

# EVOLUTION OF ANIMAL LIFE

BY

ROSSITER W. RAYMOND, PH.D.

## COLLATERAL READINGS SUGGESTED

IN CONNECTION WITH ESSAY VI.

Darwin's *Origin of Species*; Haeckel's *Creation*; Spencer's *Biology*; Huxley's *Palæontology and the Doctrine of Evolution* (in *Critiques and Addresses*), *Lectures on Evolution*, and *On the Origin of Species*; Lyell's *Geology*, and *Lamarck and Darwin, and Various Theories as to Species*; LeConte's *Geology*; Wallace's *Contribution to the Theory of Natural Selection, Geographical Distribution of Plants and Animals, and Malay Archipelago*; Chapman's *Evolution of Life*; St. George Mivart *On the Genesis of Species*; Powell's *Our Heredity from God*; Karl Semper's *Animal Life as affected by the Natural Condition of Existence*; Ransom Dexter's *The Kingdoms of Nature*.

## EVOLUTION OF ANIMAL LIFE\*

---

ANY subject displayed systematically—as, for instance, in tabular form—may be examined in two ways. We may read the columns of the table vertically, or horizontally; and each method reverses the principle of classification upon which the other is based. Thus, in Mr. Herbert Spencer's famous sociological tables, if we take the sheet devoted to a given nation, and read the columns vertically, we obtain in each column a record of the progress of that nation in some one particular, such as music, literature, mechanic arts, government, social customs, etc.; while by reading across the columns horizontally, we obtain, for the period represented by the line we follow, the condition of the nation in all these particulars. Which way is the best, depends on what we wish to study. If England in the tenth century is our special subject, we read horizontally; if the history of music in England is our subject, we read vertically.

Now Evolution can be exhibited in a similar way. We may conceive the different departments of Cosmical, Inorganic, Vegetable, Animal, Human, Social and Spiritual Evolution as constituting the first vertical column, while in other columns, under the heads of Philosophical, Geological, Morphological, Embryological, Geographical, Historical and Experimental, we may give the proofs and facts of Evolution for each department. Which way should this table be read? Horizontally, if we are satisfied as to the truth and fully informed as to the nature of Evolution; vertically, if we wish to get the force of its evidences, and a comprehension of their nature.

In the plan of this course of lectures, the horizontal lines have been followed; and I am to speak to you to-night on the Evolution of Animal Life, avoiding, as far as possible, the proofs and illustrations furnished by the fossil remains, the life-history, the distribution and the variation of plants.

This seems to me unfortunate; perhaps because it shuts me out from those wide generalizations which are so much easier for both speaker and hearer than the patient study of details. Some one has said that any smart young man, with pen, ink, and paper, can compose a scheme of cosmogony in two hours. Something like this was done by Poe, in his essay, "Eureka," stating a theory of the universe which, he said, must be true because it was so beautiful. The trouble with such arguments is, that we are not able to say what is beautiful until we have discovered what is true. Still, they have a wonderful charm for us. I think the very general acceptance of the philosophy of Evolution which has come about within the last twenty-five years has been largely due to the perception of its beauty, as a harmonious and comprehensive arrangement of all phenomena. And if I were only permitted to traverse the table to-night vertically, instead of horizontally, I should feel much more certain of entertaining, if not instructing you. In fact, there is no telling how brilliant would be the address I am not going to make! Let me smother my regrets and awaken yours, as I come humbly down to the horizontal method, and confine myself to my theme: the evolution of animal life.

Under this title, I do not understand that the origin of animal life by evolution from plant-life, or the origin of the organic by evolution from the inorganic, is meant, although a strict construction might require that meaning. In such a sense, little could be said except in demonstration of ignorance. Until a sharp dividing line between plants and animals can be established, it is not likely that we can philosophize to much purpose as to whether and how that line was crossed by evolution. And as to the doctrine of abiogenesis, or the spontaneous generation of organic life, its truth has neither been proved by trustworthy experiments nor disproved by the failure of such experiments. Nor does that failure discredit in any degree the philosophy of evolution. Indeed, Professor LeConte, one of the latest and most lucid of writers on this subject, deduces from his second fundamental law of evolution the corollary, that if spontaneous generation ever took place, it necessarily cannot be possible now. To this extent, I do not follow him. It is sufficient here, however, to point out that the origin

of animal life has little to do with our present subject, which is the operation of evolution in the animal kingdom, or, in other words, the evolution of animal forms. This involves more particularly the consideration of the Darwinian hypothesis; but, at the risk of seeming superfluously simple and trite, I venture a prefatory explanation of the distinction between Evolution and Darwinism.

I. WHAT IS THE EVOLUTION OF ANIMAL FORMS ?

LeConte happily describes Evolution as "continuous, progressive change, according to certain laws and by means of resident forces." As applied to animals, it means that all existing forms, and all of which we have evidence from the past, have been produced by descent with modifications from pre-existing forms.

The "laws" of this continuous change are merely formulas to express in general terms its observed facts. As given by LeConte, they are :

1. The law of differentiation, namely, the general fact of a constantly increasing range of difference among existing forms.

2. The law of the progress of the whole, namely, the general fact that, although there is retrogression and reversion in parts, the whole system steadily advances to higher functions and wider variety, like a tree, the upward and spreading growth of which as a whole is not measured by the irregular form or deficient development or retrogressive metamorphosis or death of any subordinate branch or leaf.

3. The law of cyclical movement, namely, the wave-like, successive domination of types, which rise, reach a maximum and decline.

These laws are not proofs of Evolution. Indeed, they were chiefly established in their completeness by Agassiz, the great opponent of that theory, who read in them merely the expression of the order in which successive forms have been introduced.

It is the third clause of LeConte's definition, "*by means of resident forces,*" that characterizes the theory of Evolution. These resident forces are *internal* (determining heredity, variability, functional adaptability, etc.) or *external* (the forces exercised by climate, supply of food, enemies and rivals, etc.) The latter are summed up in the phrase, "the environment." Evidently the forces which are internal to

any one individual are part of the environment to other individuals, even of the same species, with which it may come into competition.

Now the theory of Evolution is that in some way, by the combination of such interior and exterior forces, successive animal forms have been produced. How this probably took place, it not necessary to show, in order to establish Evolution as the most rational explanation of the facts. It is quite true that a plausible suggestion of the mode of Evolution would greatly assist in recommending the theory; but it is conceivable that an argument may exist — and, in fact, such an argument does exist — based on undisputed observations, and establishing the theory of *some sort* of Evolution. In other words, a man might with perfect consistency believe that animal forms had originated by descent, and yet reject the Darwinian hypothesis as a complete or half-complete statement of the mode. He might think that Darwin's formula left out more important factors than any of those it contained.

This is, indeed, the attitude, to a greater or less extent, of the great body of scientific men at the present day. The Darwinian agents of natural selection and sexual selection are very generally held to have less controlling importance than he (or rather, his ardent disciples — for Darwin was not an extreme Darwinist) gave to them, in their first enthusiasm. Mr. Spencer, and many eminent naturalists (especially in America) lay greater weight upon laws and processes, some of which are known, and others only surmised, by which, more definitely than by natural selection as he conceived it, specific stability has been determined.

And this is the secret of the occasional announcements which we hear (mostly, I am sorry to say, from the pulpit), that Evolution has had its day, and is already on the wane; that the best scientific authorities are rejecting it, and so on. How far this is true of Darwinism, we shall presently see. Of Evolution, in its wider sense, it is not true at all. The victory of that philosophy is complete; and the sooner theology realizes it, the better for theology.

## II. WHAT IS THE THEORY OPPOSED TO EVOLUTION, IN THE ANIMAL KINGDOM?

The opposite theory is, that species are substantially permanent, originating, each in its present form, in a first pair or pairs; spreading by migration; forming, perhaps, varieties

or races but never truly new species; and, when extinguished, being replaced by other species of similar independent origin.

It is important to note what is really involved in the issue thus stated.

1. The theory of independent specific origins does not necessarily imply an appeal to direct, miraculous, special acts of creation, outside of natural law. Its most zealous advocates have always asserted the creative power in ordinary birth. The catechism asks, "Who made *you*?" not "Who made Adam?" The answer is "God"; not "My father and mother." And the old theory of specific origin requires no greater miracle than birth. It involves merely, first, the denial that species have originated from one another; and secondly, the declaration of complete ignorance as to the manner in which they did originate.

On the other hand, Evolution does not exclude the Divine agency, but simply presents a process in which that power may act as truly as in the process of birth. If the evolutionist does not believe that God made him and you and me, he will probably not believe that God made anything. But there is nothing in Evolution to force him to that conclusion. In short, the whole controversy can be carried on perfectly well by atheists, or by theists, on both sides; and the *odium anti-theologicum*, as well as the *odium theologicum*, is quite out of place in it.

2. Neither theory involves the denial of design in the universe. Evolution, indeed, indicates a far wider, more harmonious and more comprehensive design, to one who is willing to see any; but pantheist, agnostic or atheist may hold either view of the origin of species. There were atheists plenty, before Spencer and Darwin were heard of.

3. Neither theory affects the authority of Scripture. Even the most extreme believer in the infallibility of the letter of Scripture finds no description there of the manner in which God "created the heavens and the earth," or the succession of living things, or man "out of the dust of the earth." He finds no statement of a specific act any more precise than that of a hundred natural phenomena, the secondary causes of which are now known. "He toucheth the mountains, and they smoke!" Does that contradict the theory of volcanoes?

Moreover, in the interpretation of Scripture (still on the

basis of the most extreme view as to its infallible authority), the very first step is the inquiry, what the particular Scripture interpreted is: Poetry, Law, Drama, Prophecy, Parable, Fiction, Proverb, Quotation, Philosophy, Doctrine, Prayer, History, Legend, Myth, or Allegory. They are all there; and though some of them are easily recognized, the nature of others is not so clear, especially when they are mingled together, as is often the case. Hengstenberg, the great orthodox interpreter of Messianic texts, declares, in his "Christology of the old Testament," that some of these prophecies were intended to have a literal, others only a spiritual, fulfillment; and that the way to tell them apart is very simple. Those which have had a literal fulfillment were intended to have it; and those which have failed in that respect were spiritual. This leaves a third class, for the fulfillment of which we must wait, before putting them under one or the other head!

I shall not stop to criticize this method of handling Scripture, more than to point out how little it leaves of real authority, even in an infallible text. Applied to the first chapter of Genesis, it has given us, not an inspired and accurate scientific guide, revealed through Moses, but Hugh Miller's and Professor Hitchcock's, and Professor Guyot's, and Professor Tayler Lewis's, and Professor John Phin's, and a hundred other explanations of Genesis, modified to suit the successive advances of geology. I complained once to Mr. Beecher that the clergy would not stand still in their interpretations of Moses. Said I, "If you have got an authorized revelation, why don't you give it to us?" "My boy," he replied, in a mysterious whisper, "It is all your fault! If you geologists will once tell us, finally and absolutely, what science proves, we will give you the exact meaning of Moses on the following Sunday!"

Now, this attempt to preserve the nominal infallibility of Scripture, while substituting for it in reality the authority of variable interpretations — as the fiction of the divine right of a powerless Emperor has often been maintained by Princes who did what they liked in spite of him — may be a great mistake. I think it is. But what I want to say at present is, that physical science is not its chief antagonist. The notions of the inspiration, authority and literal infallibility of the Bible are not attacked, as has been popularly supposed, by astronomy, geology, biology and Evolution,

but by archæology, philology and historical and literary criticism. It is the analysis of Scripture itself, its structure, its origins, and its meaning, which has undermined and shaken the post-Reformation doctrine, put forward with ludicrous audacity as ancient and orthodox; and it is this study of the Bible itself which will restore to us the truly Scriptural and truly Christian doctrine of inspiration. With that contest, the physical and biological sciences have little or nothing to do.

4. Neither theory necessarily either involves or excludes the origin of species from single pairs. Darwinism, as first propounded, may seem to require a numerous ancestry; yet even this condition ceases to be necessary under the latest form of that hypothesis. But, however that may be, Evolution makes no such requirement. Nor, on the other hand, does the independent origin of species require a single pair; since it is equally conceivable that the natural or super-natural cause which could produce one pair could produce any number at the same time.

### III. THE INQUIRY.

Having thus cleared the ground of misleading and confusing side-issues, we may freely inquire whether species are permanent or plastic; whether they originated independently, or by descent with modifications. The argument cannot be a mathematical demonstration. It remains to the end a weighing of probabilities. And you will doubtless be relieved to hear that it is not the purpose of the remainder of this lecture to state it in detail. You will pardon me for saying that I am no great believer in the usefulness of lectures for such a purpose. They may stimulate, suggest and assist; but they cannot replace the study of books which alone will enable you to appreciate the considerations urged on either side. Fortunately, there are books enough, both learned and popular.

What I purpose now, is simply to lay out before you the elements of the discussion, and to explain, briefly, and therefore incompletely, its general situation at the present day, particularly as regards the Darwinian hypothesis, as a mode of Evolution.

First of all, we start with a postulate, common to both sides, namely, that the universe is a system addressing itself to reason (whether it be, or be not, the product of a Divine reason). The sequence of cause and effect is uni-

versal, and identical effects, or consequents, must be ascribed to identical causes, or antecedents. We are conscious of indefinite liability to mistake in the application of this principle; but our faith in it remains unaltered and fundamental. Hence, when we are able to say with high probability of any phenomenon that it is, together with all related phenomena, in all respects *exactly as if* it had been caused in a certain way, we conclude, subject to correction from larger knowledge, that it was so caused.

And while waiting and working for such larger knowledge, we proceed, and are right in proceeding, *exactly as if* our inference were correct. In scientific phrase, we make it our "working-hypothesis." Thus, when we find rocks disposed in layers *exactly as if* they had been deposited as sediments of sand or clay from water, we conclude that they were so deposited. When we find in them forms which resemble perfectly the remains of animals buried in such sediments, we conclude that the bodies of animals were so buried. The monkish fathers, who declared fossils to be but evidences of the Almighty power which was able to make such *simulacra*, to mock the human reason, were as false to religion as to science. God issues no counterfeit bills. The inscriptions He writes—if we can only make them out—are true. The question then is, what do the phenomena of animal life and its records in the earth's crust indicate as the probable cause of the present and past variety of species?

#### IV. ADMITTED FACTS.

It is a remarkable circumstance that there should be so little controversy as to the facts, however much opinions differ as to their significance and relative importance. The following list will suffice to recall the facts admitted by all parties.

A. The lapse of vast periods of time since the introduction of animal life on the earth.

B. Continuous change in geological, geographical, topographical, climatic and other conditions, constituting the environment.

C. The successive appearance of different species, in a certain general order, exhibiting the laws of differentiation, progress of the whole, and cyclical movement. The first law is shown in "prophetic types," or forms combining the characteristics of two groups, which are found to have ex-

isted before the appearance of either group; the second, in the recognized advance of life on the whole, as for instance, in the series Mollusk, Fish, Reptile, Mammal, Man; the third, in the successive culmination of each of the groups of the series just named, in the Silurian, Devonian, Mesozoic, Tertiary and Quaternary, and Present geological ages respectively.

*D.* The inclusion of all past and present animal forms within a few great, persistent types of structure. (Protozoans, Radiates, Mollusks, Articulates and Vertebrates.) We think mostly of the Vertebrates, when we speak of animals. In the series just named as an illustration, all the members except the first are vertebrates. Yet of more than 500,000 species determined, the vertebrates number only 25,000. It is a noteworthy fact that of the myriad other forms not one has ever been found that could not be recognized as belonging to one of the few great types mentioned.

*E.* The facts revealed by comparative anatomy concerning the adaptations to special uses, within each type, of the structural elements common to the type, or their retention without use—the facts of homology, morphology, rudimentary organs, etc.

*F.* The facts of embryology—particularly the wonderful passage of the embryo through successive stages of resemblance to features characteristic of species of earlier origin, in the order in which those species appeared in nature. This phenomenon is not everywhere discernible; but it has been proved in certain instances—notably with regard to the brain of the human embryo, which resembles successively that of a fish, a reptile, and a mammal, before assuming human shape and proportions. There are other facts of embryology, of which time will not permit the mention here.

*G.* The geographical distribution of species.

*H.* The fact that, within the life of a single individual, organs are affected in size and structure by change of functions, use or disuse, and, to some extent, directly by the environment.

*I.* The fact of heredity: that offspring always resemble their parents and ancestors, and that inherited peculiarities are likely to be intensified when both parents or many ancestors have possessed them.

*K.* The fact of variation: that offspring are never exactly like their parents, but combine individual character-

istics with the features of ancestral resemblance. The facts, both of variation and of heredity, are known but imperfectly; and their laws have not been discovered.

*L.* The fact of multiplication, namely, that even the slowest-breeding species of plants or animals, if permitted to increase at its normal rate, would have crowded the globe long ago, as is shown not only by theoretical calculations, according to the rules for the summation of geometrical series, but also by well-known and recent instances, in which single species, imported into regions new to them, have spread with astonishing rapidity, sometimes to the extinction of native species. The Canada thistle and the Norway rat in this country, the wild horses of Mexico, the English grasses in Australia and the rabbits in Tasmania, are familiar and striking examples.

*M.* The fact of population, namely, that this rapid normal increase does not, in general, take place, but, on the contrary, the numbers of each species, in the absence of decisive changes introduced by nature or man, remain comparatively stationary. Occasional decimation, as, for instance, by exceptional weather or famine, is quickly made good by the increase of the species again to its normal proportion. The disturbance of this proportion by man is often followed by the rapid increase of some other species, previously held in check by the one he has destroyed or driven away.

*N.* The fact of the effective life-period, as concerned in this inquiry, namely, that animals have fulfilled the function of life when they have been born, grown to maturity, produced and (in some cases) nurtured their normal number of offspring. Until these functions are completed, death is premature; afterwards, it is natural, and, so far as this inquiry is concerned, relatively insignificant. *N*, it will be seen, includes the sphere of "sexual selection."

*O.* The fact of competition and struggle among individuals and species and against the forces of nature, for food, strength, shelter, victory over enemies or escape from them, and for the production of offspring, etc., in short, a struggle for effective life, as defined under *N*.

*P.* The fact of the "premature" death of the majority (generally the vast majority) of each generation.

*Q.* The production, by selection and close breeding, of

artificial varieties of plants and animals, showing peculiarities as marked as those of species.

*R.* The intersterility of species and the interfertility of varieties, together with the phenomena of reversion to the ancestral form.

#### V. DEDUCTIONS FROM THE FACTS.

We may for convenience recapitulate the foregoing facts under brief titles, thus:

*A.* Time; *B.* Change of Environment; *C.* Succession of Forms; *D.* Types; *E.* Homologies; *F.* Embryonic Stages; *G.* Geographical Distribution; *H.* Direct Organic Modifications; *I.* Heredity; *K.* Variation; *L.* Multiplication; *M.* Population; *N.* Effective Life; *O.* Competition; *P.* Premature Death; *Q.* Artificial Selection; *R.* Intersterility of Species.

And for further convenience, we may refer to these facts by the letters which designate them, by which device we shall be enabled to put in small space our summary statement of the discussion.

*A* to *G* inclusive are so much better explained on the theory of *some* derivation of species by descent, than in any other way, that Evolution, to this extent, may be said to have been fairly established. In the present state of our knowledge, we are obliged to say that the facts are *as if* specific derivation had taken place, and we cannot believe that either natural law or a rational Creator is mocking us with delusive appearances. Nor do the advocates of independent specific origins suggest any theory whatever to explain how these indications of relationship have been produced.

*G*, it must be confessed, lends itself to either view, so far as the distribution of species is the result of migration. But in many respects, it is more in harmony with Evolution; and the one point which has been suggested as a difficulty, namely, the absence of any shading-off or blending of specific peculiarities on the borders of the geographical *habitat*, is founded in a misconception. "Missing links" are to be sought in the past, not in the present; at the junction of branches, not in the air between their extremities.

*H* is the "Lamarckian" factor, and, together with *I*, was principally relied upon in the theories of descent suggested by Lamarck, the elder Darwin, Robert Chambers (author of

“The Vestiges of Creation”) and others. But the notion that changes produced in the individual could be accumulated by simple inheritance into permanent specific structural peculiarities, was rejected as inadequate. So indeed it was, standing alone; but as factors in derivation, according to our present conception of that process, the Lamarckian or interior resident forces are gaining wider recognition.

Darwin’s theory includes *H*, but is based mainly on *I* to *P* inclusive, with *A* and *B*. We might symbolize it as follows, taking care not to attach a mathematical meaning to our equations :

$$(1) \quad MN=L$$

$$(2) \quad LO=P$$

$$(3) \quad L-P=M=\frac{L}{KO}$$

$$(4) \quad MI=\frac{IL}{KO}$$

$$(5) \quad \left\{ \frac{IL}{KO} \right\} AB=AQ=R.$$

Or in words :

1. The number of individuals in a given generation of a species, who complete the functions of life, produces by the law of multiplication the number which will compete for similarly complete life in the next generation.

2. In this multiplied offspring, competition causes the premature death of the majority.

3. The remainder constitutes the effective population for that generation, and since it will tend to consist of those individuals best fitted for *N*, it will be the result of individual differences according to *K*, and will constitute a fraction of *L*, determined by *K* and *O*.  $\frac{L}{KO}$  is therefore a symbol

for “the survival of the fittest.”

4. The population of the fittest survivors, thus preserved, will tend through *I* to intensify its advantageous peculiarities, in each succeeding generation.

5. This process, continued long enough (*A*) under the changes of environment (*B*), will produce results like those of artificial selection, and moreover, will bring about, as artificial selection might do if continued long enough, true physiological species, characterized by intersterility.

The Lamarckian equation, on the other hand, might be written  $ABHI=R$ .

#### VI. THE FAILURE OF DARWINISM.

Now the Darwinian argument, as shown in equations 1, 2 and 3, is unquestionably sound. There is a competition for life and there must be a survival of the fittest. It is in equation 4, with the introduction of  $I$ , that the trouble begins. For  $R$  belongs in this equation too, and  $R$  cannot be had without  $A$ . It is therefore extremely doubtful whether the theory provides for  $R$ .

In other words, according to the Darwinian formula, the results of natural selection are achieved "in the long run"; the amount of the variation selected by nature through competition is, for any single generation, according to this theory, extremely small; and the analogy of artificial breeding which it invokes calls for the production first of interfertile varieties, which shall harden in time into intersterile species. But what is to prevent these varieties from being swamped in the very first generation by cross-breeding with the parent stem? Again, if the struggle for life results in the perpetuation of useful variations only, why should not specific characters not belonging to this class go on varying? As a matter of fact, it is the generic rather than the specific peculiarities which are most clearly advantageous.

Mr. Darwin foresaw these difficulties, as what did not that patient and candid investigator foresee? They center in the laws of heredity, variation and fertility or sterility, all of which are as yet relatively unknown. In his acute discussion of them, he followed still the analogy which had led him from the first, and assumed that the species created by nature began with interfertile varieties. He argued indeed, in his "Origin of Species," that the intersterility of species is not produced by natural selection, but is due to unknown peculiarities of the reproductive system.

#### VII. DARWINISM AS PERFECTED BY ROMANES.

It was left for Dr. Romanes of London, to propound in 1886 what is, as Professor LeConte justly observes, perhaps the most important, if not the only important, addition which the Darwinian theory has received, namely, the hypothesis that natural selection operates upon those varieties only which are not interfertile with other varieties; in other words, that such peculiarities of relative intersterility are the factors

which determine, among the "fittest survivors," which shall breed true, and so transmit their fitness. This hypothesis is based on a fact which may be added to our accepted catalogue (though it is included under *K*), namely, the frequent intersterility of individuals of the same species, and the corresponding interfertility of the same individuals otherwise grouped. The causes are both physiological and, among the higher animals, psychological. The former are almost wholly unknown to us; the latter are evinced in repugnance and avoidance between the individuals. Whatever the causes, the phenomenon is undeniable.

Now the reproductive system of animals is most sensitive of all to causes of change; and it is not improbable that in every generation of a wild species there exists this partial intersterility. Let us suppose, then, that out of a million individuals competing for life in an environment which will support 400,000, say 100,000 of the survivors possess a small advantageous peculiarity, while the other 300,000, though at some disadvantage, manage to live to the next generation. That is, there are 100,000 "fit" survivors, and 300,000 lucky ones. Assume that, out of this 100,000, there happen to be 1000 individuals, who can or will pair with one another only. The rest breed freely with the unprotected but fortunate 300,000, and the next generation gives us 1,000,000 individuals again, of which say 2500 are the offspring of the close-breeding 1000. Perhaps only half of these retain both the protective peculiarity and the protective sterility or aversion. But it will easily be seen that while natural cross-breeding obliterates in each generation the majority of the variations, there is a protected close-breeding going on, which, if it only produces, at last, a single pair with well-marked and permanent peculiarities, and sterile toward the rest, has given the condition for a new species.

And this process shortens immensely the *time* required. We know by experience how quickly a new species of superior fitness will exterminate or drive out all others.

Migration is thus not necessary as an element of preservation to the fittest. It is the inferior which must run away.

Again, this theory accounts for the preservation of protective specific characters. It permits even the formation of new specific characters not protective.

The analogy of artificial breeding is deceptive in this: that we select plants and animals for their desired peculiarities, and prevent cross-breeding. We do not select out of the aggregate of forms we desire to perpetuate those which, besides having that peculiarity, are fertile with one another, but sterile towards the rest. Hence our varieties are subject always to cross-breeding and reversion. In other words, we do not get specific sterility, because we do not breed for it. But Nature starts with that, and performs by her selection the close-breeding which we secure by artificial devices.

Finally, this theory, which makes relative sterility with special interfertility one of the protective modifications upon which natural selection proceeds, is after all only a restatement of the Darwinian formula itself. For the survivors in each generation, retaining in most effective degree the advantageous peculiarities which distinguish them, are most likely to be the offspring of the protected parents on both sides. Cross-breeding will be punished by reversion and loss of advantageous peculiarities.

This may be expressed in our fanciful symbolism by substituting for Darwinian equations 4 and 5, the following:

$$(4) \quad \left\{ \frac{M}{K} \right\} I = \frac{IL}{K^2O}$$

$$(5) \quad \left\{ \frac{IL}{K^2O} \right\}^n AB = A \left\{ \frac{Q}{R} \right\} = R$$

That is to say, natural selection acts twice on each generation, selecting from the fittest to survive ( $M$ ) the fittest to breed; and this process, repeated through numerous ( $n$ ) generations produces physiologically permanent species, as artificial selection ( $Q$ ) would do, if it were directed towards intersterility ( $R$ ) as one of its objects, and continued through a sufficient period ( $A$ ).

What Mr. Darwin apparently overlooked was the probable decrease in numbers of the pure-blooded variety, accompanied by a complete isolation from related forms, until the new species takes its start, perhaps from a single pair, which, in its swift multiplication thereafter, sweeps away all the feeble varieties of the old stock which may have accompanied its history.

As I have said, the laws of heredity and variation are little known. It is in this direction, doubtless, that further light may be expected. But there is already light enough to permit us to see that the production of specific animal forms by derivation, and not by independent origin, is the only rational theory we can entertain; that the Darwinian hypothesis, as now reinforced and complemented, is more satisfactory than ever as an explanation of the mode of such derivation; and that, thus explained, the succession of life upon the globe falls into its place as a harmonious element in what I, for one, conceive to be the vast, complex, yet orderly and rational expression of an immanent, self-revealing God.

**ABSTRACT OF THE DISCUSSION.**

DR. ROBERT G. ECCLES :—

Professor Raymond's method of presenting the subject strikes me as the most incisive and best of any I have ever read or listened to. It displays marked originality of arrangement and a keen, clear appreciation of the subject in every detail. The method pursued in showing the evidence from embryology is particularly lucid, and no doubt perfectly understood by all present even though entirely new to some.

I am pleased to note that Dr. Raymond is among the progressive evolutionists who have accepted Professor E. D. Cope's "Neo-Lamarckism." No purely mechanical theory can ever explain the present arrangement of things; and the evidence is multiplying that shows mind to be an active participant in the moulding process in the development of animal forms. Their desires and feelings direct their actions, and these in turn alter their shapes.

I think that the speaker of the evening made a little too much of the argument from the infertility of crossed species. Darwin himself has shown that so far was this from being an insuperable objection, that, instead, it is just what we might expect in an evolutionary system. The only reason why we have not artificially produced infertile crosses, is the shortness of the time during which we have been experimenting. In the plant world, where generation is more rapid, it has been shown that there is a degree of kinship at which fertility is at its maximum, and that from this it shades off in both directions toward greater and greater infertility. -The most remote will not blend at all. Those nearer will blend, but produce infertile progeny. Approach nearer still, and the progeny will run out in a generation or two. At the maximum point no known limit is found. Get nearer than this, and fertility again diminishes; we find some highly differentiated species infertile to their own pollen. Experiments have shown that artificial selection travels along this line, only it has not had time to reach the point of remote total infertility, or even that of infertility after a generation. Had the pouter pigeon been selected with reference to generation as it has in reference to shape, *it is not unlikely* that we would have had in it a true new species. It is manifestly impossible in an hour's talk to refer to every phase

of a subject so vast as that of the evolution of animal life. Many telling arguments in its favor must be neglected.

The relations of island-life to the subject are most interesting, but did not happen to come under the speaker's consideration. Where islands are remote from a mainland, the type of life found thereon is usually unlike in the two; and in proportion to remoteness, so is difference. If streams and winds flow and blow from the nearest mainland, the type of life in each is nearer alike than is that of the island to that of any remote mainland. Under such circumstances fossil life heightens the affiliation, just as it should if evolution is true. When ocean-currents and trade-winds come from a remote mainland toward the island, then the life is very much unlike that of the near mainland, but markedly like that of the remoter place. But even here there is not identity. New varieties and new species exist in the two. The kinship is clearly marked, but time has effaced identity by the efforts of natural selection. Adaptation to new conditions has necessitated change.

The story of geographical palæontology is necessarily much mixed because of innumerable migrations from country to country; but its general outlines are highly confirmatory of evolution. Excluding the contrast of places in the North Temperate Zone because of undoubted pre-glacial migrations even across the arctic region, and a number of telling facts can be adduced. Conditions in the past isolated South America and Australia from such invasions, and what do we find there, accordingly? The fossil animals of the latest tertiary rocks of the North Temperate Zone are like the living animals of the same region, but unlike those of Australia and South America. The same is the case of the last two when contrasted with each other and with the former. South America, for instance, contains Sloths and Armadillos, and its rocks reveal the sloth-like *Megatherium* and the armadillo-like *Glyptodon*. Its past fauna does not resemble that of Australia nor Europe, but bears a striking resemblance to its own living forms.

The theologic bearing of evolution has frequently been referred to in the lectures of this course. That the doctrine is not anti-theistic can be most successfully maintained. It certainly leaves the God-idea free from the degrading implications of current every-day thought. For a carpenter to make a chair may show great human skill on his part; but his power would be infinitely short of that of a being who could *make a chair make itself*. Even so, a God that could make a world might be quite a skilful artizan; but such a conception as applied to Deity is degrading. How much more sublime is the thought of an Omnipotent Being who

*makes worlds make themselves!* Such was evidently the thought of the apostle who said, "By the *word* of his power were all things made."

PROFESSOR P. H. VAN DER WEYDE:—

I desire to present to the Association an autograph letter of Charles Darwin, never heretofore published, and of interest as bearing upon the subject of this lecture. It was written to my son, who was traveling in South America, and taking photographs of such noteworthy objects and animal remains as he thought worthy of preservation and subsequent study. Some of these photographs, at my suggestion, he sent to Mr. Darwin, receiving this letter in acknowledgment.

LETTER OF CHARLES DARWIN:—

The letter of Mr. Darwin, which was read to the Association by the President, Dr. Janes, is as follows:

DOWN, BECKINGHAM, KENT,  
September 29, 1876.

*Dear Sir:* I am much obliged for the photographs which you were so kind as to send me. I have sent them to Professor Flower (one of the most capable judges in England) of the Royal College of Surgeons, where my specimens from the Rio Plata were deposited. He admires the fine specimens of *Toxodon*, and says that all the others apparently belong to *Mylodon*. I am extremely glad that you and your friends intend collecting the fossil mammals. I will make two or three suggestions, though perhaps superfluous.

Judging from a distance, the Barrancas de Gregorio seem to me worth investigating; and it would be advisable to ascertain where these cliffs are contemporaneous with the Pampean formation. Secondly, as far as I know, the bones of the smaller mammals have not been collected, and these might be as valuable as those of the gigantic mammals: at M. Hermora, near Bahia Blanca, I found the remains of small species. Thirdly, it would be of *paramount* importance to find mammalian remains in the tertiary strata, such as those at Sta. Fè Bajada beneath and older than the Pampean formation. Near the mouth of the Uruguay I found such strata with great extinct oysters, and **BENEATH** these a formation in character quite like the Pampean, and which therefore it is probable would contain mammalian remains.

Heartily wishing you success, I remain, dear sir,

Yours faithfully,

CHARLES DARWIN.