links occur in the teleosaur, steneosaur, &c.

The remainder of the sauria present various forms tolerably distinguished from each other, but which are usually comprehended under the general term lacertine, the lizard being regarded as their type. First, and nearest to the crocodiles, may be cited the *Varanidæ*, a group composed of the Ouran or varan of the Nile, the Monitors of both worlds, the tupinambis, and other genera; animals living upon small reptiles and insects, chiefly frequenting land, but also occasionally haunting the banks of rivers. The varan is so like the crocodile, and makes such an approach to it in bulk, that the Egyptians believe it to spring from an egg of that animal which has been hatched in dry earth. The skin of the varanians is "furnished with enchased scales, which are tuberculous, projecting, rounded upon the head as well as upon the back and sides, always distributed in rings or circular bands, parallel under the belly and round the tail." The teeth are planted in a furrow, and curve backward. Next may be mentioned the *Lacertidæ*, or True Lizards, of which the only living examples are small insect-eating animals, in a great variety of specific forms, scattered over the warm and temperate countries of the Old World; the least repulsive of all reptiles, often indeed of beautiful form and colouring. In intimate alliance with them may be placed the *Geckos*, which are of nocturnal habits, and the *Chameleons*, which again are inhabitants of trees, all of these being likewise insectivorous. In palæontology, the lacertian animals date from an earlier time than any other Sauria. The huge extinct Monitors of the Thuringian Zechstein, the thecodonts of the nearly contemporary dolomitic conglomerate of Redland near Bristol, were the patriarchs of these families, and are the earliest fossil reptiles certainly known to us. The Mosasaurus, Geosaurus, and Megalosaurus, were likewise huge early specimens of this division of the sauria. Finally, we have the *Iguanidæ*, the most harmless of all the Sauria, being generally restricted to a vegetable diet; likewise small animals in our time, but exemplified at a former period in the enormous iguanodon of the Wealden. To this family belong the anolis, stellio, dragons, basilisks, and other species.

The serpents (*Ophidia*) are usually placed as a distinct order of reptiles; such was the arrangement of Cuvier; but Merrem and several other modern naturalists of high character, place them in connexion with the squamate sauria; and there, undoubtedly, natural classification requires that they should be. From those sauria to the ophidia, there is such a series of transitional forms in the scinks and chalcidæ, where we see the body gradually becoming elongated and more serpentiform, and the limbs diminishing away to mere rudiments, that it is impossible to assign exact limits to the various genera. We may even see in the perfect varanians a preparation for this new form. In these animals, the bones of the head have, in part, that looseness of structure and adherence which is carried to so remarkable an extent in the serpents, which, being obliged to take their prey entire, could not otherwise swallow it. The varanians, too, move in a serpentine manner, using their long tail to aid their progression, and to enable them the better to leap upon their prey; peculiarities in which they greatly resemble the serpents. In the last lacertilia, the ribs are increased in number, the two pairs of limbs are removed farther and farther from each other, and become small and weak; in some species the anterior, and in others the posterior pair, alone remain; until at last they are reduced to mere rudiments which do not appear above the skin. The common slow-worm is an example of a lacertilian in this state. At the same time, to suit the necessities of a body considerably attenuated, one of the lungs is gradually shrunk up, until at length, in the true serpent, only a vestige of it remains. Such is the actual history of the great serpent families—reductions from the lacertilia, to suit a life generally skulking and furtive; and there could not well be a more lively illustration of the doctrine of the transformation of animals. It furnishes a strong proof of the readiness of nature to go back as well as to go forward, according as circumstances shall dictate. It shows how futile is the objection to the development theory, from such facts as the crocodile-like arrangement of teeth in the thecodont lizards, the fathers of this order; an advance of grade being a *saltus* which may give such a superiority to the patriarchs of a series, while it depends on the accident of external conditions whether this is to be improved upon, maintained, or degraded. Many existing serpents are much larger than any existing lacertilia, the parent family; but it must be remembered that the early lizards were of enormous bulk. How perfectly does palæontology harmonize with this view of the genesis of the ophidia! no fossil serpent occurring in that secondary formation, where all the other reptilian forms so greatly abounded. Such harmonies may always be expected where the true track of natural investigation has been arrived at.

A naked moist skin, sometimes smooth, sometimes covered with papillæ or tubercles, is the only universal character of the third division of the Reptiles—the BATRACHIA, so called from the Greek word for a frog, as that animal is the most conspicuous example of the order. The animals of this order are also remarkable for coming into active existence in a fish form (the tadpole), and passing in the course of active life through one of those metamorphoses which in other animals are undergone before birth. They realize, as has been said, before our eyes, one of the grade transitions presumed by the development theory. In some species, however, certain portions of the organization are arrested at the fish stage, and so continue through life.

The frogs and toads (*Ranidæ*) are the batrachians most universally diffused over the earth and most familiarly known. They are harmless creatures, generally of small size, living upon slugs and insects, which they catch by darting out their long soft tongue, the end of which is, for this purpose, covered with a viscid fluid. They hibernate in mud or water, thus living a long time, not only without food, but without aerial respiration, a proof of the low organic character of these animals. The frogs spend much of their time in water; some assume a partially arboreal life, and have certain peculiarities in the feet which assist them in climbing. The toads are more terrestrial in their habits; but all alike have to propagate in the water, where their shell-less eggs are deposited in long strings, a single mother producing upwards of a thousand young. Some foreign species of the ranidæ greatly exceed ours in size; but, in comparison with the two other reptilian orders, the batrachian may be said to consist of little animals. Teeth are wanting in most of the toads, and they are developed on a humble scale in the frogs. The whole of the ranidæ are destitute of tail; neither have their toes any armature, excepting a horny sheath in a few species. They are also devoid of ribs, or present at the most rudiments of such bones.

The ungainly form of the toad has caused it to be no favourite with our race, and given rise to many reports against it, particularly one respecting its venomous qualities, which is quite false. A French naturalist remarks that, if we could behold the frog without prejudice, we should see in it an animal uniting an elegant form with light and slender limbs, adorning the banks of the rivulet with its pleasing colours (only less variable in some species than those of the chameleon), and animating the scene with its light and lively gambols. The croaking noise of the frog is proverbial; this is changed in the love season to a soft and plaintive note. A modern writer says, "A traveller towards the desert shores of the Caspian and the Volga would imagine that he heard of a sudden, in the evening, a joyous assembly of men and women laughing very heartily. He approaches; the inextinguishable laughter redoubles among the rocks, and, to his astonishment, he finds that it proceeds from an assembly of enormous black toads, celebrating their nuptial rites." ([77])

Although the frogs and toads are now, generally speaking, small animals, we must recollect that such has not always been the case. The Labyrinthodon of the Warwick Sandstone, an animal allied to the frog, is believed to have been as large as a good-sized hog. It may at the same time be remarked that, if this was the utmost size attained by batrachia in the era of the secondary formation, they were then, as now, relatively much smaller than the saurian order, of which several reached the length of thirty, forty, and even, it is believed, seventy feet.

A second division of batrachia is composed of animals of which the salamander is the type; hence called *Salamandridæ*. In them, the tail is largely developed: in other respects, as in their reproductive history, they resemble the preceding division, the water newts being analogous to the frogs, and the land salamanders to the toads. They also resemble the ranidæ in habits; but one remarkable species, the Menopoma of the Ohio and Alleghany rivers, which reaches two feet in length, is more fierce and carnivorous than any of the frogs or toads. The salamandridæ are extensively diffused over the earth; they generally are small animals, but one species, Sieboltia, which inhabits a lake upon a basaltic mountain in Japan, is three feet in length, and fossil species are found in the schists of Œningen (miocene formation), which must have been of nearly twice this measurement. The fluid which exudes from the salamanders, as from other batrachia, is probably what has given rise to the vulgar notion that these animals can resist the action of fire.

The remaining batrachia are isolated species, generally limited in locality, and all of them retain in their maturity some portion of the fish character. The *Amphiuma*, an eel-like animal, two or three feet long, which is found in stagnant pools in the more southern of the United States, has apertures in the sides of the neck, the last vestige of the gill structure. Deep underground, in waters never visited by daylight, resides the blind *Proteus*, which continues to have entire gills branching from the neck throughout the whole of life, and only depends in a less degree upon lungs. With four short and feeble limbs, it departs little from the form of the fish. The *Sirens*, which inhabit marshes in Carolina, have no hind limbs, and only rudiments of the anterior pair. In the North American lakes is the *Menobranchus*, with constant gills, and four very small limbs: it sometimes attains the length of three feet. Another of these gilled batrachia is the *Axolotl* of the Mexican lakes, the flesh of which is esteemed a delicacy.

The reduction of limbs in some of these latter species reminds us of the lacertilian animals on the approach of that family to the serpent form. It is not therefore surprising, to learn that there is a genus of undoubted batrachians which are wholly serpentine in figure, that is, without limbs, and also possessed, like the serpents, of unequal lungs. These are the *Cecilia*, or blind-worm, and kindred species, all of them inhabitants of warm countries; usually of a very attenuated form, and about two feet long. Till lately, the cecilia was ranked with serpents; but its passing through a metamorphosis, united to a consideration of its naked skin, has at length assigned it to the present order. Vegetable matters, as well as mud and sand, have been found in the stomachs of the ceciliadæ.

The batrachia have a particular value on the present occasion, as, although probably but the relics of an order once containing many more genera, and some of these much larger in bulk, they present unequivocal affinities to the grade below them, and also striking affinities amongst themselves, while their reproduction supplies a faithful picture of the principal phenomenon concerned in the development theory. Several genera, by retaining portions of the fish character, make the descent of the whole from fishes still more apparent. Professor Owen has shown that not merely in the retention of gills, but in peculiarities of teeth, can the nearness of some of the batrachia to fishes be distinguished. The Ranidæ appear to compose two kindred lines; the toads, in their more terrestrial habits, may be said to make a greater advance than the frogs. In the Salamandridæ, there are also traces of at least two lines: amongst them, from smooth skins and aquatic habits, to tuberculated skins and land habits, we pass through a well-knit chain of affinities. In the other Batrachia, we see only detached developments from the neighbouring fish form, which we may suppose, in some instances at least, to have been prevented from advancing into new forms by the circumstances in which they are placed.

With this account of the Reptiles, the geological history of the class, as far as it goes, appears in harmony. First, it is after fish that reptiles occur in time, as it is after fish that they stand in organization. Early in the Carbonigenous era, after fishes had existed for the space of an entire formation, there arises a family assuming a trace of reptilian character, in an inner row of Saurian teeth. The Sauroid fishes, as they are called, increase and multiply, and, several ages thereafter,—in the Muschelkalk,—the Enaliosauria, or fish-crocodiles (ichthyosaur, etc.), are presented, in which the passage to the reptile is clear and distinct. Before this event in the saurian line, a similar and more effectual transition had taken place in at least two other animal series, resulting in those specimens of the lacertilian order which are found in the Keuper, and those batrachians upon which Mr. Owen has conferred the name of Labyrinthodon. In these instances, our records are meagre, and it is therefore not surprising that specimens uniting the fish with the reptile, as is done by the enaliosauria, are not as yet found. But still the general affinity to the fish character, as well as a certain degree of aquatic habit, is shown in the biconcave vertebræ of these early lizards and frogs. Of what has been remarked as to the late occurrence of serpents, it is not necessary to make repetition.

The next class above the Reptiles is that of Birds, in which warm blood makes its first appearance, and which are marked by various other traits of superiority, particularly in the nervous system, though an oviparous mode of reproduction is still maintained. It is a class comprehending a vast number of families, adapted to different spheres of existence and habits; some predaceous and sanguinary, others innocent and supported by a vegetable diet; some adapted for living upon the water, others upon the land; some designed to dwell upon the ground, others upon trees; yet exhibiting, throughout the whole, and under every variety of external adaptation, a much greater unity of structure than any other class of equal importance. Unusually clear chains of affinity run through the class, one genus melting into another by the nicest shadings; and yet, from the unfortunate principle of classification assumed by naturalists—in which the most external characters are taken as the chief basis of arrangement—there is no class presented to us in a more confused manner.

A true classification of the Birds exhibits them in the order of succession which they have observed in coming into existence, according to the general principle explained in this work.

The first true division of the Birds is into three stirpes; one whose food consists chiefly of vegetable matters; another which live wholly upon flesh; a third who, as compared with either of the preceding, may be said to be omnivorous. The starting point with all three is in the Swimming Birds (*Na-*

tatores of Cuvier), where the organization is admittedly the humblest, and to which an approximation from the Turtles has long been acknowledged. In this order, as it is called by Cuvier, there are some genera which present the typical bird form in a strikingly imperfect manner, the feet being placed so far behind the centre of gravity that the animal walks no better than a seal, while the anterior extremities—short, and, in some instances, scaled, rather than feathered—do not serve for flight, but are used exactly like the paddles of the marine turtles in propelling the body through the water; often for several hundred yards under it. It unexpectedly appears probable that the Birds are derived solely from this order of the Reptiles, and that this is the cause of their more concentrated unity of structure. The affinity to that inferior class is certainly less clearly shown than are the affinities which pervade the class itself; but can we be sure that the transition from class to class was always to give intermediate forms, or that these, if given, were necessarily to be preserved, either as living species or as fossils? The Chelonia present a sufficient variety of characters to have been the sole parentage of the Bird class; many being fierce and carnivorous, while others are vegetable feeders and of gentle character. They are now chiefly tropical, while the swimming birds are hyperboreal; but the secondary and tertiary formations show that the chelonia were once much more widely distributed than they now are.

The First of the great stirpes is that which gives us the birds most important of all to us—the domestic poultry. Its root is in certain of the natatorial families, the Divers (*Colymbidæ*), Grebes, &c. These are Swimmers native to the Arctic Ocean, though accustomed to migrate southward in winter. They are immediately followed by the Mergansers, Ducks, Geese, Swans, (*Anatidæ*,) and the Phalleropes (*Phalleropidæ*,) Gallinules, and Coots (*Lobipedidæ*), which still preserve the aquatic habits, and the webbed or lobated feet necessary for progression in the water, but tend more to residence in rivers and other inland waters. In these, however, we see a clear separation into three subdivisions, one composed of the Mergansers and Ducks, which live in great part upon animal matters, another comprising the Geese and Swans, which are purely vegetable feeders, and a third embracing the Gallinules and Coots, whose diet is mixed.

The tendency of these animals, in consequence of their tastes in aliment, was to advance along rivers and the shores of lakes, to those adjacent low grounds where vegetable food, worms, and insects, are to be found. They landed, we may say, either upon sandy beaches or upon those low shores which, in the early ages of the world, antecedent to a time of cultivation, were wholly covered with marshes. On came the tide of population behind; it behoves them to spread landward for subsistence. The consequence was a modification of the hitherto natatorial forms of these birds to suit a strolling life upon soft sands and in marshes. The webbing of the toes shrunk, being no longer required for swimming; the toes were elongated, so as to give support upon a yielding ground or bottom; the tarsi were also lengthened, to raise the body of the bird above the shallow water in which it walked: at the same time, the animal acquired a greater length of neck and of bill to enable it to feed in these waters. Behold then the Wading Birds (*Grallatores* of Cuvier); merely a transformation of their swimming progenitors! In some parts of the earth, however, the regions adjacent to the sea were not marshes, but extensive sandy plains, presenting means of subsistence somewhat scantier, but still not to be overlooked. The consequence was a branch of the swimmers, adapted by length and strength of limbs for that rapid progression from one place to another which is required by animals placed on extensive wastes. This branch comprises the Running Birds (*Cursores*), the Ostrich in Africa, the Emeu and Cassowary of Australia, the Rhea of America, the Apterix of New Zealand; characterized by an extinction of the hind toe, which is not needed in their field of existence, and a reduction of the wings for the same reason in a modified degree, with, however, an approximation to mammalian characters, in the hair-like appearance of the feathers, the presence of a diaphragm in the viscera, and other structural minutiæ.

The three subdivisions of the Swimmers are with tolerable distinctness seen passing each into its several progeny among the waders. Looking at once to external features, and to habits and characters, we readily select, as the descendants of the anatine birds, the *Ardeidæ* (Herons, Spoonbills, and Storks), the most brilliantly plumaged of the Waders, as the Ducks are of the Swimmers, and equally addicted to a foul kind of animal diet, being, as is well known, amongst the most active scavengers of eastern and other cities. The anserine birds claim a progeny in the *Gruidæ* (Cranes), whose form of head, and the position of the eye, as well as the elevation of the hind toe upon the leg, remind us of that family, while their constancy to a pure vegetable diet is equally conspicuous. The Phalleropes, Gallinales, and Coots, reappear in a variety of forms, possibly forming inferior divisions or branches, yet evidently all much allied, the *Rallidæ* (Rails), *Otidæ* (Bustards), partially cursorial in figure, the *Charadriadæ* (Plovers), and the *Scolopacidæ* (Snipes, Sandpipers, and Curlews). All of these birds are mixed feeders, of gentle and timid character, with a tendency to walking power, which in some instances enables the animal to escape more surely by threading the brake than by flight. This last property may be connected in some way with the form of the feet shown by the grebes, phalleropes, rails, and other genera of the subdivision, these being not webbed, like those of the other swimming birds, but lobated; that is, having a separate lobe expanded along the sides of each toe.

The origin of all the bird life as yet spoken of, was that ocean which we now see beating the northern shores of the two great continents. There is the nativity of all these Swimmers; there do they yet live in sea and air darkening abundance. Swimming birds, corresponding to them, scarcely exist anywhere in southern oceans; there is but one development of anatine birds in that quarter, in the geese and cereopsis of Australia. The rise of wading descendants was the consequence of a spread inland; that is, harmonizing with that system of animal migration which the swimming birds are still seen practising. This movement of bird life soon overpassed the borders of rivers, lakes, and marshes, and came to elevated, dry, and sylvan grounds; and a necessity for other modifications then arose.

At least two of the subdivisions under notice had descendants suited to the new fields of existence. The cranes, spread as far south as India, there gave forth, as a great colony for its rich woods, the equally beautiful and useful Pheasant family (*Phasianidæ*), comprising the trained peacock, the jungle-fowl, and common poultry; in central America, in like manner, they presented the corresponding genera of turkeys and currassows. Thus came those useful domestic birds, some of which have been our servants as long as man has had a history, and which have entered so much into our common associations and literature. From them, again, proceeded the Pigeons (*Columbidæ*) whose beauty and innocence are even more endearingly present to us. To those who see but the common fowl and the ordinary pigeon of our country, it may be difficult to suppose such a connexion; but in India, the native seat of the family, the forms of the dove are numerous, and amongst them are species (for example, Geophilus Nicobarensis) which are evidently intermediate.

The game birds, grouse, partridges, quails, &c. (*Tetraonidæ*) are descendants of the rails and bustards, appropriate to the heathy moorland and mountain. So ends the first great stirps of the class of Birds.

Some general principles are clearly to be observed in the genealogy. Each subdivision preserves its own character, particularly as to food, through all the transformations which it undergoes. Thus the anserine birds, the cranes, and the poultry and pigeons, are all of them innocent vegetable-feeding animals. There is also an invariable diminution of size of body from the oceanic original to the inland descendants: for example, the anserine birds sink in the cranes, these fall off again in the poultry, and these again in the pigeons. At the same time, intelligence and the tendency to domesticity always increase.

The Second great stirps is composed of birds destined by their organization and dispositions to act as destructives over the rest. Its chief subdivision commences in a swimming family (*Procellaridæ*), of which the huge Albatross, with its ten feet expanse of wings and its great hooked bill, is an example. The tendency of this family was not generally to low shores, but to cliffy wildernesses. Accordingly it passed through no wading forms, unless the solitary species, the Secretary of India and the Mauritius, be an exception. It passed at once into the majestic *Eagle*, the grandest of all birds, and a terrible image of unrelenting destructiveness. Some of the aquiline genus, as the Osprey, still haunt the shores and rivers, while others take up their abode in inland and generally Alpine grounds, frequenting the plains only for the sake of prey. The *Kites* and *Buzzards* show an affinity, as of descent, to the Eagles. Another subdivision presents, in suite, the *Falcons* (including hawks), and the Owls (*Strigidæ*), the latter being addicted to living near the haunts of men and pursuing prey by night. A link between the two is seen in the peregrine falcon, both in its owlish visage and its inclination to live in tall buildings.

Another swimming family, composed of the Pelicans and Cormorants (*Pelicanidæ*), gives rise to the Vultures; and thus is completed the raptorial stirps.

The Third stirps is in some respects the most remarkable of all. It spreads out into a much greater variety of species than either of the other two; it is diffused over every country of the globe. On the whole, it may be described as omnivorous, though some genera are exclusively flesh-eaters, and even distinguished by their predaceous and sanguinary character. Hopping is a prevailing, though not exclusive, mode of progression. The birds are generally, though not in every instance, remarkable for their wariness and vivacity; some are noted for their chattering and imitative powers;

some of the most advanced genera attract attention by their beautiful song.

This stirps starts with the Gulls (*Laridæ*), an oceanic tribe distributed over the whole world, of active flying habits, generally of pure white plumage, presenting a variety of species, some of which, as the Terns, tend to a river life, and are of a swallow-like form. The mental character of the gulls does not stand high in our estimate; but we often do injustice in this respect to the sea-birds, believing that to be stupidity which is only unconsciousness of danger arising from the habitat being remote from human haunts. Mr. Edmondstone of Zetland speaks of the "characteristic inquisitiveness and vivacity" of many of the gulls, being the very qualities to be expected in the patriarchs of this stirps. Certain species, as the Skua, are predaceous and fierce, and the Glaucous Gull is a well known attendant upon sailing vessels for the sake of offal. Like the crows, the gulls attack and devour: they will quickly eat up a dead whale. The common gull, again, comes to land in cultivated regions, and follows the plough in search of what it may turn up. It is not unworthy of notice, considering how this stirps is generally distinguished in respect of voice, that a particular species of the Laridæ is known, from its peculiar cry, by the name of the Laughing Gull.

Though the Gulls are upon the whole a whitish race, there are species presenting an admixture of black. This should prepare us in some degree to hear the crows (*Corvidæ*), and Kingfishers (*Halcyonidæ*) presented as the immediate successors of the Gulls, more especially as one of the former family—the Pie—is chequered, and white crows sometimes occur as exceptions to the rule. But the immediate dependence of the colour of plumage upon conditions is one of the most familiar facts of the philosophical naturalist, and the changes in this respect which individual birds undergo in their moultings before attaining maturity, might well reconcile us to the most startling transitions.

The Kingfishers—small birds of brilliant metallic plumage—belong to the sea, but extend into rivers. In their wide diffusion over the earth, in their habit of darting upon fish, and in their voice, which, in an Australian species, is a laugh, they show their title to the place assigned to them. To them we affiliate the Bee-eaters (*Meropidæ*), extensively diffused in the old world, and the Rollers. These birds are all fissirostral, a change of beak having taken place to fit them for catching the insects on which they feed.

We now come to the well known, universally diffused Crows, the ancestors of by far the greater portion of the present stirps. Intelligent, wary, social, omnivorous, though some tend more to flesh-eating than others, this family is everywhere well marked; everywhere are they an object of marvel and curious study to our species, to whom it almost appears as if their voices were a kind of speech. In the genealogy of animals, their place is extremely important, for to scarcely any has so vast and various a progeny been given. It clearly appears that various crows, the Raven, Rook, Jay, Pie, &c., are the heads of so many distinct families, which have assumed various sub-characters in different regions of the globe, according as they were affected by external conditions; "a mighty maze, but not without a plan."

Taking the predaceous corvidæ first—they start in the Raven of the old world, and misnamed Black Vulture of America; the largest of all the species; animals keen-scented, cautious, yet fierce, and which do not scruple even to attack some of the larger mammalia. In our continent, we see the raven and carrion crow followed by the hooded crow, which, being only a reduced image of its predecessor, will without much difficulty pair with it, and produce a prolific offspring.

The crows are classed by naturalists as Conirostres; that is, having a conical beak. The beak is, nevertheless, considerably curved in the predaceous species, so as to approach the hooked form: in the American carrion crow it is as decidedly hooked as that of any raptorial bird. This should prepare us for hearing of series of birds descended from the predaceous crows, with that reduced kind of raptorial beak which, having a curve and a notch or tooth in the upper mandible, gives them in classification the name of Dentirostres. One of these genera is the Shrikes or Butcher Birds (*Laniadæ*), a numerous and widely-diffused assemblage, living upon the smaller birds and insects, the former of which, the shrike sticks, when killed, upon thorns, as a butcher hangs up meat in his stall; hence the name of the genus. From the shrikes also proceed certain genera of eminently insectivorous habits, and some of which, in accordance with that kind of prey, have the reduced form of beak called fissirostral, accompanied by a great width of gape—namely, the Swallows, Swifts, and Martins (*Hirundinidæ*); the Nightjars and Goatsuckers (*Caprimulgidæ*), which, feeding by night, are to the swallows what the owls are to the falcons; also the Fly-catchers (*Muscicapidæ*), a genus so near to the shrikes in aspect, that several of the species have been classed by various naturalists in that group.

From the shrikes, moreover, if we can trust to an admitted affinity, come the Thrushes and Blackbirds (*Merulidæ*), whose fine song has blinded us in some degree to their destructive habits; as also certain corresponding birds of other countries, the Breves of India and Australia, the Water Owzel of Europe; the Mocking Bird, Water Thrush, and Ant Thrush of America. The Lyre-birds of Australia are also in strong affinity to the thrushes. Here it may be remarked, that the blackbird, as well as the crow, occasionally produces a white offspring, thus returning as it were to the primitive type.

The meruline family have an extensive progeny in the warblers (*Sylviadæ*), nightingale, stone-chat, blackcap, redbreast, redstart, &c., which are specially inhabitants of the groves and thickets, and devourers of insects. The affiliation here is peculiarly distinct: M. Vieillot remarks, "a spotted warbler is to my eye nothing but a thrush in miniature." With the thrushes are also connected the wagtails (*Mota-*

cillidæ); in the American water-thrush this affinity is exhibited very strongly.

The Chough or Red-legged Crow (*Fregilus*), an omnivorous genus, of familiar habits, is, from the admitted affinity, the undoubted progenitor of the Starlings and Pastors (*Sturnidæ*), a family in favour with the human species on account of their intelligence, sprightliness, and fine song. "They appear," says Mr. Swainson, "as a smaller kind of crows, which they very much resemble in manners and structure." Allied to the starlings, and probably an offshoot from some local genus, are the Pique-bœufs (*Buphagidæ*) of Africa, who give occasion to a remark of some importance in the present speculation. These birds derive their food from the parasite larvæ contained in the skins of ruminant animals, upon whose backs accordingly they take their meals, holding on by their cramp-iron-like feet, and using a forceps-like beak to squeeze out their food. The bird is fitted in a peculiar manner for this mode of existence; its claws are the most hooked of all birds' claws, overlooking only the birds of prey. It is curious thus to find a bird fitted for a life in intimate connexion with other animals, which we know did not come into existence till after the commencement of birds. Upon the common theory, it would be necessary to believe that the pique-bœuf was called into existence by a special fiat in connexion with the greater phenomenon of the origin of ruminant animals. It almost looks like derision to ask if this be credible, especially when we consider that the pique-bœuf is, in reality, not a bird standing in a solitary distinction of characters, but only a kind of starling adapted to special habits. Yet the reigning opinion of naturalists, if true to itself, can in no way escape from the absurdity to which our question reduces them.

Near to the starlings, but perhaps only by collateral relationship, is an important genus, numerous in both Europe and North America, the Larks (*Alaudidæ*), a ground-inhabiting, seed-eating, innocent race, endeared to us by the habit so noted in certain species of rising high in the air, and there pouring out their beautiful and joyful songs. There are many varieties of the Lark, adapted to life upon shores, in fields, and amongst the woods. They possess a remarkably strong conical beak for husking seeds, and which they occasionally employ even in breaking nuts for the sake of the kernels. Perhaps with the larks should be associated the pipits or titlings. The Buntings (*Emberizidæ*), comprising the yellow hammer, ortolan, &c., are a comparatively untuneful variation from the larks, having a shorter bill with a palatal knob, but generally similar habits, insomuch that they are often caught in the same net. From them again come the Sparrows (*Passeres*), so widely diffused and so well known—as also the Finches (*Fringillidæ*), the latter an extensive genus of field birds, comprehending the goldfinch, chaffinch, linnet, canary, cross-bill, &c. The most conspicuous external feature of this series of birds is a hind claw of unusual length and straightness. All are conirostral.

The Cuckoo is from many features entitled to a place in or about this portion of the corvine stirps, though its zygodactyle foot has caused it to be classed by naturalists in their purely artificial order of scansores or climbers. It is prevalent over the old world, including Australia, and is everywhere noted for its habit of placing its eggs in the nests of other birds, that its young may be hatched and brought up by them. As is well known, the rearing of a young cuckoo in a nest costs the life of all the foster mother's own progeny. Here we have another difficulty of a remarkable kind for those who maintain that each species has been the result of a special fiat, for how irreconcileable is it with all our ideas of *immediate* or special arrangement that a particular species can only be continued by such a sacrifice. The fact is, that the cuckoo is obliged by its constitutional character to stay an unusually short time in the northern regions where it produces its young. In our country its normal stay is only from the middle of April to the beginning of July. Belated in its approach to the nursing regions, it is obliged to make use of the nests of other birds, which it finds ready built. What is worthy of notice, it employs the nests of its own nearest relations, the larks, pipits, finches, sparrows, &c., an arrangement we may suppose to be connected in some way with the early history of the whole group of species—a family or clan sacrifice, as it were, for the benefit of a less fortunate member. Thus, it will be observed, when we take the whole group together, as only variations produced by certain natural laws from one stock, the parasitical reproduction of the cuckoo sinks into that character which alone we can reconcile with the rest of the providential scheme,—a trivial exceptive evil in the midst of much that appears, and undoubtedly is, very good.

The Jay is said by Professor Macgillivray to connect the crows with the Tits (*Paridæ*), a varied genus of notedly crow-like characters.

From the Nutcracker, another of the smaller crows, come the Woodpeckers (*Picidæ*), which present merely a modification of the corvine structure to suit an insect-eating life amidst growing timber. The woodpeckers, for this purpose, have turned back the outer toe, so as to be able to climb and cling to the stems of trees; the beak has been at the same time elongated, to enable them to search in the crevices of the timber for insects. They are spread into all the quarters of the globe. It is interesting to observe the kindred nature of the parent species: the nutcracker is often observed to climb the bark of trees; it uses the beak to split open nuts; and, as in the woodpecker, the middle feathers of the tail have been found worn in consequence of their climbing habits. In near affinity to the woodpeckers, but perhaps only in cousinship, not in descent, we must place the Creepers (*Certhiadæ*), nut-hatch, hoopoe, wren, &c.; smaller birds, which have the toes in the usual arrangement, but are not less dexterous in making their way along the bark of trees, and searching it for their favourite food. The *Trogons* of India, Africa, and America, and the kindred *Todies*, of the first of these countries and Jamaica, also appear to be of the woodpecker connexion. If we might judge by the structure of the tongue, we should place the *Humming Birds* of America in the same branch of the corvine genealogy: they eat insects, although certainly more peculiarly fitted to draw an innocent aliment from the juices of those flowers whose dyes they themselves rival. Corresponding to them in the Old World are the *Honey-eaters* of Australia and *Sun-birds* of India and Africa. Those remarkable looking birds, the Hornbills (*Buceridæ*), natives of India and Africa, are another offshoot of the great corvine nest, most probably from the Carrion crow, which, in feeding, those of Africa at least resemble. They are gregarious, noisy birds, generally of large size, with feet short for perching, their habit being to reside in trees. The tendency of the crow tribe to noise, or the exercise of voice, has led in this genus to a development which forms their most conspicuous feature, namely, a hollow protuberance blown out, as it were, like a bag, upon the top of the upper mandible, and which serves as a sounding board to increase the vociferation which the bird delights to utter. In immediate descent from these birds are the Plantain-eaters (*Musophagidæ*), which, however, are restricted to Africa.

The Toucans of Tropical America (*Ramphastidæ*) are another branch of the corvine family. They live in deep forests, much after the manner of the wood-peckers, using their enormous beaks and barbed tongues in searching out eggs and nestlings in the hollows of trees. Singular as the beak appears in this instance, it is seen to be expressly suited for the objects which the bird wishes to accomplish. Let us not wonder too much at a growth so extraordinary, or be too eager to set it down as a feature separating the bird hopelessly from all the rest of the corvine family. Naturalists daily see such modifications of this instrument, as make it very easy to understand how the animal, tempted by food in peculiar situations, came to have its beak adapted to the purpose of obtaining it. The same remark will serve on our introducing the Parrots (*Psittacidæ*) as another family of the corvine stirps, some of whose special qualities, particularly garrulity and imitativeness, they possess in an extraordinary degree. They are distributed throughout the intertropical countries of both hemispheres, as well as Australia and New Zealand. Eminently arboreal in habits, in them we see the perfection of the scansorial or zygodactyle form of the foot, the outer toe being turned completely behind.

In the stone record there are, as is well known, few entries of birds ; but such as there are bear a general correspondence with this view of the genealogy of the class. The Connecticut footsteps chiefly point to tribes which stand early in the pedigree, namely, species allied in structure to the snipes and plovers. Others, from their gigantic size, have been thought only referable to struthious birds—an equally early offshoot from the aquatic order. Some few are more dubiously assigned to rasorial birds. With regard to the absence, here or at an earlier period, of swimming birds, let it be considered that the phenomena are extremely local and limited; also, that the spot investigated is a portion of an ancient shore, a haunt of wading rather than of swimming birds. Recently, indeed, it has been announced that one of the birds indicated by the footmarks was a swimming bird—a fulica, or coot; but, as all such announcements require confirmation, little can be founded upon this, more especially as a foot print resembling that of a finch was spoken of at the same time. In rocks posterior to the Connecticut footmarks, but within the secondary formation, occur three bird fossils, one referred to the snipe family, another to the albatross, and the third to the swallow; the majority being thus applicable to early portions of the genealogy. When we at length come into the tertiary formation, we find, in the eocene, a vulterine bird; soon after which ornitholites, as they are called, become of greater abundance ; and "here," says Mr. Strickland, "as in every other department of the animal kingdom, we perceive a rapid approximation to the fauna, which is characteristic of the period in which we live." ([78])

Finally, we have to inquire into the connexions between the MAMMALIA and the lower vertebrate classes. Naturalists place the Birds between the Reptiles and Mammals ; yet in some respects the birds are not truly intermediate. We are the less to be surprised on finding that the principal mammal orders appear to be immediately connected with the Reptiles, while only the lowest come through the birds. As usual in transitions from class to class, which in general are the leaps of the development process, the passage from reptile and bird to mammal is obscure; only indicated in a few stray facts. Perhaps the fossil blank at the conclusion of the cretaceous era has also helped to keep light from this subject. Still we have enough to bear us out in saying, that, as the fish connect with reptiles, and these with birds, so do reptiles and birds together connect with mammalia; thus placing the general fact of the continued development of animal life from its lowest to its highest point beyond a doubt.

The first glimpse of the mammalian type presented by geological research is in the Cetiosaur, a huge reptile of the Oolite, nearly allied to the marine sauria, but exhibiting in the form of the larger vertebræ a clear affinity to the whale tribes. In connexion with this fact, the physiologist tells us that, in the manatus and dugong, specimens of these tribes, there is a dense texture of bone, and an absence of medullary cavities, assimilating their skeleton to the reptiles, which class they further resemble in the loose connexion of the bones of the head. It would thus appear, in this grand instance, as in all others, that the starting point of the superior class was in the marine and consequently earliest examples of that below; for the trunk of the genealogical tree of Being is short compared with the branches.

The passage from the Birds to the mammalia connected with them happens (for accident in the preservation of species and the discovery of fossils is much concerned in the case) to be more manifest. Somewhat unexpectedly—but nature must be taken as we find her—it is the humblest mammalian orders which come through this protracted channel. They are the *Digging Edentata* (armadillos, ant-eaters, pangolins, &c.), the *Insectivora* (moles, hedgehogs, &c.), and *Rodentia* (mice, squirrels, hares). By all modern comparative anatomists it is allowed that these show, in their osseous structure, imperfect dentition, and humble character of brain, an affinity to birds. There is, however, another order of animals, which can hardly be considered as fully mammalian in character; Implacental

Mammalia they may at the best be called; and which are even nearer to the bird character than the three orders above enumerated. These are the *Monotremes* and *Marsupials;* animals now almost restricted to Australia, but which were formerly more widely distributed. In the brain and other parts of the organization, they are decidedly bird-like. But this is not all, for, in the only surviving monotremes, the ornithorhynchus and echidna, we see the bill and web-feet of the swimming-bird still unchanged, the former animal being a semi-rodent, and the latter a semi-insectivore. Here is a gradation most remarkable, the point reached being only, as it were, half way towards the higher form of existence. It is also very remarkable to find amongst the more numerous marsupials, genera recalling the rodent and the insectivorous forms, as if these were only further advances along similar lines.

Reverting to the genealogy of the higher orders of Mammalia, we find ourselves introduced by the cetiosaur and the remark as to the osteology of the dugong, into the confines of the *Cetacea*, the marine or fish-like order of their class. In this group of animals, what first strikes us is that, while united by a common medium of existence, and some peculiarities fitted thereto, they are otherwise extremely various, as much so indeed as all the land mammalia together. The whale, the dolphin, the seal, are animals fully as different from each other as the panther and the elephant, the deer and monkey. Naturalists now begin to say that the Carnivora (lions, bears, genets, shrews) are *represented* in the seals, and the great pachyderms in the cetacea;—the ruminants, also, in the herbivorous cetes (manatus and dugong). Obscure as is our knowledge of the aquatic mammals, this relation is indubitable, but its real character has never been read. It becomes quite intelligible when we arrive at the idea of a genealogical system; but in no other way, to all appearance, can it be explained.

The aquatic mammals are not properly one distinct order, nor two either. They merely form the initiatory stages of certain terrestrial orders,—a cross section, as it were, at the bottom of those orders, and part of the composite chain by which they are connected with the reptiles.

The first of these terrestrial orders is that of the *Carnivora:* it starts in the seals (*Phocidæ*). We see in that family genera bearing a positive resemblance to both the ursine and the feline tribes, and respectively called in consequence sea-bears and sea-lions. It is also of importance in the case of the bears, that there are genera (such as the arctic bear) geographically adjacent to the haunts of the phocal tribes, partly similar in their semi-aquatic habits, and also akin in the low (plantigrade) organization of their hind extremities. From the bears—startling as it may appear—proceed the *Canidæ* (wolf, fox, dog), in which there is at once an improvement in form (digitigrade) and an advance in intelligence. Let not prejudice resist this pedigree. We must remember that the dog is still a carnivorous animal, and, in the wild state, a ferocious one. But the almost identity of teeth, and the fact of the bear and dog having proved fruitful, are the facts on which the genealogy chiefly rests.

A third carnivorous line, which may be called the *Musteline*, is clearly traceable from the seal called the Otaria, through the sea-otter, the river otter, and so on to the shrews and musteline animals in general. One, in which the succession is not so distinctly seen, embraces the *Viverrine* animals, including the hyæna, procyon, genet, ichneumon, etc.

The alliance of the Pachydermata to the whales is fully admitted by modern geologists, being seen in the thick and naked skin, the gigantic body, massive bones, and even the variable and irregular teeth, peculiar to the latter animals. Here it is also important to observe that some of the pachyderms nearest to the whales in bulk, as the hippopotamus and rhinoceros, are partly aquatic in their habits. Even the elephants and tapirs are but one step further on to terrestrial habits, seeing that they chiefly haunt the savannahs and jungles adjacent to great rivers. The *Equidæ* (horse, ass, quagga, onager) and the *Suidæ* (pig, babyroussa, peccary) are pachyderms applicable to inland situations, reduced in bulk, but improved in organization. Their respective parentages in the bulkier families may be left for future decision. Meanwhile, Professor Owen's opinion may be quoted for a connexion between the hippopotamus and peccary through the medium of the Chœropotamus, an extinct animal whose remains are found in South America.

The herbivorous cetes, dugong, manatus, and walrus form the basis of the great order *Ruminantia*, to which they are allied in their gregarious habits and large bulk, as well as in their food. ([79]) This order presents two distinct subdivisions—the *Bovidæ* (aurochs, bison, buffalo, ox), leading on by such intermediate forms as the ovibos or musk-ox to the sheep; and the *Cervidæ* (elk, deer), leading on to the goat; the animals of low and alluvial grounds thus, as usual, passing into smaller species adapted to more inland and elevated situations.

The last mammalian order is that which Linnæus called *Primates*, comprehending, however, not only the monkeys and lemurs, and the Cheiroptera or bats, but the Sloths (*Bradypodidæ*), which Cuvier, merely from their want of certain teeth, placed elsewhere.([80]) For this order there remains a basis in the *Delphinidæ*, the last and smallest of the cetacean tribes. This affiliation has a special support in the brain of the Dolphin family, which is distinctly allowed to be, in proportion to general bulk, the greatest amongst mammalia, next to the oran-outang and man. We learn from Tiedeman, that "each of the cerebral hemispheres is composed, as in man and the monkey tribe, of three lobes—an anterior, a middle, and a posterior;" and these hemispheres "present much more numerous circumvolutions and grooves than those of any other animal." Here it might be rash to found anything upon the ancient accounts of the dolphin—its familiarity with man, and its helping him in shipwreck and various marine disasters, although it is difficult to believe these stories to be altogether without some basis in fact. There is no doubt, however, that the dolphin evinces a predilection for human society, and charms the mariner by the gambols which it performs beside his vessel.

The first steps from this aquatic family are perhaps not to be seen upon earth. It appears as if we had to take up the lines in decidedly inland species—the Monkeys and Sloths, which are sylvan; the Bats, which are partially aerial; and man, who is geographically universal. For the sloths alone, do we discern any trace of intermediate species. These appear distinctly enough in the fossil megatherium and megalonyx. (81) The want of the rest is not a formidable difficulty, for it appears, generally, that the species hovering between sea and land, or those adapted to live upon shores and low grounds, are most apt to become extinct. Hence it is that the tapirine and elephantine animals are visibly fading from the face of the earth. Thus has the anoplothere perished, while the llama survives. It cannot fail to be remarked that the geological history of the mammalia is, as far as we obtain from it any distinct ideas, in conformity with these views regarding their classification. The marsupials and aquatics appear early, even before the cretaceous era. After the long blank which that formation represents, what are the animals found predominant in the beginning of the tertiary? The great pachyderms and cetacea, particularly manatidæ. The dog, horse, and other culminating species of the various lines, come comparatively late, the sheep and goat not at all; man also is absent, till the most recent formations.

We cannot but regard with profound interest the question respecting our own immediate ancestry. The mind immediately refers to the simial family, whose form, size of brain, and general characters make so manifest an approach to our own. Yet it may be doubted if the particular species whence the human family was derived, has ever come under the attention of naturalists. It seems, judging from analogy, as if a larger species than any as yet described were required for this place in the tree of being. It may here be observed that of all the reptilian orders, the batrachian is that which has best pretensions to a place in the origin of the Primates. "It is singular," says Dr. Roget, "that the frog, though so low in the scale of vertebrated animals, should bear a striking resemblance to the human conformation in its organs of progressive motion." It is the only animal besides man with a calf to its leg. It evidently "is making," says Dr. Roget, "an approximation to the higher orders of mammalia." The frog, however, is but a humble offshoot of the main line terminating in the Primates. There is something more like a lineal predecessor of the order in the Labyrinthodon of Owen, that massive batrachian, which leaves its hand-like footsteps in the New Red Sandstone, and then is seen no more. Not for nothing is it that we start at the picture of that strange impression,—ghost of anticipated humanity,—for apparently it really is so. In these things the superficial thinker will only see matter of ridicule: the large-hearted and truly devout man, who puts nothing of nature away from him, will, on the contrary, discover in them interesting traces of the ways of God to man, and a deeper breathing of the lesson, that whatever lives is to him kindred.

Our view of the animal kingdom is now completed, and I venture to claim for it the character of being, with all necessary and unavoidable imperfections, the only approach yet made to a truly natural classification. Proceeding everywhere upon obvious affinities, most of them admitted by zoologists, or else upon equally acknowledged facts in the doctrine of embryology, it presents an arrangement in almost every point conformable to palæontology, or the geological history of animals upon earth. Nay more; so far is that history from being irreconcilable with any assumed progress of animated being from simple to complex forms, that I would now say, any discoveries violently altering it, or doing more than filling up its blanks, would be at issue with the true plan of being, and a source of doubt with regard to the whole of our hypothesis of creation.

It now appears that the animal kingdom (and by analogy the vegetable also) is composed of series of forms, each usually taking an origin in the lowest sub-kingdom, and afterwards passing through higher grades, but not in every case through all, until the highest is reached. It appears that the grand matrix of organic being is the sea, that what may be called trunk lines pass through this medium as high as the mammalian type, and that the terrestrial families may all be regarded as branches of these marine lines, though in some instances a passage from one class form to another has taken place on land. Two principles are thus seen at work in the production of the organic tenants of the earth—first, a gestative development pressing on through the grades of organization, and bringing out particular organs necessary for new fields of existence; secondly, a variative power re-acted upon by external conditions, and working to minor effects, though these may sometimes be hardly distinguishable from the other. Everywhere along the central scale of organization, the land has been, as it were, a temptation or provocation to new and superior forms adapted for inhabiting it. We might almost regard the progression as the result of an aspiration towards new and superior fields of existence, as from the deep sea to the shallow or river-embouchure, from the shore to the bank, from that again to the higher ground in the interior. He may not yet be held as a very fanciful naturalist who would regard the megatherium as eager to climb the tree which he could only shake, and thus producing a progeny fitted to do that which was the object of his wishes,—or the rock-nose whale, which loves to rest its head on rocks beside the beach, as wishful of that mode of life which was at length vouchsafed to a more highly developed descendant. Such too may be found to be the true principle of perfectibility in nature—a continual, though it may be an irregularly shown tendency to press on to better and better powers,—an indefinite improveableness, which may work, as in seconds, in the individual, or strike hours in the species.

The present view of the Genealogical Classification of Animals was nearly completed, when my attention was drawn to certain appearances, as if the arrangement had what may be called a numerical foundation. Within the last twenty-five years, Mr. Macleay originated a theory of this kind, which has been wrought out by Messrs. Swainson, Vigors, and other naturalists. The prevalent opinion amongst them was, that the true divisions and subdivisions were in groups of five: thus, five sub-kingdoms, five classes of vertebrata, five orders of the class mammalia, and so on, the general character of each *class* being represented in a corresponding *order*, and the same character being further reflected even in the *families* or *genera* into which the orders were subdivided. There were striking appearances of a basis of truth in this theory, though, in the excessive ardour of its first advocates, it was carried to a pitch of refinement in which nature was lost sight of, and the whole was greatly marred by the notion that all the groups arranged themselves in circles. Acknowledging the value of the theory as, with all its faults, a great step in philosophical zoology, I shall proceed to show what appeared to me as true grounds for some such arrangement of the animal kingdom.

To me, as to Mr. Macleay and his followers, the Birds present the clearest traces of a determinate grouping, with an analogous sub-grouping. We see three great divisions; first, birds of solitary, predaceous, carnivorous habits; second, birds of gregarious habits, accustomed to walking on the ground, slow of movement, large of bulk, generally granivorous, and harmless; third, birds which are, generally speaking, omnivorous, rapid of movement, comparatively of small bulk, not merely gregarious, but social, often marked by garrulity, imitative power, cunning, and mischievousness. The eagle and vulture mark the first; the common fowl, pigeons, and game birds, the second; the crow, pie, parrot, thrush, lark, sparrow, the third. As for sub-groupings, it would be rash to attempt precision; but certainly in the second, the geese, cranes, gallinæ, and pigeons, with their peculiarly innocent characters, might stand as representatives of the group itself, while the more carnivorous ducks, herons, and plovers appear in analogy to the predaceous or first group, and the rails to the third. In the third group, again, the three are not less strikingly represented by the following in succession —the shrikes and warblers,—the larks and sparrows,—the parrots, toucans, pies, starlings, &c.

If we start from the birds with these three general characters in our mind, we shall find that the reptiles fall under them in this order;—the Sauria—the Chelonia—the Batrachia. So do the Mammalia, after we have laid aside those which appear as lateral offshoots through the birds. They rank thus: the Carnivora—the Herbivora (using this term to include pachyderms, equidæ, and ruminants)—and the Primates. Thus, again, analyse the Herbivora, and it seems allowable to regard such animals as the pig and hippopotamus as representing the carnivores, the ruminants as representing the innocent group, and the equidæ, with their rapid movements and familiar character, as standing appositely to the third. So also, in the third, the bats—the sloths—and the apes — appear in precisely the same series of relations. Whether there be still another grade of sub-analogies, I will not take it upon me in any manner to pronounce.

It may here be remarked that this system is not affected by any determination which may be arrived at with regard to the genealogy of the birds, for these, whether descended from one order of reptiles or all three, would exhibit the same groupings. It may also be remarked that their supposed descendants, the Edentata, Rodentia, and Insectivora, conform to the relations as thus collocated. The Fish must not yet be speculated upon; but in the Mollusca, I am tempted to think that the relations apply in this order—Cephalopoda—Gasteropoda—Cochifera.

Even with those relations here indicated, we acquire—first the idea of three great strands of organic being, each composed of three inferior strands, respectively representing the principal lines, and which probably were the true genealogical series of our system. Verily, it would give us a curious conception of organic nature, if we could satisfy ourselves that, like chemistry, it had a mysterious foundation in mathematical proportions. Threes under threes, each subordinate three reflecting the trinity to which it belongs, and all others! Such an idea is obviously favourable to the development theory, as arguing a unity in animated nature, and the definite character of its entire constitution. It suggests how, under the flowing robes of nature, where all looks arbitrary and accidental, there is an artificiality of the most rigid kind. The Natural appears to sink into and merge in a higher Artificial. To adopt a comparison more apt than dignified, we may be said to be placed here as insects in a garden of the old style. Our first unassisted view is limited, and we perceive only the irregularities of the minute surface, and single shrubs which appear arbitrarily scattered. But our view at length extending and becoming more comprehensive, we begin to see parterres balancing each other, trees, statues, and arbours placed symmetrically, and that the whole is an assemblage of parts mutually reflective. It can scarcely be necessary to point to the inference hence arising with regard to the origination of nature in some Power, of which man's mind is a humble and faint representation. The insects of the garden, supposing them to be invested with reasoning power, and aware how artificial are their own works, might, of course, very reasonably conclude that, being in its totality an artificial object, the garden was the work of some maker or artificer. And so also, when we attain a knowledge of the artificiality which is at the basis of nature, must we conclude that nature is wholly the production of a being resembling, but infinitely greater than ourselves.

By the same light we are enabled to see more clearly than ever the providential arrangement with respect to the various characters of animals; some to draw nutriment directly from the vegetable kingdom; others to keep the numbers of these in check, and prevent their carcasses from cumbering the earth—to be, in fact, a medium for returning their constituent substances to the atmosphere from which these were originally extracted by the vegetation; others again destined to a higher and more intelligent enjoyment than either, and turning animal as well as vegetable substances to their use. It is most interesting also to trace by this light the perseverance of characters and habits, and even of points in organization, from grade to grade. Travelling in the east, we might see the gavial acting as the scavenger of the Ganges, and the dog serving the same purpose in the neglected streets of the great cities: the latter, a descendant of the line of being of which the former is an offshoot, merely serves on land the purpose served by his relative in the river. The vulture corresponds amongst birds, and the shark amongst fishes, to the dog amongst the mammalian carnivora: behold all of these animals furnished alike with the most acute powers of smell, for the discovery of their prey. A living naturalist speaks thus of the resemblance of the parrots to the monkeys:—"There can be little doubt that the parrots, among birds, emulate the monkeys among placentals: they eat all kinds of food they can procure; they obtain it in the same situations; they seek it in the same way,—by climbing,—for a parrot actually climbs like a monkey; it does not leap or run like other birds; but, like a monkey, or more especially a lemur, climbs slowly and solemnly from bough to bough: its toes are placed two and two, presenting an exact analogy to the opposable thumb of the Primates; and its foot is constantly used as a hand for conveying food to the mouth: its chattering voice is also similar, and in the gift of speech it rivals man himself: its large brain and peculiar tact in imitation are still additional similarities. I should, therefore, place the genus Psittacus as one of the Primates among birds.(82) The explanation is easy: the monkeys either are the descendants of the line which at an earlier period gave parrots, or the parrots come from a sub-line representing the monkeys in their greater line. In the same way, the pig is the relative or analogue of the duck, the bullock of the turkey, the squirrel of the monkey, the furtive springing cat of the equally furtive springing serpent, and so forth. Strange thus to trace in the humble and ancient animal a prophecy of the higher and more recent; the cephalopod, for example, foreshowing the shark—the shark the saurian, the saurian the vulture and mammalian carnivore. Equally curious to see the migratory habits of the chelonia reproduced in the migratory habits which attach both to birds and to the ruminants: thus the voyage of three thousand miles which the turtle will make in order to lay her eggs on Ascension island, the vast vernal flight of the swallow from Africa to England for incubation, the roaming disposition of the hyperborean deer and the American bison, are all kindred phenomena, comprehended under one law of their gracious Creator: each race and sub-race true from first to last to its allotted instincts.

A result of very profound interest may be expected from the perfect development of this view of the system of nature; it will enable us to see with tolerable distinctness the status of man as one of the vessels of life. Even from the sketch now before us we may draw some curious inferences. It appears that the stirps which terminates in the Primates is one which may be considered as central between the other two, combining characters from both, along with characters of its own. Its central sub-line is eminently eclectic, and particularly in its food, uniting the carnivorous instincts of the bats, on the one hand, with the phytophagous habits of the sloths, on the other. Sociality, vocality or the use of voice, a prehensive use of the extremities, imitativeness, drollery, sagacity, all form characteristics generally applicable to this line of animals. They are, in the reptilian grade, and perhaps in inferior grades also, rather below than above their fellows; but in the mammalian stage, they suddenly ascend to a pre-eminence, not by superior strength, but by greater relative magnitude of brain, by agility, and by the use of the hand. The signal superiority of the human species is thus prepared for and betokened in the immediately preceding portions of the line: it might have been seen, ere man existed, that a remarkable creature was coming upon the earth. The advance, nevertheless, which man makes above his immediate predecessors is very great; the highest of these cannot rank above an infant of our species in sagacity or morale.

This advance is no isolated fact. In each of the other sub-lines, there is what may be called a crowning species, greatly superior to its immediate ancestry, and these are the most distinguished of all animals. In the herbivorous stirps, the sub-carnivorous line is topped by the pig, the sub-herbivorous by the sheep, the sub-central by the horse. In the carnivorous stirps, the sub-central is topped by the dog. The horse and dog, so eminent for their sagacity and usefulness, are in this peculiar manner analogues to man, whom they serve so faithfully. A signal superiority, however, belongs to him as the centre and apex of all; the undoubted king and lord of this portion of animated nature. His greatness—considering him merely as a unit in the animal kingdom—lies primarily in the concentration of qualities which he derives from this situation. He is not an animal solely herbivorous, or solely carnivorous; solely innocent, or solely destructive. He has all these characters and habits, with the addition of others proper to his own family of being. There is great virtue in this principle of concentration, or, as it may rather be called, this universality of character. We see that an intensity of it marks all the greatest individuals of our species, such as Shakspeare and Scott, of whom it has been observed that they must have possessed within themselves, not only the poet, but the warrior, the statesman, the philosopher, and the man of affairs, and who, moreover, appear to have had the mild and manly, the moral and impulsive parts of our nature, in the finest balance.

When the naturalists of modern times began to inquire into the geographical distribution of plants and animals, they quickly found that the prevalent notion of their dispersion from one common centre was untenable. From facts observed by them, they have latterly concluded that, so far from this being the case, there are many provinces of the earth's surface occupied by plants and animals almost wholly peculiar, and which must accordingly have had a separate origin. Professor Henslow, of Cambridge, speaks of no fewer than forty-five such provinces for the vegetable kingdom alone.

A botanical or zoological province is generally isolated in some manner,—either as an island in the midst of a wide ocean—as, for example, St. Helena or the Isle de Bourbon—or as a portion of a continent separated from the rest either by a range of high mountains, or by the boundaries of a climate. It is also found that elevation of position comes to the same effect with regard to vegetation as advance in latitude; so that, as we ascend a lofty mountain in a tropical country, we gradually pass through zones exhibiting the plants of kinds appropriate to temperate and arctic regions. Even the neighbourhood of a salt marsh, however remotely placed amongst grounds of a different kind, exhibits plants appropriate to such a soil.

Fewer distinct zoological regions are enumerated, but perhaps only in consequence of imperfect observation. Here, however, the evidences against communication of organisms from one region to another are even more decided. If, however, it were surmised that the organisms of isolated regions had been communicated from other countries, and merely modified in their new abodes, the disproof of the conjecture would be more positive with regard to the zoology of the question than the botany. For, while it might appear possible that seeds had been floated even five hundred miles to a new soil like that of the Isle de Bourbon, how can we account, by such a supposition, for the existence there of bats, reptiles, and other animals, the progenitors of which could never have swam so far for the sake of a change of residence? This island, be it remarked, is of volcanic origin, and known to have become dry land at a comparatively recent period.

The two great continents of the earth are the first zoological divisions of its surface. The animals as well as plants of the old and new world are specifically different, with very few exceptions; that is, they are different in the degree which naturalists agree to consider as sufficient to establish distinct species. But even North and South America present different animals. We also find that the animals in the north and south of Asia are different, and that most of the African species are distinct from those of Asia.

The differences are in some instances so great as to be held by naturalists as generic. Beyond this point, however, there are parities or indentities. We see, for instance, in all these various regions, feline animals, ruminants, pachyderms, rodents, etc. Thus, for the lion and tiger of Asia, we have a different lion and the panther in Africa, the jaguar in South America, and the puma ranging from Brazil to Canada. Instead of the elk of Northern Europe and the argali of Siberia, we have, in North America, the moose deer and mountain sheep. Asia and Africa have elephants, to which the extinct mastodon of Northern Europe and the extinct mammoth of North America are parallels; and it now appears that even the horse, of which there are several varieties in the old world, was abundant in the new, at a period long antecedent to the introduction of the present breed by the colonists. Australia has its emeu, Africa its ostrich, and America her rhea, all similar animals, though specifically different. We find simiæ planted in three great regions—Southern Asia, Western Africa, and equinoctial America, but all of different character, those of America being peculiarly distinct in their want of the opposable thumb and of callosities in the seat, as also in the use of the tail as a prehensile instrument. Australia has only a few very unimportant mammalian animals of her own besides the marsupials, which are represented by a few species in America; but to the southern part of the latter continent are confined the whole family of the sloths. Africa, in like manner, has exclusive possession of the giraffe. To North America belongs a great number of genera of birds quite peculiar to it, and also a greater number and variety of the rodents than are found in other parts of the earth. Similar facts could be stated respecting other classes of animals; but I limit attention to the mammalia, as being the most restricted in number and the best known.

Some principles governing the parity and variation of the organisms spread over different regions have been observed. It is found, for instance, that there is more uniformity between two continents which are both in the north or south hemisphere, albeit divided by wide oceans, than between two portions of one continent extending into both of these hemispheres. North America is zoologically less allied to South America than it is to Northern Europe. An island, however far apart, is apt to show zoological features reflective of those of the nearest continent. Two countries, again, divided only by a narrow sea, have usually the same flora.

Some principle affecting the development of the higher animals can also be detected, in connexion with geological chronology. Startling as it may appear, we are now assured that the present great continent comprising Europe, Asia, and Africa, has been, with minor changes in the relative position of sea and land, one theatre of organic being since the commencement of the existence of land animals upon the surface of the earth; that is to say, there has been, on one part or another of this geographical area, an uninterrupted chain of living forms from an early period in the secondary formation. This is the zoological province whose history is presented by the geologists; it is the oldest we are acquainted with. There are, however, some isolated regions which are known with certainty to have been in a condition of dry land for a less space of time. Such are the volcanic islands, of which the Isle of Bourbon is an example. Such also are the Galapagos islands, placed in the Pacific, above five hundred miles from South America. Now it is remarkable in such regions to find the mammalia either wholly wanting or in very small numbers.

Australia itself—a fifth great section of the habitable globe—appears to be one of these regions of an incomplete zoology. It is well known to have no native mammalia besides that humble implacental kind which are nearly peculiar to it, and a few rodents and bats. Professor Owen remarks how the fishes of the oolitic era—acrodus psammodus, etc.—with the contemporary mollusks (trigoniæ and terebratulæ), which served these fishes for food, are represented in the living cestraceon which swims the Australian seas, with exactly the same sea mollusks to yield them sustenance. "Araucariæ and cycadeous plants likewise," he says, "flourish on the Australian continent, where marsupial quadrupeds abound, and thus appear to complete a picture of an ancient condition of the earth's surface, which has been superseded in our hemisphere by other strata and a higher type of mammalian organization."(83)

Such being the facts of the case, we are to inquire whether they best agree with the hypothesis of an origin of organisms by special Divine exertion, or that of their origination in Divine power working in the manner of natural law; and also, if the latter supposition appear preferable, how far the facts agree with the plan of animated nature delineated in the preceding pages.

It is remarkable at the very first that there is any variety of species in different regions, more especially as the species of one region usually thrive when transplanted to another of generally similar character in point of soil and climate. Had organisms been produced by special attention—taking this according to any ideas we can form of it—we might rather have expected to see identical plants in similar countries. It will not avail here to attribute the variation to the cultivation of variety as a principle on the part of the Divine Disposer, for the differences evidently follow no such principle, being of various intensities in near and in remote situations. In this consideration, there is a great obstacle to the reception of the special-exertion hypothesis. It seems much more likely that organisms took their rise in germs springing from inorganic elements; which germs being different in accordance with such slight local differences in the combinations of the elements as physical studies inform us of, and the external conditions attending their development being also locally different, the resulting vessels of life were various accordingly. Such variations of result are exactly of a piece with hundreds of other simply natural events—for example, the difference of animals born at one birth; and similar natural causes are therefore presumable for them.

The facts respecting the geographical distribution of organisms are in perfect harmony with the plan of their origin, which, from the geological history, the principles of organic development, and their external affinities, has here been sketched. That plan *necessitates* the facts of distribution, which the other hypothesis does not. First, a development of vegetable organisms, we shall say, taking place in the sea, it is exactly what we would expect that they should spread upon the neighbouring shores in every direction, and that we should thus, for example, have one flora surrounding the Mediterranean,—which is the fact. So it is also likely that islands should botanically and zoologically partake of the character of the neighbouring continents. In regions, on the other hand, sufficiently distant to be involved in the influence of diverse foci of life, we are to expect differences proportioned to the difference of original elements, and also of conditions attending the development of the various lines; there we may only expect to see such ultimate parities attained as those between the emeu of Australia and the rhea of America, or the jaguar and puma of the latter continent and the tiger of Asia. Here it is important to observe that the cetacea and the marine birds in the neighbourhood of the different continents, present less variation than do the land mammals and birds: they have advanced less way along the lines, and have been less exposed to the conditions productive of external variations. In the case of a well-defined zoological region, such as the northern parts of North America, we see the indigenous animals expressly confined to those families which our plan sets forth as springing from the marine tribes above adverted to. There is the polar bear, with his various progeny, the brown bear, black bear, the wolf, fox, and dog; these from a phocal ancestry. The sea-otter, sprung from an allied stock, gives birth to the few musteline animals which dwell in these dreary regions. Then we have herbivorous cetes, giving rise to the moose deer and musk ox, these again being the progenitors of the goat and sheep. And finally, we have the unusually numerous rodents from the aquatic birds, which nowhere are seen in greater numbers than on the borders of the Arctic Ocean. Such, with the mole, is the whole show of mammalia in this province: it is, it will be observed, of a limited kind; but it is interesting to remark that it presents nearly all the animals of that class, which we have supposed from their affinities to be descended from the marine families of which there is such abundance upon the adjacent ocean. And, supposing this ocean to be the *berceau* of these land animals, we can easily see why they should be more akin to the terrestrial mammalia of Northern Europe than to those of South America. The Northern Ocean, spreading in one character of climate along the confines of the two first regions, enables a set of maritime animals which may have come into existence in any part of it, to spread into the two continents alike—the same bear, nearly the same ruminants, and so forth; but, if the Southern Ocean have possessed, as is likely from its distance, a different development of animal life from the Northern, and be supposed as sending off terrestrial animals in like manner into South America, the interposition of several great zones of different climate stands forth as a sufficient reason why there should not have been the same communication of zoological forms in that case to the hyperborean seas, as there was from those laving North America to those which dash upon Scandinavia, Russia, and Siberia.

The hypothesis is equally applicable to the imperfect developments of life upon the more recently raised lands, such as the Galapagos islands and Australia. Development is a matter of time, and in the case of these regions, the full time has not yet elapsed. It is therefore exactly what we might expect, upon the natural hypothesis, that, in these regions, animal life should have yet hardly reached the mammalian stage, the point which was attained in our elder and greater province about the time of the oolite.(84) But no rational cause for this imperfect zoological show can be presented in consonance with the plan of special exertions. Its advocates can only refer to some vague assumption regarding the Divine will, to which it is treason against judgment to come, while a single surmise of natural procedure remains unexhausted.

EARLY HISTORY OF MANKIND.

The human race is known to consist of numerous nations, displaying considerable differences of external form and colour, and speaking in general different languages. This has been the case since the commencement of written record. It is also ascertained that the external peculiarities of particular nations do not change rapidly. While a people remain upon one geographical area, and under the influence of one set of conditions, they always exhibit a tendency to persistency of type, insomuch that a subordinate admixture of various type is usually obliterated in a few generations. Numerous as the varieties are, they have all been found classifiable under five leading ones:—1. The Caucasian, or Indo-European, which extends from India into Europe and Northern Africa; 2. The Mongolian, which occupies Northern and Eastern Asia; 3. The Malayan, which extends from the Ultra-Gangetic Peninsula into the numerous islands of the South Seas and Pacific; 4. The Negro, chiefly confined to Africa; 5. The aboriginal American. Each of these is distinguished by certain general features of so marked a kind, as to suggest to many inquirers that they have had distinct or independent origins. Of these peculiarities, colour is the most conspicuous: the Caucasians are generally white, the Mongolians yellow, the Negroes black, and the Americans red. The opposition of two of these in particular, white and black, is so striking, that of them, at least, it seems almost necessary to suppose separate origins. Of late years, however, the whole of this question has been subjected to a rigorous investigation by a British philosopher, who has been remarkably successful in adducing evidence that the human race might have had one origin, for anything that can be inferred from external peculiarities.

It appears from this inquiry,(85) that colour and other physiological characters are of a more superficial and accidental nature than was at one time supposed. One fact is at the very first extremely startling, that there are nations, such as the inhabitants of Hindostan, apparently one in descent, which nevertheless contain groups of people of almost all shades of colour, and likewise discrepant in other of those important features on which much stress has been laid. Some other facts, which may be stated in brief terms, are scarcely less remarkable. In Africa, there are Negro nations, —that is, nations of intensely black complexion, as the Jolofs, Mandingoes, and Kafirs, whose features and limbs are as elegant as those of the best European nations. While we have no proof of Negro races becoming white in the course of generations, the converse may be held as established, for there are Arab and Jewish families of ancient settlement in Northern Africa, who have become as black as the other inhabitants. There are also facts which seem to show the possibility of a natural transition by generation from the black to the white complexion, and from the white to the black. True whites (apart from Albinoes) are not unfrequently born among the Negroes, and the tendency to this singularity is transmitted in families. There is, at least, one authentic instance of a set of perfectly black children being born to an Arab couple, in whose ancestry no such blood had intermingled. This occurred in the valley of the Jordan, where it is remarkable that the Arab population in general have flatter features, darker skins, and coarser hair, than any other tribes of the same nation.(86)

The style of living is ascertained to have a powerful effect in modifying the human figure in the course of generations, and this even in its osseous structure. About two hundred years ago, a number of people were driven by a barbarous policy from the counties of Antrim and Down, in Ireland, towards the sea-coast, where they have ever since been settled, but in unusually miserable circumstances even for Ireland; and the consequence is, that they exhibit peculiar features of the most repulsive kind, projecting jaws with large open mouths, depressed noses, high cheek bones, and bow legs, together with an extremely diminutive stature. These, with an abnormal slenderness of the limbs, are the outward marks of a low and barbarous condition all over the world; it is particularly seen in the Australian aborigines. On the other hand, the beauty of the higher ranks in England is very remarkable, being, in the main, as clearly a result of good external conditions. "Coarse, unwholesome, and ill-prepared food," says Buffon, "makes the human race degenerate. All those people who live miserably are ugly and ill-made. Even in France, the country people are not so beautiful as those who live in towns; and I have often remarked that in those villages where the people are richer and better fed than in others, the men are likewise more handsome, and have better countenances." He might have added, that elegant and commodious dwellings, cleanly habits, comfortable clothing, and being exposed to the open air only as much as health requires, co-operate with food in increasing the elegance of a race of human beings.

Variations also arise, through inexplicable causes, amidst a state of things generally permanent. They tend most to occur among the humbler families of plants and animals, but also frequently take place in the very highest. A notable instance of variety-production in an animal family by no means low, is often referred to, as having happened under the observation of persons still alive to attest it. On a New England farm there originated, in the latter part of the last century, a variety of sheep with unusually short legs, which was kept up by breeding, on account of the convenience in that country of having sheep which are unable to leap over low fences. The starting and maintaining a *breed* of cattle, that is, a variety marked by some desirable peculiarity, are familiar to a large class of persons. It appears only necessary, when a variety has been thus produced, that a union should take place between individuals similarly characterized, and that the conditions under which it has been produced should be persisted in, in order to establish it. Early in the last century, a man named Lambert was born in Suffolk, with semi-horny excrescences, of about half an inch long, thickly growing all over his body. The peculiarity was transmitted to his children, and was last heard of in a third generation. The peculiarity of six fingers on the hand and six toes on the feet, appears in like manner in families which have no record nor tradition of such a peculiarity having affected them at any former period, and it is then sometimes seen to descend through several generations. It was Mr. Lawrence's opinion, that a pair, in which both parties were so distinguished, might be the progenitors of a new variety of the race, who would be thus marked in all future time. We have but obscure notions of the laws which regulate this variability within specific limits ; but we see them continually operating, and they are obviously favourable to the supposition that all the great families of men may have been of one stock.

The tendency of the modern study of the languages of nations is to the same point. The last fifty years have seen this study elevated to the character of a science, and the light which it throws upon the history of mankind is of a most remarkable nature.

Following a natural analogy, philologists have thrown the earth's languages into a kind of classification : a number bearing a considerable resemblance to each other, and in general geographically near, are styled a *group* or *sub-family ;* several groups, again, are associated as a *family*, with regard to more general features of resemblance. Six families are spoken of.

The Indo-European family nearly coincides in geographical limits with those which have been assigned to that variety of mankind which generally shows a fair complexion, called the Caucasian variety. It may be said to commence in India, and thence to stretch through Persia into Europe, the whole of which it occupies, excepting Hungary, the Basque provinces of Spain, and Finland. Its sub-families are the Sanskrit, or ancient language of India, the Persian, the Slavonic, Celtic, Gothic, and Pelasgian. The Slavonic includes the modern languages of Russia and Poland. Under the Gothic, are (1) the Scandinavian tongues, the Norske, Swedish, and Danish; and (2) the Teutonic, to which belong the modern German, the Dutch, and our own Anglo-Saxon. I give the name of Pelasgian to the group scattered along the north shores of the Mediterranean, the Greek and Latin, including the modifications of the latter under the names of Italian, Spanish, &c. The Celtic was, from two to three thousand years ago, the speech of a considerable tribe dwelling in Western Europe; but these have since been driven before superior nations into a few corners, and are now only to be found in the highlands of Scotland, Ireland, Wales, Cornwall, and certain parts of France. The Gaelic of Scotland, Erse of Ireland, and the Welsh, are the only living branches of this sub-family of languages.

The resemblances amongst languages are of two kinds,—identity of words, and identity of grammatical forms; the latter being now generally considered as the most important towards the argument. When we inquire into the first kind of affinity among the languages of the Indo-European family, we are surprised at the great number of common terms which exist among them, and these referring to such primary ideas as to leave no doubt of their having all been derived from a common source. Colonel Vans Kennedy presents nine hundred words common to the Sanskrit and other languages of the same family. In the Sanskrit and Persian, we find several which require no sort of translation to an English reader, as *pader*, *mader*, *sunu*, *dokhter*, *brader*, *mand*, *vidhava;* likewise *asthi*, a bone, (Greek, *osteon;*) *denta*, a tooth, (Latin, *dens*, *dentis;*) *eyeumen*, the eye; *brouwa*, the eye-brow, (German, *braue;*) *nasa*, the nose; *karu*, the hand, (Gr. *cheir;*) *genu*, the knee, (Lat. *genu;*) *ped*, the foot, (Lat. *pes*, *pedis;*) *hrti*, the heart; *jecur*, the liver, (Lat. *jecur;*) *stara*, a star; *gela*, cold, (Lat. *gelu*, ice;) *aghni*, fire, (Lat. *ignis;*) *dhara*, the earth, (Lat. *terra*, Gaelic, *tir;*) *arrivi*, a river; *nau*, a ship, (Gr. *naus*, Lat. *navis;*) *ghau*, a cow; *sarpam*, a serpent.

The inferences from these verbal coincidences were confirmed in a striking manner when Bopp and others investigated the grammatical structure of this family of languages. Dr. Wiseman pronounces that the great philologist just named, "by a minute and sagacious analysis of the Sanskrit verb, compared with the conjugational system of the other members of this family, left no doubt of their intimate and positive affinity." It was now discovered that the peculiar terminations or inflections by which persons are expressed throughout the verbs of nearly the whole of these languages, have their foundations in pronouns; the pronoun was simply placed at the end, and thus became an inflection. "By an analysis of the Sanskrit pronouns, the elements of those existing in all the other languages were cleared of their anomalies; the verb substantive, which in Latin is composed of fragments referable to two distinct roots, here found both existing in regular form; the Greek conjugations, with all their complicated machinery of middle voice, augments, and reduplications, were here found and illustrated in a variety of ways, which a few years ago would have appeared chimerical. Even our own language may sometimes receive light from the study of distant members of our family. Where, for instance, are we to seek for the root of our comparative *better?* Certainly not in its positive, good, nor in the Teutonic dialects in which the same anomaly exists. But in the Persian we have precisely the same comparative, *behter*, with exactly the same signification, regularly formed from its positive *beh*, good." ([87])

The second great family of languages is the *Syro-Phœnician*, comprising the Hebrew, Syro-Chaldaic, Arabic, and Gheez or Abyssinian, being localized principally in the countries to the west and south of the Mediterranean. Beyond them, again, is the *African* family, which, as far as research has gone, seems to be in like manner marked by common features, both verbal and grammatical. The fourth is the *Polynesian* family, extending from Madagascar on the west, through the Indian Archipelago, besides taking in the Malayan dialect from the continent of India, and comprehending Australia and the islands of the western portion of the Pacific. This family, however, bears such an affinity to that next to be described, that Dr. Leyden and some others do not give it a distinct place as a family of languages.

The fifth family is the *Chinese*, embracing a large part of China, and most of the regions of Central and Northern Asia. The leading features of the Chinese language are, its consisting altogether of monosyllables, and being destitute of all grammatical forms, except certain arrangements and accentuations, which vary the sense of particular words. It is also deficient in some of the consonants most conspicuous in other languages, b, d, r, v, and z; so that this people can scarcely pronounce our speech in such a way as to be intelligible: for example, the word Christus they call *Kuliss-ut-oo-suh*. The Chinese, strange to say, though they early attained to a remarkable degree of civilization, and have preceded the Europeans in many of the most important inventions, have a language which resembles that of children, or deaf and dumb people. The sentence of short, simple, unconnected words, in which an infant amongst us attempts to express some of its wants and its ideas—the equally broken and difficult terms which the deaf and dumb express by signs, as the following passage of the Lord's Prayer!—"Our Father, heaven in, wish your name respect, wish your soul's kingdom providence arrive, wish your will do heaven earth equality," &c.—these are like the discourse of the refined people of the so-called Celestial Empire. An attempt was made by the Abbé Sicard to teach the deaf and dumb grammatical signs; but they persisted in restricting themselves to the simple signs of ideas, leaving the structure undetermined by any but the natural order of connexion. Such is exactly the condition of the Chinese language.

Crossing the Pacific, we come to the last great family, in the languages of the aboriginal Americans, which have all of them features in common, proving them to constitute a group by themselves, without any regard to the very different degrees of civilization which these nations had attained at the time of the discovery. The common resemblance is in the grammatical structure as well as in words, and the grammatical structure of this family is of a very peculiar and complicated kind. The general character in this respect has caused the term Polysynthetic to be applied to the American languages. A long many-syllabled word is used by the rude Algonquins and Delawares to express a whole sentence: for example, a woman of the latter nation, playing with a little dog or cat, would perhaps be heard saying, "*kuligatschis*," meaning, "give me your pretty little paw;" the word, on examination, is found to be made up in this manner: *k*, the second personal pronoun; *uli*, part of the word wulet, pretty; *gat*, part of the word wichgat, signifying a leg or paw: *schis*, conveying the idea of littleness. In the same tongue, a youth is called *pilape*, a word compounded from the first part of pilsit, innocent, and the latter part of lenape, a man. Thus, it will be observed, a number of parts of words are taken and thrown together, by a process which has been happily termed *agglutination*, so as to form one word, conveying a complicated idea. There is also an elaborate system of inflection; in nouns, for instance, there is one kind of inflection to express the presence or absence of vitality, and another to express number. The genius of the language has been described as accumulative; it "tends rather to add syllables or letters, making farther distinctions in objects already before the mind, than to introduce new words."(88) Yet it has also been shown very distinctly, that these languages are based in words of one syllable, like those of the Chinese and Polynesian families; all the primary ideas are thus expressed: the elaborate system of inflection and agglutination is shown to be simply a farther development of the language-forming principle, as it may be called—or the Chinese system may be described as an arrestment of this principle at a particular early point. It has been fully shown, that between the structure of the American and other families sufficient affinities exist to make a common origin or early connexion extremely likely. The verbal affinities are also very considerable. Humboldt says, "In eighty-three American languages examined by Messrs. Barton and Vater, one hundred and seventy words have been found, the roots of which appear to be the same; and it is easy to perceive that this analogy is not accidental, since it does not rest merely upon imitative harmony, or on that conformity of organs which produces almost a perfect identity in the first sounds articulated by children. Of these one hundred and seventy words which have this connexion, three-fifths resemble the Manchou, the Tongouse, the Mongol, and the Samoyed; and two-fifths, the Celtic and Tchoud, the Biscayan, the Coptic, and Congo languages. These words have been found by comparing the whole of the American languages with the whole of those of the Old World; for hitherto we are acquainted with no American idiom which seems to have an exclusive correspondence with any of the Asiatic, African, or European tongues.(89) Humboldt and others considered these words as brought into America by recent immigrants; an idea resting on no proof, and which is much discountenanced by the common words being chiefly those which represent primary ideas; besides, we now know, what was not formerly perceived or admitted, that there are great affinities of structure also. I may here refer to a curious mathematical calculation by Dr. Thomas Young, to the effect, that if three words coincide in two different languages, it is ten to one they must be derived in both cases from some parent language, or introduced in some other manner. "Six words would give more," he says, "than seventeen hundred to one, and eight near 100,000; so that in these cases the evidence would be little short of absolute certainty." He instances the following words to show a connexion between the ancient Egyptian and the Biscayan:—

	Biscayan.	Egyptian.
New	Beria	Beri.
A dog	Ora	Whor
Little	Gutchi	Kudchi.
Bread	Ognia	Oik.
A wolf	Otgsa	Ounsh.
Seven	Shashpi	Shashf.

Now, as there are, according to Humboldt, one hundred and seventy words common to the languages of the new and old continents, and many of these are expressive of the most primitive ideas, there is, by Dr. Young's calculation, overpowering proof of the original connexion of the American and other human families.

It seems to me, after a full consideration of this kind of evidence, in connexion with the development theory, that there is no reason to regard more than two local origins for the human race as *necessary;* namely, one for the Asiatic, American, and European varieties, and another for the African. The former seems to be connected with the great development of the quadrumana in southern Asia; the latter, with that of western Africa.

What is known of the migrations of the first group of races, and also their traditions, point to southern Asia as the scene of their origin. The lines of these migrations all converge, and are concentrated about the region of Hindostan. The language, religion, modes of reckoning time, and some other peculiar ideas of the Americans, are now believed to refer their origin to North-Eastern Asia. Trace them further back in the same direction, and we come to the north of India. The history of the Celts and Teutones represents them as coming from the east, the one after the other, successive waves of a tide of population flowing towards the north-west of Europe: this line being also traced back, rests finally at the same place. So does the line of Iranian population, which has peopled the east and south shores of the Mediterranean, Syria, Arabia, and Egypt. The Malay variety, again, rests its limit in one direction on the borders of India. Standing on that point, it is easy to see how this great section of the human family, originating there, might spread out in different directions, passing into varieties of aspect and of language as they spread, the Malay variety proceeding towards the Oceanic region, the Mongolians to the east and north, and sending off the red men as a sub-variety, the European population going off to the north-westward, and the Syrian, Arabian, and Egyptian, towards the countries which they are known to have so long occupied. The Negro alone is here unaccounted for; and that race is the one most likely to have had an independent origin, seeing that it is a type so peculiar in an inveterate black colour, and so humble in development. The traditions of the first section exhibit an agreement with this view of its origin. There is one among the Hindoos which places the cradle of the human family in Thibet; another makes Ceylon the residence of the first man.

It is one of those things necessary to complete our view of the world as wholly under law, that civilization should appear to be capable of arising in a natural manner. The tendency of the uninstructed mind is to suppose supernatural causes for such phenomena, and there are even educated persons whose habits of thinking predispose them to take similar views. By one of these it has lately been argued, that facts are in favour of a supernatural origin for civilization. We see, says this authority, many examples of nations falling away from civilization into barbarism, while, in some regions of the earth, the history of which we do not clearly know, there are remains of works of art far superior to any which the present unenlightened inhabitants could have produced. The appearances are therefore in favour of a decline from some great and wide-spread civilization of early times. To this it may be answered that these appearances are partial, compared with what we know from history of an advance and an extension of civilization from early times. The decadences from civilization in such regions as Medea or Greece are only such local instances of failure or suppression as might be expected when civilization was cradled amidst nations generally barbarous, and who had an interest in attacking their wealthier neighbours. This, at least, were as legitimate an inference from the facts which are known. But it is also alleged that we know of no such thing as civilization being ever self-originated. It is always seen to be imparted from one people to another. Hence, of course, we must infer that civilization at the first could only have been of supernatural origin. There again it may be answered—It is not to be expected that we should know of any of the ancient nations originating civilization amongst themselves, for history commences when they are already somewhat advanced in that course. As to the instances in which it has been seen to be imparted, these may be true, without necessarily implying that there was not a natural origin of civilization in some of the earlier nations. It may be questioned, however, if these instances are in themselves true. The efforts made to trace the civilizations of Central America to Egypt and other countries have all signally failed. There is even a fallacy in supposing that, because Greece, for example, obtained certain kinds of knowledge and forms of art from Egypt, its whole civilization was descended from that and similar quarters. There are characteristic features in all civilizations which support the idea that they are usually for the most part original. There is not only this peculiarity, but there is an isolatedness in some civilizations, which tallies much better with the theory of their independent than their imparted origin. When it is said that civilization is never seen to arise without aid from external sources, an affirmation is made on very imperfect grounds. It appears that civilization does sometimes rise in a manner clearly independent amongst a horde of people generally barbarous. A striking instance is described in the laborious work of Mr. Catlin on the North-American tribes. Far placed among those which inhabit the vast region of the north-west, and quite beyond the reach of any influence from the whites, he found a small tribe living in a fortified village, where they cultivated the arts of manufacture, realized comforts and luxuries, and had attained to a remarkable refinement of manners, insomuch as to be generally called "the polite and friendly Mandans." They were also more than usually elegant in their persons, and of every variety of complexion between that of their compatriots and a pure white. Up to the time of Mr. Catlin's visit, these people had been able to defend themselves and their possessions against the roving bands which surrounded them on all sides; but, soon after, they were attacked by small-pox, which cut them all off except a small party, whom their enemies rushed in upon and destroyed to a man. What is this but a repetition on a small scale, of phenomena with which ancient history familiarizes us—a nation rising in arts and elegancies amidst barbarous neighbours, but at length overpowered by the rude majority, leaving only a Tadmor or a Luxor as a monument of itself to beautify the waste? What can we suppose the nation which built Palenque and Copan to have been but only a kind of Mandan tribe, which chanced to have made its way further along the path of civilization and the arts, before the barbarians broke in upon it? The flame essayed to rise in many parts of the earth; but there were strong agencies working against it, and down it accordingly went, times without number; yet there was always a vitality in it, nevertheless, and a tendency to progress, and at length it seems to have attained a strength against which the powers of barbarism can never more prevail. The state of our knowledge of uncivilized nations is very apt to make us fall into error on this subject. They are generally supposed to be all at one point in barbarism, which is far from being the case, for in the midst of every great region of uncivilized men, such as North America, there are nations partially refined. The Jolofs, Mandingoes, and Kafirs, are African examples, where a natural and independent origin for the improvement which exists, is as unavoidably to be presumed as in the case of the Mandans.([90])

The most conclusive argument against the original civilization of mankind is to be found in the fact that we do not now see civilization existing anywhere except in certain conditions altogether different from any we can suppose to have existed at the commencement of our race. To have civilization, it is necessary that a people should be numerous and closely placed; that they should be fixed in their habitations, and safe from violent external and internal disturbance; that a considerable number of them should be exempt from the necessity of drudging for immediate subsistence. Feeling themselves at ease about the first necessities of their nature, including self-preservation, and daily subjected to that intellectual excitement which society produces, men begin to manifest what is called civilization; but never in rude and shelterless circumstances, or when widely scattered. Even civilized men, when transferred to a wide wilderness, where each has to work hard and isolatedly for the first requisites of life, soon show a retrogression to barbarism: witness the plains of Australia, as well as the backwoods of Canada and the prairies of Texas. Fixity of residence and thickening of population are perhaps the prime requisites for civilization, and hence it will be found that all civilizations as yet known have taken place in regions physically limited. That of Egypt arose in a narrow valley hemmed in by deserts on both sides. That of Greece took its rise in a small peninsula bounded on the only land side by mountains. Etruria and Rome were naturally limited regions. Civilizations have taken place at both the eastern and western extremities of the elder continent—China and Japan, on the one hand; Germany, Holland, Britain, France, on the other, —while the great unmarked tract between contains nations decidedly less advanced. Why is this, but because the sea in both cases has imposed limits to further migration, and caused the population to settle and condense?—the conditions most necessary for social improvement.([91]) Even the simple case of the Mandans affords an illustration of this principle; for Mr. Catlin expressly, though without the least regard to theory, attributes their improvement to the fact of their being a small tribe, obliged, by fear of their more numerous enemies, to *settle in a permanent village*, so fortified as to ensure their preservation. "By this means," says he, "they have advanced further in the arts of manufacture, and have supplied their lodges more abundantly with the comforts and even luxuries of life than any Indian nation I know of. The consequence of this," he adds, "is, that the tribe have taken many steps ahead of other tribes *in manners and refinements*."

These conditions can only be regarded as natural laws affecting civilization. It is also necessary for a civilization that at least a portion of the community should be placed above mean and engrossing toils. Man's mind is subdued, like the dyer's hand, to that it works in. In rude and difficult circumstances, we unavoidably become rude, because then only the inferior and harsher faculties of our nature are called into exercise. When, on the contrary, there is leisure and abundance, the self-seeking and self-preserving instincts are allowed to rest, the gentler and more generous sentiments are evoked, and man becomes that courteous and chivalric being which he is found to be amongst the upper classes of almost all civilized countries. These, then, may be said to be the chief natural laws concerned in the moral phenomenon of civilization. If I am right in so considering them, it will, of course, be readily admitted that the earliest families of the human race, although they might be simple and innocent, could not have been in anything like a civilized state, seeing that the conditions necessary for that state could not have then existed. Let us only for a moment consider some of the things requisite for their being civilized,—namely, a set of elegant homes ready furnished for their reception, fields, ready cultivated to yield them food without labour, stores of luxurious appliances of all kinds, a complete social enginery for the securing of life and property,—and we shall turn from the whole conceit as one worthy only of the uninstructed mind.

Yet, as has been remarked, the earliest families might be simple and innocent, while at the same time unskilled and ignorant, and obliged to live upon only those substances which they could readily procure. The traditions of all nations refer to such a state as that in which mankind were at first: perhaps it is not so much a tradition as an idea which the human mind naturally inclines to form respecting the fathers of the race; but nothing that we see of mankind absolutely forbids our entertaining this idea, while there are some considerations rather favourable to it. A few families, in a state of nature, living near each other, in a country supplying the means of subsistence abundantly, are generally simple and innocent; their instinctive and perceptive faculties are also apt to be active, although the higher intellect may be dormant. If we therefore presume India to have been the cradle of the principal portion of our race, they might at first exemplify a kind of golden age; but it could not be of long continuance. The very first movements from the primal seat would be attended with deterioration, nor could there be any tendency to true civilization till groups had settled and thickened in particular seats physically limited.

The causes of the various external peculiarities of mankind now require some attention. Why, it is asked, are the Africans black, and generally marked by ungainly forms; why the flat features of the Chinese, and the comparatively well-formed figures of the Caucasians? Why the Mongolians generally yellow, the Americans red, and the Caucasians white? These questions were complete puzzles to all early writers; but physiology has lately thrown a great light upon them. It is now shown that the brain, after completing the series of animal transformations, passes through the characters in which it appears in the Negro, Malay, American, and Mongolian nations, and finally becomes Caucasian. The face partakes of these alterations. "One of the earliest points in which ossification commences is the lower jaw. This bone is consequently sooner completed than the other bones of the head, and acquires a predominance, which, as is well known, it never loses in the Negro. During the soft pliant state of the bones of the skull, the oblong form which they naturally assume, approaches nearly the permanent shape of the Americans. At birth, the flattened face, and broad smooth forehead of the infant, the position of the eyes rather towards the side of the head, and the widened space between, represent the Mongolian form; while it is only as the child advances to maturity, that the oval face, the arched forehead, and the marked features of the true Caucasian, become perfectly developed."([92]) *The leading characters, in short, of the various races of mankind, are simply representations of particular stages in the development of the highest or Caucasian type.* The Negro exhibits permanently the imperfect brain, projecting lower jaw, and slender bent limbs, of a Caucasian child, some considerable time before the period of its birth. The aboriginal American represents the same child nearer birth. The Mongolian is an arrested infant newly born. And so forth. All this is as respects form; (93) but whence colour? This might be supposed to have depended on climatal agencies only; but it has been shown by overpowering evidence to be independent of these. In further considering the matter, we are met by the very remarkable fact that colour is deepest in the least perfectly developed type, next in the Malay, next in the American, next in the Mongolian, the very order in which the degrees of development are ranged. *May not colour, then, depend upon development also?* We do not, indeed, see that a Caucasian fœtus at the stage which the African represents is black; neither is a Caucasian child yellow, like the Mongolian. But the case of a Caucasian fœtus, or child, at any of its stages of development, is different from that of a being whose *mature form* only comes up to the same point. When a being is presented, who at full time has only attained a point of formation such as the Caucasian passed at a comparatively early stage of this embryotic history, there may be a character of skin liable to a certain tinting on being exposed. Development being arrested at so immature a stage in the case of the Negro, the skin may take on the colour as an unavoidable consequence of its imperfect organization. It is favourable to this view, that Negro infants are not deeply black at first, but only acquire the full colour after exposure for some time to the atmosphere; also that the parts of the body concealed by clothing are not generally of so deep a hue as the face and hands. The phenomenon, in short, appears identical in character with the photographic process; not a result of the action of heat, as has been so long blunderingly supposed, but of light! It takes its place under the infant science of actino-chemistry, to which, perhaps, many other remarkable phenomena connected with the natural history of our race will yet be referred. This view, seeming to account for all the varieties of mankind as only the result of so many gradations in the developing power of the human mothers, is favourable to the doctrine of one origin; but it cannot be considered as settling the question, seeing that separate developments may have attained various points in the scale of the human organization—as one of the pachydermatous lines has reached the full equine form in Asia, but only the comparatively humble quagga in Africa.

We have seen that the traces of a common origin in all languages afford a ground of presumption for the unity of at least the principal portion of the human race. They establish a still stronger probability that that portion of mankind had not yet begun to disperse before they were possessed of a means of communicating their ideas by conventional sounds—in short, speech. This is a gift so peculiar to man, and in itself so remarkable, that there is a great inclination to surmise a miraculous origin for it, although there is no proper ground, or even support, for such an idea in Scripture, while it is clearly opposed to everything else we know with regard to the providential arrangements for the creation of our race. Here, as in other cases, a little observation of nature might have saved much vain discussion. The real character of language itself has not been thoroughly understood. Language, in its most comprehensive sense, is the communication of ideas by whatever means. Ideas can be communicated by looks, gestures, and signs of various other kinds, as well as by speech. The inferior animals possess some of those means of communicating ideas, and they have likewise a silent and unobservable mode of their own, the nature of which is a complete mystery to us, though we are assured of its reality by its effects. Now, as the inferior animals were all in being before man, there was language upon earth long ere the history of our race commenced. The only additional fact in the history of language, which was produced by our creation, was the rise of a new mode of expression—namely, that by *sound-signs* produced by the vocal organs. In other words, speech was the only novelty in this respect attending the creation of the human race. No doubt it was an addition of great importance, for, in comparison with it, the other natural modes of communicating ideas are insignificant. Still, the main and fundamental phenomenon, language, as the communication of ideas, was no new gift of the Creator to man; and in speech itself, when we judge of it as a natural fact, we see only a result of some of those superior endowments of which so many others have fallen to our lot through the medium of a superior organization.

The first and most obvious natural endowment concerned in speech is that peculiar organization of the larynx, trachea, and mouth, which enables us to produce the various sounds required. Man started at first with this organization ready for use, a constitution of the atmosphere adapted for the sounds which that organization was calculated to produce, and, lastly, but not leastly, a mental power prompting to, and giving directions for, the expression of ideas. Such an arrangement of mutually adapted things was as likely to produce sounds as an Eolian harp placed in a draught is to give forth tones. It was unavoidable that human beings so organized, and in such a relation to external nature, should utter sounds, and also come to attach to these conventional meanings, thus forming the elements of spoken language. The great difficulty which has been felt is to account for man going in this respect beyond the inferior animals. There could have been no such difficulty, if speculators in this class of subjects had looked into physiology for an account of the superior vocal organization of man, and had they obtained a true science of mind to show man possessing a faculty for the expression of ideas which is only rudimental in the lower animals. Another difficulty has been in the consideration that, if men were at first utterly untutored and barbarous, they could scarcely be in a condition to form or employ language—an instrument which it requires the fullest powers of thought to analyze and speculate upon. This difficulty comes strangely from those who can see none in the miraculous imparting of a full vocabulary to beings as yet possessing but a portion of the ideas which an entire language represents.

But, in reality, it is not necessary to suppose the fathers of our race as early attaining to great proficiency in language, and, in the second, language itself seems to be amongst the things least difficult to be acquired, if we can form any judgment from what we see in children, most of whom have, by three years of age, while their information and judgment are still as nothing, mastered and familiarized themselves with a quantity of words, infinitely exceeding in proportion what they acquire in the course of any subsequent similar portion of time.

Discussions as to which parts of speech were first formed, and the processes by which grammatical structure and inflections took their rise, appear in a great measure needless, after the matter has been placed in this light. The mental powers could readily connect particular arbitrary sounds with particular ideas, whether those ideas were nouns, verbs, or interjections. As the words of all languages can be traced back into roots which are monosyllables, we may presume these sounds to have all been monosyllabic accordingly. The clustering of two or more together to express a compound idea, and the formation of inflections by additional syllables expressive of pronouns and such prepositions as of, by, and to, are processes which would or might occur as matters of course, being simple results of a mental power called into action, and partly directed, by external necessities. This power, however, as we find it in very different degrees of endowment in individuals, so would it be in different degrees of endowment in nations, or branches of the human family. Hence we find the formation of words, and the process of their composition and grammatical arrangement, in very different stages of development in different races. The Chinese have a language composed of a limited number of monosyllables, which they multiply in use by mere variations of accent, and which they have never yet attained the power of clustering or inflecting ; the language of this immense nation—the third part of the human race—may be said to be in the condition of infancy. The aboriginal Americans, so inferior in civilization, have, on the other hand, a language of the most elaborately composite kind, perhaps even exceeding, in this respect, the languages of the most refined European nations. These are but a few out of many facts tending to show that language is in a great measure independent of civilization, as far as its advance and development are concerned. Do they not also help to prove that cultivated intellect is not necessary for the origination of language?

Facts daily presented to our observation afford equally simple reasons for the almost infinite diversification of language. It is invariably found that, wherever society is at once dense and refined, language tends to be uniform throughout the whole population, and to undergo few changes in the course of time. Wherever, on the contrary, we have a scattered and barbarous people, we have great diversities, and comparatively rapid alterations of language; insomuch that, while English, French, and German, are each spoken with little variation by many millions, there are islands in the Indian archipelago, probably not inhabited by one million, but in which there are hundreds of languages, as diverse as are English, French, and German. It is easy to see how this should be. There are peculiarities in the vocal organization of every person, tending to produce peculiarities of pronunciation: for example, it has been stated that each child in a family of six gave the monosyllable, fly, in a different manner, (eye, fy, ly, &c.) until, when the organs were more advanced, correct example induced the proper pronunciation of this and similar words. Such departures from orthoepy are only to be checked by the power of example; but this is a power not always present, or not always of sufficient strength. The self-devoted Robert Moffat, in his work on South Africa, states, without the least regard to hypothesis, that amongst the people of the towns of that great region, "the purity and harmony of language is kept up by their pitchos or public meetings, by their festivals and ceremonies, as well as by their songs and their constant intercourse. With the isolated villages of the desert it is far otherwise. They have no such meetings; they are compelled to traverse the wilds, often to a great distance from their native village. On such occasions, fathers and mothers, and all who can bear a burden, often set out for weeks at a time, and leave their children to the care of two or three infirm old people. The infant progeny, some of whom are beginning to lisp, while others can just master a whole sentence, and those still further advanced, romping and playing together, the children of nature, through the live-long day, *become habituated to a language of their own.* The more voluble condescend to the less precocious, and thus, from this infant Babel, proceeds a dialect composed of a host of mongrel words and phrases, joined together without rule, and *in the course of a generation the entire character of the language is changed.*" (94) I have been told, that in like manner the children of the Manchester factory workers, left for a great part of the day, in large assemblages, under the care of perhaps a single elderly person, and spending the time in amusements, are found to make a great deal of new language. I have seen children in other circumstances amuse themselves by concocting and throwing into the family circulation entirely new words; and I believe I am running little risk of contradiction when I say that there is scarcely a family, even amongst the middle classes of this country, who have not some peculiarities of pronunciation and syntax, which have originated amongst themselves, it is hardly possible to say how. All these things being considered, it is easy to understand how mankind have come at length to possess between three and four thousand languages, all different at least as much as French, German, and English, though, as has been shown, resemblances suggesting a common origin are observable in most of them.

What has been said on the question whether mankind were originally barbarous or civilized, will have prepared the reader for understanding how the arts and sciences, and the rudiments of civilization itself, took their rise amongst men. The only source of fallacious views on this subject is the so frequent observation of arts, sciences, and social modes, forms, and ideas, being not indigenous where we see them now flourishing, but known to have been derived elsewhere: thus Rome borrowed from Greece, Greece from Egypt, and Egypt itself, lost in the mists of historic antiquity, is now supposed to have obtained the light of knowledge from some still earlier scene of intellectual culture. This has caused to many a great difficulty in supposing a natural or spontaneous origin for civilization and the attendant arts. But, in the first place, several stages of derivation are no conclusive argument against there having been an originality at some earlier stage. In the second, such observers have not looked far enough, for, if they had, they might have seen various instances of civilizations which it is impossible, with any plausibility, to trace back to a common origin with others; such are those of China and America. They would also have seen civilization springing up, as it were, like oases amongst the arid plains of barbarism, as in the case of the Mandans. A still more attentive study of the subject would have shown, amongst living men, the very psychological procedure on which the origination of civilization and the arts and sciences depended.

These things, like language, are simply the effects of the spontaneous working of certain mental faculties, each in relation to the things of the external world on which it was intended by creative Providence to be exercised. The monkeys themselves, without instruction from any quarter, learn to use sticks in fighting, and some build houses—an act which cannot in their case be considered as one of instinct, but of intelligence. Such being the case, there is no necessary difficulty in supposing how man, with his superior mental organization, (a brain five times heavier), was able, in his primitive state, without instruction, to turn many things in nature to his use, and commence, in short, the circle of the domestic arts. He appears, in the most unfavourable circumstances, to be able to provide himself with some sort of dwelling, to make weapons, and to practise some simple kind of cookery. But, granting, it will be said, that he can go thus far, how does he ever proceed further unprompted, seeing that many nations remain fixed for ever at this point, and seem unable to take one step in advance? It is perfectly true that there is such a fixation in many nations; but, on the other hand, all nations are not alike in mental organization, and another point has been established, that only when some favourable circumstances have settled a people in one place, do arts and social arrangements get leave to flourish. If we were to limit our view to humbly endowed nations, or the common class of minds in those called civilized, we should see absolutely no conceivable power for the origination of new ideas and devices. But let us look at the inventive class of minds which stand out amongst their fellows—the men, who, with little prompting or none, conceive new ideas in science, arts, morals—and we can be at no loss to understand how and whence have arisen the elements of that civilization which history traces from country to country throughout the course of centuries. See a Pascal reproducing the Alexandrian's problems at fifteen; a Ferguson making clocks from the suggestions of his own brain, while tending cattle on a Morayshire heath; a boy Lawrence, in an inn on the Bath road, producing, without a master, drawings which the educated could not but admire; or look at Solon and Confucius, devising sage laws, and breathing the accents of all but divine wisdom, for their barbarous fellow-countrymen, three thousand years ago—and the whole mystery is solved at once. Amongst the arrangements of Providence is one for the production of original, inventive, and aspiring minds, which, when circumstances are not decidedly unfavourable, strike out new ideas for the benefit of their fellow-creatures, or put upon them a lasting impress of their own superior sentiments. Nations, improved by these means, become in turn *foci* for the diffusion of light over the adjacent regions of barbarism—their very passions helping to this end, for nothing can be more clear, than that ambitious aggression has led to the civilization of many countries. Such is the process which seems to form the destined means for bringing mankind from the darkness of barbarism to the day of knowledge and mechanical and social improvement. Even the noble art of letters is but, as Dr. Adam Ferguson has remarked, "a natural produce of the human mind, which will rise spontaneously, wherever men are happily placed;" original alike amongst the ancient Egyptians and the dimly monumented

Toltecans of Yucatan. "Banish," says Dr. Gall, "music, poetry, painting, sculpture, architecture, all the arts and sciences, and let your Homers, Raphaels, Michael Angelos, Glucks, and Canovas, be forgotten, yet let men of genius of every description spring up, and poetry, music, painting, architecture, sculpture, and all the arts and sciences, will again shine out in all their glory. Twice within the records of history has the human race traversed the great circle of its entire destiny, and twice has the rudeness of barbarism been followed by a higher degree of refinement. It is a great mistake to suppose one people to have proceeded from another on account of their conformity of manners, customs, and arts. The swallow of Paris builds its nest like the swallow of Vienna, but does it thence follow that the former sprung from the latter? With the same causes we have the same effects; with the same organization we have the manifestation of the same powers."

MENTAL CONSTITUTION OF ANIMALS.

No clear ideas have as yet been entertained by the generality of even educated men, with regard to the mental constitution of animals. The very nature of this constitution is not as yet generally known or held as ascertained. There is, indeed, a notion of old standing, that the mind is in some way connected with the brain; but the metaphysicians insist that it is, in reality, known only by its acts or effects, and they accordingly present the subject in a form which is unlike any other kind of science, for it does not so much as pretend to have a basis in nature. There is a general disinclination to regard mind in connexion with organization, from a fear that this must interfere with the cherished religious doctrine of the spirit of man, and lower him to the level of the brutes. A distinction is therefore drawn between our mental manifestations and those of the lower animals, the latter being comprehended under the term instinct, while ours are collectively described as mind, mind being again a received synonyme with soul, the immortal part of man. There is here a strange system of confusion and error, which it is most imprudent to regard as essential to religion, since candid investigations of nature tend to show its untenableness. There is, in reality, nothing to prevent our regarding man as being specially, in accordance with his position as the head or chief of all animals, endowed with an immortal spirit, at the same time that his ordinary mental manifestations are looked upon as simple phenomena resulting from organization, those of the lower animals being phenomena absolutely the same in character, though developed within narrower limits.(95)

What has chiefly tended to take mind, in the eyes of learned and unlearned, out of the range of nature, is its apparently irregular and wayward character. How different the manifestations in different beings! how unstable in all!—at one time so calm, at another so wild and impulsive! It seemed impossible that anything so subtle and aberrant could be part of a system, the main features of which are regularity and precision. But the irregularity of mental phenomena is only in appearance. When we give up the individual, and take the mass, we find as much uniformity of result as in any other class of natural phenomena. The irregularity is exactly of the same kind as that of the weather. No man can say what may be the weather of to-morrow; but the quantity of rain which falls in any particular place in any five years is precisely the same as the quantity which falls in any other five years at the same place. Thus, while it is absolutely impossible to predict of any one Frenchman that during next year he will commit a crime, it is quite certain that about one in every six hundred and fifty of the French people will do so, because in past years the proportion has generally been about that amount, the tendencies to crime in relation to the temptations being everywhere invariable over a sufficiently wide range of time. So also, the number of persons taken in charge by the police in London for being drunk and disorderly in the streets, is, week by week, a nearly uniform quantity, showing that the inclination to drink to excess is always in the mass about the same, regard being had to the existing temptations or stimulations to this vice. Even mistakes and oversights are of regular recurrence, for it is found in the post-offices of large cities, that the number of letters put in without addresses is year by year the same. Statistics has ascertained an equally distinct regularity in a wide range, with regard to many other things concerning the mind, and the doctrine founded upon it has lately produced a scheme which may well strike the ignorant with surprise. It was proposed to establish in London a society for ensuring the integrity of clerks, secretaries, collectors, and all such functionaries as are usually obliged to find security for money passing through their hands in the course of business. A gentleman of the highest character as an actuary spoke of the plan in the following terms:—"If a thousand bankers' clerks were to club together to indemnify their securities, by the payment of one pound a year each, and if each had given security for 500*l.*, it is obvious that two in each year might become defaulters to that amount, four to half the amount, and so on, without rendering the guarantee fund insolvent. If it be tolerably well ascertained that the instances of dishonesty (yearly) among such persons amount to one in five hundred, this club would continue to exist, subject to being in debt in a bad year, to an amount which it would be able to discharge in good ones. The only question necessary to be asked previous to the formation of such a club would be,—may it not be feared that the motive to resist dishonesty would be lessened by the existence of the club, or that ready-made rogues, by belonging to it, might find the means of obtaining situations which they would otherwise have been kept out of by the impossibility of obtaining security among those who know them? Suppose this be sufficiently answered by saying, that none but those who could bring satisfactory testimony to their previous good character should be allowed to join the club; that persons who may now hope that a deficiency on their parts will be made up and hushed up by the relative or friend who is security, will know very well that the club will have no motive to decline a prosecution, or to keep the secret, and so on. It then only remains to ask, whether the sum demanded for the guarantee is sufficient?" ([96]) The philosophical principle on which the scheme proceeds, seems to be simply this, that amongst a given (large) number of persons of good character, there will be, within a year or other considerable space of time, a determinate number of instances in which moral principle and the terror of the consequences of guilt will be overcome by temptations of a determinate kind and amount, and thus occasion a certain periodical amount of loss which the association must make up.

This statistical regularity in moral affairs fully establishes their being under the presidency of law. Man is seen to be an enigma only as an individual; in the mass he is a mathematical problem. It is hardly necessary to say, much less to argue, that mental action, being proved to be under law, passes at once into the category of natural things. Its old metaphysical character vanishes in a moment, and the distinction usually taken between physical and moral is annulled. This view agrees with what all observation teaches, that mental phenomena flow directly from the brain. They are seen to be dependent on naturally constituted and naturally conditioned organs, and thus obedient, like all other organic phenomena, to law. And how wondrous must the constitution of this apparatus be, which gives us consciousness of thought and of affection, which makes us familiar with the numberless things of earth, and enables us to rise in conception and communion to the councils of God himself! It is matter which forms the medium or instrument—a little mass which, decomposed, is but so much common dust; yet in its living constitution, designed, formed, and sustained by Almighty Wisdom, how admirable its character! how reflective of the unutterable depths of that Power by which it was so formed, and is so sustained!

In the mundane economy, mental action takes its place as a means of providing for the independent existence and the various relations of animals, each species being furnished according to its special necessities and the demands of its various relations. The nervous system—the more comprehensive term for its organic apparatus—is variously developed in different classes and species, and also in different individuals, the volume or mass bearing a general relation to the amount of power. Passing over the humblest orders, where nervous apparatus is so obscure as hardly to be traceable, we see it in the nematoneura of Owen,(97) in filaments and nuclei, the mere rudiments of the system. In the articulata, it is advanced to a double nervous cord, with ganglia or little masses of nervous matter at frequent intervals, and filaments branching out towards each side; the ganglia near the head being apparently those which send out nerves to the organs of the senses; and this arrangement is only less symmetrical in the mollusca. Ascending to the vertebrata, we find a spinal cord, with a brain at the upper extremity, and numerous branching lines of nervous tissue,(98) an organization strikingly superior; yet here, as in the general structure of animals, the great principle of unity is observed. The brain of the vertebrata is merely an expansion of the anterior pair of the ganglia of the articulata, or these ganglia may be regarded as the rudiment of a brain, the superior organ thus appearing as only a further development of the inferior. There are many facts which tend to prove that the action of this apparatus is of an electric nature, a modification of that surprising agent, which takes magnetism, heat, and light, as other subordinate forms, and of whose general scope in this great system of things we are only beginning to have a faint conception. It has been found that simple electricity, artificially produced, and sent along the nerves of a dead body, excites muscular movement. The brain of a newly-killed animal being taken out, and replaced by a substance which produces electric action, the operation of digestion, which had been interrupted by the death of the animal, was resumed, showing that the brain, in one of its capacities or powers, is identical with the galvanic battery. Nor is this a very startling idea, when we reflect that electricity is almost as metaphysical as ever mind was supposed to be. It is a thing perfectly intangible, weightless. A mass of metal may be magnetized, or heated to seven hundred of Fahrenheit, without becoming the hundredth part of a grain heavier. And yet electricity is a real thing, an actual existence in nature, as witness the effects of heat and light in vegetation—the power of the galvanic current to re-assemble the particles of copper from a solution, and make them again into a solid plate—the rending force of the thunderbolt as it strikes the oak. See also how both heat and light observe the angle of incidence in reflection, as exactly as does a stone thrown obliquely against a wall. So mental action may be imponderable, intangible, and yet a real existence, and ruled by the Eternal through his laws.(99)

Common observation shows a great general superiority of the human mind over that of the inferior animals. Man's mind is almost infinite in device; it ranges over all the world: it forms the most wonderful combinations; it seeks back into the past, and stretches forward into the future; while the animals generally appear to have a narrow range of thought and action. But so also has an infant but a limited range, and yet it is mind which works there, as well as in the most accomplished adults. The difference between mind in the lower animals and in man is a difference in degree only; it is not a specific difference. All who have studied animals by actual observation, and even those who have given a candid attention to the subject in books, must attain more or less clear convictions of this truth, notwithstanding all the obscurity which prejudice may have engendered. We see animals capable of affection, jealousy, envy; we see them quarrel, and conduct quarrels in the very manner pursued by the ruder and less educated of our own race. We see them liable to flattery, inflated with pride, and dejected by shame. We see them as tender to their young as human parents are, and as faithful to a trust as the most conscientious of human servants. The horse is startled by marvellous objects, as a man is. The dog and many others show tenacious memory. The dog also proves himself possessed of imagination, by the act of dreaming. Horses finding themselves in want of a shoe, have of their own accord gone to a farrier's shop where they were shod before. Cats closed up in rooms, will endeavour to obtain their liberation by pulling a latch or ringing a bell. A monkey, wishing to get into a particular tree, and seeing a dangerous snake at the bottom of it, watched for hours till he found the reptile for a moment off its guard; he sprang upon it, and, seizing it by the neck, bruised its head to pieces against a stone; after which he quietly ascended the tree. We can hardly doubt that the animal seized and bruised the head, because he knew or judged there was danger in that part. It has several times been observed that in a field of cattle, when one or two were mischievous, and persisted long in annoying or tyrannizing over the rest, the herd, to all appearance, consulted, and then, making a united effort, drove the troublers off the ground. The members of a rookery have also been observed to take turns in supplying the needs of a family reduced to orphanhood. All of these are acts of reason, in no respect different from similar acts of men. Moreover, although there is no heritage of accumulated knowledge amongst the lower animals, as there is amongst us, they are in some degree susceptible of those modifications of natural character, and capable of those accomplishments, which we call education. The taming and domestication of animals, and the changes thus produced upon their nature in the course of generations, are results identical with civilization amongst ourselves; and the quiet, servile steer is probably as unlike the original wild cattle of this country, as the English gentleman of the present day is unlike the rude baron of the age of King John. Between a young, unbroken horse, and a trained one, there is, again, all the difference which exists between a wild youth reared at his own discretion in the country, and the same person when he has been toned down by long exposure to the influences of refined city society. Of extensive combinations of thought we have no reason to believe that any animals are capable—and yet most of us must feel the force of Walter Scott's remark, that there was scarcely anything which he would not believe of a dog. There is a curious result of education in certain animals, namely, that habits to which they have been trained, in some instances become hereditary. For example, the accomplishment of pointing at game, although a pure result of education, appears in the young pups brought up apart from their parents and kind. The peculiar leap of the Irish horse, acquired in the course of traversing a boggy country, is continued in the progeny brought up in England. This hereditariness of specific habits suggests a relation to that form of psychological manifestation usually called instinct; but instinct is only another term for mind, or is mind in a peculiar stage of development; and though the fact were otherwise, it could not affect the conclusion, that manifestations such as have been enumerated are mainly intellectual manifestations, not to be distinguished as such from those of human beings.

More than this, the lower animals manifested mental phenomena long before man existed. While as yet there was no brain capable of working out a mathematical problem, the economy of the six sided figure was exemplified by the instinct of the bee. The dog and the elephant prefigured the sagacity of the human mind. The love of a human mother for her babe was anticipated by nearly every humbler mammal, the carnaria not excepted. The peacock strutted, the turkey blustered, and the cock fought for victory, just as human beings afterwards did, and still do. Our faculty of imitation, on which so much of our amusement depends, was exercised by the mocking-bird; and the whole tribe of monkeys must have walked about the pre-human world, playing off those tricks in which we see the comicality and mischief-making of our character so curiously exaggerated.

The unity and simplicity which characterize nature give great antecedent probability to what observation seems about to establish, that, as the brain of the vertebrata generally is only an advanced condition of a particular ganglion in the mollusca and crustacea, so are the brains of the higher and more intelligent mammalia only further developments of the brains of the inferior orders of the same class. Or, to the same purpose, it may be said, that each species has certain superior developments, according to its needs, while others are in a rudimental or repressed state. This will more clearly appear after some inquiry has been made into the various powers comprehended under the term mind.

One of the first and simplest functions of mind is to give *consciousness*—consciousness of our identity and of our existence. This, apparently, is independent of the *senses*, which are simply media, and, as Locke has shown, the only media, through which ideas respecting the external world reach the brain. The access of such ideas to the brain is the act to which the metaphysicians have given the name of perception. Gall, however, has shown, by induction from a vast number of actual cases, that there is a part of the brain devoted to perception, and that even this is subdivided into portions which are respectively dedicated to the reception of different sets of ideas, as those of form, size, colour, weight, objects in their totality, events in their progress or occurrence, time, musical sounds, etc. The system of mind invented by this philosopher — the only one founded upon nature, or which even pretends to or admits of that necessary basis—shows a portion of the brain acting as a faculty of comic ideas, another of imitation, another of wonder, one for discriminating or observing differences, and another in which resides the power of tracing effects to causes. There are also districts of the brain for the sentimental part of our nature, or the affections, at the head of which stand the moral feelings of benevolence, conscientiousness, and veneration. Through these, man stands in relation to himself, his fellowmen, the external world, and his God; and through these comes most of the happiness of man's life, as well as that which he derives from the contemplation of the world to come, and the cultivation of his relation to it, (pure religion.) The other sentiments may be briefly enumerated, their names being sufficient in general to denote their functions — firmness, hope, cautiousness, self-esteem, love of approbation, secretiveness, marvellousness, constructiveness, imitation, combativeness, destructiveness, concentrativeness, adhesiveness, love of the opposite sex, love of offspring, alimentiveness, and love of life. Through these faculties, man is connected with the external world, and supplied with active impulses to maintain his place in it as an individual and as a species. There is also a faculty, (language,) for expressing, by whatever means, (signs, gestures, looks, conventional terms in speech,) the ideas which arise in the mind. There is a particular state of each of these faculties, when the ideas of objects once formed by it are revived or reproduced, a process which seems to be intimately allied with some of the phenomena of photography, when images impressed by reflection of the sun's rays upon sensitive paper are, after a temporary obliteration, resuscitated on the sheet being exposed to the fumes of mercury. Such are the phenomena of memory, that handmaid of intellect, without which there could be no accumulation of mental capital, but an universal and continual infancy. Conception and imagination appear to be only intensities, so to speak, of the state of brain in which memory is produced. On their promptness and power depend most of the exertions which distinguish the man of arts and letters, and even in no small measure the cultivator of science.

The faculties above described—the actual elements of the mental constitution—are seen in mature man in an indefinite potentiality and range of action. It is different with the lower animals. They are there comparatively definite in their power and restricted in their application. The reader is familiar with what are called instincts in some of the humbler species, that is, an uniform and unprompted tendency towards certain particular acts, as the building of cells by the bee, the storing of provisions by that insect and several others, and the construction of nests for a coming progeny by birds. This quality is nothing more than a mode of operation peculiar to the faculties in a humble state of endowment, or early stage of development. The cell-formation of the bee, the house-building of ants and beavers, the web-spinning of spiders, are but primitive exercises of constructiveness, the faculty which, indefinite with us, leads to the arts of the weaver, upholsterer, architect, and mechanist, and makes us often work delightedly where our labours are in vain, or nearly so. The storing of provision by the bees is an exercise of acquisitiveness,—a faculty which with us makes rich men and misers. A vast number of curious devices, by which insects provide for the protection and subsistence of their young, whom they are perhaps never to see, are most probably a peculiar restricted effort of philo-progenitiveness. The common source of this class of acts, and of common mental operations, is shown very convincingly by the melting of the one set into the other. Thus, for example, the bee and bird will make modifications in the ordinary form of their cells and nests when necessity compels them. Thus, the alimentiveness of such animals as the dog, usually definite with regard to quantity and quality, can be pampered or educated up to a kind of epicurism, that is, an indefiniteness of object and action. The same faculty acts limitedly in ourselves at first, dictating the special act of sucking; afterwards it acquires indefiniteness. Such is the real nature of the distinction between what are called instinct and reason, upon which so many volumes have been written without profit to the world. All faculties are instinctive, that is, dependent on internal and inherent impulses. This term is therefore not specially applicable to either of the recognised modes of the operation of the faculties. We only, in the one case, see the faculty in an immature and slightly developed state; in the other, in its most advanced condition. In the one case it is *definite*, in the other, *indefinite*, in its range of action. These terms would perhaps be the most suitable for expressing the distinction.

In the humblest forms of being we can trace scarcely anything besides a definite action in a few of the faculties. Generally speaking, as we ascend in the scale, we see more and more of the faculties in exercise, and these tending more to the indefinite mode of manifestation. And for this there is the obvious reason in providence, that the lowest animals have all of them a very limited sphere of existence, born only to perform a few functions, and enjoy a brief term of life, and then give way to another generation, so that they do not need much mental power or guidance. At higher points in the scale, the sphere of existence is considerably extended, and the mental operations are less definite accordingly. The horse, dog, and a few other animals, noticed for their serviceableness to our race, have the indefinite powers in no small endowment. Man, again, shows very little of the definite mode of operation, and that little chiefly in childhood, or in barbarism, or idiocy. Destined for a wide field of action, and to be applicable to infinitely varied contingencies, he has all the faculties developed to a high pitch of indefiniteness, that he may be ready to act well in all imaginable cases. His commission, it may be said, gives large discretionary powers, while that of the inferior animals is limited to a few precise directions. But when the human brain is congenitally imperfect or diseased, or when it is in a state of infancy, we see in it an approach towards the character of the brains of some of the inferior animals. Dr. J. G. Davey states that he has frequently witnessed, among his patients at the Hanwell Lunatic Asylum, indications of a particular abnormal cerebration which forcibly reminded him of the specific healthy characteristics of animals lower in the scale of organization;[100] and every one must have observed how often the actions of children, especially in their moments of play, and where their selfish feelings are concerned, bear a resemblance to those of certain familiar animals. Behold, then, the wonderful unity of the whole system. The grades of mind, like the forms of being, are mere stages of development. In the humbler forms, only a few of the mental faculties are traceable, just as we see in them but a few of the lineaments of universal structure. In man the system has arrived at its highest condition. The few gleams of reason, then, which we see in the lower animals, are precisely analogous to such a development of the fore-arm as we find in the paddle of the whale. Causality, comparison, and other of the nobler faculties, are in them *rudimental.*

Bound up as we thus are by an identity in the character of our mental organization with the lower animals, we are yet, it will be observed, strikingly distinguished from them by this great advance in development. We have faculties in full force and activity which the animals either possess not at all, or in so low and obscure a form as to be equivalent to non-existence. Now these parts of mind are those which connect us with the things that are not of this world. We have veneration, prompting us to the worship of the Deity, which the animals lack. We have hope, to carry us on in thought beyond the bounds of time. We have reason, to enable us to inquire into the character of the Great Father, and the relation of us, his humble creatures, towards him. We have conscientiousness and benevolence, by which we can in a faint and humble measure imitate, in our conduct, that which he exemplifies in the whole of his wondrous doings. Beyond this, mental science does not carry us in support of religion: the rest depends on evidence of a different kind. But it is surely much that we thus discover in nature a provision for things so important. The existence of faculties having a regard to such things is a good evidence that such things exist. The face of God is reflected in the organization of man, as a little pool reflects the glorious sun.

The affective or sentimental faculties are all of them liable to operate whenever appropriate objects or stimuli are presented, and this they do as irresistibly and unerringly as the tree sucks up moisture which it requires, with only this exception, that one faculty often interferes with the action of another, and operates instead, by force of superior inherent strength or temporary activity. For example, alimentiveness may be in powerful operation with regard to its appropriate object, producing a keen appetite, and yet it may not act, in consequence of the more powerful operation of cautiousness, warning against evil consequences likely to ensue from the desired indulgence. This liability to flit from under the control of one feeling to the control of another, constitutes what is recognised as free will in man, being nothing more than a vicissitude in the supremacy of the faculties over each other.

It is a common mistake to suppose that the individuals of our own species are all of them formed with similar faculties —similar in power and tendency—and that education and the influence of circumstances produce all the differences which we observe. There is not, in the old systems of mental philosophy, any doctrine more opposite to the truth than this. It is refuted at once by the great differences of intellectual tendency and moral disposition to be observed amongst a group of young children who have been all brought up in circumstances perfectly identical—even in twins, who have never been but in one place, under the charge of one nurse, attended to alike in all respects. The mental characters of individuals are inherently various, as the forms of their persons and the features of their faces are; and education and circumstances, though their influence is not to be despised, are incapable of entirely altering these characters, where they are strongly developed. That the original characters of mind are dependent on the volume of particular parts of the brain and the general quality of that viscus, is proved by induction from an extensive range of observations, the force of which must have been long since universally acknowledged but for the unpreparedness of mankind to admit a functional connexion between mind and body. The different mental characters of individuals may be presumed from analogy to depend on the same law of development which we have seen determining forms of being and the mental characters of particular species. This we may conceive as carrying forward the intellectual powers and moral dispositions of some to a high pitch, repressing those of others at a moderate amount, and thus producing all the varieties which we see in our fellow-creatures. Thus a Cuvier and a Newton are but expansions of a clown; and the person emphatically called the wicked man, is one whose highest moral feelings are rudimental. Such differences are not confined to our species; they are only less strongly marked in many of the inferior animals. There are clever dogs and wicked horses, as well as clever men and wicked men; and education sharpens the talents, and in some degree regulates the dispositions of animals, as it does our own.

There is, nevertheless, a general adaptation of the mental constitution of man to the circumstances in which he lives, as there is between all the parts of nature to each other. The goods of the physical world are only to be realized by ingenuity and industrious exertion; behold, accordingly, an intellect full of device, and a fabric of the faculties which would go to pieces or destroy itself if it were not kept in constant occupation. Nature presents to us much that is sublime and beautiful: behold faculties which delight in contemplating these properties of hers, and in rising upon them, as upon wings, to the presence of the Eternal. It is also a world of difficulties and perils, and see how a large portion of our species are endowed with vigorous powers, which take a pleasure in meeting and overcoming difficulty and danger. Even that principle on which our faculties are constituted—a wide range of freedom in which to act for all various occasions—necessitates a resentful faculty, by which individuals may protect themselves from the undue and capricious exercise of each other's faculties, and thus preserve their individual rights. So also there is cautiousness, to give us a tendency to provide against the evils by which we may be assailed; and secretiveness, to enable us to conceal whatever, being divulged, would be offensive to others or injurious to ourselves,—a function which obviously has a certain legitimate range of action, however liable to be abused. The constitution of the mind generally points to a state of intimate relation of individuals towards society, towards the external world, and towards things above this world. No individual being is integral or independent; he is only part of an extensive piece of social mechanism. The inferior mind, full of rude energy and unregulated impulse, does not more require a superior nature to act as its master and its mentor, than does the superior nature require to be surrounded by such rough elements on which to exercise its high endowments as a ruling and tutelary power. This relation of each to each produces a vast portion of the active business of life. It is easy to see that, if we were all alike in our moral tendencies, and all placed on a medium of perfect moderation in this respect, the world would be a scene of everlasting dulness and apathy. It requires the variety of individual constitution to give moral life to the scene.

The indefiniteness of the potentiality of the human faculties, and the complexity which thus attends their relations, lead unavoidably to occasional error. If we consider for a moment that there are not less than thirty such faculties, that they are each given in different proportions to different persons, that each is at the same time endowed with a wide discretion as to the force and frequency of its action, and that our neighbours, the world, and our connexions with something beyond it, are all exercising an ever-varying influence over us, we cannot be surprised at the irregularities attending human conduct. It is simply the penalty paid for the superior endowment. It is here that the so-called imperfection of our nature resides. Causality and conscientiousness are, it is true, guides over all; but even these are only faculties of the same indefinite potentiality as the rest, and partake accordingly of the same inequality of action. Man is therefore a piece of mechanism, which never can act so as to satisfy his own ideas of what he might be—for he can imagine a state of moral perfection, (as he can imagine a globe formed of diamonds, pearls, and rubies,) though his constitution forbids him to realize it. There ever will, in the best disposed and most disciplined minds, be occasional discrepancies between the amount of temptation and the power summoned for regulation or resistance, or between the stimulus and the mobility of the faculty; and hence those errors, and shortcomings, and excesses, without end, with which the good are constantly finding cause to charge themselves. There is at the same time even here a possibility of improvement. In infancy, the impulses are all of them irregular; a child is cruel, cunning, and false, under the slightest temptation, but in time learns to control these inclinations, and to be habitually humane, frank, and truthful. So is human society, in its earliest stages, sanguinary, aggressive, and deceitful, but in time, becomes just, faithful, and benevolent. To such improvements there is a natural tendency which will operate in all fair circumstances, though it is not to be expected that irregular and undue impulses will ever be altogether banished from the system.

It may still be a puzzle to many, how beings should be born into the world whose organization is such that they unavoidably, even in a civilised country, become malefactors. Does God, it may be asked, make criminals? Does he fashion certain beings with a predestination to evil? He does not do so; and yet the criminal type of brain, as it is called, comes into existence in accordance with laws which the Deity has established. It is not, however, as the result of the first or general intention of those laws, but as an exception from their ordinary and proper action. The production of those evilly disposed beings is in this manner. The moral character of the progeny depends in a general way, (as does the physical character also,) upon conditions of the parents,—both general conditions, and conditions at the particular time of the commencement of the existence of the new being, and likewise external conditions affecting the fœtus through the mother. Now the amount of these conditions is indefinite. The faculties of the parents, as far as these are concerned, may have oscillated for the time towards the extreme of tensibility in one direction. The influences upon the fœtus may have also been of an extreme and unusual kind. Let us suppose that the conditions upon the whole have been favourable for the development, not of the higher, but of the lower sentiments, and of the propensities of the new being, the result will necessarily be a mean type of brain. Here, it will be observed, God no more decreed an immoral being, than he decreed an immoral paroxysm of the sentiments. Our perplexity is in considering the ill-disposed being by himself. He is only a part of a series of phenomena, traceable to a principle, good in the main, but which admits of evil as an exception. We have seen that it is for wise ends that God leaves our moral faculties to an indefinite range of action: the general good results of this arrangement are obvious; but exceptions of evil are inseparable from such a system, and this is one of them. To come to particular illustration—when a people are oppressed, or kept in a state of slavery, they invariably contract habits of lying, for the purpose of deceiving and outwitting their superiors, falsehood being a refuge of the weak under difficulties. What is a habit in parents becomes an inherent quality in children. We are not, therefore, to be surprised when a traveller tells us that black children in the West Indies appear to lie by instinct, and never answer a white person truly, even in the simplest matter. Here we have secretiveness roused in a people to a state of constant and exalted exercise; an over tendency of the nervous energy in that direction is the consequence, and a new organic condition is established. This tells upon the progeny, which comes into the world with secretiveness excessive in strength and activity. All other evil characteristics may be readily conceived as being implanted in a new generation in the same way. And sometimes not one, but several generations, may be concerned in bringing up the result to a pitch which produces crime. It is, however, to be observed, that the general tendency of things is to a limitation, not the extension of such abnormally constituted beings. The criminal brain finds itself in a social scene where all is against it. It may struggle on for a time, but it is sure to be overcome at last by the medium and superior natures. The disposal of such beings will always depend much on the moral state of a community, the degree in which just views prevail with regard to human nature, and the feelings which accident may have caused to predominate at a particular time. Where the mass was little enlightened or refined, and terrors for life or property were highly excited, malefactors have ever been treated severely. But when order is generally triumphant, and reason allowed sway, men begin to see the true case of criminals—namely, that while one large section are victims of erroneous social conditions, another are brought to error by tendencies which they are only unfortunate in having inherited from nature. Criminal jurisprudence then addresses itself less to the direct punishment than to the reformation and care-taking of those liable to its attention. And such a treatment of criminals, it may be farther remarked, so that it stop short of affording any encouragement to crime, (a point which experience will determine,) is evidently no more than justice, seeing how accidentally all forms of the moral constitution are distributed and how thoroughly mutual obligation shines throughout the whole frame of society—the strong to help the weak, the good to redeem and restrain the bad.

The sum of all we have seen of the psychical constitution of man is, that its Almighty Author has destined it, like everything else, to be developed from inherent qualities, and to have a mode of action depending solely on its own organization. Thus the whole is complete on one principle. The masses of space are formed by law; law makes them in due time theatres of existence for plants and animals; sensation, disposition, intellect, are all in like manner developed and sustained in action by law. It is most interesting to observe into how small a field the whole of the mysteries of nature thus ultimately resolve themselves. The inorganic has been thought to have one final comprehensive law, GRAVITATION. The organic, the other great department of mundane things, rests in like manner on one law, and that is—DEVELOPMENT. Nor may even these be after all twain, but only branches of one still more comprehensive law, the expression of a unity, flowing immediately from the One who is First and Last.

PURPOSE AND GENERAL CONDITION OF THE ANIMATED CREATION.

We have now to inquire how this view of the constitution and origin of nature bears upon the condition of man upon the earth, and his relation to supra-mundane things.

That enjoyment is the proper attendant of animal existence is pressed upon us by all that we see and all we experience. Everywhere we perceive in the lower creatures, in their ordinary condition, symptoms of enjoyment. Their whole being is a system of needs, the supplying of which is gratification, and of faculties, the exercise of which is pleasurable. When we consult our own sensations, we find that, even in a sense of a healthy performance of all the functions of the animal economy, God has furnished us with an innocent and very high enjoyment. The mere quiet consciousness of a healthy play of the mental functions—a mind at ease with itself and all around it—is in like manner extremely agreeable. This negative class of enjoyments, it may be remarked, is likely to be even more extensively experienced by the lower animals than by man, at least in the proportion of their absolute endowments, as their mental and bodily functions are much less liable to derangement than ours. To find the world constituted on this principle is only what in reason we should expect. We cannot conceive that so vast a system could have been created for a contrary purpose. No averagely constituted human being would, in his own limited sphere of action, think of producing a similar system upon an opposite principle. But to form so vast a range of being, and to make being everywhere a source of gratification, is conformable to our ideas of a Creator, in whom we are constantly discovering traits of a nature, of which our own is a faint and far-cast shadow.

It appears at first difficult to reconcile with this idea the many miseries which we see all sentient beings, ourselves included, occasionally enduring. How, the sage has asked in every age, should a Being so transcendently kind, have allowed of so large an admixture of evil in the condition of his creatures? Do we not at length find an answer to a certain extent satisfactory, in the view which has now been given of the constitution of nature? We there see the Deity operating in the most august of his works by fixed laws, an arrangement which, it is clear, only admits of the main and primary results being good, but disregards exceptions. Now the mechanical laws are so definite in their purposes, that no exceptions ever take place in that department; if there is a certain quantity of fluid matter to be agglomerated and divided and set in motion as a planetary system, it will be so with hair's-breadth accuracy, and cannot be otherwise. But the laws presiding over meteorology, life, and mind, are necessarily less definite, as they have to produce a great variety of mutually related results. Left to act independently of each other, each according to its separate commission, and each with a wide range of potentiality to be modified by associated conditions, they can only have effects generally beneficial. Often there must be an interference of one law with another; often a law will chance to operate in excess, or upon a wrong object, and thus evil will be produced. Thus, winds are generally useful in many ways, and the sea is useful as a means of communication between one country and another; but the natural laws which produce winds are of indefinite range of action, and sometimes are unusually concentrated in space or in time, so as to produce storms and hurricanes, by which much damage is done; the sea may be by these causes violently agitated, so that many barks and many lives perish. Here, it is evident, the evil is only exceptive. Suppose, again, that a boy, in the course of the lively sports proper to his age, suffers a fall which injures his spine, and renders him a cripple for life. Two things have been concerned in the case: first, the love of violent exercise, and second, the law of gravitation. Both of these things are good in the main. Boys, in the rash enterprises and rough sports in which they engage, are only making the first delightful trials of a bodily and mental energy which has been bestowed upon them as necessary for their figuring properly in a scene where many energies are called for, and where the exertion of these powers is ever a source of happiness. By gravitation, all moveable things, our own bodies included, are kept stable on the surface of the earth. But when it chances that the playful boy loses his hold (we shall say) of the branch of a tree, and has no solid support immediately below, the law of gravitation unrelentingly pulls him to the ground, and thus he is hurt. Now it was not a primary object of gravitation to injure boys; but gravitation could not but operate in the circumstances, its nature being to be universal and invariable. The evil is, therefore, only a casual exception from something in the main good.

The same explanation applies to even the most conspicuous of the evils which afflict society. War, it may be said, and said truly, is a tremendous example of evil, in the misery, hardship, waste of human life, and mis-spending of human energies, which it occasions. But what is it that produces war? Certain tendencies of human nature; as keen assertion of a supposed right, resentment of supposed injury, acquisitiveness, desire of admiration, combativeness, or mere love of excitement. All of these are tendencies which every day, in a legitimate extent of action, produce great and indispensable benefits to us. Man would be a tame, indolent, unserviceable being without them, and his fate would be starvation. War, then, huge evil though it be, is, after all, but the exceptive case, a casual misdirection of properties and powers essentially good. God has given us the tendencies for a benevolent purpose. He has only not laid down any absolute obstruction to our misuse of them. That were an arrangement of a kind which he has nowhere made. But he has established many laws in our nature which tend to lessen the frequency and destructiveness of these abuses. Our reason comes to see that war is purely an evil, even to the conqueror. Benevolence interposes to make its ravages less mischievous to human comfort, and less destructive to human life. Men begin to find that their more active powers can be exercised with equal gratification on legitimate objects ; for example, in overcoming the natural difficulties of their path through life, or in a generous spirit of emulation in a line of duty beneficial to themselves and their fellow-creatures. Thus, war at length shrinks into a comparatively narrow compass, though there certainly is no reason to suppose that it will be at any early period, if ever, altogether dispensed with, while man's constitution remains as it is. In considering an evil of this kind, we must not limit our view to our own or any past time. Placed upon the earth with faculties prepared to act, but inexperienced, and with the more active propensities necessarily in great force to suit the condition of the globe, man was apt to misuse his powers much in this way at first, compared with what he is likely to do when he advances into a condition of civilization. In the scheme of Providence, thousands of years of frequent warfare, all the so-called glories which fill history, may be but a subordinate consideration. The chronology of God is not as our chronology. See the patience of waiting evinced in the slow development of the animated kingdoms, throughout the long series of geological ages. Nothing is it to him that an entire goodly planet should, for an inconceivable period, have no inhabiting organisms superior to reptiles. Progressive, not instant effect, is his sublime rule. What, then, can it be to him that the human race goes through a career of impulsive acting for a few thousand years? The cruelties of ungoverned anger, the tyrannies of the rude and proud over the humble and good, the martyr's pains, and the patriot's despair, what are all these but incidents of an evolution of superior being which has been pre-arranged and set forward in independent action, free within a certain limit, but in the main constrained, through primordial law, to go on ever brightening and perfecting, yet never, while the present dispensation of nature shall last, to be quite perfect!

The sex passion in like manner leads to great evils. Providence has seen it necessary to make very ample provision for the preservation and utmost possible extension of all species. The aim seems to be to diffuse existence as widely as possible, to fill up every vacant piece of space with some sentient being to be a vehicle of enjoyment. Hence this passion is conferred in great force. But the relation between the number of beings, and the means of supporting them, is only on the footing of general law. There may be occasional discrepancies between the laws operating for the multiplication of individuals, and the laws operating to supply them with the means of subsistence, and evils will be endured in consequence, even in our own highly favoured species. But against all these evils, and against those numberless vexations which have arisen in all ages from the attachment of the sexes, place the vast amount of happiness which is derived from this source—the basis of the whole circle of the domestic affections, the sweetening principle of life, the prompter of all our most generous feelings, and even of our most virtuous resolves and exertions—and every ill that can be traced to it is but as dust in the balance. And here, also, we must be on our guard against judging from what we see in the world at a particular era. As reason and the higher sentiments of man's nature increase in force, this passion is put under better regulation, so as to lessen many of the evils connected with it. The civilized man is more able to give it due control; his attachments are less the result of impulse: he studies more the weal of his partner and offspring. There are even some of the resentful feelings connected in early society with love, such as hatred of successful rivalry, and jealousy, which almost disappear in an advanced state of civilization. The evil springing, in our own species at least, from this passion, may therefore be an exception mainly peculiar to a particular term of the world's progress, and which may be expected to decrease greatly in amount.

With respect, again, to disease, so prolific a cause of suffering to man, the human constitution is merely a complicated but regular process in electro-chemistry, which goes on well, and is a source of continual gratification, so long as nothing occurs to interfere with it injuriously, but which is liable every moment to be deranged by various external agencies, when it becomes a source of pain, and, if the injury be severe, ceases to be capable of retaining life. It may be readily admitted that the evils experienced in this way are very great; but, after all, such experiences are no more than occasional, and not necessarily frequent—exceptions from a general rule of which the direct action is to confer happiness. The human constitution might have been made of a more hardy character; but we always see hardiness and insensibility go together, and it may be of course presumed that we only could have purchased this immunity from suffering at the expense of a large portion of that delicacy in which lie some of our most agreeable sensations. Or man's faculties might have been restricted to definitiveness of action, as is greatly the case with those of the lower animals, and thus we should have been equally safe from the aberrations which lead to disease; but in that event we should have been incapable of acting to so many different purposes as we are, and of the many high enjoyments which the varied action of our faculties places in our power; we should not, in short, have been human beings, but merely on a level with the inferior animals. Thus, it appears, that the very fineness of man's constitution, that which places him in such a high relation to the mundane economy, and makes him the vehicle of so many exquisitely delightful sensations—it is this which makes him liable to the sufferings of disease. It might be said, on the other hand, that the noxiousness of the agencies producing disease might have been diminished or extinguished; but the probability is, that this could not have been done without such a derangement of the whole economy of nature as would have been attended with more serious evils. For example—a large class of diseases are the result of effluvia from decaying organic matter. This kind of matter is known to be extremely useful when mixed with earth, in favouring the process of vegetation. Supposing the noxiousness to the human constitution done away with, might we not also lose that important quality which tends so largely to increase the food raised from the ground? Perhaps (as has been somewhere suggested) the noxiousness is even a matter of special design, to induce us to put away decaying organic substances into the earth, where they are calculated to be so useful. Now man has reason to enable him to see that such substances are beneficial under one arrangement, and noxious in the other. He is, as it were, commanded to take the right method in dealing with them. In point of fact, men do not always take this method, but allow accumulations of noxious matter to gather close about their dwellings, where they generate fevers and agues. But their doing so may be regarded as only a temporary exception from the operation of mental laws, the general tendency of which is to make men adopt the proper measures. And these measures will probably be in time universally adopted, so that one extensive class of diseases will be altogether or nearly abolished.

Another large class of diseases spring from mismanagement of our personal economy. Eating to excess, eating and drinking what is noxious, disregard to that cleanliness which is necessary for the right action of the functions of the skin, want of fresh air for the supply of the lungs, undue, excessive, and irregular indulgence of the mental affections, are all of them recognised modes of creating that derangement of the system in which disease consists. Here also it may be said that a limitation of the mental faculties to definite manifestations (*vulgo*, instincts) might have enabled us to avoid many of these errors; but here again we are met by the consideration that, if we had been so endowed, we should have been only as the lower animals are,—wanting that transcendently higher character of sensation and power, by which our enjoyments are made so much greater. In making the desire of food, for example, with us an indefinite mental manifestation, instead of the definite one, which it mainly is amongst the lower animals, the Creator has given us a means of deriving far greater gratifications from food (consistently with health) than the lower animals generally appear to be capable of. He has also given us reason to act as a guiding and controlling power over this and other propensities, so that they may be prevented from becoming causes of malady. We can see that excess is injurious, and are thus prompted to moderation. We can see that all the things which we feel inclined to take are not healthful, and are thus exhorted to avoid what are pernicious. We can also see that a cleanly skin and a constant supply of pure air are necessary to the proper performance of some of the most important of the organic functions, and thus are stimulated to frequent ablution, and to a right ventilation of our parlours and sleeping apartments. And so on with the other causes of disease. Reason may not operate very powerfully to these purposes in an early state of society, and prodigious evils may therefore have been endured from diseases in past ages; but these are not necessarily to be endured always. As civilization advances, reason acquires a greater ascendancy; the causes of the evils are seen and avoided; and disease shrinks into a comparatively narrow compass. The experience of our own country places this in a striking light. In the middle ages, when large towns had no police regulations, society was at frequent intervals scourged by pestilence. The third part of the people of Europe are said to have been carried off by one epidemic. Even in London the annual mortality has greatly sunk within a century. The improvement in human life, which has taken place since the construction of the Northampton tables by Dr. Price, is equally remarkable. Modern tables still show a prodigious mortality among the young in all civilized countries—evidently a result of some prevalent error in the usual modes of rearing them. But to remedy this evil there is the sagacity of the human mind, and the desire to adopt any reformed plans which may be shown to be necessary. By a change in the management of an orphan institution in London, during the last fifty years, an immense reduction in the mortality took place. We may of course hope to see measures devised and adopted for producing a similar improvement of infant life throughout the world at large.

In this part of our subject, the most difficult point certainly lies in those occurrences of disease where the afflicted individual has been in no degree concerned in bringing the visitation upon himself. Daily experience shows us infectious disease arising in a place where the natural laws in respect of cleanliness are neglected, and then spreading into regions where there is no blame of this kind. We then see the innocent suffering equally with those who may be called the guilty. Nay, the benevolent physician who comes to succour the miserable beings whose error may have caused the mischief, is sometimes seen to fall a victim to it, while many of his patients recover. We are also only too familiar with the transmission of diseases from erring parents to innocent children, who accordingly suffer, and perhaps die prematurely, as it were for the sins of others. After all, however painful such cases may be in contemplation, they cannot be regarded in any other light than as exceptions from arrangements, the general working of which is beneficial.

With regard to the innocence of the suffering parties, there is one important consideration which is pressed upon us from many quarters—namely, that moral conditions have not the least concern in the working of the physical laws. These arrangements proceed with an entire independence of all such conditions, and desirably so, for otherwise there could be no certain dependence placed upon them. Thus it may happen that two persons ascending a piece of scaffolding, the one a virtuous, the other a vicious man, the former, being the less cautious of the two, ventures upon an insecure place, falls, and is killed, while the other, choosing a better footing, remains uninjured. It is not in what we can conceive of the nature of things, that there should be a special exemption from the ordinary laws of matter, to save this virtuous man. So it might be that, of two physicians, attending fever cases, in a mean part of a large city, the one, an excellent citizen, may stand in such a position with respect to the beds of the patients as to catch the infection, of which he dies in a few days, while the other, a bad husband and father, and who, unlike the other, only attends such cases with selfish ends, takes care to be as much as possible out of the stream of infection, and accordingly escapes. In both of these cases man's sense of good and evil—his faculty of conscientiousness —would incline him to destine the vicious man to destruction and save the virtuous. But the Great Ruler of Nature does not act on such principles. He has established laws for the operation of inanimate matter, which are quite unswerving, so that, when we know them, we have only to act in a certain way with respect to them, in order to obtain all the benefits and avoid all the evils connected with them. He has likewise established moral laws in our nature, which are equally unswerving, (allowing for their wider range of action,) and from obedience to which unfailing good is to be derived. But the two sets of laws are independent of each other. Obedience to each gives only its own proper advantage, not the advantage proper to the other. Hence it is that virtue forms no protection against the evils connected with the physical laws, while, on the other hand, a man skilled in, and attentive to these, but unrighteous and disregardful of his neighbour, is in like manner not protected by his attention to physical circumstances from the proper consequences of neglect or breach of the moral laws.

Thus it is that the innocence of the party suffering for the faults of a parent, or of any other person or set of persons, is evidently a consideration quite apart from that suffering.

In short, the whole question of evil, a puzzle throughout all ages, only becomes explicable when we receive and study the system of a mundane government in the manner of law. There is no need for considering it as a detraction from either the power or the goodness of God. The dispensation under which we live has been constituted by him on the principle of law; but this is not necessarily to imply that either his goodness or his power is to stop at this point. That such, however, is the character of the pageantry of worldly events now passing, is the only idea we can arrive at when we approach the question without prejudice. How else should it be that in any case the guilty flourish and the innocent suffer? How else should it be that men often endure bitter woe and pain while prosecuting the noblest objects? How else should we ever see so simple an event as the following, which meets my eyes in the journals, while these sheets pass through the press:— A multitude of poor Irish emigrants are embarked in a canal boat, about to leave their native district for a port whence they are to sail for America. At the moment of parting, they crowd to one side, to shake hands for the last time with their friends. The vessel is overbalanced and turned upon its side. Of the multitude thrown into the water, seven are taken up dead. Here an action rather amiable and laudable than otherwise, leads to the loss of life,—a pure evil, unmixed with good. It is impossible to imagine such a transaction occurring under the immediate direction of the Deity; it would be profaning human nature to attribute any such act to the immediate command or interference of a man. But there is no difficulty in understanding how such occasional evils should take place in the course of a chain of causes which only proceed in consequence of a general impulse designed in the main for good.

Evil, indeed, is one of the strongest proofs that could be desired for the reality of this system. We see it in one of its most familiar forms in the destructive animals. An innocent little bird in the claws of the cruel hawk—a poor stag grasped by the ruthless boa—a lamb in the fangs of the wolf—can we imagine a form of misery greater than these animals? Yet millions of such creatures perish in this manner annually, and have so done since long before there existed a human heart to pine or break with its more sentimental, but not less real wretchedness. Upon no theory can this be understood except upon that of an economy governed by general laws. The carnivorous animals are simply the police and undertakers of the inferior creation, preventing their too great increase, and clearing off all such as grow weakly and die, ere they can become in any degree a burden to themselves or a nuisance to other creatures. For these functions the destructive tribes have been expressly organized, and their organization of course is of divine appointment. Constituted as we are, we cannot suppose a plan involving so much suffering to have been adopted except with a view to that independency, or completeness within itself, which is here argued for as the manner in which the Deity's operations on earth are revealed to us. He has endowed the families which enjoy his bounties with an almost indefinite fecundity, that enjoyment may be as widely diffused as possible; but the limitation of the results of this fecundity within the line necessary according to circumstances, were no right immediate employment for himself. The object is accomplished, in a befitting manner, by his ordaining that certain other animals shall have endowments sure so to act as to bring the rest of animated beings to a proper balance. And the object is accomplished well; insomuch that we never hear of any but the most partial and transient discrepancy between the volume of inferior animal life and the power appointed for its regulation. Even in this painful chapter of nature, we are forced to acknowledge that, upon the theory of law, everything is very good.

Another proof, or rather another branch of the same proof, lies in the relation of the individual to the mass, as far as endowment and destiny are concerned. We see, for example, powerful impulses in human nature, which often occasion great inconveniences both to those yielding to them and to others. But such impulses are in the main necessary. Destructive, in many cases, to the individual, they are conservative with respect to the totality. What is this but an appointment to render the machine in that respect (so to speak) a self-acting one? Many of the confusions of the moral scene might be thus explained; but it is also to be observed that such impulses are not sent alone—they come in company with intelligence and moral emotion, powers continually tending more and more to soften and regulate their actions.

Nor are any of the ordinary evils of our world altogether unmixed. God, contemplating apparently the unbending action of his great laws, has established others which appear to be designed to have a compensating, a repairing, and a consoling effect. Suppose, for instance, that, from a defect in the power of development in a mother, her offspring is ushered into the world destitute of some of the most useful members, or blind, or deaf, or of imperfect intellect, there is ever to be found in the parents and other relatives, and in the surrounding public, a sympathy with the sufferer, which tends to make up for the deficiency, so that he usually is in the long run not much a loser. Indeed, the benevolence implanted in our nature seems to be an arrangement having for one of its principal objects to cause us, by sympathy and active aid, to remedy the evils unavoidably suffered by our fellow-creatures in the course of the operation of the other natural laws. And even in the sufferer himself, it is often found that a defect in one point is made up for by an extra power in another. The blind come to have a sense of touch much more acute than those who see. Persons born without hands have been known to acquire a power of using their feet for a number of the principal offices usually served by that member. I need hardly say how remarkably fatuity is compensated by the more than usual regard paid to the children born with it by their parents, and the zeal which others usually feel to protect and succour such persons. In short, we never see evil of any kind take place where there is not some remedy or compensating principle ready to interfere for its alleviation. And there can be no doubt that in this manner suffering of all kinds is very much relieved.

We may, then, regard the globes of space as theatres designed for the residence of animated sentient beings, placed there with this as their first and most obvious purpose—to be sensible of enjoyments from the exercise of their faculties in relation to external things. The faculties of the various species are very different, but the happiness of each depends on the harmony there may be between its particular faculties and its particular circumstances. For instance, place the small-brained sheep or ox in a good pasture, and it fully enjoys this harmony of relation; but man, having many more faculties, cannot be thus contented. Besides having a sufficiency of food and bodily comfort, he must have entertain-ment for his intellect, whatever be its grade, objects for the domestic and social affections, objects for the sentiments. He is also a progressive being, and what pleases him to-day may not please him to-morrow; but in each case he demands a sphere of appropriate conditions in order to be happy. By virtue of his superior organization, his enjoyments are much higher and more varied than those of any of the lower animals; but the very complexity of circumstances affecting him renders it at the same time unavoidable, that his nature should be often inharmoniously placed and disagreeably affected, and that he should therefore be unhappy. Still, unhappiness amongst mankind is the exception from the rule of their condition, and an exception which is capable of almost infinite diminution, by virtue of the improving reason of man, and the experience which he acquires in working out the problems of society.

To secure the immediate means of happiness, it would seem to be necessary for men first to study with all care the constitution of nature; and, secondly, to accommodate themselves to that constitution, so as to obtain all the realizable advantages from acting conformably to it, and to avoid all likely evils from disregarding it. It will be of no use to sit down and expect that things are to operate of their own accord, or through the direction of a partial deity, for our benefit; equally so were it to expose ourselves to palpable dangers, under the notion that we shall, for some reason, have a dispensation or exemption from them: we must endeavour so to place ourselves, and so to act, that the arrangements which Providence has made impartially for all may be in our favour, and not against us; such are the only means by which we can obtain good and avoid evil here below. ([101]) And, in doing this, it is especially necessary that care be taken to avoid interfering with the like efforts of other men, beyond what may have been agreed upon by the mass as necessary for the general good. Such interferences, tending in any way to injure the body, property, or peace of a neighbour, or to the injury of society in general, tend to reflect evil upon ourselves through the re-action which they produce in the feelings of our neighbour and of society, and also the offence which they give to our own conscientiousness and benevolence. On the other hand, when we endeavour to promote the efforts of our fellow-creatures to attain happiness, we produce a re-action of the contrary kind, the tendency of which is towards our own benefit. The one course of action tends to the injury, the other to the benefit of ourselves and others. By the one course, the general design of the Creator towards his creatures is thwarted; by the other, it is favoured. And thus we can readily see the most substantial grounds for regarding all moral emotions and doings as divine in their nature, and as a means of rising to and communing with God. Obedience is not selfishness, which it would otherwise be—it is worship. The merest barbarians have a glimmering sense of this philosophy, and it continually shines out more and more clearly as men advance in intelligence. Nor are individuals alone concerned here. The same rule applies as between one great body or class of men and another, and also between nations. Thus, if one set of men keep others in the condition of slaves—this being a gross injustice to the subjected party, the mental manifestations of that party to the masters will be such as to mar the comfort of their lives; the minds of the masters themselves will be degraded by the association with beings so degraded; and thus, with some immediate or apparent benefit from keeping slaves, there will be in a far greater degree an experience of evil. So also, if one portion of a nation, engaged in a particular department of industry, grasp at some advantages injurious to the other sections of the people, the first effect will be an injury to those other portions of the nation, and the second a re-active injury to the injurers, making their guilt their punishment. And so when one nation commits an aggression upon the property or rights of another, or even pursues towards it a sordid or ungracious policy, the effects are sure to be redoubled evil from the offended party. All of these things are under laws which make the effects, on a large range, absolutely certain; and an individual, a party, a people, can no more act unjustly with safety, than I could with safety place my leg in the track of a coming wain, or attempt to fast thirty days. We have been constituted on the principle of only being able to realize happiness for ourselves when our fellow-creatures are also happy; it is therefore necessary that we both do to others only as we would have others to do to us, and endeavour to promote their happiness as well as our own. There is even a higher law, which has long been announced, but never acted on to any considerable extent, that our greatest happiness is not to be realized by each having a regard for himself, but by each seeking primarily to benefit his fellow-creatures. When man comes to have confidence in his own nature, he will begin to act on this principle, and the result will be a degree of happiness such as we only see at present faintly shadowed forth in the purest and sweetest charities of life—a happiness from which there will be no class exceptions.

The question whether the human race will ever advance far beyond its present position in intellect and morals, is one which has engaged much attention. Judging from the past, we cannot reasonably doubt that great advances are yet to be made; but if the principle of development be admitted, these are certain, whatever may be the space of time required for their realization. A progression resembling development may be traced in human nature, both in the individual and in large groups of men. The individual is in childhood under the influence of the propensities and instinctive aptitudes; in youth, he is swayed by marvellousness, the love of the beautiful, the imaginative; in full maturity, he passes under (comparatively) the domination of reason. In perfect analogy, a nation is at first impulsive and unreasoning; afterwards it is conducted by the second class of sentiments, (the age of mythologies, hierocracies, man and idea worships;) finally, its institutions approximate to an accurate regard for what is convenient and profitable, under the control of justice and humanity. The advance of knowledge favours the progress of the moral conditions, and in improved moral conditions knowledge becomes more sound. In tolerably favourable circumstances, this tendency onward never fails to make itself visible; and it is evident that, though many nations seem nearly stationary and others appear to retrograde, there is always a progress in some place, so that no long space of time ever elapses without showing, upon the whole, a certain advance. By the work of our thoughtful brains and busy hands, we modify external nature in a way never known before. Under the operations of tillage, of mechanism, of building, making, and inventing; of those applications of natural powers and forces which human wit turns to account in so many ways; of all the results of social experience, of knowledge, and of arrangement; the earth tends to become a much serener field of existence than it was in the earlier ages of man's history. Its progress in this respect may not be clearly seen at a particular time, through the obscuring effect of temporary and accidental causes; but that the tendency of the physical improvements wrought by man upon the surface, and of the mechanic movements which he invents for the saving of his own labour, is to improve the daily comforts, and allow room for the intellectual and moral advancement of earth's children, cannot be denied without something like flying in the face of Providence itself. These improvements, then, thus partly wrought out by the exertions of the present race, I conceive as at once preparations for, and causes of, the *possible development* of higher types of humanity,—beings less strong in the impulsive parts of our nature, physical nature giving less matter for that nature to contend with and subdue to its needs,—more strong in the reasoning and the moral, because there will be less of the opposite to give these marring or check,—more fitted for the delights of social life, because society will then present less to dread and more to love.

The history and constitution of the world have now been explained according to the best lights which a humble individual has found within the reach of his perceptive and reasoning faculties. We have seen a system in which all is regularity and order, and all flows from and is obedient to a divine code of laws of unbending operation. We are to understand from what has been laid before us, that man, with his varied mental powers and impulses, is a natural problem, of which the elements can be taken cognizance of by science, and that all the secular destinies of our race, from generation to generation, are but evolutions from a primal arrangement in the counsels of Deity. To many, at first sight, it is apt to appear as a dreary view of the divine economy of our world, as if it placed God at an immeasurable distance from his creatures, and left them without refuge or remedy from the numberless ills that "flesh is heir to," and which no one can hope altogether to escape. But in reality, God may be presumed to be revealed to us in every one of the phenomena of the system, in the suspension of globes in space, in the degradation of rocks and the upthrowing of mountains, in the development of plants and animals, in each movement of our minds, and in all that we enjoy and suffer, seeing that, the system requiring a sustainer as well as an originator, he must be continually present in every part of it, albeit he does not permit a single law to swerve in any case from its appointed course of operation. Thus, we may still feel that He is the immediate breather of our life and ruler of our spirits, that we may, by rightly directed thought, come into communion with him, and feel that, even when his penal ordinances are enforced upon us, his hand and arm are closely about us. Nor is this all. It may be that, while we are committed to take our chance in a natural system of undeviating operation, and are left, with apparent ruthlessness, to endure the consequences of every collision into which we knowingly or unknowingly come with each of its regulations, there is a system of Mercy and Grace behind the screen of nature, towards which we stand in a peculiar class of relations, which is capable of compensating for all casualties endured here, and whose very largeness is what makes these casualties a matter of indifference to God. For the existence of such a system, the actual constitution of nature is indeed a powerful argument. The reasoning may proceed thus:—the system of nature assures us that benevolence is a leading principle in the Divine Mind. But that system is at the same time deficient in a means of making this benevolence of invariable operation. To reconcile this to the character of the Deity, it is necessary to suppose that the present system is but a part of a whole, a stage in a Great Progress, and that the Redress is in reserve. Another argument here occurs—the economy of nature, beautifully arranged and vast in its extent as it is, does not satisfy even man's idea of what might be; he feels that, if this multiplicity of theatres for the exemplification of such phenomena as we see on earth were to go on for ever unchanged, it would not be worthy of the Being capable of creating it. An endless monotony of human generations, with their humble thinkings and doings, even though liable to a certain improvement, seems an object beneath that august Being. But the mundane economy might be very well as a portion of some greater phenomenon, the rest of which was yet to be evolved. Our system, therefore, though it may at first appear at issue with other doctrines in esteem amongst mankind, tends to come into harmony with them, and even to give them support. I would say, in conclusion, that, even where the two above arguments may fail of effect, there may yet be a faith derived from this view of nature sufficient to sustain us under all sense of the imperfect happiness, the calamities, the woes, and pains of this sphere of being. For let us but fully and truly consider what a system is here laid open to view, and we cannot well doubt that we are in the hands of One who is both able and willing to do us the most entire justice. Surely in such a faith we may well rest at ease, even though life should have been to us but a protracted malady, or though every hope we had built on the secular materials within our reach were felt to be melting from our grasp. Thinking of all the contingencies of this world as to be in time melted into or lost in some greater system, to which the present is only subsidiary, let us wait the end with patience, and be of good cheer.

NOTE CONCLUSORY.

RE-WRITTEN FOR THE SIXTH EDITION.

The original note conclusory stated that this work had been composed in solitude, and with hardly the cognizance of a single fellow-being, for the sole purpose (or as nearly so as might be) of adding to the knowledge of mankind, judging their happiness to be improveable through that medium. It was published anonymously, and the author expected not ever to respond to one word of approbation, or to parry or deprecate any adverse criticism. His name was likely to remain in its original obscurity, and never to be generally known. He also stated that he was prepared to find the book unsuccessful in drawing attention, but that, with an author so circumstanced, this could excite no regret, except for the failure of his wish to promote the public benefit by making an advance towards a true view of the system of the world.

I have now to refer to facts since emerged, that the work attracted an unusual degree of attention, and met with much opposition. On the first I have no remarks to make, except that it is gratifying to find that the subject is safe from ever falling into the oblivion which originally appeared its most likely fate. On the second I have to observe that, if I could have convinced myself that one-third of the objections to the theory were just, I should unhesitatingly have abandoned it.

I gave these objections a careful study; endeavoured to judge of them dispassionately, and to allow them the utmost possible weight; I deeply pondered on the consequences which might flow from error in a question of such importance. But to whatever cause attributable—and I am quite prepared to hear a derogatory one attributed—so it is, that I have never for a moment seen reason to doubt that the view of nature presented in this volume is in the main right.

To take these criticisms somewhat in detail. A large portion of them referred to particular illustrations of the argument—facts, or supposed facts in science—which either were incorrectly stated, or incorrectly applied, or perhaps were dissented from by some scientific men while assented to by others. Without the least regard to the strength of the general argument, or the force of other illustrations, an exception was taken, on the strength of these, to the whole work. What was to be expected from me in this case? Surely not to abandon the general argument, which remained untouched. It seemed enough to dismiss or rectify the challenged facts, and leave the book otherwise as it was. *This I have done.*

Another set of objections was of a more positive nature. It was said that the highest invertebrates came at the beginning. Of the fishes the highest were first. The earliest reptiles had the highest kind of teeth. There was no imperfection, no appearance of a rude first effort of nature, in the earliest animals. The progress, too, was not uniformly shaded, but contained great breaks and blanks which no theory of development could account for. Was I to give way to these objections, presented by persons who, in their eagerness to magnify them, almost sank out of sight the great facts that invertebrates preceded vertebrates, and that the latter, as far as classes, at least, were concerned, came in the succession of an improved organization? Holding rather to the great and indubitable facts, I thought it well to examine carefully the strength of those smaller ones which were thought adverse. The consequence was the discovery that some of the objections rested on false or partial views of science (see Note 55), and that others were grounded on false assumptions regarding the theory itself. For instance, there is nothing in it to imply that the early animals were imperfect or of rude form; they only are low in the scale. Neither does the development theory forbid that the early lacertine sauria should have had better teeth than the same family in our own time; the explanation is, that the transitions from class to class were, in general, comparatively great advances in development, and comparatively independent of physical conditions, while some of the inferior mutations were, partly through the agency of physical conditions, towards a reduction in some of the external features of organization, particularly in the teeth and the character of the locomotive system; nature being, as was said from the first in this work, alike willing to go forward and to go back, at least within a certain range. Partly by this general width of class transitions, were the so-called breaks to be accounted for—for example, that which seems to isolate the birds. Partly, these breaks were owing to blanks in the series of deposits, as suggested by some of the geologists themselves. It therefore seemed sufficient, with regard to this class of objections, to present the statements to which they refer in such a manner and with such explanations as might quietly set them aside. *This I have likewise done.*

The rest of the opposition was solely based in preconceptions of a different nature with regard to the history of the world. Here the only question, of course, was as to the comparative strength of the grounds for these preconceptions. Did they rest on positive natural evidence? were they more in harmony with what is ascertained in science than my views? It was always assumed that these preconceptions were of good foundation of one kind or another; but the assumption could bear no examination. View for a moment the objection from scripture: the same would hold equally well against the heliocentric theory of the solar system, or the now undoubted fact that the earth passed through mutations extending to many thousand years, before the existence of man! As to the geologists' notion of successive creations by special fiat, it is but a notion in itself, and one not over consistent with facts (see pp. 51, 52), not to speak of its gross inconsistence as an event with the origin of the physical arrangements of the universe. It was said, "we must reason from what we know to what we do not know. We see no species originate or change in our time, nor in some species has there been any change during two or three thousand years." But, what if the transactions contemplated were of such a nature that we could expect no immediate trace of them in our time, or that a thousand times three thousand years were insufficient to realize them before our eyes? Very right to reason from what we know to what we do not know; but in this case let it be from the material to the organic arrangements, from the embryotic progress of a single being to that of the animal kingdom. Let us take the facts we have, and not clamour vainly for others which are unattainable. Let us judge not from a few isolated difficulties, perhaps engendered by our ignorance, but from the bearing of the whole facts, contemplated as if we had had no preconception on the subject. *This I have all along done, and I have done nothing more.*

Thus it is that the work maintains its original ground, without one material alteration, although with many minor modifications designed to render it more convincing and less assailable. Far, far it must still be from that completeness and accuracy which a more experienced student of science could give it; still farther is it from what such a work might be in the next age. Yet, such as it is, I once more present it with unabated confidence in its general truth as a theory, and in its power of beneficially affecting the opinions of my fellow-creatures. As yet opposition has only tended to results which have fortified the argument. Let it continue, and all of it that is just will produce no effect but that of clearing away more and more of the mists which prevent scientific men from seeing the true lineaments of nature. For my own part, I can only congratulate myself on the difficulties which have been conjured by truth and by prejudice into my path, since all of them have been found superable. I can only rejoice in having been led to additional study, which has shown me the world of the past more and more in harmony with that of the passing time; impressing the unchangeableness of nature within any age which we can grasp, and deepening all reasons for a perfect trust in nature's author. It is a smaller advantage, and perhaps will appear a more doubtful one, that the discussion has led to views respecting the varieties of animated being which tend greatly to simplify that subject. With these remarks—with a mind sensitive only to the fear of error, but calm in the conviction of truth and the beneficence and beauty of whatever is true—willing to think the best of other men's opinions, and claiming, in the spirit of social kindness, tolerance for my own—I respectfully take my leave.

NOTES.

(1.) See address of Sir John Herschel to the Astronomical Society of London, (1841), in the Transactions of that body, vol. xii.

(2.) Professor Mosotti, on the Constitution of the Sidereal System, of which the sun forms a part. *Lond. Ed. and Dub. Philosophical Magazine.* Feb. 1843.

(3.) Sir John Herschel's Address, *ut supra.*

(4.) There is an exception, but doubtless apparent only, in the motion of the satellites of Uranus, which, compared with the rest, is retrograde. The axes of the planets are, as is well known, at various degrees of inclination to their orbits; for which there must have been a cause in the circumstances under which the planets were produced. The axis of Uranus is removed but eleven degrees from the plane of his orbit: I suggest, as the explanation of the apparent exception, that what we call the north pole of this planet is in reality the south, the axis having passed across the plane of the orbit, so that the planet may be said to be in that small measure upside down. It will be observed, that between the admitted and the suggested arrangement, there is only a difference of 22 degrees.

(5.) A fifth member of this community was announced by M. Henke in December 1845.
In September 1846, a new planet of greater magnitude was discovered beyond Uranus. Till our knowledge of this stranger is somewhat greater and more settled, the text may be left undisturbed. But it is meanwhile worthy of remark, that the extent of the solar system is now double what it was supposed to be.

(6.) Treatise on Astronomy.

(7.) See "Professor Plateau, on the Phenomena presented by a free Liquid Mass withdrawn from the action of Gravity." *Taylor's Scientific Memoirs*, Nov. 1844.

(8.) Among the most extraordinary phenomena of natural science must be placed those relating to the fall of *meteoric stones.* The fact itself, so long doubted, has now been established by an accumulation of the most positive and unexceptionable evidence. The stones have been seen to fall, and taken up in a still heated state;—there can be no manner of doubt about the fact, although the explanation is extremely difficult. All these stones are found on examination to resemble each other in their general characters; they usually consist of an earthy material, having disseminated through its substance globules and small masses of metallic iron containing nickel in the state of alloy. The stones are often covered by a thin vitreous crust, as if partial fusion had commenced. It is well known, also, that large masses of soft, malleable iron, also containing nickel, are found in several places far removed from each other, lying loose upon the earth, as in South America and in Siberia, and no doubt can exist of the meteoric origin of these masses. It has been conjectured that these meteoric stones proceed from the moon, having been shot out from volcanoes with such violence as to be brought within the reach of the earth's attraction. A view now more generally received supposes the existence in space of very numerous small bodies, moving in more or less regular orbits around the sun and larger planets, which at certain periods undergo such perturbation that their motion becomes completely deranged, and they at length fall upon the surface of the earth or other planet, whose attraction has been the exciting cause of the derangement of their orbits. Whatever may be their real origin, they are by common consent looked upon as foreign to the earth: their physical constitution is completely different from any known minerals. But what is exceedingly remarkable, and particularly worthy of notice as strengthening the argument that all the members of the solar system, and perhaps of other systems, have a similar constitution, *no new elements* are found in these bodies; they contain the ordinary materials of the earth, but associated in a manner altogether new, and unlike anything known in terrestrial mineralogy.—*Note by a Correspondent.*

(9.) The researches on this subject were conducted chiefly by the late Baron Fourier, perpetual secretary to the Academy of Sciences of Paris. See his *Théorie Analytique de la Chaleur*, 1822.

(10.) See Geological Researches by Sir Henry de la Beche, 1834.

(11.) That the rocks anterior to the protozoic may represent a time of earlier life is admitted by Sir R. Murchison, who, speaking of the Lower Silurian rocks which he examined in Sweden, says, "We have come to the conclusion that the lowest of these beds that are fossiliferous are the exact equivalents of the Lower Silurian strata of the British Isles, and that they have been formed out of, and rest upon slaty and other rocks, which had undergone crystallization before their particles were ground up to compose the earliest beds in which the remains of organic life appear. We apply to these crystaline masses, therefore, the term *Azoic*, simply to express that, while as far as research has hitherto gone no vestiges of living things have been found in them, so also, from their nature, they seem to have been formed under such accompanying conditions of intense heat and fusion, that it is hopeless to attempt to find in them traces of organization." *Quar. Jour. of Geol. Society*, i. 475.

(12.) Ansted's Geology, i. 60.

(13.) See De la Beche's Geological Researches.

(14.) Mr. Horner, president of the Geological Society, in his address, February, 1846, speaking on this subject, and remarking on the proofs afforded by the sub-silurian rocks, of the existence at that time of land and water, says, " Is it not highly improbable that this sea was untenanted?" And then he proceeds to recal the observations made by Professor Edward Forbes, as to a depth of sea below which no life exists. The seas of that age, *in the districts hitherto examined*, might be seas too deep to afford a proper habitat for any plants or animals.

(15.) Murchison's Geology of Russia in Europe.

(16.) Emmerich on the Morphology of the Trilobites. Taylor's Scientific Memoirs, Aug. 1845.

(17.) Lyell, Travels in North America.

(18.) Murchison's Silurian System and Geology of Russia in Europe.

(19.) The head fountain of information on the early fishes is M. Agassiz's Poissons Fossiles, a splendid but not readily accessible book. For more popular descriptions, reference may be made to "New Walks in an Old Field, by Hugh Miller," and to Jameson's Journal, July and October, 1844. See also the excellent manual of Professor Ansted.

(20.) Ansted's Geology, i. 185.

(21.) See some remarks on the *grade* of the cartilaginous fishes in a subsequent note.

(22.) Buffon's History of the Earth.

(23.) Mr. Lyell tells us that remains of plants allied to the lepidodendron, one developed on a large scale afterwards, are found in America, in rocks thought to be Upper Silurian. To these are added forms in the lowest Devonian strata of that country.

(24.) From the experiment of Professor Lindley, which seemed to prove that dicotyledonous trees perish in water sooner than the monocotyledons, it has been said that, probably, we only find the carbonigenous vegetation to be lowly because the higher trees were incapable of being preserved. It is, however, remarkable, that the dicotyledons abound in the tertiary strata, which could hardly have been the case if they were incapable of resisting the effects of water. The objectors would need, at least, to account for these trees withstanding dissolution in that age, if they are to be supposed to have perished so readily in the earlier epoch. It is also to be remarked, that the dicotyledons do exist in the carbonigenous era; only they are extremely few. Finding simple sea-plants in the earlier fossiliferous strata and dicotyledons abundant in the last, while the intermediate carbonic period presents the intermediate kinds of plants in abundance, and only a scantling of any higher forms, it appears the most legitimate inference in the case, that the earth has witnessed a botanical progress connected with time, and only reached the highest vegetable forms at a comparatively recent period; thus presenting a history entirely analogous to what geology shows us of the animal kingdom.

(25.) A specimen from Bengal, in the staircase of the British Museum, is forty-five feet high.

(26.) See Witham on the Internal Structure of Fossil Vegetables, 1834.

(27.) See remarks on the period of occurrence of sauroid fishes in a subsequent note.

(28.) "Two species [of insects], belonging to the family of Curculionidæ, have been found in the coal-fields of Coalbrook Dale, as well as a neuropterous insect, which closely resembles the genus Corydalis now living in Carolina; also a libellula, or an insect related to the Phasmidæ. * * Count Sternberg has likewise announced the discovery of a fossil scorpion in the coal-measures at Chomle, near Radnitz, in Bohemia. It is easily conceivable that, as insects could only leave traces of their existence in exceptional and very rare instances, it is very improbable that we should ever have a satisfactory knowledge of this part of the fauna of the ancient formations."—*D'Archiac and De Verneuil on the Fossils of the Older Deposits, &c. Geol. Trans.* vi. (*2d ser.*) 330.

(29.) In Westmoreland county, Pennsylvania, foot-marks, including those of a biped animal, apparently of the order Grallæ, besides several reptilian vestiges, have been found in strata of the carboniferous era—"a coarse-grained sandstone about 150 feet beneath the largest of our coal-seams, and near 800 feet beneath the topmost stratum of the coal formation." The reptilian foot-marks exhibit a *ball* with five toe-marks, circular and elongated, placed in radiating fashion before it. In similar strata, at another place, are footsteps of a different kind, resembling the human hand, with the rudiment of a sixth toe at the side, opposite that presenting what stands for the thumb.—*Silliman's Journal*, *April* 1845.

These markings point most probably to batrachian reptiles. The existence of birds at so early a period, especially after the celebrated Wealden relics are set down as belonging to pterodactyles, would require strong evidence.

(30.) Volcanic disturbances break up the rocks; the pieces are worn in seas; and a deposit of conglomerate is the consequence. Of porphyry, there are some such pieces in the conglomerate of Devonshire, three or four tons in weight.

(31.) Literally red dead liers; that is, strata of red colour, and having no remains of living things in them.

(32.) Murchison's Geology of Russia in Europe.

(33.) See *eundem;* also Mr. Horner's address as president of the Geological Society, Feb. 1846.

Russia presents another notable example of a change of fossils in a conformable series of strata; that is, a series showing no record of volcanic disturbances. This takes place between the Devonian and Carboniferous formations. " The uppermost beds of the Devonian," says Sir R. Murchison, "loaded with Holoptychius and Onchus, Coccosteus, Placosteus, and Dendrodus, are at once *conformably* surmounted by strata containing the most universally diffused carboniferous types. In short, fishes identical with those of the Old Red Sandstone of Scotland are invariably surmounted by the *Stigmaria ficoides* and the large Producti of our British mountain limestone; and thus the examination of Russia has taught us, not only in this instance, but also in the overlying Permian succession, that *the great changes in animal life have not been dependent on physical revolutions of the surface*, but are distinct creations, independent of any proximate local causes; though I would by no means pretend to say that the grand operations of change which have affected the conterminous regions of Russia did not tend to produce these results."

(34.) Dr. Buckland (Bridgewater Treatise) quoting an article by Professor Hitchcock in the American Journal of Sciences, 1836.

(35.) Murchison's Silurian System.

(36.) Buckland, Bridgewater Treatise.

(37.) Murchison's Geology of Russia in Europe.

(38.) Fragments attributed to a cetaceous animal, another humble form of the mammal class, have likewise been found in the great oolite, near Oxford.

(39.) De la Beche's Geological Researches, p. 344.

(40.) Lyell's Elements of Geology.

(41.) The tertiary mammalia are chiefly described from the beautiful work of Professor Owen, *A History of British Fossil Mammalia and Birds*, 1845.

(42.) Supplement to the Atomic Theory.

(43.) Carpenter on Life, Todd's Cyclopædia.

(44.) From the Prize Essay of Dr. Carpenter (1838), under the award of the professors of the Edinburgh University.

(45.) Alison's Principles of Physiology, quoted in the above Prize Essay.

(46.) Treatise on the Forces which produce the organization of Plants. New York, 1844.

(47.) The absence of philosophic discrimination from the present work has been illustrated by many critical references to this passage. The simple fact is, that the reviewers have themselves failed in discrimination; not observing that it is the *forms* merely, not the *internal constitution*, of living bodies, which I have suggested to be a result of similar forces to those productive of the forms of crystals. The idea, after all, did not originate here, but was adopted partly from the following passage in Mr. Leithead's work on Electricity, (1837):—

"——— the form of the route of free electricity is modified by the medium through which it passes, and also by the electrical state of such medium, or of that of the relative electrical conditions of two bodies between which it is transmitted. If the medium through which it passes possesses a very inferior conducting power, it is obvious that a certain momentum must be requisite to enable the fluid to force its passage to a given distance, and there will be a point at which the momentum of the fluid and the resistance of the body will exactly counterbalance each other; but so soon as the electricity has again accumulated to a sufficient degree to overcome the resistance, it will again force its way in another direction, until it arrives at another point of equilibrium. *In this way we may readily see the modus operandi of the electric fluid in imparting regular forms to bodies; and it is highly probable that its action in this respect extends to the vegetable kingdom, and perhaps operates* *even on animals, from the time in which they exist in the embryo state.* . . . . Another fact, in support of the opinion that the distinctive forms of bodies are produced by electrical action, is, that crystals, and the twigs and leaves of vegetables, all terminate in points or sharp edges, so that the electrical action can proceed no further in increasing the growth, or, in other words, in propelling fresh portions of matter for the extension of the plant, or the crystal, beyond the pointed or edged termination."

(48.) Carpenter's Report on the Results obtained by the Microscope in the Study of Anatomy and Physiology, 1843.

(49.) See Dr. Martin Barry on Fissiparous Generation; Jameson's Journal, Oct., 1843.

(50.) The reader will please to understand that this is only a humble attempt to bring illustrations from a department of science on which at present much doubt and obscurity rest. I have followed the best lights that could be found, but cannot be assured that better will not yet be evolved from the researches of the many able physiologists now engaged in the investigation of ultimate structure and of embryology. I am bound to admit, in the meantime, that the identity of the globules produced in albumen by electricity with *living cells*, and the fact of the reproduction of living globules, are both doubted by physiologists of high character. In this, as in other instances, particular illustrations may be held in doubt, or may altogether fail, without necessary injury to other arguments.

(51.) Article *Generation*, in Todd's Cyclopædia of Anatomy and Physiology.

(52.) Article Zoophytes, Encyclopædia Britannica, 7th edition. A more general, but more arresting argument in favour of primitive production, though not conclusively so, has been presented in the following terms:—

"We see a simple germ—the nucleus of a cell—develop itself into a feeling, moving, thinking man, by drawing into itself, and combining into new forms, the particles of what we are accustomed to call inorganic matter. These new forms are caused, by the very act of combination, to manifest properties of a new and peculiar kind; and their actions constitute the life of the being. Hence we must attribute to all those substances, which are thus drawn from the inorganic into the organic mode of existence, *a latent capacity* for the latter;—just as we say that the oxygen, hydrogen, carbon, and nitrogen, which make up the organic substance termed muscular fibre, and which, in *that* state or mode of combination, possess certain vital properties, possess also *a latent capacity* for combining in that mode of aggregation termed crystaline, and for exhibiting the solubility, translucency, and other qualities of a salt (all of which are totally opposed to its vital properties, and cannot co-exist with them), when united into the form of cyanate of ammonia. If we were only acquainted with those elements as they exist in organic compounds, their transposition into a crystaline salt would be almost as marvellous to us as the opposite change is now. If this *latent organizability or vitality* be admitted (as we conceive logical proof to have been given that it must) as a property of a large proportion of what we call inorganic matter, is there any such wonderful difficulty in imagining that it may be brought into play in some other manner than by the agency of a pre-existing germ? We think not. But let further investigation and more extended experience decide." —*British and Foreign Medical Review*, January, 1845.

(53.) See a pamphlet circulated by Mr. Weekes in 1842. For a detail of further and more conclusive experiments, reference may be made to *Explanations, forming a Sequel to Vestiges, &c.*

(54.) The writer of the critique upon this work in the *British and Foreign Medical Review*, after saying that "none of the easy solutions which have been offered of the difficult problem presented by the appearance of this acarus, can be admitted," proceeds to make a few remarks much to the above purpose; and adds—"Not the least curious part of its (the acarus's) history is the series of metamorphoses which it undergoes before quitting the solution; these being *entirely different from the very slight changes which other acari undergo after their emersion from the egg.* Further, we believe it may be positively asserted, that, in whatever mode these acari are first generated, *it is not from eggs;* since, after they have escaped from the solution, they live in the neighbourhood, and readily breed; and their eggs, which we have ourselves seen, are quite large enough to have been readily visible in the solution, had they existed there."

The metamorphoses here adverted to will perhaps go some way to satisfy those who have objected that the acarus, belonging, as it does, to the articulata, is too high an animal to have been produced otherwise than from ova.

I would, nevertheless, remark that the Acarus Crossii is only brought forward as one illustration, and in order that a hypothesis which I think has strong probabilities on its side may have the benefit of any doubts that can be instituted with regard to the production of this creature. The decision of the question against the conclusion here leant to, would still leave much sound illustration, and not in the least affect the *general* argument.

(55.) The objections made to the idea of a parity between advancing organization and the succession of fossils are all in regard to subordinate points, and either rest on assumptions as to the grades of animals which are entirely without solid foundation, or take hold for a feeble support of certain blanks and imperfections in the geological record.

One of these objections relates to the occurrence of cephalopodous mollusca, which, generally speaking, are the most highly organized class of invertebrates, at the first or lowest point in the rock series where *distinct* fossils are found. The answer is—(1.) that, in a right view of the genealogies of the animal kingdom, the only predecessors of the cephalopoda possessing hard parts are certain pteropodous families, whose shells are almost too slight to have had a chance of being preserved; (2.) there is a lower aqueous formation which may have contained remains of lower families of animals, but which has been acknowledgedly so affected by the agency of heat, that any fossils which it ever bore must have been obliterated; (3.) the first cephalopoda are of low families in their class, and higher genera come afterwards. See, on these points, the section on the Silurian Era, and that regarding the Affinities and Geographical Distribution of Animals.

The second great objection rests upon certain peculiarities of the cartilaginous order of fishes, those to which the earliest of the class belonged. While existing specimens of the *Cartilagines* reach lower down in the scale of organization than the osseous fishes, and while their imperfect vertebral structure, heterocercal tails, and other peculiarities, indicate a general inferiority, some of them present characters in the nervous and reproductive systems, which the osseous fishes do not possess. A few are viviparous, and manifest an affection for their offspring. On these partial grounds, an assumption has been built that the fishes commence with the highest forms! The occurrence of cestraceons in the Upper Silurians is particularly insisted upon as evidence for this conclusion. In reality, the few traits of superiority in the cartilaginous order, even if general to it, which they are not, are light in the scale, against the truly general inferiority. It is well known that no family of the animal kingdom is equally high in all points of structure and endowment, and that many forms, generally humble, have characteristics of a comparatively elevated kind. There are features of even the human organization which would place our race below some of the inferior animals, if these were to be made an exclusive criterion. The partial superiority possessed by certain cartilaginous genera seems partly to relate to their place in creation as destructives: they have a well-developed nervous system to enable them to conquer their prey (see *Explanations*, pp. 49—56). That the nervous system determines the character of the reproductive system is an admitted law in physiology (see *Owen*, *Philosophical Transactions*, 1834, p. 359). To find, then, some of these cartilagines exhibiting a generative system superior to other fishes, is no true difficulty in our course. On the very same ground, the star-fishes (radiata), where the sexes are in different individuals, are superior to the annelides (articulata), which present "an androgynous combination of simple ovaria and testes;" yet no one would think of describing the radiata generally as superior to the articulata. Or the polypes might be said to be superior to the star-fishes, because in some of them "the digestive canal presents an œsophagus, a gizzard, a glandular stomach, and an intestine," while the latter animals have only "a radiated sac with one aperture." Yet, does any one, for that reason, think of placing the polypes above the star-fishes? It cannot be pretended that these and many similar facts are not well known, for they are in every tolerable manual of physiology. Yet, in direct contradiction of them, the opponents of the theory of development persist in asserting that the first fishes in the geological record are the highest in the book of the zoologist!

For further explanations on this point, the reader is referred to the chapter entitled *The Affinities and Geographical Distribution of Organisms.*

The early occurrence of fishes, with a peculiarity of structure allying them to the reptilian class, while fishes possessing no reptilian affinities come into existence, in large numbers, long afterwards, is sometimes brought forward as one of the proofs that the fish class commenced with its highest forms. In strict fact, the Sauroids are not the first fish: they were preceded in the Upper Silurian formation by Placoids, and in the chart of M. Agassiz (copied in Jameson's Journal, Oct. 1844), they come after another large family of their own order, the Lepidoids. With regard to the subsequent rise of non-reptilian fishes, the reader will see some suggestions in the chapters on *The Affinities and Geographical Distribution of Organisms.*

An objection of more recent occurrence arises from certain reptilian remains found in strata, supposed to be of the New Red Sandstone, in South Africa. One portion of these remains indicates an animal more huge than the crocodile. Another goes to form a new lacertian genus, combining characters of the lizard, crocodile, and tortoise, and to which Mr. Owen has given the name of *Dicynodon*, on account of two canine tusks which projected downwards with an outward curve from the upper jaw of the animal, the rest of the mouth being horny and toothless. These tusks, both as to their form and internal structure, are regarded as of mammalian character.

Here, too, it is said by the opponents of the development theory, we find traits of superior organization in the earliest animals of a particular class.

That these Bidentals, as Mr. Owen more comprehensively calls them, are amongst the earliest reptiles, is by no means ascertained; for the situation of the strata, in which they have been found, is unfixed. But, admitting that they were of early occurrence among reptiles, their exhibiting an approximation to mammalian dentition cannot truly be regarded as a proof of their being high in their class. We know well that a superior development of one organ, more especially an external one, tells nothing to that effect. The echinus, a member of the echinodermata, is furnished with teeth, while, in the superior family of holothuria, they are reduced to rudiments. Müller detected in the scorpion most of the parts which enter into the eye of the vertebrated animal, as well as a similarity in their arrangement, and yet we know how far inferior the scorpion is, on general grounds, to the vertebrate sub-kingdom. The fact is, that animals are endowed with such partial superiorities, when necessary with regard to the circumstances in which they are destined to live; but their place in the animal scale is to be determined on totally different considerations. How, if it were otherwise, should we find teeth in certain radiata, and wanting in the great bulk of the mollusca and articulata? How should we find this branch of organization, which prevails generally in the reptiles, become extinguished in the superior class of the birds, and even in some of the mammalia (the manatus stelleri, for example)?

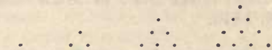
In plain truth, the seizing upon this fact of bidental reptiles as a proof against the development theory, and that before even the place of the strata in which they were found was determined, is only an evidence of the rashness of the counter-theorists on this question, and of the weakness of the arguments by which their opposition is maintained.

(56.) Lord's Popular Physiology.

(57.) The numbers 1, 3, 6, 10, 15, 21, 28, &c., are formed by adding the successive terms of the series of natural numbers thus:

$$1=1$$
$$1+2=3$$
$$1+2+3=6$$
$$1+2+3+4=10, \text{ \&c.}$$

They are called triangular numbers, because a number of points corresponding to any term can always be placed in the form of a triangle; for instance:



1 3 6 10

(58.) Modified from one in Carpenter's General Physiology.

(59.) Kirby and Spence's Introduction to Entomology.

(60.) M. Hampe has observed in the creeping willow (*salix repens*) that twigs above the water blossom as females, whilst those twigs which have been in the water, and subsequently blossomed when the water dried up, had only male blossoms. This seems a case analogous to that of the determination of sex by the bees, and may be held as an additional proof of the power of circumstances to affect development to very important results.

(61.) Gardeners' Chronicle, July 11, 1846 (*Review of Vestiges of Creation*).

(62) The Vegetable Kingdom, 8vo, 1846, p. 5.

(63.) Darwin's Journal of a Voyage round the World.

(64.) Lamarck's Philosophie Zoologique.

(65.) Gardeners' Chronicle, 1846, p. 118. The witness in this case signs himself, C. Wayth, Bearsted House, Maidstone. See p. 102 of the same volume; also the Gardeners' Chronicle for August and September, 1844, where an experiment by Lord Arthur Hervey is recorded. See, further, the Magazine of Natural History, new series, i. 574, and Reports of Ray Society, 1846, p. 381.

(66.) Steinstrupp on Alternate Generation, published by the Ray Society.

(67.) Yarrell's Birds, iii. 571.

(68.) Magazine of Natural History, vii. 57.

(69.) A correspondent states that he has seen a variety of the goldfinch marked by strong distinguishing characters,—considerably larger size, more graceful form, and much richer and more lustrous plumage,—which, bird-catchers say, occurs frequently as a progeny of the ordinary bird. The distinctions of this animal are greater than those held in many instances as specific; there seems no room to doubt in such an instance that pairs so peculiar might, in fresh ground of their own, give rise to a race which naturalists would call a separate species.

(70.) See letter of the Dean of Manchester in Gardeners' Chronicle, July 18, 1846.

(71.) Lectures on the Invertebrate Animals, p. 369.

(72.) See this series of forms illustrated in Professor E. Forbes's beautiful volume on the Echinodermata.

(73.) See the presumed steps of conversion fully described in Professor Rymer Jones's Animal Kingdom, p. 224.

(74.) Professor Edward Forbes, in Jameson's Journal, xxxvi. 326.

(75.) Carpenter's General Physiology.

(76.) See p. 33 of this volume.

(77.) Griffith's Cuvier, ix. 42.

(78.) Report on the Progress and Present State of Ornithology, by H. E. Strickland; British Association, 1844.

(79.) A different position was assigned to the herbivorous cetes in the fifth edition. Since then, the balance of evidence appears to me decidedly for the arrangement above indicated.

(80.) The sloths have been raised from association with the ant-eaters and armadillos to the Primates, by a French naturalist, in consideration of the complete nature of the fore-arm, the head of the radius being round and apt for rotation; also, from the thorax being rather wide than deep, and from the form of the trunk in its lower part. Mr. Owen is opposed to the translation; but it is supported by Mr. Edward Newman, a living zoologist of good reputation. The following are Mr. Newman's reasons:—

"The face of the sloth is round, short, and remarkable for its almost human expression, a character even more observable in this animal than in the majority of monkeys. The structure of the skull and teeth also exhibits some approaches to the monkeys, but none to the ant-eaters. The size, figure, and general external appearance is that of a monkey. The mammæ are two only, and these are pectoral. The feet are always used as hands for grasping and climbing, and never as feet for walking or running on the ground. The sloth spends his time entirely in trees, among the branches of which he travels with wonderful rapidity."—*System of Nature*, 1843.

(81.) It was suggested that the megatherium might exhibit an alliance to the armadillos by a bony armour. Mr. Newman (*System of Nature*) expresses his dissent to this notion, because "the dorsal vertebræ want those lateral processes so essential to the support of a weighty osseous carapace. I should rather fancy him a sloth in all his characters, with a round monkey-like face, an awkward gait, shaggy hair, pectoral mammæ, &c. Megalonyx, Milodon, and (if distinct) Dr. Harlan's Oryctotherium Missouriense, evidently approach Megatherium, and unite in forming a group of animals, &c."

(82.) Newman's System of Nature.

(83.) British Fossil Mammalia and Birds, p. 69.

(84.) See this argument more fully elucidated in *Explanations, a Sequel to the Vestiges*, &c.

(85.) See Pritchard's Researches into the Physical History of Man.

(86.) Buckingham's Travels among the Arabs.

(87.) Wiseman's Lectures on the Connexion between Science and Revealed Religion, i. 44.

(88.) Schoolcraft.

(89.) Views of the Cordilleras.

(90.) The view of civilization here controverted is to be found in Archbishop Whateley's *Lectures on Political Economy.* In Additions to the fifth edition of his Grace's *Elements of Rhetoric*, the argument from the Mandans is impugned, on the grounds that there is no proof of their originally having been savages, or of the same race with the other North Americans, or of their civilization not having been introduced from without. Mr. Catlin is also represented as stating in private that he presumed the Mandans, from their external appearance, to be a distinct race. Their distinctness and the independent origin of the civilization I am represented as having *assumed*, contrary to all logical science. I would reply briefly, that censure on the last point, were it just, would come ill from one who is willing wholly to assume, in this case, the opposite position. It is not just, however, for were the Mandans, as his Grace supposes, the remains of a civilized people introduced from without, they ought to have had a distinct language, which is not pretended. External peculiarities are precisely those which civilization modifies, and they therefore tell not in the case. Then as to Mr. Catlin's privately expressed admission, it is sufficient to refer to his own words, quoted at a later portion of my text, where he expressly attributes the improvement of the Mandans to the external circumstances to which I in part trace all civilization. Unprompted, unprejudiced, untampered with testimony, such as we find in Mr. Catlin's book, seems to me worth considerably more than anything on the opposite side of a merely theoretical nature.

(91.) The problem of Chinese civilization, such as it is—so puzzling when we consider that they are only, as will be presently seen, the child race of mankind—is solved when we look to geographical position producing fixity of residence and density of population.

(92.) Lord's Popular Physiology, explaining observations by M. Serres.

(93.) Conformably to this view, the beard, that peculiar attribute of maturity, is scanty in the Mongolian, and scarcely exists in the Americans and Negroes.

(94.) Missionary Scenes and Labours in Southern Africa.

(95.) "Is not God the first cause of matter as well as of mind? Do not the first attributes of matter lie as inscrutable in the bosom of God—of its first author—as those of mind? Has not even matter confessedly received from God the power of experiencing, in consequence of impressions from the earlier modifications of matter, certain consciousnesses called sensations of the same? Is not, therefore, the wonder of matter also receiving the consciousnesses of other matter called ideas of the mind a wonder more flowing out of and in analogy with all former wonders, than would be, on the contrary, the wonder of this faculty of the mind not flowing out of any faculties of matter? Is it not a wonder which, so far from destroying our hopes of immortality, can establish that doctrine on a train of inferences and inductions more firmly established and more connected with each other than the former belief can be, as soon as we have proved that matter is not perishable, but is only liable to successive combinations and decombinations?

"Can we look farther back one way into the first origin of matter than we can look forward the other way into the last developments of mind? Can we say that God has not in matter itself laid the seeds of every faculty of mind, rather than that he has made the first principle of mind entirely distinct from that of matter? Cannot the first cause of all we see and know have *fraught matter itself, from its very beginning, with all the attributes necessary to develop into mind* as well as he can have from the first made the attributes of mind wholly different from those of matter, only in order afterwards, by an imperceptible and incomprehensible link, to join the two together?

" * * [The decombination of the matter on which mind rests] is this a reason why mind must be annihilated? Is the temporary reverting of the mind, and of the sense out of which that mind develops, to their original component elements, a reason for thinking that they cannot again at another later period and in another higher globe, be again recombined, and with more splendour than before? * * The New Testament does not, after death here, promise us a soul hereafter unconnected with matter, and which has no connexion with our present mind—a soul independent of time and space. That is a fanciful idea, not founded on its expressions, when taken in their just and real meaning. On the contrary, it promises us a mind like the present, founded on time and space; since it is, like the present, to hold a certain situation in time, and a certain locality in space; but it promises a mind situated in portions of time and of space different from the present: a mind composed of elements of matter more extended, more perfect, and more glorious: a mind which, formed of materials supplied by different globes, is consequently able to see farther into the past, and to think farther into the future, than any mind here existing: a mind which, freed from the partial and uneven combination incidental to it on this globe, will be exempt from the changes for evil to which, on the present globe, mind as well as matter is liable, and will only thenceforth experience the changes for the better which matter, more justly poised, will alone continue to experience: a mind which, no longer fearing the death, the total decomposition, to which it is subject on this globe, will thenceforth continue last and immortal."—Hope, *on the Origin and Prospects of Man*, 1831.

(96.) Dublin Review, Aug. 1840.

(97.) Including rotifera, entozoa, echinodermata, &c.

(98.) The ray, which is considered as low in the scale of fishes, gives the first faint representation of a brain in certain scanty and medullary masses, which appear as merely composed of enlarged origins of the nerves.

(99.) If mental action is electric, the proverbial quickness of thought—that is, the quickness of the transmission of sensation and will—may be presumed to have been brought to an exact measurement. The speed of light has long been known to be about 192,000 miles per second, and the experiments of Professor Wheatstone have shown that the electric agent travels (if I may so speak) at the same rate, thus showing a likelihood that one law rules the movements of all the "imponderable bodies." Mental action may accordingly be presumed to have a rapidity equal to one hundred and ninety-two thousand miles in the second—a rate evidently far beyond what is necessary to make the design and execution of any of our ordinary muscular movements apparently identical in point of time, which they are.

(100.) Phrenological Journal, xv. 338.

(101.) The doctrine of the natural laws as affecting human welfare is clearly and satisfactorily explained in Mr. Combe's *Essay on the Constitution of Man*, to which and to the excellent works of Dr. Andrew Combe, may be ascribed no small share of that public movement towards improved sanitary regulations which is one of the most gratifying features of our age.

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