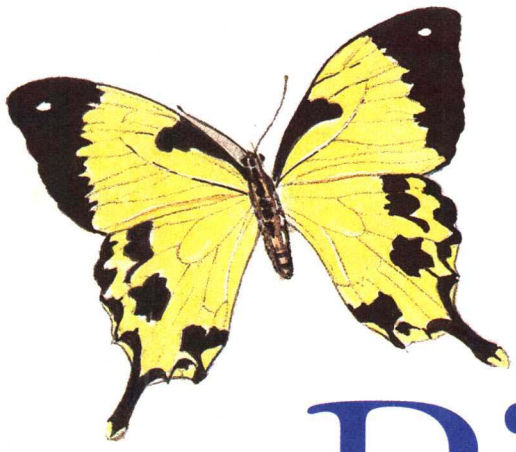
Biology

The Network of Life

Michael C. Mix Paul Farber Keith I. King



Biology

The Network of Life

Michael C. Mix

Paul Farber

Keith I. King

Oregon State University

HarperCollins*Publishers*

Sponsoring Editor: Glyn Davies
Development Editor: Rebecca Strehlow
Project Editor: Nora Helfgott
Design Supervision and Cover Design: Lucy Krikorian
Text Design: Edward Smith Design, Inc.
Cover Photos: Jim Trotter/SUPERSTOCK (front); Kim Taylor/Bruce Coleman, Inc. (back)
Photo Researcher: Karen Koblik
Director of Production: Kewal K. Sharma
Production Assistant: Jeffrey Taub
Compositor: Black Dot Graphics
Printer and Binder: Arcata Graphics/Kingsport
Cover Printer: The Lehigh Press, Inc.

BIOLOGY: THE NETWORK OF LIFE

Library of Congress Cataloging-in-Publication Data

Mix, Michael C.
Biology: the network of life / Michael C. Mix, Paul Farber, Keith I. King.
p. cm.
Includes index.
ISBN 0-673-39869-2 (student edition)
ISBN 0-673-52200-8 (teacher edition)
1. Biology. I. Farber, Paul Lawrence, 1944- . II. King, Keith I. III. Title.
[DNLM: 1. Biology. QH 308.2 M685b]
QH308.2.M58 1992
574—dc20
DNLM/DLC
for Library of Congress 91-20850
CIP

91 92 93 94 9 8 7 6 5 4 3 2 1

Preface

Biology and the teaching of biology are undergoing profound changes as we approach the twenty-first century. Recent reports from the largest and most prestigious scientific societies in the United States have provided guidance for transforming both textbooks and college courses. For years, too many biology textbooks and courses have emphasized facts, vocabulary, and memorization, and there has been little effort to expose students to scientific process and science as a way of thinking or knowing. Consequently, many students have not developed a sense of the importance of science, scientific thinking, or the excitement that characterizes studies of the living world.

Biology: The Network of Life concentrates on knowledge that an educated person requires for understanding the living world and making informed decisions related to that world. Scientific inquiry and scientific process are the conceptual foundations of our book. *Scientific inquiry* refers to the ways in which scientists investigate problems. *Scientific process* is a broader concept. Historically, science has been presented as a body of knowledge concerning the natural world. Using an elegantly simple but wholly imaginary "scientific method," scientists allegedly added bits of information to an ever-enlarging picture of nature. Several factors ultimately led to a fundamental alteration of this static view. These included the scientific revolutions of the early twentieth century, research done in the history and philosophy of science in response to those revolutions, and recent investigations into the sociology of science. What has emerged is a view of science as a process: a dynamic activity based on scientific inquiry—making careful observations, collecting relevant information, conducting experiments, and constructing hypotheses and broad explanations (theories).

The scientific process allows us to acquire a deep understanding of the natural world. Since the process of science is dynamic, a historical perspective is important for understanding current concepts, hypotheses and theories, and future biological research. Far from being based on a simple, "cookbook" scientific method, the scientific enterprise is stunningly creative, yet rigorously exact. Our study of biology goes far beyond the catalog of facts, which is merely an outer shell. By emphasizing the *process* of science, it becomes possible to understand science as a way of thinking that all citizens can use in problem solving.

Consistent with the new goals for teaching biology, Unit I begins with the origin and maturation of Earth (Chapter 2). After setting the stage, we describe the characters—the organisms that inhabit Earth—examine the different habitats of Earth, and learn how the physical world preconditions the biological world (Chapters 3–6). How do these organisms interact? How do humans affect those interactions? How do long-term physical changes influence those interactions? These questions are addressed in Chapters 7–11.

In Units II and III, we focus on this question: What explains the appearances, functions, and survival capacities of organisms? In the short term, organisms look and function as they do because they resemble their parents. The study of genetics explains why and how this occurs (Chapters 12–21). In the long term, organisms have characteristic traits because they are members of species populations that have evolved through time (Chapters 22–28). The theory of evolution explains how living organisms change in response to their environments and to each other.

Unit IV is concerned with how organisms function. It begins with the basic process of energy capture and use (Chapter 29). In three chapters on the world of plants (Chapters 30–32), the forms and functions of plants are related to their evolution and the environments in which they survive. Chapters 33–40 emphasize human biology. The enormous strides made in human biological research will

become evident from reading these chapters. We describe what is now known about human organ systems that control our every activity, how the human immune system works, and where research is heading in medicine with special emphasis on infectious diseases, cancer, cardiovascular diseases, and AIDS. Chapter 41 looks to the future to underscore the reality that biology, like all exciting science, is constantly changing.

TO THE STUDENT

This textbook does not attempt to give you biology "once and forever." Rather, it will prepare you to understand the ever-widening scope of knowledge about the living world. Every week brings some interesting and potentially significant development in biology that may affect your life. As an educated citizen, you will probably be called on to discuss and even vote on issues that have a biological dimension, and to make intelligent choices you will need to stay informed. For example, you might be asked to take a position on the release of genetically engineered organisms in your state or on the teaching of evolution in your schools. We hope that our text will provide you with the background necessary to become scientifically curious and literate on biological issues. Yet it will not replace the excitement of a hands-on experience you will receive in a laboratory or the thrill of being out in the field on a gorgeous spring day. The photographs in the text are beautiful, but they cannot substitute for the experience of actually observing tide pools or birds in the wild or flowers poking up through snow or a cell dividing under a microscope. Perhaps, in the final analysis, this text can be a guide for identifying and understanding interesting and important areas of biology that will affect you throughout your life and help you develop a continuing appreciation for science.

LEARNING AND TEACHING TOOLS

Each chapter opens with an outline and a set of reading questions to establish a conceptual framework for the student. Within chapters, key terms are printed in boldface where they are defined. Four types of enrichment essays provide deeper insights into the nature of science: "Focus on Scientific Inquiry," "Focus on Scientific Explanation," "Focus on Science and Society," and "Focus on Science and Technology." At the end of each main section, a brief in-text summary highlights key ideas. Chapters conclude with a concise summary, review questions, essay and discussion questions, and a list of references and recommended readings. Numerous illustrations and tables complement the narrative. The book also includes an appendix on the classification system used, an extensive glossary, and a thorough index.

ANCILLARIES

Instructor's Manual by the authors. The manual is available free to adopters. It provides an index to appropriate images on the laser disk, plus suggested lecture outlines, lists of key concepts, and lecture demonstrations. The *Instructor's Manual* also includes 150 transparency masters.

Study Guide by Elizabeth Godrick of Boston University. The guide contains chapter overviews, learning objectives, concepts in review, key terms (with page numbers from the text for reference), and self-tests featuring matching, true/false, multiple-choice, and short-answer questions.

Laboratory Manual by Bill Tietjen of Bellarmine College. All lab experiments have been carefully chosen and class tested. Art is included for each exercise, helping to clarify the experiment.

Test Bank by Ken Saladin of Georgia College. The test bank consists of 2,500 multiple-choice, true/false, matching, and sentence completion questions.

Testmaster. The test bank is available to adopters in a computerized form for your IBM or Macintosh.

Acetate Transparencies. A comprehensive set of 125 four-color acetates of art and photomicrographs from the text is available free to adopters.

The HarperCollins Biology Encyclopedia Laser Disk. The Biology Encyclopedia Laser Disk, produced in conjunction with Nebraska Interactive Video, Inc., offers the latest in visual technology. It contains transparencies, micrographs, slides, and film and video footage. Over 1,500 images were provided by Carolina Biological Supply. The laser disk allows instant access to any image or footage, frame-by-frame or moving, simply by pushing a few buttons on a hand-held remote. The disk enhances the principles of biology covered in the text much more effectively than transparencies or videos.

Student Environmental Action Guide. The Earthworks Group and HarperCollins have joined with the Student Environmental Action Coalition to bring your students a handbook of the environmental movement on campuses around the country. It contains a series of strategies through real campus examples for approaching the administration, the community, political leaders, student leaders, and one's own personal habits to achieve positive change. Examples include population control, transportation, water conservation, and newsletter publication.

Two Minutes a Day For a Greener Planet by Marjorie Lamb, a veteran reporter on environmental affairs. This book provides easy, practical answers to what all of us can do to save the Earth. It gives suggestions for individual action, on a small scale, that can make a big impact on our planet's future.

Harper Dictionary of Biology by W. G. Hale and J. P. Margham, both of the Liverpool Polytechnic Institute. The dictionary contains 5,600 entries, which go far beyond basic definitions to provide in-depth explanations and examples. Diagrams illustrate such concepts as genetic organization, plant structure, and human physiology. The dictionary covers all major subjects (anatomy, biochemistry, ecology, etc.) and also includes biographies of important biologists.

The Biology Coloring Book, Anatomy Coloring Book, Physiology Coloring Book, Botany Coloring Book, Zoology Coloring Book. An exciting new approach to learning biology. Coloring provides an enjoyable and effective means of learning the fundamentals of biology. Participation by the reader, through creative coloring, provides significant learning reinforcement. The text accompanying each coloring plate provides supportive explanatory material and leads the reader through the plate in a step-by-step manner. Furthermore, when finished, the colored plates provide an excellent review that the reader has helped create.

Writing About Biology by Jan A. Pechenik, professor of biology at Tufts University. This brief but straightforward guide includes sections on writing lab reports, essays, term papers, research proposals, critiques and summaries, and in-class essay examinations. It also includes special sections on effective note taking, how to give oral presentations, and how to prepare applications for summer and permanent jobs in biology. Appendices listing commonly used abbreviations for lengths, weights, volumes, and concentrations are also featured.

REFERENCES

The following articles and reports are important to everyone interested in improving biology education.

American Association for the Advancement of Science. 1989. *Biological and Health Sciences: Report of the Project 2061 Phase I. Biological and Health Sciences Panel.* Washington, D.C.: AAAS Publications.

———. 1989. *Science for All Americans: A Project 2061 Report on Literacy Goals in Science, Mathematics, and Technology.* Washington, D.C.: AAAS Publications.

American Society of Zoologists. 1984–1990. *Science as a Way of Knowing.* Cosponsored by the American Society of Naturalists, the Society for the Study of Evolution, the Biological Sciences Curriculum Study, the American Institute of Biological Sciences, the American Association for the Advancement of Science, the Association for Biology Laboratory Education, the National Association of Biology Teachers, the Society for College Science Teachers, the Ecological Society of America, and the Genetic Society of America. All related materials were published in a special issue of *American Zoologist,* once each year from 1984 to 1990.

National Academy of Sciences. 1989. *On Being a Scientist.* Washington, D.C.: National Academy Press.

National Research Council. 1990. *Fulfilling the Promise: Biology Education in the Nation's Schools.* Washington, D.C.: National Academy Press.

ACKNOWLEDGMENTS

This book grew out of our 20 years of teaching university biology and history of science courses. Along the way we have been aided by many people from numerous institutions. A comprehensive list of acknowledgments would be unreasonably long and unavoidably incomplete. However, this project could not have been initiated or completed without help from the following individuals.

Bonnie Roesch was the first to recognize the novel dimensions of our project, and she has been a tireless supporter. Her continuous encouragement was inspiring, and we will always feel indebted to her. Rebecca Strehlow tactfully but rigorously used her editor's pencil on several chapter drafts; the end product was immeasurably improved by her efforts. Likewise, Marilyn Henderson edited all of the first drafts, sparing us considerable embarrassment once they fell into editors' and reviewers' hands. Glyn Davies skillfully guided the entire project, and we appreciated his hard questions and open mind. Karen Koblik was indefatigable in pursuing the beautiful photographs that grace this book. Bill Davis offered early, enthusiastic support for our ideas. We also thank Jim Winton and the many reviewers listed below who offered constructive criticism and shared their ideas for improving the book. They, too, deserve great credit for bringing this book to its final state.

John Adler, Michigan Technological University

Bonnie Amos, Angelo State University

Kay Antunes de Mayalo, American River College

Al Avenoso, University of Houston

Amy Bakken, University of Washington

Cecilio R. Barrera, New Mexico State University

Barry Batzing, State University of New York at Cortland

Robert A. Bell, Loyola University

Kristen Bender, California State University at Long Beach

Linda Berg, University of Maryland

Charles J. Biggers, Memphis State University
Richard G. Bjorklund, Bradley University
Richard Blazier, Parkland College
Antonie Blockler, Cornell University
James Botsford, New Mexico State University
William R. Bowen, University of Arkansas at Little Rock
Clyde Brashier, Dakota State College
J. N. U. Brown, University of Houston
Gloria Cadell, University of North Carolina at Chapel Hill
S. Dan Caldwell, Georgia College
John Campbell, Northwest College
Nina Caris-Underwood, Texas A&M University
Galen E. Clothier, Sonoma State University
David Davis, University of Alabama
Thomas Davis, University of New Hampshire
Linda Dion, University of Delaware
Lee C. Drickamer, Southern Illinois University
Marvin Druger, Syracuse University
Dorothy C. Dunning, West Virginia University
Andres Durstenfeld, University of California at Los Angeles
Thomas C. Emmel, University of Florida
Stanley H. Faeth, Arizona State University
Michael Fine, Virginia Commonwealth University
Herman S. Forest, State University of New York at Geneseo
Sally Frost, University of Kansas
Rita Ghosh, Indiana State University
David C. Glenn-Lewin, Iowa State University
Judith Goodenough, University of Massachusetts at Amherst
Kenneth Goodhue-McWilliams, California State University at Fullerton
Thomas Gorham, California Lutheran University
Nels H. Granholm, South Dakota State University
Thomas Griffiths, Illinois Wesleyan University
Gilbert F. Gwilliam, Reed College
James Habeck, University of Montana
Marcia Harrison, Marshall University
Thomas Herbert, University of Miami
David Hicks, Manchester College
Linda Margaret Hunt, Notre Dame University
David T. Jenkins, University of Alabama at Birmingham
C. Weldon Jones, Bethel College
Leonard Kass, University of Maine
Elizabeth Keith, University of Mississippi
Kenneth Klemow, Wilkes University
Bob Kosinski, Clemson University
John Krenetsky, Metropolitan State College
Karen Kurvink, Moravian College
John M. Lammert, Gustavus Adolphus College
Howard Lenhoff, University of California at Irvine
Ronald Lindahl, University of Alabama
Michael Lockhart, Northeast Missouri State University
Ruth Logan, Santa Monica College
Raymond Lynn, Utah State University
David Mark, St. Cloud State University
James Marker, University of Wisconsin at Platteville
Gayton C. Marks, Valparaiso University
Samuel Maroney, University of Virginia
Joyce Maxwell, California State University at Northridge
Helen C. Miller, Oklahoma State University
Neil Miller, Memphis State University
Charles Mims, University of Georgia
Herbert L. Monoson, Bradley University
Walter A. Morin, Bridgewater State College
Keith Morrill, South Dakota State University
Alexander Motten, Duke University
Tom Nye, Washington and Lee University
Clifford Night, East Carolina University
Robert W. O'Donnell, State University of New York at Geneseo
Lowell P. Orr, Kent State University
Elizabeth Painter, Colorado State University
Robert A. Paoletti, King's College
Patricia Pearson, Western Kentucky University
Richard Peifer, University of Minnesota

Herbert B. Posner, State University of New York at Binghamton
Greg Rose, West Valley College
Monica Rudzik, Westminster College
William Rumbach, Central Florida University
Douglas Sampson, Emory University
Lawrence C. Scharmann, Kansas State University
Joan Schuetz, Towson State University
Richard Search, Thomas College
David Senseman, University of Texas at San Antonio
Linda Simpson, University of North Carolina at Charlotte
Daryl Smith, University of Northern Iowa
Kingsley Stern, California State University at Chico
Charles L. Stevens, University of Pittsburgh
Lewis Stratton, Furman University
Gerald Summers, University of Missouri
Marshall Sundberg, Louisiana State University
Daryl Sweeney, University of Illinois at Urbana
Linda C. Twining, Northeast Missouri State University
Patrick K. Williams, University of Dayton
William Wissinger, St. Bonaventure University
John L. Zimmerman, Kansas State University

Many people have provided valuable aid on parts of this book. Foremost among these is Bill Winner, who wrote the initial drafts of Chapters 30–32 and supervised the creation and development of the accompanying art. He was also a valued source of information and ideas used in Unit I. Past and present colleagues in the Department of General Science at Oregon State University helped shape the general biology course over the past two decades. Some of our ideas originated in work done in the course by Jack Lyford, Henry Van Dyke, Dennis McDonald, Larry Forslund, Bruce McCune, and Patricia Muir. The teaching assistants in our course gave us excellent feedback on our ideas for teaching biology. Susie Bratsch helped us translate ideas into images and provided many sketches that led to finished illustrations in this book. Barbara Moritsch gave us advice on several art pieces. Administrators at Oregon State supported our ideas for developing a contemporary nonmajors general biology course. Fred Horne, dean of the College of Science, was especially helpful.

Jerry Kling, of Oregon State, provided assistance related to computer literacy and served as a consultant on material cycling in soils. Darrell L. King, of Michigan State University, provided photographs and ideas about deciduous forests and sand dune succession. La Verne D. Kulm, of Oregon State, supplied photographs and also reviewed sections of Chapter 9.

Several distinguished scientists and scholars graciously answered our questions about how they would like to see biology develop in the coming decades. We thank Ernst Mayr, Ledyard Stebbins, David Hull, E. O. Wilson, Marvin Druger, and Linus Pauling for their time and thoughts.

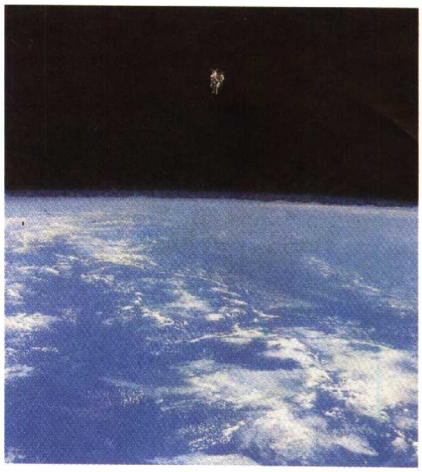
The production of this book also involved considerable assistance from others. Karla Russell, of the General Science Department, typed and edited drafts, balanced deadlines, and was otherwise helpful in ways too numerous to list but that are easily understood by anyone who has the good fortune to work where there is a superior office staff. Laura Mix Kohut, now of Morrison & Foerster, provided the legal assistance necessary in such a large project and even succeeded at making us understand what some of it meant. Leslie Mix typed drafts of some of the early material. Many remarkably talented and patient individuals at HarperCollins brought this book to completion; they include Nora Helfgott, project editor, and Teresa Delgado, art director. Bruce Emmer assisted as copyeditor, and David Fox provided input during art production.

Finally, we recognize our wives, Marilyn Henderson, Vreneli Farber, and Roberta King. They suffered longest and most, yet were unfailing in their encouragement and support.

The students we have had the good fortune to have in classes during the past 20 years were, in a real sense, the source of inspiration for this project. To all biology students—past, present, and future—we dedicate this book.

MICHAEL C. MIX
PAUL FARBER
KEITH I. KING

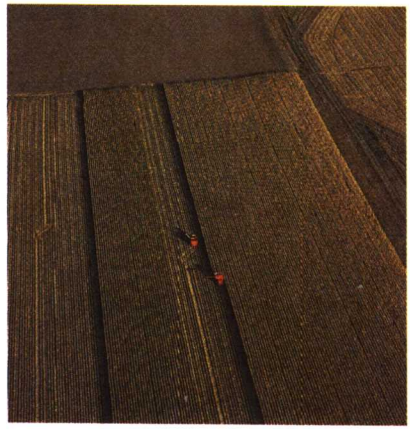
Detailed Contents

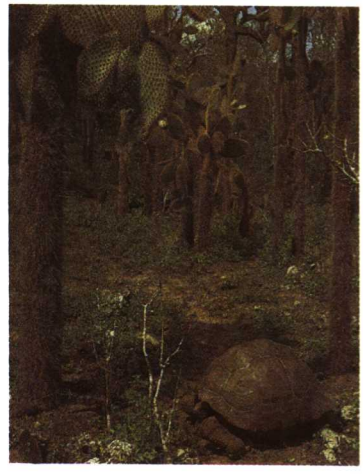


Detailed Contents

Detailed Contents

Detailed Contents





Detailed Contents

Detailed Contents

Detailed Contents