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Scientific Process and Social Issues in Biology Education

Springer

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ISSN 2366-7672 ISSN 2366-7980 (electronic)
Springer Texts in Education
ISBN 978-3-319-44378-2 ISBN 978-3-319-44380-5 (eBook)
DOI 10.1007/978-3-319-44380-5

Library of Congress Control Number: 2016947760

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG Switzerland

Preface

This book is the product of the authors' teaching introductory biology and related science courses at several different colleges and universities, though primarily at Wesleyan University, Middletown, Connecticut (Baker) and Washington University, St. Louis, Missouri (Allen). One of us remembers in his earliest years of teaching having the distinct feeling that, more often than not, some of his most creative students received only mediocre grades: unmotivated by the presentation of a dazzling array of detailed factual information, they would often ask unexpectedly thoughtful and highly reflective questions. Conversely, students receiving As, while able to regurgitate biological "facts," (e.g., details of the Krebs citric acid cycle), were often totally incapable of mapping out a strategy for investigating even the simplest of research projects. A variation on this theme was the comment of one faculty colleague that he found himself becoming increasingly uncomfortable with the recognition that a few of his students could complete a basic introductory biology course satisfactorily yet still remain convinced of the intellectual validity of Creationism!

These and other such experiences convinced us that students may do well in a science course but fail completely to comprehend the nature of science itself, the underlying reasons for its immense power as an intellectual process, and the relationship between the natural sciences, social sciences, and humanities. Perhaps worse, when considering science at all, students seem to drift from one extreme to another, either buying into popular press versions of science as the ultimate source of all truth or viewing it as just one of many systems of intellectual thought, of no greater or lesser validity than any other. Unfortunately, this latter view is one often found even among the ranks of college faculty in the social sciences and the humanities, in which modern science may be referred to as "just another system of myths," "the predominant myth of the twentieth century," or other words to that effect. Such a view does a profound disservice to the meaning of both the terms "science" and "myth." If indeed modern science is to be viewed as a myth, then clearly it is by far the most powerful one yet devised by the human imagination!

It was in an attempt to deal with this confusion that, over the years, we began to incorporate material into our course designed to confront this and other such problems. Ironically, one of the anonymous reviewers of the manuscript for this

book wrote a comment that reflects beautifully the sort of resistance one encounters to such efforts:

> As part of a debate with faculty over curricular issues some years ago, I asked one of my colleagues how our science students would fare if they were asked to distinguish between science and the humanities. . . . The response of my colleague was silence. This silence was born of what I believe to be a pervasive fact: that those of us who teach science rarely considered these issue so explicitly. . . . It is much easier to present the facts of normal science (what we know) than to consider how we know it.

In one of our earlier books we put forward what we think is the essence of a process approach to science: ". . . it is the process, not merely the content or "facts" of biology, that should form the basic thrust of introductory courses. By the process of science we mean *how we know what we know*; how experiments are designed, data analyzed and conclusions drawn—in short, the logic and method of science."[1] This approach is designed to stress to students that today's scientific "facts" may be tomorrow's errors. In our efforts over the past few years to produce an updated version of our approach, however, we found ourselves immersed in a publishing world far more concerned with the commercial success of encyclopedic and fact-driven textbooks and much less in scientific process. Beyond that, the introduction of full color to both art and photographs has driven the cost to the student of such textbooks to astronomical heights, in some cases, well over $100! As lovely as these books may appear, in this day and age of widespread student access to color TV, photography and the Internet, one cannot help but wonder if such an expense is justifiable. Thus when the Fitzgerald Science Press originally expressed interest in the underlying philosophy of our work and in publishing it as a series of low cost yet high quality, two-color volumes, we felt that a genuine meeting of the minds had occurred.

The format of this book is designed specifically to address the nature of science in general and of the biological sciences in particular. Chapter 1 deals with the historical development of the life sciences and looks ahead to what the field might be like in the next century. It also uses examples of current research in the field to stress that biology, like all the natural sciences, has many unsolved problems researchers today are still trying to understand and is therefore a field no less dynamic now than in the past.

Chapter 2 begins with an in-depth look at biology as a science in the context of hypothesis formulation and the underlying inductive and deductive logic involved. Here we stress the differing types of hypotheses, the role that conscious and unconscious bias may play in both formulating questions and evaluating answers, as well as the strengths and limitations of science as an intellectual discipline.

Chapter 3 deals with how scientific hypotheses are tested and how the logic involved may be analyzed in terms of its inductive and deductive framework. We have often elected here and elsewhere in this book to use older studies from the

[1]Preface, *The Study of Biology,* 4th, edition, Baker, Jeffrey J. W., and Allen, Garland E. Reading, MA. Addison Wesley Publishing Company, 1982, p. v.

seventeenth, eighteenth, and nineteenth centuries. So doing enables us to avoid having to provide a great deal of subject matter background and, since the student reader more than likely already knows the "answer," he or she is forced to concentrate instead on the underlying intellectual structure involved. We then apply insights from these older case studies to contemporary issues: e.g., conflicting hypotheses concerning the cause of the AIDS epidemic now sweeping many developed and developing nations. For those instructors interested in introducing early the concept of statistical analysis in hypotheses evaluation, we provide an appendix dealing with some of the essential concepts and techniques and means used to illustrate experimentally established correlation.

Chapter 4 compares three case studies, the first an example of research carried out in the laboratory and the second an example of research in the field, with all the difficulties in terms of controlling variables that such studies entail. The third case study deals with problems inherent in evolutionary studies in which events have occurred that cannot be observed directly.

Finally, Chapter 5 is concerned with the interrelationship of science and the society within which it develops and the social responsibility of scientists to the society that funds their research. Using Creationism as our example, we end with issues raised by the still all-too-powerful attraction of pseudoscience and its misuse to further a particular political agenda. Doubtless here instructors may wish to bring in other examples of their own.

It is only appropriate here that we express our gratitude for the assistance provided us by the late Irma Morose, Teresa L. Tate (née Lowe), and Cindy Marks. All too often such valuable input goes unrecognized, despite the fact that little or nothing could be accomplished without it. It would be difficult to find greater justification for this book.

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March 2014

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