What Makes Biology Unique?

Considerations on the Autonomy of a Scientific Discipline

Ernst Mayr

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WHAT MAKES BIOLOGY UNIQUE?

This new book, a collection of revised, collected, and some new essays written in time for his 100th birthday by the most eminent evolutionary biologist of the past century, explores biology as an autonomous science, offers insights on the history of evolutionary thought, critiques the contributions of philosophy to the science of biology, and comments on several of the major ongoing issues in evolutionary theory. Notably, Ernst Mayr explains that Darwin's theory of evolution is actually five separate theories, each with its own history, trajectory, and impact. Natural selection is a separate idea from common descent, and from geographic speciation, and so on. A number of the perennial Darwinian controversies may well have been caused by the confounding of the five separate theories into a single composite. Those interested in evolutionary theory or the philosophy and history of science will find useful ideas in this book, which should appeal to virtually anyone with a broad curiosity about biology.

Ernst Mayr is Professor Emeritus at Harvard University and former Director of the Museum of Comparative Zoology. For his contributions as an evolutionary biologist, taxonomist, and ornithologist, as well as historian and philosopher of biology, Mayr has been called "the Darwin of the 20th century." This is his twenty-fifth book.

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Considerations on the autonomy of a scientific discipline

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To my daughters

Christa Eisabeth Menzel

and

Susanne Mayr Harrison

in love and gratitude for

all they have given me

Contents

Preface

THIS WILL BE MY LAST SURVEY of controversial concepts in biology. I have previously published papers on nearly all these subjects, in some cases more than one. Indeed, an analysis of my bibliography reveals that I have discussed the species problem in no fewer than sixty-four of my publications, and have been involved in numerous controversies. What I now offer is a revised, more mature, version of my thoughts. I am not so optimistic to believe that I have settled all (or even most) of these controversies, but I do hope to have brought clarity into some rather confused issues.

What I do not understand is why most philosophers of science believe the problems of the philosophy of science can be solved by logic. Their interminable arguments, documented by whole issues of the journal *Philosophy of Science*, show that this is not the best way to reach a solution. An empirical approach (see, for example, chapter 3 for teleology and chapter 4 for reduction) seems to be a better way.

Indeed, this conclusion raises a legitimate question – whether the traditional approach of the philosophy of science is really the best possible one. This possibility must be faced if one plans to develop a philosophy of biology. The traditional approach is based on the assumption that biology is a science exactly like any of the physical sciences, but there is much evidence to question this assumption. This raises the troubling question of whether one should not choose a different approach for the construction of a philosophy of biology from the one hitherto traditional in the philosophy of science. An answer to this question requires a deep analysis of the conceptual framework of biology and its comparison with the conceptual framework of physics. Such an analysis and comparison apparently have never been made. To do that is the major objective of this work.

During this task I discovered that throughout biology there are numerous unresolved controversies dealing with problems such as the species problem, the nature of selection, the use of reduction, and several others. It is necessary to obtain clarity on these problems before one can deal with the problem of the status of biology compared with various physical sciences. Any uncertainty about some minor problem may be used by some opponents of certain major theories of biology to reject that basic theory. This has happened particularly often with Darwinism as a whole. There are still some uncertainties about some evolutionary phenomena like the conflict between the explosive speciation of cichlid fishes in the lakes of eastern Africa and the stasis of the phenotype in living fossils, but the validity of the basic Darwinian paradigm is now so firmly established that it simply cannot be questioned any longer.

However, the critical analysis of the controversial problems discussed in chapters 5–11 will help to clarify some obscure points. At first sight, bringing the topics of these chapters together would seem to produce disturbing heterogeneity. More detailed study shows, however, that the conclusions reached in each of these chapters make an important contribution to our understanding of evolution as a whole. Those who are teaching a course on the history and philosophy of biology will find the chapters on the maturation of Darwinism, on selection, and on the evolution of the human particularly helpful. These chapters also supplement treatments of these subjects in *What Evolution Is* (Mayr 2001).

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Acknowledgments

THIS WORK, the product of nearly eighty years of study, owes a great debt of gratitude to scores of friends and mentors. Most of you are no longer with us, such as Erwin Stresemann, Bernard Rensch, Theodosius Dobzhansky, Michael Lerner, James P. Chapin, J. B. S. Heldane, E. B. Ford, David Lack, Konrad Lorenz, Niko Tinbergen, and so many others.

Fortunately there are some to whom I can say my thanks in person. Walter Bock is the one to whom I owe the most. He has read my draft manuscripts critically and I have greatly benefited from his constructive suggestions. I frequently consulted Francisco Ayala, Jared Diamon, Doug Futuyma, Michael Ghiselen, Verne Grant, Axel Meyer, David Pilbeam, Frank Sulloway, and Bruce Wallace and always received useful information and constructive advice. I also consulted Fred Burkhardt, J. Cain, J. Coyne, James Crow, Frances DeWaal, J. Haffer, François Jacob, Lynn Margulis, Robert May, Eviatar Nevo, J. W. Schoff, Steve Stanley, Robert Triver, James D. Watson, E. O. Wilson, and R. W. Wrangham. They contributed valuable information and wise counsel. All this improved the reliability and competence of this volume.

I had no permanent secretary in the period when this volume was in production, but I was provided with part-time student help during the last seven years, who made invaluable contributions to the quality of this work. But it was Alison Pine who very efficiently saw this volume through the press in the last two years. To her, I owe a special debt of gratitude.

Introduction

My father had a large library. Even though he was a jurist by profession, his major interests were history and philosophy, particularly the German philosophers Kant, Schopenhauer, and Nietzsche. I never read any of these philosophy books, unless one classifies Haeckel (Welträtsel) as a philosopher. However, in my parents' home philosophy was always referred to with great respect. Philosophy was the favorite reading of my father's maiden sister whom the family considered brilliant.

My real contact with philosophy, however, did not come until I prepared myself for the philosophy portion of my PhD examination. At the University of Berlin, one had to pass an examination in philosophy to complete a PhD. I took courses in the history of philosophy and a seminar in Kant's *Critique of Pure Reason*. Frankly, I really did not understand what it all was about. I was permitted to specify in what branch of philosophy

I wanted to be examined and I was duly examined in positivism as I had specified. I passed with an A because I had been well prepared.

As a result of my studies, I concluded that the traditional philosophy of science had little if anything to do with biology. When I inquired (ca. 1926) which philosophers would be most helpful to a biologist, I was told Driesch and Bergson. When I left for New Guinea one and a half years later, the major books of these two authors were the only books I dragged around with me in the tropics for two and a half years. In the evenings, when I was not busy with bird skinning, I would read in these two volumes. As a result, by the time I returned to Germany, I had concluded that neither Driesch nor Bergson was the answer to my search. Both authors were vitalists and I had no use for a philosophy based on such an occult force as the *vis vitalis*.

But I was equally disappointed by the traditional philosophy of science, which was all based on logic, mathematics, and the physical sciences, and had adopted Descartes' conclusion that an organism was nothing but a machine. This Cartesianism left me completely dissatisfied and so did saltationism. Where else could I turn?

For the next twenty years or so, I more or less ignored philosophy, but then, in due time, my activities in theoretical systematics and even more so in evolutional biology brought me back to philosophy. I developed a vague feeling that the new concepts and principles encountered in the more theoretical branches of biology might be a good starting point for a genuine philosophy of biology. But here I had to be very careful. I did not want to fall into a trap like vitalism or become a teleologist, like Kant in his *Critique of Judgment*. I was determined not to accept any principles or causes that were in conflict with the Newtonian natural laws. The biology for which I wanted to find a philosophy had to qualify as a genuine, bona fide science.

Even though quite a few books were published in the twentieth century entitled *The Philosophy of Biology*, they live up to this title only in part. Works such as those of Ruse (1973), Kitcher (1984), Rosenberg (1985), and Sober (1993) deal with biological issues and theories but use the same epistemological framework as books on the philosophy of physics. One looks in vain for an adequate treatment of the autonomous aspects of biology, such as biopopulations and dual causation (explanation). Even though much of the methodologies of the philosophy of physical sciences can also be used in a philosophy of biology, the neglect of the specifically biological subjects leaves a painful gap. Owing to their basic philosophy, these volumes have been referred to as Cartesian. Those who were looking for a philosophy of biology had the choice between a volume that was either vitalistic in its basic spirit or Cartesian.

I had a half-hearted ambition to write a book that would fill the gap, but I realized that I was deficient in my background in philosophy. Also I was still preoccupied with unfinished researches in systematics, evolution, biogeography, and the history of biology. I simply was not in a position to try to compose such a philosophy of biology as I had in mind.

What I could do instead was to write a series of essays that might serve as a basis for such a book by a properly qualified philosopher. I have written such essays for the last twenty years; sometimes an earlier version was replaced in due time with a more mature one. Indeed, of the twelve chapters in this volume, all but four (chapters 1, 4, 6, and 10) are considerably revised versions of earlier publications. A reader casting a quick glance at the list of the chapter headings might come to the wrong conclusion that this book is a hodgepodge of unrelated themes. But this is not the case as I will now describe in a short characterization of each chapter.

The historian of biology is in a peculiar predicament. There were a number of fields dealing with the living world – physiology, taxonomy, and medicine-related embryology – in which studies were done that later became respectable components of the biological sciences. But in the eighteenth and early nineteenth centuries, they were not treated as part of the cohesive science eventually recognized as biology.

Even though Linnaeus led to a great flourishing of systematics, it was really Buffon (Roger 1997) who directed attention to the living organism. The word biology was introduced around 1800 independently by three authors, but it described something that was going to come and not a field that already existed. It finally came in the nineteenth century when in a period of about forty years all the major subdivisions of biology were established. These developments are indicated by the following names and dates: K. E. von Baer (1828), embryology; Schwann and Schleiden (1838–1839), cytology; J. Müller and Bernard (1840s–1850s), physiology; Darwin and Wallace (1858–1859), evolution; and Mendel (1866, 1900), genetics. Biology developed into a separate branch of science during this forty-year period. But it was not until the second half of the twentieth century that biology acquired dominance among the sciences.

The object of each chapter

Chapter 1 – Science and sciences

In Chapter 1 I show that biology is a bona fide science, even though it has some properties that are not found in the physical sciences. What is important, however, is that biology has the indispensable characteristics of true sciences such as chemistry and physics. It is justified to try to develop a branch of the philosophy of science devoted to biology.

Chapter 2 – The autonomy of biology

However, I also found that biology, even though it is a genuine science, has certain characteristics not found in other sciences; in other words, I show in this chapter that biology is an autonomous science.

The remaining ten chapters discuss various aspects of biology that must be fully understood by anyone wanting to study the philosophy of biology. The conclusions reached in these chapters will strengthen the foundations of a genuine philosophy of biology.

Chapter 3 – Teleology

Biology could not be accepted as a bona fide science until it eliminated cosmic teleology from its framework of theories. Therefore, it is essential to show that the word teleological has been used for five different kinds of phenomena or processes in nature, which must be carefully distinguished from each other. Satisfactory empirical explanations are available for four kinds of phenomena or processes that traditionally are referred to as teleological; these can be explained exhaustively by natural laws. Yet no evidence has ever been found for the existence of the fifth one, cosmic teleology.

Chapter 4 – Analysis or reductionism?

Until the middle of the twentieth century, an important philosophical belief of the physicalists was that a phenomenon had to be reduced to its smallest components to achieve a complete explanation. This was generally interpreted as meaning that explanation could be achieved only at the lowest level of organization. This conclusion was particularly disturbing for biologists, because at the lowest levels of organization such a reduction abandoned biology and dealt exclusively with physical phenomena. However, I will show in this chapter that such reduction is not only not necessary but indeed quite impossible. The support for reduction was in part the result of a confusion with the process of analysis. Analysis is and always will be an important methodology in the study of complex systems. Reduction, on the other hand, is based on invalid assumptions and should be removed from the vocabulary of science.

Chapter 5 – Darwin's influence on modern thought

Charles Darwin contributed many of the concepts on which the paradigm of modern biology rests. Some of them were controversial for a long time and are still opposed by certain evolutionists. A full understanding of the autonomy of biology therefore is not possible without an analysis of Darwinism. Indeed, modern biology is conceptually Darwinian to a large extent. Although I attempted in previous publications to characterize this Darwinian contribution to our modern biological thinking, its importance for the philosophy of biology is so great that this renewed analysis should be welcome.

Chapter 6 – Darwin's five theories of evolution

Darwin, throughout his life, referred to his theorizing on evolution as "my theory," in the singular. However, it is now quite clear that Darwin's evolutionary paradigm consists of five theories, which are independent of each other. Failing to appreciate this independence unfortunately led Darwin, and others who followed him, to several misinterpretations. One will never fully understand the autonomy of biology if one does not understand the nature of Darwin's five theories.

Chapter 7 – Maturation of Darwinism

The set of ideas and theories that leading evolutionists now consider to be the basic components of Darwinism are still remarkably similar to Darwin's original proposals in 1859 – largely but not entirely. In particular, Darwin had not realized that "his theory" [in the singular] is actually a compound of five different theories. These were accepted by other evolutionists at different times, with natural selection, after nearly eighty years of argument, accepted as the last.

The acceptance of evolution is of course a prerequisite for acceptance of the other four theories. But the validity of each of these four theories is independent of the validity of the other three. One can have a theory of speciation even if one rejects natural selection or gradualism. Many of the Darwinian controversies were due to the neglect of the finding that the validity of each of the four Darwinian theories is largely independent of the validity of the others.

Chapter 8 – Selection

This theory (or bundle of theories) was, for several reasons, longest resisted. Indeed, our modern concept of this theory differs in a number of ways from the original Darwinian version. For instance, we now consider selection more as a process of nonrandom elimination than of positive selection, and this may facilitate the survival of more and more deviant variants. Also, we no longer consider variation and elimination simply as each other's opposites but are beginning to consider the production of variety and the succeeding step of elimination as two steps in a single process. There remains considerable uncertainty about the role of variation during the evolutionary process, but there is no argument that selection is involved in nearly every instance of evolutionary change. A knowledge of all aspects of selection therefore is basic for a full understanding of evolution.

Chapter 9 – Do Thomas Kuhn's scientific revolutions take place?

It is extraordinary how biology has changed in the last two hundred years: first the establishment of biology as a valid science in the years from 1828 to 1866, then the Darwinian revolution, then genetics and the new systematics, and finally the revolution of molecular biology. The philosopher is deeply interested in the nature of these changes. Were they gradual or did they occur in a number of scientific revolutions, and if so what was the nature of these revolutions? One cannot understand the nature of the currently accepted science of biology unless one understands the nature of the conceptual changes of the last two hundred years. In particular, I attempt to answer in this chapter the question of whether Kuhn's concept of scientific revolutions is or is not supported by biology.

Chapter 10 – Another look at the species problem

No matter in what branch of biology one is interested, it is necessary to work with species. This is the major unit in biogeography, in taxonomy, and in all comparative branches of biology. Evolution is characterized by irreversible changes at the species level. Considering this outstanding importance of the species in biology, it strikes me as almost scandalous that there is still so much disagreement and uncertainty about almost every aspect of species. There is no other problem in biology on which more has been written in recent years and less unity has been achieved than the species problem. Any discussion of the autonomy of biology that did not attempt to shed light on the origin and the nature of species would be incomplete. My own account focuses on the reasons for this long-standing and seemingly insoluble problem and makes suggestions for a solution.

Chapter 11 – The origin of humans

It was one of Darwin's shocking findings that the human species is not something altogether different from the rest of the living world, as nearly everybody believed, but instead is part of it – indeed that apes are the ancestors of humans. Even though this conclusion had already been made inevitable, on the basis of both comparative biology and the fossil record, it has now been a thousandfold confirmed by molecular biology. What is particularly interesting is that by proposing historical narratives including the life history of our ancestors, it is possible to reconstruct a rather convincing hominid history. The scenario suggested in this chapter is based largely on inferences, but they can be tested against a great deal of evidence from fossils and from molecular biology. The novel historical narrative suggested by me will have to be tested again and again. However, it has the great advantage that it provides a cohesive and quite plausible account of the various stages by which a chimpanzee-like ancestor in the rainforest evolved into *Homo sapiens*. It is precisely the autonomous features of biology that make a plausible reconstruction possible. It produces a solid foundation for the reconstruction of human history, which a purely physics-based explanation would never be able to provide.

Chapter 12 – Are we alone in this vast universe?

This question has been asked for more than two thousand years. As an outgrowth of space research in recent years, a definite research program has been developed, trying to establish contact with any possible civilizations elsewhere in the universe. Those who have given thought to this project can readily be assigned to two groups: an optimistic one consisting almost entirely of physical scientists, particularly astronomers. They are convinced that a search for extraterrestrial intelligence is promising. By contrast a pessimistic group, consisting mostly of biologists, has developed a list of reasons why such a search is totally hopeless. In this chapter, I present the biological reasons, usually neglected by astronomers, why there is such a low probability of success.

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