SCIENCE

VOL. LXIII MAY 14, 1926 No. 1637

CONTENTS

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. McKeen Cattell and published every Friday by

THE SCIENCE PRESS

Lancaster, Pa. Garrison, N. Y.

New York City: Grand Central Terminal.

Annual Subscription, $6.00. Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

Entered as second-class matter July 18, 1923, at the Post Office at Lancaster, Pa., under the Act of March 8, 1879.

THE HISTORY OF ORGANIC EVOLUTION[1]

THE meaning of evolution is probably more misunderstood than any doctrine of science. The reason is that it has been discussed very freely by those who are not informed, and in this way much misinformation has been propagated.

The general meaning of organic evolution is that the plant and animal kingdoms have developed in a continuous, orderly way, under the guidance of natural laws, just as the solar system has evolved in obedience to natural laws.

There are at least three important reasons why evolution should be regarded as a necessary part of college training.

(1) It has revolutionized modern thought. Every subject to-day is being attacked on the basis of its evolution. Not only are inorganic and organic evolution being considered, but also the evolution of language, of literature, of society, of government, of religion. In other words, it is a point of view which represents the atmosphere of modern investigation in every field.

(2) It is persistently misunderstood. From the press, the lecture platform and even the pulpit, one frequently hears or reads amazing statements in reference to organic evolution. If it were made an essential feature of student training, there would be developed a propaganda of information instead of misinformation.

(3) It has revolutionized agriculture. The practical handling of plants and animals, in the way of improving old forms and securing new ones, was made possible and definite when the laws of inheritance began to be uncovered through experimental work in evolution.

PERIODS IN THE HISTORY OF EVOLUTION

There have been three distinct periods in the history of evolution, based upon the method of attack. These three methods may be spoken of in general as speculation (ancient), observation and inference (medieval) and experimentation (modern).

[1] Lecture delivered at a joint meeting of the New York Association of Biology Teachers, the Chemistry Teachers Club of New York, the Physics Club of New York, and the Torrey Botanical Club, at the Hotel Majestic, New York City, on March 27, 1926, and arranged under the direction of the Science Committee of the Board of Education.

(1) *Speculation:* The idea of organic evolution is as old as our record of men's thoughts, for all the old mythologies are full of it. No modern man, therefore, is responsible for the *idea,* although it is a common misconception to load this responsibility upon certain distinguished modern students of evolution. For example, the name of Darwin is so conspicuous in connection with evolution that many seem to think that Darwinism and evolution are synonymous. Until 1790, however, organic evolution was a pure speculation, with no basis of scientific work. It should be emphasized that the *idea* of evolution has always been present in the mind of man.

During the latter part of this ancient period of speculation, certain facts began to be observed that made some thinking men conclude that evolution might be a fact, and not merely a speculation. It will be helpful to note briefly, in historical succession, the kind of facts that set these men to thinking, and that resulted in the second period in the history of evolution, when it became a science.

In classifying plants and animals, which was the initial phase of biology, men rigidly defined the different species, the thought being that the different kinds had descended in unbroken succession "from the beginning," whenever that may have been. When more extensive observations were made in the field, numerous intergrades began to be found. The species, as defined, seemed to intergrade freely. In other words, the pigeon-hole arrangement, with rigid partitions, did not express the facts. It became evident that species had been defined by man rather than by nature. Some were distinct enough, but many intergraded. This intergrading suggested that one species might come from another, the intergrades marking the trail.

The next observations suggesting that evolution might be a fact had to do with what was called the "power of adaptation," which we now call "responses." It was observed that plants and animals respond to changes in environment, often in a striking way. I have seen what were regarded as two good species changed into one another by changing from a moist habitat to a dry one, or the reverse. This ability to respond to changing conditions seemed to indicate that species are not so rigid and invariable as had been supposed.

As technique developed, and the internal structures of plants and animals became known, it often happened that rudimentary structures were found, which never developed to a functioning stage, but which occurred fully developed in related forms. For example, it was found that in the developing parrot a set of embryo teeth begins, but never matures. The inference was natural that these structures had been functional in the ancestors, but had been abandoned by some of their descendants. In these days, it has become the habit to call these rudimentary structures "vestiges." Many such illustrations could be given. One in the human body is the vermiform appendix. It seems safe to say that we are walking museums of antiquity.

As technique developed still further, the embryology of plants and animals began to be studied in detail, the whole progress from egg to adult being observed. In very many cases, during this progress, glimpses of fleeting structures and resemblances were obtained, which had disappeared when the adult stage was reached, but which related the form to other species.

After this succession of facts, there came a revelation which convinced more men that evolution is a fact than any evidence which had preceded. The geologists had begun to uncover that wonderful succession of plants and animals from the earliest geological periods to the present time. They saw in the oldest periods forms unlike any now existing; they saw gradual changes with each succeeding horizon; they saw a steady approach to forms like those of to-day, until by insensible gradations the present flora and fauna were ushered in. This geological record, becoming continuously more detailed in its interpretation, set men to thinking seriously.

Finally, after all this evidence was in, men began to look around them and to realize what they had been doing for centuries in domesticating animals and plants. They had been bringing them from the wild state and changing them so much by the methods of culture that in many cases the wild originals could not be recognized. Most of our cultivated plants, if found in nature associating with their wild originals, would be regarded as extremely distinct species.

In the presence of such an array of facts, is it to be wondered at that certain men began the serious, scientific study of evolution? As a result, the second period in the history of evolution was ushered in, and evolution became a science.

(2) *Observation and inference:* In time, this period extends from 1790 to 1900. It is characterized by the appearance of a succession of explanations of evolution. It is important to remember that the men who offered these explanations are not responsible for the *idea* of evolution, but merely attempted to explain the *fact* of evolution. They were explainers rather than authors. It is also important to realize the method used. It may be called the method of comparison and inference. Plant and animal forms were observed, and resemblances were assumed to indicate relationship through descent. It was not dem-

onstration, but inference based on observation. Darwin carried the method to the limit of its possibilities, observing not a small range of forms, but observing through several years a world-wide range of forms, in connection with the famous voyage of the *Beagle*. His caution is also indicated by the fact that his observations were under consideration for some twenty years before his conclusions were published.

This second period in the history of evolution, which we may call the medieval period, is marked by the appearance of several explanations. I shall mention only the three most conspicuous ones, and there is no need to define these in detail.

The explanation which ushered in the period was proposed simultaneously and independently in 1790 by Goethe, of Germany, St. Hilaire, of France, and Erasmus Darwin, of England. Observations of responses to changed environment led them to the conclusion that environment is the direct cause of change, actually molding forms. This evolutionary factor, therefore, is entirely external to animal or plant. It was a natural first explanation, but of course it was too superficial, and environment as a *direct* cause of evolution soon passed into the historical background. It deserves mention only because it was the first attempt at an explanation. In 1801 Lamarck, in a series of lectures, announced his explanation, calling it the theory of "appetency." This was really the first explanation with a body of doctrine, and hence Lamarck has often been called the "founder of organic evolution." The term "appetency," however, has been abandoned, and its real meaning expressed by the phrase "the effect of use and disuse." With Lamarck, environment is not the direct *cause* of the change, according to the earlier explanations, but the *occasion* for the change. The cause is the striving, the effort to do something that had become necessary. Thus organs would become developed as a consequence of some change in environment calling them into use; and, conversely, organs would gradually become aborted as a consequence of some change in environment that eliminated their use. This explanation rests absolutely upon the inheritance of acquired characters, meaning characters not inherited by the possessor, but acquired during the life of the individual.

In 1858 the epoch-making explanation of Darwin was announced, an explanation which was dominant for about fifty years. It is too familiar to need explanation. In brief, it claims that nature selects among variations, that the method of selection is competition, that the result is the destruction of the relatively unfit, or as Spencer puts it, "the survival of the fittest." In brief, the theory is really an explanation of what is called adaptation.

As facts multiplied, the current explanations of evolution were found to be inadequate to explain some of them. This led to a general misunderstanding of the situation by the uninformed public. For example, more intensive study developed the fact that Darwin's explanation does not always explain. His name is so identified with evolution in public thought that this criticism of the universal application of his conclusions by certain scientific men was taken to mean that the theory of evolution was being abandoned. The real situation is that every proposed *explanation* may prove inadequate, and yet the *fact* of evolution remains to be explained.

All the explanations offered are partial explanations, which simply means that no one of them applies to all the facts. We need them all and more besides. So far from being abandoned, evolution is the basis of all biological work to-day.

The method of comparison and inference continued until the beginning of the present century. Then came a new epoch in the history of evolution.

(3) *Experimentation:* This may be called the modern period, in contrast with the medieval and ancient periods. It was ushered in by the work of DeVries, who introduced the experimental study of evolution, and announced his explanation of evolution by means of *mutation*. The problem was to discover whether one species actually produces another one. It had been inferred that it does, but inference is not demonstration. By means of carefully controlled pedigree cultures, DeVries discovered a plant in the actual performance of producing occasionally a new form among its numerous progeny. This form bred true and preserved its distinctive characters; in other words, it was a new species or at least a different species from its parent. Many such species have now been observed originating in this way, both in plants and animals. That one species can produce another one is no longer inferred, but demonstrated, and demonstrated repeatedly. There is no longer any doubt, therefore, that evolution is a *fact*. It is quite a different question whether the proposed explanations are adequate.

When inferences were the only results, in the medieval period of evolution, it was natural to extend inference to the evolution of the plant and animal kingdoms, and this involved the origin of man. In these days there is no such attempt, for experimental demonstration of the evolution of the whole series of organic forms, culminating in man, is clearly impossible. Biologists, therefore, are no longer concerned with the whole story of evolution, but only in discovering experimentally how one species may produce another one. The *fact* of evolution is estab-

lished, but the whole story of evolution must remain an inference.

PRESENT STATUS OF EVOLUTION

Only a very general statement can be made of the present status of evolution, since a full statement would involve an extensive discussion. The experimental study of evolution has led to the development of the field of genetics ("heredity"), a subject which has grown with remarkable rapidity. It is genetics which must uncover the machinery of evolution, which of course is fundamentally a matter of inheritance. The facts thus far uncovered indicate complexities which were not realized before, but which should have been anticipated, for inheritance, with its resulting evolution, represents the most complex biological situation imaginable.

The present status of evolution as a body of doctrine may be said to be in a state of flux, out of which the truth will emerge eventually. Any meeting of biologists at which evolution is discussed discloses considerable diversity of opinion, not as to the *fact* of evolution, but as to some attempt to explain the process.

It is evident, of course, that whatever produces variation furnishes a basis for evolution. But what produces variation? Environment is one factor; sex is another factor, especially when strains are crossed; and other factors might be cited. Any factor claimed to induce variation must stand the test of genetics. Variations, however produced, are of two general kinds, as indicated by behavior, namely, the so-called continuous variation of Darwin's explanation, and the so-called discontinuous variation of DeVries's explanation. The differences of opinion have to do with the method of variation production, that is, variation that may result in a new species.

After such variation is secured, there is no question as to the function of selection. It is merely a statement of fact to say that some variations persist and some are eliminated. It is a very different matter to claim that only the "fit" persist. In some way the selection is made, and the selection factors may be quite variable. In general, it may be said that there is no serious difference of opinion that evolution is based on variation and subsequent selection. It is only a matter of detail to determine the exact factors.

There is a much more serious problem of evolution, however, which is still baffling. The variations observed, which result in new species, as tested by genetics, and for which the cytological machinery has been observed, produce species either laterally or retrogressively; that is, species of the same rank or of declining rank. There is as yet no adequate explanation of progressive evolution, the advance from one great group to another of higher rank. Progressive evolution is a very evident fact, as shown by many an impressive series disclosed by the geological records. The theory of "orthogenesis" is often cited as an attempt to explain progressive evolution. Orthogenesis is not an explanation, however, but a name for progressive evolution. The fact remains to be explained. The multiplication of species is within the reach of experimental study as to causes and methods, and the results are leading to conclusions that may vary with the investigator, but which will be checked up by further investigation. The progressive advance of species, however, is still within the region of inference. It is something like the difference between the tracks in a switch-yard and the main line. We have succeeded in investigating the switching, but the through trains are baffling.

PRACTICAL RESULTS

I wish now to call attention to the practical results that the study of evolution has made possible. The experimental study of evolution, leading to the development of the science of genetics, resulting in increasing knowledge of the laws of inheritance, has led to practical results which the public in general do not appreciate. I shall select only one illustration from very many, but it will serve to indicate the sort of service the study of evolution has rendered in a practical way, in addition to its service in the advancement of knowledge. I have selected the revolution in agriculture. It seems a far cry from speculations concerning evolution to a revolution in agriculture, but the continuity is unbroken. Speculation led to observation; observation led to experimentation; experimentation resulted in discovering laws of inheritance; and the application of these laws has enabled us to handle plants and animals in a way that was never dreamed of before. It is a good illustration of the fact that there is no sharp dividing line between what are called pure science and applied science, for pure science may prove immensely practical.

A very brief statement will illustrate the agricultural results in the application of our knowledge of inheritance. It had become evident, for example, that for various reasons the ratio of increase in population was much greater than the ratio of increase in food production. The statement was made that during the ten years preceding the great war our population had increased 20 per cent. and our food production about 1 per cent. It was certainly an alarming outlook. Under these circumstances, plant crops began to be studied from the standpoint of genetics, and plant breeding became a science.

The lack of crop production arose chiefly from three causes, namely, lack of adaptation of crops to environment, destruction by drought and destruction by disease. The same races were being cultivated everywhere, and only in certain places was the maximum result obtained. A study of races of crop plants throughout the world, and of the environment necessary for maximum yield, resulted in such an adjustment of crops to conditions that total food production was enormously increased.

The problem of drought is being rapidly solved by the discovery or development of drought resistant races, not only insuring against loss from this cause, but also enormously increasing the possible area of cultivation.

The problem of disease has been attacked in the same way, and disease resistant races of most of the important crops have been developed, much reducing loss from this source. As a result, food production is now beginning to overtake population, and we may thank the persistent study of evolution for the result.

To summarize the present situation in reference to evolution, the following statements may be made. Biologists are testing the earlier conclusions by means of the multiplying facts. They are continually discovering factors which complicate the situation. They must learn the influence of factors by experimentation. As a result the problem of evolution has been discovered to be very complex, not to be explained so simply as had been supposed, and therefore is still "in the melting pot," as a distinguished scientist has remarked. All this means, however, that although this difficult problem has not been solved in all its details, it is still recognized by every biological investigator as a problem to be solved. It is not the fact of evolution that is being tested, but the explanation of evolution.

JOHN M. COULTER

BOYCE THOMPSON INSTITUTE,
YONKERS, N. Y.

BARRO COLORADO ISLAND BIOLOGICAL STATION

THE National Research Council has received the second annual report of the Executive Committee of the Institute for Research in Tropical America, prepared by Dr. Thomas Barbour, acting chairman of the committee. From this report I submit the following extracts that the readers of SCIENCE may be informed of the conditions and activities at the Barro Colorado Island Biological Station in the Panama Canal Zone.

The past year, reports Dr. Barbour, has been even more eventful and full of promise for the future than was the first. The officials of the Panama Canal and of the army have continued their invaluable and sincere interest and to them our thanks are heartily offered. Dr. Zetek and his assistant, Mr. Molino, have both continued their constant and efficient devotion.

The main laboratory building has been considerably altered. In the first place the kitchen has been removed to a new separate 12′ x 12′ building connected with the rear of the main house. The latter has been improved by the addition of more window space and by the partitioning off of the sleeping quarters. The area beneath the building has been provided with a concrete floor and has been walled in and screened, thus making an additional study connected by a stairway to the floor above. This now serves as shop, dining room and a place where certain sorts of scientific work, such as gross dissections, may be more conveniently carried on than in the laboratory upstairs. Beside the kitchen, a fuel house and a screened building 12′ x 24′ to serve as laborers' quarters has been finished and is in use.

The total length of trails now cut through the jungle is about twelve thousand meters and many small bridges have been built across some of the steepest ravines.

A Decauville railway track with steel cable, winch and car now makes it possible to hoist baggage, provisions and heavy equipment from the wharf to the laboratory in about twenty-five minutes, thus obviating the heavy labor previously involved when all material had to be carried up the 180 steps leading to the station from the lake level.

Thanks to the continued generosity of Mr. Barbour Lathrop, the station at last has an adequate launch. This craft is 26′ long, 9′ beam and draws 3′ 6″. She is well engined and safe and capable of going anywhere about Gatun Lake. Indeed, she has made trips up the Pacific Coast as far as Pedregal in the Province of Chiriqui, about three hundred nautical miles distant from Balboa at the Pacific entrance of the Canal. She has been named the "Barbour Lathrop."

Thanks to the generosity of Dr. F. M. Chapman, we have an additional new dugout canoe for work about the island shores. The old skiff with outboard motor is now kept at the island; the launch being at Frijoles.

Thanks also to Dr. Chapman's generosity, several "Cambridge Cans" such as are used in museums for the storage of bird skins have been placed in the laboratory and we plan generally to accumulate a study series of a pair of each species of bird found on the island. This will aid students in identifying the species. At present collecting is strictly limited to the taking of birds absolutely needed to check identification of species upon which intensive life his-