RESEARCHES
ON
FOSSIL BONES,
IN WHICH ARE ESTABLISHED
THE CHARACTERS OF
VARIOUS ANIMALS
WHOSE SPECIES HAVE BEEN DESTROYED
BY THE REVOLUTIONS OF
The Globe;

BY

BARON CUVIER

Great Officer of the Legion of Honour, Counsellor of State, and Member of the
Royal Council of Public Instruction, One of the Forty of the French Academy,
Perpetual Secretary to the Academy of Sciences, Member of the Aca-
demies and Royal Societies of London, Berlin, Petersburg,
Stockholm, Edinburgh, Copenhagen, Gottingen, Turin,
Bavaria, Modena, The Netherlands, Calcutta, and of
the Linnæan Society of London, &c. &c. &c. &c.

FOURTH EDITION,

Revised and Completed

BY ADDITIONAL NOTES,

AND A

SUPPLEMENT LEFT BY THE AUTHOR.

Triomphante des eaux, du trépas, et du temps,
La terre a cru revoir ses premiers habitants.

DELILLE.

IN FOUR VOLUMES.

LONDON:**G. HENDERSON, 2, OLD BAILEY, LUDGATE-HILL.**

AND SOLD BY ALL BOOKSELLERS.

1834.

Fig. 3.

Fig. 5.

Fig. 3

Fig. 2

Fig. 1

Fig. 5

Fig. 4

Fig. 1 & 2. Two jaws a portion of the skeleton of a Bat discovered at Montmartre: the natural size. Fig. 3. The upper jaw palates & teeth of the *As. pithernum lepermonti*: the natural size.
Fig. 4 & 5. The lower jaw of the narrow-toothed *Mastodon*.

PRELIMINARY OBSERVATIONS.

BY M. FREDERIC CUVIER *(a)*.

I HAVE felt it incumbent upon me to superintend the publication of this new edition of the "Researches on Fossil Bones," as I have already considered it my duty to do with respect to the other works of my brother. My only object, in assuming this laborious office, was to take care that whatever *he* published should be promulgated with good faith, and with that stamp of truth which is so indelibly impressed on all his works. This is the character which, in the midst of the destructive revolutions that in after-times natural history must have to encounter, will secure these works from all violence, however it may originate, that may be directed against them.

The paramount determination, which uniformly actuated my brother in the composition of these works, was to lay beneath the edifice of the natural history of Animals such a solid foundation, as that the materials of which it was composed, rendered less capable of degeneration by the wasting power of time, would communicate their durability to the fabric that reposed upon them.

Such a perspective as this before the view of my brother; the deep

✍ *(a)* In the present edition of the original work, we find, in the early pages of the first part, a very interesting panegyric on our immortal naturalist, which, on its presentation to the Academy of Sciences, of Besançon, caused its author, Mr. Laurillard, to be crowned on the 24th of the present month (August) in the year that has just passed. We have deemed it the best policy, on mature deliberation, to postpone this admirable emanation of eloquence and truth to some later numbers of the series of parts which are to compose our first volume; our sole object being to so accommodate our readers, as that they should enjoy the earliest opportunity of becoming acquainted with the merits of the great author.—ENG. ED.

sentiment of truth which never deserted him under any circumstances ; the immense knowledge, which enabled him to behold, at once, the whole of the facts of science ; in a word, the powerful intellect whereby he could penetrate into the remotest future consequences that were deducible from these facts, were to him a source of great disquietude, because he saw that the imagination would be let loose upon a field of science, which, from its very nature and its vastness, calls, more than any other theatre of intellectual exertion, for exactness and precision. If, then, he opposed every tendency which, in his view of its effect, would prove to be a delusion and therefore dangerous, I myself can well be a witness that he did so, not so much for the purpose of obtaining a victory, or even with any hope of converting those who were engaged in widening the high road which terminated in so fatal a precipice, but rather with the expectation of protecting those from its influence who were most likely to become its victims. The disastrous picture was presented to his eye, of a youthful community exposed to the seductive power of doctrines highly calculated to fascinate the imagination—that faculty which is most predominant and victorious at an early age, but, on that account, the most liable to commit some mischievous error in the cultivation of the sciences. My brother, therefore, felt it an obligation upon him to undertake the repugnant functions of a preceptor, who, in obedience to the voice of conscience, sets himself down to the task of controlling the passions of his pupils, in just apprehension that they should be overpowered by those who would labour to excite and would cover them with adulation.

From the observations collected by my brother, and from several of his notes which appear to refer to topics not previously broached by him, but which he was to treat at large in a new edition of the “*Researches*,” it is obvious, in my judgment at least, that this work was intended by him to be enriched with numerous facts, communicated to him by the learned men of all countries, who seemed to have no other object in view in their generous labours, than to send the results to him, and also by some general conclusions received by him relative to the ancient animals which were deducible from them.*

One of the questions to which his attention was particularly directed, arose from the series of novel facts discovered by M. Champollion in Egypt. From the information thus obtained, this latter illus-

* When the subject will admit of it, the new facts collected by my brother will be added to the text in the form of notes, in order that the text may be preserved in all its original integrity. The greater number of the facts, however, will be found in the SUPPLEMENT, of which, the materials have been wholly supplied by my brother, and which M. Laurillard is to add to the *Researches on Fossil Bones*.

trious academician, this creator also of a new science, was induced to believe that he had traced the origin of the human race to a period considerably more remote from the present time, than the limits assigned to it by the scientific monuments which have been discovered up to the present era. Were we to decide respecting the opinions of my brother by the contents of some of the notes just spoken of, we should say that he was very much disinclined indeed to admit, as demonstrated, the proofs supplied by his learned colleague from his discoveries. Very unfortunately he has left nothing from which we can infer the nature of the reasons that led him to this expression of doubt.

Some persons have presumed that this opinion of my brother, respecting the origin of man, was maintained by him in consequence of the influence of a prejudice that was calculated to blind him with respect to the facts which should have formed the true premises of his inductions. Consequently, they contended against this judgment as if it was not only an hypothesis, but a very false hypothesis, one that was destined, at the utmost, to encourage doctrines which reason could not possibly admit. Now, such charges as these were not promulgated by learned men; for it was not, by any means, in historical monuments that a rational mind would attempt to discover proofs of a greater antiquity of the world; and, in point of fact, the critical investigation of these monuments, contained in the Preliminary Discourse to these Researches, leaves very little hope indeed that any other conclusions can be fairly deduced from that examination, save those to which my brother has conducted us. The most sanguine foes to the doctrine of the recent origin of our species, belonged to that class of naturalists which entirely trusted to the strata of our planet for proofs in favour of their opinion.

Every authentic observation that has been accumulated up to the present moment, has convincingly corroborated the obviously justifiable conclusion which has been established by my brother, namely, that the human species was *subsequent* to the last of the catastrophes which had laid bare our present continents. It was of the first consequence to those who were inclined to disbelieve that such was the case, to find out, if possible, in the older strata of the earth, particularly in those rocks containing the remains of animals, whose existence is regarded as having been long before that of man—to find out, we repeat, the relics of human skeletons; for, by such a discovery, they would have immediately obtained the most direct and the most irrefragable demonstration of the falsehood of the doctrine against which they were leagued in hostility. The investigations which were undertaken to

prove the propriety of these views of the above Naturalists, showed actually what they were persuaded to believe were human bones mixed with the osseous remains of those former animals, which were said to have inhabited the surface previously to the era of the human race on this globe. But the desperate hope of extinguishing, by one solitary case, one unexampled instance, so vastly important, a general principle, and also the hope of burying in the same ruin those truths regarding cosmogony which received in this same general principle a support as well as a rational foundation on which it was partially itself constructed—such a hope, I repeat, could not, for any length of time, be maintained. The whole, therefore, of these pretended facts instantly vanished at the application of the test of a rigorous enquiry, and were thus consigned to merited oblivion.

Nothing, we readily admit, can be more agreeable to nature and to justice, than for a man to oppose any opinion which he cannot adopt, provided only, be it remembered, that, upon all such occasions, he has adequate reasons for rejecting such an opinion; nay, nothing is more justifiable than for a man to collect information, which shall support the views he has established for himself, let but his mind be uninfluenced by any other motive than this opinion itself, quite isolated from any source of modifying interference. But then, how is it, I ask, do we see so much of this ardent spirit opposed to every accidentally discovered truth, which never had the least pretension to a different sort of character; to which, no hostility has, at any time, been shown, which no defect of the reasoning process employed in it can have tarnished, and which should, as a necessary consequence, command the assent of every well-constituted mind? Now, the whole of the reply, which I propose to give to this interrogation, must be limited to the simple remark, that were even this accidental truth weakened or completely subverted by the discovery of human remains in the older rocks of the earth, still, that such a discovery would not, in the least, detract from the merit belonging to the profound investigations and the most ingenious arguments by which that truth was established, and therefore that it would not diminish the glory of him who devoted an assiduous life to the one, and exerted the indefatigable labours and perseverance which were indispensable to the others; nor will that Discourse, in which it is demonstrated with such consummate clearness, and expressed in so noble a style, be received with the less ardour and interest on the same account, as an elegant model, by all the right-minded men who may come after him, and who may be disposed to labour for the promotion of the Sciences to their perfect condition, animated by true-hearted worship of Truth.

The rigorous method, which presides over the whole of this discourse ; the links of mutual dependance which connect together the whole of the successive propositions ; the cautious severity which distinguishes every single modification under which the argument is presented to us ; these can only be, as it were, dead letters, perpetually illegible to those ill-starred minds which are destitute of all natural or inherent logic, to which truth becomes an object completely stripped of all its fascinating attractions, and which by no one of its peculiar characters can it ever be recognized by such an order of minds.

In this place, it becomes my duty to enter into a vindication of my brother from another of the reproaches which assailed him, and which, certainly, would be an exceedingly serious one, did he really deserve it. But, at the same time, that I am sensible of the obligation which his memory imposes upon me, I must yet remember that there are considerations of another kind that render this task particularly different to me in my present peculiar circumstances. Nevertheless I entertain the strongest hopes that, in a discussion so purely scientific in its nature, and in which, so far as I am concerned, a feeling of affection will be uppermost towards the learned gentleman of whom I reluctantly become the antagonist, and that character of sobriety and moderation which are most congenial to such a theme will be sacredly maintained, whilst nothing whatever shall escape my pen which may be inconsistent with this sentiment.

The reproach to which I allude as having been attempted to be fixed on my brother, amounts to nothing less than the accusation that he declined to adopt as certainly proved, when he laid the foundation of his labours on the extinct animals, an ancient speculation, revived in modern times, and which asserted that all the animal species, both those which existed in the earliest times, as well as those which now inhabit our-globe, were produced from one or more primitive species.

The presumption, therefore, that was entertained on this occasion respecting my brother was this, that his power of comprehension was too limited to allow him to form a conception so vast, and it was thought that he was so addicted to the study of material facts, as to be utterly unable to elevate his mind beyond this humble boundary of observation, thus being in the condition of those who are obliged to keep the eye uninterruptedly fixed on objects that can only be seen in a much nearer position, and who, under such circumstances, at last become deprived of the power of commanding the full extent of the ordinary horizon. I have no means whatever of ascertaining if even the thought of defending himself from this reproach ever entered the mind of my brother. Indeed, there are strong doubts in my mind that

it did not, for there is not a single word respecting this charge in the whole of the notes he has left. But besides, altogether independently of this silence, we have a complete proof that, so far from estimating this hypothesis as a gigantic conception, he actually placed it in the rank of those frivolous pastimes of the fancy, with which truth has nothing whatever in common, and we are greatly diverted when they are invested with a certain grace and address, but which are deprived of all their recommendations the moment we begin to consider them as objects of serious contemplation.

Most cordially do I wish that, consistently with my duty, I could have allowed this topic to remain in the silence to which my brother seemed desirous of consigning it; but, whilst he was amongst us, in life, this complete reserve had an obvious import, which in the present circumstances it cannot possibly convey, since the reproach has been revived, and since it is not by our silence that we should meet it. The researches on fossil bones, and all the successive works which in imitation of my brother's productions have had for their subject, those animals whose remains are discovered buried deeply beneath the surface of our earth, and which inhabited our continents previously to the latest catastrophe that has displayed their remains to our eyes, the whole I repeat of all the compositions just spoken of, contain demonstrations of the truth, that these animals of a high antiquity, without any exception whatever, are specifically distinguishable from all those now living on the earth; that the more deeply we descend in the earth, the more shall we find the differences increased between the ancient and the modern species; and, in short, that the number of aquatic animals compared with the terrestrial species, is governed by the same law of progressive increase of mutual difference, in proportion to the sum of the descent which we make from the superficial strata of the earth, to the deepest of the rocks. Thus we find animals of the mammalia description only in the uppermost or intermediate strata, and, beneath them again, we meet with the oviparous class. Such are the facts which result from the aggregate evidence of all these works, each author recognizing them independently of the rest; the whole of the conclusions, the whole of the inductions, which are justified by right reasoning, having been deduced and then expressed in a perfectly intelligible language. But even this was not sufficient for those more indulgent spirits, according to whose authority it was essential to infer from the whole assemblage of scientific facts maturely considered this distinct conclusion, viz., that the modern species of animals were not different in any specific character from the ancient animals, that the former were mere modifications of

the latter, that the whole of these animals were merely divided into individual races, and that these races were formed under the influence of a great variety of modified forms, in which the primitive species had been successively developed from the beginning of the world to the very time in which we live. But, in speaking of species, it is just possible that I might be guilty of a very unintentional error. I should perhaps tell the exact species, inasmuch as, according to the system which I am explaining, there would have been originally only a single one, which no doubt was represented by some number of individuals, were it not for the living organic molecules, as the theory of Buffon supposed, which individuals becoming developed each according to conditions peculiar to it, which after the lapse of thousands upon thousands of years are themselves modified into as many myriads of times, have at last been brought to that state in which they were able to produce this world of living animals which now covers the surface of the globe, from the creatures that can only be rendered visible by the interposition of the aid of the microscope, and whose whole life would appear to be of the vegetative kind, up to man the intelligent and free being.

Previously to becoming familiarized with the profound study of nature, every student is liable to be prejudiced by some system which, being very simple in its principle, leads him to an explanation, not less simple, of all the distinctions between animals. Those who habitually adopt, without further enquiry, ideas of this description, particularly such ideas as flatter their imagination, appear to believe that nothing can be happier than this system, which of course they zealously defend; for how could it be possible for anybody to renounce, without a painful emotion, the power of disposing, according to his pleasure, the whole of the forces of nature, and to generate in some measure, by every touch of his wand, some one or other of those beings on the earth, which are endowed with life and sensibility? Paganism, in the flower of its youth, and in all its profound ignorance, was never such a daring and such a brilliant piece of poetry as this! On the contrary, those who have understood, that every system must have its basis resting on facts, will, of necessity, agree with us in the opinion which we have just expressed, because, they will see that such a system could not have been proposed, unless every effort had been previously made for collecting the proofs that would render the facts certain; but still nothing is less founded than this persuasion.

When we seek to describe the amount of knowledge required for giving a real basis to this system, and the facts, which must be proved, in order that they should be traced to some better authority than the

imagination, and shewn to be the real result of an induction, no matter how slight the foundation was, on which such an inference was founded—when we make such an experiment as this, we immediately become convinced that our system certainly rests on analogies which are altogether deceptive, and that our conclusion is nothing more than the mischievous fruits of false reasoning. After all, in order to give a character of truth to this system, it is indispensable that we should set out with some definite notions respecting the circumstances under which the early animals were found. We must become acquainted with the succession of alterations which these circumstances have undergone down to the era when that state of stability was attained at which we are now arrived, which admit, even, the supposition that the early animals were very simply constructed. Now, with respect to all these various points, our ignorance is absolutely complete, so that we are unable to do more at present on this question than to indulge in vague speculations. It would, after that, be necessary to show, by well-conducted observations, whether or not these conditions exercised any influence on the developement of the animals; and, also, what is the influence of certain animals amongst them, if it be not the influence of the whole. Alas! upon these topics, as well as on the former, our ignorance is just as profound, and our conjectures just as fruitless. In fact, we are unable to estimate at all the influence of the conditions of the past race of animals, or of the existing one, in modifying their respective species; and hence, we should endeavour to find in the facts, to which we have access, and in the species which we have the opportunity of observing, those mysterious modifications, the causes of which, though hidden from our eyes, still must, of necessity, be consonant with nature, and, therefore, dependant on one or the other of the conditions in which we find the animals presented to us. Otherwise, where could we obtain the smallest foundation for the theory of such an effect of circumstances on the principal organic systems of animals? The truth really is this, that there is no fact whatever, of this description, amongst the records of science; for no person in the world has ever seen any species transform its state of existence to any extent, or in any shape, in order to be converted either totally or even partially into another species; nor does it require a deeper knowledge of this science, than may be obtained from a slight initiation into it, to believe that this transformation, however tardily we may be allowed to suppose that the gradual process was carried on, is perfectly inconceivable. These results, to which we are led, by simple enquiry, alone are of such a nature, as that they may give rise to charges against us of making exaggerated

statements, and that too, strangely enough, at the very time when we have actually avoided drawing the whole of the conclusions capable of being deduced from these facts in favour of our side of the question.

It is not to be denied, that this theory of the transformation of one species into another, together with all the hypotheses which flow from it, will be found to be very strongly countenanced by various natural phenomena. There never was a time when naturalists thought of explaining objects in nature without having recourse to analogy, and, in the present case, it is upon analogy that we altogether rest. But as, in a logical sense, we are prohibited from departing from the exact import of the premises, in coming to our conclusion, so are we, here, at once, interdicted from deducing from the analogies established as principles, now before us, truths of a very different kind from the principles incorporated in these analogies; and there is no doubt whatever, that, by neglecting this rule in all cases, where it ought to have been applied, the mistake has been made which we find ourselves compelled to oppose; and this is a work of no difficulty whatever. We say, further, that all these faults, these fantastic and confused speculations, which have been brought into vogue by *Naturalism*, may be traced to the same cause; namely, a complete forgetfulness of the rule, without the assistance of which, the process of induction, instead of being a mine of wealth, as it is at present, to the sciences, would only be an instrument of confusion and endless labour.

It is well known that our domestic animals are divided into races, more or less numerous, according to the species, and that these races are chiefly to be distinguished by such characters as those of size, bodily proportions, degrees of developement in the limbs, length of their ears and hair, their colours, &c. Thus, for example, amongst some of the most domestic of our canine race, we see a fifth toe developed in the hind paws. This toe is sometimes formed of bones quite as complete in their formation as those of the other toes, and here, in my humble opinion, is presented to us, an organic hereditary modification the most prominent that is supplied by the animal kingdom. We may follow up this, by stating further, as a permanent law, that modifications resulting from accident, which become renewed in several successive generations, are ultimately transmitted from father to son, as characters of the individual race.

Ere we enter upon the examination of these facts, in relation to the system which we are now contemplating, we shall be convinced, at once, that, with the exception of the aliment, which must have been so abundant as to be very favorable to the promotion of the size of the animal body, we must be altogether ignorant of the causes of these modifications. Under no possible circumstances, by no methods whatever, with which we are acquainted, can we produce any thing at all resembling these ancient animals; and hence, we conclude, that such facts are absolutely mere nullities in leading us to the discovery of the causes that have produced the modifications of species, together with their transformations.

We shall presently recall to the attention of our readers the fact, that such a thing as one of our domesticated species was never yet seen as appearing with the characters of some other species of the genus to which it belongs, either domesticated or in the wild state; neither has there been a single case known, throughout the world, in which one of our dogs has been found turned into a wolf or a jackal, or a fox. There is no example in the records of natural history of a horse having assumed the characters of an ass, or an ass taking on those of a zebra. Never did we find, on any occasion, a single instance in which any one variety of our goats was metamorphosed into a variety of sheep, or vice versa. As a necessary consequence, it follows, that, as we are destitute altogether of any fact of this nature, we can have no possible foundation to justify the general inference of a real transformation; but we may turn to the particular facts alluded to above, to show whether or not they are able to supply any support to the conclusion just spoken of.

Differences of dimensions are, by far, the best specific characters, as is seen attested by our large and small races of domestic animals. The same thing occurs, but within certain limits, in the proportions of the body as is well exemplified in the sea bear, the common bear, and the long-lipped bear. This character also belongs to species in which it is manifested by the developement of the limbs, as is displayed in the thighs of the elk and the rein-deer, and in the tail of the macacus properly so called, and the rhesus. With evidently, very good reason indeed, is the length of the ears, considered under this character, as well as the length and colour of the hair; the ass is the species nearest in affinity to the horse; the very fine and long-wooled fleece cannot be separated from the short-haired lama, and we have yellow, grey, black, &c. squirrels. Facts, such as these, belong to the same category as those that are classed amongst the true

characters, whereby the species of any given genus are distinguished from each other ; in other words, these constitute their specific characters. The only inference then, which, in such circumstances, we could possibly come to, is, that a given species may grow to the size of a neighbouring species, and assume its proportions, its hair, colours, &c. ; but the system would be crumbled to a nullity if it was refused to admit that the change of one species of the same genus may take place ; it requires the transition of one genus into another genus, of one order into another one, and of one class also into another class, and it is in the existence of this very transition, which is made out from the individual facts, that have been just recognised by us, and also characterised. Hence, has arisen the tendency of certain persons to detect analogies between facts, when really nothing of the sort subsists ; also, on account of this does it happen, that analogies are sought between the organs of the lowest order, characteristic of the species, and the organs of the highest order, characteristic of genera, orders, or classes ; that is to say, between organs which are endowed with no sort of influence for limiting the conditions of animal existence, and those on which these conditions essentially depend. In a word, as we have already observed, the conclusion on this occasion has been carried beyond the confines of the premises, and consequently the result is, that the reasoning adopted is false.

It now remains for us to determine whether or not the system of the transformation of species receives more support than it has from the facts just stated, in the important discovery to which we have already alluded, that of the developement of the fifth toe.

This phenomenon being wholly unprecedented, we shall be able to show how very narrow the foundation of this system must be ; we shall succeed also in showing an increase in the difference of the conclusions, at present entertained, respecting the origin of the distinctions subsisting between the different canine species ; nay, we shall justify ourselves for declining to admit, that the inferences drawn from the experience of domestication, from facts entirely occurring in a state of nature, do not belong to the class of legitimate arguments. But, in order not to waste time, we shall go so far as to admit that the developement of the fifth toe is favourable to the system ; even then, I ask, what advantage has the system gained by this admission ? It is very manifest that it has gained none at all ; for, the step which has been attained by this concession, is still very remote indeed from the confines of the genera, and, despite the numerous affinities which exist between the dogs, the latter genera

of the family of martens and the civets; yet, there is not a single fact before us to cast the slightest doubt on the existence of the decided partition which separates these genera. The supplemental toe, therefore, of certain races of domestic dogs, is also a fact quite as feeble in support of the views which we are now considering, as the whole of those to which we have previously referred.

The solution of problems like these is far from being facilitated by appealing to the weak authority, as is done in the present case, of such men as De Maillet, or the more respectable one of Buffon, or, again, that of Lamarck; since it is well known that the theory, expressed by Buffon in his Discourse on the Degeneration of Animals and on the Epochs of Nature, like those which Lamarck has put forth on the causes of the various forms of animals, has not obtained the slightest assent, and are now universally regarded as merely silly emanations of the fancy, or as inferences deduced from principles, the admission of which was not founded on any proof or demonstration; and, so far as these Epochs are concerned, the reason why we read them now is, that they possess a merit of their own, which is quite independent of that derived from the expression of genuine principles.—Why was it that no credit or confidence was bestowed on the system which Buffon described with such luminous eloquence? Why was not the theory of Lamarck believed, supported, as it was, by so many arbitrary propositions? In answer to these questions we may state, that it was because these systems were not consistent with the facts; that they were not sustained upon any foundation whatever of exact observation, nor by any sort of rigorous experiments. For the purpose of assuming the privilege of promulgating, once more, these systems, and endeavouring to support their authority, in order to exhibit them in some new point of view, it is indispensable that the partisans of such doctrines should prove, that they found in the facts opposed to them other facts which they deemed favourable to their notions; that, by these, they would inspire more confidence than they were able to produce at their first appearance, and, lastly, that science, with respect to them, had been utterly subverted. But this, as we have already seen, is not the fact. In putting them forward as demonstrations of the system which we combat, and with which they are confounded, we are consequently placed in a vicious circle, and there is made to us now what, in logic, is styled a *petitio principii*.

But if there were only the slightest proof, I shall not say of transformation, but of the possibility of the transformation of one species

into another, how is it the case, that no anatomist, physiologist, or naturalist of any description whatever, has, from the very commencement, devoted his mind to this other order of phenomena? It was necessary to have avoided every remembrance of the circumstance of this transformation, involving as it did an absolute miracle to believe that a mind capable of conceiving it could, for an instant, resist the ascendancy of such a sentiment, and that, the instant when he recognised it, he would not, at once, apply himself to the forming of a radical revolution in all the sciences which, far and near, have animals for their subject; and now this transformation is proclaimed anew, but nothing of the like of what we anticipated is threatened to be done.

We fall back, therefore, on the ordinary supposition, that this idea only fails to produce its effect, because the age is not at its highest point of refinement, and because the idea has been promulgated too prematurely to be as yet comprehended; in a word, it is with this idea as it was with those of Galileo on the motion of the earth. Very nearly a century has passed since De Maillet's reveries were presented to the public. In 1778, Buffon published his *Epochs of Nature*, and Lamarck, more than thirty years ago, proceeded to revive the ideas of his predecessors. Nobody will imagine that science has remained stationary since that period, and yet, at this hour, these ideas remain the same as in the middle of the eighteenth century, as in the era of Buffon, and as in the time of Lamarck, for not only has no fact been discovered, which could render this transformation at all probable, but nothing has even been suggested that can afford to this theory the slightest countenance; on the contrary, the whole of the facts are against it in every natural phenomenon in which it is sought, and in whatever it is attempted to be detected.

If I have been understood in the criticism now given of a system which I should have preferred leaving to the support of others, I have reason to believe that the world will consider my brother, at least, excusable for having declined to adopt those ideas, since to his mind, which always yearned for truth and light, they must have appeared surrounded with doubts and obscurities.

I have limited myself to the examination of two questions, which have just occupied me; namely, the antiquity of the human race, and the transformation of animal species from the one into the other, these being the only ones that have been directly pointed against opinions which all have sanctioned, and still sanction at this day. I

might have mentioned others, but the labours of my brother are much too numerous and too important, and have raised too high the public estimation in which he is held, so that criticism may well be spared, particularly when it is presented in an equitable manner; but as these questions relate indirectly only to fossil bones, I shall not dwell on them. In some other portion of the new edition of his works, a better opportunity will be presented for the treatment of such subjects.

TO THE MARQUIS DE LA PÉROUSE.

PEER OF FRANCE, GRAND OFFICER OF THE LEGION OF HONOR,

ONE OF THE FORTY OF THE FRENCH ACADEMY.

MEMBER OF THE ACADEMY OF SCIENCES, AND OF THE

BOARD OF LONGITUDE, &c.

MY DEAR AND ILLUSTRIOUS COLLEAGUE :

I had many motives for my eagerness to offer you the homage of my work on its first publication. While yet a young man, and I imparted to you my first notions of the undertaking, you encouraged me to pursue my plan ; since that period, having been admitted to a place amongst my masters, I have found in the class of the sciences in the Institute, counsels, encouragements, and helps of every kind ; it was in the midst of this learned body, that the opportunity was afforded of imbibing that severe *esprit*, the fruit of the happy association established in the Academy between mathematicians and naturalists. You, Sir, who, after having achieved the subjection of the Heavens to Geometry, have so happily applied it to terrestrial phenomena, you contribute, more than any other person to keep up that spirit. It will therefore be at all times a great honour for me to see your name at the head of my book, and I feel the more gratified in inscribing it there now, for the second time, as I have never ceased to have new motives for offering you this testimony of my respectful admiration and devotedness.

G. CUVIER.

ADVERTISEMENT

TO THE SECOND EDITION.

THE first edition of this work, published in 1812, is nothing more than a collection of Memoirs, published successively by the Author in the Annals of the Museum of Natural History, to which he endeavoured to give some appearance of connection, by means of supplementary articles, and an Introduction.

From this mode of publication, many of the chapters remained incomplete, others had been composed of various fragments written at different times and in contradiction with each other. It was not possible to arrange them all in an order sufficiently methodical.

Notwithstanding, this edition had a rapid sale; some parts of it were translated in different languages, with comments and additions by the translators. There are four editions in English of the Preliminary Discourse, followed by extracts from the rest of the work, and interesting notes by the editor, Mr. Jameson, Professor of Geology in Edinburgh. A learned American Naturalist, Dr. Mitchell, has published an edition of it at New-York, enriched with valuable observations on the geology of the United States.

The science of fossils has besides made great progress in Europe since the publication of the first edition. Many celebrated men have collected the fossils of their respective countries, and have published them with drawings, and excellent descriptions; such, for instance, are those of Sir Everard Home in London, Privy Councillor de Sæmmering at Munich, Councillor Cortesi at Placenza, Professor Buckland at Oxford, President Schlotheim at Gotha, Professor Nesti at Florence, the Aulic Councillor de Fischer at Moscow, and of many other geologists or anatomists, from whose works and correspondence, the Author has derived abundant materials.

He has himself pursued with unabated ardour his researches in France, and travelled into Italy, Germany, Holland, and England, principally with a view to collect fossils, to describe those which

have been collected in public or private cabinets, and to observe attentively the sites in which they had been found. He was received everywhere with infinite kindness by persons capable of instructing him, or supplying him with the objects he was in quest of. The observers established in different parts of France and other countries were no less zealous in seconding his views, and in communicating to him their discoveries; and he has thus been enabled to depose, in the Royal Museum at Paris, considerable additions to its scientific stores, or to swell his portfolio with a great number of interesting drawings, which form the materials of the present edition.

Through the means of all these aids, a vast number of objects already known have been studied, not only with more care, but an infinity of new ones have been added to those with which we were already acquainted: at present, the number of fossil hippopotamuses amounts to four; that of rhinoceros to the same number; that of crocodiles to six or seven, without speaking of the new genus of the *ichthyosaurus*. In the environs of Paris alone, the list of lost animals will be increased by two genera, and, perhaps, ten or twelve new species.

The history of the strata in which fossil bones are imbedded; of the minerals, shells, and other animal and vegetable productions which accompany them, has also, since 1812, received large and important improvements.

Learned societies have been formed in different countries, solely with the view of throwing light on the history of this part of the history of the globe. The Geological Society of London has already published several quarto volumes of its memoirs; Mr. Greenough, and several of its most distinguished members, have travelled over the British Isles and the principal countries of Europe. These researches have produced a splendid geological chart of England, which shews the analogy and connexion of the strata of that country with those of France. Our French geologists have not been backward in this great movement; a friend and colleague of the author, Mr. Brongniart, a member of the Academy of Sciences, who had taken a principal part in the examination of the earths in the environs of Paris, being occupied on a general treatise on positive geology, has visited, in minute detail, Germany, Switzerland, Italy, and most parts of France, to study their strata. The most interesting of the earths of our environs, that which M. Brongniart and Cuvier have named fresh-water earth, has been traced in England by Mr. Webster, in France

by M. Beudant and de Ferussac, and, by the latter, as far as the extremities of Spain and Silesia. It has been ascertained, that, in an infinite number of places, it is covered by earths of purely marine origin, a circumstance which removes all doubt as to the great fact—as important in the history of man as in that of the earth—that, at a certain epoch, the terrestrial continents, formerly inhabited by quadrupeds and birds, covered with vegetables, and watered with fresh water, have been invaded by the sea.

The other auxiliary science to that of the fossil bones, the osteology of animals, has received additions no less important than those of the strata of the globe. The efforts which the author has been constantly making to add to the great collection of skeletons, which he has made in the Museum of Natural History, have been warmly seconded by the travellers recently sent by the King into all parts of the world, such as M. Leschenault de la Tour, Milbert, Lesueur, de Lalande, Auguste de Saint Hilaire, Diard, Duvaueel, &c. He has thus obtained skeletons of several species of rhinoceroses, tapirs, tigers, hyenas, dogs, bears, stags, and fourmiliers, of which he was not in possession at the time of his early labours; and it is thus that he has procured, on the bones of almost all those animals, at the different periods of their growth, notions, without which his results could not have attained all the solidity desirable.

While he was occupied in writing this first volume, M. de Lalande brought from the Cape of Good Hope the complete skeletons of the hippopotamus, the two-horned rhinoceros, the orycterope, and of many other species of great importance to this work. At the same time, MM. Diard and Duvaueel sent from Batavia the skeleton of a new species of rhinoceros belonging to the Island of Java, that of the large and fine species of tapir discovered by them in Asia, and of some others equally unknown.

The labours of several other anatomists who have been engaged in the philosophical study of comparative osteology, such as MM. Geoffroy, Saint Hilaire, Spix, Oken, Bojanus, Ulrich, Tiedeman, &c., have also made known or promoted a more minute examination of the bones and parts of bones of divers animals, and from which great advantages were to be derived in the explanation of fossil osteology.

The profound study of the teeth of quadrupeds, undertaken by M. Frederic Cuvier, and the objects of comparison that have been thus obtained, have been no less useful, more especially on account of the facility thus acquired of recognising each quadruped, in some degree, from the inspection of a single tooth.

Finally, the history of ancient races of people, a basis so necessary to the formation of any positive opinion on the history of the globe itself, has also had light shed on it, in these latter years, by the researches of several German and French writers, and by the extracts given to us by some learned Englishmen from the sacred books of the Hindoos; or rather those studies and extracts have proved more and more how recently those races of people without exception, had been established at the time when history first speaks of them, and how vain and fabulous are the traditions, which ascribe to them ages and dynasties without number.

All things agree more and more every day to shew the truth of a great catastrophe, which has changed the face of continents, destroyed races of living beings, transported to great distances the scanty remnants of those it had spared, and enabled us to follow the traces several such catastrophes which preceded it.

It is with these numerous materials the author has undertaken this new edition, in which he will make known all he has collected, and all that others have described, since 1842, relative either to fossil bones, or to the osteology of living species, bordering on those from which the bones are derived.

Not confining himself to oviparous and viviparous quadrupeds, he will speak of the cetaceæ, and hopes to be able to furnish on the osteology of this family, which is so important to be accurately known, many facts, which still appear new, notwithstanding the recent publication of the works of Camper and Albers.

The author has also endeavoured to put the whole work in better order, and to free it from that fragmentary and successive character in which the Memoir composing the first edition had been drawn up; each fact and each idea will be found in its proper place, so that it may be read and studied at once, without obliging the reader to revert to or to rectify them by means of the new ideas and supplements contained in the subsequent Memoirs.

He could have wished to arrange the figures in the same order, so that they would follow each other in the plates as they are mentioned in the text; but to do this, it would have been necessary to re-engrave all the old plates, a labour which would have occasioned an expense quite out of proportion with the advantages of such an arrangement. Perhaps, too, the necessity for looking for those figures in the plates through which they are dispersed will call for more attention; and besides, it will be an easy matter for the reader to mark them, for those purposes of arrangement most suitable to his studies.

Finally, for the last eight years, the author has been constantly engaged in revising, completing, and remethodizing his work ; and he flatters himself, in its new form, it will not be found less worthy of the attention of those who take an interest in the great questions of which it treats.

Garden of Plants, Paris, 1831.

RESEARCHES
ON
FOSSIL BONES.

—*—*—
A DISCOURSE

ON
THE REVOLUTIONS OF THE SURFACE OF THE GLOBE,
AND THE CHANGES THEREBY PRODUCED IN THE
ANIMAL KINGDOM.

IN my work on Fossil Remains, I proposed to determine to what animals those fragments of bones should be assigned which occupy the superficial strata of the globe. This was an attempt to traverse the whole of a region of which as yet the first approaches were scarcely known. Being an antiquary of a new kind, it was necessary at the same time to restore those monuments of past revolutions and to expound their meaning. I had to collect and arrange in their original order the composing relics; to re-model the creatures to whom the fragments belonged; to reproduce them in their just proportions and with their proper characteristics; and then to compare them with those beings now existing—an art almost unknown, and which implies a science scarcely before even glanced at, that of the laws which preside at the co-existence of the forms of the various parts of organized beings. In such an attempt it was necessary to prepare myself by long and indefatigable researches into the structure of living animals; for a survey only of nearly the whole mass of created beings now existing could lead me to a certain and determinate result in my speculations on the ancient creation this would at the same time afford me a great result of rules and affinities not less useful, and the whole animal kingdom would thus, in some measure, become subjected to new laws resulting from this essay on a small portion of the theory of the earth.

I was supported in my two-fold labours by the interest which it seemed to evince both for anatomy—the essential basis of all those sciences which treat of organised bodies, and for the physical history of the globe, the foundation of mineralogy, of geography, and, we

may say, of the history of man, and that which it most imports him to know in relation to himself.

If we are interested in tracing out the nearly effaced vestiges of the early periods of our species, in so many nations utterly extinct, why should we not seek to discover, in the obscurity which envelopes that infancy of the earth, relics of revolutions long anterior to the existence of all nations? We admire that power of the human mind, the exercise of which has enabled us to ascertain those motions of the planets which Nature seemed for ever to have held from us. Genius and science have soared beyond the limits of space. Observations, developed by reason, have detected the mechanism of the world. Would it not be some renown for man, in like manner, to penetrate beyond the limits of time, and to discover, by research and reflection, the history of this world, and of a succession of events which preceded the birth of the human race?

Astronomers have advanced in science more rapidly than naturalists; and the present state of the theory of the earth somewhat resembles that of the period when certain philosophers believed heaven to be formed of polished freestone, and the moon in size like the Peloponnesus; but after Anaxagoras have arisen Copernicus and Kepler, who paved the way for a Newton; and why should not natural history one day boast also of her Newton?

Plan.

It is the plan and result of my labours on fossil bones which I particularly intend to lay before you in this discourse. I shall also attempt to trace a rapid sketch of the means employed down to the present time to discover the history of the revolutions of the globe. The facts which I have been able to arrive at form certainly but a very small portion of those of which doubtlessly this history of antiquity was composed; but many of them lead to decisive results, and the severe method which I have exercised in deciding on them gives me reason to believe that they may be received as assured data, and will constitute an epoch in the science. I trust their novelty will be my excuse if I ask for them the undivided attention of my readers.

My first object will be to show the relation between the history of fossil bones of terrestrial animals and the theory of the earth, and the motives which in this respect give it a peculiar importance. I shall then unfold the principles of deciding on these bones, or, in other words, of ascertaining a genus and distinguishing a species by a single fragment of bone—an art on the certainty of which rests that of the whole of my labours. I shall slightly notice new species and genera formerly unknown, which I have discovered by the application

of these principles, as well as the different kinds of earth which contain them; and, as the difference between these species and those of the present day is confined to certain limits, I shall show that these limits much exceed those which at present distinguish the varieties of the same species. I shall make known how these varieties are circumscribed, either by the influence of time, climate, or domesticity. I shall thus be enabled to conclude, and enable my readers to arrive at a similar conclusion, that there must have been remarkable events to have effected the great differences that I have detected. I shall detail the peculiar modifications which my researches have enabled me to introduce into the opinions at present entertained respecting the revolutions of the globe; and finally, I shall examine how far the civil and religious history of nations agree with the results of my observations on the physical history of the earth, and with the probabilities which these observations give rise to concerning the period when human societies found fixed dwellings, and fields capable of cultivation, and when, consequently, they received a settled permanent form.

First Appearance of the Earth.

When the traveller passes over those fertile plains where the peaceful waters preserve, by their regular course, an abundant vegetation, and the soil of which, crowded by an extensive population, enriched by flourishing villages, vast cities, and splendid monuments, is never disturbed but by the ravages of war or the oppression of despotism, he is not inclined to believe that Nature has there had her intestine war, and that the surface of the globe has been overthrown by revolutions and catastrophes; but his opinions change as he begins to penetrate into that soil at present so peaceful, or as he ascends the hills which bound the plain. They extend as it were with the prospect; they begin to comprehend the extent and grandeur of those events of ages past as soon as he ascends those more elevated chains of which these hills form the base, or, in following the beds of those torrents which descend from these chains, he penetrates into the interior.

First Proofs of Revolutions,

The strata of the earth, the lowest and most level, only show, even when penetrated to very great depths, horizontal layers of matter more or less varied, which contain countless marine productions. Similar layers and similar productions form the hills to very considerable heights. Sometimes the shells are so numerous that they form by themselves the entire soil; they are found at heights greatly above the level of the sea, and where at the present day no sea could reach from existing causes; they are not only imbedded in light sand, but

the hardest stones often incrust them, and are everywhere penetrated by them. Every part of the world, both hemispheres, all the continents, all the islands of any extent, afford the same phenomenon. The time is past when ignorance could assert that these relics of organic bodies were but freaks of Nature, productions engendered in the bosom of the earth by its inmate creative power; and the efforts of metaphysicians will not suffice to establish such assertions. A minute investigation of the formation of these deposits, of their contexture, and even of their chemical composition, does not detect the least difference between the fossil shells and those produced from the sea. Their conformation is not less perfect. We do not observe either the marks of friction or fracture, evincing violent removal. The smallest of them preserve their most delicate parts, their finest points, their most minute indications. Thus they have not only lived in the sea, but have been deposited by the sea. The sea has left them in the places where they are found; but the sea has for a time remained in these places, it has remained there sufficiently long and undisturbedly to be enabled to form those deposits, so regular, so thick, so extensive, and so solid, which compose these layers of aquatic animals. The basis of the sea has then experienced a change either in extent or situation. What a result from the first examination and the most superficial observation!

The traces of revolution become more striking when we ascend higher, when we approach closer to the foot of the great chains of mountains.

There are also banks of shells. Their thickness and solidity are remarkable. The shells are equally numerous, equally well preserved, but they are not the same species. The layers which contain them are no longer generally horizontal; they lie obliquely, sometimes nearly perpendicular. Instead of digging deeply, as in the plains and broad hills, to ascertain the order of the banks, we here have them side-ways in following the valleys formed by the convulsions which have rent them asunder. Immense masses of their remains constitute at the foot of their pinnacles heavy mounds, the height of which is increased by every thaw and every storm.

And these upright (*redressés*) banks, which form the crests of the secondary mountains, are not placed on the horizontal banks of the hills which form their lower ascents; on the contrary, they are sunk beneath them. These hills rest on their declivities. When the horizontal layers in the vicinity of these mountains with oblique strata are laid open, we again find the layers oblique in the excavation; sometimes even when the oblique layers are not very much elevated,

their summit is crowned with horizontal layers. The oblique layers are then more ancient than the horizontal layers; and as it is impossible, at least with regard to the greater number, that they were originally formed obliquely, it is evident that they have been lifted up; that they have been so before the others were deposited on them.*

Thus the sea, previously to the formation of horizontal layers, had formed, others which certain causes had broken up, formed again, and destroyed in a thousand ways; and, as many of these oblique banks which it had at first formed are loftier than those horizontal layers which have succeeded them, and which environ them, the causes which have given this obliquity to these banks have also forced them above the level of the sea, and formed them into islands, or at least into rocks and inequalities, whether elevated at one end, or that the sinking of the other end had thrown off the waters; a second result not less clear nor less apparent than the former to any one who will give himself the trouble to study the monuments which authenticate this fact.

Proofs that these Revolutions have been numerous..

But the revolutions and changes which have left the earth as we now find it, are not confined to the overthrow of the ancient layers, to this retreat of the sea after the formation of new layers.

When we compare in detail the various layers one with another, and the productions of nature which they comprise, we soon discover that this ancient sea has not always deposited stones exactly similar, nor the remains of animals of the same species, and that each of its deposits has not extended over the whole surface that it has covered. There have been successive variations there established, the first of which has been in great measure general, and the others appear to be less so. The more ancient the layers are, the greater their uniformity and extent; the more recent, the more limited and more subject are they to vary at short distances. Thus the displacing of the layers was accompanied and followed by alterations in the nature of the liquid and the materials which it held in solution: and when certain layers, raising themselves above the waters, had divided the surface of the

* The idea supported by some geologists, that certain layers have been formed in the oblique position in which we now find them, in supposing it true with respect to some that are crystallized, as Mr. Greenhough says, in the same manner as a deposit incrusts the inside of all vessels in which gypseous waters are boiled, it cannot be applied to those which contain shells or round stones, which could not remain thus suspended, awaiting the formation of the cement which was necessary to conglomerate them.

sea into islands by projecting chains, there must have been various changes in many particular basins.

We must perceive, that, in the midst of such changes in the nature of the liquid, the animals which it nourished could not remain the same. The species, their very genus, changed with the layers; and, although at short intervals we may meet with a recurrence of similar species, it is correct to say, in a general sense, that the shells of the ancient layers have their peculiar shapes, which are gradually lost, and not found again in recent layers, still less in the sea itself, where we never detect analogous species, nor are many of the species itself found; that the shells of recent layers, on the contrary, resemble in genus those still to be found in our seas, and that in the most recent and most shifting of these layers, and in certain lakes and more limited deposits, there are some species which the most practised eye cannot distinguish from those to be found on neighbouring coasts.

There has then been in animal nature a succession of changes which has been occasioned by those of the liquid in which the animals lived, or which at least have had relation to them, and these variations have gradually brought the classes of aquatic animals to their present state; in fact, when the sea finally quitted the continents its inhabitants differed but very little from those which it now produces.

We say, *finally quitted*, because if we scrutinize with the most exact care these relics of organic beings, and discover amidst marine layers, even the most ancient, layers composed of animal or vegetable productions of the earth and soft water, and amongst the most recent layers, that is, the most superficial, we shall find those in which terrestrial animals are buried beneath masses of marine productions. Thus the various catastrophes which have shaken the layers have not only produced by degrees from the bosom of the waters the different portions of our continents, and lessened the basin of the sea; but the basin has been displaced in many ways. It has often happened that lands left dry by the retiring of the waters have been again overflowed by that element, whether they have been cast down, or the waters have only flowed over them; and as to the soil left dry by the sea at its last retreat, which man and terrestrial animals now inhabit, it had been already left dry once before, and then nourished quadrupeds, birds, plants, and every kind of terrestrial productions; the sea which has left it had formerly covered it. The changes in the height of the waters have not arisen solely from a retiring, more or less gradual or general; it has proceeded from divers overflowings and divers retirings, the final result of which has been an universal sinking of the level.

Proofs that the Revolutions have been sudden.

But, it is of great importance to note that these repeated irruptions and retreats have not all been gradual, not all uniform; on the contrary, the greater portion of these catastrophes have been sudden; and that is easily proved by the last of these events, that which by a two-fold action inundated, and then left dry, our present continents, or at least a great portion of the soil which now composes them. It also left, in the northern countries, carcasses of large quadrupeds frozen in the ice, and which have been preserved down to the present period with their skin, their hair, and their flesh. [If they had not been frozen as soon as killed, putrefaction would have decomposed them. And besides, this eternal frost did not previously exist in those parts in which they were frozen, for they could not have existed in such a temperature. The same instant that these animals were bereft of life, the country which they inhabited became frozen. This event was sudden, momentary, without gradation; and what is so clearly proved as to this last catastrophe equally applies to that which preceded it. The convulsions, the alterations, the reversings of the most ancient layers, leave not a doubt on the mind but that sudden and violent causes reduced them to their present state; and even the powerful action of the mass of waters is proved by the accumulation of relics and round flints which in many places intervene between the solid layers. Existence has thus been often troubled on this earth by appalling events. Living creatures without number have fallen victims to these catastrophes: some, the inhabitants of dry land, have been swallowed up by a deluge; others, who peopled the depths of the waters, have been on land by the sudden receding of the waters, their very race become extinct, and only a few remains left of them in the world, scarcely recognised by the naturalist.

These are the consequences to which the subjects which meet us at every step, and which we may find in almost every clime, necessarily conduct us. These overpowering and stupendous events are clearly imprinted everywhere, and are legible to the eye that knows how to trace their history in the monuments they have left. But what is yet more remarkable and no less certain is, that life has not always existed on the globe, and that it is easy for the observer to discover the precise point whence it began to deposit its productions.

Proofs that there have been Revolutions anterior to the Existence of Living Beings.

Let us ascend, let us mount the lofty mountain tops, the steep summits of the great chains; soon these relics of marine animals, these

numberless shells will become more and more rare, and finally disappear; we shall reach layers of a different nature, which contain no vestige of a living being. They will, however, show by their crystallization and even stratification that they were originally formed in a liquid state; by their oblique situation, their steepness, that they have been overthrown; by the manner in which they bury themselves obliquely under the layers of shells, that they were formed before them; finally, by the elevation with which their jagged and naked tops rise above all these layers of shells, that these summits were already above the level of the waters when these shelly layers were formed.

Such are those famous primitive or primordial mountains which traverse our continents in different directions; elevated above the clouds, separating the beds of rivers, they hold in their perpetual snows the reservoirs which feed the sources, and in a manner form the skeleton or vast frame-work of the earth.

From a vast distance the eye perceives by the indentions with which their crests are marked, in the sharp points which form their summits, signs of the violent manner of their formation: far different from those conical mountains, those hills with long broad surfaces, in which the recent mass has remained since the period when it was quietly deposited by the latest receding of the seas.

These signs become more manifest in proportion as we contemplate them nearer.

The valleys have no longer sides with gradual declivities, those projecting angles, intersecting each other, which seem to have been the beds of some ancient currents: they expand and contract without regularity; their waters sometimes spread out into lakes, sometimes are precipitated in torrents, sometimes their rocks, suddenly approximating, form transverse clefts, whence the waters fall in cataracts. The disturbed layers on the one side exposing their edge to the summit, present on the other large and oblique portions of their surface. They do not correspond in height, but that which on the one side forms the peak of the steep height, is buried on the other side, and does not reappear.

However, in the midst of all this disorder, great naturalists have arrived at the conclusion that there is a certain arrangement, and that these immense banks, broken and misplaced as they are, have yet a systematic order, which is nearly the same in all great chains. The granite, they say, of which the greater portion of the summits are composed, the granite which protrudes beyond all, is also the stone which is buried under all others; it is the most ancient of those which

we are enabled to see in the place assigned to it by nature, whether it owes its origin to that universal liquid which formerly held all bodies in solution, or that it was originally the first body consolidated by the sudden cooling of a vast mass in a state of fusion or even of evaporation(a). Rocks repose on their sides, and form the lateral crests of

(a) This is the nebular Hypothesis of Laplace, and deserves to be more fully explained.

Laplace who, as a mathematician possessing natural abilities, strongly expressed the opinion that the arrangement by which the stability of the solar system is secured is not, in his conception, the result of chance:—that a two-fold cause has guided the planetary motions. This author, however, having arrived, as we ourselves have done, at this conviction, does not for once attempt to draw from it the conclusion which in our opinion appears quite irresistible, that “the admirable arrangement of the solar system cannot but be the work of an intelligent and omnipotent being.” He quotes these expressions which are those of Newton, and points at them as instances where that celebrated philosopher had deviated from the general method of true philosophy. He proposes another hypothesis himself concerning the nature of the *primitive cause* of which he conceives its existence to be thus probable:—and this hypothesis, on account of the facts which it attempts to combine, the view of the universe which it presents, and the eminence of the person by whom it is propounded, deserves our notice.

This writer imagines, that, in the original condition of the solar system, the sun revolved upon his axis surrounded by an atmosphere which, in virtue of an excessive heat extended far beyond the orbits of all the planets, the planets as yet having no existence. The heat gradually diminished, and, as the solar atmosphere contracted by cooling, the rapidity of its rotation increased by the laws of rotatory motion, and an exterior zone of vapour was separated from the rest, the central attraction being no longer able to overcome the increased centrifugal force. This zone of vapour might in some cases retain its form as we see it in Saturn’s ring; but more usually the ring of vapour would break into several masses, and these would generally coalesce into one mass which would revolve about the sun. Such portions of the solar atmosphere, abandoned successively at different distances, would form “planets in the state of vapour.” These masses of vapour it appears from mechanical considerations would have each its rotatory motion, and, as the cooling of vapour still went on, would each produce a planet which might have satellites and rings formed from the planet, in the same manner as the planets were formed from the atmosphere of the sun.

It may easily be conjectured that all the primary motions of a system so produced would be nearly circular—nearly in the plan of the original equator of the solar rotation, and in the direction of that rotation. Reasons are submitted also to show that the motions of the satellites thus produced, and the motion of rotation of the planets, must be in the same direction. And thus it is held that the hypothesis accounts for the most remarkable circumstances in the structure of the solar system; namely, the motions of the planets in the same direction, and almost in the same place; the motions of the satellites in the same direction as those of the planets; the motions of rotation of these different bodies still in the same direction as the other motions, and in the planes not much different; the eccentricity of the orbits of the planets, upon which condition, along with some of the preceding ones, the stability of the system solely depends, and the position of the source of light and heat in the centre of the system.

It is not necessary for the purpose, nor suitable to the place of the present treatise, to examine, on physical grounds, the probability of the above hypothesis. It is proposed with great diffidence by its author, as a conjecture only. We might therefore very reasonably put off all discussion of the bearings of this opinion upon our own views of the government of the world, till the opinion itself should have assumed a less indistinct and precarious form. It can be no charge against our doctrines that there is a difficulty in reconciling with them arbitrary guesses and half-formed theories. We shall, however, make a few observations upon this *nebular hypothesis*, as it is termed.

these vast chains; rocks of schist, porphyry, freestone, and talc, mingle in layers; then coarse marble, and other calcareous substances without shells, resting on the schistus, form the exterior crests, the lower divisions, the supporters of these chains, and are the last work by which this unknown liquid, this sea without inhabitants, seemed

If we for a moment grant the hypothesis, it by no means proves that the solar system was formed without the intervention of intelligence and design. It only transfers our own view of the skill exercised and the means employed to another part of the work. For how came the sun and its atmosphere to have such materials, such motions, such a constitution, that these consequences followed from their primordial condition? How came the parent vapour thus to be capable of coherence, separation, contraction, solidification? How came the laws of its motion, attraction, repulsion, condensation to be so fixed as to lead to a beautiful and harmonious system in the end? How came it neither to be too fluid nor too tenacious, to contract neither too generally nor too slowly for the successive formation of the several planetary bodies? How came that substance, which at one time was a luminous vapour, to be at a subsequent period solids and fluids of many various kinds? What but design and intelligence prepared and tempered this previously existing element, so that it should by its natural changes produce such an orderly system.

If we suppose that a planet will be produced in this way, what sort of a body would it be? Something, it may be presumed, resembling a large meteoric stone. How comes this mass to be covered with motion and organization, with life and happiness? What primitive cause stocked it with plants and animals, and produced all the wonderful and subtle contrivances which we find in their structure; all the wide and profound mutual dependencies which we trace in their economy? Was man, with his thought and feeling, his powers and hopes, his will and conscience, also produced as an ultimate result of the condensation of the solar atmosphere? Except we allow a prior purpose and intelligence presiding over this material "primitive cause," how irreconcilable is it with the evidence which crowds in upon us at every side.

In the next place, we may observe concerning this hypothesis, that it carries us back to the beginning of the present system of things, but that it is impossible for our reason to stop at the points thus presented to it. The sun, the earth, the planets, the moon, were brought into their present order out of a previous state, and, as it is supposed in the theory, by the natural operation of laws. But, then, how came that previous state to exist? We are compelled to suppose that it in like manner was educed from a still prior state of things; and this again must have been the result of a condition prior still. Nor is it possible for us to find in the tenets of the nebular hypothesis any existing place or satisfaction for the mind. The same reasoning faculty which seeks for the origin of the present system of things, and is capable of assenting to or dissenting from the hypothesis propounded by Laplace, as an answer to this enquiry, is necessarily led to seek in the same manner for the origin of any previous system of things out of which the present may appear to have grown, and must pursue this train of enquiries unremittingly, so long as the answer which it receives describes a mere assemblage of matter and motion, since it would be to contradict the laws of matter and the nature of motion to suppose such an assemblage to be the *first* condition.

The reflection just stated may be illustrated by the further consideration of the nebular hypothesis. This opinion refers us for the origin of the solar system to a sun surrounded by an atmosphere of enormously elevated temperature revolving and cooling. But while we descend to a still earlier time, what state of things are we to suppose? A still higher temperature, a still more diffused atmosphere. Laplace imagines, that, in its original state, the sun consisted in a scattered luminosity, so as to resemble those nebula among the fixed stars which are viewed by the aid of the telescope, and which produce a nucleus more or less luminous encompassed, by a cloudy brightness. "This anterior state was itself preceded by other states, in which the nebulous matter was more and more extended, the nucleus being less and

to congregate materials wherewith to form mollusca and zoophytes, which would soon deposit on these foundations immense masses of their shells or corals. We even see the first productions of these mollusca, of these zoophytes, showing themselves in small numbers, at intervals, amongst the latest layers of these primitive earths, or in

less brilliant. We arrive," Laplace says, "in this manner at a nebulosity so diffuse, that its existence could scarcely be suspected."

"Such is," he adds, "in fact the first state of the nebula which Herschel carefully observed by means of his powerful telescopes. He traced the progress of condensation, not indeed on one nebula, for this progress can only become perceptible to us in the course of centuries, but in the assemblage of nebulae, much in the same manner as large, we may trace the growth of trees among the examples of different ages which stand side by side. He saw in the first place the nebulous matter dispersed in patches in the different parts of the sky. He saw in some of these patches this matter feebly condensed round one or more faint nuclei. In other nebulae these nuclei were brighter in proportion to the surrounding nebulosity. When by a further condensation the atmosphere of each nucleus becomes separated from the others, the result is multiple nebulous stars formed by brilliant nuclei very near each other, and each surrounded by an atmosphere; sometimes the nebulous matter condensing in a uniform manner has produced nebulous systems which are called *planetary*. Finally, a still greater degree of condensation transforms all the nebulous systems into stars. The nebulae classed according to this philosophical view indicate with extreme probability their future transformation into stars, and the anterior nebulous condition of the stars which now exist."

It would seem, then, that the most elevated point to which this series of suppositions can conduct us is, "an extremely diffuse nebulosity," accompanied, we may suppose, by a far greater degree of heat than that which, at a later time of the hypothetical process, keeps all the materials of our earth and planets in a state of fume. Now, is it not impossible to avoid asking, whence was this light, this heat, this diffusion? How came the laws which such a state implies to be already in existence? Whether light and heat bring forth their effects by means of fluid vehicles or otherwise, they have complex and varied laws which show the existence of some acute machinery for their action? When and how was this machinery constructed? whence, too, that great dilating power which the nebulous matter is supposed to possess? And if, as would seem to be thought in this doctrine, all the material ingredients of the earth existed in this copious nebulosity, either in the state of vapour, or in some state of still greater expansion, when were they and their properties, how came there to be of each simple substance which now enters into the composition of the universe just so much and no more? Do we not far more than ever need an origin of this source? an explanation of this explanation? Whatever may be the merits of the opinion as a physical hypothesis, with which we do not here attempt to interfere, can it for one moment prevent our looking beyond the hypothesis, to a first cause, an intelligent Author, an origin proceeding from free volition, not from material necessity.

But again: let us ascend to the most prominent point of the hypothetical progression: let us imagine the nebulosity diffused throughout all space, so that its course of running into patches is not yet begun. How are we to suppose it distributed? Is it equally diffused in every part? Certainly not; for if it were so, what should cause it to gather into masses, so different in size, form, and arrangement? The separation of the nebulous matter into distinct nebulae implies, as a matter of course, some primitive inequality of distribution, some determining circumstances in its original condition. Whence were these circumstances? this inequality? We are still compelled to seek some ulterior agency and power.

Why must the original condition be of one change at all? Why should not the nebulous matter be equally diffused throughout space, and continue for ever in its state of equable diffusion, as it must do, from the absence of all cause to determine the time and manner of its separation? Why should this nebulous matter grow cooler and cooler? Why should it not continue for ever in the same degree of heat,

that portion of the superficies of the globe which geologists have termed transition rocks. We meet here and there with layers of shells interposing between some granites more recent than others, amongst divers schists and amongst some later deposits of the coarse marble. Life which sought to possess itself of this globe seems in these early periods to have struggled against the inert nature which first predominated; it was a long time ere it entirely gained the mastery it contended for, and appropriated to itself the right of continuing and raising the solid coating of the earth.

Thus it is undeniable, that the masses which now form our highest mountains were originally in a state of liquefaction; for a long time they were covered by waters which did not then nourish living bodies; it was not only after the appearance of vitality that important changes took place in the nature of the deposited matter; the masses formed before have changed, as well as those subsequently produced; they have even undergone violent changes in their situation, and a portion of these changes took place when these masses alone were existing, and were not covered by layers of shells. The proof is evident in the overthrows, in the dislocations, the rents, which we perceive in the layers, as well as in the posterior layers of earth, which are even more numerous and more strongly marked.

But these primitive masses have experienced other revolutions, subsequently to the formation of these secondary layers of earth, and have perhaps occasioned, or at least shared, some of those changes

whatever heat it be? If heat be a fluid, as many philosophers suppose, what becomes of the fluid heat of the nebulous matter, as the matter cools down? Into what unoccupied region does it find its way?

Many questions of the same nature might be asked, and the conclusion to be drawn is, that every new physical theory which we include in our view of the universe involves us in new difficulties and perplexities, if we try to erect it into an ultimate and final account of the existence and arrangement of the world in which we live. With the evidence of such theories looked upon as scientific generalizations of ascertained facts, with their claims to a place in our natural history, we have here nothing to do. But if they are put forward as a disclosure of the final cause of that which occurs, and as superseding the necessity of looking further or higher; if they claim a place in our natural theology, as well as our natural philosophy, we conceive that their pretensions will not bear a moment's examination.

Leaving them to other persons and to future ages to decide upon the scientific merits of the nebular hypothesis, we think that the final fate of this opinion cannot in sound judgment affect all the view which we have tried to illustrate: the view of the universe as the work of a wise and omnipotent Creator. Let it be supposed that the point to which this hypothesis guides us is the ultimate point of physical science, that the most remote glimpse we can obtain of the material universe by our natural faculties shows it to us occupied by a boundless abyss of brilliant matter. Still we ask, how space came to be thus occupied, how matter came to be thus luminous? If we fully establish by physical proofs that the first fact which can be traced in the history of the world is, that "there was light," we shall still be led even by our natural reasoning faculties to suppose that before this could possibly occur, "God said, let there be light."—ENG. ED.

which these layers themselves have undergone. There are indeed considerable portions of these primitive layers exposed, although in situations even lower than those of secondary layers; if they had not been exposed by subsequent convulsions, the latter would have concealed them. Vast and various blocks of primitive substances are found scattered, in particular countries, over the secondary layers, separated by deep vallies; or even arms of the sea, from the summits or crests whence they must have come. They have been either thrown there by eruption, or the depths which would have arrested their progress did not exist at the period of their removal, or else the fury of the waters which conveyed them there exceeded in violence anything that we can imagine from our own experience *

Here then is a combination of facts, a series of epochs anterior to the present, the order of which can be infallibly verified, although the period of their intervals cannot be precisely defined. They are so many points which serve as rules and directions in the ancient chronology.

Examination of the Causes which operate at present on the Surface of the Globe.

Let us now examine what is at present operating on the habitable

* The voyages of Saussure and Deluc present us with a multitude of these facts; and these geologists have judged that they could only have been effected by surprising eruptions. M. M. de Buch and Escher have employed themselves on this subject more recently. The memoir of the latter, inserted in 'La Nouvelle Alpina de Stein-Muller,' vol. i, details the whole in a remarkable manner, of which this is the summary:—Those blocks which are scattered in the lowlands of Switzerland or Lombardy came from the Alps, and have descended along the vallies. They are in all parts and of all dimensions, even to fifty thousand cubic feet, in the great extent which separate the Alps from Mount Jura, and they are found on the declivities of Jura which front the Alps to the height of four thousand feet above the level of the sea; they are on the surface or in the superficial layers of remains, but not in those of freestone, or pudding stone, which occupy nearly the whole space in question; they are sometimes found perfectly isolated, sometimes in masses: the height of their situation has no relation to the size, only that the smaller appear sometimes a little worn, but the larger not all so. Those which form the bed of any river are found, on examination, of the same kind as the mountains of the peaks or sides of the high vallies, whence arise the sources of these rivers; we observe them in the vallies, and they are found accumulated especially in those places where they are narrowest; they have passed over defiles when they have not exceeded four thousand feet; and then we see them on the other sides of the summits in the cantons between the Alps and Jura, and on Jura itself; it is opposite the openings of the vallies of the Alps that they are seen of greatest size and in greatest numbers; those in the space between are carried less high; in the chains of Jura, the most distant from the Alps, they are only found in places exactly opposite to the openings of the nearest chains.

From these facts, the author draws this conclusion, that the conveyance of the blocks took place subsequently to the deposits of freestone and pudding stone: that it was probably effected at the last revolution of this globe. He compares their removal to that which still occurs amongst the torrents; but the objection of the vastness of the blocks, and that of the depth of the intervening vallies, seem to us to offer a powerful opposition to this part of his hypothesis.

globe; let us analyse the causes which still affect its surface, and let us determine the possible extent of their effects. It is a portion of the history of the earth, so much the more important, as we have long thought we could explain anterior revolutions by existing causes; as in political history we easily unfold past events, when we are well acquainted with the systems and intrigues of our own times. But unfortunately, we shall find that this is not the case with physical history; the thread of the operations is broken; the march of nature is changed; and not one of her agents now at work would have sufficed to have effected her ancient works.

There are now existing four active causes which contribute to alter the surface of our continents: the rains and thaws which lower our lofty mountains, and cast their relics at their feet; the flowing waters, which carry away their remains, and leave them in places where they retard their currents; the sea, which sups the base of the lofty coasts, and which forms the beach on which it casts the sand hills; and finally, the volcanoes, which perforate the solid layers, and elevate or scatter on the surface the masses which they vomit forth.*

The Falling away of portions of the Masses.

Everywhere, where the broken layers present their edge on the rugged fronts, there falls at their base every spring, and even at every storm, fragments of their component parts, which become round by rolling one on the other, and which, in a mass, assumes a determined inclination, conformably with the laws of cohesion, thus forming, at the foot of the height, a ridge more or less elevated, according as the fall of materials be more or less abundant; these ridges form the sides of the valleys in all the high mountains, and are covered with rich vegetation when the falling away of the upper parts becomes less frequent; but their want of solidity renders them liable to slip themselves, when they are undermined by streams; and it is then that cities, rich and thickly-populated districts, are overwhelmed by the slipping of a mountain; that the course of rivers is interrupted; and that lakes are formed on spots once fertile and luxuriant. But fortunately these stips occur but seldom, and the principal influence of these accumulated hills is to supply materials for the ravages of the torrents,

Alluvial Deposites.

The waters which fall on the peaks and summits of mountains, the condensed vapours, or the liquefied snows, descend along their declivi-

* See, on the changes of the earth's surface, known from history or tradition, and consequently attributable to known causes, the German work of M. de Hof, in 2 vols. 8vo. The collection of facts is gathered with as much care as learning.

ties by innumerable channels ; they collect in their progress some particles, and trace light furrows in their passage. These channels soon unite in the deepest cavities which are indented in the mountain's side ; they glide along the deepened valleys which are formed at the foot, and proceed thus to produce those rivers and streams which return to the sea those waters which had been previously imbibed from it by the atmosphere. At the melting of the snows, or when a storm arises, the mass of these mountainous waters suddenly increases, and precipitates itself with a rapidity proportional to the slope of the declivity. Dashing with violence against the foot of those ridges which cover the sides of all the lofty valleys, the torrents carry with them the rounded fragments of which they are composed ; they rub and polish them in their passage ; but in proportion as they arrive in the closer vallies where their fall is lessened, or in large basins where they can spread themselves, they cast on the beach the largest of these stones which they have thus rounded ; the lesser are deposited lower, and nothing reaches the main channel of the river but the smallest particles, or a scarcely perceptible slime. The course of these waters, before they form the larger and lower stream, is often through an extensive and deep lake, in which they deposit their mud, and emerge perfectly pure. But the lower rivers, and all the streams which arise in the lower mountains or hills, also produce, in the soils through which they run, effects more or less analogous to those of the torrents of the lofty mountains. When they are swollen by heavy rains, they assail the foot of the clayey or sandy hills which oppose them in their progress, and carry portions of them into the lower lands which they overflow, and which each inundation thus tends to elevate to a certain extent ; and when these rivers reach the extensive lakes or the sea, and that rapidity which carried with it the particles of mud suddenly ceases, these particles are left at the sides of the mouth ; they finally form lands which extend the coast ; and if it be a coast where the sea also deposits her sand, and contributes to this accumulation, it produces in this way provinces, whole kingdoms ; usually the most fertile, and soon the richest in the world, if their governors will allow industry to use its efforts without interruption.

Downs.

The effects of the sea without the co-operation of these inland rivers are less productive. When the coast is flat and the bottom sandy, the waves drive the sand toward the shore ; at each ebb a portion is left dry, and the wind, which generally blows from the sea, casts it higher on the beach. Thus the *downs* are formed, those sandy hills which,

if the invention of man does not teach him how to fix by introducing herbage suited to the soil, progress slowly, but with certainty, towards the interior of the country, and then overwhelm fields and dwellings; because the same wind which conveys the sand of the beach on to the *down* casts that of the summit of the *down* still farther inland. But if the nature of the sand and that of the water it absorbs, are such as form a durable cement, the shells and bones cast on the shore will become incrustated with it; woods, trunks of trees, and plants which grow near the sea-side, will become enveloped in these accumulations; and thus will be formed those solid downs such as are to be met with on the coasts of New Holland. We can have a clear idea of them from the description given by Péron*.

Steep Shores.

When, on the contrary, the coast is lofty, the sea, which can deposit nothing, is perpetually destroying; its waves wear away the bank, and destroys the summit, because the higher parts, being left without foundation, are incessantly falling away into the sea, where they are tossed about by the waves until the softer and looser particles are lost. The harder portions, by dint of continued friction, form those round pebbles, or that accumulated strand which serves to strengthen the base of the steeps.

Such is the action of the waters on terra firma, which consists only in small levellings, and those not indefinite. The falling materials of the mountain tops into the vallies; their particles, those of the hills and plains, conveyed to the sea; the alluvial deposits extending the coasts at the expense of the heights,—are the limited effects which vegetation has in some degree put a boundary to; which suppose, beside the pre-existence of mountains, valleys, in short, of all the inequalities of the globe, and which consequently could not themselves have produced those inequalities. The downs are a still more limited phenomenon, both in height and horizontal extent; they have no relation to those enormous masses into the origin of which geology seeks to penetrate.

As to the operation of the waves in their own element, although we cannot accurately ascertain it, yet we can to a certain extent point out its effects.

Deposites under the Waters.

Lakes, ponds, marshes, and sea-ports into which streams flow, particularly when issuing from neighbouring and rugged hills, deposit at

* In his "Voyage aux Terres Australes."

their bottom shoals of mud, which would in time choke them up, if constant care was not taken to cleanse them ; the sea also leaves in harbours, creeks, and all parts where its waters are most calm, mud and sediment. Currents are formed amongst these deposites, or throw upon them the sand which they collect from the sea ; and thus are shoals and shallows made.

Stalactites.

Certain waters, after depositing the calcareous substances, by means of the superabundant carbonic acid with which they are impregnated, become crystallized when the acid has evaporated, and form stalactites and other concretions. There are mingled crystallized layers in soft water, sufficiently extensive to be compared with some of those left by the ancient sea. Every one knows the famous Travertine quarries in the vicinity of Rome, and the rocks of this stone which the river Teverona accumulates and produces, perpetually varying in form. Its twofold action may be thus accounted for : the accumulated deposites of the sea may become hardened by stalactites ; when, perhaps, springs replete with calcareous matter, or containing some other substance in solution, fall into the places where these masses are formed, and then become a combination formed by the union of the marine deposites with the fresh water. Such are the banks of the Guadeloupe, which contain marine and terrestrial shells and human skeletons. Such, also, is the quarry near Messina, described by Saussure, where the sand-stone is produced by the sands cast up by the sea, and which there consolidate.

Litophytes.

In the torrid zone, where litophytes are numerous in species and propagate rapidly, their stony columns are formed into rocks, reefs, &c. ; and, reaching to the level of the waves, block up the entrance of the ports, and are the destructive foes of navigation. The sea casting sand and slime on the top of these rocks, frequently raises their surface above the proper level, and thus generates islands which soon exult in rich vegetation.*

Incrustation.

It is possible, also, that in certain places shell-fish leave their testaceous coverings, which, amalgamated with slime more or less concreted, or with some other cements, form extensive deposites, or a kind of shelly reef ; but we have no evidence that the sea at present can incrust these shells with a paste as solid as marble, sand-stone,

* See Forster's ' Observations on the South Sea.'

and even the compact lime-stone in which we see the shells of our layers embedded. Still less do we find that it deposits any portion of those more solid and more flinty layers which preceded the formation of shell-reefs.

All these causes united would not perceptibly affect the level of the sea, would not raise a single layer above that level, and assuredly would not produce the least hillock on the surface of the earth. It has been asserted, with some appearance of probability, that the sea gradually decreases, and that observations to that effect have been made on the shores of the Baltic.* But whatever may be the causes of these variations, it is certain that they are not universal; that in the greatest number of ports where there are so many persons interested in observing the height of the sea, and when fixed and ancient works afford so many means of computing these variations, the mean level is constantly the same; there is no general sinking; there is no universal encroaching. In other places, as Scotland and various parts in the Mediterranean, they have supposed, on the contrary, that the sea has become higher, and now covers shores formerly above its level.†

Volcanoes.

The action of volcanoes is still more limited and more locally confined than any others which we have adverted to. Although we have no clear idea of the means by which nature feeds these fierce furnaces so profound, we yet judge clearly, by their effects, of the alterations which they have occasioned on the earth's surface. When a volcano appears, after some shocks, some earthquakes, it finds an opening. Stones and ashes are thrown far and wide; lava is vomited forth; the more fluid portion glides away in long streams; the more solid is stopped at the edges of the aperture which it serves to elevate, and forms a cone terminated by a crater. Thus volcanoes accumulate on

* It is a prevalent opinion in Sweden, that the sea lowers, and that we can ford or even walk dry-shod in many places where formerly it was impassible. Very learned men have espoused this popular idea, and to so great an extent is M. de Buch imbued with it, that he supposes that gradually the whole soil of Sweden will become dry land. But it is singular that no regular and precise observations to confirm a theory broached so long, have been made, and made public, which would leave no doubt, if, as Linnæus says, this difference of level be as much as four or five feet annually.

† Mr. R. Stevenson, in his observations on the bed of the North Sea, and the British Channel, asserts that the level of these seas has become constantly and sensibly higher during the last three centuries. Fortis says the same thing of certain places in the Adriatic; but the example of the temple of Serapis, near Pozzuola, proves that the borders of this sea are in many places of a nature occasionally to elevate themselves and sink again. But, on the other hand, there are thousands of quays, roads, and other places, made along the coast by the Romans, from Alexandria to Belgium, the relative level of which has never altered.

the surface (after having in a measure modified them) materials before buried in the depths of the earth ; they form mountains ; they have, in earlier ages, covered some parts of our continents with them ; they have suddenly produced islands in the midst of the ocean ; but these mountains, these islands are always composed of lava, all their materials have undergone the action of fire ; they are distributed as materials must be which emanate from an elevated spot. Volcanoes do not elevate, nor overthrow the layers which lie along their apertures ; and if certain causes have operated from their abysses and assisted in overthrowing vast mountains, it has not been by means of volcanic agents of which we have any knowledge.

Thus, we repeat, it is in vain to seek amidst the forces now acting on the surface of the earth ; for causes sufficiently powerful to produce the revolutions and catastrophes of which its exterior bears traces ; and if we have recourse to the external causes at present in action, we shall not find them adapted for the purpose.

Constant Astronomical Causes.

The pole of the earth moves in a circle about the pole of the ecliptic ; its axis inclines more or less according to the ecliptic ; but these two motions (which are well understood) are performed within known directions and limits, and have no proportion to the effects, the extent of which we have just considered. In every instance, their extreme slowness would preclude the idea that they had any influence on the catastrophe which we have proved to be violent and sudden.

This latter reason is applied to all the slow agencies that have been imagined, doubtlessly, in the hope that their existence could not be denied, because it would be always easy to assert that their tardiness made them imperceptible. True, or not, is of little consequence ; they explain nothing, for no slow causes can produce sudden results. There may have been a gradual diminution of the waters, the sea may have conveyed every kind of solid matter, the temperature of the globe may have increased or diminished, but none of them have been the agents which have disturbed our layers, which have clothed with ice great quadrupeds with their flesh and skin ; which have thrown on dry land those testaceous remains, still as perfect as if they contained living fish ; which have, in fine, destroyed whole species and genera.

These arguments have struck the majority of naturalists ; and, amongst those who have sought to explain the present state of the globe, there is scarcely one who has attributed it entirely to slow causes still less to causes operating before our eyes. The necessity they have experienced of discovering different causes from those now in action has given rise to many extraordinary speculations, and has involved them

in so many and so contrary suppositions, that the very name of their science has been long a subject of raillery for some prejudiced persons, who only look at the various systems that have been broached, and forget or are ignorant of the long and important series of positive facts that have been developed.*

Ancient Systems of Geologists.

For a long time only two events, only two changes of the globe, have been admitted—the creation and the deluge; and all the labours of geologists have tended to explain the present state, by imagining a certain primitive state afterwards modified by the deluge,† and to which each speculist assigned his own causes, action, and effects.

Thus, according to one,‡ the earth at first had an equal and light crust which covered the abyss of waters. and which burst to produce the deluge; its relics formed the mountains. According to another,§ the deluge was occasioned by a momentaneous suspension of the cohesion in minerals; the whole mass of the globe was dissolved, and the paste of it was penetrated by shells. According to a third,|| God lifted up the mountains to allow the waters, which produced the deluge, to escape; and removed them to places where there were more stones, because otherwise they could not have been supported. A fourth|| created the earth with the atmosphere of one comet, and deluged it through the tail of another; the heat which remained to it from its first origin excited all mankind to sin; thus they were all drowned except the fishes, which had apparently passions less unruly.

We see that, even in confining ourselves to the limits fixed by Genesis, naturalists have a wide field before them: they soon found themselves in difficulties, and when they had succeeded in attributing to the six days of creation indefinite periods, ages costing them nothing, their systems took a flight proportioned to the intervals which they could dispose of.

The great Leibnitz amused himself, like Descartes, in making the earth a quenched sun¶, a vitrified globe, on which vapours having fallen at the time of its extinction, seas were formed, which in their turn deposited calcareous formations.

* When I say this, I announce a fact daily proved, but I have not pretended to express my own opinion, as some geologists have thought. As some ambiguity in my speech has given rise to the error, I must apologize for it.

† Burnet *Telluris Theoria Sacra*. 1681.

‡ Woodward's *Essay towards the Natural History of the Earth*. 1702.

§ Scheuchzer, *Mem. de l'Acad*: 1708.

|| Whiston. *A New Theory of the Earth*. Lond. 1708.

¶ Leibnitz, *Protogæa. Act. Leips*. 1683. *Gott*. 1749.

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From another part of this luminous Report, we extract the following allusion to Cuvier, and his greatest work.

“We have to deplore within the present year, the loss of that illustrious Naturalist who was the first to raise Comparative Anatomy to the rank of an exact science, and, who, by his highly philosophical generalization of the constant co-ordinate relations of the animal structure, became at once the Newton of that science. *Many an investigator, following the paths he first pointed out*, has reaped brilliant discoveries by the comparatively easy labour of decyphering the remains before him by the Key fully furnished in the Ossements Fossiles.”

This Work will be translated from the copious and complete Edition, (The Fourth,) which is now in the course of publication at Paris, under the superintendence of M. F. Cuvier, the brother of the illustrious author, who has most materially enriched this edition by Notes which were collected by Cuvier himself, in his life-time.

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