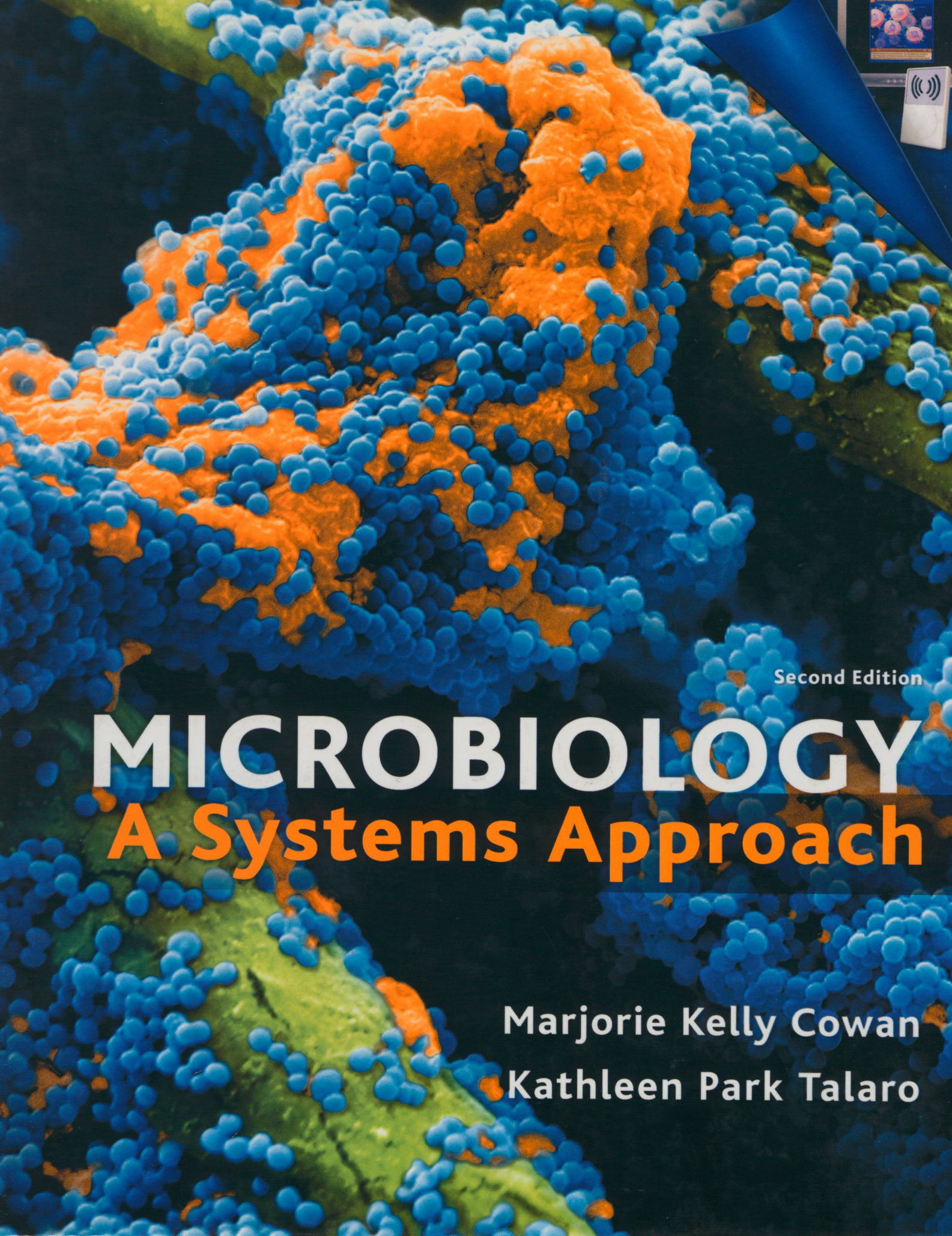
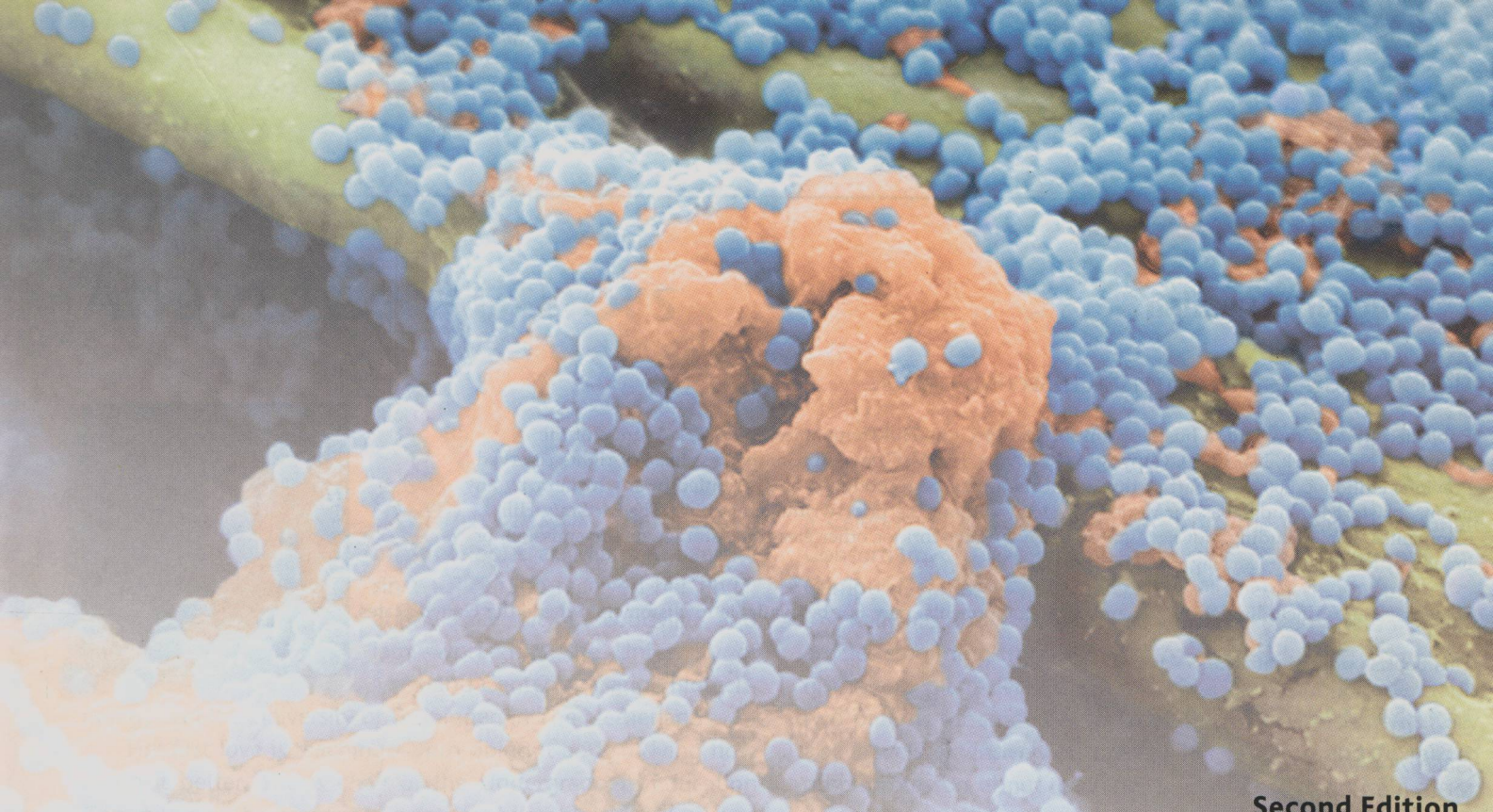


Second Edition

MICROBIOLOGY
A Systems Approach

Marjorie Kelly Cowan
Kathleen Park Talaro



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Marjorie Kelly Cowan
Miami University

Kathleen Park Talaro
Pasadena City College

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MICROBIOLOGY: A SYSTEMS APPROACH, SECOND EDITION

Published by McGraw-Hill, a business unit of The McGraw-Hill Companies, Inc., 1221 Avenue of the Americas, New York, NY 10020.

This book is printed on acid-free paper.

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

ISBN 978–0–07–726603–5
MHID 0–07–726603–X

Publisher: *Michelle Watnick*
Senior Sponsoring Editor: *James F. Connely*
Senior Developmental Editor: *Kathleen R. Loewenberg*
Senior Marketing Manager: *Tami Petsche*
Lead Project Manager: *Peggy J. Selle*
Senior Production Supervisor: *Laura Fuller*
Senior Media Project Manager: *Jodi K. Banowetz*
Cover/Interior Designer: *Laurie B. Janssen*
Senior Photo Research Coordinator: *John C. Leland*
Photo Research: *Editorial Image, LLC*
Supplement Producer: *Melissa M. Leick*
Compositor: *Aptara*
Typeface: 10/12 *Palatino*
Printer: *Quebecor World Versailles, KY*
(USE) Cover Image: *Ellen Swogger and Garth James, Center for Biofilm Engineering, Montana State University.*

The credits section for this book begins on page 841 and is considered an extension of the copyright page.

Library of Congress Cataloging-in-Publication Data

Cowan, M. Kelly.
Microbiology : a systems approach / Marjorie Kelly Cowan, Kathleen Park Talaro.—2nd ed.
p. cm.
Includes index.
ISBN 978–0–07–299528–2 ISBN 0–07–299528–9 (acid-free paper)
1. Microbiology. I. Talaro, Kathleen P. II. Title.

QR41.2.C69 2009
616.9′041—dc22 2007026927
CIP

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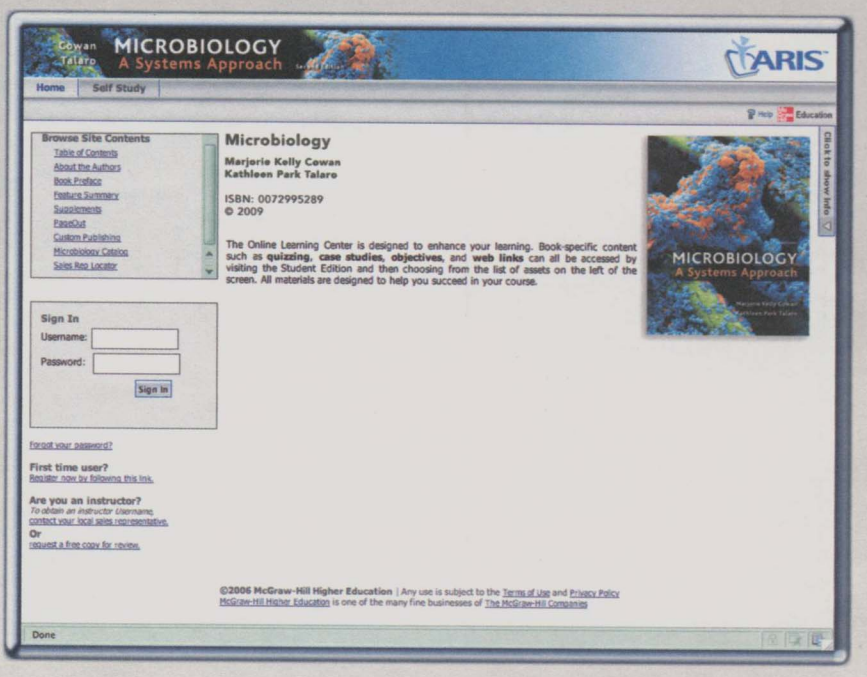
The ARIS (Assessment, Review, and Instruction System) website to accompany *Microbiology, A Systems Approach* is found at aris.mhhe.com. Just click on the subject "microbiology" and then this book's author and title. Set up by chapters, ARIS offers an extensive array of quizzing and learning tools that will help you master the topics covered in your course.



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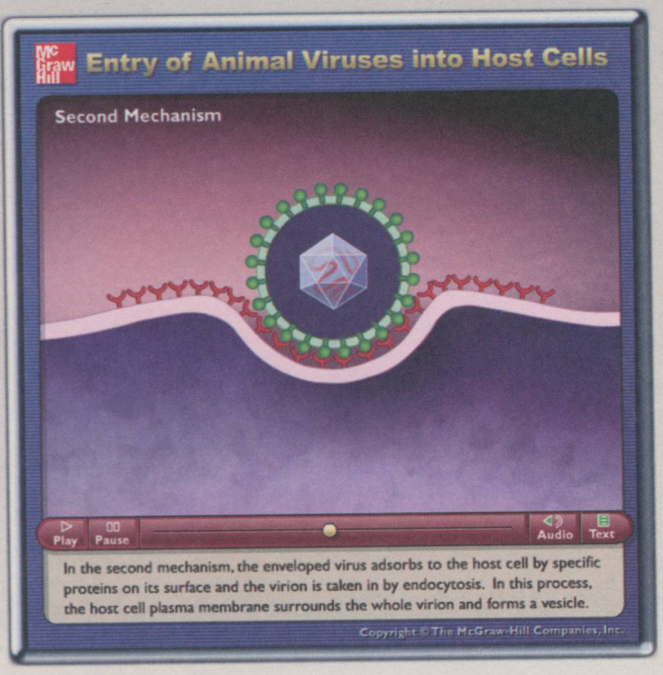
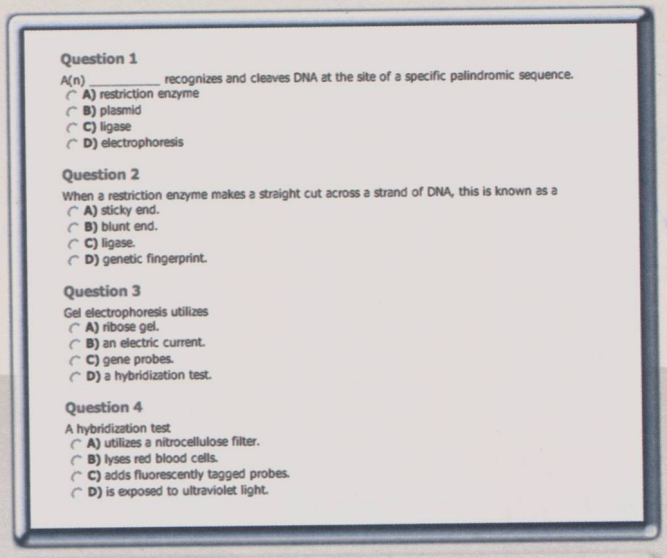
Microbiology, A Systems Approach 2/e is supported by specially formatted content for your portable media player. Listen to chapter summaries while driving to work, or use the audio version as an extra study help for that test the next day. Chapter quizzes allow you to answer questions anywhere, anytime. These convenient study tools have been developed for students like yourself who are busy and on the move. Help improve your grade while making the most of your time!

Cowan

Microbiology: A Systems Approach





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These interactive activities and quizzing keep you motivated and on track in mastering key concepts:

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- **Learning Activities** Helpful and engaging learning experiences await you at the *Microbiology, A Systems Approach* ARIS site. In addition to interactive online quizzing and animations, each chapter offers relevant case study presentations, digital images for creating PowerPoints®, vocabulary flash cards, and other activities designed to reinforce learning.

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About the Authors

Kelly Cowan has been a microbiologist at Miami University since 1993. She received her Ph.D. at the University of Louisville, and later worked at the University of Maryland Center of Marine Biotechnology and the University of Groningen in The Netherlands.

Her first love is teaching—both doing it and studying how to do it better. She is chair of the Undergraduate Education Committee of the American Society for Microbiology (ASM) and also Chair of the Education Division of ASM. In 1997, she won a Celebration of Teaching Award from the Greater Cincinnati Consortium of Colleges and Universities. She is currently the Campus Dean at Miami University's Middletown campus.

Kelly has published (with her students) twenty-four research articles stemming from her work on bacterial adhesion mechanisms and plant-derived antimicrobial compounds. She holds two patents for strategies to block microbial attachment. Kelly also travels extensively to present her research and to talk to other professors about teaching.

Kathleen Park Talaro is a microbiologist, author, illustrator, photographer, and educator at Pasadena City College. She began her college education at Idaho State University in Pocatello. There, she found a niche that fit her particular abilities and interests, spending part of her time as a scientific illustrator and part as a biology lab assistant. After graduation with a B.S. in biology, she entered graduate school at Arizona State University, majoring in physiological ecology. During her graduate studies she participated in two research expeditions to British Columbia with the Scripps Institution of Oceanography. Kathy continued to expand her background, first finishing a Master's degree at Occidental College and later taking additional specialized coursework in microbiology at California Institute of Technology and California State University.

If there is one continuing theme reverberating through Kathy's experiences, it is the love of education and teaching. She has been teaching allied health microbiology and majors biology courses for nearly 30 years. Kathy finds great joy in watching her students develop their early awareness of microorganisms—when they first come face-to-face with the reality of them on their hands, in the air, in their food, and, of course, nearly everywhere.

Kathy is a member of the American Society for Microbiology and the American Association for the Advancement of Science. She keeps active in self-study and research, and continues to attend workshops and conferences to remain current in her field. Kathy has also been active in science outreach programs by teaching Saturday workshops in microbiology and DNA technology to high school and junior high students.

We dedicate this book to all public health workers who devote their lives to bringing the advances and medicines enjoyed by the industrialized world to all humans.

Preface

Students: You just opened this book! Thank you! As the authors, we have poured our hearts and souls into helping microbiology come to life in these pages. (We can't help but point out that there are dozens of microbes on these pages that are, in fact, alive.) The interesting thing is that each of you has already had a lot of experience with microbiology. You are populated with microbes right now, and have probably had some bad experiences with quite a few. You have certainly been greatly benefited by many as well.

Many of you are interested in entering the health care profession in some way. It is absolutely indispensable for you to have a good background in the biology of microorganisms. But a grasp of this topic is important for everyone, not just health care workers. This is, after all, the Age of Biology. The 20th century was often thought of as the Age of Physics, with the development of quantum theories and the theory of relativity. The Human Genome Project is just the most visible sign of the Biology Age; in the 21st century we have an unprecedented understanding of genes and DNA, and a new respect for the beauty and power of microorganisms. But there is much more to learn.

What Sets This Book Apart?

Distinctive Organization of Infectious Disease Chapters

Following the tradition of microbiology textbooks, the first 16 chapters of ***Microbiology: A Systems Approach*** provide the basics about microorganisms: what they are, the methods used to study them, human attempts to control them, and our bodies' defenses against them. For chapters 17-23, we have developed an unequaled level of organization in our presentation of the infectious disease material.

Exclusive Chapter Chapter 17, "Diagnosing Infections," is unique among microbiology textbooks: it brings together in one place the methods used to diagnose infectious diseases. It starts with collecting samples from the patient, and details the biochemical, serological, and molecular methods used to identify causative microbes.

Highly Organized Disease Chapters Like other books, chapters 18-23 present the diseases according to the human organ systems. However, the organization of the material within each of these chapters has been taken to a new level.

The traditional organ system approach makes sense (to anyone who has experienced an infection!), but still leaves organizational threads hanging. Within a given organ system chapter, diseases are discussed in random order, and there is often no consistent pattern to what is said about each disease.

This book improves upon the approach by organizing the infectious agents according to the symptoms or condition they cause, instead of in a random order. For example, in the respiratory disease chapter, there is a major heading called "Causative Agents of Community-Acquired Pneumonia"—a condition that can be caused by several different microbes. Each of those microbes is discussed under that heading, in a systematic manner. At the end of the section, the microbes are summarized in a **Checkpoint table** called "Pneumonia by the Causative Organism." Conditions with only one possible cause, such as pertussis, also end with a Checkpoint table that includes the single causative agent.

CHECKPOINT 21.10 Pneumonia

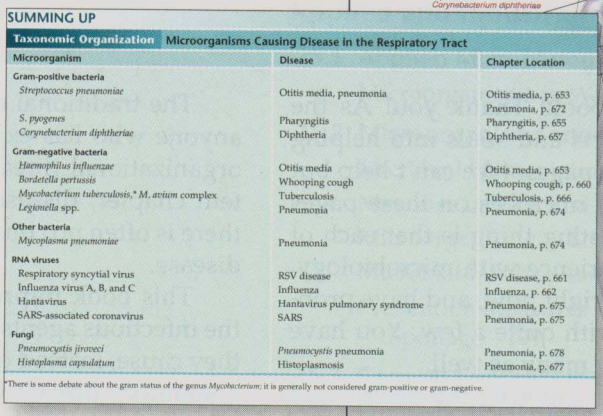
Causative Organism(s)	*Streptococcus pneumoniae*	*Legionella* species	*Mycoplasma pneumoniae*
Most Common Modes of Transmission	Droplet contact or endogenous transfer	Vehicle (water droplets)	Droplet contact
Virulence Factors	Capsule	–	Adhesins
Culture/Diagnosis	Gram stain often diagnostic, alpha-hemolytic on blood agar	Requires selective charcoal yeast extract agar; serology unreliable	Rule out other etiologic agents
Prevention	Pneumococcal polysaccharide vaccine (23-valent)	–	No vaccine, no permanent immunity
Treatment	Cefotaxime, ceftriaxone, ketek; much resistance	Fluoroquinolone, azithromycin, clarithromycin	Recommended not to treat in most cases, doxycycline or macrolides may be used if necessary
Distinctive Features	Patient usually severely ill	Mild pneumonias in healthy people; can be severe in elderly or immunocompromised	Usually mild; "walking pneumonia"

This approach is refreshingly logical, systematic, and intuitive, as it encourages clinical and critical modes of thinking in students—the type of thinking they will be using if their eventual careers are in health care. Students learn to examine multiple possibilities for a given condition and grow accustomed to looking for commonalities and differences among the various organisms that cause a given condition. In addition, they learn to consider the kinds of conditions that are caused by only one microbe.

Along with the higher level of organization offered in this book, students are provided with key pedagogical tools at the end of each disease chapter to reinforce and tie together the information they've just learned. Each disease chapter

ends with a **system summary figure**—a "glass body" that highlights the affected organisms discussed in the chapter—and a **taxonomic list of organisms**. The distinctive summary figure lists the diseases that were presented in the chapter, with the microbes that could cause them *color-coded by type of microorganism*. The taxonomic list of organisms is presented in tabular form so students can see the diversity of microbes causing diseases in that system, and also appreciate their taxonomic positions

In summary, the disease presentation in this book makes the world of infectious diseases come together for the student. It presents the information within a consistent organizational structure (known to facilitate learning) and embeds it within a structure that teaches clinical and critical modes of thinking.

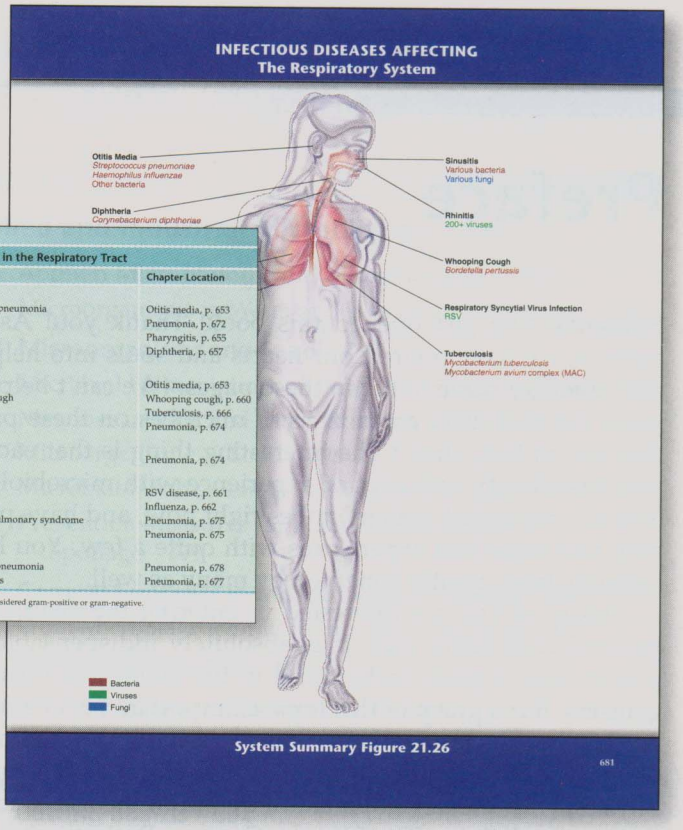


SUMMING UP

Taxonomic Organization Microorganisms Causing Disease in the Respiratory Tract

Microorganism	Disease	Chapter Location
Gram-positive bacteria		
Streptococcus pneumoniae	Otitis media, pneumonia	Otitis media, p. 653 Pneumonia, p. 672
S. pyogenes	Pharyngitis	Pharyngitis, p. 655
Corynebacterium diphtheriae	Diphtheria	Diphtheria, p. 657
Gram-negative bacteria		
Haemophilus influenzae	Otitis media	Otitis media, p. 653
Bordetella pertussis	Whooping cough	Whooping cough, p. 660
Mycobacterium tuberculosis, M. avium* complex	Tuberculosis	Tuberculosis, p. 666
Legionella spp.	Pneumonia	Pneumonia, p. 674
Other bacteria		
Mycoplasma pneumoniae	Pneumonia	Pneumonia, p. 674
RNA viruses		
Respiratory syncytial virus	RSV disease	RSV disease, p. 661
Influenza virus A, B, and C	Influenza	Influenza, p. 662
Hantavirus	Hantavirus pulmonary syndrome	Pneumonia, p. 675
SARS-associated coronavirus	SARS	Pneumonia, p. 675
Fungi		
Pneumocystis jiroveci	*Pneumocystis* pneumonia	Pneumonia, p. 678
Histoplasma capsulatum	Histoplasmosis	Pneumonia, p. 677

*There is some debate about the gram status of the genus *Mycobacterium*; it is generally not considered gram-positive or gram-negative.



An Engaging Writing Style, Praised by Reviewers

Our goal was to achieve a precise balance in writing, so students will easily comprehend the material without compromising the level of presentation. One of the key strengths of this text comes from our efforts in making difficult concepts understandable, as well as intriguing and exciting, for students. We use this consistent, direct approach throughout the text—in the narrative, the illustrations, and throughout the pedagogical aids. Analogies, case studies, and real-world examples also help students relate microbiology to their world.

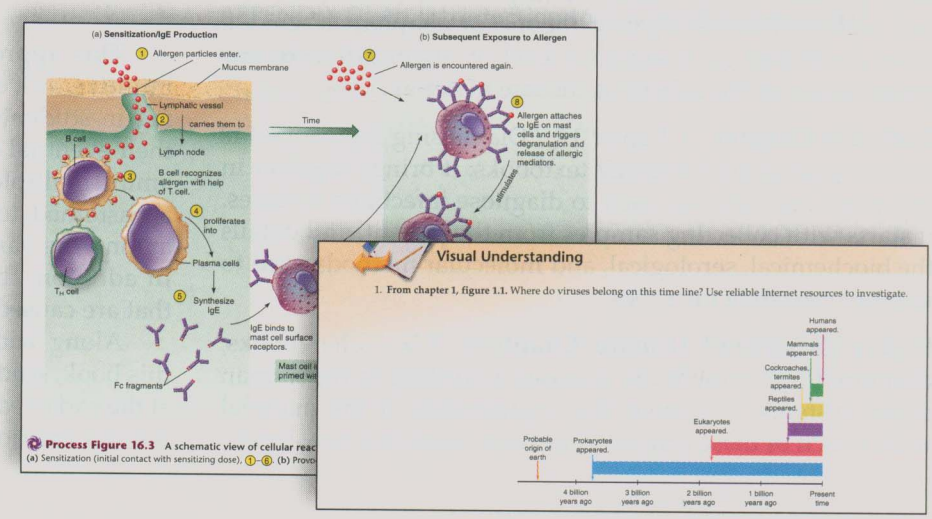
> *"The writing style of Cowan and Talaro is excellent. I feel the information is described in a very easily understood fashion. I really like the way concepts are introduced and then immediately fully explained."* —Carl David Gilbert, University of Louisiana at Monroe

> *"This book is so well organized, written, and illustrated that it is hard to identify weaknesses."* —Larry Weiskirch, Onondaga Community College

A Vivid Art Program That Explains Itself

Kathy Talaro brings her experience as a teacher, microbiologist, *and* illustrator to this text. Her insight and expertise provide an inimitable blend of scientific accuracy and aesthetics. Vivid, multi-dimensional illustrations complement self-contained, concept-specific narrative; it is not necessary to read page content surrounding the artwork to grasp concepts being illustrated. Development of the art in this manner further enhances learning and helps to build a solid foundation of understanding.

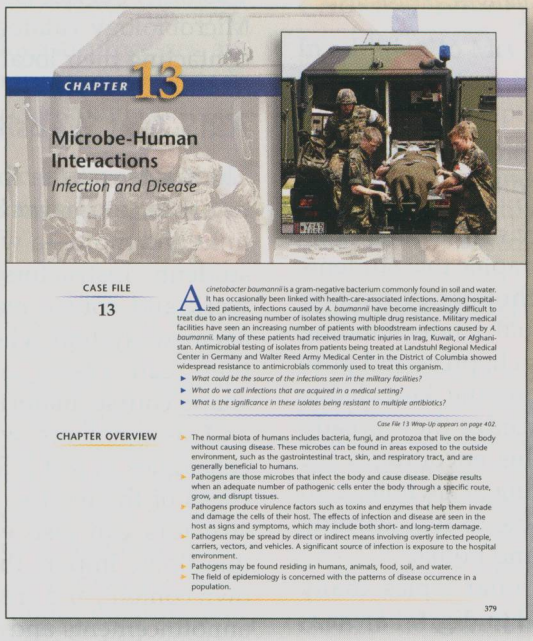
This second edition has given us the opportunity to hone and improve the art even more. In addition to many new and revised figures, the Process Figures are now clearly defined as such and include colored steps that correlate the art to step-by-step explanations. Art has also been pulled into special Visual Understanding study tools to help students make connections between concepts presented in different chapters.



Pedagogy Designed for the Way Students Learn

Microbiology: A Systems Approach makes learning easier through its carefully crafted pedagogical system. Following is a closer look at some of the key features that our students have taught us are useful.

- All chapters open with **Case File** mysteries to solve. These real-world case studies help students appreciate and understand how microbiology impacts our lives on a daily basis. The solutions appear later in the chapter, after the necessary elements have been presented.
- A **Chapter Overview** at the beginning of each chapter provides students with a framework from which to begin their study of a chapter.
- In chapters 1–16 and 24–25, major sections of the chapter are followed by **Checkpoints** that repeat and summarize the concepts of that section. In the disease chapters (18–23), the Checkpoints are in the form of the **disease tables** described earlier.
- **Insight** readings allow students to delve into material that goes beyond the chapter concepts and consider the application of those concepts. The Insight readings are divided into four categories: Discovery, Historical, Medical, and Microbiology.



CHAPTER 13

Microbe-Human Interactions

Infection and Disease

CASE FILE 13

Acinetobacter baumannii is a gram-negative bacterium commonly found in soil and water. It has occasionally been linked with health-care-associated infections. Among hospitalized patients, infections caused by *A. baumannii* have become increasingly difficult to treat due to an increasing number of isolates showing multiple drug resistance. Military medical facilities have seen an increasing number of patients with bloodstream infections caused by *A. baumannii*. Many of these patients had received traumatic injuries in Iraq, Kuwait, or Afghanistan. Antimicrobial testing of isolates from patients being treated at Landstuhl Regional Medical Center in Germany and Walter Reed Army Medical Center in the District of Columbia showed widespread resistance to antimicrobials commonly used to treat this organism.

- *What could be the source of the infections seen in the military facilities?*
- *What do we call infections that are acquired in a medical setting?*
- *What is the significance in these isolates being resistant to multiple antibiotics?*

Case File 13 Wrap-Up appears on page 402.

CHAPTER OVERVIEW

- The normal biota of humans includes bacteria, fungi, and protozoa that live on the body without causing disease. These microbes can be found in areas exposed to the outside environment, such as the gastrointestinal tract, skin, and respiratory tract, and are generally beneficial to humans.
- Pathogens are those microbes that infect the body and cause disease. Disease results when an adequate number of pathogenic cells enter the body through a specific route, grow, and disrupt tissues.
- Pathogens produce virulence factors such as toxins and enzymes that help them invade and damage the cells of their host. The effects of infection and disease are seen in the host as signs and symptoms, which may include both short- and long-term damage.
- Pathogens may be spread by direct or indirect means involving overtly infected people, carriers, vectors, and vehicles. A significant source of infection is exposure to the hospital environment.
- Pathogens may be found residing in humans, animals, food, soil, and water.
- The field of epidemiology is concerned with the patterns of disease occurrence in a population.

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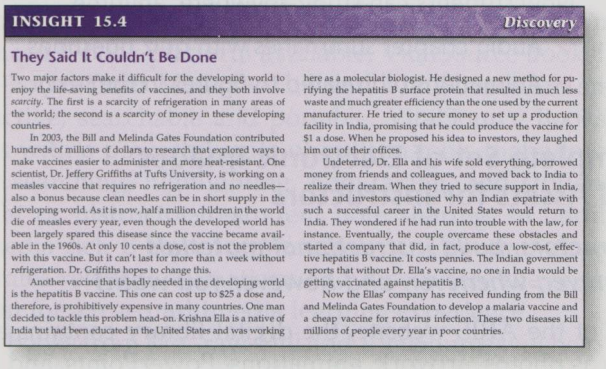


INSIGHT 15.4 *Discovery*

They Said It Couldn't Be Done

Two major factors make it difficult for the developing world to enjoy the life-saving benefits of vaccines, and they both involve *scarcity*. The first is a scarcity of refrigeration in many areas of the world; the second is a scarcity of money in these developing countries.

In 2003, the Bill and Melinda Gates Foundation contributed hundreds of millions of dollars to research that explored ways to make vaccines easier to administer and more heat-resistant. One scientist, Dr. Jeffery Griffiths at Tufts University, is working on a measles vaccine that requires no refrigeration and no needles—also a bonus because clean needles can be in short supply in the developing world. As it is now, half a million children in the world die of measles every year, even though the developed world has been largely spared this disease since the vaccine became available in the 1960s. At only 10 cents a dose, cost is not the problem with this vaccine. But it can't last for more than a week without refrigeration. Dr. Griffiths hopes to change this.

Another vaccine that is badly needed in the developing world is the hepatitis B vaccine. This one can cost up to $25 a dose and, therefore, is prohibitively expensive in many countries. One man decided to tackle this problem head-on. Krishna Ella is a native of India but had been educated in the United States and was working here as a molecular biologist. He designed a new method for purifying the hepatitis B surface protein that resulted in much less waste and much greater efficiency than the one used by the current manufacturer. He tried to secure money to set up a production facility in India, promising that he could produce the vaccine for $1 a dose. When he proposed his idea to investors, they laughed him out of their offices.

Undeterred, Dr. Ella and his wife sold everything, borrowed money from friends and colleagues, and moved back to India to realize their dream. When they tried to secure support in India, banks and investors questioned why an Indian expatriate with such a successful career in the United States would return to India. They wondered if he had run into trouble with the law, for instance. Eventually, the couple overcame these obstacles and started a company that did, in fact, produce a low-cost, effective hepatitis B vaccine. It costs pennies. The Indian government reports that without Dr. Ella's vaccine, no one in India would be getting vaccinated against hepatitis B.

Now the Ellas' company has received funding from the Bill and Melinda Gates Foundation to develop a malaria vaccine and a cheap vaccine for rotavirus infection. These two diseases kill millions of people every year in poor countries.

- All chapters end with a **summary**, and a comprehensive array of **end-of-chapter questions** that are not just multiple-choice, but also critical thinking questions, often with no correct answer. Considering and answering these questions, and even better, discussing them with fellow students, can make the difference between temporary (or limited) learning and true knowledge of the concepts. **Visual Understanding** questions incorporate art to help students connect important concepts from chapter to chapter, and **Concept Mapping** assists in retention as well as contextual organization.

"Cowan and Talaro have created a perfect tool for the instruction of microbiology to the non-major, allied health student! The text is well-designed in its layout of chapters, beginning with basic information about the discipline and building to the application of those principles in the infectious disease chapters. The authors do a great job of reminding the reader of material they have previously encountered by referencing specific pages. The writing style is very approachable, yet provides enough detail to please many instructors. This is certainly a text that would work for my teaching style." —Angela Spence, Missouri State University

What's New?

We are committed to two goals for this book: making it the most current and scientifically accurate book in the field, and turning what could be a passive educational experience into an active learning opportunity.

Up-to-Date Content

- This edition, like microbiology itself, is **full of changes in content**. Probably the most important update is the new understanding of the "central dogma" of biology: that DNA is made into RNA, which is made into proteins. With the advances in genomics of the last decade we now know that the characteristics of all organisms are influenced just as strongly by the pieces of RNA that aren't made into protein, but that are used to regulate the DNA and proteins. We address this in chapter 9.
- We've also updated content on the new "-omics": genomics, proteomics and even metabolomics.
- Throughout the book there is much more emphasis on polymicrobial infections and biofilms.
- Also, in multiple chapters we discuss a new initiative to identify the sequences present in "normal biota" body sites, a project that is likely to revolutionize the way we think of normal biota.
- We even tackle the old laboratory warhorse, the coliform test, since nearly all experts believe the test is terribly outdated, even though we continue to teach it in introductory microbiology labs.

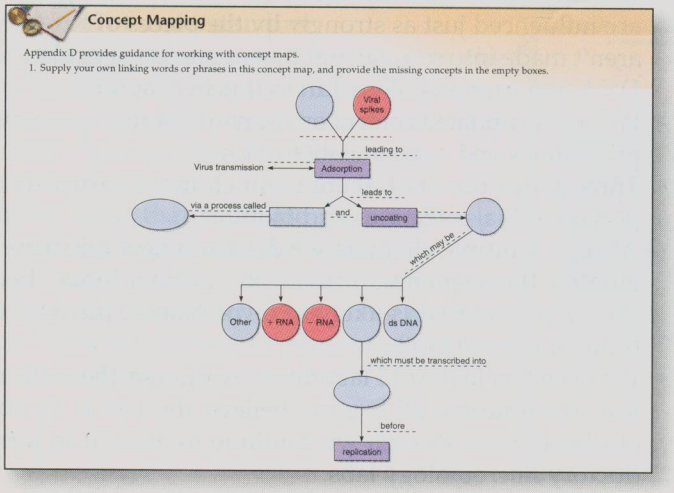
- Finally, we have split the environmental microbiology chapter into two new chapters. One of these focuses on microbes in the environment and the other examines ways we use microbes to get the things we need and want, such as food and medicines.

For a complete listing of chapter-by-chapter changes, please visit the text's ARIS website.

Active Learning Experience

Capitalizing on sound research in how students learn, we have added several new features to this edition:

- "**Visual Understanding**" is an exercise that does two things. First, it supplies a photo or a graphic that students have already seen, along with a thought-provoking question. Second, many of the Visual Understanding questions use images from previous chapters and pose queries that require students to combine knowledge from the new chapter with the knowledge they already have from the previous chapter. This encourages the making of connections and the weaving of a whole cloth of understanding, a task indispensable to real learning but very often neglected in courses and books.
- To offer different perspectives on similar topics, many **figures** in the text are now **correlated to digital animations**. Students may examine the figure's details in the book and then watch the concept in motion on their computer or download it to their portable player to study on the fly!
- **Process figures** now have matching numbered steps for easy to see explanations of complex processes.
- Perhaps most exciting of all of the changes: this is the first microbiology textbook that uses **concept maps**! Concept maps present ways for students to organize information in more meaningful forms than just simple lists. They appeal to a wide variety of learning styles and help readers get in the habit of putting facts in contextual form. Our concept maps build in varying degrees of complexity and are accompanied by an appendix on how to get started.



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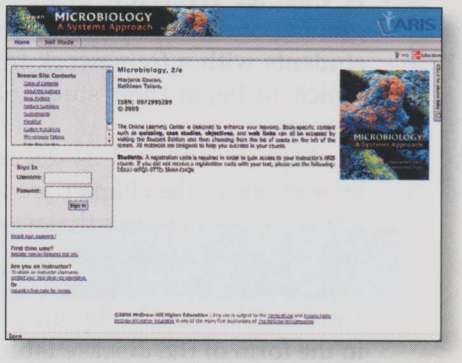
The ARIS website that accompanies this textbook includes tutorials, animations, practice quizzing, helpful Internet links and more—a whole semester's worth of study help for students. Instructors will find a complete electronic homework and course management system where they can create and share course materials and assignments with colleagues in just a few clicks of the mouse. Instructors can also edit questions, import their own content, and create announcements and/or due dates for assignments. ARIS offers automatic grading and reporting of easy-to-assign homework, quizzing, and testing.



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- **Art** Full-color digital files of all illustrations in the book can be readily incorporated into lecture presentations, exams, or custom-made classroom materials. In addition, all files are pre-inserted into blank PowerPoint slides for ease of lecture preparation.

- **Photos** The photos collection contains digital files of photographs from the text, which can be reproduced for multiple classroom uses.
- **Tables** Every table that appears in the text has been saved in electronic form for use in classroom presentations and/or quizzes.
- **Animations** Numerous full-color animations illustrating important microbial or physiological processes are also provided. Harness the visual impact of concepts in motion by importing these files into classroom presentations or online course materials.
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If you, or your students, are ready for an alternative version of the traditional textbook, McGraw-Hill and VitalSource have partnered to introduce innovative and inexpensive electronic textbooks. By purchasing E-books, students can save as much as **50%** on selected titles delivered on the **most advanced** E-book platform available, VitalSource Bookshelf.

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The Classroom Performance System (CPS) is an interactive system that allows the instructor to administer in-class questions electronically. Students answer questions via hand-held remote control keypads (clickers), and their individual responses are logged into a grade book. Aggregated responses can be displayed in graphical form. Using this immediate feedback, the instructor can quickly determine if students understand the lecture topic, or if more clarification is needed. CPS promotes student participation, class productivity, and individual student confidence and accountability. Specially designed questions for e-Instruction to accompany *Microbiology, A Systems Approach* are provided through the book's ARIS website.

Course Delivery Systems

In addition to McGraw-Hill's ARIS course management options, instructors can also design and control their course content with help from our partners WebCT, Blackboard, Top-Class, and eCollege. Course cartridges containing website content, online testing, and powerful student tracking features are readily available for use within these or any other HTML-based course management platforms.

Acknowledgments

Textbooks are never written by just one person, or two people, in this case. Textbooks are the accumulation of good suggestions, corrections, and brainstorming from a large team of faculty from all over the country who teach in all kinds of institutions. The faculty below were involved in multiple ways to improve this book and we are deeply grateful to them. All of their names should be on the cover!

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A Note of Thanks from Kelly Cowan

I am grateful to my many students who have tried to teach me how to most effectively communicate a subject I love to them. My partner, Kathy, has been a constant inspiration to me. I had significant content help with chapters 1, 8, 24, and 25 from Martin Klotz from the University of Louisville and Bob Findlay from the University of Alabama. I am grateful to Kathy Loewenberg at McGraw-Hill for being polite enough not to point out how often she had to fix things for me and for putting her heart into this project. Peggy Selle, Jim Connely, Jeanne Patterson, Tami Petsche, Laurie Janssen, and Alison Hammond were indispensable members of the team that helped this edition come together. A special thank you to Trina Zimmerman and Greg Duncan for believing in me and, when all else failed, buying me a burrito. Donna Hensley, Danielle Blevins, Tara Eagle, and Brittany Brewer provided vital logistical help. The real heroes in all of this are my sons Taylor and Sam who, over the course of two editions, have grown used to looking for their mom behind a stack of papers in the study. Their patience and understanding—and their awesomeness—know no bounds. Finally, Ted, all I can say is: thank you.

A Message from Kathy Talaro

In the second edition of this text, Kelly Cowan has continued to distinguish herself by bringing a fresh perspective and novel ideas for organizing and presenting the subject of microbiology. She has been a successful advocate and developer of case studies as an integral component of microbiology textbooks, and in this new edition, she has introduced concept maps and visual understanding exercises as well. These alternative learning aids will add immeasurably to the value of the textbook for teachers and students seeking different ways to explore its concepts.

Many thanks to the team of editors, researchers, designers, artists, and reviewers who helped bring this book to fruition. Without your expert guidance and insights, our endeavors would be a lot more work and a lot less fun. We salute you.

A special thanks to my family and friends for your unflagging support and understanding when taking all those little side trips to get pond samples, take photographs of relevant scenes or intriguing microbes, and just generally playing second fiddle to the demands of book creation. You're such good sports to endure my experiments incubating in the laundry room and admiring "beautiful" molds growing on food left in the refrigerator too long. I'm sure that often you know more about the microbial world than you wanted to.

Unique Systems-Based Approach Enhances Comprehension

An Unequaled Level of Organization in the Infectious Disease Material

Microbiology, A Systems Approach takes a unique approach to diseases by consistently covering multiple causative agents of a particular disease in the same section and summarizing this information in Checkpoint tables. The causative agents are categorized in a logical manner based on the presenting symptoms in the patient. Through this approach, students study how diseases affect patients—the way future healthcare professionals will encounter the material on the job.

"The systems approach to the study of microbiology and the organization of the important concepts and sub-concepts by Cowan and Talaro's textbook are the strongest features of the book and should definitely be retained in future editions. Furthermore, the chapter dealing with 'Diagnosing Infections' represents a novel approach. Often I tell my pre-med, pre-dental, and pre-vet students that they'll eventually have to think critically when diagnosing their patients."
—Manuel Varela, Eastern New Mexico University

Consistent, Clinical Presentation of Diseases

For each disease, the discussion begins with an introduction to the disease and its signs and symptoms. Next, the causative agent or agents of that disease are presented and the following areas are discussed:

- pathogenesis and virulence factors
- transmission and epidemiology
- culture and diagnosis
- prevention and treatment

Summary Checkpoint Tables

Following the textual discussion of each disease, a table summarizes the characteristics of agents that can cause that disease.

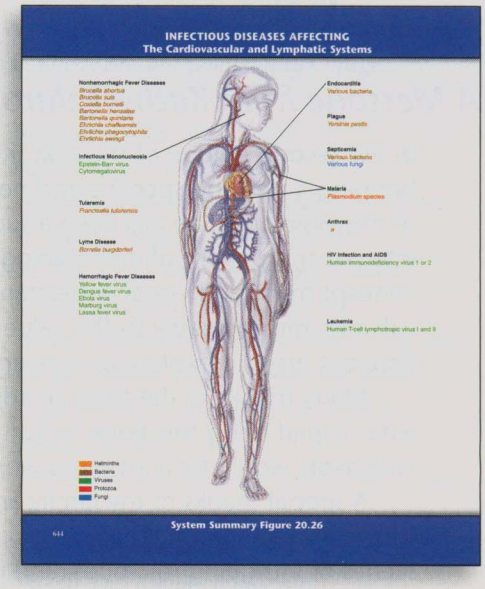
CHECKPOINT 19.5 Subacute Encephalitis

Causative Organism(s)	*Toxoplasma gondii*	Subacute sclerosing panencephalitis	Prions
Most Common Modes of Transmission	Vehicle (meat) or fecal-oral	Persistence of measles virus	CJD = direct/parenteral contact with infected tissue; or inherited vCJD = vehicle (meat, parenteral)
Virulence Factors	Intracellular growth	Cell fusion, evasion of immune system	Avoidance of host immune response
Culture/Diagnosis	Serological detection of IgM, culture, histology	EEGs, MRI, serology (Ab versus measles virus)	Biopsy, image of brain
Prevention	Personal hygiene, food hygiene	None	Avoiding tissue
Treatment	Pyrimethamine and/or sulfadiazine	None	None
Distinctive Features	Subacute, slower development of disease	History of measles	Long incubation period; fast progression once it begins

"The strong points of this book are the writing style and the attention to detail. The coverage is exceptional. There is nothing missing!! I found it easy to read and it makes difficult concepts understandable. I especially like the way the disease chapters are handled with the Checkpoints summarizing the diseases. It is a great feature." —Judy Kaufman, Monroe Community College

System Summary Figures

After the diseases of a particular body system have been discussed, students are invited to study the system summary figure at the end of the chapter—a "glass body" that highlights the affected organs and lists the diseases that were presented in the chapter. In addition, the microbes that could cause the diseases are color-coded by type of microorganism. The System Summary figures, along with the Checkpoint tables, provide an excellent set of study tools.



Taxonomic List of Organisms

A taxonomic list of organisms is also presented at the end of each disease chapter so students can see the diversity of microbes causing diseases in that system.

SUMMING UP

Taxonomic Organization Microorganisms Causing Disease in the Genitourinary Tract

Microorganism	Disease	Chapter Location
Gram-positive bacteria		
Staphylococcus saprophyticus	Urinary tract infection	UTI, p. 737
Gardnerella (note: stains gram-negative)	Vaginosis	Vaginitis or vaginosis, p. 741
Group B *Streptococcus*	Neonatal disease	Group B strep neonatal disease, p. 759
Gram-negative bacteria		
Escherichia coli	Urinary tract infection	UTI, p. 737
Leptospira interrogans (spirochete)	Leptospirosis	Leptospirosis, p. 738
Proteus mirabilis	Urinary tract infection plus kidney stones	UTI, p. 737
Neisseria gonorrhoeae	Gonorrhea	Discharge diseases, p. 744
Chlamydia trachomatis	"Chlamydia"	Discharge diseases, p. 747
Treponema pallidum (spirochete)	Syphilis	Genital ulcer diseases, p. 748
Haemophilus ducreyi	Chancroid	Genital ulcer diseases, p. 752
DNA viruses		
Herpes simplex viruses 1 and 2	Genital herpes	Genital ulcer diseases, p. 752
Human papillomaviruses	Genital warts, cervical carcinoma	Wart diseases, p. 755
Poxviruses	Molluscum contagiosum	Wart diseases, p. 758
Fungi		
Candida albicans	Vaginitis	Vaginitis or vaginosis, p. 740
Protozoa		
Trichomonas vaginalis	Trichomoniasis (vaginitis)	Vaginitis or vaginosis, p. 742
Helminth—trematode		
Schistosoma haematobium	Urinary schistosomiasis	Urinary schistosomiasis, p. 739

Unparalleled Art Program

Instructional Art Program Clarifies Concepts

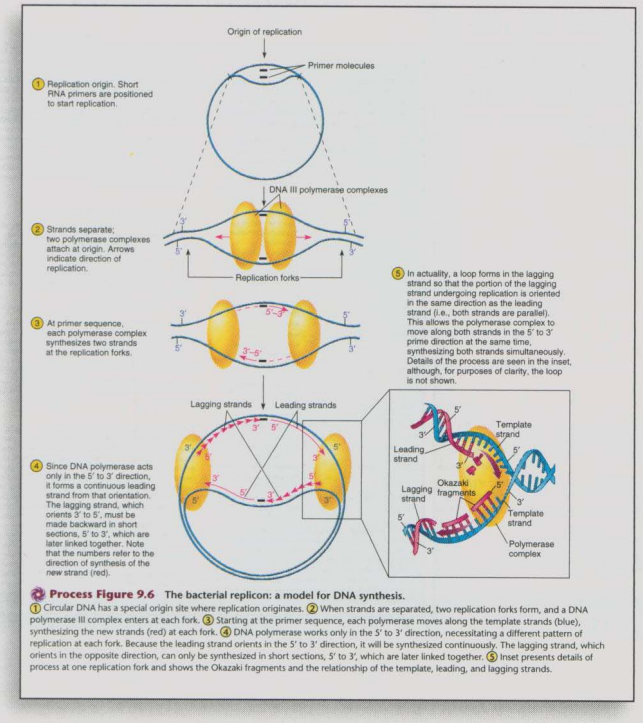
Microbiology, A Systems Approach provides visually powerful artwork that paints conceptual pictures for students. The art combines vivid colors, multi-dimensionality, and self-contained narrative to help students study the challenging concepts of microbiology from a visual perspective—a proven study technique. Art is often coupled with photographs to enhance visualization and comprehension.

> *"Illustrations are strong and appropriately used to explain more difficult topics. I think this is one of the great strengths of the text."*
> —Kay Rezanka, Central Lakes College

> *"The figures and illustrations are some of the best that I have seen."*
> —Juliette Tinker, Boise State University

Process Figures

Microbiology, A Systems Approach illustrates many difficult microbiological concepts in steps that students find easy to follow. Each step is clearly marked with a yellow, numbered circle and correlated to accompanying narrative, also marked with yellow, numbered circles, to benefit all types of learners. Process Figures are now identified next to the figure number. The accompanying legend provides additional explanation.



Process Figure 9.6 The bacterial replicon: a model for DNA synthesis.
(1) Circular DNA has a special origin site where replication originates. (2) When strands are separated, two replication forks form, and a DNA polymerase III complex enters at each fork. (3) Starting at the primer sequence, each polymerase moves along the template strands (blue), synthesizing the new strands (red) at each fork. (4) DNA polymerase works only in the 5′ to 3′ direction, necessitating a different pattern of replication at each fork. Because the leading strand orients in the 5′ to 3′ direction, it will be synthesized continuously. The lagging strand, which orients in the opposite direction, can only be synthesized in short sections, 5′ to 3′, which are later linked together. (5) Inset presents details of process at one replication fork and shows the Okazaki fragments and the relationship of the template, leading, and lagging strands.

Combination Figures

Line drawings combined with photos give students two perspectives: the realism of photos and the explanatory clarity of line drawings. The authors choose this method of presentation often in every chapter.

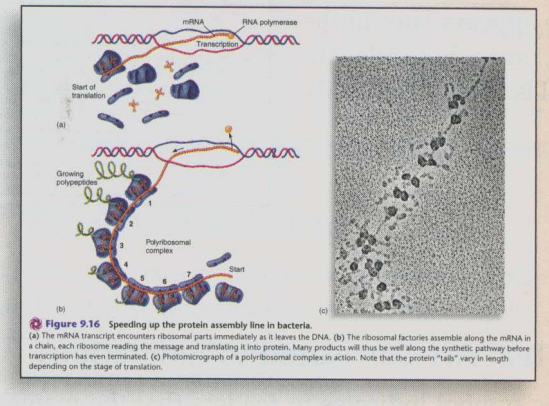


Figure 9.16 Speeding up the protein assembly line in bacteria.
(a) The mRNA transcript encounters ribosomal parts immediately as it leaves the DNA. (b) The ribosomal factories assemble along the mRNA in a chain, each ribosome reading the message and translating it into protein. Many products will thus be well along the synthetic pathway before transcription has even terminated. (c) Photomicrograph of a polyribosomal complex in action. Note that the protein "tails" vary in length depending on the stage of translation.

Clinical Photos

Color photos of individuals affected by disease provide students with a real-life, clinical view of how microorganisms manifest themselves in the human body.

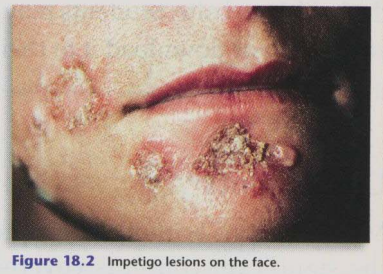


Figure 18.2 Impetigo lesions on the face.

Overview Figures

Many challenging concepts of microbiology consist of numerous interrelated activities. *Microbiology, A Systems Approach* visually summarizes these concepts to help students piece the activities together for a complete, conceptual picture.

> *"I really like the illustrations in this chapter. They are clearly tied to the text and they are effective in presenting the information. I found them easy to understand. The photographs are great too."*
> —Carola Wright, Mt. San Antonio College

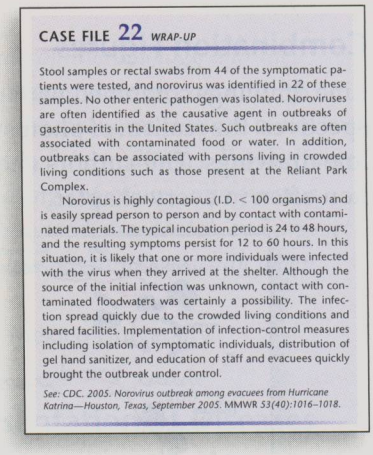
Pedagogy Designed for the Way Students Learn

Pedagogical Aids Promote Systematic Learning

Microbiology, A Systems Approach organizes each chapter with consistent pedagogical tools. Such tools enable students to develop a consistent learning strategy and enhance their understanding and retention of the concepts.

Case Files

All chapters open with a real-world case file to help students appreciate and understand how microbiology impacts lives on a daily basis. The solution to the case file appears later in the chapter, near where relevant material is being discussed.



CASE FILE 22 *WRAP-UP*

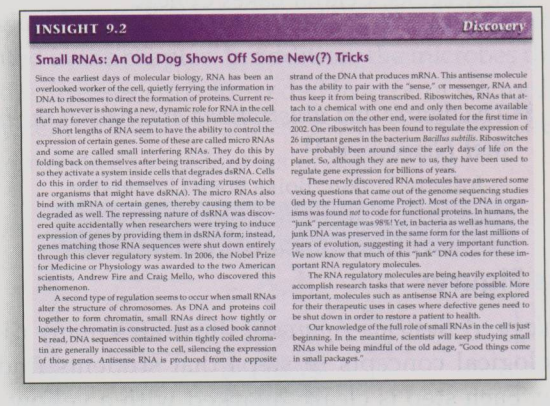
Stool samples or rectal swabs from 44 of the symptomatic patients were tested, and norovirus was identified in 22 of these samples. No other enteric pathogen was isolated. Noroviruses are often identified as the causative agent in outbreaks of gastroenteritis in the United States. Such outbreaks are often associated with contaminated food or water. In addition, outbreaks can be associated with persons living in crowded living conditions such as those present at the Reliant Park Complex.

Norovirus is highly contagious (I.D. < 100 organisms) and is easily spread person to person and by contact with contaminated materials. The typical incubation period is 24 to 48 hours, and the resulting symptoms persist for 12 to 60 hours. In this situation, it is likely that one or more individuals were infected with the virus when they arrived at the shelter. Although the source of the initial infection was unknown, contact with contaminated floodwaters was certainly a possibility. The infection spread quickly due to the crowded living conditions and shared facilities. Implementation of infection-control measures including isolation of symptomatic individuals, distribution of gel hand sanitizer, and education of staff and evacuees quickly brought the outbreak under control.

See: CDC. 2005. Norovirus outbreak among evacuees from Hurricane Katrina—Houston, Texas, September 2005. MMWR *53(40):1016–1018.*

Insight Readings

Current, real-world readings allow students to consider applications of the concepts they are studying. The Insight readings are divided into four interesting categories: Discovery, Historical, Medical, and Microbiology.



INSIGHT 9.2 *Discovery*

Small RNAs: An Old Dog Shows Off Some New(?) Tricks

Since the earliest days of molecular biology, RNA has been an overlooked worker of the cell, quietly ferrying the information in DNA to ribosomes to direct the formation of proteins. Current research however is showing a new, dynamic role for RNA in the cell that may forever change the reputation of this humble molecule.

Short lengths of RNA seem to have the ability to control the expression of certain genes. Some of these are called micro RNAs and some are called small interfering RNAs. They do this by folding back on themselves after being transcribed, and by doing so they activate a system inside cells that degrades dsRNA. Cells do this in order to rid themselves of invading viruses (which are organisms that might have dsRNA). The micro RNAs also bind with mRNA of certain genes, thereby causing them to be degraded as well. The repressing nature of dsRNA was discovered quite accidentally when researchers were trying to induce expression of genes by providing them in dsRNA form; instead, genes matching those RNA sequences were shut down entirely through this clever regulatory system. In 2006, the Nobel Prize for Medicine or Physiology was awarded to the two American scientists, Andrew Fire and Craig Mello, who discovered this phenomenon.

A second type of regulation seems to occur when small RNAs alter the structure of chromosomes. As DNA and proteins coil together to form chromatin, small RNAs direct how tightly or loosely the chromatin is constructed. Just as a closed book cannot be read, DNA sequences contained within tightly coiled chromatin are generally inaccessible to the cell, silencing the expression of those genes. Antisense RNA is produced from the opposite strand of the DNA that produces mRNA. This antisense molecule has the ability to pair with the "sense," or messenger, RNA and thus keep it from being transcribed. Riboswitches, RNAs that attach to a chemical with one end and only then become available for translation on the other end, were isolated for the first time in 2002. One riboswitch has been found to regulate the expression of 26 important genes in the bacterium *Bacillus subtilis*. Riboswitches have probably been around since the early days of life on the planet. So, although they are new to us, they have been used to regulate gene expression for billions of years.

These newly discovered RNA molecules have answered some vexing questions that came out of the genome sequencing studies (led by the Human Genome Project). Most of the DNA in organisms was found not to code for functional proteins. In humans, the "junk" percentage was 98%! Yet, in bacteria as well as humans, the junk DNA was preserved in the same form for the last millions of years of evolution, suggesting it had a very important function. We now know that much of this "junk" DNA codes for these important RNA regulatory molecules.

The RNA regulatory molecules are being heavily exploited to accomplish research tasks that were never before possible. More important, molecules such as antisense RNA are being explored for their therapeutic uses in cases where defective genes need to be shut down in order to restore a patient to health.

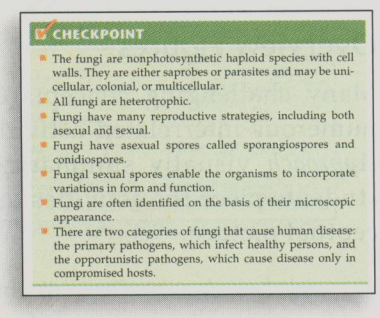
Our knowledge of the full role of small RNAs in the cell is just beginning. In the meantime, scientists will keep studying small RNAs while being mindful of the old adage, "Good things come in small packages."

New! Text Art Correlated to Animations

This symbol indicates to readers that the material presented in the text is also accompanied by an animation on the book's website. Students may view the animation on their computers or download it to their portable player and watch it on the fly!

Checkpoints

Major sections within the chapters end with a summary of the significant concepts covered. In the disease chapters, the Checkpoints take the form of tables that summarize the characteristics of the infectious agent(s) discussed. Students can use these as self-testing tools as well.

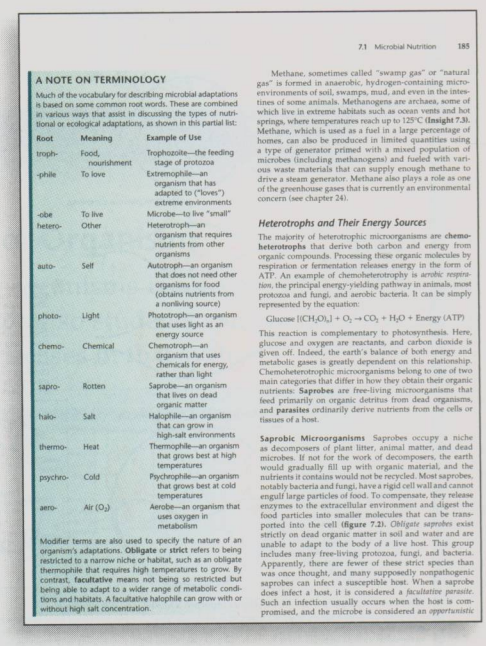


CHECKPOINT

- The fungi are nonphotosynthetic haploid species with cell walls. They are either saprobes or parasites and may be unicellular, colonial, or multicellular.
- All fungi are heterotrophic.
- Fungi have many reproductive strategies, including both asexual and sexual.
- Fungi have asexual spores called sporangiospores and conidiospores.
- Fungal sexual spores enable the organisms to incorporate variations in form and function.
- Fungi are often identified on the basis of their microscopic appearance.
- There are two categories of fungi that cause human disease: the primary pathogens, which infect healthy persons, and the opportunistic pathogens, which cause disease only in compromised hosts.

Notes

"Heads-up" type material appears when appropriate letting students know about various terminology, exceptions to the rule, or, in the case of chapter 18, differences in chapter organization and pedagogy.



7.1 Microbial Nutrition 185

A NOTE ON TERMINOLOGY

Much of the vocabulary for describing microbial adaptations is based on some common root words. These are combined in various ways that assist in discussing the types of nutritional or ecological adaptations, as shown in this partial list:

Root	Meaning	Example of Use
troph-	Food, nourishment	Trophozoite—the feeding stage of protozoa
-phile	To love	Extremophile—an organism that has adapted to ("loves") extreme environments
-obe	To live	Microbe—to live "small"
hetero-	Other	Heterotroph—an organism that requires nutrients from other organisms
auto-	Self	Autotroph—an organism that does not need other organisms for food (obtains nutrients from a nonliving source)
photo-	Light	Phototroph—an organism that uses light as an energy source
chemo-	Chemical	Chemotroph—an organism that uses chemicals for energy, rather than light
sapro-	Rotten	Saprobe—an organism that lives on dead organic matter
halo-	Salt	Halophile—an organism that can grow in high-salt environments
thermo-	Heat	Thermophile—an organism that grows best at high temperatures
psychro-	Cold	Psychrophile—an organism that grows best at cold temperatures
aero-	Air (O_2)	Aerobe—an organism that uses oxygen in metabolism

Modifier terms are also used to specify the nature of an organism's adaptations. **Obligate** or **strict** refers to being restricted to a narrow niche or habitat, such as an obligate thermophile that requires high temperatures to grow. By contrast, **facultative** means not being so restricted but being able to adapt to a wider range of metabolic conditions and habitats. A facultative halophile can grow with or without high salt concentration.

Methane, sometimes called "swamp gas" or "natural gas" is formed in anaerobic, hydrogen-containing microenvironments of soil, swamps, mud, and even in the intestines of some animals. Methanogens are archaea, some of which live in extreme habitats such as ocean vents and hot springs, where temperatures reach up to 125°C (**Insight 7.3**). Methane, which is used as a fuel in a large percentage of homes, can also be produced in limited quantities using a type of generator primed with a mixed population of microbes (including methanogens) and fueled with various waste materials that can supply enough methane to drive a steam generator. Methane also plays a role as one of the greenhouse gases that is currently an environmental concern (see chapter 24).

Heterotrophs and Their Energy Sources

The majority of heterotrophic microorganisms are **chemoheterotrophs** that derive both carbon and energy from organic compounds. Processing these organic molecules by respiration or fermentation releases energy in the form of ATP. An example of chemoheterotrophy is *aerobic respiration*, the principal energy-yielding pathway in animals, most protozoa and fungi, and aerobic bacteria. It can be simply represented by the equation:

Glucose $[(CH_2O)_6] + O_2 \rightarrow CO_2 + H_2O +$ Energy (ATP)

This reaction is complementary to photosynthesis. Here, glucose and oxygen are reactants, and carbon dioxide is given off. Indeed, the earth's balance of both energy and metabolic gases is greatly dependent on this relationship. Chemoheterotrophic microorganisms belong to one of two main categories that differ in how they obtain their organic nutrients: **Saprobes** are free-living microorganisms that feed primarily on organic detritus from dead organisms, and **parasites** ordinarily derive nutrients from the cells or tissues of a host.

Saprobic Microorganisms Saprobes occupy a niche as decomposers of plant litter, animal matter, and dead microbes. If not for the work of decomposers, the earth would gradually fill up with organic material, and the nutrients it contains would not be recycled. Most saprobes, notably bacteria and fungi, have a rigid cell wall and cannot engulf large particles of food. To compensate, they release enzymes to the extracellular environment and digest the food particles into smaller molecules that can be transported into the cell (**figure 7.2**). *Obligate saprobes* exist strictly on dead organic matter in soil and water and are unable to adapt to the body of a live host. This group includes many free-living protozoa, fungi, and bacteria. Apparently, there are fewer of these strict species than was once thought, and many supposedly nonpathogenic saprobes can infect a susceptible host. When a saprobe does infect a host, it is considered a *facultative parasite*. Such an infection usually occurs when the host is compromised, and the microbe is considered an *opportunistic*

> *"I think the checkpoints in the chapters are effective tools in that they reinforce what students have just finished reading. [They] clearly state the concepts the students should take from each section of the text."*
> —Suzanne Butler, Miami-Dade College

Chapter Summary with Key Terms

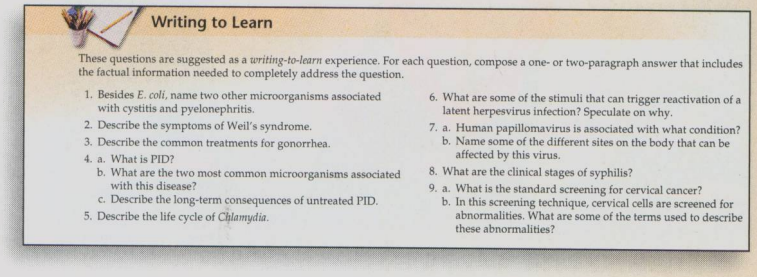
A brief outline of the main chapter concepts is provided with important terms highlighted. Key terms are also included in the glossary at the end of the book.

Multiple-Choice and New True-False Questions

Students can assess their knowledge of basic concepts by answering these two sets of questions. Other types of questions and activities build on this foundational knowledge.

Writing-to-Learn Questions

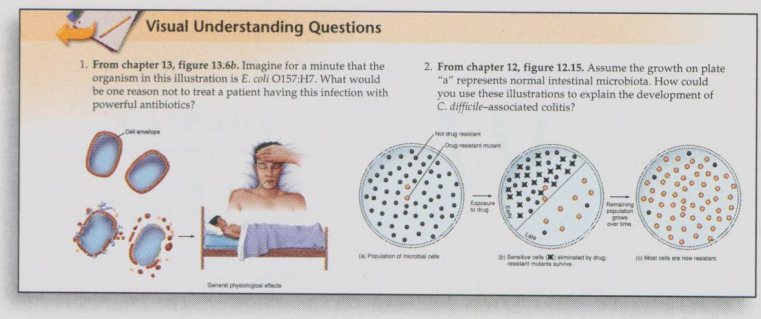
Using the facts and concepts they just studied, students must reason and problem-solve to answer these critical-thinking questions. Such questions do not have a single correct answer, and thus, open doors to discussion and serious thought.



Writing to Learn

These questions are suggested as a *writing-to-learn* experience. For each question, compose a one- or two-paragraph answer that includes the factual information needed to completely address the question.

1. Besides *E. coli*, name two other microorganisms associated with cystitis and pyelonephritis.
2. Describe the symptoms of Weil's syndrome.
3. Describe the common treatments for gonorrhea.
4. a. What is PID?
   b. What are the two most common microorganisms associated with this disease?
   c. Describe the long-term consequences of untreated PID.
5. Describe the life cycle of *Chlamydia*.
6. What are some of the stimuli that can trigger reactivation of a latent herpesvirus infection? Speculate on why.
7. a. Human papillomavirus is associated with what condition?
   b. Name some of the different sites on the body that can be affected by this virus.
8. What are the clinical stages of syphilis?
9. a. What is the standard screening for cervical cancer?
   b. In this screening technique, cervical cells are screened for abnormalities. What are some of the terms used to describe these abnormalities?



Visual Understanding Questions

1. **From chapter 13, figure 13.6*b*.** Imagine for a minute that the organism in this illustration is *E. coli* O157:H7. What would be one reason not to treat a patient having this infection with powerful antibiotics?

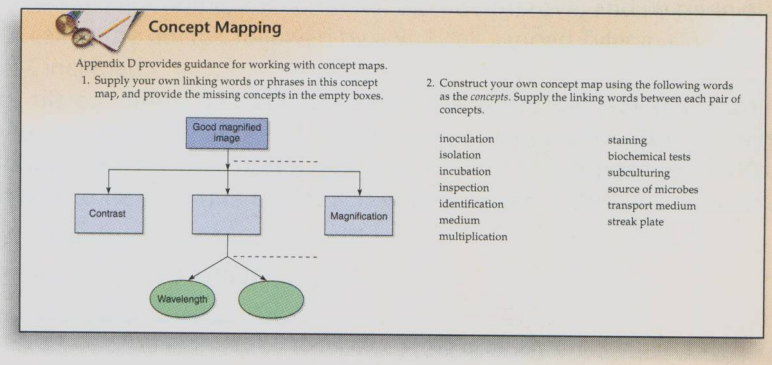
2. **From chapter 12, figure 12.15.** Assume the growth on plate "a" represents normal intestinal microbiota. How could you use these illustrations to explain the development of *C. difficile*–associated colitis?

New! Visual Understanding

Images from previous chapters are combined with integrated learning questions based on material in the current chapter to encourage an understanding of how important explanations and concepts are linked.

New! Concept Mapping

Three different types of concept mapping activities are used throughout the text in the end-of-chapter material to help students learn and retain what they've read.



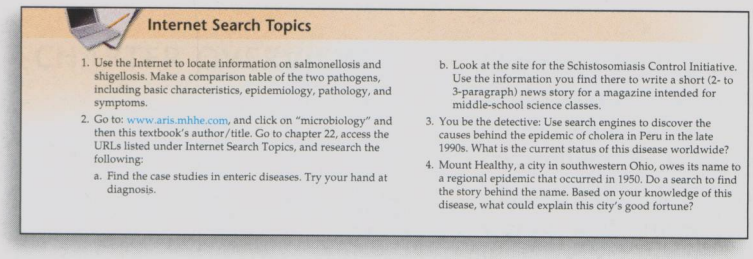
Concept Mapping

Appendix D provides guidance for working with concept maps.

1. Supply your own linking words or phrases in this concept map, and provide the missing concepts in the empty boxes.

2. Construct your own concept map using the following words as the *concepts*. Supply the linking words between each pair of concepts.

inoculation
isolation
incubation
inspection
identification
medium
multiplication
staining
biochemical tests
subculturing
source of microbes
transport medium
streak plate



Internet Search Topics

1. Use the Internet to locate information on salmonellosis and shigellosis. Make a comparison table of the two pathogens, including basic characteristics, epidemiology, pathology, and symptoms.
2. Go to: www.aris.mhhe.com, and click on "microbiology" and then this textbook's author/title. Go to chapter 22, access the URLs listed under Internet Search Topics, and research the following:
   a. Find the case studies in enteric diseases. Try your hand at diagnosis.
   b. Look at the site for the Schistosomiasis Control Initiative. Use the information you find there to write a short (2- to 3-paragraph) news story for a magazine intended for middle-school science classes.
3. You be the detective: Use search engines to discover the causes behind the epidemic of cholera in Peru in the late 1990s. What is the current status of this disease worldwide?
4. Mount Healthy, a city in southwestern Ohio, owes its name to a regional epidemic that occurred in 1950. Do a search to find the story behind the name. Based on your knowledge of this disease, what could explain this city's good fortune?

Internet Search Topics

Opportunities for further research into the material just covered are outlined at the end of each chapter, in addition to the numerous resources available on the ARIS website accompanying the textbook.