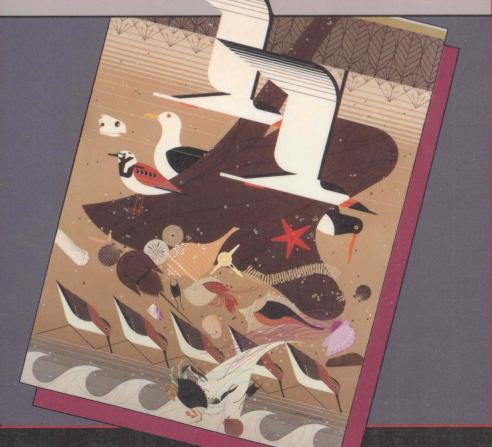


TOWARD A NEW

PHILOSOPHY OF

BIOLOGY





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Toward a New Philosophy of Biology

Preface

Since the Scientific Revolution, the philosophy of science has been characterized by an almost exclusive reliance on logic, mathematics, and the laws of physics. But in recent years we have witnessed a laudable state of ferment in the field. This unrest stems mainly from the growing realization that any sound philosophy of science must do justice to the living world as well as to the physical one.

Yet, is the conceptual framework of biology sufficiently established to be made part of a philosophy of science? How far have we come in creating a respectable philosophy of biology? As I will attempt to show in the following essays, a great deal of conceptual confusion or at least vagueness persists in biology, and we will not arrive at a satisfying philosophy of this field until more clarity has been achieved. To make a contribution to this clarification is my objective in this volume.

The building of an autonomous philosophy of biology started with Darwin, but this fact was quite universally ignored. Twenty or thirty years ago, almost everything about evolutionary biology, but particularly the concept of selection, seemed incompatible with the axioms of logical positivism, the dominant philosophy of the time. Even as recently as 1974 Karl Popper said that "Darwinism is not a testable scientific theory, but a metaphysical research program." One philosopher and historian after the other would say with conviction: "Darwin was no philosopher."

Actually, Darwin scholars have now clearly established that Darwin carefully read the writings of William Whewell, John Herschel, and other philosophers and conscientiously attempted to conduct his research along the lines prescribed by them. However, he could not help it that biology—especially evolutionary biology—has numerous specific properties not met with in the sciences of inanimate objects. Most important, the very essence of that which characterizes living organisms was left out in the analyses of the logicians and positivists—namely, a historical component in the form of an inherited genotype. The role which this historical program

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plays in development and behavior was completely ignored. As Max Delbrück observed in 1949, every organism carries with it the information acquired by its ancestors during the past three billion years. A philosophy of science that would include the study of the living world must emphasize this fact, along with many other phenomena and processes that are either nonexistent or unimportant in inanimate matter.

Eventually a much needed change took place. Beckner, Hull, and Ruse included evolution in their philosophies of biology, and a new generation of philosophers arose who specifically concentrated on evolution: Beatty, Brandon, Burian, Munson, Rosenberg, Sober, Wimsatt, and M. Williams, to mention some names. At the same time a handful of biologists—Simpson, Dobzhansky, Rensch, Ghiselin, and myself—began to write on philosophical aspects of biology. Finally, in 1985, the time was right for the founding of a new journal, *Biology and Philosophy*.

These recent philosophical developments are distinguished not only by the incorporation of uniquely biological phenomena (such as life, selection, coded information, and teleology) but also by a pronounced shift in methodology and *Fragestellung*. One important change is the deemphasis of laws. In most classical philosophies of science, explanation consists in connecting phenomena with laws. Although laws are also encountered in biology, particularly in physiological and developmental processes, most regularities encountered in the living world lack the universality of the laws of physics. Consequently, biologists nowadays make use of the word law only rarely. But a reliance on laws is unnecessary, according to the so-called semantic view of philosophy (as J. Beatty has pointed out).

The philosophy of biology is characterized by its emphasis on concepts and their clarification. The importance of concepts has been articulated by M. J. West-Eberhard: "The spectacular recent progress in this field [evolution of social behavior] has been primarily due to conceptual advances in biology (especially "adaptationist" thinking), not improvements in the precision of measurements." The demonstration of the significance of concept clarification was one of the main themes in my Growth of Biological Thought. Alas, the older generation of philosophers of science still ignore this insight. Too many of them persist in dissecting with the sharpest tools of logic the grueness or not of emeralds or the blackness or not of ravens. Fortunately, the younger philosophers of biology entirely agree with the scientists that a careful analysis of the underlying concepts has primacy in philosophy over exercises in logic.

Because of these recent shifts in the interests of philosophers, the analysis of concepts undertaken in Parts 2 through 8 of this volume—dealing

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with such specific biological subjects as speciation, adaptation, and macro-evolution—will, I hope, be of as much interest to the philosopher as to the biologist. In fact, philosophers of biology have written on all of these topics in recent years. I am convinced that the joint efforts of both classes of scholars are required if we are to achieve a full understanding of these difficult aspects of living organisms. Too often in the past the biologists have ignored the analyses of the philosophers, and the philosophers have ignored the discoveries of the biologists. My hope is that this book will help to strengthen the bridge between biology and philosophy, and point to the direction in which a new philosophy of biology will move.

E.M.

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E.M.

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PHILOSOPHY

Introduction

In order to qualify for my Ph.D. at the University of Berlin I had to take an examination in philosophy. I continued the study of philosophy throughout my biological career, and during the past twenty-five years have attempted some contributions of my own (Mayr 1969; 1976). One of my special concerns has been the neglect of biology in works claiming to be philosophies of science. From the 1920s to the 1960s the logical positivists and physicalists who dominated the philosophy of science had little interest in and even less understanding of biology, because it simply did not fit their methodology. Their endeavors to solve all scientific problems by pure logic and refined measurements were unproductive, if not totally irrelevant, when applied to biological phenomena.

The assumption that it should be possible to "reduce" the theories and concepts of all other sciences, including biology, to those of the physical sciences has clearly dominated not only philosophy but science itself, from the days of Galileo and Descartes. But the further the study of biological systems advanced during the past 200 years, the more evident it became how different living systems are from inanimate systems, no matter how complex the inanimate system or how simple the organism. Attempts to "reduce" biological systems to the level of simple physico-chemical processes have failed because during the reduction the systems lost their specifically biological properties. Living systems, as we shall see in Essay 1, have numerous properties that are simply not found in the inanimate world.

These pecularities of organisms must be duly considered in a balanced philosophy of science. The new generation of philosophers of science is fully aware of this. By contrast, some members of the older generation seem to assume that any reference to the autonomy of biology is an attempt to reintroduce the philosophy of vitalism by the back door. It

must therefore be emphasized that the modern biologist rejects in any form whatsoever the notion that a "vital force" exists in living organisms which does not obey the laws of physics and chemistry. All processes in organisms, from the interaction of molecules to the complex functions of the brain and other whole organs, strictly obey these physical laws. Where organisms differ from inanimate matter is in the organization of their systems and especially in the possession of coded information.

The greatest advance in our thinking on this subject has been the recognition that organisms have a dualistic nature. They consist of (1) a genetic program represented by the nucleic acids, in eukaryotes largely in the cell nucleus (genotype), and (2) an extended body or soma (phenotype) produced under the instructions of the genetic program. The entire ontogeny as well as the physiological processes and the behavior of organisms are directly or indirectly controlled by the information encoded in the genes (Essay 2). There is nothing in any nonliving (except man-made) system that corresponds to the genotype, a system that has selectively stored vital information during the billions of years that life has existed on the earth.

The development of completely new disciplines—evolutionary biology and genetics—was necessary before the centuries-old battle between mechanists and their opponents could be resolved. To the distress of both camps, the conclusion reached was that both were, to some extent, correct. The finding that all processes in living organisms strictly obey the laws of physics and chemistry—that there is no residue of "vital forces" outside the realm of the physical sciences—meant that the mechanists were right. But the finding that the coded information system of living organisms has no equivalent in inanimate nature meant that the antimechanists were also right. This genotype-phenotype duality of the living organism is the reason why it is not sufficient in biology to search for a single cause in the study of a phenomenon, as is often sufficient in the physical sciences.

In Essay 2 I emphasize the need to distinguish two causations underlying all phenomena or processes in organisms. These have been referred to by earlier authors as proximate and ultimate causations. The proximate causes consist of answers to "how?" questions; they are responsible for all physiological and developmental processes in the living organism, and their domain is the phenotype. The ultimate or evolutionary causes consist of answers to "why?" questions, and provide the historical explanation for the occurrence of these phenomena. Their domain is the genotype. For instance, when T. H. Morgan (1932) asserted that sexual dimorphism could be fully explained by a study of the physiological, including hor-

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monal, factors causing the dimorphism, he completely ignored the ultimate causes. Only evolutionary explanations can account for the fact that different species display pronounced, slight, or no sexual dimorphism. Many famous controversies in various fields of biology have been due to a failure of opponents to realize that one of them was interested in proximate, the other in evolutionary, causes.

The clear recognition of two types of causation in organisms has helped to solve an important problem in biology, the problem of teleology. What is teleology, and to what extent is it a valid concept? These have been burning questions since the time of Aristotle. Kant based his explanation of biological phenomena, particularly of the perfection of adaptations, on teleology (Löw 1980)—the notion that organisms were designed for some purpose. Teleology was the principal argument used by some of Darwin's major opponents (Sedgwick and von Baer). And the numerous autogenetic theories of evolution, such as orthogenesis (Eimer), nomogenesis (Berg), aristogenesis (Osborn), and omega principle (Teilhard de Chardin), were all based on a teleological world view. Indeed, as Jacques Monod (1971) rightly stressed, almost all of the most important ideologies of the past and the present are built on a belief in teleology.

It is my belief that the pervasive confusion in this subject has been due to a failure to discriminate among very different processes and phenomena, all labeled "teleological." In Essay 3 I show that the word teleological has been indiscriminately applied to four entirely different phenomena or processes. By partitioning so-called teleological phenomena into these four categories, and by introducing an appropriate terminology for each, it is possible to study each of them separately and show that three of them can be explained scientifically. On the other hand, no evidence whatsoever has been found for the existence of the fourth one, cosmic teleology.

The most important conclusion of the recent research on teleology is that it is illegitimate to extrapolate from the existence of teleonomic processes (that is, those directed or controlled by the organism's own DNA) and teleomatic processes (those resulting from physical laws) to an existence of cosmic teleology. There is neither a program nor a law that can explain and predict biological evolution in any teleological manner. Nor is there, since 1859, any need for a teleological explanation: The Darwinian mechanism of natural selection with its chance aspects and constraints is fully sufficient.

If we had to name a single person as responsible for the refutation of cosmic teleology, it would be Charles Darwin. Natural selection, as he showed in the *Origin*, can explain all the phenomena for which, up to

that time, a principle of finality had been invoked (Essay 14). But this conclusion was completely unacceptable to some of Darwin's contemporaries, such as Adam Sedgwick, K. E. von Baer, and Louis Agassiz. And even today, more than 125 years later, there are some philosophers who not only uphold the existence of a teleological principle in the world but seem to be quite unable to develop a philosophy of life without teleology.

The study of genetics has shown that seemingly goal-directed processes in a living organism (teleonomic processes) have a strictly material basis, being controlled by a coded genetic program. Curiously, the coded program is a concept philosophers with a background in logic, physics, or mathematics seem to have great difficulty in understanding and accepting. Since the term *program* was taken over from the field of informatics, it is sometimes rejected as an anthropomorphism. Yet, the use of the term in biology is fully justified (Beniger 1986). Even though the mechanism by which the DNA stores and codifies information is of course different from that of a computer, the basic principle is remarkably similar, as demonstrated by the researches of molecular biology.

Returning for a moment to the rift between the physicalists and biologists, we must note that advances during the last 150 years not just in biology but in the physical sciences as well have greatly helped to narrow the gap that existed between the two camps. Many of the concepts of classical mechanics and the traditional philosophy of science that were questioned by biologists, such as strict determinism (vs. high frequency of probability), the predictiveness of all processes, or the universality of laws, have now also been either given up entirely by modern physics or at least restricted in applicability.

Classical physics was strictly deterministic. Laplace's boast that he would be able to predict the future course of events on earth ad infinitum if he had a complete catalogue of the existing situation was symptomatic of this attitude. Not surprisingly, natural selection with its emphasis on the chance nature of variation was not palatable to the physicists. This is why John Herschel referred to it as the "law of the higgledy-piggledy." Modern physics has theoretically abandoned such determinism, and yet physicists still are far more deterministic in their thinking than biologists.

This difference is amusingly reflected in the divergent positions taken by most physicists and biologists vis-à-vis the probability of the existence of life—particularly intelligent life—on other planets. Physicists tend to reason that if life originated anywhere else in the universe (and most of them think that this might have happened millions of times), then it is a virtual certainty that in many or most cases intelligent beings would

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have evolved. Since space travel to other solar systems and other galaxies is impossible, in 1959 various radio astronomers initiated a project to communicate with possibly existing extraterrestrial intelligent beings with the help of signals. Thousands of hours and hundreds of thousands, if not millions, of dollars have been devoted to the search for extraterrestrial intelligence (SETI). Although the costs are minimal compared with other NASA projects, various scientists began to question the rationality of the whole enterprise.

Looking at the SETI project from a biologist's point of view in Essay 4. I demonstrate that each step leading to the evolution of intelligent life on earth was highly improbable and that the evolution of the human species was the result of a sequence of thousands of these highly improbable steps. It is a miracle that man ever happened, and it would be an even greater miracle if such a sequence of improbabilities had been repeated anywhere else. The real message of this essay is to call attention to the difference in the psychology of physical scientists and evolutionists. This difference is not, of course, universal. A few biologists, particularly molecular biologists, believe that the probability of extraterrestrial intelligence is sufficiently great to justify the search for it, and a few physicists have forcefully called attention to the unbelievably large improbability of success. The arguments of these physicists, however, are rather different from those of a biologist such as myself. Rather than questioning the probability of the existence of extraterrestrial intelligence, they question the feasibility of sending out enough directional beams for long enough a time to make a call-response probable, or else they call attention to the extremely short duration of civilizations as compared with astronomical time. The difference in the approach of physical scientists and biologists to this problem ought to be of considerable interest to the philosopher.

In Essay 5 I enter a field where angels fear to tread—the origin of human ethics. An enormous amount of recent literature exists on this highly controversial subject, and I have studied only a very small part of it. Being anything but an authority in the field of ethics, I have not been concerned with finding definitive answers in this essay. Rather, I have attempted to develop some previously neglected aspects and to ask open questions.

No simple answer can be given to the most frequently posed question: What portion of human ethics is part of mankind's primate heritage? If the individual is the target of selection, that is, if natural selection rewards only that which is of benefit to the individual, then it is a puzzle how any altruism beyond parental care could ever have evolved. The origin of

human ethics posed a formidable problem for Darwin. Human morality, for the natural theologians, was part of the creation. To replace God's design by the strictly material process of natural selection, said Sedgwick and others, deprived morality of its very foundation. Ever since Darwin, efforts have been made either to derive human ethics from evolution or at least to demonstrate that no conflict exists between Darwinism and the origin of human ethics.

Any acceptable solution would seem to require the recognition that the human species is indeed unique in having a culture and in thus possessing the capacity to transmit ethical norms from generation to generation without their being encoded in genes. Genetics is not entirely uninvolved, however, because there is the evolutionarily selfish altruism provided by inclusive fitness (Essay 5), and because, as Waddington (1960) has suggested, there must have been a premium on the evolution of an open behavior program capable of accepting culturally transmitted ethical norms.

The controversies surrounding sociobiology have renewed the old argument. It is evident from the extent of the recent literature on this subject, and the seeming irreconcilability of opposing opinions, that we are still far from a resolution of questions surrounding the role of genetics in human ethics. I hope I have been able to articulate some of these issues a little more concisely than has been done by the more passionate writers. Here is one of the many areas in philosophy where it is of the utmost importance to ask well-defined questions. This much is certain: The problem of evolution and ethics can be solved only by the most careful analysis of the underlying biological processes.

Additional problems in the philosophy of biology will be treated in other parts of this volume. Nearly all of them deal with topics that had been poorly dealt with or entirely ignored in the traditional volumes of the philosophy of science. A broader, more adequate philosophy of science requires, however, the development of a critical philosophy of biology. Endeavors to fill this gap have been made by a number of philosophers, including Ruse (1973), Hull (1974), Rosenberg (1985), Sattler (1986), and Smith (1976). As praiseworthy as the writings of these philosophers are, they seem to lack the balance and perspective one would hope for. Perhaps this type of synthesis cannot be achieved until individual areas of biology have been treated as authoritatively as Brandon and Sober have treated natural selection (Essay 6). This essay volume, I hope, is another step on that road.

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