Philosophy of Biology

A Contemporary Introduction

Alex Rosenberg and
Daniel W. McShea

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Philosophy of Biology

Is life a purely physical process? Does the theory of natural selection conflict with theism and, if so, how can we rationally choose between them? What is human nature? Which of our traits are essential to us?

Biology is the branch of science most immediately relevant to many distinctively human concerns, so it is natural that it should be the site of great controversy and debate. The philosophy of biology addresses not only those questions that biology cannot yet (or perhaps ever) answer but also the further questions about why biology may be unable to answer those questions.

In this volume, Daniel McShea and Alex Rosenberg—a biologist and a philosopher, respectively—join forces to create a new gateway to the philosophy of biology, making the major issues accessible and relevant to biologists and philosophers alike.

Exploring concepts such as supervenience, the controversies about genocentrism and genetic determinism, and the debate about major transitions central to contemporary thinking about macroevolution, the authors lay out the broad terms in which we should assess the impact of biology on human capacities, social institutions, and ethical values.

Alex Rosenberg is R. Taylor Cole Professor of Philosophy at Duke University. He is the author of *Philosophy of Science: A Contemporary Introduction* (2nd edition, 2005) and co-editor with Yuri Balashov of *Philosophy of Science: Contemporary Readings* (2002).

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Philosophy of Biology

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For three friends and colleagues from whom we have learned much biology and not a little philosophy: Robert Brandon, Fred Nijhout, and Louise Roth

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Introduction

What is the philosophy of biology?

Philosophy asks two kinds of questions

Philosophy, Aristotle wrote, begins with wonder. And, for a long time, philosophy meant the same thing as science. Indeed, in some universities, physics is still called "natural philosophy," and philosophy is taught in the department of "moral science." The reason is not hard to see. The history of Western philosophy is the history of a discipline that has been "spinning off" sciences since about 300 BC when Euclid wrote the *Elements* and established the separate discipline of mathematics. It was only much later, in the seventeenth century, that physics finally established itself as a discipline distinct from philosophy, followed in the late eighteenth century by chemistry, and, as we will argue in the next chapter, by biology as late as 1859, when Darwin published *On the Origin of Species*. This process continues, for there are other disciplines, still in the process of spinning themselves off from philosophy. As the sciences establish their separate existences, two questions arise: Do the sciences leave anything to philosophy when they "spin off," and, if so, why do they leave unfinished business to philosophy? The answer to the first question is obvious. Each of the sciences leaves to philosophy issues that they might be expected to answer but have not. Consider the question of what a number is. A number is not after all a numeral, which is just the symbol we use to name a number. For "2," "II," "two," "dos," and "dho" all name the very same number, in Arabic, Roman, English, Spanish, and Hindi notation. We may hold, as many followers of Plato still do, that numbers are "abstract objects," or that there are no such things and that numbers are mental constructs. But it will be in vain to look to mathematics for an answer to the question of what a number is. That question has remained one for philosophical inquiry since Plato. Or consider the question of what time is. Time is a variable in many of the most important physical laws. Newton's second law, for example, tells us that force equals mass×acceleration, $F = ma$, where acceleration is defined as the rate of change of velocity with respect to time, $a = \mathrm{d}v/\mathrm{d}t$. But the question of what is time, t in the equation, has remained unanswered in physics and left to philosophers.

Biology too has left questions that philosophy addresses. In fact, the questions biology leaves to philosophy are hard to avoid and of great interest beyond biology (and beyond philosophy for that matter). This is part of

the reason that the philosophy of biology has become one of the liveliest and most publicly visible of philosophy's subdisciplines. Another is that the questions biology leaves to philosophy are the most immediately relevant to many distinctively human concerns. For example, it is to biology that many look for insight into "human nature." It is biology that appears to address the question of what is "life" and whether things have a meaning or purpose beyond the merely physical and chemical processes that constitute them. Now, biological science itself does not tell us whether it has the power to answer these questions. And for that reason there are lively debates about biology's scope and limits, its authority to answer such perennial questions of deep human concern. These questions about biology's scope and limits are clearly philosophical ones.

Like the other natural sciences, biology is an experimental discipline, and, as such, it is a fallible one. For experiments, observation, and collecting data can never establish the truth of a theory with perfect certainty. Like other scientists, however, biologists have the confidence that though their findings are always subject to revision and improvement, their method—the scientific method—is the right one, indeed, the only way to assure the increasing reliability of their results. But there are disputes within biology, and between biologists and other scientists, both about what the "scientific method" is and about whether various research programs and their results honor that method. Then there are disputes about whether and why the application of the scientific method in biology differs from that in the physical sciences. And, finally, there are disputes about whether there is any such thing as *the* scientific method, with the emphasis on the uniqueness suggested by the definite article. All of these issues are well and truly part of the agenda of the philosophy of biology and, of course, the philosophy of science generally. For the sciences cannot themselves answer questions about the warrant of their own methods, the justification of their modes of research, and the adequacy of each discipline's distinctive approaches to its own and other disciplines' domains. A physicist's argument that biology should be more like physics, or a chemist's claim that biological facts need to be explained by chemistry, cannot be settled by experiment and observation, if they can be settled at all. These questions are the purview of the philosophy of these sciences and the philosophy of science in general. This does not mean that scientists have no right to express views about these matters or that only philosophers of science are qualified to do so. It means merely that when informed participants debate these issues, they are engaged in a philosophical dispute.

Recall now our second question. If there are questions that the sciences cannot answer, why do such questions exist? This can be construed as a question about the limits of science. It is well known that many people reject the findings and theories of natural science in favor of other beliefs, often religious ones, and often with the accompanying claim that some facts of the world are forever beyond the reach of science. No science is more often met with claims of this sort than biology. Questions about the meaning of life are often said to lie in this unreachable domain. Some go even further,

arguing that questions about the origin of life, or of the human species, lie there also. Further, there are social and behavioral scientists, and scholars in the humanities too, who deny the relevance of biology to their research questions, for example questions having to do with the causes of human behavior or the foundation of ethics. Now it would seem that those who hold that biology, or other natural sciences, cannot answer certain questions owe an account of why not, as of course do those who argue that science *can* answer them. And these accounts of the limits of science, or of the absence of limits, will be philosophical arguments, as traditionally understood.

Like biology, philosophy is divided into subdisciplines: metaphysics studies the basic kinds of things, processes, and properties in the universe, and addresses questions about them such as: What are numbers? Does God exist? Are all events governed by physical law, and, if so, is there such a thing as human freedom? Epistemology, or the theory of knowledge, treats the nature, extent, and grounds of knowledge: What distinguishes knowledge from mere opinion? Why are mathematical truths more certain than scientific theory? Can we reliably infer the future from the past? The philosophy of science, of course, overlaps these two subdisciplines considerably. It also intersects with logic, the subdivision that seeks to identify the principles of valid reasoning, and that therefore is of the greatest importance in science and mathematics. Beyond these three subdivisions of philosophy, there are those of ethics, aesthetics, and political philosophy. These last subdivisions might seem most clearly to be addressing questions beyond the limits of scientific inquiry, questions about what ought to be the case, and not just what, as a matter of fact, is the case. But it is a more than curious fact about biology that it is the only scientific discipline that anyone has ever supposed might be able to answer the questions of moral and political philosophy. Evolutionary biology in particular has often, at least since Darwin's day, inspired a hope of putting ethics on a "scientific" footing. We will address this hope in the last chapter of this book. Meanwhile, let us draw a working definition of philosophy from this section: it is the discipline that addresses those questions that the sciences cannot (yet, or perhaps ever) answer and the questions about why the sciences cannot answer these questions. Thus, the philosophy of biology addresses those questions that arise from biology but that biology cannot answer, at least not yet, and the further questions about why biology may be unable to answer these questions.

Philosophy and language

So, what are these questions biology raises but cannot address? Here are some candidates:

1 Is life a purely physical process? Are biological processes "nothing but" complex physical and chemical ones? If so, what does this mean for the science of biology as an independent discipline?

2 Does evolution have any goal or purpose, perhaps one that might give our existence meaning or intelligibility?
3 Is there any such a thing as evolutionary progress? Is complexity increasing in evolution? If so, is that increase inevitable? And what, if anything, does increasing complexity say about values? Are more complex organisms somehow better than, or higher forms of life than, less complex ones?
4 Does the theory of natural selection conflict with theism, and, if so, how can we rationally choose between them?
5 What is human nature? Which of our traits are essential to us? Are some traits innate? Do any determine our characters more than others? Are they fixed or not? Are socially important human traits more the result of heredity, nature, and our genetic programs than the result of learning, nurture, and our environments?
6 To what extent are humans adapted in the biological sense? To what environmental conditions are we adapted, and at what level does this adaptation occur—the individual human, the family or the lineage, the whole population, or perhaps the species?

If we ask any one of these questions, almost inevitably the right initial response turns out to be: "It depends." And what it depends on is the meaning of key words in each of the questions. How we eventually answer these questions will turn on what meaning we agree to confer on terms such as "life," "purpose," "progress," "complexity," "theism," "genetic program," "adaptation," and so on. For this reason a great deal of the philosophy of science, and analytical philosophy generally, is given over to the clarification of the meaning of the concepts in which questions are framed. Philosophy is not itself an experimental, observational discipline. It does not have its own domain of data about the world. Rather, philosophy addresses the questions raised by the sciences—at least in part—by clarifying the concepts on which these questions hinge.

Sometimes, the result of such a philosophical analysis is to show that a question is ambiguous and that the difficulty or debate about its answer reflects the failure to see the ambiguity. It might reveal that a crucial concept such as "life," "program," or "adaptation" has two or more alternative meanings. Armed with this insight, we can then decide which alternative meaning is relevant and appropriate. This may not settle the matter. The focal question may remain unanswered. But at least we will have a clearer idea of what the question means. And we will also have a clearer idea of what would count as a satisfactory answer.

How do we go about deciding on the meaning of a crucial concept? Only rarely will looking up the word in a dictionary help, for dictionaries usually provide many alternative meanings and our problem is to decide which among the alternative meanings is the one relevant to our inquiry. Just try to answer the question whether life is wholly a matter of physical and chemical

processes by looking up the word "life" in a dictionary. Moreover, many of the concepts with which the philosophy of science is concerned are discussed in technical terms, neologisms, the meaning of which are given in large part by the scientific theories in which they figure. Consider the term "positive charge" in physics. Suppose someone asked what it is that positively charged protons have and that negatively charged electrons lack (the word positive implying that something is present or added and negative implying an absence or loss). This silly question simply reflects ignorance of the relevant theory and a reliance on the dictionary meanings of "positive" or "negative." To be clear on the meaning of the concepts with which the philosophy of biology deals, we need to understand the scientific theories in which these concepts figure. This of course makes the biologist who understands these theories at least as much of an expert on questions in the philosophy of biology as the philosopher!

So deciding on the meaning of a scientific concept requires that we understand the theory in which it figures. Further, understanding a scientific theory requires that we be able to identify the domains in which it explains and predicts phenomena, and the experimental techniques and instruments that can be employed to test the theory. And, indeed, many of the questions the philosophy of biology considers are questions about the domain of a theory and the domain's appropriate methods of investigation. Consider, for example, question 6 above, about whether biological theory can explain human social phenomena. Does the domain of the notion of adaptation by natural selection include human behavior? In other words, is human behavior the sort of phenomenon that the theory could in principle explain? Does the theory's domain extend to human societies? Just what is the range of entities to which the notion is applicable?

What all this means is that the process of identifying the meanings of the scientific terms we need to make our philosophical questions unambiguous is not really separable from the development of scientific theory itself. It also means that the difference between philosophy and theoretical science is not a matter of kind but of degree. Of course there will be differences between laboratory and field science on the one hand and theory and the more abstract inquiries of the philosopher on the other, but these differences lie on a continuum. Because philosophers' interests are abstract, they do not require laboratories. Instead, they often proceed by undertaking "thought experiments." Philosophers will often have to create "science fiction" scenarios, to explore scientifically impossible scenarios, in order to extract the logical relations of implication, exclusion, and compatibility between scientific theories and data—and among theories themselves. Scientists are advised not to lose patience with such explorations. For one important aspect of scientific progress is—beyond the increasing precision of tests that confirm or falsify scientific theories—the broadening of the domain of those theories. And such advancement requires the same kind of thought experiment, albeit more tightly constrained by immediately available data than the philosopher needs to worry about.

Once the key terms in a question have been made clear, we can turn to considering how it may be answered. Of course, it may be that, once made clear, a question no longer troubles us. Perhaps the answer to the question is obvious, or perhaps the question rests on a false presupposition, or is otherwise "defective" in a way that is obvious. Not every interrogative sentence expresses a bona fide question. Some are what philosophers call "pseudo-questions." Some obvious examples include the following: "Do green ideas sleep furiously?" "What time is it on the sun when it is noon at Greenwich, England?" or "Did you phone your wife?" asked of a 10-year old girl. The first of these "questions" looks grammatically like one, but once we know the meanings of the terms that express it, we see that it is a pseudo-question, one that has the right syntax but really has no coherent content. The second question can be disposed of once we recognize that local time at a point on the Earth depends on the Earth's position with respect to the sun, and it makes no sense to ask what the sun's position is with respect to itself. The last question makes syntactic and semantic sense but is based on several false presuppositions: that the pronoun "you" refers to a married person, and a married male person to boot. None of these questions can be answered, but they can be disposed of as not needing answers. Some philosophers have held that many or all philosophical questions are like these pseudo-questions. On their view philosophical problems are dissolved, not solved. They are disposed of, not answered.

Suppose that one held, as some scientists who have no patience with philosophy do, that there are no real philosophical questions, no questions in the philosophy of science. One might hold, for example, that all real questions can, at least ultimately, be answered by science, given enough genius, enough time, and enough money, leaving nothing to philosophy. On this view, questions such as "What is time?" or "Is abortion morally wrong?" will turn out to be either questions to which empirical inquiry broadly considered can give definitive answers or pseudo-questions expressing pseudo-problems that need dissolution, not solution. If all real questions can be answered by science, then there is no such subject as philosophy, defined as the discipline addressing questions not answered by science and questions about why science cannot answer these questions.

The view that science will ultimately answer all real questions and that the remainder will turn out to be pseudo-questions, faces a serious problem, however. For it must be granted that there are many questions raised by science that it cannot *yet* answer. And in that case, why be so confident that all these questions are either answerable by science or pseudo-questions? There are only two ways to respond. The first is quite tedious. It is to take on each and every apparently unanswerable question and show what is the matter with it, show why we need not take it seriously, or else show that it is in principle answerable. The second is to show that in principle there can be no real questions beyond the reach of science. But notice that either of these two endeavors is properly and recognizably a philosophical project! We

have a right to conclude, therefore, that even those who assert that science alone will eventually answer every real question owe us an argument for this claim, and that any such an argument will be a philosophical one. That makes philosophy pretty much unavoidable, even for those who deny that there are any real questions for philosophy to address.

In any case, in the absence of such an argument, we can safely assume that the sciences really do raise questions that they cannot answer and that once we have identified these questions, the philosophy of science should address them.

The agenda of the philosophy of biology

Darwinian theory is central to the philosophy of biology. One reason is its relevance to the questions listed at the beginning of the previous section, questions that interest almost all thinking people. Another is the very large amount of evidence that the theory is correct, a claim that cannot be made by other theories—coming mainly from the social and behavioral sciences—relevant to those same issues. In the physical sciences, there are other theories that are more strongly confirmed by scientific experiment. For example, quantum electrodynamic theory makes predictions that have been confirmed to 12 decimal places. That is an accuracy roughly equivalent to measuring the distance from the tip of the spire of the Empire State Building in New York City to the point of the Space Needle in Seattle to within the breadth of a single hair. But, for all its accuracy, the theory appears to have little explanatory relevance to human life. The atomic theory that stands behind the Periodic Table of the Elements is also a very well-established theory with ever-increasing application in technology and engineering. But its account of the chemical relations among the atoms that compose our bodies, for all its completeness, will not answer questions about human nature, human behavior, human institutions, and human history. Darwin's theory does not attain the standards of accurate prediction and detailed explanation that theories in physics and chemistry do, but it is potentially far more relevant to questions about ourselves.

On the other hand, there are theories in the social and behavioral sciences that, unlike Darwinian theory, were developed explicitly to explain and (more recently) to predict human behavior, human action, and the large-scale social processes, i.e. culture and history. Indeed, social and behavioral scientists have been offering such theories at least since the late nineteenth century. Most of them should be familiar: Freud's psychodynamic theory, Skinner's behavioral learning theory, the competing theories of social structure and function attributed to Durkheim and Weber, Marxist economic theory, classical, Keynesian, and neoclassical economic theory, and their successors. One reason that there are so many such theories, and that we could go on listing others, is that none has secured anything like the scientific confirmation required for general acceptance in science, social or natural, and therefore we

continue to seek more such theories. Were any of these theories well enough confirmed, we might be able to rely on them to explain human affairs, or at least to do so to a greater extent than a theory such as Darwin's, which may have significant implications for the human sciences but secures its considerable scientific support in other domains. Alas, none of these theories has secured general acceptance in its discipline to match the well-established role of Darwinian theory in biology.

Darwin's theory of natural selection and its subsequent scientific elaboration more fully combines explanatory relevance to human affairs with independent scientific confirmation than any other theory in science. And this is what makes the theory a potential lightning rod for public controversy. Exploring its implications for humans, some see in it the gravest threat to religion generally or theism in particular. Others find in it the rationalizations for the worst excesses of capitalism. Some treat it as destructive of the very essence of our humanity, on which our values and the very meaning of life depend. Still others see Darwinian theory and the biological understanding it inspires as finally providing the basis for an enduring moral concern for all living things and the planet on which we and other living things find ourselves.

Whether or not Darwinian theory has any such implications is a question that biology certainly cannot yet answer. It may turn out to be a question that biology can never answer. And that of course is what makes the question a philosophical one. And it explains why the philosophy of biology has become so consequential a subject, so consequential that among all the technical subdisciplines of philosophy it is about the only one to find itself represented on bestseller lists, to be expounded in courts of law examining constitutional issues of church and state, and to be the subject of debate in popular culture generally.

The aim of this book is to shed light on at least some of these human questions, but to do so we will need to guide the reader through the narrower scientific and philosophical issues on which answers to the big questions may turn. Thus, a great deal of our concern will be with matters the relevance of which for the lively public debates—the nature–nurture debate, the intelligent design debate, and so on—may not be obvious until understood. To get to the big questions, we will need to travel through issues that may look technical, complicated, and even out of touch with the target questions. We think, we hope, that the pay-off is worth the journey, and also that the journey itself will prove valuable in its own right.

Decades ago, the famous evolutionary biologist Theodosius Dobzhansky wrote, "Nothing in biology makes sense except in the light of evolution." This statement needs some explanation and qualification. First, evolution is descent with modification, the notion that all organisms are modified descendants of a common ancestor. It is broader than Darwin's theory of natural selection, which is a mechanism of change, an explanation for how modification occurs. (And as will be seen, selection is not the whole story.) Second,

the statement overreaches somewhat. Biological questions can be posed the answers to which involve evolution only very indirectly (for example, questions relating to the physical properties—the biomechanics—of biological materials). Nevertheless, understood as a claim about shared ancestry, as well as natural selection, we think it is close to true. And that is why, as will be seen, evolution emerges as central in every chapter and virtually every section of this book. Biology is inescapably historical.

We begin in the first chapter by discussing the theory of natural selection, its structure, the scientific problems it raises, common misunderstandings of the theory, and its major metaphysical consequence, the extension of the mechanistic worldview of the physical sciences to the life sciences. This extension raises an epistemological problem about the kind of knowledge that biological theory provides. For Darwin's theory does not look much like the sorts of theories familiar in physics and chemistry, the explanatory and predictive powers of which have vindicated mechanism as a metaphysical worldview for these disciplines. Differences between biology and the physical sciences, and indeed between it and the human sciences, must be reflected in the epistemology of biological science, in the kinds of knowledge it provides. For this reason, philosophers of biology have been as interested in the grounds of the theory of natural selection as in its structure. In Chapter 2 we consider how and why scientific theory should turn out to look so different in biology from the way it looks in physics. We do so by examining the question of why there seem to be no scientific laws in biology, or none to rival those of physical science in scope, simplicity, and power. Answering this question will reveal a great deal about the nature of biological theory and also shed light on the human sciences too, as we shall see in the last chapter.

Chapter 3 continues the examination of epistemic issues raised by Darwinian theory, in particular three "technical issues" about evolution that vex biology but that are often invisible to nonspecialists. One is the nature and extent of biological adaptation and the role of constraints of various kinds in shaping organismal design. It will turn out that adaptation and constraint—often considered to be alternatives in evolutionary explanation—are for certain kinds of questions jointly essential to explanation. The second is the role of statistics and probability in biology. It will be seen that the notion of objective chance—so essential to Darwinian thinking—is only imperfectly understood and remains problematic. The third is the foundation of functional explanation and description. We will show that two very different conceptions of function survive in biology, and that the imperfect overlap between them has consequences for how questions about function are posed and answered, both in biology and in the social sciences. In general, we try to show how these apparently abstract matters bear on the larger questions that drive interest in the philosophy of biology. For example, we show in this chapter how the problem of reconciling the theism of the Abrahamic religions with biology's commitment to natural selection turns in part on how we are to understand "probability" and "drift."

Chapter 4 examines the relationship between molecular biology and the other subdisciplines of biology, from cell biology to paleontology. It raises the question of whether all biological processes can or must eventually be explained by theories about their macromolecular constituent processes. The issue is reductionism. Biologists and philosophers have argued mainly against reductionism, yet it persists both among many physical scientists and even a few prominent biologists. It is clear that answers to the reductionism question will drive a good deal of future scientific research in the discipline. Further, the reductionism question is relevant to a number of important philosophical issues such as the mind–body problem and determinism versus free will. All of this makes reductionism a threat or a promise that few philosophers or biologists will be neutral about. Reductionism is a very old issue in biology. But in addressing it we cover some new territory, issues that have arisen or become especially problematic only in recent decades on account of new discoveries. One is the problem of what is a gene. The modern understanding of genetic mechanisms makes the concept of a gene problematic, varying as it does from one research context to another. The gene of molecular biology seems not to refer to the same concept as the gene in population genetics. If population biology is reducible to genetics, in what sense of the word "gene" is it so reducible? Another issue has to do with the dynamics of complex systems of interacting components, such as the gene networks in an organism are said to be. Such networks seem, from an antireductionist standpoint, to have higher-level properties and to be affected by higher-level controls, that raise new challenges to the reductionist view. Finally, the principle of natural selection seems to present a barrier to the reduction of biology to physical science. In particular, it seems to create an unbridgeable gap between explanation at the level of chemistry and physics and that at the level of macromolecules. If so, then the scope of reduction will be limited, necessarily coming to an end at the level of molecular biology.

In the last three chapters of the book, we turn to some more specific issues. The question of whether evolution is progressive—raised briefly in Chapter 1—is addressed at length in Chapter 5, along with the further issue of the evolution of complexity. Progress has an evaluative component, which raises the question of whether it is even a proper subject for putatively value-neutral science. If it is, if progress can be understood in a way that makes it suitable for scientific study, what does evolutionary theory predict about progress? Is it an expectation or merely a possibility? And then, what is the relationship between progress and complexity? If they are related, what does the history of life tell us about complexity and how it changes? The discussion reveals how advances in empirical science sometimes can hinge critically on advances in conceptual clarification.

In Chapter 6, we return to the connected questions of metaphysics and epistemology that biology raises. The metaphysical ones are those about whether, along with genes, cells, and organisms, biology must recognize "higher levels" of organization—for example groups or societies of

organisms—and questions about whether there is something causally unique about genes and the genome that should accord them a special explanatory role in biology. Finally, in Chapter 7, we consider the relationship between biology and the social sciences and, more narrowly, between biology and human nature. Humans are members of a biological species, and therefore arguably human adaptations are not exempt from the operation of natural selection. But the degree to which human psychology and behavior is molded by selection, and the mechanism by which it is molded—for example by selection at the level of the individual versus the level of the group—are open questions. And then there is a pressing further question: if biology *is* relevant to human affairs, what are the implications for distinctively human concerns such as ethics?

Our outline of the agenda of the philosophy of biology is not aimed at settling any of its debates. Indeed, the authors of this book have divergent views about almost all of the unavoidable questions biology raises and cannot (yet) answer. Our aim is to provide the reader with the resources to see how serious the questions are and what would count as good answers to them.