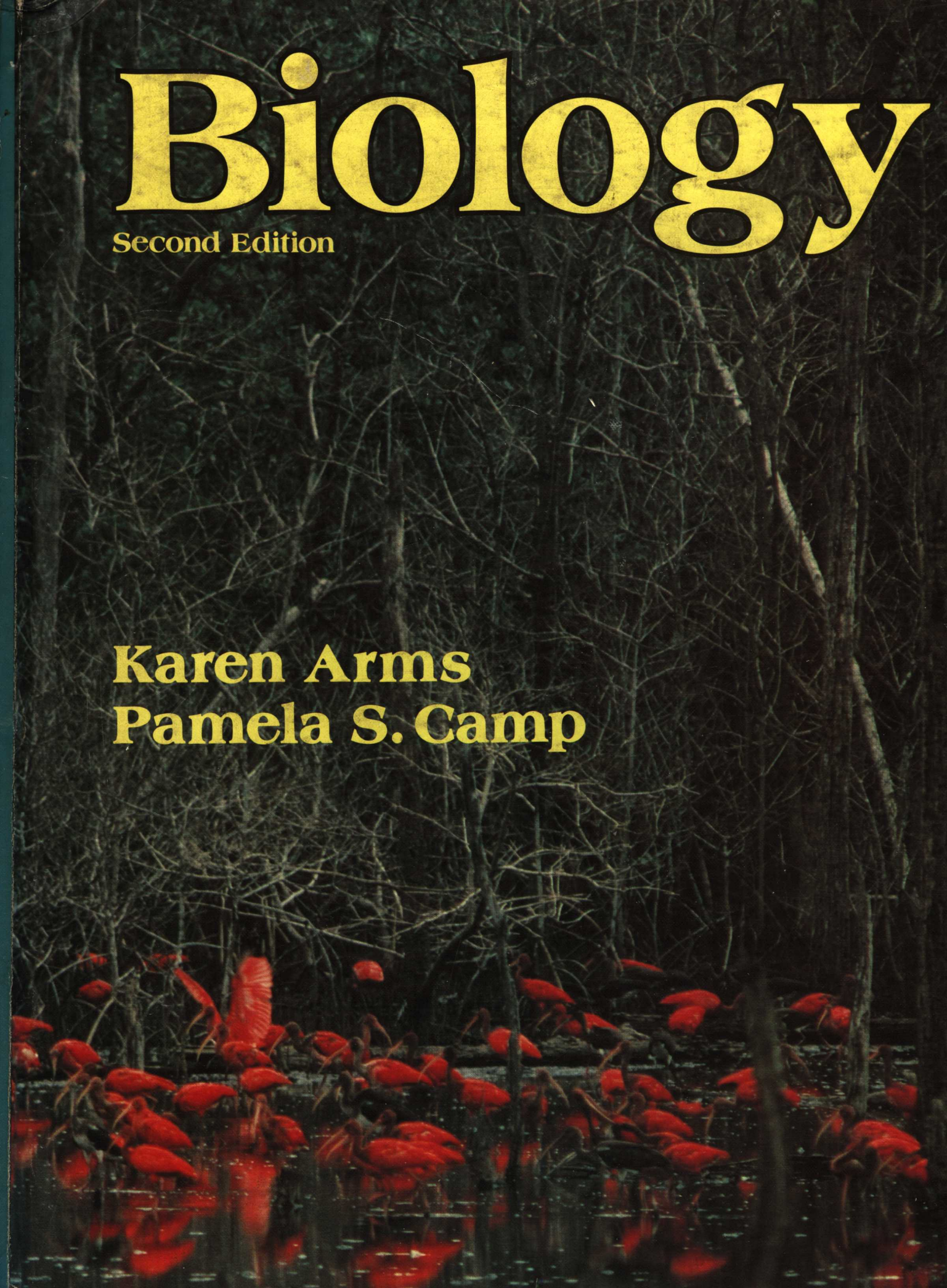


Biology

Second Edition

Karen Arms
Pamela S. Camp



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This book was set in Primer by York Graphic Services.
The editors were Michael Brown, Lee Walters, Carol Field, and Elizabeth Galbraith.
The art & design director was Richard L. Moore.
The text design was done by Nancy E. J. Grossman.
The cover design was done by Richard L. Moore.
The artwork was drawn by Vantage Art, Inc.
The production manager was Tom O'Connor.
This book was printed by Kingsport Press.

Cover credit: Scarlet Ibis in Trinidad Swamp, © Townsend Dickinson.

Part Opening Photographs:

- Part One: Section of pancreatic tissue (Biophoto Associates)
- Part Two: Pollen grains of carnation (Biophoto Associates)
- Part Three: Pterodactyls flying through the Royal Scottish Museum, Edinburgh (Biophoto Associates)
- Part Four: Cyanobacteria (Biophoto Associates)
- Part Five: Red deer (Biophoto Associates)
- Part Six: Rhododendrons in the landscape garden at Stourhead, England (William Camp)
- Part Seven: Penguins in Antarctica (U.S. Navy)

BIOLOGY

ISBN 0-03-059961-X

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All rights reserved. Printed in the United States of America.
Library of Congress catalog card number 81-53080.

34 071 9876543

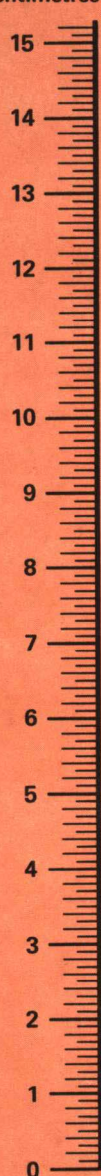
CBS COLLEGE PUBLISHING
Saunders College Publishing
Holt, Rinehart and Winston
The Dryden Press

THE METRIC SYSTEM

LENGTH

Centimetres

Inches



A centimetre is less than half an inch.

A pen cap is about 1 centimetre in diameter at its widest part

A metre is a little longer than a yard

A kilometre is about 3/5 of a mile

Speed limit in town is 50 kph (31 mph)

150 kph (93 mph) is usually a speeding ticket

Length Conversion

1 in. = 2.5 cm	1 mm = 0.04 in.
1 ft = 30 cm	1 cm = 0.4 in.
1 yd = 0.9 m	1 m = 40 in.
1 mi = 1.6 km	1 m = 1.1 yd
	1 km = 0.6 mi

WEIGHT

A plastic pen cap weighs about 1 gram

A recipe for lasagna calls for 700 grams of ground beef and 113 grams of shredded cheese

This book weighs about 2.3 kilograms

A football player can weigh as much as 126 kilograms

Weight Conversion

1 oz = 28 g	1 g = 0.035 oz
1 lb = 0.45 kg	1 kg = 2.2 lb

VOLUME

A millilitre is about
one-fifth of a teaspoon

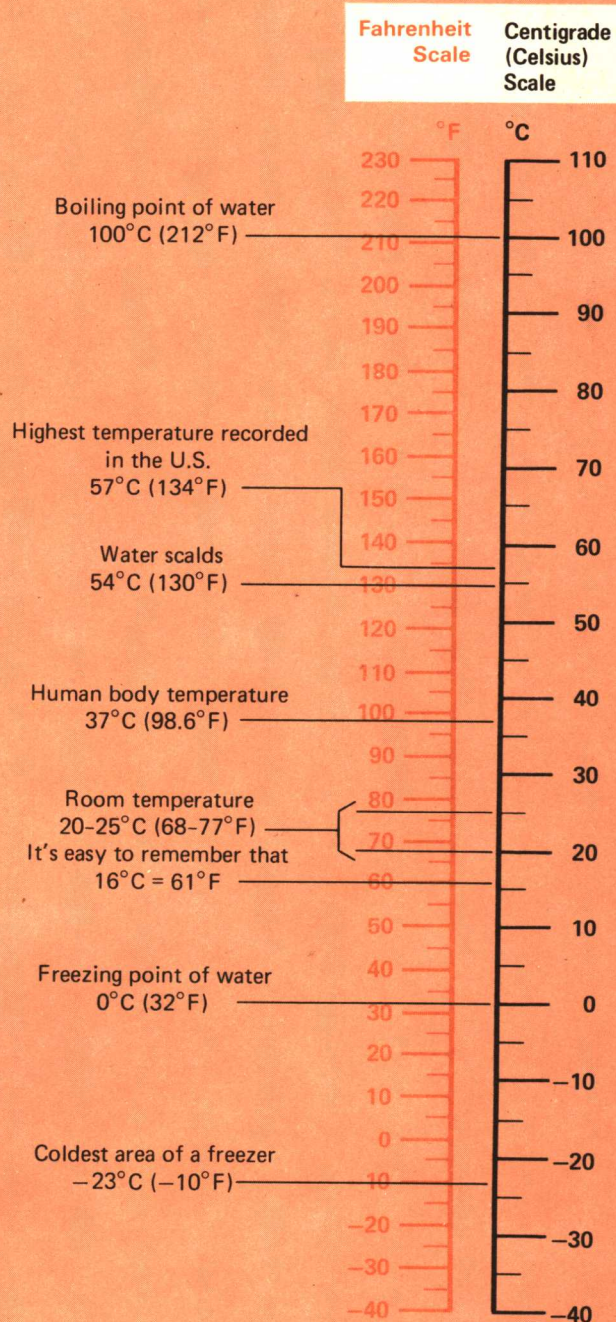
A litre is becoming the standard
size for soft drink, wine, and
liquor bottles in the U.S. If
its price is the same as for the
old quart bottle, you're in luck
because a litre is equal to
slightly more than a quart

The gas tank of a large car
holds 64 to 75 litres of gasoline

Volume Conversion

1 tsp	= 5 ml	1 ml = 0.03 fl oz
1 tbsp	= 15 ml	1 l = 2.1 pt
1 fl oz	= 30 ml	1 l = 1.06 qt
1 cup	= 0.24 l	1 l = 0.26 gal
1 pt	= 0.47 l	
1 qt	= 0.95 l	
1 gal	= 3.8 l	

TEMPERATURE



Temperature Conversion

$$^{\circ}\text{C} = \frac{(^{\circ}\text{F} - 32) \times 5}{9}$$

$$^{\circ}\text{F} = \frac{^{\circ}\text{C} \times 9}{5} + 32$$

Interval Equivalents

°C	°F
1°	= 1.8°
5°	= 9°
10°	= 18°



SAUNDERS COLLEGE PUBLISHING

Philadelphia New York Chicago
San Francisco Montreal Toronto
London Sydney Tokyo Mexico City
Rio de Janeiro Madrid

*To Paul and Bill,
the critics on the hearth,
with love*

PREFACE

Preparing this second edition of *Biology* has been an exciting task — a chance to bring in new ideas, incorporate biological discoveries of the last few years, and make material easier to understand by rewriting, redrawing, and finding new photographs. Despite these opportunities, many pitfalls gape for the unwary authors of a new edition. Our first impulse was to start from scratch. But our editors and users kept us in check with frequent reminders that the idea was to revise, and not to destroy what people liked in the first edition.

Although it is a relatively small part of preparing a new edition, recording the advances of the last few years' research is the greatest thrill. How exciting it is to report that we now know the nucleotide sequences of dozens of genes, when we remember hours spent listening to chemists

explain why it was unlikely that anyone would analyze the nucleotide sequence of a DNA or RNA molecule in our lifetimes!

The temptation to add large quantities of new material which “should be in the book” can mean that each new edition is longer than its predecessor, to the deep distress of users whose academic calendars were too short to include all the material in the first edition. Deciding what to delete to make way for new material is seldom easy, but we have goaded each other on to the disagreeable task and this book contains no more text than the first edition.

Teachers often greet new editions of their favorite textbooks with some dread: a new edition means the drudgery of updating the now-obsolete reading lists and handouts used with the older version. To save most of this labor, the Instructor’s Manual provides a detailed list showing the new location of all the material in the first edition, as well as identifying material added or deleted. Here we mention only the major changes in content and organization.

First, there are three new chapters:

Chapter 6, “Energy and Living Cells,” summarizes the basics of energetics that a student needs for the chapters on respiration and photosynthesis, and, we hope, removes some of the pain from the study of these two difficult chapters.

Chapter 18, “Evolution and Reproduction,” introduces some new material and pulls together discussions of the evolutionary origin of different reproductive systems, which were scattered in various places in the first edition.

Chapter 34, “Defenses Against Disease,” is largely an introduction to immunology, much expanded (and, of course, updated) from the coverage in the first edition.

In addition, the kingdom Protista now has a chapter all to itself.

Second, several chapters have disappeared. Most of these are from the part of the book on ecology and evolution. Most users of the first edition did not have time for all of these chapters. Rather than see many chapters unused, we have tried to cut out the less-essential or repetitive material, and have merged the more interesting and important topics from the deleted chapters into those that remain. Parts of the chapter on communities have been merged into Chapter 43, “Biomes,” and Chapter 44, “Ecosystems,” and sections from other chapters have been moved forward into the Parts on plant or animal biology. We have also combined the two chapters on animal transport systems with the chapter on thermoregulation.

Third, the chapters on evolution are now placed nearer the front of the book, immediately after the related topics of molecular biology and genetics, because many users taught the topics in this order in their courses. Our choice of chapter order may not matter much; biology is thoroughly web-like, and anything is easier to understand when you already know everything else. As far as we know, all users of the first edition reordered the chapters to some extent in their teaching. The feedback we received confirms that the chapters are independent enough to be taught in various orders, according to teachers’ preferences.

The running glossary and cross references to sections in other chapters are especially useful when the chapters are taught in a different order from that in the book. In this edition, we have incorporated more of the running glossary into the text to avoid what many users felt were too many footnotes; as before, the terms in the running glossary are indicated by asterisks. The text is again divided into short, numbered sections for easy identification, and we have now added subheadings to make an easier-to-follow outline. Many of the first edition's lettered sections are now subsections, so that the number of lettered sections is smaller. The extensive index/glossary of course remains, for we anticipate that this will be used as a reference book as well as a textbook.

All the main features of the first edition are still present — each chapter contains a summary, objectives, a self-quiz, questions for discussion, and a list of references and further reading. We have moved the objectives to the end of the chapters; we find that many students are intimidated if they read objectives with a lot of long, unfamiliar words before they start a chapter; they tend to skip the objectives and they may or may not remember to study the objectives after they have read the chapter. If students come to the objectives *after* reading the text for the first time, they find that they can already do most of the objectives but must go back and read a little more carefully to master the others before they are ready to tackle the self-quiz. Students with stronger backgrounds and vocabularies will find it worthwhile to skim the objectives before reading the chapter so that they know what to look for in the chapter. Having chosen to place the objectives at the back, we have rewritten the introductions to the chapters with special attention to preparing the students for the material in the chapter.

Objectives are a list of things so important that each student is required to know or do them in order to pass the course. The lists we provide are our attempt to point out important and well-established concepts and vocabulary and necessary skills. We do not include in the objectives conjectural material or much detail, even though we feel that it is worth presenting this material in the text of the chapter for the sake of background, completeness, or current interest. New teachers are reminded that they will often disagree with our selections, and should alter the list of objectives to suit their own courses. A more detailed discussion of the preparation and use of objectives is included in the Instructor's Manual.

The self-quiz permits students to test their mastery of some of the more important objectives; answers are in the back of the book. There is not enough space to test all objectives exhaustively, and students should treat the list of objectives itself as an essay-type examination.

The questions for discussion should not be treated as part of the self-quiz. They are just what their name implies: questions to bat around in discussion groups or over lunch. Students should be able to work out the answers to some of them from the information in the chapter. However, many are unanswerable — questions that researchers are addressing today, questions that have puzzled people for centuries, or questions of ethics or opinion that we must all answer for ourselves.

The suggested readings offer great variety. They include original work referred to in the text or figures, reference books that we find reliable,

bedtime reading with a biological slant, and works that approach difficult material from a different viewpoint.

At the behest of the United States Metric Association, we use the spellings "litre" and "metre" (instead of "meter" and "liter"), as used by scientists of all nations and by international businesses. We have also adopted the term "bisphosphate" now used by biochemists in place of "diphosphate" to indicate sugars with two phosphate groups, and have replaced the terms "blue-green algae" and "cyanophytes" with the increasingly favored "blue-green bacteria" and "cyanobacteria."

Possibly the greatest strength of this book is that it has been read and criticized by literally hundreds of biology students, teaching assistants, and experienced teachers of introductory biology. With the benefit of their experience to add to our own, we have identified difficult areas, devoted more space to them than is usual and, we hope, helped students over the conceptual hurdles involved. We hope this book presents biology as the fascinating and human subject that we ourselves enjoy so much.

KAREN ARMS

PAMELA S. CAMP

ACKNOWLEDGMENTS

The number of people who have helped to make and improve this book grows with every year that passes. The generous contributions of our teachers and students and friends and relatives have made our job much easier and cheered us on our way.

To ensure that the book is accurate and up to date, researchers in almost every area of biology have scanned chapters in their own specialties for mistakes and omissions. Dozens of experienced biology teachers also agreed to tell us what they thought was good and what was bad about the first edition, and to read the manuscript for this edition. They have helped to eliminate mistakes and, more important, have contributed their experience of areas students find difficult, additional material they have found

useful and the hundred and one details that are important to students, and so to teachers. For their contributions to the second edition, our thanks to:

Robert L. Amy
Southwestern University

Carol M. Bailey
Dean Junior College

William E. Barstow
University of Georgia

Sally Bauer
Hudson Valley Community College

William M. Bethal
Saint Louis University

Charles K. Biernbaum
The College of Charleston

Lois M. Borgman
Mount Ida Junior College

Edmund D. Brodie, Jr.
Adelphi University

Mac A. Callaham
North Georgia College

C. Blaine Carpenter
Clayton Junior College

Simon L. Chung
Trinity College

Mildred A. Collins
Stillman College

Richard Collins
Louisiana State University

Deborah F. Cooperstein
Adelphi University

Roland Corey
U.S. Naval Academy

James R. Darwood
Westchester Community College

Peter Davies
Cornell University

D. G. Davis
University of Alabama

John D. Davis
Mississippi University for Women

Margaret L. S. DeSaiz
University of North Carolina at Chapel Hill

Al Dibold
Macon Junior College

James K. Dooley
Adelphi University

Robert Egan
University of Nebraska at Omaha

John Farmer
University of Oklahoma

Gerald Fassell
Cayuga Community College

Albert E. Feldman
Dutchess Community College

Alfred F. Finocchio
St. Bonaventure University

Carl Frankel
Pennsylvania State University at Hazleton

E. C. Franks
West Illinois University

C. W. Gaddis
University of Arizona

William H. Gilbert
Simpson College

Julius Hand Gooden
Bowie State College

John R. Gregg
Duke University

David A. Haskell
Smith College

Stephen C. Hedman
University of Minnesota at Duluth

Frank Heppner
University of Rhode Island

Terry Hill
Southwestern University

Peter Hinkle
Cornell University

Kenneth M. Hoff
Cleveland State University

Linda-Margaret Hunt
University of Notre Dame

- Daniel R. Hystrom
Bakersfield College
- Andre Jagendorf
Cornell University
- Henry M. Knizeski, Jr.
Mercy College
- Shirley J. Kurtzberg
Westchester Community College
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Adelphi University
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University of Connecticut
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University of Dayton
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Mississippi University for Women
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Lake Erie College
- Marga H. Smith
Wittenberg University
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San Joaquin Delta College
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Tidewater Community College
- David Stetler
Virginia Polytechnic Institute and State University
- Darrell R. Stokes
Emory University
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Dickinson College
- Stanley Szarek
Arizona State University
- Jane B. Taylor
Northern Virginia Community College
- Dale Therrieu
Pennsylvania State University
- John Thornton
Oklahoma State University

Elizabeth K. Tomaszewski
Texas A & M University

Bik-Kwoon Tye
Cornell University

John M. Walker
Vincennes University

Eileen Walsh
Westchester Community College

Joseph Wood
*University of Missouri at
Columbia*

Theo Zemek
College of Du Page

We would also like to acknowledge the considerable contributions of those who reviewed and otherwise helped to prepare the first edition:

Kraig Adler
Cornell University

John Alcock
Arizona State University

Betty Allamong
Ball State University

John C. Belton
*California State University,
Hayward*

John P. Bihn
LaGuardia Community College

Antonie W. Blackler
Cornell University

Patricia Bonamo
*State University of New York at
Binghamton*

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Albany*

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Meramec*

Steven N. Handel
Yale University

Stephen C. Hedman
University of Minnesota

Richard F. Heller
Bronx Community College

Kenneth M. Hoff
The Cleveland State University

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University of Pittsburgh
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Tarrant County Junior College
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Cornell University
- Alan J. Jaworski
University of Georgia
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University of Mississippi
- George H. Kieffer
University of Illinois
- John A. W. Kirsch
Yale University
- David Klingener
University of Massachusetts
- Clifford E. LaMotte
Iowa State University
- Laurence A. Larson
Ohio University
- Georgia E. Lesh-Laurie
The Cleveland State University
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Community College of Philadelphia
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- John D. O'Connor
University of California, L.A.
- Lowell P. Orr
Kent State University
- Martha Constantine Paton
Princeton University
- Donald I. Patt
Boston University
- L. Jack Pierce
Mountain View College
- Caroline M. Pond
The Open University
- Gene A. Pratt
University of Wyoming
- Ralph S. Quatrano
Oregon State University
- Rudolf A. Raff
Indiana University
- Martin Sacks
City University of New York, City College
- Roger H. Sawyer
University of South Carolina
- Howard A. Schneiderman
University of California, Irvine
- Allan A. Schoenherr
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Duke University
- Daryl Sweeney
University of Illinois
- Joseph W. Vanable, Jr.
Purdue University
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University of California, Berkeley
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Stanford University
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St. Louis Community College at Meramec
- Norman Williams
University of Iowa
- John T. Windell
University of Colorado
- Clarence C. Wolfe
Northern Virginia Community College
- Joseph M. Wood
University of Missouri, Columbia
- Newell A. Younggren
University of Arizona
- John L. Zimmerman
Kansas State University

In addition to these reviewers are people who have helped us in a variety of ways. They transported, fed and housed us, argued with us about biology and grammar, read chapters, and contributed ideas, reprints, and moral support. Without all these people this book would be but a pale shadow of itself: Mary Ahl, Nan Arms, Frank Avedon, Amy Avnet, Robert Blakemore, William Blau, Clive Bransom, David Campbell, James Case, Brian Chabot, Anna Chao, John and Roberta Christy, Edward Cox, Catherine Craig, Karen Crassweller, Lucian Del Priore, Debbie DenHerder, Bernard Dethier, Carolyn Eberhard, Sheldon Freedman, Sidney Fox, Jane Gibson, Susan Giffen, David Gosling, Bruce Gray, Dan Gray, George Gutman, JoAnn Haick, William Hallahan, John Heiser, Ronald Hoy, Robert Ingoglia, Andrew Jones, Janis Kelly, Donald Kennedy, Harold Kipperman, Randi Lebar, Ellis Loew, Jane and John Lytle, Ross MacIntyre, Allen MacNeill, Peter Marks, Robert May, Muriel Milks, John Muller, Thomas Mullins, Nancy Ostman, Dominick Paolillo, Marie Paolillo, Richard Pflanzner, Harold Pusey, Mark Rauscher, Thomas Roberts, Monika Robke, Richard Root, Kenneth Sandlan, Heidi Schallenberg, David Schindler, Stephanie Seramitis, Jo Shapiro, Philippa Shepherd, Daniel Simberloff, Janice and Ian Skidmore, Stephanie and Stephen Sutton, Barbara and David Usher, Nicholas Wade, Watt Webb, Steven Webster, Robert Whittaker, and Kathryn Wunderlich.

A special word of thanks to Biophoto Associates, a cooperative of camera-clicking biologists run by Gordon Leedale at Leeds University in England. Gordon and his assistant, Helena Cmiech, patiently catered to our changing whims and presented us with so many gorgeous photographs that our only difficulty was deciding which we could bear not to use in this book. Without such a wonderful source of photographs, this book would be much less beautiful and could not have been published for at least another year.

Most of the cartoons scattered through the book are from the lively pen of Rosemary Smith who produced her comment on the genetic code (Chapter 10) in 1965 and has continued her frivolous commentary on biology and biologists ever since. May Berenbaum produced the scatological essay in Chapter 49 for a newsletter that accompanied the first edition of the book; we liked it so much that we borrowed it for this edition.

We are lucky enough to have found a publisher with whom it is stimulating, infuriating, amusing, and a continuing pleasure to work. Kendall Getman, who roped us into this business in the first place, has now retired and we miss him very much. This is our second book with publisher Don Jackson and editor Lee Walters. With them we have suffered much and celebrated mightily; long may it last! Our gratitude for their patience and hard work goes also to Lyn Peters of Holt, Rinehart and Winston, who edited the first edition, and to Michael Brown, Tom O'Connor, Carol Field, Nancy Grossman, Leesa Massey, and Rick Moore at Saunders College Publishing who designed, edited, produced, and kept track of the million and one bits of paper that a book of this complexity generates. We should make special mention, too, of John Tugman, our marketing manager, and his magnificent sales force. Without them, this book would be born to blush unseen. Over the years all these people have become our faithful friends and allies; we even take their advice occasionally!