LECTURE III

MECHANISM, VITALISM, AND TELEOLOGY

MANY non-mechanistic explanations of organic adaptations have been proposed, but they all agree in this—that they attribute organic structures and functions, especially those that are directed to particular ends, to some sort of will which is present as an uncaused cause, either in some supernatural being or beings, in the universe as a whole, or in organisms themselves.

Primitive people have generally regarded all the activities of nature as expressions of will, and a similar view has been maintained by certain philosophers even in modern times. As the only cause of his own actions which the primitive man knew was his will, so he attributed all activities everywhere to will. Even inorganic nature was personified, not merely poetically, but actually; winds and waves, lightning and thunder, rain and snow, the regular succession of day and night, of seed-time and harvest, of life and death, were presided over by certain deities. Of course the actions of all animate things were supposed to be voluntary; their wills moved their bodies and directed their activities to desired ends.

But step by step, before advancing knowledge of nature, supernaturalism withdrew from ordinary phenomena until it dwelt only on the misty mountain tops of origins and creations. Likewise the voluntaristic conception of inorganic phenomena was gradually abandoned, though it has long persisted, and in a rather obscure form still persists, as an explanation of vital phenomena, and especially of organic adaptations.

1. Supernatural Design

It was the fitness of living things which furnished the stock argument for the doctrine of supernatural design in nature. Since these fitnesses are evidently purposive, and since it is no longer credible that intelligent purpose is to be found in the simplest plants and animals, it was argued that an intelligent Designer must have supernaturally created each and every one of these adaptations for the specific function which it now performs. This doctrine reached its climax in the Bridgewater Treatises, in which natural history became largely a study of the designs and purposes of the Creator as revealed in his creatures, and biology was made to serve as the handmaid of theology.

But although adaptations are very general they are not universal, and although they are frequently very efficient they are not divinely perfect; indeed, all gradations of fitness are found in nature from a high degree of perfection to positive unfitness, and if all of these are the products of supernatural design some of them show more than human bungling. Furthermore, one "design" is frequently pitted against another; the parasite is exquisitely, one might suspect infernally, "designed" to prey upon its host, and the beast of prey upon its victim, but on the other hand the host is fitted to resist the parasite and the victim to escape its enemy. If adaptations are supernatural designs, they must be the designs of many intelligences working at odds rather than of one, and their prevalence in the living world would indicate that there are relatively few phenomena that are natural. Finally, the "frivolities of teleology" were carried to such an extent that they rendered the doctrine of the supernatural origin of every adaptation not only incredible but even ridiculous. And then came Darwinism, which

finally and forever put an end to this extravagant doctrine. "Bridgewaterism is dead." As Darwin says, "There seems to be no more design in the variability of organic beings and in the action of natural selection than in the course which the wind blows." The adaptations of organisms are natural and not supernatural phenomena, and their causes are to be found, not in the individual creative acts of some infinite Designer but in natural forces and conditions. It may be that these forces and conditions are at present unknown and their method of action mysterious, but at least they are natural, unless all distinctions between nature and the supernatural are to be abandoned. Certainly the fertilization of an egg, the development of an embryo, the formation of an eye, acclimatization to extreme temperatures, tolerance for poisons, repairs of injuries, etc., are natural phenomena, and neither religion nor science, poetry nor truth, are served by denying this fact.

2. *Vitalism*

At present there are few if any defenders of the dogma that each and every adaptation was supernaturally created for the purpose which it now serves, but there are many who maintain that living things contain some sort of intelligence, will, or soul which directs their activities to desired ends. The phenomena of life are so mysterious and wonderful and so different from inorganic phenomena that to the great majority of mankind it seems incredible that they should be the effects of purely mechanistic causes. Accordingly from time immemorial the activities of animals and plants have been attributed to some mysterious vital force, *anima, spiritus rector,* unconscious purpose, or will, which is wholly different from the causes of inorganic phenomena, which lies beyond the reach of scientific investigation,

and which is more inexplicable than the phenomena it is supposed to explain. To account for the phenomena of life by ascribing them to *vitalism* is no more helpful or intelligible than to explain the properties of water as due to *hydrism* or of light to *photism*. These are merely names without intelligible meaning. Explanations that explain must be in terms of other and better known phenomena.

In contrasting vitalism and mechanism it should be understood that the term "mechanism" is not used in the sense of philosophical "materialism" nor of "mechanics" in its narrower physical meaning, but rather to connote the regular and invariable sequence of cause and effect, or the principle of causality. Furthermore, it is the function of science to *classify* but not to give ultimate explanations of phenomena; to explain phenomena only in the sense of reducing them to common causes, to deal only with proximate causes and never with final ones. For example, the law of gravity does not explain the ultimate causes and mysteries of falling bodies, but it reduces a thousand causes and mysteries to one. Scientific explanations of life or of anything else attempt nothing more than this.

The biologist is often asked, either naïvely or scornfully, "What *is* life?" One might as well ask, "What *is* matter, mind, energy?" No final and complete answer to such questions is possible; these fundamentals can be defined only in terms of their properties and proximate causes. *Life is a complex of many structures and functions associated with peculiar conditions of matter.* It is never manifested except in connection with protoplasm, "the physical basis of life," and this is an organization of many parts. The universal form of protoplasmic organization is the cell, which is the smallest unit of structure and function capable of independent existence. The most general and distinctive proper-

ties of life are: (1) protoplasmic and cellular organization, (2) metabolism, (3) reproduction, (4) sensitivity, (5) adaptability.

Are these properties explicable in terms of physics and chemistry, and to what extent may they be duplicated in not-living matter? Does the law of cause and effect apply here as elsewhere in nature? Theoretical mechanism would answer each of these questions in the affirmitive, vitalism in the negative. But practically and actually, the mechanist knows that there are many properties and phenomena of life which cannot at present be explained in terms of physics and chemistry, though he has faith that they may ultimately be so explained. On the other hand, the vitalist knows that the immediate causes of certain life processes are physical and chemical, though it is always possible to assume that the more remote causes are not.

Certain simulacra of protoplasm and of cells have been produced artificially, but they bear only a few resemblances to the real living substance. Such artificial products show that some structures and functions of living cells may be explained in terms of chemistry and physics, but the more we know of protoplasm and cells the less likely it seems that it will ever be possible to synthesize them artificially.

For the past two or three hundred years, and ever increasingly up to the present time, physiology has been dealing with the chemistry and physics of living matter, and especially of metabolism. Since the time of Lavoisier it has been known that combustion goes on in the body, oxygen being consumed and carbon dioxide given off, as in combustion outside the body. Digestion is a chemical process which can be duplicated in the laboratory. Muscular contraction and even nerve conduction are accompanied by well known chemical and physical changes. No one now questions the

fact that many vital processes may be explained in terms of chemistry and physics. Even the strongest adherents of vitalism must recognize the fact that neither matter nor energy is created or destroyed in an organism, but that these merely undergo transformations (metabolism). All energy of an animal comes from its food just as the energy of an engine comes from its fuel; the vital machine is as dependent upon food as the engine is on fuel. However, only the first and last steps in constructive and destructive metabolism are known; the middle step, assimilation, is still a good deal of a mystery, but it is probably a chemical process in which each of the many kinds and varieties of protoplasm is built up out of the common nutrient materials through the action of specific enzymes.

The properties of reproduction, irritability, and adaptability are more distinctive of living things and are more difficult to explain on a physico-chemical basis than is metabolism. Certain analogies to each of these processes are found in the inorganic world, and certain steps in each of them are plainly physico-chemical in origin, but it must be admitted that there is left a large residuum which cannot at present be explained on mechanistic grounds. However, much progress is being made in this direction, and this justifies the hope that many more, if not all, vital processes will ultimately be explained in this way; certainly there seems to be no justification for abandoning the search for mechanistic explanations at a time when they are being found as never before, nor for turning at once from a mechanistic philosophy of life to obscurantism or mysticism. For although mechanism may not in the last analysis explain vital phenomena, or anything else for that matter, it is evident that very much of a mechanistic nature remains to be discovered in organisms, and the great advantage of mechanism over

vitalism is not only that it is more intelligible but also that it encourages scientific investigation, whereas a thoroughgoing belief in vitalism discourages research.

Of late several notable attacks have been made upon the mechanistic conception of life, particularly with reference to the causes of adaptation. Bergson, Driesch, Noll, Pauly, Reinke, Schneider, Thomson, G. Wolff and other "neo-vitalists" hold that many vital processes are indeterminate, non-predictable, non-mechanistic, and creative; they attempt to solve the riddles of life by a direct appeal to mysterious conditions or principles which are found only in living things.

Bergson's evidence for his *élan vital* is found in part in phenomena of parallel or convergent evolution. He maintains that, starting from different sources and proceeding by wholly different routes, organisms may reach the same terminus. For example, he holds that the eye of the mollusk, Pecten, and the eye of a vertebrate are practically the same in structure, though they have evolved by wholly different paths and from wholly different sources; or again, that societies of ants and of men are fundamentally alike, although they have evolved in entirely different ways. If identical results can thus come from wholly different causes, there is scientific indeterminism, and some principle other than cause and effect must be involved, some form of vitalism rather than mechanism.

But neither in the living nor the not-living world do identical results come from dissimilar causes; in short, convergent evolution does not result in identical structures. When Mivart denied that homologies are evidences of evolution and claimed that the eye of a cuttle-fish and the eye of a vertebrate were homologous, though they could not have had a common origin, Darwin replied by showing that these two types of eyes are in no sense homologous; that is, they are

fundamentally dissimilar though superficially alike. And in reply to Bergson it may be said that although the eye of Pecten is in a single feature, namely, the inverted retina, like the vertebrate eye, it is in other respects fundamentally different. These eyes are not homologous and Bergson's contention is groundless.

Neither are the similarities between societies of ants and men, and many other examples of a like nature which are cited by Bergson, real homologies or examples of convergent evolution. The similarities which are present are merely such as are due to principles of universal application, such as the extension of differentiation and integration from individuals or persons to colonies and states. Practically all of Bergson's cases of convergent evolution are of this sort. They indicate only the essential unity of all living things, that certain properties are characteristic of all life and are present in the simplest as well as in the most complex organisms. They certainly do not prove that life processes are indeterminate or that identical results may follow different causes, and therefore that vital activity is non-mechanistic.

It is true that it is often impossible to predict what living things will do, but this is probably owing to the fact that the factors involved are very numerous and complex. Whenever the number of factors is large and the times and circumstances of their action numerous, it is difficult to predict results, as is seen for example in so simple a phenomenon as the weather. This is especially true of the behavior of higher animals, for here the number of factors is much greater than in many inorganic phenomena and the interactions of these factors are most complex. Professor W. K. Brooks used to comment upon the ease of predicting what would happen when you kick a stone, as compared with the difficulty of predicting the results of kicking a dog. In the

latter case one needs to take into account many hereditary and environmental factors; one needs to know the breed and size of the dog, whether he is at home or not, whether the one who kicks is a stranger or not, etc. There is good reason to believe that when all these factors are taken into account the results in the case of the dog would be as predictable as in that of the stone. Certainly none of the cases cited by Bergson proves that the activities of animals are indeterminate and non-mechanistic.

Driesch also has maintained that adaptive responses in general cannot be explained by mechanistic science. His first proof of vitalism is that a living thing is a "harmonic, equipotential system"; that is, "the pattern of the whole exists in every part," and under suitable conditions a fragment of an egg, embryo, or adult can give rise to a typical whole. Likewise, when the cells and nuclei of segmenting eggs are forced out of their normal positions by pressure normal development may result, and Driesch holds that neither cytoplasm, nucleus, nor medium are the causes of differentiation, but that "the fate of a part is a function of its position" in the whole, and that "any part is capable of any fate." Some organisms may be cut up in the three dimensions of space and yet each fragment that is sufficiently large may give rise to a complete organism like the original one. It is inconceivable, he says, that any machine could be broken up in this way and yet the parts be capable of becoming complete. He therefore concludes that something, not mechanistic nor causal, lies in the background of development; this something he calls, in the language of Aristotle, "entelechy."

His second proof of vitalism is drawn from the genesis of this complex equipotential system. It is absurd to suppose, he says, that any machine could give rise to such a sys-

tem, and again he invokes the aid of "entelechy." Finally, he finds a third proof of vitalism in the field of behavior, or what he calls the "individuality of correspondence between stimuli and responses." In such cases something non-mechanistic interferes when the good of the organism requires it, and this something, which resembles the "indwelling soul" of Plato, he calls "psychoid." In short, Driesch's three "proofs" of vitalism are all based upon *adaptive* responses.

However, all the parts of living things, whether eggs, embryos, or adults, are rarely, if ever, equipotential. Even parts of the embryos of the sea-urchin, upon which Driesch did much of his work and based most of his conclusions, are not equipotential in the chief axis; that is, fragments from the upper or lower poles are not capable of regenerating a whole embryo or larva. Fragments of the hydroid Tubularia are not equipotential so far as proportionality is concerned (Child). Regeneration in the ascidian Clavelina is complicated by degeneration, regeneration, and budding (ZurStrassen). The different cleavage cells of the eggs of mollusks, annelids, and ascidians are not equipotential, and when one of these cells is destroyed its function is not taken by other cells, but the embryo remains incomplete (mosaic development).

When Driesch maintains that neither cytoplasm, nucleus, nor medium is the cause of differentiation what can he mean? All of these factors are in varying ways and degrees the causes of differentiation. And when he asserts that it is inconceivable that any machine could be broken up in the three dimensions of space and the fragments still be capable of producing whole machines, or that it is absurd to suppose that any machine could give rise to an equipotential system, it is evident that his conception of a machine is

too narrowly limited to those of human invention. The living machine is not a single one, as is an engine or a watch, but it is composed of machines within machines. Every living body is composed of cells within which are nuclei. The visible differentiations of a body are developed from the portion of the cell outside of the nucleus, but always under the influence of the nucleus. The nucleus itself rarely undergoes differentiation, so that there is in every such nucleus a complete machine which under certain conditions may be capable of developing a complete organism, as in the case of development from an egg cell. If this nuclear machine is fragmented or destroyed no regeneration is possible. Therefore the machine-theory of organization does not fail in this case; only Driesch's conception of the vital machine fails because the real organism is more complex than he supposed.

But even granting Driesch's claims that organisms are equipotential systems capable of complete regeneration after injury, that they differ greatly from machines of human invention, and that they generally respond beneficially to stimuli, it does not follow that they are in any respect removed from the field of mechanistic causality.

In the works of Bergson, Driesch, Thomson and other "neo-vitalists" hundreds of pages are devoted to labored refutations of mechanistic explanations of life and to eloquent presentations of mystical, allegorical, and unintelligible causes. In a notable contribution by Jennings[1] the ground is cleared of mere verbiage and the solid foundations of a mechanistic conception of life are laid in eighteen pages. Jennings shows that diversities in life phenomena are accompanied or preceded by diversities in materials, functions, and structures, and that they are not indeter-

[1] "Life and Matter." Johns Hopkins Univ. Circ., 1914.

minate or capricious. He points to the very significant fact that there is no evidence of life apart from protoplasm, and that such phenomena as development, adaptation, reason, and purpose are not annulled if they are found to be bound up with matter, for it is no more extraordinary that they should be associated with matter than that they should be separate from it.

In living as in lifeless things, mechanistic factors are not merely additive as Driesch maintains, but they are frequently creative. In chemical compounds new qualities appear which were not present in any of the elements entering the compounds. No one could predict beforehand the qualities of water from the properties of hydrogen and oxygen, and in general one cannot predict the results of combinations before they have been learned by experience. The fact that one could not predict consciousness from a knowledge of the organic or inorganic constituents of the body is not fundamentally different from these other cases in which new things are formed by new combinations. The "creative evolution" of Bergson is not different in principle from "creative synthesis," which is found everywhere in the living and the lifeless worlds; it is therefore no proof of vitalism.

The new vitalism no less than the old has failed at every point to establish its main proposition, namely, that the reactions of organisms are not causal, and that they require, in order to explain them, a special principle which is lacking in the inorganic world and which is non-mechanistic in action and wholly unrelated to the principle of cause and effect. This is not to deny that there may be a teleological principle in all nature, but rather to affirm that there is no sufficient reason for supposing that in this regard the living world differs fundamentally from the lifeless.

3. Mechanism and Purpose

The only mechanism of adaptation that has ever been suggested is the elimination of the unfit and the persistence of the fit. Inherited or racial adaptations may be explained as the result of the elimination of unfit individuals ("personal selection" or "Darwinism" in the strict sense), while acquired adaptations and useful responses to new conditions can be accounted for by the elimination of unfit structures and functions within the individual (intra-personal and reactional selection). Thus the simple mechanical principles of overproduction of varied individuals or reactions and the elimination of the less fit furnish a mechanistic explanation of all kinds of fitness in the living world.

But in man at least, and probably also in some of the higher animals, there is conscious purpose, and the behavior of many lower animals suggests that they also possess something similar to human purpose, though it is probably not accompanied by consciousness. If conscious purpose has evolved during the course of evolution, as it certainly develops during the individual development of man, do we not here find a phenomenon which cannot be explained as due to mechanistic causes? And if conscious purpose is non-mechanistic in its origin, is it not probable that "unconscious purpose," such as is manifested in the many apparently purposive responses of digestion, respiration, circulation, development, regulation, and the adaptive behavior of lower organisms, is also non-mechanistic? In short, if we approach this problem of fitness from the standpoint of human consciousness rather than from that of the physiology of the lowest organisms, from the top rather than from the bottom, do we not find that the mechanistic philosophy fails to furnish an adequate explanation? Mechanism must ac-

count for purpose in man, as well as for fitness in lower organisms, if it is a universal principle.

It is this point of view that gives weight and force to non-mechanistic philosophy. Any system that denies will and purpose to man must be false, not only because it contradicts one of the most fundamental facts of consciousness, one of the most general experiences of men, but also because it is impractical and unlivable.

If man is the product of mere chance or accident; if as one biologist has said, "The evolution of consciousness is the greatest blunder in the universe"; if men live and die like the beasts and leave only their bones and implements behind; if life and evolution and consciousness are purposeless and lead to nothing—if this were the teaching of the mechanistic philosophy, then certainly it would be true that it debases man, and destroys the hopes of mankind. The blighting effect of such a philosophy is that it substitutes blind chance and necessity for plan and purpose, both in nature and in human life. If there is no teleology in nature, the course of evolution leading to man and to consciousness is the result of blind and blundering accident. If there is no purpose or value in human labor and suffering, life is not worth living, and the only sane and sensible thing to do is to end it all by suicide and race extinction.

But there are evidences of teleology in nature and of purpose in human life. Even struggle, suffering, and death have their value if in the long course of evolution they lead to progress. Men do not die and leave only their bones and implements, but "they rest from their labors and their *works* do follow them." "Others have labored and we have entered into their labors." Civilization is what it is today because of the labor and influence of millions of persons, most of whom are wholly unknown to us. Only a few men have achieved immortal fame, but multitudes have contributed to human progress.[1]

In man at least intelligent purpose exists and must be accounted for. Here is the crucial test of universal mechanism —the purpose, consciousness, soul of man! If these psychic phenomena are not mechanistic in origin some principle other than mechanistic causality is present in man; and when

[1] "Direction of Human Evolution," pp. 231, 232.

we observe the purposive actions of animals, for example crows dropping mussels on rocks to break them open, cats turning buttons to open doors, or horses unlatching gates, it is evident that we are here dealing with the same fundamental problem that we have in human purpose. Finally, even non-conscious and purely instinctive acts, that are purposive, belong in the same category; for example, the mating, nest-building, brooding, and care of young on the part of birds, or similar reproductive habits of mammals, show instinctive, but not perceptual purpose. In man only, so far as we know, does purposive action at certain times rise into the field of consciousness, but most of his activities are non-conscious, although they are purposive. All such phenomena, from conscious purpose at one extreme to instinctive reactions and to tropisms at the other, seem to be fundamentally akin, and if mechanism fails to explain any of them it probably fails with all; if tropisms and instincts are entirely explicable on mechanistic grounds, it is probable that even perceptual purpose may be so explained.

In commenting upon the fact that adaptations are mechanisms for securing the persistence of organisms, Roux[1] says: "Persistence is not an *aim* of living things but an indispensably necessary *condition.* Life cannot suddenly arise anew, but if it exists it must be preserved, and so must before all be capable of persisting, otherwise it disappears. This is no *aim* but a direct necessity of its existence."

But after all, the real question is how living things are able to meet these necessary conditions of life. It may be granted that adaptations are not caused by conscious aims or purposes, but their results are much the same as if they were; they do attain certain desirable ends, and to this extent they are purposive. But results may be purposive while

[1]Arch. Entwick. Mech. Bd. 26, 1908.

their causes are mechanistic; the contrary view is due to a false conception of purpose or of mechanism. There are good reasons for believing that purpose and will in ourselves are not uncaused but rather that they are results of antecedent causes; that they also are links in the chain of cause and effect, and hence are mechanistic in origin.

We have already found that many of the beneficial responses of protozoa and germ-cells are the residuum left after the elimination of non-beneficial responses; in these cells, however, there is little if any capacity to profit by experience. On the other hand, a cat that by random movements accidentally unlatches a door and lets itself out, as in Thorndike's experiment, gradually omits useless movements, remembers past successes, and finally learns to unlatch the door at once, thus showing intelligent purpose, developed through the mechanistic process of the elimination of useless responses. Are intelligence and purpose in man fundamentally different from this? There is every reason to believe that human beings arrive at intelligence and reason by the same process—a process of many trials and errors, a few trials and successes, a remembering of these past experiences, and an application of them to new conditions. All solving of problems, directed thinking and consecutive reasoning are accompanied by, if they do not consist in, rapid elimination of unfit ideas and mental activities. Thus intelligence and purpose in man, no less than fitness in all organisms, may be explained as results of the elimination of the unfit; they also are adaptations; and for this reason, if for no other, adaptations appear to be intelligent and purposive.

4. Teleology

Nevertheless, this mechanistic explanation of fitness and purpose is not complete and many things are left unex-

plained. For example, the mechanism of trial and error by which Paramecium avoids extremes of heat and cold is based upon its ability to distinguish between favorable and unfavorable, or between satisfactory and unsatisfactory, conditions. In some of the simplest forms of living things as well as in the most complex this capacity exists, and for the present at least it cannot be accounted for on mechanistic grounds. Thus in our mechanistic explanation of fitness we put in at the beginning what we get out at the end, namely, a capacity to distinguish between the fit and the unfit, and a tendency to retain the one and eliminate the other. And so in all mechanistic sciences from mathematics to biology, we introduce in one form or another in our factors the qualities which we seek to explain in the end product. It is said that in some rural districts hogs are weighed by driving them on to one side of a balanced platform, throwing stones on to the other side until they equal the weight of the hogs, and then guessing at the weight of the stones. When we attempt to explain the actual origin of fundamental qualities by quantitative mechanistic methods, do we not, with much labor, perform a similar operation? It is a striking fact that at present it is impossible to explain the organization of a cell, the potencies of development or of evolution, or the elements of fitness, purpose, and consciousness on purely mechanistic grounds. "It is because living things are irritable, registrative, persistent, variable, that they have been able to evolve in adaptive ways," but we cannot explain the fact that they possess these qualities. Thus we introduce on one side of the equation the equivalents of the things on the other side which we seek to explain.

In a recent treatise on evolution in its widest aspects, Macfarlane[1] has proposed as one of the principal factors in

[1] "Causes and Courses of Organic Evolution," p. 628.

evolution and adaptation what he calls "proenvironment"; this he defines as "the capacity of any organism for perceiving and then positively growing or moving toward an environment that is the most *satisfying* for it." This capacity he holds is present in all living things and has its analogue even in chemical affinity. Certainly when one observes how almost universally organisms distinguish between beneficial and injurious environments, one is compelled to admit that some such capacity must be present in all living things, and that it must be an important factor in the adaptive or beneficial responses of organisms. Whether it is also a factor in the evolution of racial adaptations depends upon the answer to the question whether such individual or acquired adaptations can become hereditary. Macfarlane takes it for granted that they can be, and he would probably maintain, though he has not developed this thesis specifically, that all inherited adaptations were in their individual origins beneficial or satisfying responses to the environment. Against this view may be urged all the weighty objections to the doctrine of the inheritance of acquired adaptations which are familiar to all biologists. It is difficult if not impossible to explain on this ground the origin of numerous inherited adaptations which are for the good of the species only and are destructive of the individual; for example, the peculiar structures, functions, and instincts of worker and drone bees, which lead to the sacrifice of the individual for the good of the colony, cannot be explained by any form of Lamarckism, but are readily explained by Darwinism.

According to the Darwinian theory, the guiding and directing power of selection should be directly proportional to its severity. If it eliminates only those mutants that are positively injurious or non-viable, as many adherents of the

mutation theory believe, would it be possible to explain such perfect adaptations as are found, for example, in the eye? If these be attributed to the chance occurrence of favorable mutations, do we not place upon chance a perfectly impossible burden when we load upon it not only all the wonderful adaptations in such an organ as the eye, but also all the multitudes of adaptations and coadaptations which exist in every part and function of man or one of the higher animals?

Most of all, when we turn from analysis to synthesis and consider the whole course of organic evolution from amœba to man, from the simplest motor responses to the development of an intellect capable of studying the universe and its origin, are we impressed with the idea that evolution has been guided by something other than chance. Progressive evolution consists in increasing complexity of organization and in increasing adaptation to the environment. It is probably no accident that organization, mutations, and environment have been so correlated that they have led to the perfection of organization and adaptation which we see all about us. Evolution has not been an eternal seesaw: it has led somewhere. The fact that organisms can adapt themselves to changing environment is no accident; the fact that environment has so changed as to bring about progress is no accident. Philosophically, it is difficult to avoid the conclusion that evolution has revealed a larger teleology than was ever dreamed of before—a teleology which differs from vitalism in that it takes in not only the living but also the lifeless world.

And yet science cannot deal with teleology but only with causes and effects and mechanisms; *given* matter and energy and life, with all their potentialities, science deals with the succession of events in evolution, explaining them in a purely

mechanistic manner. In biology the desire for simple mechanical explanations is so great that it often causes us to minify the difficulties and magnify the successes of such explanations. We may temporarily close our eyes to these difficulties, but they remain and must be reckoned with. Few persons have the intellectual honesty of Darwin, who wrote down at once the objections to his theory as they occurred to him, lest he might forget them, and who confessed that he never thought of explaining the evolution of the eye without a shudder. But even if an ultimate mechanistic explanation of adaptations is not possible, it does not follow that we must *at once* resort to an explanation which is either non-mechanistic or supernatural. Many things which were once supposed to be due to supernatural causes are now readily explained by natural ones. The earlier students of evolution proposed absurdly simple mechanical explanations of the process. Later these were replaced by more complex mechanisms, and when these latter fail to offer a satisfactory explanation the scientific solution must be sought in more and more complex mechanisms; for science deals only with mechanisms, and a scientific explanation must be mechanistic.

Some of the world's great philosophers and scientists, from Aristotle and Plato to Kant, Schopenhauer, Lamarck, Cope, Bergson, Driesch, and Henderson, have maintained that the fitness and order of nature can be explained only by assuming that there is some sort of teleological principle in nature, which lies back of or runs parallel with the principle of causality—something which acts more or less like human will or purpose, and which is itself an uncaused cause lying outside the field of scientific inquiry.

Kant has expressed this opinion in a well-known passage: "It is quite certain that we cannot become sufficiently acquainted with organized creatures and their hidden potentialities by aid of purely mechanical natural principles, much less that we can explain them; and this is so certain that we may boldly assert that it is absurd for

man even to conceive such an idea, or to hope that a Newton may one day arise to make even the production of a blade of grass comprehensible, according to natural laws ordained by no intention."

Haeckel and other pure mechanists have hailed Darwin as Kant's impossible Newton of the living world and his theory of "natural selection" as the purely mechanical principle which accounts for the adaptations of organisms. . . . In the light of Darwin's theory we see that adaptations are the results of natural causes: the causal mechanism applies to all the fitnesses of nature as well as to other phenomena; but back of all mechanism, or running through all mechanism, is teleology or purpose.

From the standpoint of science and philosophy the origin of this order and mechanism is the great secret of the universe. Science deals only with mechanisms, and a purely scientific explanation must be mechanistic, but there is no mechanical explanation for the ultimate mechanism of the universe; mechanism cannot explain itself. The mechanism of a locomotive will explain what it does, but it will not explain its origin nor the purpose which it subserves. The organization of an animal or plant or egg is said to explain what it does, but it will not explain the teleological nature of that organization.

Biologists no longer think of any adaptation as having been directly created for the purpose which it now serves but rather as having been slowly developed in the course of evolution. Nevertheless, in tracing an adaptation to its sources we do no more than transfer the origin of fitness to earlier causes. We may explain the fitness of the eye as due to its ontogenetic development, and this as due to heredity and environment, but this does not explain how the potentialities of the eye came to be in the germ-plasm. We have merely shifted the problem to an earlier stage. And the same is true of the evolution of eyes: our explanation of the origin of eyes may be that they are due to mutation and natural selection, or to the inherited effects of use and disuse: but in either case we do not explain the fact that eyes were potentially present in these causes. We have merely shifted the problem from the fitness of results to the fitness of the causes of those results: and in spite of Darwin and his great theory, it is still true that no Newton has yet arisen "to make even the production of a blade of grass comprehensible, according to natural laws ordained by no intention."[1]

In two recent books of great philosophical and scientific value, Henderson has shown that very many elements of the

[1]Conklin, "Direction of Human Evolution," pp. 221-224.

environment are chemically and physically the best possible for life phenomena. In particular, water, carbonic acid and the compounds of carbon, hydrogen, and oxygen possess many unique properties which are necessary to life, and these substances are better fitted to the life processes than any other known substances. He concludes, "Therefore the fitness of the *environment* is both real and unique." The origin of this fitness of the environment for life "lies at least as far back as the phenomena of the periodic system, at least as far back as the evolution of the elements, if they were ever evolved." And yet he holds that it "is conclusively proven that the whole process of cosmic evolution from its earliest conceivable state to the present is pure mechanism." In explanation of this fitness which runs through the whole of nature, he concludes that it is conceivable that a teleological "tendency would work parallel with mechanism without interfering with it. The effect of such a tendency working steadily through the whole process of evolution is also at least conceivable, however small its bearing upon science, provided, like time itself, it be a perfectly independent variable, making up therefore, with time the constant environment, so to speak, of the evolutionary process. This tendency must not be demonstrable either by weighing or by measuring, else it would amount to an interference with the mechanistic process, and it must not itself be liable to any kind of variation whose detection would directly reveal it. Where, then, can the origin of such a tendency be located? Why, clearly, if we accept the induction in favor of mechanism, only where Bergson[1] has shrewdly placed his vital impulse, at the very origin of things, just before mechanism begins to act. In short, our new teleology cannot have

[1]Bergson places his *vital impulse* not at the origin of the universe but only at the beginnings of life. It is a form of *vitalism* rather than of general *teleology*.

originated in or through mechanism, but it is a necessary and preëstablished associate of mechanism. Matter and energy have an original property, assuredly not by chance, which organizes the universe in space and time."[1]

These important philosophical conclusions supplement but do not destroy a mechanistic interpretation of nature. If the chemical and physical characteristics of the environment had been very different from what they are, life as we know it could not have existed on the earth, just as it is probable that life does not exist on the moon because of the absence of water and of an atmosphere. It does not necessarily follow that the environment was made as it is for the purpose of supporting life, or that prospective life was a cause of antecedent environment, but it is impossible to reflect upon this fitness of the environment and indeed the whole order of nature without recognizing our inability to explain finally such phenomena on purely mechanistic grounds.

This conception of a general teleological principle running through all nature differs from vitalism in that it recognizes no world-wide distinction between the organic and the inorganic; both of these belong to the same universe; in both mechanism is universal, and so also is teleology. Here is common ground upon which mechanists, vitalists, and religionists may take their stand; for the thing which mechanists desire to prove is not the absence of teleology but the universal presence of mechanism, while the proposition which defenders of vitalism and of religion are concerned to prove is not the absence of mechanism but the presence of teleology.

Some of the most profound students of nature from the ancient Greeks to the present time have thought it necessary to assume some initial teleological principle. Weismann,

[1] "The Fitness of the Environment," pp. 307, 308.

whom Bernard Shaw counts the chief of scientific sinners because of his advocacy of a mechanistic conception of evolution, believed that extreme mechanism was consistent with extreme teleology; indeed, he maintained, "The most complete mechanism conceivable is likewise the most complete teleology conceivable. With this conception vanish all apprehensions that the new views of evolution would cause man to lose the best that he possesses—morality and purely human culture." And no less a mechanist than Huxley said, "Perhaps the most remarkable service to the philosophy of biology rendered by Mr. Darwin is the reconciliation of teleology and morphology, and the explanation of the facts of both which his views offer. The teleology which supposes that the eye, such as we see it in man or one of the higher Vertebrata, was made with the precise structure which it exhibits, for the purpose of enabling the animal which possesses it to see, has undoubtedly received its death-blow. Nevertheless it is necessary to remember that there is a wider teleology, which is not touched by the doctrine of evolution, but is actually based upon the fundamental proposition of evolution. That proposition is that the whole world, living and not living, is the result of the mutual interaction, according to definite laws, of the forces possessed by the molecules of which the primitive nebulosity of the universe was composed."[1] And Darwin confesses "the extreme difficulty or rather impossibility of conceiving this immense and wonderful universe, including man with his capacity of looking far backwards and far into futurity, as the result of blind chance or necessity. When thus reflecting I feel compelled to look to a First Cause having an intelligent mind in some degree analogous to that of man; and I deserve to be called a Theist. This conclusion was strong in

[1]Huxley, Collected Essays, Vol. 2, p. 110.

my mind about the time, as far as I can remember, when I wrote the 'Origin of Species'; and it is since that time that it has very gradually, with many fluctuations, become weaker. But then arises the doubt, can the mind of man, which has, as I fully believe, been developed from a mind as low as that possessed by the lowest animal, be trusted when it draws such grand conclusions?"[1]

Finally, Henderson has summed up his conclusions on this subject in the following thoughtful sentences: "We may progressively lay bare the order of nature and define it with the aid of the exact sciences. Thus we may recognize it for what it is, and now at length we clearly see that it is teleological. But we shall never find the explanation of the riddle, for it concerns the origin of things. Upon this subject clear ideas and close reasoning are no longer possible, for thought has arrived at one of its natural frontiers. Nothing more remains but to admit that the riddle surpasses us and to conclude that the contrast of mechanism with teleology is the very foundation of the order of nature, which must ever be regarded from two complementary points of view, as a vast assemblage of changing systems, and as an harmonious unity of changeless laws and qualities working together in the process of evolution."[2]

Conclusion

The great problems of the methods and causes of organic evolution and adaptation are slowly being solved. We have made many false starts and have had to retrace many steps, but nevertheless much progress has been made along many lines. Many attractive theories have had their day and are now abandoned; unfortunately we do not know that many

[1] Life and Letters, Vol. I, p. 282.
[2] "The Order of Nature," pp. 208, 209.

current theories may not suffer a similar fate. But to certain theories in one form or another we come back again and again, and always they are more secure. This is especially true of the underlying idea in the theory of Darwin, that master of those who interpret Nature.

But whether we have reached any satisfactory solution of evolution problems or not, we know at least that these problems are being attacked in the only possible scientific way, viz., by observation, analysis, and experiment. Doubtless some of these great problems will always remain unsolved, for Nature is infinite. It is not the possession of perfect truth, but its pursuit, which falls to our lot and fills up the measure of our lives; and we would not have it otherwise, "for to travel hopefully is a better thing than to arrive, and the true success is to labor."