The Epistemology of Development, Evolution, and Genetics

Collected for the first time in a single volume are essays that examine the developments in three fundamental biological disciplines – embryology, evolutionary biology, and genetics – which were in conflict for much of the twentieth century. The essays in this collection examine key methodological problems within these disciplines and the difficulties faced in overcoming the conflicts between them. Burian skillfully weaves together historical appreciation of the settings within which scientists work, substantial knowledge of the biological problems at stake, and the methodological and philosophical issues faced in integrating biological knowledge drawn from disparate sources. The final chapter describes what recent findings in developmental biology and genetics can tell us about the history and development of animals.

Written in a clear, accessible style, this collection should appeal to students and professionals in the philosophy of science and the philosophy and history of biology.

Richard M. Burian is Professor of Philosophy and Science Studies at Virginia Polytechnic Institute and State University.

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Selected Essays

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For Anne:
Companion, friend, constant source of inspiration;

and for three people without whom this book would not exist:
Jean Gayon, Marjorie Grene, and Michael Ruse

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Preface

Forty-one years ago, in August 1963, I entered graduate school in the Department of Philosophy at the University of Pittsburgh. At that time, the "post-positivist" reaction to logical empiricism in philosophy of science was well under way, although not yet in full swing. In evolutionary biology, the "synthetic theory of evolution" seemed to have won a clear victory over its major rivals. In molecular biology, Watson and Crick's proposed structure for DNA, just a decade old, was widely accepted and was serving as a fulcrum for restructuring genetics as part of molecular biology, even though "the" genetic code had not yet been fully solved. (I use scare quotes because, within twenty years after the code was fully deciphered in 1966, it was discovered that some organisms have small systematic variations in the correlations between codons and amino acids. The code can vary even within a single organism: The mitochondria of many organisms employ slight variations on the standard code so that the nuclear and mitochondrial codes differ in specific ways.)

As a physics major and then as a math major in college, I had taken no courses in biology. But, my father was a research ophthalmologist and, within two years of starting graduate studies, I realized that the sort of work he did (which I knew largely by osmosis) did not fit well with the dominant positions in philosophy of science. The then-current philosophical attempts at linguistic and structural analyses of confirmation, explanation, falsification, and "rational reconstruction" of theory-based reasoning seemed of little value in providing accounts of the work that, on minimal knowledge, I took to be central within much of biology. By the time I left Pittsburgh, I had resolved, when possible, to spend a year studying one or two branches of biology. Ideally, the disciplines in question should have strong theoretical components, yet they should involve both field observation and laboratory experiments. Thanks to a generous study fellowship from the American Council of Learned Societies and the sponsorship of Stephen Jay Gould and Ernst Mayr, I was

able to do just that in 1976–7, studying mainly evolution, genetics, and their histories at the Museum of Comparative Zoology and the Department of History of Science at Harvard University. Mayr was on leave for half the year, so I worked mainly with Gould and Richard Lewontin, taking courses not only with both and participating in their lunch seminars, but also with E. O. Wilson, Fotis Kafatos (a developmental biologist), Mark Ptashne (a molecular geneticist working on phage λ), and a number of other leading figures in allied fields. This was a major turning point in my academic career. I was fascinated by the biology I studied, the disputes among the leading figures in numerous biological disciplines, the variety of the experimental and fieldwork brought to bear to support or to test hypotheses, and the extent to which resolution of disputes depended on appropriate technology (including, in many cases, suitably "domesticated" laboratory organisms appropriate to the problem at hand). I was struck by the extraordinary difficulty of giving an adequate account of explanations that crossed (ill-defined) "levels" – molecular versus cellular, organismal versus populational, ecological versus evolutionary, and the like.

It is fitting to acknowledge here the transformative influence of Marjorie Grene on my work in history and the philosophy of biology. All but two of my articles in these domains were begun after I sat in on a course on evolutionary biology that she taught at Temple University in 1979. Shortly afterward, she asked me to assist her in running a summer institute on teaching the philosophy of biology held at Cornell University in 1982 under the auspices of the Council for Philosophical Studies. A group of us from that institute, joined by many others in the Autumn of 1982, organized a series of informal meetings that evolved into the International Society for History, Philosophy, and Social Studies of Biology (known as Ishkabibble, or just ISH, to its friends). The spirit of cooperative interdisciplinarity of that summer institute, also embodied in the meetings of Ishkabibble, helped to shape my work. I hope that the chapters of this book convey some of the sense of community we had then and that they reflect how much I learned from working in collaboration with others.

Indeed, I have been fortunate to work with historians and philosophers interested in biological topics and with biologists working on development, evolution, genetics, and the theoretical biology of complex systems. Due to the defects of my memory, I am often unable to disentangle the extent to which my work draws on the contributions of many friends, collaborators, critics, and students. I apologize here to all of those whose contributions I fail to mention, for I owe an enormous intellectual debt to many individuals beyond those named in this preface. I am also glad to acknowledge, with

gratitude, the support of my colleagues in Philosophy and in Science and Technology Studies at Virginia Tech. Perhaps the most influential among the many people who have helped me rethink my views along the way are the three Gs: Jean Gayon, Scott Gilbert, and Marjorie Grene. Their influence has been matched (and tempered) by Ron Amundson, Robert Brandon, Lindley Darden, Michael Dietrich, Stuart Kaufman, Richard Lewontin, Jane Maienschein, Anne McNabb, Robert Richardson, Denis Thieffry, William Wimsatt, Doris Zallen, and many others. I am grateful to these dear friends and to a host of others. I am also grateful to Andrew Garnar for his help with many matters connected with this book, especially for his help in preparing the illustrations.

Finally, and most important, Anne McNabb has been a constant friend and companion for twenty years. She not only has been enormously supportive but also has been always ready with a challenge whenever I grew complacent. To her, I owe far more than I can ever say or repay.