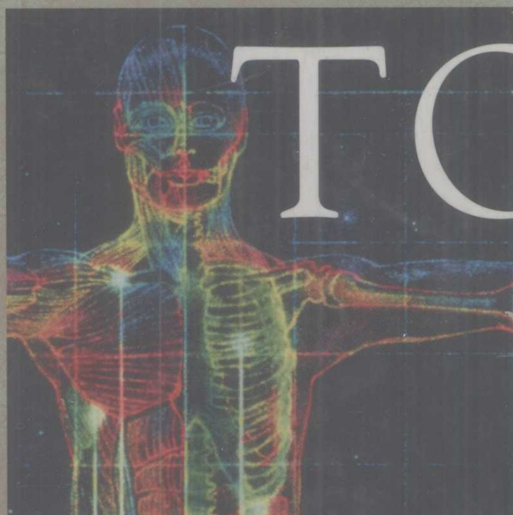
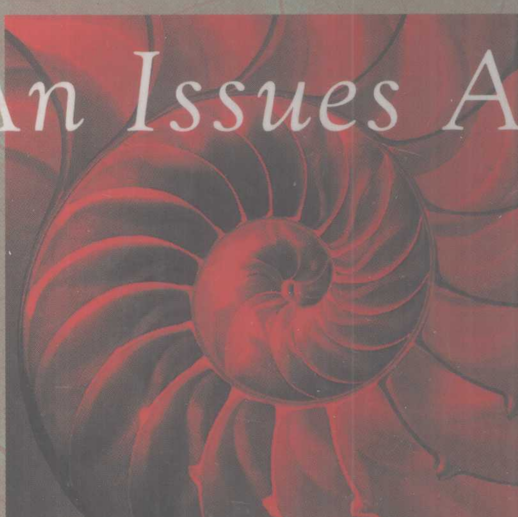
BIOLOGY TODAY



An Issues Approach



SECOND EDITION

Eli C. Minkoff • Pamela J. Baker

BIOLOGY TODAY

An Issues Approach

SECOND EDITION

Eli C. Minkoff
Pamela J. Baker

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Commissioning Editor: Jane Mackarell
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Preface

Our book takes an issues-oriented approach to the teaching of biology, one that emphasizes coherent understanding of selected issues rather than an attempt to cover everything. The issues we have chosen to include are current topics that students are likely to see in the news or are of general interest. It is our belief that students (especially those not majoring in biology) are more likely to remember this material if it is meaningfully related to issues of concern to them. Our approach accordingly helps students to experience the connections among the fields of biology, the interdisciplinary nature of today's biology, and the intimate connections between biological and social issues. We also hope to instill in students the feeling that biology is both interesting and relevant to their lives, and that a further understanding of biology can be a delight rather than a burden.

One of the aims of our approach is to educate good citizens, biologists and nonbiologists alike, with an understanding that will enable them to evaluate scientific arguments and make appropriate decisions affecting their own lives and the well-being of society. We are committed to teaching science as a human activity that impinges upon other aspects of society and gives rise to social issues that require discussion. Citizens are increasingly called upon to deal with science-based issues throughout their lives, in the foods they choose to eat, the medicines they take, and the very air they breathe. Legislators, juries, and corporate managers need to make important decisions, affecting many lives, based in part on the findings of science. We think that all good citizens need to be aware of science and the way that scientists work, and they also need to know how science can be used and how it can be misused.

We are committed as teachers to fostering understanding of biology, what some now call 'biological literacy.' Thus, we have chosen to teach 'facts' in a context that emphasizes how they are produced, organized, and used to solve problems. Subsequently, the issues we have selected are ones that are not only of current importance, but ones that lend themselves as vehicles for teaching the major concepts of biology.

Biology as a discipline has become fragmented to the extent that different perspectives on the same problem, for example, molecular perspectives and environmental perspectives, are often taught in separate courses with no reference to each other. We aim for a more comprehensive view of each issue. The current understanding of each issue is covered from different perspectives, which often include cellular and molecular perspectives, organismal or individual perspectives, and global or population perspectives, combined as appropriate. Coverage of each issue also includes its social context, both historical and contemporary. Phrasing ideas as 'our current understanding' will help students to realize the ongoing nature of discovery and to identify the processes that are necessary for new ideas to be accepted.

Those who have been teaching introductory biology for the last two or three decades have been burdened with the supposition that *absolutely everything* needs to be covered in a single course. Textbooks written in this tradition are weighty, encyclopedic works with a thousand or more pages and hefty pricetags. Students are exposed to the *results* of biology without gaining understanding of biology as a *process of discovery*. It is an understanding of this *process* that we hope to instill in students. To help students appreciate this process, we have presented multiple interpretations or points of view as much as possible. Societal and ethical issues are mentioned wherever relevant, and part of the initial chapter is devoted to an examination of ethical principles. We encourage teachers to set aside time for class discussions to further stimulate student thought, or for students to set up such discussions among themselves informally. With *Biology Today* we aim to stimulate critical thinking and questioning rather than memorization.

We would like to take this opportunity to thank the many people who reviewed portions of this text and provided us with helpful suggestions. In alphabetical order; they were: Lee Abrahamsen, Bates College; Gregory Anderson, Bates College; Andrew N. Ash, Pembroke State University; David Baker; Virginia Bliss, Framingham State College; Bruce Bourque, Bates College; Joe W. Camp, Jr., Purdue University North Central; William J. Campbell, Louisiana Tech University; Phillip D. Clem, University of Charleston; Mary Colavito-Shepanski, Santa Monica College; Diane Cowan, The Lobster Conservancy; Martha Crunkleton, Pitzer College; David Cummiskey, Bates College; Christine P. Curran, University of Cincinnati; Mark Dixon, formerly of Bates College; Elizabeth Eames, Bates College; Lynn A. Ebersole, Northern Kentucky University; Edward Goldin, Columbia University School of Dentistry; Helen Greenwood, University of Southern Maine; David Handley, University of Maine Agricultural Research Station; Pat Hauslein, St. Cloud State University; Susan Hutchins, Itasca Community College; Alan R. P. Journet, Southeast Missouri State University; Donald E. Keith, Tarleton State University; John Kelsey, Bates College; Sharon Kinsman, Bates College; Virginia G. Latta, Jefferson State Community College; Laura Malloy, Hartwick College; Richard J. Meyer, Humboldt State University; Glendon R. Miller; Wichita State University; Nancy Minkoff; Neil Minkoff, Deaconess-Waltham Hospital; Sandra L. Mitchell, Western Wyoming College; Jane Noble-Harvey, University of Delaware; Mark Okrent, Bates College; Lois Ongley, Bates College; Joseph G. Pelliccia, Bates College; Karen Rasmussen, Maine Cancer Research and Education Foundation; Larry G. Sellers, Louisiana Tech University; Gary Shields, Kirkwood Community College; Thomas P. Sluss, Fort Lewis College; Barbara Stewart, Swarthmore College; Gregory J. Stewart, West Georgia College; Robert Thomas, Bates College; Robert M. Thornton, University of California-Davis; Robin W. Tyser, University of Wisconsin; James E. Urban, Kansas State University; Aaron Wallack, Cognex Corporation; Linda Wallack; Thomas Wenzel, Bates College; Anne Williams, Bates College; Thomas M. Wolf, Washburn University of Topeka; and H. Elton Woodward, Daytona Beach Community College.

Special thanks are due to Denise Schanck and Jane Mackarell, who saw us through the work on two editions. Elmarie Hutchinson provided numerous helpful suggestions, both large and small, and Nigel Orme drew most of the illustrations. We also thank Angela Bennett, Mark Ditzel, Sarah Gibbs, Emma Hunt, Angela Kao, Richard Woof and the rest of the staff at Garland Publishing and the Taylor & Francis Group who helped us throughout the process of bringing the second edition to completion.

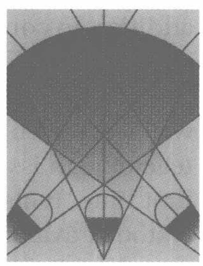
Eli C. Minkoff
Pamela J. Baker

ABOUT THE BOOK

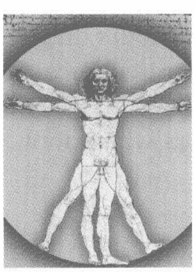
This second edition of *Biology Today* has undergone considerable revision and reorganization. The basic biology content has been expanded on several topics while current issues and recent science have been updated.

Here is an overview of the study aids and features included in this second edition.

Chapter outlines: Chapters begin with an outline detailing major section headings. The outline enables students to assess the full range of biological and issue-related content covered within the chapter.

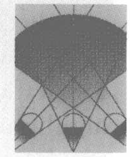


Issues: Each chapter in *Biology Today* encourages the student to perceive biology as a process, where the biologist is constantly questioning the facts they are presented with. Every chapter raises a number of critical issues, and asks the student to consider a number of important, pivotal questions. These underlying questions within the chapter are listed in the Issues section. The perspectives icon links these underlying questions with other critical thinking sections within the chapter, such as the Thought Questions and the concluding paragraph for each chapter.



Biological Concepts: When teaching an issues-oriented introductory biology course, it is still vital to cover key biological concepts. These sections summarize the biology that is covered within the chapter. The Biological Concepts sections are directly related to key biological concepts developed by the Biological Sciences Curriculum Study. This table of concepts is fully cross referenced to the material in the book and can be found on the *Biology Today* web sites.

Opening Narrative: The opening narrative scenario immediately introduces the science covered in the chapter by placing it within an interesting and relevant societal context.



Thought Questions: Sets of Thought Questions appear at the end of each chapter section. They are linked to the chapter opening Issues section and the concluding paragraph of each chapter by the perspectives icon. Although a few thought questions have factual 'right' answers, most do not. Some questions require students to do further reading and many encourage students to think about the limitations of available data or the applications and implications of science. We encourage students with differing viewpoints to discuss these questions among themselves and to ask, "What further information would help us resolve our differences or reach decisions?". These questions can form the basis for discussion either in class or in informal study groups.

Illustrations: Since many of the concepts of biology can be understood and remembered visually, the book is well illustrated with photographs and drawings. The captions to these illustrations often provide another important avenue to understanding.

Tables: Some of the tables included summarize important sections of text while others provide specific examples.

Boxes: Boxes provide additional material that supplements the text.

Box 2.1 Science and Fair Play: The Case of Rosalind Franklin
Box 3.1 Ethical Issues in Medical Decision-making Regarding Genetic Testing
Box 3.2 Who Decides What is Considered a 'Defect'?
Box 4.1 Procaryotic and Eucaryotic Cells Compared
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Box 7.1 The Sociobiology Paradigm
Box 8.1 How Does Sugar Contribute to Tooth Decay?
Box 9.1 The Ames Test
Box 13.1 ELISA and Western Blot Tests for Detection of Antibodies to HIV
Box 13.2 Can Mosquitoes Transmit AIDS?

Key Terms to Know: Important vocabulary is highlighted in bold type in the text. All of the Key Terms from a chapter are listed at the end of that chapter with page references. Key Terms are mainly concepts rather than specific examples (that is, neurotransmitter rather than the name of a specific neurotransmitter). Additional terms are highlighted in blue type in the text. These terms are defined in an expanded glossary that can be found on the *Biology Today* web sites (see below).

Connections to Other Chapters: *Biology Today* aims for an integrated comprehensive view of biology. The Connections to Other Chapters section at the end of each chapter helps reinforce this integrated view of biology as a science. Icons placed throughout the book indicated cross-references to other material in the text.

Practice Questions: Learning biological concepts still requires some memorization of the facts. End-of-chapter Practice Questions are straightforward review questions for students to answer.

Glossary: Each of the Key Terms is defined in an alphabetically arranged glossary at the end of the book. An expanded glossary which contains definitions of the Key Terms and the blue-highlighted terms can be found on the *Biology Today* web sites.

Bibliography: Suggestions for further readings are presented on the web site, organized by chapter.

BIOLOGY TODAY WEB SITE

Biology Today offers two complementary websites that serve as a complete teaching and learning resource—an essential supplement to an issues-oriented biology course.

Where the web site icon is featured in the book, students are encouraged to go to the *Biology Today* web site at http://www.garlandscience.com/biologytoday for additional textual content as well as a bibliography and expanded glossary.

The Garland Science Classwire web site, located at http://www.classwire.com/garlandscience offers extensive instructional resources. In addition to containing all materials on the first site, it provides a testbank, additional critical thinking questions, web links and bibliography, as well as curriculum advice and assistance for those teaching an issues-oriented biology course for the first time. It also contains all the images from the textbook available in a downloadable, web-ready, as well as Power Point-ready, format. Instructors can choose whether they wish to make these resources available to students.

Garland Science Classwire also does much more than offer supplementary teaching resources. It is a flexible and easy to use course management tool that allows instructors to build web sites for their classes. It offers features such as a syllabus builder, a course calendar, a message center, a course planner, virtual office hours and a resource manager. No programming or technical skills are needed. Garland Science Classwire is offered free of charge to all instructors who adopt *Biology Today* for their course.

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1 Biology: Science and Ethics

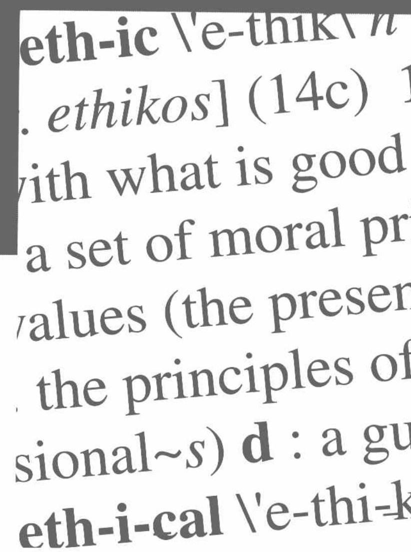
CHAPTER OUTLINE

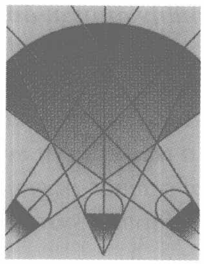
Science Develops Theories by Testing Falsifiable Hypotheses
- Hypotheses
- Theories
- A theory to describe living systems
- Hypothesis testing in experimental science
- Hypothesis testing in naturalistic science

Revolutionary Science Differs from 'Normal Science'
- Scientific revolutions
- Molecular genetics as a paradigm in biology
- The scientific community

Scientists Often Consider Ethical Issues
- Ethics
- Resolving moral conflicts
- Deontological ethics
- Utilitarian ethics
- How societies make ethical decisions

Ethical Questions Arise in Decisions about Experimental Subjects
- Uses of animals
- The animal rights movement
- Humans as experimental subjects





ISSUES

How do we know what we know?

How do scientists make discoveries and advance our knowledge?

What constitutes a 'discovery' in science?

How is science creative?

Does science contain absolute truths?

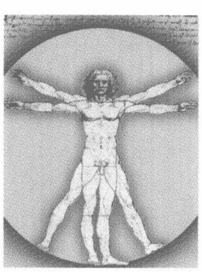
How do ethics and morals fit into science?

How do scientists make ethical decisions in a social context?

How are decisions made on social issues, and to what extent can science help in these decisions?

What rights do animals have? How do we safeguard those rights?

How do we safeguard the rights of experimental subjects?



BIOLOGICAL CONCEPTS

Properties of living organisms (metabolism, selective response, homeostasis, genetic material, reproduction, population)

Hypotheses and theories

Experimental science versus naturalistic science

Normal science and paradigm shifts

Science and society

Biological ethics

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***Biology** is the scientific study of living systems. Our gardens, our pets, our trees, and our fellow humans are all examples of living systems. We can look at them, admire them, write poems about them, and enjoy their company. The Nuer, a pastoral people of Africa, care for their cattle and attach great emotional value to each of them. They write poetry about—and occasionally to—their cattle, they name themselves after their favorite cows or bulls, and they move from place to place according to the needs of their cattle for new pastures. They come to know individual cattle very well, almost as members of the family. The Nuer have also acquired a vast store of useful knowledge about the many animal and plant species in their region. Many other people who live close to the land have a similar familiarity with their environment and the many species living in it. Scientific understanding of the world around us grew out of this kind of familiarity with nature, supplemented by a tradition of systematic testing. In this chapter we examine the methods of science in general and the application of those methods to the study of living systems.*

*Because living systems are complex and continually changing, an understanding of these systems often requires special methods of investigation or ways of formulating thoughts. This chapter describes the special methods that have come to be called **science**. Many people think that science is defined by its subject matter, but this is not correct.* Science is defined by its methods.

The scientific method does not answer questions about values and, therefore, cannot by itself answer questions such as whether certain types of research should be done, or to what uses scientific results should be put. Such decisions often involve a branch of philosophy called ethics. Many issues confronting societies today have a science and technology dimension. Policy decisions on such issues involve both science and ethics.

SCIENCE DEVELOPS THEORIES BY TESTING FALSIFIABLE HYPOTHESES

The essence of science is the formulation and testing of certain kinds of statements called hypotheses. At the moment of its inception, a hypothesis is a tentative explanation of events or of how something works. What makes science distinctive is that hypotheses are subjected to rigorous testing. Many hypotheses are falsified (rejected as false) by such testing. Eliminating one hypothesis often helps us to frame the next hypothesis. If a hypothesis is repeatedly tested and not falsified, it may be put together with related hypotheses that have also withstood repeated testing. Such a group of related hypotheses may become recognized as a theory.

Hypotheses

Hypotheses must be statements about the observable universe, formulated in such a way that they can be tested. To be a hypothesis, a statement must be either **verifiable** (confirmable) or **falsifiable** (capable of being falsified). Observations gathered for testing any hypothesis are generally called **data**. Certain types of statements cannot be used as scientific hypotheses. Moral judgments and religious concepts differ from scientific statements because they are not falsifiable. For example, the statement, "there is a God," cannot be disproven or falsified by any possible demonstration of empirical fact or observation. Similarly, judgements about what ideas or things are valuable, beautiful, or likable are not subject to falsification by hypothesis testing.

Specific versus general hypotheses. Hypotheses that are easy to verify generally tell us very little. For example, the hypothesis "the sun will rise in the east tomorrow morning" can be tested by awakening early, facing east, and observing what happens. If the sun does rise, then our hypothesis is verified or confirmed; if the sun does not rise, then our hypothesis is falsified or disconfirmed. However, the confirmation of this hypothesis about sunrise on a certain specified day is far from an important scientific discovery. It is relatively unimportant because it is too specific, which is exactly what makes it verifiable.

Suppose, now, that we examine the much bolder hypothesis "the sun will rise in the east *every* morning." We can test this second hypothesis in the same way that we tested the first hypothesis, by rising early and facing east, and we could also declare that the hypothesis would be falsified if the sun failed to rise. But what if the sun does rise? Does this verify that the sun will rise *every* morning? Suppose we decide to watch the sunrise 5 days in a row, or 5000? A single failure of the sun to rise will absolutely falsify the hypothesis, but no finite number of sunrises would be sufficient to verify the hypothesis for all time. This is the kind of hypothesis that science usually examines: hypotheses that are absolutely falsifiable, but not absolutely verifiable.

Falsified hypotheses are rejected, and new hypotheses (which may in