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ORDINARY MEETING.*

D. HOWARD, ESQ., V.P., IN THE CHAIR.

A paper entitled "Geological Exterminations," by Charles B. Warring, M.A., Ph.D., was read by the Secretary, in the author's absence in Canada.

The Secretary also read communications from Mr. Hudleston and Dr. Kidd.

GEOLOGICAL EXTERMINATIONS.

By CHARLES B. WARRING, M.A., Ph.D.

ALL who have studied the life-history of the earth have been impressed with the fact that not only species, but entire genera, families and tribes, have become extinct—not temporarily but permanently, and, broadly speaking, have been succeeded by species more like those of the present day. Dana says: "There was a general extermination of species about the eastern portion of the American continent at the close of the Acadian or Lower Silurian epoch; at the end of the period of the Chazy formation its species, with few exceptions, disappeared."† He says also: "The introduction and extermination of species were going on during the whole course of history, instead of being confined to particular points of time; but at the close of long periods and epochs there were general exterminations."‡ He says also: "At the close of the Cretaceous period occurred one of the most complete exterminations of

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* Monday, March 6th, 1905.

† Dana, *Man. of Geol.*, Revised edition, page 182, lines 13 to 20.

‡ *Ibid.*, page 384, lines 21 to 24.

species of which we have any record."* I might multiply such quotations, but there is no need.

A very important fact in this connection is that after these exterminations the old species do not reappear, but new ones, more like those of to-day, take their places. The biological conditions, therefore, must have changed in the interval, probably a long one, between the birth and death of those species, and always in the direction of those that now prevail; and as this change of species took place all over the world, an explanation must be sought in a cause, or causes, possessing the same characteristics of permanency and universality.

It is usual to attribute these exterminations to the occurrence of continental elevations producing colder climate, or to high latitude depression of land letting cold waters from circumpolar regions flow towards the equator. It is doubtful whether these were sufficiently extensive to be world-wide, and, however that may be, they lack permanency; for in a short time, geologically speaking, the elevations were followed by depressions, and the parts that had been sunk below the normal level came up again; and as for cold water currents, if we may judge from the flora and fauna which have been preserved, circumpolar waters during by far the greatest part of the time when the exterminations occurred differed in temperature but little, if at all, from those within (or at least near) the tropics. It is found that from the Eozoic to the close of the Mesozoic, and in a less degree through the Miocene, one of the most striking characteristics of each horizon was the world-wide prevalence of very similar, and often identical species, with little or no regard to differences of latitude.

It was during that time of mild and uniform climate that the most numerous and most remarkable exterminations took place. There may have been local elevations sufficient to produce even large glaciers—mountains in tropical regions have such now—but their influence in the early days was too limited to need to be considered in this connection. We must, therefore, look elsewhere for causes which were both world-wide and permanent, and which rendered a return to former biological conditions impossible. These we shall find, if I mistake not, in the continuous improvement from the dawn of life in the character of the atmosphere, the waters, and the soil. Its influence was world-wide, never going back, perma-

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* *Man. of Geol.*, page 487, near bottom.

nent, and always working towards present conditions, and, therefore, rendering a return of former species impossible.

But the question arises, was there such improvement?

The early atmosphere must have contained an enormous amount of carbonic acid, or, as it is now called, carbon-dioxide, for though at one time carbon and oxygen were kept disassociated by the intense heat, yet as the temperature fell, a point was reached when their usual affinities brought them together till one was exhausted. Probably some free oxygen was left, because after that—I know not how soon—there were found protozoa, and these, like all other animals in the water and on the land, require such oxygen.

A very large part of the carbon dioxide had united with lime and other bases, forming insoluble deposits, before the Eozoic. The atmosphere was improved by the operation, but became no richer in oxygen; for this vegetation was necessary. When there began to be even the lowest plants, the oxygen of the dioxide commenced to be freed from the carbon, and returned to the atmosphere, while the other element, the carbon, gave suitable material to plants and their dependents, the animals. All those then living, and all that have come after them, whether now living or buried in the earth as graphite, coal, lignite, oil, gas, or in other forms, existed at the opening of the Eozoic period as carbon-dioxide. Hence its atmosphere was poorer in free oxygen by the amount necessary to turn all that carbonaceous matter back to dioxide, and this, the chemists tell us, is eight pounds of oxygen to only three of carbon; or, to put it in another way, one pound of carbon will turn into dioxide two and a half pounds of oxygen, or, more exactly, two and two-third pounds.

It is impossible to determine the amount of carbon which has passed through plants and animals, but from what has already been found in the comparatively small part of the earth's crust which has been examined, and from what we may reasonably suppose has been carried into the sea, it was sufficient to hold a very large part, probably by far the largest part of the present free oxygen, as carbon-dioxide.

In every hundred pounds of the present atmosphere there are about twenty-three pounds of free oxygen. At the beginning of the Eozoic period, when all subsequent organisms existed only as carbon-dioxide, the amount of free oxygen in one hundred pounds of the atmosphere was very small, perhaps not more than one or two pounds. The atmospheric improvement since has been enormous. The carbon-dioxide is now

only a trace, scarcely 4 parts out of 10,000, while the oxygen has increased to 2,300 out of the same amount. The ratio has so changed from being only a fraction compared with the CO^2, that the oxygen to-day is almost 600 times the greater. At no time is there evidence of a return to conditions once passed. The tendency of gases is to diffuse themselves uniformly, irrespective of their specific gravities. This process was aided by aerial currents. There resulted from such action uniformity of atmospheric composition over both land and sea, and in all latitudes. To-day we see the same thing from the same causes.

During the same geological time changes were going on in the water, changes whose biologic influence manifested themselves, or at least were accompanied by, changes of species in the direction of those which now exist. The enormous deposits of what, for lack of a better name, I may call organic limestone and silicates, indicate waters once holding in solution proportionally large amounts of lime and silica. These amounts were greatest at first, and grew less and less as plants and animals progressed in the work of making those insoluble compounds in which so much has been stored away. The amount of lime and silica held by the water was therefore greatest in the Azoic time, grew less in the Eozoic, less yet in the Silurian, less still in the Devonian, and so on down, each period having less than the one before it; until at last, probably in the Quaternary, an equilibrium was reached by the inwash from the land making good that which is removed by present animal and vegetable action.

The presence of these deposits in all latitudes indicates the world-wide character of this process. Moreover the ocean currents, tides and winds, tended to uniformity in the character of the water everywhere. To-day, from local causes, some parts of the ocean hold a larger percentage of mineral matter than do some others, yet on the whole the great ocean is everywhere substantially the same, and probably such was the case in each of the geological periods.

The third biological factor is the soil. This affects directly only vegetation, but indirectly all other forms of life.

As soil is a compound of comminuted rock and vegetable and animal matter, we may safely assume that, while before the Eozoic the former was present as clay, sand, and gravel, there was no soil. This began to form after the other ingredients had been washed upon the emerged land; it increased in quantity and improved in quality as time went on through

the ages. If we may judge from the flora, it reached its present quality in the Pliocene. The change since that period appears to have been an increase of its amount.

It seems, therefore, from the rock-record, that the free oxygen in the atmosphere, the purity of the water of the seas, and the quality of the soil went on, side by side, ever increasing from the dawn of life, till at last the loss and gain became equal near this end of the world's history. In short, there was from period to period a great improvement, world-wide and permanent, in the life-sustaining powers of these biological factors, and always towards present conditions.

Those at the first were prohibitive of any form of life; we know what they are now. Intermediate in time the conditions made only intermediate progress, and the rocks show organisms intermediate between the earliest and latest forms.

Was this coincidence merely a matter of chance, or was it an instance of cause and effect? It appears to me to be the latter, because an intimate relation exists between species and their environment. Leaving out of account temperature, which seems during by far the larger part of geological time to have been pretty much the same everywhere, what other environments existed besides those which we are now considering? Is it not reasonable to suppose that changes in them would seriously affect both plants and animals? That floras and faunas disappeared admits of no doubt, and, so far as I am aware, no other causes possessing the world-wide extent and permanency required are known.

Nor are we confined to theoretical reasoning. Not a few facts are established which have an important bearing on the question. Birds and small mammals, placed in an atmosphere having two or three times the normal amount of oxygen, do not long survive. Fishes brought out of water are said to die from the great amount of oxygen they are compelled to inhale. Plants too highly manured lose the power of reproduction. The seed does not form, or if it forms, does not mature. Even corals are sensitive to the purity of the water in which they live, and if that is materially changed they die. If this is true of present species, is it unreasonable to believe that organisms made for the atmosphere, water and soil of their native period, would die out when these had greatly changed? In this progressive improvement in the quality of these biological factors is found, it seems to me, at least one cause—perhaps the cause—of the disappearance of species and of their never reappearing. Organisms to-day have the power of adapting themselves to

new or changing influences, but only within certain limits, when these are reached they endure the strain no farther. The bow bent too far breaks. Probably it was so in those early periods. The weaker went first, at last all went, and then geologists report a general extermination.

The lower forms of life now are less sensitive to such influences than those of higher rank. It is reasonable to believe that the same was the case in geological times; and if so, may we not find in this fact an explanation of the greater length of the earlier periods as indicated by their fossil remains?

The progress of improvement would seem to have reached its limit, so far as soil and atmosphere are concerned, by the close of the Miocene, for, according to De la Saporta, *Le Monde des Plantes*, page 380, the flora of the Pliocene is still with us. He says:—"The principal groups, and even the genera of the plants which constitute the immense majority of our actual floras, were established from their beginning, probably even before the end of the Tertiary age, in the limits which they now occupy," and again, he says, page 342, "Let us not forget to remark that the European species still living occupy their actual country since the close of the Pliocene. They affect with secondary variations and shadings more or less pronounced the same characteristics as in our own day." If in this Saporta be right, and one may judge by the sameness of plant life from that time onward, neither atmosphere nor soil underwent any further essential improvement.*

There were, however, great changes in the animal world. Dana probably puts it too broadly when he says on page 518 of his revised *Manual of Geology*, "All the fishes, reptiles, birds and mammals of the Tertiary are extinct." But I think it is beyond question that an enormous proportion of the Tertiary vertebrates have ceased to exist. In the Quaternary the fishes, reptiles, birds and mammals were mainly of new species. At its close the mammals disappeared, the others are with us yet. In the next or present period, we find in place of the mammals of the Quaternary, the cattle and beasts of to-day.

The extermination of the Pliocene fauna seems probably to have been due to the great climatic changes which followed. It is difficult to see why the large, well armed, and well armoured mammals of the Quaternary became extinct. Had

* This is not quite correct. The wonderful change in the prevalent flora from monocotyledonous to dicotyledonous plants took place at the close of the Lower Cretaceous period.—ED.

the order been reversed, and the giants of the Quaternary come last, we could easily understand that order. It then would have been only a case of "the survival of the fittest." In fact it was a survival of the weakest. It adds to the perplexing nature of the problem that the birds of the Quaternary so largely survive. So far as I can see, all that can be said with certainty is that the monsters of the Quaternary would have been a detriment and hindrance to the creatures which were about to make their appearance, and that some "cause unknown to science," probably the same cause that started the chain of life, brought that section of it to an end.

If it be said that man lived at least in the latter part of the Quaternary, and that, gifted with superior intellect, and possessed of weapons, it was he that exterminated those great creatures; then for some unknown reason he destroyed the stronger and better protected species, and avoided killing the weaker but no less fierce ones which still survive. This seems too unreasonable for serious consideration, and so we are still left with the conclusion that the extermination of those monstrous Quaternary species just as present mammals were appearing was due to a "cause unknown to science."

Here I had intended to close my paper, but having been asked to give a brief statement as to the origination of new forms to succeed those exterminated, I will trespass on your patience a little longer.

What has already been said affords no assistance in the solution of this problem. Gravitation and chemical affinity account for the destruction of a building, but give no assistance in explaining the origination of a new one to take its place. For this we must invoke, in addition to physical laws, that to which the painter referred when he said he "mixed his colours with brains." In other words, we here find it necessary to supplement those laws by an intelligence able to employ the forces of nature for its purposes.

Very few will deny the intervention of a Creator when the first species came into existence. On what reasonable grounds can they say that He never did it again? So long as the train is to keep its course the switchman need only watch it as it goes by; but when its course is to be changed then his brain and his hand come into operation.

Now for the application. Imagine a species which has long been in existence approaching its final stage. We know that it did disappear, and that in close proximity to the last of its generation a new species is found.

What method did the Creator employ to bring into existence this new species? That he should have ignored all that he had thus far done and gone back to unorganised earth, air and water, is to me unthinkable: not that He lacked power, but that the All-wise should not have availed Himself of the forms then living, and which needed so little done compared with the *de novo* method, to change them into new species.

The following seems to me to have been what actually occurred, taking one species as typical of all. When this was approaching very close to the destined time of its extinction, the Creator may be supposed to have caused an ovum to develop into a creature resembling in generic traits its predecessors, but making such changes as differentiated the species which is next found. To borrow a suggestion from Huxley, it was as if in a world inhabited only by hyenas, dogs were born to them, and the hyenas ceased. If this occurred simultaneously in a sufficient number of instances, the extermination and origination would be world-wide.

To sum it all in briefest possible form, as it appears to me, the disappearance of species was due to natural law alone in the effects of the betterment of the air, water and soil, while the appearing of new species was due also to natural law, plus the supernatural at the initial point of the new species.

This opens a new theme, one, as it seems to me, of great interest. It would be out of place for me to pursue it now. If any one desires to look into it from the standpoint of the writer, I would refer him to my article in the October number of the *Bibliotheca Sacra* of 1903, entitled Miracle, Law and Evolution, a copy of which I did myself the pleasure of sending not very long ago to the Institute.

The thesis there maintained is as follows: God in all His work, whether classed as Miracle, Law, Evolution, Inspiration or Redemption, employed natural means, or, if you please, natural laws to their limit, and then, by His power, did the needed thing, after which the supernatural ceased and natural laws resumed their sole action.

The origination of new species is one of the many applications of this principle.

Discussion.

Dr. Henry Woodward, F.R.S.—Your Secretary has been so kind as to send me an invitation to come to-day.

I am sorry that the author took as his copy and authority the text-book of Dana, because geological science is one that is always progressing, and you have only to notice the fact that although this work of Dana's has been a most valued text-book of geology in America, and has been largely used on this side also, that it began its first edition about 1859, the second was published in 1874, and the third in 1879. Well now, between 1879 and the present time a great advance in geology has occurred, and I think that it is hardly possible that any geologist or palæontologist can accept the idea of the entire extermination of life in geological time in the sense that Professor Dana and the author express it. Whether we accept and endorse the views of Darwinian evolution, or we retain the old conviction with regard to the creation of all the varied forms of life, we are convinced of one thing, that from the time that life first appeared upon the globe, it has never been entirely exterminated. That is a fundamental principle which I think one might accept without any prejudice or reserve, that life having once commenced upon the earth, it has never disappeared from it.

Then with regard to the appearance of that life. All through the geological periods we have a succession of forms appearing, but of the many groups that have vivified the surface of the earth, and the waters of the sea, very few indeed have been entirely exterminated.* A few groups have become extinct in the course of long periods of time; such forms as the Trilobites have disappeared. Hugh Miller's great "cherubims" (Pterygoti), found in the Upper Silurian and Devonian rocks, have entirely ceased to live. But the great class of Crustacea to which they belong remains just the same and has gone on through all periods of time, different species having been evolved in a regular orderly sequence up to the present day. I do not think, either, that one can accept the idea of any

* Of the invertebrata I find eighteen groups which are persistent; three are extinct; and five groups are of comparatively modern appearance in time.

great break in the physical conditions of the globe. There have been great alterations locally in the earth, both in the distribution of land and water, but these changes have never so materially affected the life on the globe as to bring about its complete extermination. There have always been some parts of the waters of the ocean habitable, and of the land, after land animals first made their appearance, where life was enabled to continue. One thing has to be borne in mind, that in the earlier periods the thickness of the sedimentary deposits was so vast and the time which they occupied in their deposition was so great, that one looks in astonishment at the comparatively small period of time represented by the accumulations formed during Secondary and Tertiary ages. They are more like a few sheets of paper when compared to the vast pile of strata of the older rocks (many miles in thickness. The thousands of feet of the Tertiary and Secondary rocks are entirely eclipsed by the hundreds of thousands of feet thicknesses of strata of the older sedimentary deposits.

With regard to the points the author specially lays stress upon, I merely wish first of all to make an emphatic protest against the opinion of the universal extermination of life at any one time, or that at certain periods a universal extermination took place. Such dogmas were generally accepted by the older geologists, and they saw no other explanation. They did not know sufficiently concerning this ancient life to form a clearer idea. They saw great changes and breaks, and they were not aware that these were not continuous over the whole world; they imagined that each break in the series ushered in a fresh formation and a new creation.

My father, Samuel Woodward, of Norwich, a well known Norfolk geologist, who lived from 1790 to 1838, entertained precisely the same views as the author (Mr. Warring) and Professor Dana did: that there was a general and universal destruction of life at all the different geological epochs, marking each series of formations; but all that is now "ancient history," and no longer accepted by geologists at the present day.

In reference to the three points touched upon by the author, the air, the water, and the soil: with regard to the air, it is now universally accepted by chemists, biologists and geologists, that since life appeared upon the surface of the earth and in the waters of rivers, lakes, and seas, no material change of vast consequence

has occurred in regard to the constitution of the atmosphere or the waters of the earth. It is absolutely necessary for animal life to breathe the atmosphere, whether by taking in the air mixed with the water as fishes take it in, through their respiratory gills, or air-breathing animals, by their lungs or tracheæ. Even the existence of plants requires that there should be a certain regulated amount of oxygen in the air, and that there should be a proportionate quantity of nitrogen gas (which latter is neutral in its action) and an extremely minute quantity of carbonic acid gas.* If you place a plant in an atmosphere—and these are results of experiments at the Royal Botanic Gardens, Kew, and at other places—too richly endowed with carbonic acid gas, that plant becomes sickly and dies. Therefore there is no doubt that at the time when the great abundance of coal-plants flourished on the surface of the earth, there would not be such an excess of carbonic acid gas in the atmosphere as to prevent those plants from living. When we are dealing with mere plants, we may say for the sake of argument that plants possibly may have been able to survive with a greater quantity of carbonic acid gas *in proportion to the oxygen* in the air. But alongside these coal-plants, we know that in the Carboniferous period there were abundant examples of amphibian reptiles, fishes, mollusca, crustacea, and insects, and that those creatures spent their lives, some in the water, some among the plants, and many of the insects in flying in the air, as, for example, the great dragon-flies, some of which were twenty-four inches across from tip to tip of their wings. Insects, which were all air-breathers, were abundant in the Coal-period. Then there were land-snails, which Sir William Dawson found in hollow tree-trunks of the Sigillariæ in the coal-beds of Novia Scotia; there were also many "cock-roaches." It is surprising that cockroaches having begun in the Coal-period, should have continued living to the present day

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* Oxygen by volume, 20·96 or $\frac{1}{5}$th.
Nitrogen by volume, 79·00 or $\frac{4}{5}$ths.
Carbonic acid by volume, 0·04 or $\frac{1}{2500}$.

The amount of carbonic acid gas is extremely variable, 3 parts in 10,000 is the proportion in the open country, 5 parts in towns, and as much as 30 parts in 10,000 of air in overcrowded rooms. More than this acts *poisonously* on animal life.

scarcely at all changed. They are world-wide in distribution, and still enjoy the *coal-cellar* as they did the Coal-period. There is also a form of king-crab which has survived, but little changed, from that time. Another case of survival is that of the scorpions, which appeared first in the Upper Silurian of Lanarkshire, also in the United States of America, and in the Island of Gotland. These scorpions may have undergone some modification, but they possessed tracheæ; they breathed the air as insects breathe it nowadays. They were probably not aquatic scorpions, but true terrestrial dwellers, and the family has continued to live down to the present day. We notice also that in proportion to their great antiquity in time, so is their wide geographical distribution now. In all the warmer parts of the world we find scorpions living upon dry land. It shows what an enormous vitality these creatures must have enjoyed, which enabled them to change their *habitat* with the changed condition of land and soil, and still live on unaltered through such vast periods of geological time.

I must emphatically enter my protest against the theory of animals living either in the air or on the land without a proper supply of oxygen and a minimum of carbonic acid gas, and also that the waters of the rivers, lakes, and the sea must have been in a similar habitable state. I cannot imagine their being so full of carbonate of lime as to form a veritable peas-pudding in which the animals must swim and aërate their blood.

With regard to the extermination of the larger animals, I am afraid that the author has gone astray there also. Of course everyone who has treated the subject—and I may mention particularly the name of the illustrious Professor, Sir Richard Owen, who pointed out long years ago, that in all times of drought, or flood, or fires, or other troubles on the land, it is always the larger animals that are the first to be exterminated, because they have the greatest difficulty to maintain the struggle for life. They are bound to be killed off. In times of drought they cannot get enough water or food, and the smaller animals either escape by burrowing, or by getting up a tree in a flood, or on high ground, whereas the large animals are carried away and drowned. So when the author says that the large animals ought (according to the law of the selection of the most suitable) to have escaped, his statement is not borne out by testimony and observation. It is the larger animals that most

easily succumb, and the smaller animals that have the greatest chance of escape.

Then with regard to the Quaternary period, Mr. Warring seems to be again in error. The Quaternary period is that in which we are now living. There cannot be any distinction drawn between the latest or Quaternary deposits and those of to-day; man goes back in time through all the Quaternary period, and the animals we see to-day belong to the Quaternary period also.

Then with regard to size, I must say that the author seems to be a little in error. The larger land animals were the huge land-reptiles, the Dinosaurs, and they lived between the Trias and the Chalk periods. There was during the Chalk period a great terrestrial extent of the earth's surface exposed and habitable and whose animal remains are found in old lake-deposits, *not in marine* beds like our chalk. There were large tracks in America where animals of huge size dwelt, and among them were those reptiles, the Dinosauria. They all died out at the end of the Chalk period.

Take again the great group of fishes, for instance; they commenced in the Silurian, and forms resembling some of those living to-day are found in Devonian rocks. Sharks occur in the Devonian, and forms of scaly fishes. The principal difference is that the fish of to-day usually possess a strong bony skeleton, whereas in the earliest fishes there was no hardened skeleton—they were notochordal, having only a gelatinous or cartilaginous skeleton; many also had a covering of hard armour plates. Some of the cartilaginous fishes (*e.g.*, the sharks) are living to-day.

With regard to the birds, they appeared first in the Jurassic period, and the earliest possessed teeth, but they were clothed with feathers; they were not reptiles. We have never found any other animals, save birds, that possessed feathers. Then in the London-clay period more birds appear, some with serrated jaws (not true teeth) and some with long horny bills, like grebes and Solan geese, well adapted for catching fish, so that *modern birds* really may date from the Eocene period, and they have thus a long historical record. Mammals were supposed to begin in the Trias and go on to the present day, but the remains found in the Trias probably represent Ammodont or Theriodont reptiles that had some affinity towards mammals, but were not really mammals at all. In the Purbeck

beds there were undoubted small mammals, and so from that period we have evidence of mammalian life, and the surviving reptiles were not such huge creatures as in the earlier periods.

When it is said that the largest of living animals had disappeared, the author had forgotten the existence of the great "Right-whale," which is a mammal, 80 to 120 feet in length, and the largest of all animals that *ever lived* upon the surface or in the waters of the globe. The whales are larger than any of the great reptiles, the Dinosauria. So large a creature could not have supported existence upon the land; even had its limbs served, it would be absolutely impossible for purposes of locomotion upon dry ground, from its vast bulk. It could only move in the water, in which the more resisting medium of that fluid enabled it to support its bulk and live. The land reptiles were limited as to size. Even the largest of them, the *Brontosaurus* (perhaps 70 feet in length), one of which is is about to be set up by Mr. Andrew Carnegie in the Natural History Museum this year, is supposed to be an animal which *walked under water* and put its head out to breathe, and fed upon the aquatic plants growing at the bottom of the rivers or lakes. This has *only been suggested* by Professor Cope, and therefore is not put forward as a well-ascertained fact in science.

May I be permitted to read these few lines to you from Huxley: "If there be any result which has come more clearly out of geological investigation than another, it is that the vast series of extinct animals and plants is not divisible into distinct groups by any sharply-marked boundaries. There are no great gaps between epochs and formations, no successive periods marked by the appearance of plants and animals *en masse*. Every year adds to the list of links between what the older geologists supposed to be entirely separate epochs. Witness the Crags linking the Drift with Older Tertiaries; the Maestricht beds linking the Tertiaries with the Chalk; the St. Cassian beds exhibiting a mixed fauna of mesozoic and palæozoic types in rocks of an epoch once supposed to be eminently poor in life; witness, lastly, the incessant disputes as to whether a given stratum shall be reckoned Devonian or Carboniferous, Silurian or Devonian, Cambrian or Silurian." (Huxley, *Lay Sermons*, p. 243), [written before 1870, soon after the appearance of Darwin's *Origin of Species*]. This was written by Huxley before 1870, so that the author has overlooked an important

authority as early as Dana, whom he quotes. Dana was not so much a palæontologist as a great mineralogist, but the author of the paper certainly might have quoted Huxley and several other able authorities affording abundant evidence of the continuity of life, which has never been broken or interrupted since its first dawn upon our earth.

Rev. A. IRVING, D.Sc., B.A.—We are very much indebted to Dr. Woodward for his remarks. I have learnt something from them, and I should like to draw attention to one or two views that fell from him. As to one thing in particular, the effect of the relative proportions of carbonic acid in the atmosphere upon the life of plants. Dr. Woodward informed us that certain experiments at Kew had led to the conclusion that much carbonic acid kills the plant. My experimental investigations carried on at Wellington College in the "eighties" led to that conclusion, so long as I dealt with simply a mixture of carbonic acid and nitrogen; but when I introduced an equivalent amount of oxygen—about one volume of oxygen to one volume of carbonic acid along with nitrogen, I found that the plant-growth increased with rapidity, and moreover, with their roots saturated with water (as those of the coal measure plants were when growing), with exactly the same conditions of light, and in every way exposed to the same conditions, except in the proportions of the gases, to which their foliage was exposed.

No well-informed student of geology would dream of reviving the obsolete notion of "cataclysmic" disappearances of life, to which Dr. Woodward has made reference. That cannot fairly be read into Dr. Warring's paper. We should recollect, however, that the main business of the Victoria Institute is not with the detailed investigations of this or that special science, but with the co-ordination of the results achieved in all the sciences with those arrived at in other lines of research. From that point of view the most important and most interesting part of the paper before the meeting is found in the concluding paragraphs. It opens up a vast field for discussion, but, as time is short, it may suffice to say that in Nature and in Revelation alike we find the great law of Evolution written upon all things; but that law is not all, and does not account for all, that comes within the ken of the human mind in the universe of Being. In the light of that higher "monism" which runs through the Bible revelation we can trace a *directing influence*, which has not left the wild forces of Nature to work out

their results in a purely hap-hazard sort of way, such as is implied in the Darwinian dogma; we can, in fact, recognise directivity (as defined by Professor George Henslow) in the very variations, which must be antecedent to selection. Evolution pure and simple must imply that every new departure on the road of development is evolved *solely* out of the facts that preceded it, and the material and other properties latent in those facts, including environment. Yet when we come to consider the origin of matter and its properties, we are a long way from grasping any intelligent idea of matter originating in mind, though everything in Nature proclaims a controlling mind.

Again, the mystery of life is inscrutable; and whatever ideas we may ultimately get as to the intrinsic nature of life, it is not likely that we shall ever get rid of that element of *scientific faith* which holds the minds of Haeckel and his followers. The sneer from that side implied in the word "miracle" is but an "appeal to the (Agnostic) gallery"; and it is illogical for Haeckel to maintain that a legitimate place is found for *faith* (implying an exercise of the imagination) in science, and at the same time to dismiss the exercise of precisely the same intellectual faculties in the field of religion as mere "illusion and fancy." And so we are led on to the mysteries involved in the great Christian verities, and to that "pure Agnosticism" of George Romanes, which is content to say, "I don't know," "I don't understand," without having the effrontery to say (ergo) "You don't know or understand." "Nobody can know or understand." Such Agnostic dogmatism is utterly unphilosophical, and must remain so, until at least the origin of *matter* and its properties, and the origin of *life* with its vast variety of manifestations are *removed from the region of the unexplained quâ* natural causation.

Rev. JOHN TUCKWELL, M.R.A.S.—With very much of this paper I am in entire agreement. But there are some important facts to which insufficient weight has been allowed. First of all I do not think we can rely upon the uniformitarian principle altogether in the geological processes of the past.

The very fact that at certain epochs many more forms of life disappeared and with much greater geological suddenness than at others, implies something more than the ordinary processes of nature. The late Professor Prestwich, in a paper read before this Institute ten years ago, pointed out that a great diluvial catastrophe overtook

the continent of Europe in post-Pliocene times, I believe, which must have swept away the whole of its mammalian life. He connected this with the traditional Deluge, and I suppose the tens of thousands of mammoths and mastodons whose remains have been found in some cases frozen, and the flesh in a perfect state of preservation, must have perished suddenly and probably in connection with the same event.

I quite agree with the author that the mere elevation of the earth's surface will not account for these events.

Dr. WALTER KIDD, F.Z.S.—Without being a geologist, I desire to point out that this important subject of geological exterminations has considerable bearing upon current and unsolved problems in biology. The exclusive sway of selection in the production of new forms of life has received of late years strong support from Darwin's greatest follower, and Weismann has summed up his own life's work in two volumes, *The Evolution Theory*, in which he has elaborated further his theory of germinal selection invented ten years ago, so as to rehabilitate the doctrine of Darwin's natural (personal) selection. He has finally declared, after great study of the matter, that Lamarckism is a delusion, and that acquired characters are not *transmissible*. This sweeping doctrine is intimately connected with our subject of to-day thus: granting that evolution or modification of species has taken place through the ages of geology, this must have come about in one of three ways—either by direct modification of the organism by its environments and use of function—or by selection alone,—or by the combined actions of selection and use—inheritance and direct environmental action. Weismann is forced to allow that among unicellular organisms environmental influence is supreme, but maintains that when multicellular organisms arose and *amphimixis* (or the mingling of two streams of heredity from two parents) occurred, the influence of environments and use and disuse in evolution abruptly ceased, and that at this dividing line in the history of the organic world selection remained in unquestionable predominance, and that selection is even anterior to the birth of the organism, for it begins in the germ. The fact shown to-day, in the paper before us, that exterminations on a vast scale have continued through geological history by reason of changes of atmosphere, water and soil, is a glaring contradiction to this pan-selectionist theory of Weismann. These exterminations are, many of them at

least, wholesale, and so much so that individual variations could have no influence upon individual survival. We may not affirm the old doctrine of repeated catastrophes, but surely many of the great extinctions of floras and faunas of the world have been quite as vast as the catastrophes formerly supposed, although they have been obviously gradual in most cases. We have but to look at the face of a chalk cliff some hundred feet high, literally composed of the skeletons of the Foraminifera, Polycistina, and Diatoms with their *débris*, or the "Atlantic Ooze" of to-day, going through the experience of the chalk of the Cretaceous period, or to study a bed of Nummulitic limestone some thousands of feet in thickness, and to examine a piece of this from the Great Pyramid, and find nummulites of all sizes from a split pea to a florin; we have only to consider these gigantic evidences of organism entombed *en masse* by the physical agencies concerned in geological exterminations, to see that individual fitness to survive can have had, in these vast masses of organisms, no part or lot in the matter. What individual fitness, we may ask, determined the death or survival of the myriads of club-mosses and tree-ferns which went to make up the coal-measures of the world? They perished evidently *en masse*, and it may be assumed that such of them as happened to live to propagate their species with variations suited to new environments were *directly* modified by the changing environments.

We have heard of the heroic Sixth Brigade of the Japanese before Port Arthur, making one of the most desperate assaults ever made by infantry on powerful forts, going into action with 5,000 men, of whom 400 alone remained when the forts were taken, and of the Colonel of the 1st Regiment, the hero of fifty-seven combats, who habitually exposed himself in the firing line, and who according to the usual calculations should have been long ago dead and buried, and we are forced to admit that no more did the colonel survive because he was fitted to survive than did the 4,600 of the Sixth Brigade fall because they were unfitted to survive under the remorseless extermination of shell fire and bullets. This, I submit, is parallel to the wholesale and impartial destruction of masses of organisms of an early and lowly class, though not all of that unicellular group in which alone does Weismann fail to bring in selection as the *deus ex machinâ*.

This aspect of the subject gives "geological exterminations" a

living interest for the naturalist in addition to the other useful points raised in the paper.

Rev. G. F. WHIDBORNE, M.A., F.G.S.—I have read Dr. Warring's suggestive paper with very great interest. The extermination of species is self-evident, *e.g.*, Spirifer, Pterodactyle, Ammonites, etc., must have been exterminated. That any living species is descended from them is unthinkable. The many monotremata are now reduced to two.

That at times extermination was synchronously predominant may also be predicated, without, of course, suggesting that it was at any time complete. There are often rapid disappearances of whole groups of species that never recur in the same profuseness again. At most continuance is accounted for by "survival of the fittest." But evidently that expression is intrinsically inaccurate; its meaning is intended to be "survival of the fittest in a modified form." Dr. Warring I understand tells us that the commonly suggested causes for these survivals are insufficient, and suggests three others of a chemical character. Whether these in turn are altogether adequate for the effects may perhaps be questioned. We have far the most evidence in geological history of sea animals. Their genealogy may be treated alone. Two of Dr. Warring's three causes practically vanish with regard to them. Atmosphere and soil could have had very slight and indirect effects upon *them*. We have then only the chemical change of the sea to account for their genealogy. Is it sufficient to have produced the evolution ascribed to it? For instance, the assumed excess of lime might be supposed to have resulted in more massive shells, but as an instance Spiriferina of the Oolites are, speaking generally, more massive than Spirifera of the Devonian. Devonian Gasteropods from Chudleigh, placed besides recent specimens of similar form, are almost similar in massiveness. But I in no way wish to suggest that Dr. Warring's three causes are not effective, but only that they are not in themselves fully adequate for the effects assigned them. They may come to the help of the other causes asserted to produce evolution; the result is that we get a still greater variety of assigned causes, and the advantage in Dr. Warring's causes is that a sequence in the causes is at least implied congruous with the sequence of effects, though insufficient in itself to account for them. But what Dr. Warring emphasises is that the sequence of effects is orderly, a

continued orderly advance towards the present conditions. So after all it seems to me that the conclusion of his argument is reached, that behind any causes that can be imagined to have worked in the building up of biological history, there must have been a constant directive energy designing that such results should come. The instance he gives of the evident "survival of the unfittest" in the Quaternary age—that is, the "unfittest physically, though the fittest cosmically," is certainly remarkable.

In the closing paragraph he suggests a relationship between "natural law" and "the supernatural." This raises the question whether the general conception of "natural law" is not in itself defective. To us "natural laws" appear binding rules, necessitating effects. But from the point of view of the divine Lawgiver natural laws are not necessities but perfection of will. He, being what the Christian believes Him to be, has not enacted regulations by which the work and progress of nature shall be independently governed; but He Himself evolves it throughout and to the minutest particular by the infinite congruity and consistency of His will. The law of God is perfect from its inception to its action. His law is His will; voluntary to the minutest degree, but also consistent to the minutest degree. And so the supernatural to us is only a further manifestation of His volition, which to our eyes seems above natural law, but which in itself is only another cycle in the active consistency of God.

Professor EDWARD HULL, F.R.S. (Secretary).—The subject brought before us is one of great interest and great difficulty. Mr. Hudleston writes on this subject: "Exterminations in the Earth's history are more apparent than real and are largely due to the imperfection of the Geological Record." I concur in Mr. Hudleston's view—yet there are some points bearing on the subject which require explanation. In the first place, we may notice the great longevity (so to speak) of some genera and the brief duration of others. Thus the *Nautilus* which survives in our oceanic waters commenced its career in the Silurian period; so with the *Lingula* and a few other forms. On the other hand, a most prolific oceanic genus, the Trilobite, ended its career in the Carboniferous. It is difficult to account for the longer duration of the former as compared with the latter, for both were inhabitants of the successive oceans. Another biological fact of great interest and obscurity is

the excessively limited range of the various species of *Ammonites* throughout the Jurassic and Liassic periods, so that their life's history seems limited to the time necessary for the deposition of a few inches or feet of strata. The succession of the Ammonite forms without any apparent change in the environment, as far as it is possible to carry observation, is one of the most curious problems in the life history of oceanic forms. It is otherwise with land forms and those which inhabited estuaries and shallow waters, there, slight physical changes may easily have brought about the destruction of whole races.

P.S.—On reading Dr. Woodward's important remarks, it seems to me that he has rather mistaken the views of the author of this paper. It does not seem to me that Dr. Warring wished to be understood as holding that all life was at any time exterminated over the globe after its original appearance, and was subsequently reintroduced, but that from time to time, certain genera and species were exterminated, or failed to leave descendants.