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Marcel Weber

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Philosophy of Experimental Biology

Philosophy of Experimental Biology explores some central philosophical issues concerning scientific research in modern experimental biology, including genetics, biochemistry, molecular biology, developmental biology, neurobiology, and microbiology. It seeks to make sense of the explanatory strategies, concepts, ways of reasoning, approaches to discovery and problem solving, tools, models, and experimental systems deployed by modern life science researchers and also integrates recent developments in historical scholarship, in particular the New Experimentalism. It concludes that historical explanations of scientific change that are based on local laboratory practice need to be supplemented with an account of the epistemic norms and standards that are operative in science. This book should be of interest to philosophers and historians of science as well as to scientists.

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For Andrea, Liliane, and Ardian

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Preface

In the century between the rediscovery of Mendel's laws (1900) and the completion of the Human Genome Project (2001), biology has come a very long way. During this time, biologists have made spectacular advances in understanding the cellular and molecular basis of life. This knowledge has considerable potential for improving people's lives – a potential that is only beginning to be realized. Thus, in terms both of the knowledge it produces and of the technological opportunities it offers, modern experimental biology is one of the most successful scientific endeavors of all time. Yet remarkably little is known about its epistemology and the underlying metaphysics.

This book explores some central philosophical issues concerning scientific research in modern experimental biology, that is, in areas such as genetics, biochemistry, molecular biology, microbiology, neurobiology, and developmental biology. Evolutionary theory – traditionally the center of attention in the philosophy of biology – only appears marginally, and only where it is relevant to understanding experimental biology. There already exists a massive amount of philosophical literature on evolutionary theory (including a book by this author, Weber 1998a), while experimental biology has not received the philosophical attention that it deserves and needs.

In addition to filling this gap, the present work also reveals a certain independence of experimental biology from evolutionary theory. This is not necessarily to imply that Theodosius Dobzhansky was mistaken when he said, "Nothing in biology makes sense except in the light of evolution," but perhaps that there are different ways of making sense of things. This book is an attempt to make sense of the explanatory strategies, concepts, ways of reasoning, approaches to discovery and problem solving, tools, models, and experimental systems deployed by modern life science researchers. To a considerable extent, this can be done independent of evolutionary theory. However, I will also show where evolutionary thinking is indispensable.

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The readers I have in mind are philosophers and historians of science as well as practicing scientists. To the latter group of potential readers, apologies are extended for the strange questions sometimes asked by philosophers. Philosophy is a long and highly elaborate discussion that has been going on for more than 2,000 years now, and some of the questions raised by philosophers today are a result of things that were said by other philosophers centuries ago. But philosophy and modern science are birds of a feather. Their common historical origins should ensure that communication is possible across the boundaries of today's academic specialties. I have tried to facilitate this by providing brief introductions to the philosophical issues at the beginnings of the chapters, and to the scientific principles involved when I discuss actual examples from experimental biology.

Teachers may find the book helpful for a graduate-level course in philosophy of biology. In particular, it could complement the standard readings in philosophy of evolutionary biology. For courses in general philosophy of science, this book covers some of the central problems in the field, such as laws and explanation, reduction, scientific inference, experimentation, discovery and problem solving, and scientific realism. Traditionally, these issues are treated in the context of physics. But classical physics is outdated, while contemporary physics is incomprehensible to anyone without a Ph.D. in physics. By contrast, the science covered in this book should be accessible to everyone with some basic knowledge of biology.

If the book should lead students, teachers, and researchers to a deeper appreciation of some of the exciting philosophical problems that lurk behind the headline-making scientific discoveries of modern biology, my aim would be fulfilled.

Acknowledgements

Special thanks to Paul Hoyningen-Huene for his continuing support. The great team spirit at the center for Philosophy and Ethics of Science at the University of Hannover has been a major inspiration during the genesis of this book. A part of the book was written in spring 2001 at the Max-Planck-Institute for the History of Science in Berlin. I am grateful to Hans-Jörg Rheinberger and his group for giving me access to their stimulating intellectual community and for their patience in listening to a philosopher's problems. Martin Carrier, Paul Hoyningen-Huene, Peter McLaughlin, and three anonymous readers for Cambridge University Press have read drafts of the whole work and have provided valuable criticism. Individual chapters were read by Roberta Millstein, Tatjana Tarkian, Hanne Andersen, Douglas Allchin, Jay Aronson, Hans-Jörg Rheinberger, Howard Sankey, Ken Waters, Daniel Sirtes, Werner Eisner, Ingo Brigandt, Helmut Heit, Renato Paro, Ulrich Stegmann, and Eric Oberheim. Their numerous objections, criticisms, comments, and suggestions (as well as some kind words and a few insults) allowed me to write a much better book than I could have accomplished all by myself. Of course, none of these colleagues should be held responsible for any of the shortcomings that remain.

My research has also benefited from discussions with a number of scientists, especially Gottfried Schatz, Walter Gehring, Renato Paro, and Bernhard Dobberstein. Thanks also to Greta Backhaus and Liliane Devaja for their help with the illustrations.

Furthermore, I wish to thank audiences at the Minnesota Center for Philosophy of Science and the University of Minnesota's Studies of Science and Technology Program in Minneapolis, the Max-Planck-Institute for the History of Science in Berlin, the Department of Medical Philosophy and Clinical Theory at the University of Copenhagen, the 1999 Spring School in Science and Technology Studies at the University of Zürich, the Zentrum für Molekulare Biologie (ZMBH) at the University of Heidelberg, and the philosophy

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departments at the Universities of Bielefeld, Heidelberg, Erfurt, and Münster for stimulating discussion of paper presentations related to this book. Last but not least, I thank my editor, Michael Ruse, for his encouragement, and Stephanie Achard for seeing the book through the press.

My apologies go to those colleagues whose original work on the relevant topics is not cited. The literature in the history and philosophy of biology as well as in general philosophy of science has grown vast; I could not read it all.