BOOKS: PHILOSOPHY OF SCIENCE

Structure for Theories of Biology

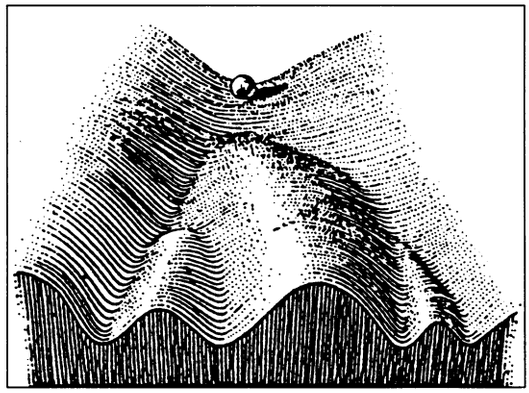
Ernst Mayr

Fifty years ago, there was no philosophy of biology. Biology was dealt with as part of a philosophy of science based on mathematics, logic, and physics. Now a new book with the words "philosophy of biology" in its title is published almost every year. Sterelny and Griffiths' *Sex and Death*, as its subtitle clearly states, is an introduction to the philosophy of biology.

Sex and Death
An Introduction to Philosophy of Biology
by Kim Sterelny and Paul E. Griffiths
University of Chicago Press, Chicago, 1999. 456 pp. $60, £47.95. ISBN 0-226-77303-5. Paper, $22, £17.50. ISBN 0-226-77304-3.

There are two ways to present such a philosophy. One can base it on biology's principal philosophical concepts such as population thinking, the dual causation (physical laws and genetic programs) of all biological processes, teleology or its absence (the lack of goals), reductionism, modes of selection, pluralism, continuity versus discontinuity, prediction, and emergence. Alternatively, one can focus the discussion on major biological phenomena or processes—the nature of life, genes, phenotype development, gene regulation, targets of selection, species, speciation, territory, asexuality, adaptation, niche, biodiversity, extinction, and emotion. The authors have chosen this second focus. The result is in some respects more of a theoretical biology than a philosophy of biology. In either approach, however, largely the same controversial issues have to be dealt with.

When dealing with controversies, Sterelny and Griffiths have adopted a very useful approach. Within the last 15 or 20 years, a favored solution for most controversial problems has emerged. The authors call this the "received view." In a most stimulating manner, the authors also present the various opposing views, with extensive references to the relevant literature. This provides readers with the opportunity to make their own decisions as to the validity of the conflicting interpretations. Although the solution the authors favor is usually evident, the presentation is sometimes so neutral that one cannot guess their preference. I found the listing of the literature under each problem remarkably complete. These references will be immensely helpful to anyone first approaching one of these problems. Only in the coverage of the older literature did I note some misses, such as D. Lack's refutation of group selection and W. Bock and G. von Wahlert's very important discrimination between physiological function and ecological role. Entire chapters are devoted to the philosophical aspects of particular biological disciplines, such as ecology and developmental biology. One can, perhaps, complain that so much space has been given to the media stars R. Dawkins, S. J. Gould, and E. O. Wilson, while some of the more basic aspects of the philosophy of biology have been neglected in comparison. Still, I warmly recommend this book as a helpful first introduction into the philosophical problems of biology.



Controlling topography. C. H. Waddington's representation of developmental canalization. The path of the descending ball, which represents the organism's developmental trajectory, is determined by the landscape shaped by the effects of all of the developmental inputs to the organism.

There are, however, a number of decisions made by the authors that can be criticized. Perhaps sometimes their knowledge of biology is not quite adequate for a fully satisfactory analysis. Much of their treatment is presented on the basis of the gene-based concepts of replicators and interactors. Unfortunately, they missed E. Sober's helpful distinction between "selection of" and "selection for." "Selection of" refers to the biological entity (gamete, individual, social group) that is the target of selection, while "selection for" indicates the particular attribute for which this entity is favored by selection. The authors' arguments in favor of genes as objects of selection are mostly based on "selection for" evidence. Their emphasis on identity in replication is perhaps responsible for the fact that variation is rather shortchanged in their treatment. What they say about variation is perfectly correct, but they fail to bring out that without the astonishing extent and ubiquity of variation, the whole process of selection would have never been able to produce the remarkable organic diversity.

Nor is the extraordinary importance of pluralism in biology (in contrast to the physical sciences) sufficiently emphasized. Most sexually reproducing organisms belong to biological species, but there are also agamospecies, which replicate without the sexual process. Speciation in mammals and birds, and presumably in most other animals and most plants, occurs through geographic separation; but in other groups, sympatric and instantaneous speciation, to give only two possibilities, are quite frequent. To be sure, the authors rightfully mention that several major controversies in biology were terminated by adopting pluralism, a solution exceedingly rare in the physical sciences. Exceptions to "laws" are very common in biology—the major reason why some philosophers deny that there are any biological laws. The biological species concept is based on the claim that species are reproductive communities. Yet, hybridization occurs not infrequently because the isolating mechanisms are "leaky." Anyone going into biology expecting to find the sorts of exceptionless laws that characterize physics will be sorely disappointed.

In the chapter on reduction, the authors fail to make clear that the need for analysis is accepted by every anti-reductionist. Analysis, however, is not the same as reduction. Furthermore, it seems that Sterelny and Griffiths fail to realize that there is a great difference between species concept and species taxon. In a species concept, one expresses one's views as to the role of species in nature. A species taxon is an aggregate of populations one assigns to a named species. Some of the recently proposed so-called species concepts do not qualify as concepts but are simply operational methods for how to delimit species taxa. And, in their discussion of classification, the authors adopt the cladists' claim that similarity should not be used as a basis for a classification. But prior to W. Hennig (1950), every philosopher, every leading systematist, and virtually all practitioners (librarians, retailers, philolo-

CREDIT: FROM C. H. WADDINGTON, *THE STRATEGY OF THE GENES* (ALLEN AND UNWIN, LONDON, 1957).

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gists, and so forth) agreed that the very diagnostic criterion of a classification is that it is based on similarity. All but the cladists have maintained this view. Hence it has been quite correctly said that "cladistic classification" is an oxymoron.

All in all, I have much praise for *Sex and Death*, but it must be read critically.

BOOKS: DECISION-MAKING

Calculating the Chances

John S. Evans

Richard Wilson, a pioneer of risk assessment, notes that its essence "is the application of ... knowledge of past mistakes in an attempt to prevent new mistakes in new situations" (*1*). Put this way, risk assessment sounds as natural as breathing.

William Ruckleshaus, a former administrator of the U.S. Environmental Protection Agency and strong proponent of risk analysis, characterized it as "the attempt to quantify the degree of hazard that might result from human activities; a kind of pretense to avoid the paralysis that would result from waiting for definitive data; somewhat of an intellectual orphan" (*2*). He also noted that many scientists are uncomfortable with risk analysis because it uses scientific data "in a way that is outside of the normal constraints of science." Put this way, risk assessment appears necessary but perhaps a bit less informative and somewhat more controversial than one might have hoped.

More recently, the Environmental Research Foundation published an article on the Internet entitled "The Waning Days of Risk Assessment" in which Peter Montague asserted that "[r]isk assessment, it is now clear, promises what it cannot deliver, and so is misleading at best and fraudulent at worst ... Risk assessment is inherently an undemocratic process because most people cannot understand the data, the calculations, or the basis for the risk assessor's judgment" (*3*). Put this way, risk assessment seems treacherous.

What, then, is risk analysis? And where can one turn to learn what all the fuss is about?

Should We Risk It? Exploring Environmental, Health, and Technological Problem Solving
by Daniel M. Kammen and David M. Hassenzahl
Princeton University Press, Princeton, NJ, 1999. 424 pp. $39.50, £23.95. ISBN 0-691-00426-9.

Should We Risk It?, an exciting new text by Daniel Kammen and David Hassenzahl, explores the nature and methods of risk analysis through a set of carefully selected, critically analyzed and clearly explained problems. An introductory chapter provides an overview of the history and philosophy of the field. Nine substantive chapters cover the scientific and analytic foundations of risk assessment: modeling, statistics, uncertainty, toxicology, epidemiology, exposure assessment, technological risk, decision analysis, and communication. Each chapter includes an extensive set of solved problems, which provide a grounding in the scientific concepts and analytic methodologies underlying the field. These examples introduce the reader to many of the substantive environmental health problems where risk assessment has been instrumental in the analysis of public policy.

The basic principles of epidemiology are taught through examinations of data on lung cancer in smokers and non-smokers, cholera in London during 1853–54, leukemia in workers exposed to benzene at Pliofilm rubber manufacturing facilities, and the spread of the AIDS epidemic in the United States from 1982 to 1996. Rather than starting with a lengthy set of definitions, terminology, and formulae, Kammen and Hassenzahl dive straight into the data and use a series of thoughtfully crafted questions to guide the reader on a fascinating tour of the field.

The authors consider toxicology from an analytic perspective, using data from rats exposed to a hypothetical pesticide (Kill-EZ) and data from mice exposed to benzene via oral gavage (delivered through a tube into the stomach). The reader is asked to use the Kill-EZ data to determine whether the pesticide is a rat carcinogen or a human carcinogen and, if it is a carcinogen, to determine its potency. The data from the experiments with benzene are used to explore maximum likelihood estimation of three different dose-response models and to examine the issue of interspecies scaling. The authors' approach is informative, although it may disappoint those looking for complex diagrams of the mechanisms of particle deposition in the alveoli, detailed descriptions of the biochemistry governing receptor-ligand interactions in endocrine modulation, nuanced discussions of the role of peroxisome proliferation in cancer induction, or similar aspects of the biology underlying the risks.

Grandville's *Infinity Juggler*.

The primary strengths of Kammen and Hassenzahl's book are its careful, but intuitive, development of the nature of models; its extensive use of worked problems; and the sophistication and balance of its approach to the relationship between science and policy. For all its strengths, the book does have a few weaknesses: somewhat too strong an emphasis on methods for assessing cancer risks; a tendency to unduly limit citations and reference lists; and a relatively weak chapter on exposure assessment. In addition, the authors have been a bit too assiduous in their effort to minimize the use of unnecessary technical terminology.

Should We Risk It? would serve well as the textbook for an introductory undergraduate course in risk assessment or, with supplementary readings from the current literature, as the basic text for a graduate course. Perhaps more importantly, the book is written in a way that it should be accessible to nearly any scientist with an interest in the field.

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References
1. R. Wilson and E. A. Crouch, *Science*, **236**, 267 (1987).
2. W. D. Ruckleshaus, *Issues Sci. Technol.*, **1**, 19 (1985).
3. www.rachel.org/bulletin/bulletin.cfm?Issue_ID=1479 (27 May 1999).