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BORDERLAND BETWEEN LIVING
AND NON-LIVING THINGS.

A Lecture

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BY

EDWARD B. AVELING, D.Sc.Lond.,

Fellow of University College, London.

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THE BORDERLAND BETWEEN LIVING AND NON-LIVING THINGS.

A STRANGE fascination has always hung around the border-lands of human knowledge. By border-lands I mean those regions where one order of phenomena glides into another. The fascination was once due to the fact that men believed it possible to draw hard and fast lines between diverse orders of phenomena, and anything on either side of these imaginary lines was of deep interest. But now-a-days the fascination of studies such as these, lies mainly in the fact that the old lines of demarcation are fading into indistinctness in the light of advancing knowledge. They were shadows due to the night of ignorance. They were as imaginary as the equator, or the earth's axis. The interest in the study of border-lands to-day lies in the truth that is growing towards universal recognition that Nature is one vast continuous whole, whose parts are all connected, and in whose infinite history no break, no interposition from without occurs. The charm, therefore, of the investigation of these regions now lies in the indistinctness of their outlines, in the exquisite gradation of one order of phenomena into another.

Much attention has been given to the connexion between man and the lower animals, and to the gliding of the kingdoms of the plants and of the animals one into

ERRATA.

Syllabus, line 2. For "Archebiosis (*the beginning of life*)" read "Abiogenesis (*living from non-living.*)"

Page 4, line 6. For "Archebiosis" read "Abiogenesis."

labor, and it is to this subject that we now turn once again. This subject, once discussed under the name, Spontaneous Generation, is now dealt with under that of Archebiosis.

A brief historical survey of the great question as to the origin of living matter, certain definitions of life, the way in which the question has undergone simplification with the advance of time, certain facts bearing on the subject under discussion, and the relation of that subject to the great truths of Evolution, will constitute the plan of this lecture.

A.—HISTORICAL.

Human thought on almost all points takes first one extreme view, then its opposite, then settles down between these two extremes. The thoughts of man in regard to the origin of living matter have followed this general law. At first men imagined that living things habitually or at least frequently were developed from the non-living. Spontaneous generation, as this process was called, was assumed to occur very generally. Later the opposite extreme of thought was reached. Men imagined that living things never were developed, and never had been developed from non-living. To-day we are balancing in our thought between these two extremes, each of which is probably equally erroneous. We are striking a mean between the two antagonistic ideas, and many have come to the conclusion that whilst the ancient spontaneous generation is far less general than it was once believed to be, yet the evidence is in favor of Abiogenesis, or the evolution of living matter from non-living, in the past, and of its possible evolution to-day.

the other. The relation between the living and the non-living has also had the devotion of no inconsiderable labor, and it is to this subject that we now turn once again. This subject, once discussed under the name, Spontaneous Generation, is now dealt with under that of Archebiosis.

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The ancient thinkers considered spontaneous generation of very frequent occurrence. Aristotle held that eels were generated from the mud of rivers, insects from the dew-drops on the plants, parasites on animals from the decaying matter of their integuments. Lucretius and Ovid, 200 years later, had like fancies. When the flood ended, and the stones thrown by Deucalion and Pyrrha became men and women, lower animals and the plants were produced from the inanimate earth and the dead waters.

Possibly with Harvey, the discoverer of the circulation of the blood, and certainly with Redi, a physician of Florence, the inevitable reaction against the old order of thought set in. Harvey's position is a little doubtful, and, as Professor Bastian puts it, "grave doubts may be entertained as to the propriety of expressing Harvey's doctrine by the phrase, '*Omne vivum ex ovo*' (every living thing from an egg)." In 1638 Redi exploded once and for ever one of the ancient fallacies. He showed that the maggots in putrefying meat were due to eggs that had been laid by flies. More than a century later the extreme of opposed thought, which is as inevitable as the reaction that precedes it, found its utterance in the writings of Spallanzani. It is to this Italian thinker that we owe the idea of Panspermism. Panspermism—from "*πας*," all, and "*σπέρμα*," seed—is the name for an idea largely held for the last hundred years, that every living thing takes origin from an egg or ovum that is produced by a pre-existing living thing. Panspermists hold that no organic being can originate by any other method than the fertilisation of an egg. *Omne vivum ex ovo* is their motto; and by a slight and natural extension of their central idea *omne vivum ex vivo* follows. This order of thought is, as I have said, the extreme antagonist of spontaneous gener-

ation, the conception of the very early thinkers. It is possibly, as I have said, as inaccurate as the thought to which it is opposed. If Panspermism means that not only to-day are living things produced from pre-existing things but that this has always been the case, it is impossible to avoid the conclusion that Panspermism "doth protest too much"; for the obvious inquiry arises as to the origin of the first living thing. And the only answer to this, on the theory of Panspermism, is in the ominous words "special creation."

Whilst it is hardly possible to say that the scientific thought of to-day has yet struck out the happy medium between the two extreme ideas of spontaneous generation and Panspermism, signs are not wanting that the opinions of men are settling down to something between these two. It is true that some of our most illustrious observers deny, not altogether without a suspicion of virulence, that abiogenesis, or origin of living things from non-living, ever occurs. All the world knows that much controversy has, within the last few years, taken place in respect to this question. The distinguished Frenchman, Pasteur, cosmopolitan in his thought and in his benefactions to mankind, does not believe that the organic can arise from the inorganic. Our great Englishmen, Huxley and Tyndall, as the result of a large number of experiments, all of which, as some of us think, have little or no bearing upon the ultimate question at issue, have declared that abiogenesis does not take place to-day. I have written above, the "ultimate question." For whilst these experiments of Pasteur, Huxley, and Tyndall may prove that under certain conditions to-day the inorganic is not transformed into the organic, they are by no means convincing to many minds in respect to the great question of the first production of organic matters on the earth;

and it may be said that whilst the two illustrious Englishmen are firm in their belief that abiogenesis did not occur in such experiments as they conducted, in all probability neither of them would be prepared to say that abiogenesis has never happened.

As that of an antagonist, even upon experimental grounds, to the three men just mentioned, the name of Dr. Bastian must be given. Whether we accept the result of Dr. Bastian's experiments or not, whether we hold or join issue with him in his conclusion that even at the present time inorganic matter is transformed into organic, we must at least be grateful to him for the historical information he has collated on the question, and for the great help he has given all men towards its solution.

B.—DEFINITIONS OF LIFE.

As we are dealing with living matter, it will be well to remind ourselves of some of the definitions that have been given of life. The definitions of life are almost as numerous as living people. But some four or five are, by the common consent of educated people, regarded as ranking in accuracy and completeness higher than their fellows; I quote those of Schelling, Richerand, de Blainville, Lewes, and Spencer.

Schelling.—The tendency to individuation.

Perhaps the greatest objection to this is the word tendency. Something seems wanting in the definition of so distinct a series of phenomena as those which we call life, when it is spoken of only as "a tendency."

Richerand.—The collection of phenomena which succeed one another in an organised body during a limited time.

This definition would appear to be an instance of

petitio principii; for an organised body is none other than a living one.

De Blainville.—The twofold internal movement of composition and decomposition, general and continuous.

As Mr. Herbert Spencer has pointed out, this definition applies equally well to a galvanic battery. And, at present, no one is prepared to call a galvanic battery a living thing.

Lewes.—Definite successive changes in structure and composition without loss of identity.

An important new idea, and one that seems necessary, is introduced in the last four words. But life seems to imply changes not only of matter, but of motion, and the latter changes are apparently ignored in this definition.

Spencer.—The continuous adjustment of internal to external relations.

This is the definition given by Mr. Spencer after his review of those already quoted.

C.—ADVANCING SIMPLIFICATION OF THE QUESTION.

As time has elapsed, the question as to the origin of living matter has, like many other questions, undergone successive simplifications. Originally, the question was as to the origin of large and complex animals. As long as people, with Aristotle, thought insects, maggots, and eels were produced from inorganic matter, so long the question was one of overwhelming difficulty. But while the difficulty is still apparent, no doubt can exist that it has been considerably lessened. When Redi showed that maggots were due to eggs deposited by flies, he led human thought a considerable distance in the direction of simplification. Many years later, when the researches of Schwann and Schleiden convinced the scientific world that all plants and animals were made up of cells more

or less modified, a gigantic stride was made. These acute observers, after much patient investigation, arrived at the majestic generalisation which has never yet been gainsaid, that all the tissues of organic bodies are made up of cells. Further, it has been shown that every organic body begins as a single cell, and also that the lowest organic bodies are, throughout their existence, nothing more than single, simple cells. As therefore the lowest plants and animals consisted only of one cell, as every plant and animal began its existence as one cell, and as every tissue of every plant and animal was in the ultimate analysis reduceable to cells, the question as to the origin of living matter centred in the cell. Now a cell is a semi-fluid mass invested by a membrane, and containing within it a more solid portion or nucleus. A cell, in short, from without inwards consists of cell-membrane, cell-contents (usually protoplasm), and cell-nucleus.

Further investigation has shown that the cell is not the simplest form of living matter. The discoveries of Ernst Haeckel in 1864 and succeeding years, confirmed and extended by Cienkowsky and Von Kleinenberg, revealed the important fact, that organisms exist in sea-water and fresh-water, whose structure is even simpler than that of the cell. These Monera consist of cells destitute of nuclei. To such a structure the name cytod is given. Thus the question as to the origin of living matter has, by these investigations, been narrowed down to the question as to the origin of cytods. But simpler structures even than the cytods have been discovered by the aid of our improved microscopes, and by our improved methods of observation. Imagine a cell, not only destitute of nucleus, but of the external investing membrane; imagine, in short, a microscopic piece of protoplasm, and you have the conception of the simplest form of living

matter known at the present time. Such a piece of protoplasm we know to be made of carbon, hydrogen, oxygen, nitrogen, and perhaps of traces of sulphur and phosphorus. We know it to be semi-fluid; we know it to be contractile, and we call it living. The vast question as to whence living matter originated is no longer, therefore, a question as to the origin of complex animals, nor as to the origin of a cell with its membrane, contents, and nucleus, nor as to the origin of a cytod with its membrane and contents. It is as to the origin of exceedingly minute portions of protoplasm. And, with the advancing simplification of this question, the possibility of its solution increases hour by hour.

D.—FACTS BEARING ON THE SUBJECT UNDER DISCUSSION.

Direct evidence as to archebiosis is, confessedly, difficult to obtain. According to some, its attainment is impossible. Whether at the present time inorganic matter does, on occasion, pass into the organic condition is at least doubtful. But there is no doubt, that when the first passage of inorganic into the organic occurred, no man was living to observe that passage. Hence, confining our attention to the primary origin of living matter, it is clear that no direct evidence is obtainable. Our only resource, therefore, is the study of indirect evidence. In this question, as in the almost equally important question as to the origin of man, it is as foolish as it is hopeless to ask for or to expect direct evidence. All that the reasonable thinker has expectation of finding is, indirect or circumstantial evidence that may aid him in his decision. It may be well, however, to remind a certain order of thinkers, that whilst there is no direct evidence of man's origin from the lower animals, or of the origin of organic matter from inorganic, there is equally no direct

evidence of the special creation of man, or the special creation of living matter. As far as direct evidence is concerned, the two antagonistic theories are on a level. Just as no man has ever seen living matter evolve, so no man has ever seen living matter created. There is absolutely no single direct fact in support of the view, either of the evolutionist or of the special creationist on these two points. But while the two antagonistic views are thus on a level in regard to direct evidence, they are very widely asunder in regard to indirect evidence. For there is not one single fact that is indirectly in support of the idea of special creation, whilst the facts in support of the idea of evolution of the living from the non-living are many. It is not denied that there are difficulties in the way of this last conception. Of these difficulties, the special creationists, in their amiable fashion, do not cease to remind us. But they may be in their turn reminded, that to point out the difficulties of a particular theory is no proof of its converse. They may be reminded that there is something of ungraciousness in the ceaseless repetition of the difficulties not yet surmounted, when that repetition is made by those who have done absolutely nothing in the good work already accomplished, and when it is made to those who by patient endeavor have cleared our path to some extent at least.

Of the many facts that indirectly support the view that living matter has evolved from non-living, one or two of the most prominent will now be quoted :—

1. The first of these is *the manufacture of organic substances*. Not many years ago we were told that man would never be able to manufacture organic substances. Such things as starch, sugar, and alcohol, manufactured by the plant and the animal, were never to be made in the laboratory of the chemist. It was impossible for man

ever to obtain these organic compounds in any other way than from plants and animals. But these very organic compounds are now in several cases manufactured by man, and manufactured by him out of inorganic substances. Wöhler has converted the inorganic salt ammonium cyanate, H^4NCNO , into the organic substance urea, $\text{CO} \begin{matrix} \text{H}^2\text{N} \\ \text{H}^2\text{N} \end{matrix}$. Again alcohol, $\text{C}^2\text{H}^6\text{O}$, clearly an organic body, is now manufactured in the laboratory out of carbon, hydrogen, and sulphuric acid, H^2SO^4 . Tartaric acid, $\text{C}^4\text{H}^6\text{O}^6$, a well-known product of the vegetable kingdom, is also by somewhat complex processes manufactured by man, and alizarine, $\text{C}^{14}\text{H}^8\text{O}^4$, the principle of the color matter of the dye madder, has comparatively recently been prepared artificially. These four, urea, which is a product of animal bodies, alcohol, tartaric acid, and alizarine, the product of vegetable bodies, are at the present time manufactured out of inorganic substances. If then man, with his limited knowledge, limited powers, and limited time has been able to prepare the organic from the inorganic, it is at least conceivable that in the enormous time during which this earth has been in existence, certain collocations of mineral matters may have occurred, ultimating in the production of what is called organic matter. If man so soon has been able to work this momentous result, it is exceedingly probable that in Nature the same result has been produced times and again.

2. *The great Food Cycle.*—We may see the transformation of the inorganic into the organic going on around us, and even in us at the present time. Let us consider the food of plants and of animals. The food of plants is in the main mineral matter. Its three chief constituents are carbonic acid, water, ammonia. Putting on one side the cases of insectivorous plants, these three

binary compounds, together with certain salts that are met with in the soil, constitute the chief food stuffs of plants. The plant kingdom, in short, feeds upon the mineral. Here then in the life of every plant we have the constant building up of the organic plant-substances from the inorganic. The carbonic acid, water, ammonia, and salts are built up into starch, sugar, gluten, quinine, and a thousand more complex compounds. For these plant substances are ternary and quaternary, that is, consist of three or four chemical elements. And the number of atoms of these elements is large as compared with the number in the simpler compounds taken in as food. Thus carbonic acid has symbol CO^2 , water, H^2O , ammonia, H^3N . But starch has symbol $\text{C}^6\text{H}^{10}\text{O}^5$; sugar, $\text{C}^{12}\text{H}^{22}\text{O}^{11}$; quinine, $\text{C}^{20}\text{H}^{24}\text{N}^2\text{O}^2$. So that we see, I repeat, in the plant life the inorganic simple compounds constantly built up into the organic more complex compounds.

The food of animals is derived mainly from the vegetable kingdom. Even the carnivorous animal devours herbivorous ones that are in their turn feeders upon the plants. By the animal, the complex organic substances of the plant are built up into yet more complex bodies. The sugar, starch, gluten, become albumen and its fellows, quaternary compounds, or compounds that may contain even five or six different chemical elements in their individual molecules, whilst the number of atoms of each element is very large. So complex are these organic bodies of animal nature, that for the most part they are at present not representable by definite chemical symbols. Their percentage composition alone can, as yet, be given.

Thus then the mineral or inorganic is even at this hour built up under our eyes, into the vegetable, and this last

into the animal, organic bodies. But animal and plant alike, as they decay, break up into mineral compounds. Every organic being ultimately is resolved into carbonic acid, water, ammonia, salts, into, in a word, the inorganic compounds with which our vast, unending food-cycle began. From mineral to vegetable, from vegetable to animal, from vegetable and animal to mineral once again. The organic ever returns to the inorganic, whence it came.

At no place in this food-cycle is there any room for the intervention of the supernatural. The series of natural changes is without a hiatus. And if, in view of these facts, we bear in mind the momentous generalisation that the life of every individual is a brief, condensed epitome of the life of the race, a new light breaks in upon us. Every living being in its own life-history passes with exceeding swiftiness through all the stages of development that its ancestors have slowly traversed in the long past. Every stage in their lengthy evolution is represented by some transient condition in the life of each of their descendants. If we apply this majestic generalisation to organic beings in regard to their food-history, we are forced to believe that as to-day the complex organic substances of living bodies are fashioned out of mineral matters, so in the past, living matter was first formed out of non-living. That which we see take place rapidly in the life of each individual, the upbuilding of the mineral into the organic, probably took place very much more slowly in the infinitely remote past. The transformation of non-living substances into living so swiftly effected to-day tells us that in a very distant yesterday such a transformation occurred for the first time.

3. *Experiments.*—It has been said already that the elaborate and carefully conducted experiments made by

so many excellent observers have little or no bearing upon the real question as to the origin of life in the past. For all the results of these experiments admit of two explanations, one of which is, at least, as reasonable as the other. On the one hand, we are told that the heating of solutions, the filtering air through cotton wool, the subjecting that air to high temperatures and to the action of acids, destroy "invisible germs" that, untampered with, would and do develop into living pieces of protoplasm. But another explanation, at least as reasonable, is that this filtering, this heating, this passing through acids, this rough treatment thermally and chemically, have altered the nature of the inorganic materials concerned, and prevented the possibility of their conjunction and mutual reaction. The one school says invisible germs are destroyed. The other school replies that the physical and chemical properties of the mineral matters are altered. The former tells us that no living matter appears because its parent germs are killed. The latter tells us that with the great change in the properties of the inorganic substances wrought by the treatment to which they are subjected, all their potentiality for combination into the new order of matter called living is destroyed. To some of us the later voices seem to speak the greater truth.

E.—EVOLUTION.

The name of the great principle of modern thought suggests another kind of indirect evidence in favour of abiogenesis. There is neither need, to-day, to explain the principle nor to give facts in order to its establishment. All that is needed is to continue the accumulation of facts with a view to the strengthening of our beautiful faith. Its foundations are laid firmly enough. It remains for us to build upon them.

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The whole of the evidence for Evolution is so much indirect evidence in favor of the origin of living matter from non-living. For, let it be remembered, the only other alternative before us is that of special creation, of supernatural intervention. Of this last absolutely no evidence is in existence throughout the long series of advancing evolution in plants and animals. Clearly, then, to invoke it in respect to the appearance of organic bodies on the earth is unphilosophical. If the great principle holds, it holds throughout. Who will be the Canute to cry to this great sea—"Thus far shalt thou go and no farther?" Supernaturalism has failed us all along the line. Supernaturalism tried to explain man's mind as essentially different from other functions and from other forces. It failed. Supernaturalism tried to explain man's origin as different from that of other animals. It failed. Supernaturalism tried to separate the animal world from the vegetable, and to make us believe that the two orders of organic things were distinct creations. It failed. Supernaturalism is trying to-day to separate the kingdoms of the living and the dead by a hard and fast line. It will fail.

But where Supernaturalism has thus been found wanting, the purely natural explanation of Evolution has been our guide and comfort. Evolution has shown us that man's mind is developed from lower minds, that man's body is the outcome of the advancement from lower forms, that the animal and plant kingdom glide one into the other. And it tells us, also, as we think, that the living and the dead are akin, that the inorganic in the past became organic, that the mineral is the ancestor of the plant and of the animal, that here, as everywhere, no gap occurs, but in the long ages by slow degrees living matter has been evolved from the non-living.
