JOURNAL OF

THE TRANSACTIONS

OF

The Victoria Institute,

OR,

Philosophical Society of Great Britain.

EDITED BY THE SECRETARY.

VOL. XXXVIII.

LONDON:

(Published by the Institute, 8, Adelphi Terrace, Charing Cross, W.C.)

1906.

ORDINARY GENERAL MEETING,

WAS HELD IN THE ROOMS OF THE INSTITUTE, ON MONDAY, FEBRUARY 5TH, 1906.

COLONEL HENDLEY, C.I.E., IN THE CHAIR.

The Minutes of the previous Meeting were read and confirmed.

The following elections took place :—

MEMBER :—Joshua Ratynski Hershensohnn, Esq., Pietermaritzburg.

ASSOCIATE :—Edmund Eaton, Esq., C.E., Ticehurst.

The following paper was read by the Author :—

BIOLOGICAL CHANGE IN GEOLOGICAL TIME.

By Professor J. LOGAN LOBLEY, F.G.S., F.R.G.S.

CONTENTS.

INTRODUCTION.

THE paper read before the Victoria Institute last session, entitled "Geological Exterminations,"* seems to call for a more extended reply than the time allowed for discussion permitted. Any adequate consideration of the subject must be founded upon, in the first place, a careful estimate of the facts revealed by palæontological research not only with respect to the termination of the existence of species and genera, but also with respect to the character, morphological and physiological, of the species and genera existing both before and after these extinctions. And, furthermore, notice must be taken of the persistence of certain genera through vast geological periods during which other and allied genera had but a comparatively short existence.

---

* "Geological Exterminations," by Charles B. Warring, M.A., Ph.D., *Journal of the Victoria Institute*, vol. xxxvii, p. 165.

With the object of inviting the Institute to this fuller consideration of a most important subject, I have here briefly brought together some of the data which appear to be necessary to form a sufficiently stable and wide basis for a sound conclusion.

In the consideration, however, of the results of palæontological observation and research, we ought never to lose sight of that most important truth that all the geological data available, and all that ever will be available, for our use must be but a most imperfect record of the past. The fossiliferous rocks now existing are but the remnants that have been left of those vast accumulated deposits formed in the past after having been subjected for enormously prolonged periods of time to the action of the disintegrating forces of nature.

Thus, for example, not to go further than our own well known islands of Great Britain and Ireland, the Jurassic rocks, now restricted, to the south-east side of a line from Axmouth, in Devonshire, to the mouth of the River Tees, have left small remnants in the Hebrides and Sutherlandshire to attest their former extension over parts of the area that is now Great Britain. The Cretaceous rocks, now confined to the southern and eastern counties, have similarly left small remnants in Mull and Morven on the west and fossils near Aberdeen on the east of Scotland; and as far north-west as Antrim, in Ireland, the uppermost formation of the Cretaceous, the Chalk, is found preserved by a protecting overlying sheet of volcanic basaltic rock, from which it is seen that this formation once extended over what is now part of England and the Irish Sea and away to the extreme north of Ireland. A small outlier of the Woolwich Beds at Newhaven, on the coast of Sussex, shows the former extension of Tertiary deposits over the whole area of the older Cretaceous rocks now forming the surface between Croydon and the south coast. At St. Erth, in Cornwall, there are remnants of Pliocene deposits 290 miles west of the nearest beds of this age.

While, therefore, the Jurassic rocks now spread over only the Midlands and the south and east of England, there is evidence that they once covered nearly the whole area now included in the British Islands and adjacent seas,* and that the Cretaceous rocks, now confined to a still more limited area, had an equal, if not greater, extension, while the Tertiaries furnish grounds

* Highly improbable that the Jurassic rocks extended over North Wales, the Lake District, the Border Hills of Scotland, and the Highland Mountains, or that the Cretaceous rocks extend over these regions. See my *Physical History of the British Isles.*—Ed.

for a similar conclusion. The extent of Jurassic rocks removed from the region of these islands, not including sea areas, may be estimated at about 100,000 square miles, of Cretaceous rocks 110,000 square miles, and of Tertiary deposits 115,000 square miles, the total area of the British Islands being 121,700 square miles. So that in this region alone only a very small proportion is left of these once wide-spreading Neozoic groups of formations.

Again, in Ireland the Coal Measures evidently once covered the whole of its interior area, while now it is found that almost the whole of those deposits, extending over fully 16,000 square miles, and containing most valuable beds of coal, have been removed and swept into the sea. The thickness of these destroyed rocks was very great also. Professor Ramsay estimated that fully 10,000 feet thickness of Lower Silurian (not Coal Measures) slate had been removed from what is now the summit of Snowdon.

The great unconformabilities and lacunæ are other obvious illustrations of the imperfection of the geological record. In Somersetshire, the Carboniferous Limestone, highly inclined, is succeeded immediately by horizontal Inferior Oolite. Under the London area Cretaceous rocks lie upon Devonian, while below Dover the Coal Measures have been reached immediately below Jurassic rocks.

Of the animals and plants living at the time of the deposition of the various sedimentary rocks of the globe, only a small proportion have left fossil remains, even of marine testacea, and of land animals and plants very few indeed, for the great bulk of marine shells would be broken up and destroyed by wave action, while of terrestrial animals and plants only the remains of those would be preserved that escaped decay and decomposition by entombment under exceptionally favourable conditions for their preservation. And finally, it must be remembered that only in a few places, each of very limited area, and aggregating altogether not one-millionth of their extension at the surface, have the sedimentary rocks been carefully examined.

But very imperfect as this record of the rocks undoubtedly is, it gives, as far as it goes, a true revelation of the successive faunas that have peopled, and of the successive floras that have clothed the globe. What it tells us is therefore so much positive knowledge of the highest value, although it be but a fragment of the great story of Creation.

Geological Time.

An adequate consideration of the causes of biological changes also requires attention to the duration of geological time, for the amount of the time during which these changes have taken place is the frame, so to speak, of the picture that contains all the details of the whole. The magnitude of that frame must therefore be known before we can fairly judge of the factors that have produced the components of the picture.

It is now but a common-place to speak of geological time as vast, although only half a century ago this great fact was most warmly and obstinately disputed. But though an enormous period is now undisputed, its duration can only be realised by those who have paid some attention to the details of geological science. The facts establishing the very high antiquity of the earth are so many, so striking, and so certain, that the conclusion is obvious, and yet that conclusion is often overlooked. Only a few of these facts can be noticed here, and these very briefly.

The enormous thickness of the sedimentary rocks, averaging at least 50,000 feet,* at once requires us to allow for their formation as accumulated deposits a vast period of time. When further it is found that these accumulations of sediment constitute $\frac{99}{100}$ of the land area of the globe, or 50,000,000 square miles, giving 500,000,000 cubic miles of accumulated detrital matter, we are compelled to greatly extend our conception of geological time, even if we allow a much more rapid destruction of surface rocks and deposition of their detritus, throughout geological time, than now. But careful examination of the rocks, even of Pre-Cambrian rocks, gives no evidence of more rapid destruction and deposition in the past than at present. "One of the very oldest formations of Western Europe, the Torridon Sandstone of North West Scotland," Sir Archibald Geikie says, "presents us with a picture of long-continued sedimentation, such as may be seen in progress now round the shores of many a mountain-girdled lake. In that venerable deposit the enclosed pebbles are not mere angular blocks and chips, swept by a sudden flood or destructive tide from off the surface of the land, and huddled together in confused heaps over the floor of the sea. They have been rounded and polished by the quiet operation of running water, as stones are rounded and polished now in the channels of brooks or on the shores of lake and sea. They have been laid gently down above each other, layer over layer, with fine sand sifted in between them. So tranquil were the waters in which these sediments accumulated, that their gentle currents and oscillations sufficed to ripple the sandy floor, to arrange the

* The aggregate maximum thickness of the sedimentary rocks is fully 250,000 feet.

sediment in laminæ of current bedding, and to separate the grains of sand according to their relative densities."*

The testimony of the Torridon Sandstone is repeated by every succeeding formation, and so we may estimate geological time by them and get a conception of it by the witness of a few. The Old Red Sandstone of Herefordshire, 10,000 feet thick, is an accumulation of grains of quartz and clay, derived from the surface of older rocks. The Carboniferous Limestone of England has a thickness, visible to any visitor to Clifton, of 5,000 feet, all of carbonate of lime extracted from sea-water by marine living forms which has received its solution from the land. Our English Chalk is over 1,000 feet thick and occupies thousands of square miles after very great extensions have been removed, and the whole of this vast mass of carbonate of lime has been formed by the accumulation of minute shells and their more minute fragments all produced by microscopic animals. A single foot of thickness of this wonderful deposit, the work of countless generations of myriads of microscopic animals, would require fully 1,000 years for its accumulation, giving at least a million years for the formation of the Chalk alone. The great Nummulitic Limestone we see in France, in Egypt, and as far east as China, has a thickness in the south of France of 3,000 feet all similarly accumulated. The Nagelfluhe of the Rigi in Switzerland, is an accumulation of water-worn pebbles, all rounded fragments of hard rocks, of 5,000 feet in thickness. In Asia, too, the still newer Pliocene deposits of the Punjab of India, attain the enormous thickness of 14,000 feet. All these, and many other vast deposits, were accumulated not contemporaneously but during quite different periods of geological time.

The mean rate of surface erosion to produce the detritus given to the sea at the present time by six representative rivers, the Po, Hoang Ho, Rhone, Ganges, Yang tse kiang, Mississippi, and the Danube, is 1 foot in 3,090 years, or $\frac{1}{3090}$ of a foot in one year.

When such facts as these are duly weighed it will, I think, be admitted that geologists have very good grounds for estimating geological time at a minimum of 100 millions of years.

The attempt made some years ago on physical grounds to reduce this estimate has now lost its force through the discovery of radio-active bodies, which are potential givers of renewed heat to the earth and the sun. Professor Darwin, now Sir George Darwin, showed that the assumption of the permanency

* Geikie, *Text-Book of Geology*, p. 76.

of the deviation from spheroidicity of the earth since the solidification of its exterior could not be granted. Two other assumptions, the secular cooling of the globe and the expenditure of the sun's heat, I ventured to contend, could not be allowed either, for, as I then wrote, "we know little of the interior constitution of the sun, and that therefore we are ignorant as to whether there may not be some process by which the solar heat is maintained," and that in the so-called new star, "Nova Persei," there was a reminder that accessions of heat and light by suns might be received at any period of their existence, and if in this case the accession was sudden and great, he would be bold indeed who would say that an accession of heat and light might not be given slowly and to a small extent. Since then the discovery of radium has supported this hypothetical contention.

The physical estimates ignore the facts of geology, yet it must be admitted, I think, even by pure physicists themselves, that the bases of such estimates are more assumptive, more open to dispute, are less clearly established and less substantial facts, and therefore more uncertain and less reliable than are the grounds on which are based geological estimates. To again quote Geikie: "The geological record furnishes a mass of evidence which no arguments drawn from other departments of Nature can explain away, and which, it seems to me, cannot be satisfactorily interpreted save with an allowance of time much beyond the narrow limits which recent physical speculation would concede."

Biological Change.

Probably during nearly the whole of geological time, biological change has been going on, for in the Lower Cambrian rocks there are the remains of highly developed animals, pointing to, if not demonstrating, the previous existence during the Pre-Cambrian epoch of lower or simpler organisms, although none have hitherto been with certainty discovered in the rocks of that early period of the world's history. This inference is strongly supported by the fact that in the Pre-Cambrian rocks are limestones and masses of graphite, the limestones pointing to the Pre-Cambrian existence of animal life and indirectly to that of plant life, while the graphite points directly to a Pre-Cambrian terrestrial flora. But leaving out of consideration this Pre-Cambrian epoch, the rocks of which have not yet yielded decided fossils, and taking only the time from the commencement of the Cambrian period, in the lower rocks of which are well-preserved remains of highly developed animals, as the *Olenellus* and *Paradoxides* of the Menevian Beds and Primordial Zone of Wales and Bohemia, we have undoubtedly a vast frame for the picture of organic form and organic change.

When we look at the bottom of this picture and then at the top we are at once struck by the enormous character of the change revealed. Although there were highly developed trilobites in the Cambrian seas with all the Classes of Mollusca abundantly represented in the Ordovician or Lower Silurian period, yet no vertebrates appear to have existed in any part of those most lengthy epochs.

The backbone, the basis of the skeleton of the animals which to so large an extent people the earth and its waters now, was then non-existent, its advent being in a long subsequent Upper Silurian period. This remarkable morphological feature, the backbone, with its most important physiological attributes, is undoubtedly the most conspicuous differentiating characteristic of the post-Ordovician fauna. Its appearance gave to the world the fishes of the seas, then the amphibians of the shallow waters, and afterwards the great dinosaurs, the pterosaurs and other Reptilia, to be followed by the marsupials and monotremes of the land and the feathered birds of the air, with, long subsequently, the larger Mammalia unlike to those we now see, to be succeeded by the larger Mammalia in forms akin to those we know as living creatures, and lastly, the speaking and reasoning genus Homo.

It is this vast development of the Vertebrata in both greater and lesser variation, in those great differences that constitute Class distinctions as well as in the smaller differences of genera and species, together with the great increase of individuals, that alters entirely the upper part of the great picture of life on the globe from the Cambrian times to the present. The appearance of the backbone marked, consequently, a most momentous period in the life-history of our planet, which seemed, as it were, to be a fresh starting-point for organic development. The concentration of the nerve-matter of the animal in one cephalic ganglion, the brain, accompanied by an incipient and then by a developed vertebral column and canal, must be regarded as the greatest biological change that the fauna of the globe has undergone, inasmuch as it was the necessary step on the road to all subsequent developments of animal life.

But while this great development of vertebrate animals was in progress, changes by no means small were taking place in the Invertebrata also. An entire Order of Actinozoa, the Rugosa, disappeared, while three others advanced. Two Orders of

Echinodermata, Cystoidea and Blastoidea ceased to exist and Echinoidea greatly increased. In the highest Class of the Mollusca, the Cephalopoda, many genera that are conspicuous in the Palæozoic rocks, as Cyrtoceras, Gomphoceras, etc., although tetrabranchs, are not to be found in Secondary rocks, while Ammonites, and the dibranchiate Belemnites, of which there is no trace in the older rocks, are most conspicuous, both by their abundance and specific development, in Secondary formations, and again are absent in more recent deposits and at the present day.

The dying out of species and genera of Gasteropoda, Lamellibranchiata and Brachiopoda, and their replacement by others between the Lower Silurian period and the Quaternary, are too numerous to be here enumerated.

And if the great picture of the biological aspects presented by this planet during geological time is strikingly vivified in its upper part by the crowds of Vertebrata, both terrestrial and marine, that are absent from the stiller world of early Palæozoic times, so is it abundantly enriched by the higher forms of plants that clothe the plains, the hilly uplands and the mountain slopes. In the Carboniferous period of the Palæozoic epoch, it is true, an abundant flora covered low-lying plains, but all the plants were cryptogams or gymnosperms. Magnificent ferns, equisetums and lycopods, grew thickly and rapidly where humid and warm conditions prevailed, but there were no trees such as those that form the forests of the temperate zone of to-day, or offer food to man on their fruit-laden branches, nor were there such flower-bearing shrubs as those that now beautify both cultivated and uncultivated lands. These, the higher forms of the Vegetable Kingdom, were reserved to make their appearance in Cretaceous times, and to develop in Tertiary times until in the Miocene period they formed umbrageous woods and flowery glades that have left for our inspection, admiration and instruction, beautifully preserved leaves in great abundance, from which we see that many of our familiar friends of the woodlands and the hedgerows were flourishing long before the advent of man.

Thus both the Animal and the Vegetable worlds were enormously changed from Palæozoic to Tertiary times rather by the introduction of new and higher types than by the extinction of species or genera. It is not too much to say that if all the Palæozoic species we know had continued in existence to the present time, the difference of aspect of the whole fauna and the whole flora of to-day would have been slight. The fauna, however, of the Secondary epoch with its huge armed dinosaurs and its flying pterosaurs was markedly different from that of the Tertiary epoch, and therefore a great change was produced by the extinction of those reptilian monsters.

The result of all biological change has, however, been to give to the globe a succession of higher and higher forms with greater complexity of structure and higher physiological power and capabilities.

PERSISTENCY OF TYPES.

When we look a little closer at the wondrous picture and examine its details both in its lower and its upper portions, we are struck by the marvellous persistency of certain forms and structures, and the persistency, too, of the functional power and purpose of similar organs. We see forms close to the bottom of the picture and we see similar forms at the top, even the very top. So like do they appear that it requires close scrutiny by trained and expert observers to detect any difference. And when it is borne in mind that of the organisms existing in the far-back Cambrian period only a few can have come to our notice, we must conclude that very many of the lower organisms of the present day are generically related to organisms of the Cambrian period. This compels a recognition of the unity of the whole organic world which must be regarded as one great biological chain without a break and with every link connected with another throughout geological time.

Although the trilobites which were so abundant in older Palæozoic times became extinct before the Secondary epoch, yet the Limulus or King Crab of the present day, especially in the young state, strikingly reproduces their main features, and the sessile and compound eyes of the common crayfish, crab, and lobster, are almost identical with those of the *Calymene* and *Phacops* of Silurian times, in some of which trilobites very many facets in each eye have been counted. The four-eyed Limulus first appears in Jurassic, but the allied *Neolimulus* is in Upper Silurian strata, and the eurypterids of these Palæozoic rocks are scorpion-like also, and are now regarded as Scorpionidæ and Arachnida, although aquatic, the present scorpions and spiders differing in being air-breathers, even as land snails differ from aquatic gasteropods. There is, moreover, a true scorpion in Upper Silurian rocks, the *Palæophonus Hunteri*, while from Carboniferous strata no less than seventy-five species of Arachnids have been obtained.

The graptolites are also confined to Palæozoic rocks, but they were structurally similar to the Sertularians or sea-pens of the present day. Their habitat was similar, the functions of their organs were similar, their life was similar.

And so it may be said of the still older Oldhamia of the lowermost Cambrians that has not been found in any less ancient rocks, for it was structurally similar to some Hydrazoa of to-day. In Cambrian rocks, too, are fossil lamellibranchs and gasteropods of families that flourish in our own seas, as the Arcidæ, the Nuculidæ, and the Patellidæ, while Silurian genera of these Classes allied to living genera are numerous. These were in all respects similar to living species in all essentials of structure and physiological function. Again, the small Class Pteropoda that gives the little *Clio borealis* as food to the great Whale of northern seas, gave the *Conularia* to Silurian seas, and specimens of these have been so wonderfully preserved that their fine striations, exactly like the fine striations of the glassy shells of the living *Clio*, are most distinctly seen.

In Cephalopoda, with one exception, Palæozoic generic forms were markedly different, it is true, from later and recent forms. The straight, the swollen, and the slightly curved forms of Tetrabranchiata, so abundant in Palæozoic rocks, are almost absent from Secondary* and quite absent from Tertiary formations, and the shell-less Dibranchiata that gave the multitudes of belemnites to the Jurassic and Cretaceous rocks, were absent from Palæozoic seas. Yet the essentials of the cephalopod of to-day were present in the Palæozoic cephalopods, and the chambers, and septæ, and the siphuncle of the living Nautilus, were matched by the chambers and septæ, and the siphuncle of the Lower Silurian Orthoceras, which was also four-gilled and so in the same Order, Tetrabranchiata. The exception is the Nautilus itself, that not only has remained true to its Class, its Order, and its Family, but also to its genus from Palæozoic times to the present. Through all the varying marine conditions, the varying character of deposits, and the varying temperatures during the long æons between the Palæozoic epoch and to-day, the *Nautilus* has lived, and it is now flourishing in great abundance in the Indian and Pacific Oceans as *Nautilus pompilius*, the well-known "pearly nautilus."

The corals have lost an Order, but all the Palæozoic coral animals had the same physiological powers based on the same organs, with the same functions, as the corals of our present

* The genus Orthoceras occurs in the Alpine Trias.

seas. It could obtain and secrete in a solid form, the carbonate of lime in solution in the sea-water, and with that secreted solid calcareous matter build a surrounding habitation exactly as does the coral animal of to-day. The Echinodermata has lost two Orders since Palæozoic times, but each of the existing three Orders, Asteroidea, Echinoidea and Crinoidea, were represented in the seas of that epoch, and the little *Palæaster* of the Silurian seas was quite like a little star-fish of our southern shores.

The early fishes had a peculiar structure, but it was not a structure peculiar to Palæozoic times, for there is the same structure to be seen in many living fishes. This was the extension of the backbone to the end of one of the lobes of the tail, the other lobe being merely a fin lobe. And with this unsymmetrical tail the earliest fishes had an exterior coating of bony plates instead of scales. But in the sturgeon this type of fish still lives, and not in tropical waters or under exceptionally warm conditions, since sturgeons are often caught off British coasts and, as is well known, abound in the Russian Caspian and Volga. The sharks are also representative of the heterocercle tailed fishes, as they are called, but the majority of recent fishes have equal lobed or homocercle tails. Even the peculiar *Dipterus* of Devonian age has its living representative in the both lung and gill-possessing *Ceratodus* of Australia.

Insects quite like those now living abounded in Palæozoic times, for cockroaches, crickets, beetles, dragon-flies, etc., were plentiful, and no less than 239 species of Orthoptera have been taken from Carboniferous strata. There are besides, in the Jurassic rocks, remains of earwigs, grasshoppers, white-ants, may-flies, and that genus of Diptera we know so well, the fly.

But perhaps the most striking example of persistency of form and structure and the continuance of the same physiological power implying the same function of the same organs, is afforded by the little *Lingula*, a genus of the Class Brachiopoda. The fossil, *Lingulella Davisii* is in sufficient numbers in one of the divisions of the Cambrian rocks to give it the name Lingula Flags, and the *Lingula* is now living in abundance in the China seas. These two species are essentially the same animal. Their general form and size are similar, the character of the horny shell, in composition and structure, of both, was similar, and thus we see that the animal of Cambrian times was morphologically and physiologically allied to the *Lingula* of our own day. As might be expected, the *Lingula* is found fossil in many formations between the Lingula Flags and the latest deposits, and all the species show wonderful similarity.

The space at my disposal will not allow of other illustrations of the great fact of persistency of animal types, the numerous examples of which are well known to students of palæontology, but the facts now stated are sufficient to show that animal life has existed with similar forms and similar physiological powers from the far-back Cambrian period to our own times.

In the plant world, too, the persistence of types is conspicuous. The oldest land-plants we know are ferns very like recent ferns, and the *Lepidodendron, Sigillaria* and *Calamites* of the Coal Measures are lycopods and equisetums now abundantly represented.

This persistence of form, of structure, and of similar functional capabilities of organs, clearly indicates generally similar inorganic conditions to the present in Palæozoic times. It tells of conditions of sea-water and atmosphere, of temperature and light, at least not greatly differing from those we know, and shows, I think, conclusively, that whatever marked cooling of the exterior of the globe, and whatever consequent shrinkage of the globe has taken place in the past, that cooling and that shrinkage took place before the Cambrian, and I believe before the Pre-Cambrian, sedimentary rocks were formed by accumulation of detrital matter. The evidence afforded by the Cambrian rocks and the evidence afforded by the Cambrian fossils is indeed so cogent that we are enabled to picture to ourselves the world in Cambrian times. As I wrote some years ago:* we can see, as it were, its lands and its seas, its spreading plains and elevated uplands, with its broad and deep seas, and their shallower bays and gulfs. On the land, too, are rushing torrents, rippling streams, and larger and smoother flowing rivers, carrying eroded material to the Cambrian ocean, fringed by sandy shores and shingly beaches. And the sky above is now an unblemished azure, now flecked with cirrus and now dark with nimbus. Rain falls, winds blow, tides ebb and flow, and we can see the broad expanse of waters in their calm majesty or angry with storm and tempest, rolling mighty waves upon the Cambrian strand, and we can think of the millions of splendid sun-risings and gorgeous sunsets, and almost feel the heat of the noontide summer sun or the cold of the mid-winter night. We can even look through the clear salt-water on to the ocean bed, and see

* Presidential Address to the City of London College Science Society, 1897.

the groves of algæ, with the trilobites and molluscs peopling those ancient seas, while along their coasts volcanic fires at intervals break forth, and lavas are outpoured that cover the surrounding rocks with basaltic or trachytic coatings. But save for these volcanic outbursts, the crash of thunder, and the roar of wind and wave, a silent world it was. No lowing herds or roaring beasts of prey were on the land, and no birds sang their songs either on tree-top or high upon the wing. And how desolate was the unnavigated sea, for whales and porpoises, seals and sharks, and flying fishes were not in its waters and no sea bird's mew was heard, for no stormy petrel, gull or penguin was upon its surface.

Change and Environment.

If the conclusion is warranted that the cosmic inorganic conditions on the globe, however locally or even regionally varied, have been generally similar during the whole period of the deposition of the sedimentary rocks, and therefore during the whole period of the life on the globe that has given all the information we possess of biological change, we must, I think, further conclude that this change has accompanied in its progress small rather than great alternations of environing conditions. It is also evident from the testimony of the rocks that while great biological changes have synchronised with very small, if any changes of environment, slight biological changes and even morphological continuance, have accompanied considerable alterations of environing conditions.

The marine conditions of the Ludlow could have been little different from those of the Wenlock period, during both of which argillaceous and calcareous matter was largely deposited, giving the Ludlow and Wenlock shales and limestones, and yet the fauna of the one gives us Vertebrata which is absent in the other; corals and echinoderms greatly decreased; other Invertebrata greatly alter; and large arachnid Crustaceans take the place of many species of trilobites. The British Permian deposits of sandstones and marls show similar marine conditions to those indicated by the Triassic sandstones and marls. Red sandstones with conglomerates and stiff red marls make up 3,000 feet of the Permians of this country, and red and variegated sandstones with conglomerates and stiff red marls make up 3,000 feet of the Trias of England. Yet our Permian mollusca is wanting in our Triassic rocks, while the homocercle fishes and the dinosaurs of the Trias are altogether wanting in the Permian. Indeed the Triassic rocks are much more allied lithologically to the Permian than to the Jurassic rocks, but the Triassic fauna is much more like the Jurassic fauna above than that of the Permian below.

The Rhætic limestones and shales of England are very similar to the Lower Lias limestones and shales, indicating similar marine conditions. Yet our Rhætic beds are without ammonites and belemnites, without many genera of Brachipoda, Lamellibranchiata and Gasteropoda, and without *Ichthyosaurus* and *Plesiosaurus,* all of which genera are most conspicuous in our Lower Lias. The Bathonian and the Portlandian marine conditions, both giving thick-bedded oolitic limestones, must have been very similar, but while Brachiopoda are most abundant in the Bath limestones, they are entirely wanting in the Portland limestones, and although ammonites are present, belemnites are absent.

On the other hand, very considerable alterations of environment have been accompanied by very small biological change. Trilobites are in the shales as well as in the limestones of the Silurian rocks, although these greatly differing deposits indicate at one time abundant argillaceous matter in shallow seawater and at another a clear and deeper sea.

So also do ammonites and belemnites abound both in the Jurassic limestones and the Jurassic clays, while in Cretaceous rocks they are both in the calcareous Chalk and the argillaceous Gault. The range in time of the Orders and genera of Cephalopoda, indeed, present several remarkable features. Tetrabranch cephalopods have lived through all conditions from Lower Silurian times to the present, while dibranchiate cephalopods appear in Secondary times. Two conspicuous tetrabranchs, the *Nautilus* and the *Ammonite,* with the dibranchiate *Belemnite,* flourished throughout the Secondary period under the same marine conditions, but at its close the tetrabranch *Ammonite* and the dibranchiate *Belemnite* became extinct together, while the *Nautilus* which lived in Palæozoic seas continued to live and is still abundant. Again the tetrabranchiate *Orthoceras* died out in Triassic times while then it was that the Ammonoidea of the same Order had its greatest development, 1,000 species having been described.

And so it appears to have been with terrestrial organisms also, if we may judge from the comparatively few land fossils that have been preserved. Nothing could well be more different in land surface conditions than the warm and humid and low-lying conditions of the Coal Measure areas, and the cool and breezy and elevated conditions of our mountain sides.

Yet the *Pecopteris* of the Coal Measures is very similar to the bracken of the upland slopes of England and Wales, from which we may conclude that the ferns, at least, of the Carboniferous flora flourished under very varied conditions of moisture and temperature all through the Secondary and Tertiary epochs. These remarkable and instructive facts doubtless present great difficulties, but they cannot be ignored and must be taken into account in any adequate consideration of this subject.

EXTINCTIONS.

The term "exterminations" applied to the extinctions or dying out of species or genera during geological time seems to imply a sudden termination of the existence of the whole of the individuals; but such sudden extinctions, as was well said by Mr. Hudleston, are more apparent than real.* An apparent extinction may only have been occasioned by the migration of a species to another area the rocks of which have not been examined or possibly have been destroyed. Extended and more careful research has over and over again given a greater stratigraphical range to species and genera than had before been regarded as established. Species thought to be limited to a particular formation have been subsequently found in newer and, in some cases, much newer rocks. I have myself found species that were thought to be confined to certain formations in other beds sometimes much higher in the stratigraphical scale. This result of extended examination of fossiliferous rocks was well exemplified by the extension of the known stratigraphical range of the trilobite, *Arethusina Konincki*, which up to a certain time had not been found higher than in a zone of the Upper Silurians of Bohemia, although in that and lower zones it was most abundant, and accordingly the species was considered to be quite characteristic of these rocks. But at length the *A. Konincki* was discovered in the much newer Upper Devonian rocks of Westphalia.

Such facts as these render it certain that future research will give similar results, and this forbids the conclusion that a species or a genus has become extinct at the time of the formation of the newest bed in which it has hitherto been found. Even those species of Ammonites which are usually regarded as marking certain zones in the Jurassic rocks may not have had

---

* *Journal of the Victoria Institute*, vol. xxxvii, p. 184.

the relatively short existence that the small thickness of the strata they characterise may seem to indicate. They may have migrated to, and lived on in, other areas at a greater or less distance from that we have been able to examine. Although the theory or principle of homotaxis as propounded by Huxley cannot be allowed to apply to the extent its author anticipated, it yet has undoubtedly a considerable kernel of truth, for migration may entirely remove a species from a locality and give it to another where it will be contemporaneous with later deposits.

The difference in the fossil fauna of the same formation in two localities not very far apart is remarkable. If we take the Inferior Oolite of Gloucestershire and Dorsetshire, for example, we find an abundance of Brachiopoda in the former and an abundance of Cephalopoda in the latter. The *Terebratula subglobata* is most numerous near Stroud and almost absent in Dorsetshire, while almost only at Crewkerne in Somersetshire is *Ceromya Bajoceana* to be found. From one small locality in Dorsetshire a large number of species of Ammonites have been obtained, while in other localities the Inferior Oolite gives only a few of these species. Near Enslow Bridge, in Oxfordshire, the Great Oolite contains a bed in which *Terebratula maxillata* is most abundant, but any such a congeries of this species is not to be found elsewhere. Yet in none of these cases is a species altogether confined to one locality, and as more and more places are examined the evidence of wider extension is obtained. In two Austrian areas of contemporaneous Triassic rocks it has been recently ascertained that the fossils of one are very different from the fossils of the other, and that some remarkable zones with Palæozoic species are only to be found in one of these areas.

The very small area in which a number of individuals of a species may be localised, as it were, in a colony, is strikingly shown by the occurrence of that fine gasteropod the *Purpuroidea Morrissia*. Thirty or forty years ago this fossil was abundant in the Great Oolite of Minchinhampton, while now it is not to be found there. The same bed is exposed but the continued working of the quarry has removed a few horizontal yards of rock which has obliterated the little colony, but only a colony, since it is not to be concluded that no other individual of this species lived in other areas on this geological horizon. At the present time there are thousands of cockles on our coasts in certain places and not a single cockle in others, even where the conditions are similar; and so it is with mussels, periwinkles, etc.

If this is so, and has been so, horizontally, time will make it so vertically also, and this should give no cause before asserting that a species has become extinct because it has not been found so far in a bed above its so-called zone. It is indeed not too much to say, that until all the fossiliferous rocks in all parts of the world have been well examined, we ought not to positively assert the restriction of a species to a particular zone or even to a particular formation.

Doubtless, extinctions in geological time have been in the aggregate vast, but the time has been vast also. Some of the extinctions, it is true, have embraced not only species but genera, in a few cases families, and in a very few cases, only five in all, Orders, but these have, in most cases, if not in all, been effected during long-extended periods of time.

Causes of Biological Change.

From the facts revealed by geology and palæontology, a few of which have here been very briefly presented, it is evident, I think, that it will be most difficult to formulate a specific cause, or specific causes, for specific biological changes, including the appearance of new and the extinction of old forms.

The hypothesis, which has been advanced, of natural causes operating to effect a certain amount of change, or rather modification, and these being supplemented by direct supernatural action to complete the change and give a new species or a new genus,* seems to leave out of sight the fact that some newer species and newer genera were decidedly inferior to those preceding them, for we can scarcely call in supernatural power to reverse advance, to retard progress, and to undo good. The more complex graptolites are from Lower Silurian formations and the simpler forms from the Upper Silurian and Devonian rocks. The largest and most highly developed genus of trilobites, the *Paradoxides*, is in Lower Cambrian rocks, while the two late Carboniferous genera, the *Phillipsia* and the *Griffithides*, are both simple and small. The earliest Lamellibranchs were dimyarian and the much later *Ostrea*, *Gryphea*, and others, were monomyarian. The tetrabranchiate cephalopods flourished in Palæozoic seas long before the appearance of the dibranchiate genera. The *Ammonite* was not in advance of the

* Dr. C. B. Warring, *Journal of the Victoria Institute*, vol. xxxvii, p. 172.

Nautilus, which both preceded and survived it. And if Professor Hyat is right in saying that the efforts of the orthoceratite "to become completely a littoral crawler developed the Ammonoidea," it was a step that led to nothing further, since there is no genus that we can regard as being developed from the *Ammonite*, for the *Nautilus* is the only living tetrabranchiate.

The extinct Palæozoic brachiopods cannot either be said to be lower steps towards higher genera in Secondary times since *Terebratula*, *Rhynchonella*, *Discina* and *Lingula*, all lived in Palæozoic times contemporaneously with *Productus*, *Spirifer*, *Chonetes*, *Pentamerus*, etc., and *Lingula* earlier than any. The two Palæozoic Orders of Echinodermata, Cystoidea and Blastoidea passed away without being followed by any more highly developed successors, for the only three existing Orders of that Class, the Asteroidea, the Echinoidea, and the Crinoidea, were in existence as early as the two Orders that have become extinct, so that the several Orders of the Echinodermata were geologically contemporaneous in their appearance. Though the Pterodactyles had affinities with both reptiles and birds, they have passed away without leaving any developed successors, and the only creatures having affinities with them in their chief peculiarity are the mammalian bats. And writing of fossil plants, the eminent botanist, Mr. W. Carruthers, says: "Ferns, equisetums, and lycopods, appear as far back as the Old Red Sandstone, not in simple or more generalised but in more complex structures than their living representatives."* It may indeed be said generally that in the case of very many species it is quite impossible to find any cause for saying that a newer is higher than an older form, or to see any reason in their structure for the order in time which they have made their appearance.

But apart from these special instances, there is the great general fact of the introduction of new genera and species of lower Classes all through the Secondary and Tertiary epochs after the higher Classes of Vertebrata had come into existence. That supernatural interference with the Laws of Nature should be employed to produce a Cardium, a Trophon, or a Littorina, in addition to the vast multitude of similar genera, occupying a similar position and playing a similar part in the cosmos, and when there were already much higher animals in existence, is incredible.

---

* *Geological Magazine*, 1876, p. 362.

Although the facts of palæontology are so multifarious, so varied, and in some cases so apparently inconsistent with each other, and even seemingly contradictory, that we cannot assign specific causes for them, the only conclusion that observation of Nature, and Science, seem to warrant is that biological changes with introductions of new and extinctions of old species are not due to any suspension or supersession of the Reign of Law, and that, therefore, however difficult it may be to explain the cause of specific changes, they are all due to natural causes.

In some cases, indeed, it does not seem difficult to suggest a cause of extinction, as in the case of the great dinosaurs of the Secondary epoch. These great creatures required much food, which sometimes might not be easily procurable, and their heavy and unwieldy bodies and very small brains would not assist them in their search for sustenance. So also the great mammals of the Pliocene and Pleistocene periods would be severely handicapped by their great food and water requirements when seasons were unfavourable, or changes of level or temperature altered the quantity or character for the worse of the plants on which they fed. Changes in physical geography, as Lyell long since pointed out, are capable of producing great effects on the flora and the fauna of a region. By the slight subsidence of an extensive coastal plain it may be flooded by sea-water, and immense forests of trees and jungle plants destroyed, by which great herds of animals may lose the food on which alone they can thrive. Great swarms of locusts, again, have the power of devastating a wide extent of country, and so may deprive of food multitudes of small animals by which large carnivora may lose their prey and so die of starvation.

In his great work, *The Principles of Geology*, Lyell gives an interesting summary of the far-reaching effect of such an apparently small and unimportant thing as the transportation of a few polar bears by drift-ice to an island in northern seas before the time of man, such as Iceland has seen since its colonisation by Norwegians, who have been able to prevent the mischief by exterminating the invaders. In the absence of armed men and stronger carnivora, "the deer, foxes, seals, and even birds," on which polar bears sometimes prey, "would be soon thinned down. But this would be a part only, and probably an insignificant portion, of the aggregate amount of change brought about by the new invader. The plants on which the deer fed, being less consumed in consequence of the lessened numbers of that herbivorous species, would soon supply more food to several insects, and probably to some terrestrial testacea, so that the latter would gain ground. The increase of these would furnish other insects and birds with food, so that the numbers of these last would be augmented. The diminution of the seals would afford a respite to some fish which they had persecuted; and these fish, in their turn, would then multiply and press upon their peculiar prey. Many water-fowls, the eggs and young of which are devoured by foxes, would increase when the foxes were thinned down by the bears; and the fish on which the water-fowls subsisted would then, in their turn, be less numerous. Thus the numerical proportions of a great number of the inhabitants, both of the land and sea, might be permanently altered by the settling of one new species in the region; and the changes caused indirectly would ramify through all classes of the living creation, and be almost endless."

When it is found that extensive areas have been elevated 14,000 feet since Pliocene times, for in the Himalayas deposits of that age are now 14,000 feet above sea level, we must be impressed with the magnitude and vast number of geographical alterations that have taken place throughout geological time, and also with the almost infinite number of consequent possibilities that would affect, in one way or another, animal and vegetable life on the globe, and so be productive of biological change. The exact conditions of each period of geological time, and of each sea, and bay, and estuary, and lake, existing in each of these periods, or each of the many and constantly varying land conditions of elevation, exposure, temperature, and humidity, we cannot hope to know, and so we cannot hope to be able to give the specific causes of specific changes, but the general cause of biological change does not appear so inexplicable.

"The fact of heredity is recognised," Dr. Saleeby says, "by every man who would show surprise on hearing that an acorn had developed into a human being or a mushroom," and "the man in the street need not leave the street in order to find conclusive evidence of the fact of variation."* But it is also necessary to remember that "the link which unites all organisms is not always the common bond of heritage, but the uniformity of organic laws acting under uniform conditions."†

---

* *Fortnightly Review*, 1905, p. 604.
† G. H. Lewes, *Fortnightly Review*, 1868, p. 373.

Heredity, variation and environment, each acting in modification of the other two, and the vast duration of geological time, seem to furnish this general cause, and render less inexplicable the results of modern palæontological investigation, and we are therefore not called upon by these results to doubt that the Reign of Law is as supreme in the Organic as in the Inorganic world.

DISCUSSION.

Rev. G. F. WHIDBORNE, F.G.S.—I am not concerned to defend Dr. Warring's views, but I agree with our Secretary's editorial note that his use of the word exterminations has been misunderstood; and in my remarks on his paper I used it in the sense which our Secretary attached to it. Certainly the old scientific idea of a number of successive creations and obliterations is disproved alike by Genesis and modern geology, which equally show a single progressive changing creation.

The true view of the existence of exterminations seems only emphasized by Professor Lobley's interesting paper, and the question remains whether in sweeping away the false idea that geologic periods indicated independent creations, we have not too much minimized the fact that they present us, as it were, with a series of cinematograph views, directly related, but each individualized. Is there a meaning not yet fully appreciated in the fact that geology displays to us a series of correlated tableaux and not a continuous diorama?

In his paper the Professor emphasizes not only exterminations (or as he better calls them, extinctions), but origins. Thus he points to the assumed origin of vertebrates in Upper Silurian times. It is easy to call Upper Silurian long subsequent to Cambrian, but relatively to the whole catena it is remarkably early for the appearance of so high and so specialised a class as vertebrata; especially as it cannot be said that they did not before exist, but only that they are not known to have before existed. Further, the variety of the primordial fauna must indicate on any theory of evolution the pre-existence of earlier (probably vastly earlier) unknown faunas. Palæontology begins with Vol. X, not Vol. I, of biological history.

Again, it cannot be too clearly realised that the early history of land surfaces is almost *nil*. The coal, I suppose, was rather a swamp than an actual land surface. And before the coal and the Devonian what is there? But if there were sea beds, there must almost certainly have been land surfaces; and in the Silurian, Ordovician, Cambrian and Pre-Cambrian land surfaces, it may have been, and probably was, that there existed a vast library of Palæobotany. Plants being always sedentary are far more dependent on local circumstances than animals. Here there are vast unknown terms. In natural problems, as in others, unknown terms cannot safely be neglected; often they have to be retained as unknown terms in the result.

But when we come to the latter part of the paper I find myself as much in discord with Professor Lobley as with Dr. Warring. I find it as difficult to imagine natural causes not in their origin supernatural as to imagine the natural and the supernatural confused in their working out. I can conceive no natural cause which is not supernatural in primal origin; I can conceive no supernatural origin which is not natural in its result. That only is supernatural which is above and before nature, and unless nature is self-originating, it must have originated from the supernatural. But in our common and inaccurate use natural and supernatural are only conventional terms, and only mean processes we understand and processes we don't understand.

The weakness of the Professor's argument seems to me to come out at the conclusion. He gives heredity, variation, and environment as furnishing the "general causes" of Biological change. Heredity, however, is a centripetal force, it offers no explanation of progress but only of the preservation of things. The other two are valid as operating causes of progress, but they are open to the leading question, "What caused them?" The Professor seems to attempt to answer this by saying "The Reign of Law is supreme." Let this be granted. Law cannot be self-constituted, for then it would be chance and not law. So we reach the final question, "What is the origin of law?" To use Henslow's term we may answer Directivity; an older synonym is Design. I can find no other origin for the Reign of Law than the Reign of the Will of God. The fact of natural law is to me only the expression of the infinite consistency of the Almighty.

Dr. W. WOODS SMYTH.—My thanks are due to Professor Lobley for his papers both for the present and last years. I can see that he is a thorough Uniformitarian. I thought we had come to a compromise and admitted that both Uniformitarianism and Cataclysmatarianism existed. Both do exist. While changes have been going on in a placid form at some places, there have been mighty upheavals occurring at others. At Martinique at the time of the eruption of Mt. Pelée, we would have found changes going on in the same place in a very mild form indeed. Going back to former times, look at the earth when it must have resembled the moon. There was a vast volcanic globe covered with scoriæ, tufa and pumice.

The earth's crust must then have been disintegrated so that at last when rivers formed they must have brought down large deposits—in large masses of material—and that would account for some of the Pre-Cambrian sedimentary rocks.

There was a mighty change which Professor Lobley has shown us in connection with the Himalayan range, which has risen up 14,000 feet since Eocene times, so that part of that was at the bottom of the sea in the Eocene (Nummulite) period, and the same applies to the Carpathian and Alpine ranges.

Speaking of physical environment, Professor Lobley has given evidence to show its limited influence on life. He has shown the great influence of the biological environment, with which I agree. Now the influence of the biological environment goes to support the theory of selection, or the "survival of the fittest." Genesis is undoubtedly in harmony with what Professor Lobley has presented to us, the absence of any interference, or directivity. It does not occur in that wonderful chapter. The uniform flow is beautiful throughout. I mentioned before here that the Hebrew tense speaks of the incoming, the continuous, and these tenses are used forty-nine times and show the flow onward of God's creation.

Mr. WOODFORD PILKINGTON, M.Inst.C.E., expressed his concurrence with the views of the author.

Professor ORCHARD.—I must thank Professor Lobley for bringing before us "Biological Changes in Geological Time" in a series of most interesting views into which he has infused a warm glow. Anyone who has heard the description of that supposed scenery of the Cambrian age must have felt that to that solid and thorough knowledge which he possesses as a master in geology the author has added the enthusiasm not only of the investigator, but I may also say of the poet.

There are one or two slight criticisms which the paper perhaps invites :—

The author laid great stress upon the persistency of types, upon the appearance of higher forms before lower, also upon the sudden appearance of new forms. These facts are fatal to any theory of evolution whatsoever. With regard to the length of time geologically I do not know that I entirely go with the author. It is of course a matter of argument.

With regard to heredity, variation, and environment, we have to remember that heredity, as has been pointed out by the first speaker, is not the cause of the change but the cause of characteristics. Environment never changes the character, it only alters the outward appearance.

With regard to variation, that never extends beyond the limits of the species. I do not see that these three forces, whatever you like to call them, these three processes, would apply to anything further than variation within species. Possibly the author did not intend that they should.

On p. 109 the author seems to think that it is quite impossible, at least incredible, that God should have created lower forms after creating the higher. I do not see any ground for incredibility. Is it not possible that the creation was allowed by Him to subserve interests of the subsisting forms as well of higher forms. As a matter of fact, it is certain that lower and higher have gone on continually. The only explanation that at all harmonises with the real facts of science is the old theory of "special creation." Nothing else is free from most serious difficulty. Nor do I see why we should have any objection to it. It is plainly said in Genesis that the days were completed periods : the fact that the Hebrew tense would refer to the whole drama of creation, and not to the particular acts.

Professor HULL.—Mr. Chairman, I entirely associate myself with the words of Professor Orchard and others who have expressed their admiration of the manner in which this paper has been brought before us. Of course we all know Professor Lobley is a first-class authority on palæontological matters; and whether we agree with his views as to the origin and progress of species and forms or not, we must admit that he has handled his subject in a very eloquent and interesting manner. There are, however, several points, not so much connected with the palæontology as with the physiography of the subject, which I wish to call his attention to. In the first place, I do not go with him so far as he does regarding the extent of the destruction of the various formations which he indicates in his paper.

He seems to suggest that the mountains of Wales and other mountain regions to the north of Wales and the British Isles were covered over by strata belonging to the Jurassic and Cretaceous periods. I do not think this was the case at all. This is a subject I have dealt with in a work which lies on the table and which I would ask Professor Lobley to look at and see if he does not agree with me. Unquestionably the Silurian region of Wales and the north of Scotland and the Carboniferous region forming the "backbone of England" were land surfaces at the time when the Oolites, the Cretaceous limestone (or the Chalk) were being formed in submerged areas to the south. The waters of these seas did not cover these old regions at all. They were land surfaces during that period, and therefore the destruction of these formations did not go on to the extent which the author of the paper seems to assume. These formations as they approached the old land surface gradually thinned out into thinner and thinner dimensions, and therefore were ultimately denuded round their margins on the uprising of the lands to their present position.

With regard to the uniformity of denudation in these periods, I fear I cannot agree with the author of the paper. I think the denudation of strata may have been vastly more rapid in very ancient times than it is at the present day. One reason which may be adduced is the greater proximity of the moon to the earth in early geological times. If the moon was originally thrown off from the earth it inevitably increased its distance to its present state, where it seems to be permanently at a certain distance from the earth owing to the balance between gravitation and centrifugal force. During the period of gradual widening of the distance there must have been a difference in the effect of attraction of the moon's mass which would have affected powerfully the tides; and supposing at a certain period, say the Jurassic or the Old Red Sandstone period, the moon was only one-half the distance from the earth that it is now, the effect of the attraction of our satellite would have been probably quadrupled to what it is at the present day. What would be the effect of that on the tides? The tides would rise and fall enormously to a greater extent than they do at the present day, and the result of that rise of the tides would be to produce an amount of denudation and erosion of the rocks vastly greater than is now the case. If the waters rose, say, four times higher along the coasts at that period than they do now, so the period of oscillation would have to take place in the same period, or as nearly so as possible, and the effect of that upon the land would have been vastly greater than it is at the present day.* This view was many years ago suggested by Sir Robert Ball, and it imprinted itself upon my mind as a phenomenon that has to be taken into consideration when we speak of the uniformity of these natural agencies of denudation and erosion in past geological times as compared with that of the present day.

Professor LOBLEY.—I must express my thanks for the kind attention given to my paper, and so many points have been raised I am afraid that I should have to take up as much time as it took to read it to reply to them; but there are two or three points that have been put saliently.

With regard to Professor Hull's remarks about the amount of denudation, and the amount of destruction of the rocks, Professor Hull is a high authority, and I would pass that over. My estimates were round numbers and figures just to illustrate the point that a very large amount of the stratified and other rocks had been denuded away. I agree that some of the higher mountain regions of Scotland and Wales were above the sea during Jurassic times. I do not measure the amount of material which had been removed from either area.

The geological map shows that a very large proportion of the formations that have been there originally have been removed and

* On the supposition that the diurnal rotation of the earth was what it is now.

destroyed by denudation, leaving only a small proportion in this limited area of the British Isles. I took the British Isles because they are better known.

With regard to the uniformity; I am not a rigid Uniformitarian, as has been suggested. I consider there has been a general uniformity in connection with the laws of nature, in the past, and that the positive evidence we have of slow deposition shows that the general inorganic conditions of the globe were similar from the Cambrian times to the present.

The argument with respect to the proximity of the moon giving a greater tide is based on the assumption that the moon was half way to the earth in Jurassic times.* That is an assumption; there is no proof. But we have positive proof on the other hand that there has been very slow deposition, and I read an extract from Sir A. Geikie to show that in the very old rocks, the Pre-Cambrian, you have absolute evidence of extremely slow deposit entirely analogous to the deposit of the present time, and that we see ripple marks and sand marks in very old rocks, Pre-Cambrian rocks, and we must come to the conclusion that these inorganic conditions were going on very similar to the present day. That there was a great sweeping of material together in some small areas, there may have been, but the general rule is that you find evidences of deposit quite similar to the deposit that is going on at the present time.

The CHAIRMAN.—At this late time it does not become me to say very much. What strikes me is the very short time man has had to see what has been going on. We are all agreed that the paper has been both interesting, learned and picturesquely written, and I think we ought to give our best thanks to the author, Professor Lobley.

The Meeting closed with the usual vote of thanks to the Chairman.

COMMUNICATION.

Rev. Dr. IRVING.—Professor Lobley has given to the Institute a paper which will no doubt prove useful to many of the members

---

* This was only stated as an hypothesis, the actual distance may have been more or less.—E. H.

who are not express students of geology. To a student of geology, however, it contains little of anything beyond what he is familiar with; and it fails to rise much above the text-book way of looking at geological and palæontological facts. One looks in vain for help from it towards that higher "philosophy," which aims at the correlation of results obtained in that department, with those arrived at in other branches of research, the very *raison d'être* of the Victoria Institute. We find the usual old and stale arguments to support the demand of the mere geologist to make unlimited drafts upon the bank of time, including the fallacy of attempting to compute time-duration from relative thickness of strata (a sort of carpenter's rule method); while the argument from the fractional portions of stratified formations or systems of rocks is drawn from too limited an area as to its facts, and seems to overlook the larger factor of the permanence of ocean-basins. The persistency of lower forms and types both in the vegetable and the animal kingdom has long been a common-place of palæontology; they remain and abide, while through evolutionary differentiation the fact of advance from the lower to the higher, as to structure and function, is patent enough. No one can well question the potency of the factor of change of environment throughout; and it is well to emphasise the fact that our data for determining the actual extinction of species is very far from complete as yet.

Unfortunately, it seems to me, the mind of the author of the paper is insufficiently emancipated from the uniformitarian dogma of the Lyell School, which very few capable geologists are prepared to swear by in the present day. One would like to see the paper permeated a little more with the spirit of what Professor Lapworth has styled the "New Geology," as it has advanced to a large extent under the leadership of the master-mind of Professor Suess of Vienna, at whose feet even men like Sir A. Geikie seem to be willing to sit as disciples. The paper before the Institute seems to practically roll up the pages of the last decade or two of geological progress. It is only through Lyellian spectacles that the author's imagination can see the vision of what he portrays to us with some vividness (on page 104) as having constituted terrestrial scenery in Cambrian times; a picture far too much overdrawn for Silurian or even later palæozoic time, as we may see if we recollect (as some of the master-minds of geology have taught) that there is no evidence of any extensive elevation of land above the hydrosphere of the globe before (at the earliest) the Devonian age. One might do worse than recommend to Professor Lobley's notice the views propounded (as inductions from a far wider range of facts) by such masters of the science as Professor Hermann Credner and Professor Zittel, to whose works references have been given in a foot-note to page 81 of the paper read by the present writer on January 15th, 1906.

To come to closer quarters, I raise an objection against Mr. Lobley's animadversions upon some remarks I made at a meeting of the Institute last year; because they imply misunderstanding on his part, and misconstruction of what I said on that occasion. He has no right whatever to drag in the hypothesis of the "supernatural," which is a rather foolish term, though a favourite one with minds of a certain order. The dèterioration of which he speaks in detailed instances is a fact which he assumes in rather too easy a fashion; and he seems to supply no standard by which such deterioration can be gauged.

In a sense, no doubt, it is true in some cases—as in the case of the Permian fauna as compared with the Carboniferous, as I pointed out in various papers years ago. The advance of the whole fauna and flora of the globe is what we have to consider, and not to attempt to construct theory upon these or those details. That advance towards higher types, and towards a greater multiplicity of them, has been along many lines, some of which are seen (or at least appear) in the light of such an imperfect geologic record as we possess, to reach their vanishing points; but of these we can only fairly judge by considering their place in the totality of progressive advance.

Deterioration of a given set of organisms under more unfit conditions of environment is but the correlative of advance under favourable conditions; it eliminates the old notion of sudden (*quâ* miraculous) extinctions, but that is simply "slaying the slain." We may fairly contend that such cases teach merely the subordination of the interests of the individual to the economy of the whole. That that economy is all under "the reign of Law" no one questions; but the mere geologist claims too much when he assumes that the great and deep questions, as to *what really constitutes "law,"* can be settled by what appear on his single plane of mental vision.

Far wider was the outlook of one who could write of Nature :—

"From scarped cliff and quarried stone
She cries, 'A thousand types are gone ;
I care for nothing, all shall go.' "*

But that leads us into regions of thought which require other faculties of perception than those which geology can furnish to the human mind, as I have attempted to some extent to show in my recent paper.

REPLY BY PROFESSOR LOBLEY.

Dr. Irving is dissatisfied that my paper is not one quite different from what it was intended to be—a plain and concise exposition of geological facts and deductions, required by a previous paper for the consideration of an Institute not mainly, or even largely, geological, and so necessarily containing much that is well known to geologists in addition to many facts that, so far as I am aware, have not been before stated. One would have thought that an attempt to do this would have been approved by a lover of geology, but instead of approval it is met by Dr. Irving with the reverse.

The "regions of thought" and "higher philosophy," to which allusion is made, are outside the scope of my paper, and I am unable to understand how any "New Geology" can invalidate ascertained facts and sound deductions, which must remain good for all time.

---

* Tennyson's *In Memoriam.*