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# NEW YORK.

## LECTURES ON EVOLUTION.

### LECTURE I.

#### THE THREE HYPOTHESES RESPECTING THE HISTORY OF NATURE.

We live in and form part of a system of things of immense diversity and perplexity, which we call Nature; and it is a matter of the deepest interest to all of us that we should form just conceptions of the constitution of that system and of its past history. With relation to this universe, man is, in extent, little more than a mathematical point; in duration but a fleeting shadow; he is a mere reed shaken in the winds of force. But, as Pascal long ago remarked, although a mere reed, he is a thinking reed; and in virtue of that wonderful capacity of thought, he has the power of framing for himself a symbolic conception of the universe, which, although doubtless highly imperfect and inadequate as a picture of the great whole, is yet sufficient to serve him as a chart for the guidance of his practical affairs. It has taken long ages of toilsome and often fruitless labour to enable man to look steadily at the shifting scenes of the phantasmagoria of Nature, to notice what is fixed among her fluctuations, and what is regular among her apparent irregularities; and it is only comparatively lately, within the last few centuries, that the conception of a universal order and of a definite course of things, which we term the course of Nature, has emerged.

But, once originated, the conception of the constancy of the order of Nature has become the dominant idea of modern thought. To any person who is familiar with the facts upon which that conception is based, and is competent to estimate their significance, it has ceased to be conceivable that chance should have any place in the universe, or that events should depend upon any but the natural sequence of cause and effect. We have come to look upon the present as the child of the past and as the parent of the future; and, as we have excluded chance from a place in the universe, so we ignore, even as

a possibility, the notion of any interference with the order of Nature. Whatever may be men's speculative doctrines, it is quite certain, that every intelligent person guides his life and risks his fortune upon the belief that the order of Nature is constant, and that the chain of natural causation is never broken.

In fact, no belief which we entertain has so complete a logical basis as that to which I have just referred. It tacitly underlies every process of reasoning; it is the foundation of every act of the will. It is based upon the broadest induction, and it is verified by the most constant, regular, and universal of deductive processes. But we must recollect that any human belief, however broad its basis, however defensible it may seem, is, after all, only a probable belief, and that our widest and safest generalizations are simply statements of the highest degree of probability. Though we are quite clear about the constancy of the order of Nature, at the present time, and in the present state of things, it by no means necessarily follows that we are justified in expanding this generalisation into the infinite past, and in denying, absolutely, that there may have been a time when Nature did not follow a fixed order, when the relations of cause and effect were not definite, and when extra-natural agencies interfered with the general course of Nature. Cautious men will allow that a universe so different from that which we know may have existed; just as a very candid thinker may admit that a world in which two and two do not make four, and in which two straight lines do inclose a space, may exist. But the same caution which forces the admission of such possibilities demands a great deal of evidence before it recognises them to be anything more substantial. And when it is asserted that, so many thousand years ago, events occurred in a manner utterly foreign to and inconsistent with the existing laws of Nature, men, who without being particularly cautious, are simply honest thinkers, unwilling to deceive themselves or delude others, ask for trustworthy evidence of the fact.

Did things so happen or did they not? This is a historical question, and one the answer to which must be sought in the same way as the solution of any other historical problem.

So far as I know, there are only three hypotheses which ever have been entertained, or which well can be entertained, respecting the

past history of Nature. I will, in the first place, state the hypotheses, and then I will consider what evidence bearing upon them is in our possession, and by what light of criticism that evidence is to be interpreted.

Upon the first hypothesis, the assumption is, that phenomena of Nature similar to those exhibited by the present world have always existed; in other words, that the universe has existed from all eternity in what may be broadly termed its present condition.

The second hypothesis is, that the present state of things has had only a limited duration; and that, at some period in the past, a condition of the world, essentially similar to that which we now know, came into existence, without any precedent condition from which it could have naturally proceeded. The assumption that successive states of Nature have arisen, each without any relation of natural causation to an antecedent state, is a mere modification of this second hypothesis.

The third hypothesis also assumes that the present state of things has had but a limited duration; but it supposes that this state has been evolved by a natural process from an antecedent state, and that from another, and so on; and, on this hypothesis, the attempt to assign any limit to the series of past changes is, usually, given up.

It is so needful to form clear and distinct notions of what is really meant by each of these hypotheses that I will ask you to imagine what, according to each, would have been visible to a spectator of the events which constitute the history of the earth. On the first hypothesis, however far back in time that spectator might be placed, he would see a world essentially, though perhaps not in all its details, similar to that which now exists. The animals which existed would be the ancestors of those which now live, and similar to them; the plants, in like manner, would be such as we know; and the mountains, plains, and waters would foreshadow the salient features of our present land and water. This view was held more or less distinctly, sometimes combined with the notion of recurrent cycles of change, in ancient times; and its influence has been felt down to the present day. It is worthy of remark that it is a hypothesis which is not inconsistent with the doctrine of Uniformitarianism, with which geologists are familiar. That doctrine was held by Hut-

ton, and in his earlier days by Lyell. Hutton was struck by the demonstration of astronomers that the perturbations of the planetary bodies, however great they may be, yet sooner or later right themselves; and that the solar system possesses a self-adjusting power by which these aberrations are all brought back to a mean condition. Hutton imagined that the like might be true of terrestrial changes; although no one recognised more clearly than he the fact that the dry land is being constantly washed down by rain and rivers and deposited in the sea; and that thus, in a longer or shorter time, the inequalities of the earth's surface must be levelled, and its high lands brought down to the ocean. But, taking into account the internal forces of the earth, which, upheaving the sea-bottom give rise to new land, he thought that these operations of degradation and elevation might compensate each other; and that thus, for any assignable time, the general features of our planet might remain what they are. And inasmuch as, under these circumstances, there need be no limit to the propagation of animals and plants, it is clear that the consistent working-out of the uniformitarian idea might lead to the conception of the eternity of the world. Not that I mean to say that either Hutton or Lyell held this conception—assuredly not; they would have been the first to repudiate it. Nevertheless, the logical development of their arguments tends directly towards this hypothesis.

The second hypothesis supposes that the present order of things, at some no very remote time, had a sudden origin, and that the world, such as it now is, had chaos for its phenomenal antecedent. That is the doctrine which you will find stated most fully and clearly in the immortal poem of John Milton—the English *Divina Commedia*—*Paradise Lost*. I believe it is largely to the influence of that remarkable work, combined with the daily teachings to which we have all listened in our childhood, that this hypothesis owes its general wide diffusion as one of the current beliefs of English-speaking people. If you turn to the seventh book of *Paradise Lost*, you will find there stated the hypothesis to which I refer, which is briefly this: That this visible universe of ours came into existence at no great distance of time from the present; and that the parts of which it is composed made their appearance, in a certain definite order, in the space of six natural days, in such a manner that, on the

first of these days, light appeared; that, on the second, the firmament, or sky, separated the waters above, from the waters beneath the firmament; that, on the third day, the waters drew away from the dry land, and upon it a varied vegetable life, similar to that which now exists, made its appearance; that the fourth day was signalised by the apparition of the sun, the stars, the moon, and the planets; that, on the fifth day, aquatic animals originated within the waters; that, on the sixth day, the earth gave rise to our four-footed terrestrial creatures, and to all varieties of terrestrial animals except birds, which had appeared on the preceding day; and, finally, that man appeared upon the earth, and the emergence of the universe from chaos was finished. Milton tells us, without the least ambiguity, what a spectator of these marvellous occurrences would have witnessed. I doubt not that his poem is familiar to all of you, but I should like to recall one passage to your minds, in order that I may be justified in what I have said regarding the perfectly concrete, definite picture of the origin of the animal world which Milton draws. He says: —

"The sixth, and of creation last, arose  
With evening harps and matin, when God said,  
'Let the earth bring forth soul living in her kind,  
Cattle and creeping things, and beast of the earth,  
Each in their kind!' The earth obeyed, and, straight  
Opening her fertile womb, teemed at a birth  
Innumerable living creatures, perfect forms,  
Limbed and full-grown. Out of the ground uprose,  
As from his lair, the wild beast, where he wons  
In forest wild, in thicket, brake, or den;  
Among the trees in pairs they rose, they walked;  
The cattle in the fields and meadows green;  
Those rare and solitary; these in flocks  
Pasturing at once, and in broad herds upsprung.  
The grassy clods now calved; now half appears  
The tawny lion, pawing to get free  
His hinder parts — then springs, as broke from bonds,  
And rampant shakes his brinded mane; the ounce,  
The libbard, and the tiger, as the mole  
Rising, the crumbled earth above them threw

In hillocks; the swift stag from underground  
Bore up his branching head; scarce from his mould  
Behemoth, biggest born of earth, upheaved  
His vastness; fleeced the flocks and bleating rose  
As plants; ambiguous between sea and land,  
The river-horse and scaly crocodile.  
At once came forth whatever creeps the ground,  
Insect or worm."

There is no doubt as to the meaning of this statement, nor as to what a man of Milton's genius expected would have been actually visible to an eye-witness of this mode of origination of living things.

The third hypothesis, or the hypothesis of evolution, supposes that, at any comparatively late period of past time, our imaginary spectator would meet with a state of things very similar to that which now obtains; but that the likeness of the past to the present would gradually become less and less, in proportion to the remoteness of his period of observation from the present day; that the existing distribution of mountains and plains, of rivers and seas, would show itself to be the product of a slow process of natural change operating upon more and more widely different antecedent conditions of the mineral framework of the earth; until, at length, in place of that framework, he would behold only a vast nebulous mass, representing the constituents of the sun and of the planetary bodies. Preceding the forms of life which now exist, our observer would see animals and plants not identical with them, but like them; increasing their differences with their antiquity and, at the same time, becoming simpler and simpler; until, finally, the world of life would present nothing but that undifferentiated protoplasmic matter which, so far as our present knowledge goes, is the common foundation of all vital activity.

The hypothesis of evolution supposes that in all this vast progression there would be no breach of continuity, no point at which we could say "This a natural process," and "This is not a natural process;" but that the whole might be compared to that wonderful process of development which may be seen going on every day under our eyes, in virtue of which there arises, out of the semi-fluid, com-

paratively homogeneous substance which we call an egg, the complicated organization of one of the higher animals. That, in a few words, is what is meant by the hypothesis of evolution.

I have already suggested that in dealing with these three hypotheses, in endeavouring to form a judgment as to which of them is the more worthy of belief, or whether none is worthy of belief—in which case our condition of mind should be that suspension of judgment which is so difficult to all but trained intellects—we should be indifferent to all *à priori* considerations. The question is a question of historical fact. The universe has come into existence somehow or other, and the problem is, whether it came into existence in one fashion, or whether it came into existence in another; and, as an essential preliminary to further discussion, permit me to say two or three words as to the nature and the kinds of historical evidence.

The evidence as to the occurrence of any event in past time may be ranged under two heads which, for convenience' sake, I will speak of as testimonial evidence and as circumstantial evidence. By testimonial evidence I mean human testimony; and by circumstantial evidence I mean evidence which is not human testimony. Let me illustrate by a familiar example what I understand by these two kinds of evidence, and what is to be said respecting their value.

Suppose that a man tells you that he saw a person strike another and kill him; that is testimonial evidence of the fact of murder. But it is possible to have circumstantial evidence of the fact of murder; that is to say, you may find a man dying with a wound upon his head having exactly the form and character of the wound which is made by an axe, and, with due care in taking surrounding circumstances into account, you may conclude with the utmost certainty that the man has been murdered; that his death is the consequence of a blow inflicted by another man with that implement. We are very much in the habit of considering circumstantial evidence as of less value than testimonial evidence, and it may be that, where the circumstances are not perfectly clear and intelligible, it is a dangerous and unsafe kind of evidence; but it must not be forgotten that, in many cases, circumstantial is quite as conclusive as testimonial evidence, and that, not unfrequently, it is a great deal weightier

than testimonial evidence. For example, take the case to which I referred just now. The circumstantial evidence may be better and more convincing than the testimonial evidence; for it may be impossible, under the conditions that I have defined, to suppose that the man met his death from any cause but the violent blow of an axe wielded by another man. The circumstantial evidence in favour of a murder having been committed, in that case, is as complete and as convincing as evidence can be. It is evidence which is open to no doubt and to no falsification. But the testimony of a witness is open to multitudinous doubts. He may have been mistaken. He may have been actuated by malice. It has constantly happened that even an accurate man has declared that a thing has happened in this, that, or the other way, when a careful analysis of the circumstantial evidence has shown that it did not happen in that way, but in some other way.

We may now consider the evidence in favour of or against the three hypotheses. Let me first direct your attention to what is to be said about the hypothesis of the eternity of the state of things in which we now live. What will first strike you is, that it is a hypothesis which, whether true or false, is not capable of verification by any evidence. For, in order to obtain either circumstantial or testimonial evidence sufficient to prove the eternity of duration of the present state of nature, you must have an eternity of witnesses or an infinity of circumstances, and neither of these is attainable. It is utterly impossible that such evidence should be carried beyond a certain point of time; and all that could be said, at most, would be, that so far as the evidence could be traced, there was nothing to contradict the hypothesis. But when you look, not to the testimonial evidence—which, considering the relative insignificance of the antiquity of human records, might not be good for much in this case—but to the circumstantial evidence, then you find that this hypothesis is absolutely incompatible with such evidence as we have; which is of so plain and so simple a character that it is impossible in any way to escape from the conclusions which it forces upon us.

You are, doubtless, all aware that the outer substance of the earth, which alone is accessible to direct observation, is not of a homogeneous character, but that it is made up of a number of layers or strata, the titles of the principal groups of which are placed upon the

accompanying diagram. Each of these groups represents a number of beds of sand, of stone, of clay, of slate, and of various other materials.

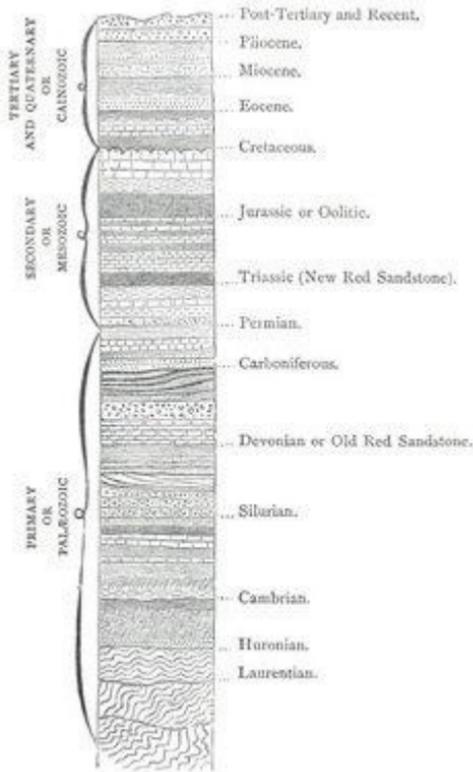


FIG. 1.—IDEAL SECTION OF THE CRUST OF THE EARTH.

Fig. 1. — Ideal Section of the Crust of the Earth.

On careful examination, it is found that the materials of which each of these layers of more or less hard rock are composed are, for the most part, of the same nature as those which are at present being formed under known conditions on the surface of the earth. For example, the chalk, which constitutes a great part of the Cretaceous formation in some parts of the world, is practically identical in its physical and chemical characters with a substance which is now being formed at the bottom of the Atlantic Ocean, and covers an

enormous area; other beds of rock are comparable with the sands which are being formed upon sea-shores, packed together, and so on. Thus, omitting rocks of igneous origin, it is demonstrable that all these beds of stone, of which a total of not less than seventy thousand feet is known, have been formed by natural agencies, either out of the waste and washing of the dry land, or else by the accumulation of the exuviae of plants and animals. Many of these strata are full of such exuviae—the so-called "fossils." Remains of thousands of species of animals and plants, as perfectly recognisable as those of existing forms of life which you meet with in museums, or as the shells which you pick up upon the sea-beech, have been imbedded in the ancient sands, or muds, or limestones, just as they are being imbedded now, in sandy, or clayey, or calcareous subaqueous deposits. They furnish us with a record, the general nature of which cannot be misinterpreted, of the kinds of things that have lived upon the surface of the earth during the time that is registered by this great thickness of stratified rocks. But even a superficial study of these fossils shows us that the animals and plants which live at the present time have had only a temporary duration; for the remains of such modern forms of life are met with, for the most part, only in the uppermost or latest tertiaries, and their number rapidly diminishes in the lower deposits of that epoch. In the older tertiaries, the places of existing animals and plants are taken by other forms, as numerous and diversified as those which live now in the same localities, but more or less different from them; in the mesozoic rocks, these are replaced by others yet more divergent from modern types; and in the palæozoic formations the contrast is still more marked. Thus the circumstantial evidence absolutely negatives the conception of the eternity of the present condition of things. We can say with certainty that the present condition of things has existed for a comparatively short period; and that, so far as animal and vegetable nature are concerned, it has been preceded by a different condition. We can pursue this evidence until we reach the lowest of the stratified rocks, in which we lose the indications of life altogether. The hypothesis of the eternity of the present state of nature may therefore be put out of court.

We now come to what I will term Milton's hypothesis—the hypothesis that the present condition of things has endured for a com-

paratively short time; and, at the commencement of that time, came into existence within the course of six days. I doubt not that it may have excited some surprise in your minds that I should have spoken of this as Milton's hypothesis, rather than that I should have chosen the terms which are more customary, such as "the doctrine of creation," or "the Biblical doctrine," or "the doctrine of Moses," all of which denominations, as applied to the hypothesis to which I have just referred, are certainly much more familiar to you than the title of the Miltonic hypothesis. But I have had what I cannot but think are very weighty reasons for taking the course which I have pursued. In the first place, I have discarded the title of the "doctrine of creation," because my present business is not with the question why the objects which constitute Nature came into existence, but when they came into existence, and in what order. This is as strictly a historical question as the question when the Angles and the Jutes invaded England, and whether they preceded or followed the Romans. But the question about creation is a philosophical problem, and one which cannot be solved, or even approached, by the historical method. What we want to learn is, whether the facts, so far as they are known, afford evidence that things arose in the way described by Milton, or whether they do not; and, when that question is settled, it will be time enough to inquire into the causes of their origination.

In the second place, I have not spoken of this doctrine as the Biblical doctrine. It is quite true that persons as diverse in their general views as Milton the Protestant and the celebrated Jesuit Father Suarez, each put upon the first chapter of Genesis the interpretation embodied in Milton's poem. It is quite true that this interpretation is that which has been instilled into every one of us in our childhood; but I do not for one moment venture to say that it can properly be called the Biblical doctrine. It is not my competency, to say what the Hebrew text does, and what it does not signify; moreover, were I to affirm that this is the Biblical doctrine, I should be met by the authority of many eminent scholars, to say nothing of men of science, who, at various times, have absolutely denied that any such doctrine is to be found in Genesis. If we are to listen to many expositors of no mean authority, we must believe that what seems so clearly defined in Genesis—as if very

great pains had been taken that there should be no possibility of mistake—is not the meaning of the text at all. The account is divided into periods that we may make just as long or as short as convenience requires. We are also to understand that it is consistent with the original text to believe that the most complex plants and animals may have been evolved by natural processes, lasting for millions of years, out of structureless rudiments. A person who is not a Hebrew scholar can only stand aside and admire the marvellous flexibility of a language which admits of such diverse interpretations. But assuredly, in the face of such contradictions of authority upon matters respecting which he is incompetent to form any judgment, he will abstain, as I do, from giving any opinion.

In the third place, I have carefully abstained from speaking of this as the Mosaic doctrine, because we are now assured upon the authority of the highest critics, and even of dignitaries of the Church, that there is no evidence that Moses wrote the Book of Genesis, or knew anything about it. You will understand that I give no judgment—it would be an impertinence upon my part to volunteer even a suggestion—upon such a subject. But, that being the state of opinion among the scholars and the clergy, it is well for the unlearned in Hebrew lore, and for the laity, to avoid entangling themselves in such a vexed question. Happily, Milton leaves us no excuse for doubting what he means, and I shall therefore be safe in speaking of the opinion in question as the Miltonic hypothesis.

Now we have to test that hypothesis. For my part, I have no prejudice one way or the other. If there is evidence in favour of this view, I am burdened by no theoretical difficulties in the way of accepting it; but there must be evidence. Scientific men get an awkward habit—no, I won't call it that, for it is a valuable habit—of believing nothing unless there is evidence for it; and they have a way of looking upon belief which is not based upon evidence, not only as illogical, but as immoral. We will, if you please, test this view by the circumstantial evidence alone; for, from what I have said, you will understand that I do not propose to discuss the question of what testimonial evidence is to be adduced in favour of it. If those whose business it is to judge are not at one as to the authenticity of the only evidence of that kind which is offered, nor as to the

facts to which it bears witness, the discussion of such evidence is superfluous.

But I may be permitted to regret this necessity of rejecting the testimonial evidence the less, because the examination of the circumstantial evidence leads to the conclusion, not only that it is incompetent to justify the hypothesis, but that, so far as it goes, it is contrary to the hypothesis.

The considerations upon which I base this conclusion are of the simplest possible character. The Miltonic hypothesis contains assertions of a very definite character relating to the succession of living forms. It is stated that plants, for example, made their appearance upon the third day, and not before. And you will understand that what the poet means by plants are such plants as now live, the ancestors, in the ordinary way of propagation of like by like, of the trees and shrubs which flourish in the present world. It must needs be so; for, if they were different, either the existing plants have been the result of a separate origination since that described by Milton, of which we have no record, nor any ground for supposition that such an occurrence has taken place; or else they have arisen by a process of evolution from the original stocks.

In the second place, it is clear that there was no animal life before the fifth day, and that, on the fifth day, aquatic animals and birds appeared. And it is further clear that terrestrial living things, other than birds, made their appearance upon the sixth day, and not before. Hence, it follows that, if, in the large mass of circumstantial evidence as to what really has happened in the past history of the globe we find indications of the existence of terrestrial animals, other than birds, at a certain period, it is perfectly certain that all that has taken place since that time must be referred to the sixth day.

In the great Carboniferous formation, whence America derives so vast a proportion of her actual and potential wealth, in the beds of coal which have been formed from the vegetation of that period, we find abundant evidence of the existence of terrestrial animals. They have been described, not only by European but by your own naturalists. There are to be found numerous insects allied to our cockroaches. There are to be found spiders and scorpions of large size,

the latter so similar to existing scorpions that it requires the practised eye of the naturalist to distinguish them. Inasmuch as these animals can be proved to have been alive in the Carboniferous epoch, it is perfectly clear that, if the Miltonic account is to be accepted, the huge mass of rocks extending from the middle of the Palæozoic formations to the uppermost members of the series, must belong to the day which is termed by Milton the sixth. But, further, it is expressly stated that aquatic animals took their origin upon the fifth day, and not before; hence, all formations in which remains of aquatic animals can be proved to exist, and which therefore testify that such animals lived at the time when these formations were in course of deposition, must have been deposited during or since the period which Milton speaks of as the fifth day. But there is absolutely no fossiliferous formation in which the remains of aquatic animals are absent. The oldest fossils in the Silurian rocks are exuvixæ of marine animals; and if the view which is entertained by Principal Dawson and Dr. Carpenter respecting the nature of the *Eozoön* be well founded, aquatic animals existed at a period as far antecedent to the deposition of the coal as the coal is from us; inasmuch as the *Eozoön* is met with in those Laurentian strata which lie at the bottom of the series of stratified rocks. Hence it follows, plainly enough, that the whole series of stratified rocks, if they are to be brought into harmony with Milton, must be referred to the fifth and sixth days, and that we cannot hope to find the slightest trace of the products of the earlier days in the geological record. When we consider these simple facts, we see how absolutely futile are the attempts that have been made to draw a parallel between the story told by so much of the crust of the earth as is known to us and the story which Milton tells. The whole series of fossiliferous stratified rocks must be referred to the last two days; and neither the Carboniferous, nor any other, formation can afford evidence of the work of the third day.

Not only is there this objection to any attempt to establish a harmony between the Miltonic account and the facts recorded in the fossiliferous rocks, but there is a further difficulty. According to the Miltonic account, the order in which animals should have made their appearance in the stratified rocks would be this: Fishes, including the great whales, and birds; after them, all varieties of terrestrial animals except birds. Nothing could be further from the facts as we