

The background of the cover is a microscopic image, likely of a cell or microorganism, showing a large, reddish-orange, oval-shaped structure with a darker, blueish-grey nucleus-like area. The overall color palette is dominated by these warm, organic tones against a slightly darker blue background.

*third edition*

FOUNDATIONS IN

# MICROBIOLOGY

*Basic Principles*

Kathleen Park Talaro  
Arthur Talaro

*third edition*

FOUNDATIONS IN  
**MICROBIOLOGY**  
*Basic Principles*

**Kathleen Park Talaro**

*Pasadena City College*

**Arthur Talaro**



Boston Burr Ridge, IL Dubuque, IA Madison, WI New York San Francisco St. Louis  
Bangkok Bogotá Caracas Lisbon London Madrid  
Mexico City Milan New Delhi Seoul Singapore Sydney Taipei Toronto

# WCB/McGraw-Hill

A Division of The McGraw-Hill Companies

## FOUNDATIONS IN MICROBIOLOGY BASIC PRINCIPLES THIRD EDITION

Copyright © 1999 by The McGraw-Hill Companies, Inc. All rights reserved. Previous edition © 1996 by Times Mirror Higher Education Group, Inc. All rights reserved. Printed in the United States of America. Except as permitted under the United States Copyright Act of 1976, no part of this publication may be reproduced or distributed in any form or by any means, or stored in a data base or retrieval system, without the prior written permission of the publisher.

♻️ This book is printed on recycled, acid-free paper containing 10% postconsumer waste.

1 2 3 4 5 6 7 8 9 0 QPH/QPH 9 3 2 1 0 9 8

ISBN 0-697-35453-9

Vice president and editorial director: *Kevin T. Kane*  
Publisher: *James M. Smith*  
Developmental editors: *Terrance Stanton/Jean Sims Fornango*  
Marketing manager: *Martin J. Lange*  
Senior project manager: *Gloria G. Schiesl*  
Senior production supervisor: *Mary E. Haas*  
Freelance design coordinator: *Mary L. Christianson*  
Senior photo research coordinator: *Carrie K. Burger*  
Art editor: *Brenda A. Ernzen*  
Supplement coordinator: *Stacy A. Patch*  
Compositor: *York Graphic Services*  
Typeface: *10/12 Times*  
Printer: *Quebecor Printing Book Group/Hawkins, TN*


Freelance designer: *Jamie O'Neal*  
Cover photograph: © *SuperStock*  
Cover: *A colorized electron microscope photograph of Helicobacter pylori, a curved motile rod that has established a niche for itself in the stomach of humans and other animals.*

The credits section for this book begins on page C-1 and is considered an extension of the copyright page.

### Library of Congress Cataloging-in-Publication Data

Talaro, Kathleen J.  
Foundations in microbiology / Kathleen Talaro, Arthur Talaro.  
Brief ed., 3<sup>rd</sup> ed.  
p. cm.  
Includes index.  
ISBN 0-697-35453-9  
1. Microbiology. 2. Medical microbiology. I. Talaro, Arthur.  
II. Title.  
QR41.2.T35 1999b  
579-dc21

98 - 19121  
CIP



WE DEDICATE THIS EDITION TO OUR  
PARENTS, DONALD AND GRACE PARK  
OF BLACKFOOT, IDAHO, AND ARSENIO  
AND FLORENTINA TALARO OF  
HONOKAA, HAWAII, AND  
ACKNOWLEDGE THEM FOR THE GIFTS  
THEY GAVE US. BY NURTURE AND  
EXAMPLE, THEY TAUGHT US THE LOVE  
OF KNOWLEDGE, THE BENEFITS OF  
MEANINGFUL WORK, AND THE JOYS OF  
CREATIVITY AND CURIOSITY. THOUGH  
OUR FATHERS ARE NO LONGER WITH  
US, OUR MEMORIES OF THEM ARE  
STILL A DAILY SOURCE OF  
ENCOURAGEMENT AND INSPIRATION.

---

## Microbiology for the Millennium and Beyond

In the three short years since the previous edition of this book was published, events have continued to validate the importance and impact of microorganisms. As we reflect on the recent past and enter the twenty-first century, we appear to be teetering on the brink of what promises to be the “era of microbiology.” The science is growing at an astounding rate, and it continues to branch out into new realms. Discoveries keep coming to light that dazzle even seasoned microbiologists. We now know that complex microbial communities living deep in the earth’s crust probably outnumber those on the earth’s surface and are intimately involved in the geologic processes of the earth. Who would have expected that an insidious type of protein (prion) could be transmitted as an infectious agent and cause serious problems for agriculture and food handling? We watch from the sidelines in surprise and alarm at reports that biological warfare agents such as anthrax are being amassed as instruments of death. And more than ever before, we are made aware (sometimes uncomfortably) of the microbial contents of the food we eat, the water we drink, and even the air we breathe. For the past twenty years, the central role of microorganisms has continued to dominate strides in molecular biology and genetic engineering, and it influences most of the new technologies in industry. As Dr. Samuel Kaplan, chairman of the De-

partment of Microbiology and Molecular Genetics at the University of Texas Medical School, said:

The science of microbiology is alive and well; it flourishes because of the intrinsic wealth of its subject matter. Its study has spawned the Human Genome Project, plant molecular biology, neurobiology, and all of the rest.

Even a casual observer would have to admit that becoming knowledgeable about microorganisms is no longer a convenience; it is a necessity, regardless of what your future holds. Studying microbiology will add immensely to your personal development, to your future career, and to your ability to make informed, perceptive decisions about the momentous new era of technology. Clearly, the more you learn about the subject of microbiology, the more you will understand about yourself and the world you live in.

---

## Mission and Organization of the Textbook

The driving force of this textbook has always been to provide students with a solid background in the science of microbiology that prepares the student for future coursework and practical applications. As do all technical subjects, microbiology contains a wide array of facts and ideas to be incorporated into your growing store of knowledge. One of the ways to remain grounded

in the subject is to concentrate on understanding concepts—important fundamental ideas or themes that explain a process or form a framework for ideas and words. Most of these concepts are laid out like links in a chain of information that lead you to the next level. As you continue to progress through the book, you can branch out into new areas, refine your knowledge, make important connections, and develop sophistication with the subject. Most chapters are structured with two levels of coverage: one that can be used to learn general concepts and one that encourages learning of specific ideas.

The order and style of our presentation are similar to those in the previous edition, but we have incorporated extensive changes. Our primary goals with this edition were to update, simplify, and improve illustrations. Although changes in written text are difficult to detect by a cursory look, every sentence has been carefully evaluated for currency, accuracy, and clarity. We have extensively updated figures and statistics and have introduced pertinent events and discoveries occurring since 1996. We have added about 10 new figures and 30 new photographs and have revised 200 figures. Although the basic design is intact, the use of color in tables and boxes has been altered to improve their readability, and the formats for chapter openers have a new look.

Despite an overwhelming amount of new information being generated every year, we have aimed to present a balanced coverage of traditional and new developments in microbiology without adding to the length of coverage.



## MAJOR AREAS OF CHANGE

We have emphasized the changes in taxonomy that have resulted from ribosomal RNA analysis, and we have updated information on emerging diseases. The presentation of media has been altered, and new photographs have replaced older illustrations on staining techniques. We have added a new illustrated table on bacterial shapes and arrangements, have supplemented information on molecular techniques in identification, and have added an expanded section on the archaea. Tables and figures in the virus chapter have been revised for simplicity. Major changes in the presentation of metabolism and genetics include new and revamped figures, refinements in tables, and fine-tuning of the text to fit figures. Several examples used for biotechnology have been updated, including a box on the Human Genome Project and use of mitochondrial DNA. Improvements have been made to figures in microbial control, including a new box on antibacterial products, new material on the use of UV radiation, and updated information on drugs and drug resistance. To reflect the changing scope of immunology, we have modified coverage on cytokines and have added a flowchart to summarize host defenses. Introduction of new vaccines and vaccine development are significant additions. The coverage of specific diseases has been researched for accuracy, and certain chapters have been retitled for clarity. Chapters 18 through 25 have been supplemented with the latest information on new bacteria, viruses, and parasites. We have also moved the actinomycetes from the fungus chapter to the gram-positive bacteria chapter. The section on AIDS has been amended to include new information on virus structure, infection, drugs, and vaccines. Improvements have been made to the coverage of photosynthesis and some elements of food microbiology. We have added more questions to most chapters and a section suggesting Internet search topics.

The heart and soul of this book join to promote interest in this fascinating subject and to share some of our sense of excitement and awe for it. We hope that our involvement in the subject, our love of language, and our fun with analogies, models, and figures are so contagious that they

stimulate your interest and get you caught up in “microfever.”

## Features of the Third Edition

### CHAPTER OUTLINE AND CONTENT

We have retained most elements of the original format from the previous editions. The Brief Contents provides chapter titles and order. Detailed chapter headings, with page numbers are given in the Contents and appear again at the beginning of each chapter.

### ORGANIZATION AND LEARNING TOOLS

The master plan for chapter organization is as follows:

#### Opening Page

Every chapter begins with a brief opening statement or description followed by an outline of major chapter headings with page references. Framed in the center is a visual image that focuses attention on an interesting snippet related to the chapter.

#### Headings

The chapter is organized into sections by means of headings. Primary and secondary headings appear in large type and introduce general sections with a word or description. Lower level headings lead into subsections and help to partition general topics into smaller, more specific areas of discussion.

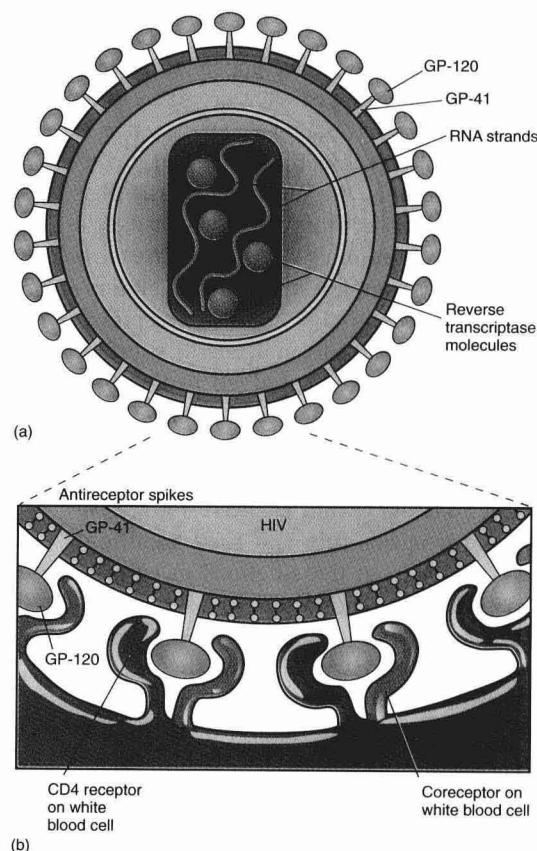
#### Illustration and Photography Program

Written text, especially that of a complex nature, is greatly enhanced by illustrations and photographs. A concrete visual image can help the reader picture abstract processes and ideas, and it can make even the most routine concept memorable. In addition to hand-tailoring figures to correspond to the text, we have thoroughly reviewed the original art program for accuracy, use of color,

labeling, legends, and placement. Most of the original illustrations have been retained, many have been revised, and several have been completely reworked to increase sophistication and to reflect new information.

### Multimedia-Supported Illustrations

Throughout the text the reader will find illustrations of microbiological concepts and processes that can be supplemented with full-color video, animations, or interactive screens from the new second edition of *Microbes in Motion* (0-072-29262-8), an interactive CD-ROM available from WCB/McGraw-Hill. The reader will be able to easily recognize these figures, because the relevant figure legends are preceded by a CD icon. Figure 25.12, reproduced here, is one example of such an illustration.



**Figure 25.12**

(a) A cutaway model of HIV. The envelope contains two types of glycoprotein (GP) spikes, two identical RNA strands, and several molecules of reverse transcriptase encased in a protein coating. (b) The snug attachment of HIV glycoprotein antireceptors (GP-41 and 120) to their specific receptors on a human cell membrane. These receptors are CD4 and a coreceptor called CCR-5 (fusin) that permit docking with the host cell and fusion with the cell membrane.

## Correlation Guide to Microbes in Motion

Finding the corresponding information on the *Microbes in Motion* CD-ROM for the multimedia-supported illustrations just described requires a correlation guide, which is available to instructors. The *Microbes in Motion* CD-ROM is organized into 17 topical “books”; the books are divided up into “chapters,” and the chapters have numbered “pages.” For each multimedia-supported illustration, the correlation guide directs the reader to the book, chapter, and page on the CD-ROM where corresponding material can be found. The correlation guide entry is shown here for multimedia-supported illustration.

## Microfiles

Every chapter contains separate boxed-off features called Microfiles. Some of them contain essential information that requires special emphasis; others provide enrichment details on newsworthy, practical, or historical topics that are related to the main text. Your instructor may assign these to you as additional reading. The Microfiles are denoted by icons in the following categories:



History



Biotechnology



Genetics



Medical Applications



Immunology



Spotlight



General Topics

## Tables and Charts

The text contains about 125 tables and charts. Tables contain data, illustrations, or both, and are used to summarize additional reference and support information. Some figures contain lists of characteristics highlighted by bullets. Flowcharts, also called separation outlines, serve to overview, compare and contrast, and show relationships between various topics.

## Chapter Checkpoints

Sometimes, the amount of factual information in a chapter can make it difficult to “see the forest for the trees.” A beneficial strategy at such times can be to pause and review some important points before continuing on to the next topic. We have in-

cluded in each chapter three to six brief summaries called Chapter Checkpoints that concisely state the most important ideas under a major heading and provide the reader with a quick recap of what has been covered to that point. Many instructors assign these as a guide for study and review.

## Vocabulary

The study of microbiology will immerse the student in a rich new language. No one expects the beginner to learn all the new terms, but some ability to understand, speak, and write this new language will certainly be essential. To assist you in building vocabulary, we have highlighted principal terms in boldface or italics and have defined them at their first appearance



## Chapter Checkpoints

**Magnification, resolving power, lens quality, and illumination source all influence the clarity of specimens viewed through the optical microscope.**

The maximum resolving power of the optical microscope is 200 nm, or 0.2  $\mu\text{m}$ . This is sufficient to see the internal structures of eucaryotes and the morphology of most bacteria.

There are five types of optical microscopes. Four types use visible light for illumination: bright-field, dark-field, phase-contrast, and interference microscopes. The fifth type, the fluorescence microscope, uses UV light for illumination, but it has the same resolving power as the other optical microscopes.

Electron microscopes (EM) use electrons, not light waves, as an illumination

source to provide high magnification (5,000 $\times$ –1,000,000 $\times$ ) and high resolution (0.5 nm). Electron microscopes can visualize cell ultrastructure (TEM) and three-dimensional images of cell and virus surface features (SEM).

Specimens viewed through optical microscopes can be either alive or dead, depending on the type of specimen preparation, but all EM specimens are dead because they must be treated with metals for effective viewing.

Stains are important diagnostic tools in microbiology because they can be designed to differentiate cell shape, structure, and biochemical composition of the specimens being viewed.

in the text. Terms marked by an asterisk or by a numbered footnote also have pronunciation and word origins given. As a rule, speaking a word will help you to spell it and learn its meaning. Because many scientific terms are derived from Latin and Greek, a grounding in these word roots will help you understand the meanings of other related words. A guide to phonetic pronunciation with examples as used in this text follows:

### Chapter Capsules with Key Terms

The major content of each chapter is condensed into short summaries, called Chapter Capsules, in the form of a free-flowing outline. Key terms are placed in the outline to keep them in context with their associated topics. Capsules can be used as both a quick review and an overview of the chapter.

### Question Section

Each chapter concludes with an extensive question section intended to guide and supplement your study and self-testing. The number and types of questions are diverse to allow your instructor to assign questions for desired focus and emphasis. Questions with several parts are differentiated by letters so that all or part of a question may be selected. Because of space constraints, this book contains answers only to multiple-choice questions (in Appendix E). A guide for answers to all other questions is available to instructors.

### Multiple-Choice (MC) Questions

This type of objective question is commonly used in class testing and standardized exams and is a quick way to assess your grasp of chapter content. These questions are compiled randomly from selected vocabulary and factual information. It is assumed that if you answer these accurately, you have a good understanding of other information in the chapter. In general, MC questions have only one correct answer, and this answer may be surmised by a process of eliminating the incorrect answers and narrowing the choices down to one.

**Matching Questions** Many chapters contain questions that list words and related descriptions. In single-matching questions, only one description matches a given word; in multiple-matching questions, several can match and you should choose all possible descriptions that fit the words in the list.

**Concept Questions** Education in a subject is not really complete until you can demonstrate understanding by writing in depth about the subject. The concept questions guide your review of the chapter by asking you to compose complete answers that cover essential ideas and correct terminology. This form of expression will require determining what is most important and rewriting it in your own words in concise, logical terms. Writing is an excellent way to learn vocabulary and usage, and working with the concepts will also help you commit them to memory. All information and terminology to answer these questions can be found in the main body of the chapter and in figures, tables, and Micro-

#### GENERAL GUIDE TO PRONUNCIATION AS USED IN THE TEXTBOOK

Letter	Pronounced	As In	Example in Text
A	ah	fat	bacteria (1st a)
	ay	day	lipase
	uh	along	schistosoma, bacteria (2nd a)
AE	ee		archaebacteria, salmonellae
C	see	cease	cellulase
c	kay	cat	anaerobic, procaryote
cc	kay, then see		vaccine, cocci
Ch	kay	chorus	chemotherapy, spirochete
	ch	chest	chickenpox
	sh	chevrolet	chancre
E	ee	discrete	nucleus, gangrene
	eh	bet	cestode, mesosome
Er	ur	finger	thermophile
Eu	oo	leukemia	<i>Pseudomonas</i> , pneumonia
	yoo		eubacteria
G	j	geologic	appendage
	guh	growth	glycolysis
I	eye	bite	halophile, spirochete, lipase
	ih	bit	facultative, aerobic
	ee	nutrient	<i>Mycobacterium</i>
O	aw	body	optical
	oh	cold	saprotroph
OY	oh-ee	oil	ameboid
oe	ee		<i>Entamoeba</i>
oo	oo	mood	zoonosis
ox	ocks	pox	toxemia
Ph	eff	phase	staphylococci
Ps	sick	Psalm	<i>Pseudomonas</i>
S	ess	sense	spirochete
	zee	pleasure	<i>Blastomyces</i> , plasmid
tion	shun	mention	sporulation
ture	chur	furniture	denature
U	yoo	uniform	papule
	uh	cup	coccus
UR	yur	cure	purine
Y	y	why	mycosis
	ee	wary	leprosy
	ih	synthetic	Chlamydiales



file readings. Most of these questions will require several sentences or paragraphs to answer fully.

### Critical-Thinking Questions

Thought questions challenge you to use scientific thinking, analysis, and problem solving. They assume a substantial grasp of factual information from the chapter in which they appear and earlier chapters, and they require you to reason, find relationships, suggest plausible explanations, and apply concepts to real-world situations. Questions may involve case studies, research findings, and everyday household settings. Some assign demonstrations, models, or ideas for class discussion; some even call for an opinion. By their nature, most of these questions allow more than one interpretation and do not have a predetermined “correct” answer.

### Internet Search Topics

One of the most significant and far-reaching sources of information in a rapidly advancing science such as microbiology is the Internet. There are thousands of Web sites covering millions of topics related to this subject. Rather than suggest specific Web sites, we prefer to direct your searches using a search engine such as Yahoo, Webcrawler, or AltaVista. Using a search engine will help you become acquainted with the wide array of coverage available, and you will not encounter inactive Web sites and dead ends. Most chapters suggest one or two topics or terminology to search, but nearly any subject or concept in the book can be accessed by simple word search. We strongly encourage you to use this fantastic and exciting resource!

### Appendices

The appendices in this edition cover the following topics:

- Appendix A: Greek letters and units and prefixes of measurement (new)
- Appendix B: exponents and logarithms
- Appendix C: methods for testing sterilization and disinfection
- Appendix D: universal blood and body-fluid precautions and biosafety levels

- Appendix E: answers to multiple-choice questions
- Appendix F: a cross-reference for the major bacterial, fungal, parasitic, and viral agents and diseases, by system affected and mode of transmission

### Glossary and Index

The glossary includes about 675 entries that define most of the boldfaced and italicized terms used in the text. Do not overlook the value of the index, which is extensive enough to include the vast majority of major and minor terms used in the text and can be an excellent tool for finding information.

### Endpapers

The inside covers of the book depict printouts from the Centers for Disease Control and Prevention on the latest summary data for major reportable infectious diseases in the United States, listed by state and region. Summary data from 1998 were not available at press time, so these data from 1997 are the most recent information available. The back endpapers (hardcover edition only) present a summary table of disease incidence in the United States from 1989 to 1996 and other statistics on diseases such as AIDS.

---

## Study Tips for the Beginning Microbiology Student

Most of you are taking this course in preparation for a career in allied health or some area of the biological sciences. You will probably already have had some experience in studying science. By their nature of being information-intensive, these courses require a significant input of time. They involve a certain amount of pure memorization, of, at the very least, terminology, and they require consistent study habits. The rewards for your commitment will be the gifts of knowledge and awareness that are crucial to your careers and lives. No one will ever be able to take those gifts away from you, and you will probably use them in some way every single day.

Teachers know that for many students the bottom line is their grade, but there are simply no shortcuts to a good grade. It is one of life's little truths that the more time you spend in serious study, the more you will learn, and an improvement in your grade will automatically follow. Just make sure the time you spend is used to maximum benefit. Many students highlight key portions in a chapter as they read, but such passive activity may exercise your hand more than your mind, and it can use up valuable time and energy.

You will retain far more information if you engage your mind in active thought about the words and ideas. Write marginal notes to yourself; question yourself on understanding; and highlight and reread only the most significant points. To add some fun to the process and speed it along, try making up mnemonic devices: little slogans that help you recall a series of ideas. One of our students developed mental pictures that helped her visualize processes. For example, she thought of DNA as the king in a castle, sending out messengers to do his bidding, or the TCA cycle as a weird Ferris wheel that takes on passengers at the top and lets them off at the bottom.

Another active learning process is to write questions and answers on index cards to quiz yourself periodically. Repetition is the secret to recalling information. Spending an hour every day with flash cards is a far more effective way of learning than trying to absorb three chapters of material in a single marathon. Biologists studying brain chemistry have recently determined the reason for that oft-repeated warning “Do not cram because it doesn't work!” It turns out that a certain receptor in the part of the brain that regulates memory must be regenerated about every 30 minutes. Any studying done when the receptors are exhausted will not be placed into memory. This means that you really should study in short bursts with frequent breaks. Even if you have to study over a longer stretch, try to relax for a few moments, take a walk, or involve yourself in something that does not require intense thought. Other worthwhile endeavors include studying with other students or a tutor in small groups, working with the study guide or CD-ROM, and surfing the Internet to find Web sites that have study guides or sample exams. And

don't forget to ask your instructor or teaching assistant for help if you are having a difficult time. They have a serious interest in your learning and success.

The subject matter in this text is fundamental, but it is not merely a review of information you have had before. Even if you have already completed a biology and chemistry course, much of the material it contains will be new to you. Microbiology is, after all, a specialized area of biology with its own orientation and emphasis. There is more information presented here than can be covered in a single course, so be guided by your instructor's reading assignments and study guide, because he or she knows what is most important for your course.

---

## Supplemental Materials for Students and Instructors

### LEARNING AIDS FOR STUDENTS

#### *A Student Study Guide*

Prepared by Jackie Butler of Grayson County Community College, the study guide contains study objectives, activities, and test-taking strategies, and a newly expanded section of questions. Answers to the objective questions are included.

#### *A Multimedia Tie-in to Foundations in Microbiology*

An interactive CD-ROM, *Microbes in Motion II*, was developed especially with this textbook. It contains full-colored animations and video programs to supplement the illustration program. Figures that are tied to the CD-ROM program are indicated by a small disc icon. This new version is Mac and Windows compatible.

#### *Web Site*

The publisher is launching a Web site for this text with links to more than 100 related microbiology sites. You can find it at <http://www.mhhe.com>.

## TEACHING SUPPLEMENTS

### *Instructor's Manual with Test Item File*

Developed by Louis Giacinti, Milwaukee Area Technical College, the instructor's manual is available as both a softbound manual and a computer diskette and contains an extended lecture outline with the complete headings of each chapter down to the fourth-level heads and Microfiles. Instructors can use this to organize their coverage and lectures. It also has a test item file of true/false, multiple-choice, matching, and short-answer questions to be used in compiling exams. A key to all questions is included.

### *Overhead Transparencies*

A set of 200 color transparencies of the most requested figures are offered to all instructors who adopt the text. A Visual Resource Library CD-ROM with key words contains these images plus 200 more. This valuable product can be used for developing lectures and power point presentations.

### *Microtest Service*

A computerized test file containing about 1,000 questions is available to all adopters. The program is compatible with Macintosh and Windows systems.

---

## Acknowledgments

This third edition has been guided by an entirely new and dedicated team from the McGraw-Hill and Wm. C. Brown Publishers merger. Each member has provided valuable support and suggestions for the revision effort. We appreciate the leadership and insights of Ron Worthington, our editor. We are especially grateful for the important input of our developmental editor, Terry Stanton, who was always there to offer calm and patient understanding and advice when the crunch of teaching and authoring overwhelmed us. We also enjoyed collaborating with the able production team, including Gloria Schiesl and

Ann Morgan. Other hardworking group members with valuable contributions are art editor Brenda Erzen and photo editor Carrie Burger. We discovered two true gems during the revision process. One is our copy editor, Margo Quinto, who helped to simplify language and added an elegant, experienced touch to the text. The other is our photo researcher, Connie Mueller, a delightful lady who doggedly and good-naturedly pursued just the right photograph to the ends of the earth, if necessary!

Significant support and feedback have come from our colleagues and students at Pasadena City College, especially Barry Chess, whose keen eye caught several errors and who graciously agreed to proofread a number of new illustrations and made meaningful suggestions for improvements. A heartfelt commendation also goes to a gifted student Garri Tsibel, who read the entire textbook, made detailed marginal notes, and demonstrated a profound love for the subject. The many other fine students of Pasadena City College have been a wonderful source of ideas and inspiration, and they continue to teach us something new every semester.

We have solicited suggestions for changes and improvements from textbook users and student readers and have been able to include most if not all of the ideas submitted. We also recognize the contributions of our team of reviewers. Their critical reading and suggestions for additions and deletions have helped us to keep the appropriate focus and perspective during revision. We owe a debt of gratitude for their able stewardship. Thank you all for being part of this continuing book partnership.

Textbooks go through an extraordinary proofreading process. They are pored over numerous times by authors, reviewers, editors, and proofreaders. Even after all of that attention, it is impossible to produce a work completely free of errors. Please feel free to contact us with any errors you find or other constructive comments for changes we can make in future editions. The e-mail address is [ktalaro@aol.com](mailto:ktalaro@aol.com).

**Reviewers, First Edition**

**Shirley M. Bishel**  
Rio Hondo College

**Dale DesLauriers**  
Chaffey College

**Warren R. Erhardt**  
Daytona Beach Community College

**Louis Giacinti**  
Milwaukee Area Technical College

**John Lennox**  
Penn State, Altoona Campus

**Glendon R. Miller**  
Wichita State University

**Joel Ostroff**  
Brevard Community College

**Nancy D. Rapoport**  
Springfield Technical Community College

**Mary Lee Richeson**  
Indiana University, Purdue University at  
Fort Wayne

**Donald H. Roush**  
University of North Alabama

**Pat Starr**  
Mt. Hood Community College

**Pamela Tabery**  
Northampton Community College

**Reviewers, Second/Third Editions**

**Rodney P. Anderson**  
Ohio Northern University

**Robert W. Bauman, Jr., Ph.D.**  
Amarillo College

**Leon Benefield**  
Abraham Baldwin Agricultural College

**Lois M. Bergquist**  
Los Angeles Valley College

**L. I. Best**  
Palm Beach Community College—Central  
Campus

**Bruce Bleakley**  
South Dakota State University

**Kathleen A. Bobbitt**  
Wagner College

**Jackie Butler**  
Grayson County College

**R. David Bynum**  
SUNY at Stony Brook

**David Campbell**  
St. Louis Community College—Meramec

**Joan S. Carter**  
Durham Technical Community College

**Barry Chess**  
Pasadena City College

**John C. Clausz**  
Carroll College

**Margaret Elaine Cox, Ph.D.**  
Bossier Parish Community College

**Kimberlee K. Crum**  
Mesabi Community College

**Paul A. DeLange**  
Kettering College of Medical Arts

**Michael W. Dennis**  
Montana State University—Billings

**William G. Dolak**  
Rock Valley College

**Bob F. Drake**  
State Technical Institute at Memphis

**Mark F. Frana**  
Salisbury State University

**Elizabeth B. Gargus**  
Jefferson State Community College

**Larry Guillou, Ph.D.**  
Armstrong State College

**Safawo Gullo**  
Abraham Baldwin Agricultural College

**Christine Hagelin**  
Los Medanos College

**Geraldine C. Hall**  
Elmira College

**Heather L. Hall**  
Charles County Community College

**Theresa Hornstein**  
Lake Superior College

**Anne C. Jayne**  
University of San Francisco

**Patricia Hilliard Johnson**  
Palm Beach Community College

**Patricia Klopfenstein**  
Edison Community College

**Jacob W. Lam**  
University of Massachusetts Lowell

**James W. Lamb**  
El Paso Community College

**Hubert Ling**  
County College of Morris

**Andrew D. Lloyd**  
Delaware State University

**Marlene McCall**  
Community College of Allegheny County

**Joan H. McCune**  
Idaho State University

**Gordon A. McFeters, Ph.D.**  
Montana State University

**Karen Mock**  
Yavapai College

**Jacquelyn Murray**  
Garden City Community College

**Robert A. Pollack**  
Nassau Community College

**Judith A. Prask**  
Montgomery College

**Leda Raptis**  
Queen's University

**Carol Ann Rush**  
La Roche College

**Andrew M. Scala, Ph.D.**  
Dutchess Community College

**Caren Shapiro**  
D'Youville College

**Linda M. Sherwood, Ph.D.**  
Montana State University

**Lisa A. Shimeld**  
Crafton Hills College

**Cynthia V. Sommer**  
University of Wisconsin—Milwaukee

**Donald P. Stahly**  
University of Iowa

**Terrence Trivett**  
Pacific Union College

**Garri Tsibel**  
Pasadena City College

**Leslie S. Uhazy**  
Antelope Valley College

**Valerie Vander Vliet**  
Lewis University

**Frank V. Veselovsky**  
South Puget Sound Community College

**Katherine Whelchel**  
Anoka-Ramsey Community College

**Vernon L. Wranosky**  
Colby Community College

**Dorothy M. Wrigley**  
Mankato State University

# BRIEF CONTENTS

- Chapter ●** THE MAIN THEMES OF MICROBIOLOGY 1
- Chapter ●** FROM ATOMS TO CELLS: A CHEMICAL CONNECTION 25
- Chapter ●** TOOLS OF THE LABORATORY: THE METHODS FOR STUDYING MICROORGANISMS 59
- Chapter ●** PROCARYOTIC PROFILES: THE BACTERIA AND ARCHAEA 88
- Chapter ●** EUCARYOTIC CELLS AND MICROORGANISMS 124
- Chapter ●** AN INTRODUCTION TO THE VIRUSES 161
- Chapter ●** ELEMENTS OF MICROBIAL NUTRITION, ECOLOGY, AND GROWTH 190
- Chapter ●** MICROBIAL METABOLISM: THE CHEMICAL CROSSROADS OF LIFE 221
- Chapter ●** MICROBIAL GENETICS 256
- Chapter ●** GENETIC ENGINEERING: A REVOLUTION IN MOLECULAR BIOLOGY 296
- Chapter ●** PHYSICAL AND CHEMICAL CONTROL OF MICROBES 327
- Chapter ●** DRUGS, MICROBES, HOST—THE ELEMENTS OF CHEMOTHERAPY 359
- Chapter ●** MICROBE-HUMAN INTERACTIONS: INFECTION AND DISEASE 391
- Chapter ●** THE NATURE OF HOST DEFENSES 431
- Chapter ●** THE ACQUISITION OF SPECIFIC IMMUNITY AND ITS APPLICATIONS 463
- Chapter ●** IMMUNIZATION AND IMMUNE ASSAYS 495
- Chapter ●** DISORDERS IN IMMUNITY 516
- 
- INTRODUCTION TO IDENTIFICATION TECHNIQUES IN MEDICAL MICROBIOLOGY 555
- Chapter 18** THE COCCI OF MEDICAL IMPORTANCE 563
- Chapter 19** THE GRAM-POSITIVE BACILLI OF MEDICAL IMPORTANCE 593
- Chapter 20** THE GRAM-NEGATIVE BACILLI OF MEDICAL IMPORTANCE 623
- Chapter 21** MISCELLANEOUS BACTERIAL AGENTS OF DISEASE 649
- Chapter 22** THE FUNGI OF MEDICAL IMPORTANCE 688
- Chapter 23** THE PARASITES OF MEDICAL IMPORTANCE 719
- Chapter 24** INTRODUCTION TO THE VIRUSES OF MEDICAL IMPORTANCE: THE DNA VIRUSES 756
- Chapter 25** RNA VIRUSES OF MEDICAL IMPORTANCE 782
- Chapter 26** ENVIRONMENTAL AND APPLIED MICROBIOLOGY 827

● Denotes chapters (1–17) that appear in the paperback *Basic Principles* version of this text.



# CONTENTS

Preface xv

## Chapter ●

THE MAIN THEMES OF  
MICROBIOLOGY 1

THE SCOPE OF MICROBIOLOGY 2  
*Infectious Diseases and the Human  
Condition 4*

**MICROFILE 1.1** Infectious Diseases in the  
Global Village 6

THE GENERAL CHARACTERISTICS OF  
MICROORGANISMS 7  
*Cellular Organization 7*  
*A Note on Viruses 7*  
*Microbial Dimensions: How Small Is  
Small? 7*

*Life-styles of Microorganisms 7*  
THE HISTORICAL FOUNDATIONS OF  
MICROBIOLOGY 7  
*The Development of the Microscope:  
“Seeing Is Believing” 8*

**MICROFILE 1.2** Spontaneous Generation  
and the Battle of the  
Hypotheses 12  
*The Rise of the Scientific Method 14*  
*The Development of Medical  
Microbiology 16*

TAXONOMY: ORGANIZING,  
CLASSIFYING, AND NAMING  
MICROORGANISMS 18  
*The Levels of Classification 18*  
*Assigning Specific Names 19*  
*The Origin and Evolution of  
Microorganisms 20*  
*Systems of Presenting a Universal Tree  
of Life 21*

Chapter Capsule with Key Terms 23  
Multiple-Choice Questions 23

Concept Questions 24  
Critical-Thinking Questions 24  
Internet Search Topic 24

## Chapter ●

FROM ATOMS TO  
CELLS: A CHEMICAL  
CONNECTION 25

ATOMS, BONDS, AND MOLECULES:  
FUNDAMENTAL BUILDING  
BLOCKS 26  
*Different Types of Atoms: Elements and  
Their Properties 27*  
*The Major Elements of Life and Their  
Primary Characteristics 28*

BONDS AND MOLECULES 28  
*Covalent Bonds and Polarity:  
Molecules with Shared  
Electrons 29*  
*Ionic Bonds: Electron Transfer Among  
Atoms 31*

**MICROFILE 2.1** Redox: Electron Transfer  
and Oxidation-Reduction  
Reactions 32  
*Solutions: Homogeneous Mixtures of  
Molecules 34*  
*Acidity, Alkalinity, and the pH Scale 35*  
*The Chemistry of Carbon and Organic  
Compounds 37*  
*Functional Groups of Organic  
Compounds 37*

MACROMOLECULES: SUPERSTRUCTURES OF  
LIFE 38  
*Carbohydrates: Sugars and  
Polysaccharides 39*  
*Lipids: Fats, Phospholipids, and  
Waxes 42*  
*Proteins: Shapers of Life 43*

*The Nucleic Acids: A Cell Computer  
and Its Programs 46*

**MICROFILE 2.2** Proteins and Paper  
Airplanes 47

CELLS: WHERE CHEMICALS COME TO  
LIFE 52  
*Fundamental Characteristics of Cells  
52*  
*Processes That Define Life 52*

**MICROFILE 2.3** Membranes: Cellular  
Skins 53

Chapter Capsule with Key Terms 55  
Multiple-Choice Questions 56  
Concept Questions 57  
Critical-Thinking Questions 58

## Chapter ●

TOOLS OF THE  
LABORATORY: THE  
METHODS FOR  
STUDYING  
MICROORGANISMS 59

METHODS OF CULTURING  
MICROORGANISMS 60  
*Inoculation and Isolation 61*

**MICROFILE 3.1** Animal Inoculation:  
“Living Media” 61  
*Media: Providing Nutrients in the  
Laboratory 62*

**MICROFILE 3.2** Media Milestones 64  
*Types of Media 64*  
*Physical States of Media 64*

**MICROFILE 3.3** Microbiology Discovers  
Agar 66  
*Chemical Content of Media 65*  
*Media to Suit Every Function 67*



**INCUBATION, INSPECTION, AND IDENTIFICATION 71***Maintenance and Disposal of Cultures 71***THE MICROSCOPE: WINDOW ON AN INVISIBLE REALM 71***Magnification and Microscope Design 72**Variations on the Optical Microscope 75**Electron Microscopy 77***MICROFILE 3.4 A Revolution in Resolution: Probing Microscopes 81***Preparing Specimens for Optical Microscopes 81***MICROFILE 3.5 The Chemistry of Dyes and Staining 83****Chapter Capsule with Key Terms 85****Multiple-Choice Questions 86****Concept Questions 86****Critical-Thinking Questions 87**

---

**Chapter****PROCARYOTIC PROFILES: THE BACTERIA AND ARCHAEA 88****PROCARYOTIC FORM AND FUNCTION: EXTERNAL STRUCTURE 89****THE STRUCTURE OF A GENERALIZED PROCARYOTIC CELL 89***Appendages: Cell Extensions 90**The Cell Envelope: The Outer Wrapping of Bacteria 94**The Cell Wall: Multipurpose Framework of the Cell 96***MICROFILE 4.1 The Gram Stain: A Grand Stain 97***The Cell Membrane: The Multipurpose Integument 100***BACTERIAL FORM AND FUNCTION: INTERNAL STRUCTURE 101***Contents of the Cells Cytoplasm 101**Bacterial Endospores: Resistance in the Extreme 102***BACTERIAL SHAPES, ARRANGEMENTS, AND SIZES 105****BACTERIAL IDENTIFICATION AND CLASSIFICATION SYSTEMS 108***Methods Used in Bacterial Identification 108**Classification Systems in the Procaryotae 109***MICROFILE 4.2 The Name Game 111****SURVEY OF PROCARYOTIC GROUPS WITH UNUSUAL CHARACTERISTICS 115***Unusual Forms of Medically Significant Bacteria 115***MICROFILE 4.3 Bulky Bacterium Baffles Biologists 116***Free-Living Nonpathogenic Bacteria 117**Archaea: The Other Procaryotes 118***Chapter Capsule with Key Terms 121****Multiple-Choice Questions 122****Concept Questions 122****Critical-Thinking Questions 123****Internet Search Topic 123**

---

**Chapter****EUCARYOTIC CELLS AND MICROORGANISMS 124****THE NATURE OF EUCARYOTES 125****FORM AND FUNCTION OF THE EUCARYOTIC CELL: EXTERNAL STRUCTURES 125***Locomotor Appendages: Cilia and Flagella 127**Surface Structures:**The Glycocalyx 127**The Cell Wall 127**The Cell Membrane 128***FORM AND FUNCTION OF THE EUCARYOTIC CELL: INTERNAL STRUCTURES 128***The Nucleus: The Cell Control Center 128**Endoplasmic Reticulum: A Maze of Membranes 129**Golgi Apparatus: A Packaging Machine 130**Mitochondria: Energy Generators of the Cell 134***MICROFILE 5.1 The Extraordinary Emergence of Eucaryotic Cells 135***Chloroplasts: Photosynthesis Machines 134**The Cytoskeleton: A Support Network 134**Ribosomes: Protein Synthesizers 136***SURVEY OF EUCARYOTIC****MICROORGANISMS 137****THE KINGDOM OF THE FUNGI 137***Fungal Nutrition 139**Organization of Microscopic Fungi 140**Reproductive Strategies and Spore Formation 140**Fungal Classification 143**Fungal Identification and Cultivation 144**The Roles of Fungi in Nature and Industry 145***MICROFILE 5.2 Fascinating Fungi 146****THE PROTISTS 146***The Algae: Photosynthetic Protists 147**Biology of the Protozoa 149***THE PARASITIC HELMINTHS 155***General Worm Morphology 155**Life Cycles and Reproduction 155**A Helminth Cycle:**The Pinworm 156**Helminth Classification and Identification 156**Distribution and Importance of Parasitic Worms 156***MICROFILE 5.3 Biological Adaptation in the Tapeworms 157****Chapter Capsule with Key Terms 157****Multiple-Choice Questions 158****Concept Questions 159****Critical-Thinking Questions 160****Internet Search Topic 160**

---

**Chapter****AN INTRODUCTION TO THE VIRUSES 161****THE SEARCH FOR THE ELUSIVE VIRUSES 162****THE POSITION OF VIRUSES IN THE BIOLOGICAL SPECTRUM 162****THE GENERAL STRUCTURE OF VIRUSES 163***Size Range 163***UNIQUE VIRAL CONSTITUENTS: CAPSIDS, NUCLEIC ACIDS, AND ENVELOPES 164****HOW VIRUSES ARE CLASSIFIED AND NAMED 170****MODES OF VIRAL MULTIPLICATION 170***The Multiplication Cycle in Bacteriophages 171*

<i>Multiplication Cycles in Animal Viruses</i>	175
<b>TECHNIQUES IN CULTIVATING AND IDENTIFYING ANIMAL VIRUSES</b>	<b>181</b>
<i>Using Live Animal Inoculation</i>	181
<i>Using Bird Embryos</i>	181
<i>Using Cell (Tissue) Culture Techniques</i>	182
<b>MEDICAL IMPORTANCE OF VIRUSES</b>	<b>183</b>
<i>Special Viruslike Infectious Agents</i>	183
<i>Detection and Control of Viral Infections</i>	185
<b>MICROFILE 6.1</b> Viruses, Fetuses, and Neonates	185
<i>Treatment of Animal Viral Infections</i>	185
<b>Chapter Capsule with Key Terms</b>	<b>187</b>
<b>Multiple-Choice Questions</b>	<b>187</b>
<b>Concept Questions</b>	<b>188</b>
<b>Critical-Thinking Questions</b>	<b>189</b>
<b>Internet Search Topic</b>	<b>189</b>

## Chapter ●

### ELEMENTS OF MICROBIAL NUTRITION, ECOLOGY, AND GROWTH 190

<b>MICROFILE 7.1</b> Life in the Extremes	191
<b>MICROBIAL NUTRITION</b>	<b>192</b>
<i>Chemical Analysis of Microbial Cytoplasm</i>	192
<b>MICROFILE 7.2</b> Dining with an Ameba	193
<i>Sources of Essential Nutrients</i>	193
<b>MICROFILE 7.3</b> Metal Ions and Infectious Disease	195
<i>How Microbes Feed: Nutritional Types</i>	196
<b>MICROFILE 7.4</b> The Language of Microbial Adaptations	196
<b>MICROFILE 7.5</b> Sunlight-Driven Organic Synthesis	197
<i>Transport Mechanisms for Nutrient Absorption</i>	199
<b>ENVIRONMENTAL FACTORS THAT INFLUENCE MICROBES</b>	<b>204</b>

<i>Temperature Adaptations</i>	204
<b>MICROFILE 7.6</b> Cashing in on “Hot” Microbes	206
<i>Gas Requirements</i>	206
<b>MICROFILE 7.7</b> Anaerobic Infections	207
<i>Effects of pH</i>	208
<i>Osmotic Pressure</i>	208
<i>Miscellaneous Environmental Factors</i>	208
<i>Ecological Associations Among Microorganisms</i>	208
<i>Interrelationships Between Microbes and Humans</i>	209
<b>MICROFILE 7.8</b> Life Together: Mutualism	210
<b>THE STUDY OF MICROBIAL GROWTH</b>	<b>212</b>
<i>The Basis of Population Growth: Binary Fission</i>	212
<i>The Rate of Population Growth</i>	212
<i>The Population Growth Curve</i>	213
<b>MICROFILE 7.9</b> Steps in a Viable Plate Count—Batch Culture Method	214
<i>Stages in the Normal Growth Curve</i>	215
<i>Other Methods of Analyzing Population Growth</i>	216
<b>Chapter Capsule with Key Terms</b>	<b>218</b>
<b>Multiple-Choice Questions</b>	<b>219</b>
<b>Concept Questions</b>	<b>219</b>
<b>Critical-Thinking Questions</b>	<b>220</b>
<b>Internet Search Topic</b>	<b>220</b>

## Chapter ●

### MICROBIAL METABOLISM: THE CHEMICAL CROSSROADS OF LIFE 221

<b>THE METABOLISM OF MICROBES</b>	<b>222</b>
<i>Enzymes: Catalyzing the Chemical Reactions of Life</i>	222
<b>MICROFILE 8.1</b> Enzymes as Biochemical Levers	224
<b>MICROFILE 8.2</b> Unconventional Enzymes	225
<b>MICROFILE 8.3</b> The Enzyme Name Game	228
<i>Regulation of Enzymatic Activity and Metabolic Pathways</i>	230

<b>THE PURSUIT AND UTILIZATION OF ENERGY</b>	<b>233</b>
<i>The Energy in Electrons</i>	233
<i>A Closer Look at Biological Oxidation and Reduction</i>	233
<b>MICROFILE 8.4</b> Energy in Biological Systems	234
<i>Adenosine Triphosphate: Metabolic Money</i>	234
<b>PATHWAYS OF BIOENERGETICS</b>	<b>237</b>
<i>Catabolism: An Overview of Nutrient Breakdown and Energy Release</i>	237
<b>MICROFILE 8.5</b> Microbial Models of Metabolism	238
<i>Energy Strategies in Microorganisms</i>	238
<i>Pyruvic Acid—A Central Metabolite</i>	240
<i>The Tricarboxylic Acid Cycle—A Carbon and Energy Wheel</i>	240
<i>The Respiratory Chain: Electron Transport and Oxidative Phosphorylation</i>	242
<i>Summary of Aerobic Respiration</i>	246
<i>Anaerobic Respiration</i>	247
<i>The Importance of Fermentation</i>	248
<b>MICROFILE 8.6</b> Pasteur and the Wine-to-Vinegar Connection	249
<b>MICROFILE 8.7</b> Fermentation and Biochemical Testing	250
<b>BIOSYNTHESIS AND THE CROSSING PATHWAYS OF METABOLISM</b>	<b>250</b>
<i>The Frugality of the Cell—Waste Not, Want Not</i>	250
<b>Chapter Capsule with Key Terms</b>	<b>253</b>
<b>Multiple-Choice Questions</b>	<b>254</b>
<b>Concept Questions</b>	<b>254</b>
<b>Critical-Thinking Questions</b>	<b>255</b>
<b>Internet Search Topic</b>	<b>255</b>

## Chapter ●

### MICROBIAL GENETICS 256

<b>INTRODUCTION TO GENETICS AND GENES: UNLOCKING THE SECRETS OF HEREDITY</b>	<b>257</b>
<i>The Nature of the Genetic Material</i>	257

**MICROFILE 9.1** Deciphering the Structure of DNA 258

**MICROFILE 9.2** The Video Genome 259

**MICROFILE 9.3** The Packaging of DNA: Winding, Twisting, and Coiling 260

*The DNA Code: A Simple Yet Profound Message* 260

*The Significance of DNA Structure* 261

*DNA Replication: Preserving the Code and Passing It On* 262

**MICROFILE 9.4** Palindromes—Word Games with the Language of DNA 263

#### APPLICATIONS OF THE DNA CODE:

##### TRANSCRIPTION AND TRANSLATION 266

*The Gene-Protein Connection* 266

*The Major Participants in Transcription and Translation* 266

*Transcription: The First Stage of Gene Expression* 268

*Translation: The Second Stage of Gene Expression* 269

*Eucaryotic Transcription and Translation: Similar Yet Different* 274

*The Genetics of Animal Viruses* 275

#### GENETIC REGULATION OF PROTEIN

##### SYNTHESIS AND METABOLISM 277

*The Lactose Operon: A Model for Inducible Gene Regulation in Bacteria* 278

*A Repressible Operon* 278

*Antibiotics That Affect Transcription and Translation* 279

#### CHANGES IN THE GENETIC CODE:

##### MUTATIONS AND INTERMICROBIAL EXCHANGE AND RECOMBINATION 280

*Causes of Mutations* 280

*Categories of Mutations* 281

**MICROFILE 9.5** Mutations: Mistakes in DNA Language 282

*Repair of Mutations* 283

*The Ames Test* 284

*Positive and Negative Effects of Mutations* 284

*Intermicrobial DNA Transfer and Recombination* 285

**MICROFILE 9.6** The Magnitude of a Mutation: Sickle-Cell Anemia 286

**Chapter Capsule with Key Terms** 292

**Multiple-Choice Questions** 293

**Concept Questions** 294

**Critical-Thinking Questions** 294

**Internet Search Topic** 295

## Chapter

### GENETIC ENGINEERING: A REVOLUTION IN MOLECULAR BIOLOGY 296

#### BASIC ELEMENTS AND APPLICATIONS OF GENETIC ENGINEERING 297

##### TOOLS AND TECHNIQUES OF GENETIC ENGINEERING 297

*DNA: The Marvelous Molecular Toy* 297

**MICROFILE 10.1** Bioethics Confronts Bioengineering 298

#### METHODS IN RECOMBINANT DNA TECHNOLOGY: HOW TO IMITATE NATURE 305

*Technical Aspects of Recombinant DNA and Gene Cloning* 305

*Construction of a Chimera, Insertion into a Cloning Host, and Genetic Expression* 307

#### BIOCHEMICAL PRODUCTS OF RECOMBINANT DNA TECHNOLOGY 308

#### RECOMBINANT ORGANISMS: HOW TO IMPROVE ON NATURE 309

*Recombinant Microbes: Modified Bacteria and Viruses* 309

*Transgenic Plants: Improving Crops and Foods* 310

*Transgenic Animals: Engineering Embryos* 311

#### GENETIC TREATMENTS: INTRODUCING DNA INTO THE BODY 314

*Gene Therapy* 314

*Antisense and Triplex DNA Technology: Genetic Medicines* 315

#### GENETIC MAPS, FINGERPRINTS, AND FAMILY TREES 317

*Genome Mapping and Screening: An Atlas of the Genome* 317

*DNA Fingerprinting: A Unique Picture of a Genome* 317

**MICROFILE 10.2** The Human Highway: Mapping the Genome 318

**MICROFILE 10.3** Genetic Junk Shop Yields Treasures 319

**MICROFILE 10.4** DNA Fingerprints: The Bar Codes of Life 321

**Chapter Capsule with Key Terms** 322

**Multiple-Choice Questions** 324

**Concept Questions** 324

**Critical-Thinking Questions** 325

**Internet Search Topic** 326

## Chapter

### PHYSICAL AND CHEMICAL CONTROL OF MICROBES 327

**MICROFILE 11.1** Microbial Control in Ancient Times 328

#### CONTROLLING MICROORGANISMS 328

*General Considerations in Microbial Control* 328

*Relative Resistance of Microbial Forms* 328

*Terminology and Methods of Microbial Control* 330

*What Is Microbial Death?* 331

*How Antimicrobial Agents Work: Their Modes of Action* 332

**MICROFILE 11.2** How Can You Sterilize the World? 334

#### METHODS OF PHYSICAL CONTROL 335

*Heat As an Agent of Microbial Control* 335

*The Effects of Cold and Desiccation* 339

*Radiation As a Microbial Control Agent* 340

*Sound Waves in Microbial Control* 342

*Sterilization by Filtration: Techniques for Removing Microbes* 343

#### CHEMICAL AGENTS IN MICROBIAL CONTROL 345

*Choosing a Microbicidal Chemical* 345

*Factors That Affect the Germicidal Activity of Chemicals* 345

**MICROFILE 11.3** Pathogen Paranoia: "The Only Good Microbe Is a Dead Microbe" 346

*Germicidal Categories According to Chemical Group* 347

**MICROFILE 11.4** The Quest for Sterile Skin 352

**Chapter Capsule with Key Terms** 355

**Multiple-Choice Questions** 357

**Concept Questions** 358

**Critical-Thinking Questions** 358

## Chapter

### DRUGS, MICROBES, HOST—THE ELEMENTS OF CHEMOTHERAPY 359

**MICROFILE 12.1** From Witchcraft to Wonder Drugs 360

**PRINCIPLES OF ANTIMICROBIAL  
THERAPY** 360

*The Terminology of*

*Chemotherapy* 360

*Drug, Microbe, Host—Some Basic  
Interactions* 361

*The Origins of Antimicrobial  
Drugs* 361

**CHARACTERISTIC INTERACTIONS BETWEEN  
DRUG AND MICROBE** 361

*Mechanisms of Drug Action* 362

**MICROFILE 12.2** A Modern Quest for Designer Drugs 363

*The Acquisition of Drug  
Resistance* 366

**SURVEY OF MAJOR ANTIMICROBIC DRUG  
GROUPS** 369

*Antibacterial Drugs* 369

**MICROFILE 12.3** The Rise of Drug Resistance 370

*Synthetic Antibacterial Drugs* 376

*Agents to Treat Fungal Infections* 377

*Antiparasitic Chemotherapy* 377

*Antiviral Chemotherapeutic  
Agents* 378

**MICROFILE 12.4** Household Remedies—From Apples to Zinc 379

**CHARACTERISTICS OF HOST-DRUG  
REACTIONS** 379

*Toxicity to Organs* 379

*Allergic Responses to Drugs* 381

*Suppression and Alteration of the  
Microflora by Antimicrobics* 381

**CONSIDERATIONS IN SELECTING AN  
ANTIMICROBIC DRUG** 382

*Identifying the Agent* 382

*Testing for the Drug Susceptibility of  
Microorganisms* 383

*Medical Considerations in Anti-  
Infective Chemotherapy* 383

*An Antimicrobial Drug Dilemma* 386

**Chapter Capsule with Key Terms** 387

**Multiple-Choice Questions** 388

**Concept Questions** 389

**Critical-Thinking Questions** 390

**Internet Search Topic** 390

## Chapter

### MICROBE-HUMAN INTERACTIONS: INFECTION AND DISEASE 391

**MICROFILE 13.1** Some Potential Results of Microbe-Human Interactions 392

**THE HUMAN HOST** 392

*Contact, Infection, Disease—A  
Continuum* 392

*Resident Flora: The Human As a  
Habitat* 393

*Indigenous Flora of Specific  
Regions* 395

*Studies with Germ-Free Animals* 398

**THE PROGRESS OF AN INFECTION** 400

*The Portal of Entry: Gateway to  
Infection* 401

**MICROFILE 13.2** Bites and Needles—A Traumatic Portal of Entry 402

**MICROFILE 13.3** What's Love Got to Do with It? 403

*The Size of the Inoculum* 404

*Mechanisms of Invasion and  
Establishment of the  
Pathogen* 404

**MICROFILE 13.4** The Classic Stages of Clinical Infections 408

**MICROFILE 13.5** A Quick Guide to the Terminology of Infection and Disease 409

*Signs and Symptoms: Warning Signals  
of Disease* 410

*The Portal of Exit: Vacating  
the Host* 410

**MICROFILE 13.6** Rashes, Rushes, and Flushes 411

*The Persistence of Microbes and  
Pathologic Conditions* 412

**EPIDEMIOLOGY: THE STUDY OF DISEASE IN  
POPULATIONS** 413

*Who, When, and Where? Tracking  
Disease in the Population* 413

**MICROFILE 13.7** Chronology of a Mystery Epidemic 416

*Reservoirs: Where Pathogens  
Persist* 417

*How and Why? The Acquisition and  
Transmission of Infectious  
Agents* 420

*Nosocomial Infections: The Hospital As  
a Source of Disease* 422

*What Is the Cause? Using Koch's  
Postulates to Determine  
Etiology* 424

**MICROFILE 13.8** The History of Human Guinea Pigs 426

**Chapter Capsule with Key Terms** 427

**Multiple-Choice Questions** 428

**Concept Questions** 428

**Critical-Thinking Questions** 429

**Internet Search Topic** 430

## Chapter

### THE NATURE OF HOST DEFENSES 431

**DEFENSE MECHANISMS OF THE HOST IN  
PERSPECTIVE** 433

*Barriers at the Portal of Entry: A First  
Line of Defense* 433

**INTRODUCING THE IMMUNE SYSTEM** 435

*The Molecular Basis of Immune  
Responses* 435

**MICROFILE 14.1** What Is Foreign? What Is Not? 436

**SYSTEMS INVOLVED IN IMMUNE  
DEFENSES** 437

*The Communicating Body  
Compartments* 437

**NONSPECIFIC IMMUNE REACTIONS OF THE  
BODY'S COMPARTMENTS** 447

**MICROFILE 14.2** Rubor, Calor, Tumor, Dolor: Gross Signs of Inflammation 448

*The Inflammatory Response: A Complex  
Concert of Reactions to Injury* 448