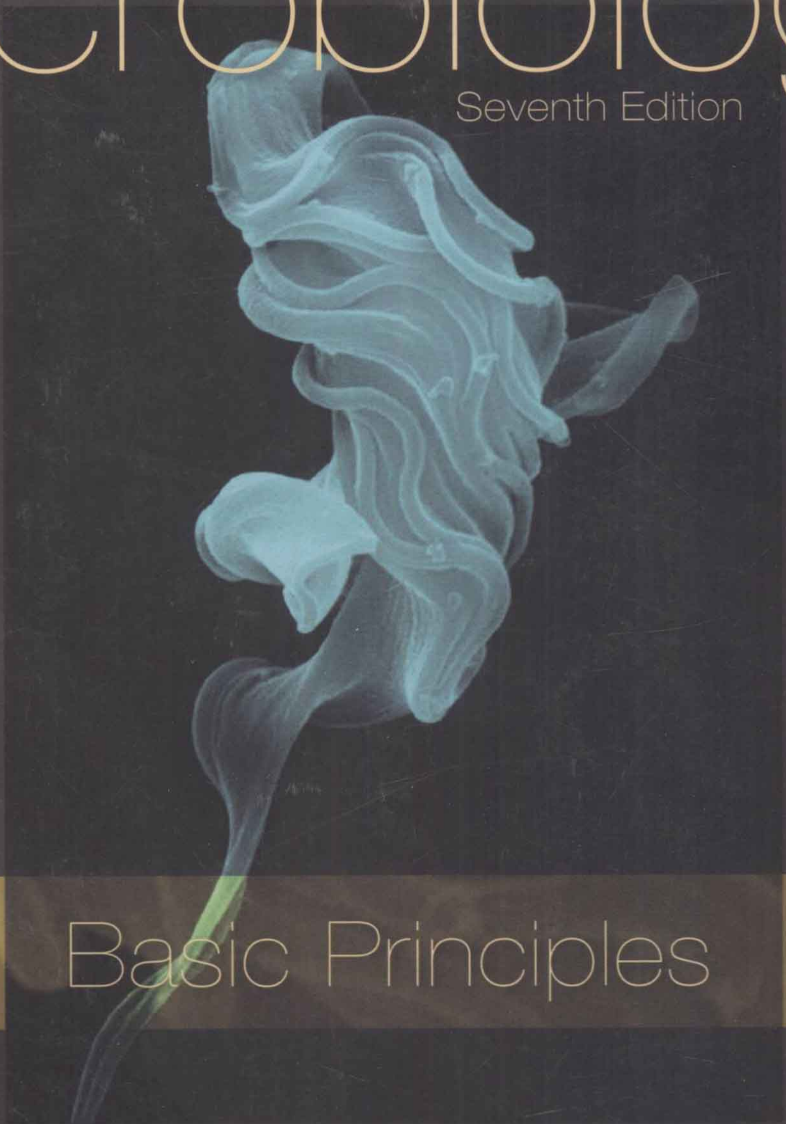
Foundations in

Microbiology

Seventh Edition



Basic Principles

Kathleen Park Talaro

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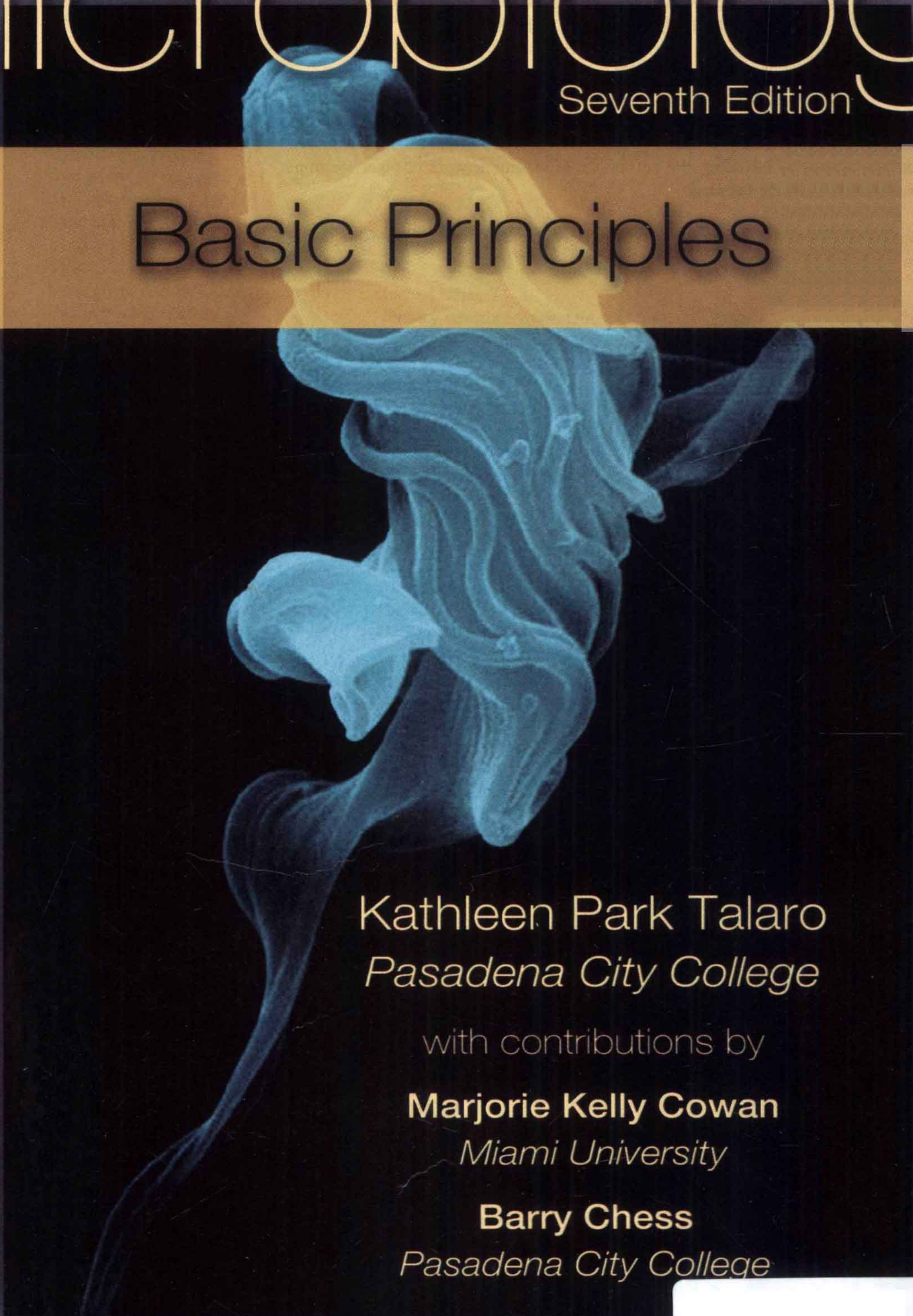

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Reference Tables

Greek Letters

α	alpha	ι	iota	ρ	rho
β	beta	κ	kappa	σ	sigma
γ	gamma	λ	lambda	τ	tau
δ	delta	μ	mu	υ	upsilon
ϵ, ε	epsilon	ν	nu	ϕ	phi
ζ	zeta	ξ	xi	χ	chi
η	eta	ο	omicron	ψ	psi
θ	theta	π	pi	ω	omega

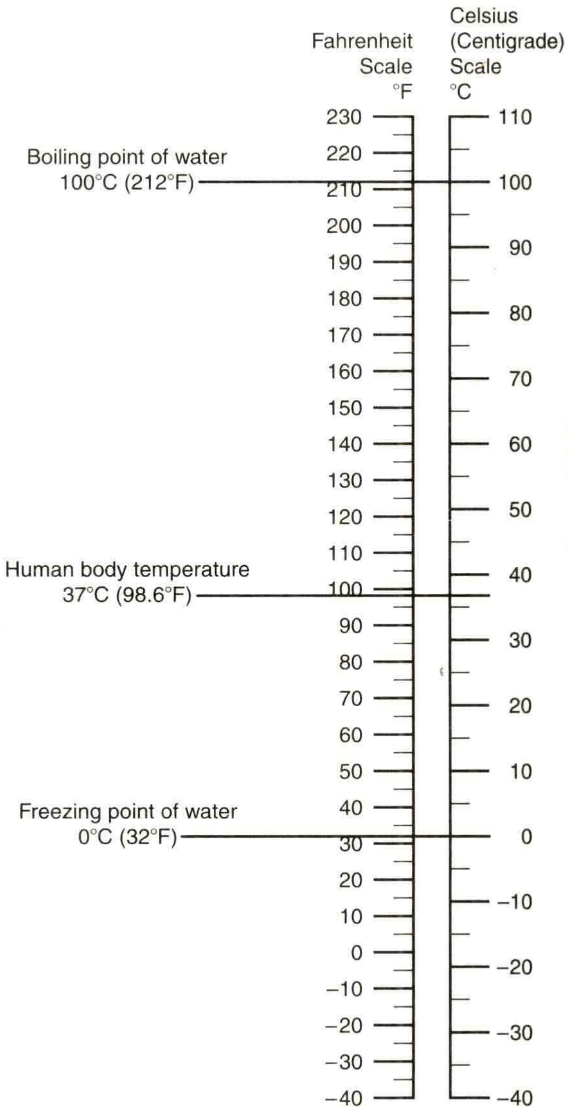
Units of Measurement

Unit	Abbreviation	Size
Length		
meter	m	approximately 39 inches
centimeter	cm	10^{-2} m
millimeter	mm	10^{-3} m
micrometer	μm	10^{-6} m
nanometer	nm	10^{-9} m
angstrom	Å	10^{-10} m
Volume		
liter	L	approximately 1.06 quart
milliliter	ml	10^{-3} L (1 ml = 1 cm^3 = 1 cc)
microliter	μl	10^{-6} L

Common Numerical Prefixes

Prefix	Value	Meaning	Example
giga (G)	1,000,000,000	by a factor of a billion	gigabyte
mega (M)	1,000,000	by a factor of a million	megaton
kilo (K)	1,000	by a factor of a thousand	kilogram
centi (c)	0.01	a hundredth	centimeter
milli (m)	0.001	a thousandth	milligram
micro (μ)	0.000001	a millionth	microliter
nano (n)	0.000000001	a billionth	nanometer
pico (p)	0.000000000001	a trillionth	picogram

Temperature Conversions*



**General rule of conversion:* Degrees Fahrenheit (°F) are converted to degrees Celsius (°C) by subtracting 32 from °F and multiplying the result by $\frac{5}{9}$. Degrees Celsius are converted to °F by multiplying °C by $\frac{9}{5}$ and adding 32 to the result.*

Notifiable Diseases—Summary of Reported Cases, United States, 2002–2007

Disease/Year	2002	2003	2004	2005	2006	2007
AIDS	38,878	41,832	43,320	36,552	39,002	40,253
Botulism, total (including wound and unsp.)	179	119	124	122	165	118
Foodborne	14	18	16	15	20	17
Infant	55	70	87	80	97	79
Brucellosis	84	90	115	107	121	118
Chancroid	67	44	30	25	33	33
Chlamydia[¶]	780,541	834,640	906,387	929,462	1,030,911	1,025,208
Cholera	5	1	5	6	9	7
Coccidioidomycosis	4,969	4,184	6,056	5,145	8,916	7,807
Cryptosporoidosis	3,016	3,406	3,372	7,595	5,636	10,243
Escherichia coli O157:H7	3,574	2,979	2,461	2,544	4,432	4,397
Giardiasis	21,206	19,195	18,498	18,126	18,953	17,123
Gonorrhea	326,017	318,411	330,132	314,370	358,366	332,511
Haemophilus influenzae, invasive	1,479	1,707	2,085	2,028	2,436	2,231
Hansen disease (leprosy)	77	72	105	89	66	60
Hepatitis A	8,323	7,254	5,970	4,284	3,579	2,708
Hepatitis B	6,988	6,799	6,741	5,497	4,713	3,936
Hepatitis, C/non-A, non-B[††]	3,585	1,802	708	869	802	775
Legionellosis	1,203	2,014	2,125	2,050	2,796	2,371
Listeriosis	665	696	753	906	975	701
Lyme disease	18,181	18,387	19,859	21,304	19,931	20,599
Malaria	1,245	1,176	1,468	1,252	1,474	1,085
Measles (rubeola)	37	42	37	62	55	30
Meningococcal disease	1,595	1,588	1,242	1,111	1,194	974
Mumps	238	197	258	265	6,584	715
Pertussis (whooping cough)	8,296	8,483	25,827	21,003	15,632	9,739
Plague	1	1	3	7	17	6
Poliomyelitis, paralytic[§§]	0	–	–	1	–	–
Psittacosis	18	15	12	21	21	[illegible]
Rabies, animal	6,875	5,545	6,346	5,277	5,534	5,31[illegible]
Rabies, human	2	3	7	2	3	–
Rocky Mountain spotted fever	975	973	1,738	1,843	2,288	2,706
Rubella (German measles)	14	7	10	16	11	11
Salmonellosis, excluding typhoid fever	40,518	40,913	42,207	41,820	45,808	43,749
Shigellosis	20,422	21,641	14,631	13,749	15,503	17,193
Streptococcus, Group A**	3,956	5,155	4,411	4,263	5,407	4,743
Streptococcus pneumoniae, total**	2,538	2,110	3,420	3,296	4,152	3,999
Syphilis, primary and secondary	6,378	6,818	7,980	8,020	9,756	10,417
Total, all stages	32,919	34,289	33,422	33,288	36,935	39,426
Tetanus	22	14	34	20	41	20
Toxic-shock syndrome	111	128	98	96	101	79
Trichinellosis	13	6	6	17	15	6
Tuberculosis	12,120	11,619	14,157	11,547	13,779	10,363
Typhoid fever	266	313	322	324	353	319
Varicella (chickenpox)***	12,261	13,474	32,868	26,532	48,445	34,507
West Nile Fever	4,156	1,933	2,539	3,000	2,774	2,334

Source: Data from Morbidity and Mortality Weekly Report.

[*]The total number of acquired immunodeficiency syndrome (AIDS) cases includes all cases reported to the Division of HIV/AIDS Prevention, Surveillance, and Epidemiology, National Center for HIV, STD, and TB Prevention (NCHSTP) through December, 2007.

[¶]Chlamydia refers to genital infection caused by C. trachomatis.

[**]Not previously nationally notifiable.

[††]Anti-HCV antibody test was available as of May, 1990.

[§§]Numbers may not reflect changes based on retrospective case evaluations or late reports (see MMWR 1986;35:180–2).

[¶¶]Cases were updated through the Division of Tuberculosis Elimination, NCHSTP, as of December, 2007.

[***]Varicella was taken off the nationally notifiable disease list in 1991. Many states continue to report these cases to CDC.

About the Author

Kathleen Park Talaro is a microbiologist and educator at Pasadena City College. A native of Idaho, she began her college education at Idaho State University in Pocatello. There she found a comfortable niche that fit her particular abilities and interests, spending part of her free time as a scientific illustrator and part as a teaching assistant. After graduation, she started graduate studies at Arizona State University, with an emphasis in the physiological ecology of desert organisms. Additional graduate work was spent participating in 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 the California Institute of Technology and California State University.

Kathy has been teaching medical microbiology and majors' biology courses for over 30 years. She has been involved in developing curricula and new laboratory exercises in microbiology, and she has served as an advisor to the school's medical professions club. Throughout her career Kathy has nurtured a passion for the microbial world and a desire to convey the importance of that world to beginning students. She finds tremendous gratification in watching her students emerge from a budding awareness of microorganisms into a deeper understanding of their significance in natural phenomena.

Kathy is a member of the American Society for Microbiology. She keeps active in self-study and research and continues to attend workshops and conferences to remain current in her field. She also has contributed to science outreach programs by bringing mini-courses in microbiology to students from kindergarten to high school.

This book is dedicated to the devoted public health workers who introduce medical advances and treatments enjoyed by the industrialized world to all humans.

Preface

There are a Million Stories in the Microbe Jungle

One measure of a subject's impact on the everyday lives of people is how often it is mentioned in the popular press. By this measure, it seems that microbiology has really come of age. Consider some of the "buzz words" creeping into the tabloids of late: MRSA, *C. diff,* killer cold viruses, bacterial cultures in yogurt, the bird flu, biofilms, cancer vaccines, designer bacteria, and personal gene chips, just to name a few. If a quick glance at some of the latest headlines has inspired you to enhance your understanding of these topics and hundreds of others, this book is a good place to start. Inquiring minds want to know!

It is true that a substantial portion of discoveries in science right now are emerging from the realm of microbiology. In fact, microbiology has entered a new "golden age" that is generating information at a rapid rate. Much of it relates to genetics and infectious disease, but a lot of it comes from discoveries about the activities of microbes in the natural environment. Because microbes are so small, widespread, and largely nonvisible, there will always be some places that have not yet been thoroughly explored where microbes are living and doing their thing. As greater attention is focused on the rainforest, oceans, bedrock, or even the human body, and advanced tools are used in probing these environments, our perspectives on the microbial world are expanded to new and greater dimensions.

What Sets This Book Apart?

The primary aims of this book have been 1) to present guiding principles in a straightforward and readable style that is neither too wordy nor too simplistic, and 2) to explain complex topics clearly and vividly. I have continued to organize the content in a logical order that builds foundations from early chapters to later ones. The text is backed up with numerous tables, flow charts, and other support features. Having many different levels and cognitive styles for students increases retention, understanding, and success in learning.

A Vivid, Self-Explanatory Art Program

My experiences as a teacher, microbiologist, and illustrator have helped me to visualize abstract concepts and transform them into scientifically accurate and attractive illustrations. Vivid, multidimensional art pieces 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 seventh 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.

Early Survey of Microbial Groups and Taxonomy

A unique feature of this text's format is the early survey of microbial groups and their taxonomy (chapters 4, 5, and 6). By using general and specific names for microbes from the very beginning students develop a working background that eases them into the later chapters. I have always felt that microbes are the "stars of the show," and that students have a far greater appreciation for later topics of nutrition, metabolism, genetics, and microbial control if they recognize the main characters—bacteria, viruses, and eukaryotic microorganisms, and already know significant facts about them.

Pedagogy Designed for the Way Students Learn

Foundations in Microbiology 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.
- Major sections of each chapter are followed by **Checkpoints** that repeat and summarize the concepts of that section.
- **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.

- All chapters end with a **summary,** and a comprehensive array of **end-of-chapter questions** that are not just multiple-choice, but also questions that require writing and critical thinking about topics in the chapter. 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.
- **Concept Mapping** assists in retention as well as contextual organization.

What's New with This Edition?

Since the science of microbiology is constantly changing and advancing, the textbook must also change and advance to stay current and continue to be useful and relevant. With each edition we will continue to create a current, well-organized, and scientifically accurate book, and provide an active learning opportunity for students.

I have been fortunate to have my colleague Barry Chess, of *Pasadena City College* and Kelly Cowan of *Miami University of Ohio* continue in their capacity as significant contributors. They have helped write new sections and Insight boxes, suggested ideas for new and improved figures, edited and updated text, and improved chapter overviews, summaries, and questions. Kelly is instrumental in developing case files and both she and Barry have constructed some of the active learning features in the end-of-chapter sections. Many additions and innovations were done at the request of reviewers and users, whose input continues to be invaluable.

Active Learning Experience

- New **Visual Understanding** Questions supply a photo or a graphic that students have already seen, along with a thought-provoking question. Many of these questions use images from previous chapters and pose queries that require students to combine knowledge from the current chapter with the material they already have learned from previous chapters.
- **Concept Mapping** Exercises ask students to organize information in more meaningful forms than just simple lists. Three different types of concepts maps are used throughout the text. A new Appendix introduces students to concept mapping.
- **Process figures** now have matching numbered steps for easy to see explanations of complex processes.
- **Special icons** correlate over 100 total animations to figures in the text. When students see the icon next to a figure legend, they'll know to check out the accompanying website for a helpful animation to actively illustrate the concept. Additional animations with quizzes are also on the website.
- **Study on the Fly Content**—now students have access to downloadable chapter summaries and animations so they can study anywhere, anytime.

Up-To-Date Content

- Chapter 9 introduces some of the newer concepts in genetics that have emerged from genome analysis studies. The most significant discovery involves the role of special types of RNA in regulating genes and their expression.
- Applications of regulatory RNA in biotechnology and engineering of transgenic animals have been added to chapter 10.
- To consolidate and streamline the section on chemical control of microorganisms in chapter 11, we have compiled several new tables that summarize and illustrate common applications.
- Now that probiotics have become more widely used and understood, their coverage has been updated and enlarged in chapters 12 and 13.
- Throughout the book there is much more emphasis on polymicrobial infections and biofilms.
- In chapter 17 we have included a more detailed table of specimen collection and increased coverage of PCR technology in diagnosis of infections.
- After much consideration and a number of requests, the spelling of prokaryote and eukaryote and related terms has been revised to the form with a "k" instead of a "c" throughout all chapters.
- Overall, we have added a number of new case studies (called case files), photographs, figures, notes, and boxes.

Acknowledgments

My involvement in this textbook goes back over twenty-five years. Throughout this active and fulfilling time, I have had the good fortune to be supported by the best publishing staff in the business. I have collaborated with dozens of top-notch editors, researchers, production staff, illustrators, and designers. It has been clear to me that, from the very beginning, the textbook teams have shared my love for the project, and have brought their own expertise and commitment to maintaining a high quality product. This seventh edition has carried on this tradition.

Several key people made significant contributions to this edition. First, I wish to commend my senior developmental editor, Kathleen Loewenberg, for her enthusiastic support and suggestions. Her experience and thoughtful comments have been a real asset, and she is an awesome "figure wrangler," bringing a fresh perspective and keen eye to the art program. I greatly appreciate the contributions of the editorial coordinator Ashley Zellmer, who cheerfully takes on the sometimes tedious work of preparing and processing manuscript and keeping track of the numerous revisions in text and figures. I am indebted to senior sponsoring editor Jim Connely, who keeps us laughing when we need it, and whose advice "If you put something in, you'll need to take something out" has been a useful guide for many a decision about content, length, and new features. I have received much helpful input from publisher Michelle Watnick, another experienced and well-informed member of the book team. I admire her ability to grasp "the big picture" of book creation. Senior project manager, Jayne Klein, has done a first-rate job of overseeing the minutiae of production. I especially appreciate her flexibility in considering changes I feel strongly about and the detailed efforts from her team. They can actually find an italicized period in a footnote—just to give you an idea of the level of scrutiny this book receives! Other gifted and dedicated personnel that I would like to thank include the photo research coordinator, Carrie Burger; photo researcher, Danny Meldung at Photo Affairs; Jeanne Patterson, copy editor; and the book designer, Michelle Whitaker. No list of acknowledgments would be complete without mentioning senior marketing manager Tami Petsche, who has to wear several hats, including having to take a crash course in microbiology with each new edition.

Just like the living world, this textbook is evolving. A major force behind this trend relates to the constant discoveries happening in microbiology that must be addressed and updated. But another undeniable force for change is the feedback that we get from users and reviewers. I want to make special mention of Dr. Wan H. Ooi and his colleagues Pramilla Sen, Marsha Turell, and Donna Wiersma of *Houston Community College*, and Dr. Reza Marvdashti of *San Jacinto College* for their insights in several chapters. Other reviewers who have provided substantive comments on content and accuracy are Melissa Rubin, Kelly Gridley, Dana Nayduch, and Davis Prichett. Our team of reviewers for the seventh edition has contributed valuable ideas for new figures, boxes, and coverage. They have helped to fine tune language, terminology, headings, Checkpoints, and pedagogy. These reviewers teach the subject and are interpreters of it to beginning students. It is obvious that they share a passion for knowledge and wish to impart the excitement of microbiology to their classes. We commend you for your dedication.

For the users of this book, we hope that you enjoy our journey into the world of microbiology and nurture a long-term interest in this fascinating science. Though many elaborate steps are taken to weed out errors, the very nature of an evolving book means that "mutations" may slip in without notice. If you detect any missing or misspelled words, missing labels, mistakes in content, or other errata, do not hesitate to contact the publisher, representative, or the author (ktalaro@aol.com).

Reviewers

Arden Aspedon, *Southwestern Oklahoma State University*

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Barry Chess, *Pasadena City College*

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John Dahl, *Washington State University*

Alison Davis, *East Los Angeles College*

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Edwin Gines-Candalaria, *Miami Dade*

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Madhura Pradhan, *Ohio State University*

Louise Thai, *University of Missouri*

Delon Washo-Krupps, *Arizona State University*

Samia Williams, *Santa Fe Community College*

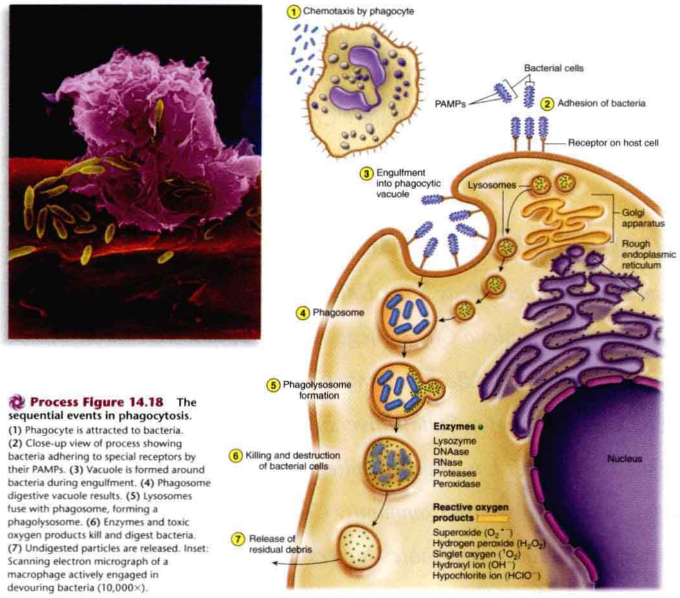
Instructional Art Program Clarifies Concepts

Foundations in Microbiology provides 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.

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!

Figure 11.4 Modes of action affecting protein function.
(a) The native (functional) state is maintained by bonds that create active sites to fit the substrate. Some agents denature the protein by breaking all or some secondary and tertiary bonds. Results are **(b)** complete unfolding or **(c)** random bonding and incorrect folding. **(d)** Some agents react with functional groups on the active site and interfere with bonding.



Process Figure 14.18 The sequential events in phagocytosis.
(1) Phagocyte is attracted to bacteria. (2) Close-up view of process showing bacteria adhering to special receptors by their PAMPs. (3) Vacuole is formed around bacteria during engulfment. (4) Phagosome digestive vacuole results. (5) Lysosomes fuse with phagosome, forming a phagolysosome. (6) Enzymes and toxic oxygen products kill and digest bacteria. (7) Undigested particles are released. Inset: Scanning electron micrograph of a macrophage actively engaged in devouring bacteria (10,000×).

Process Figures

Foundations in Microbiology 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 to benefit all types of learners. Process Figures are now identified next to the figure number. The accompanying legend provides additional explanation.

Chapter 9 Microbial Genetics

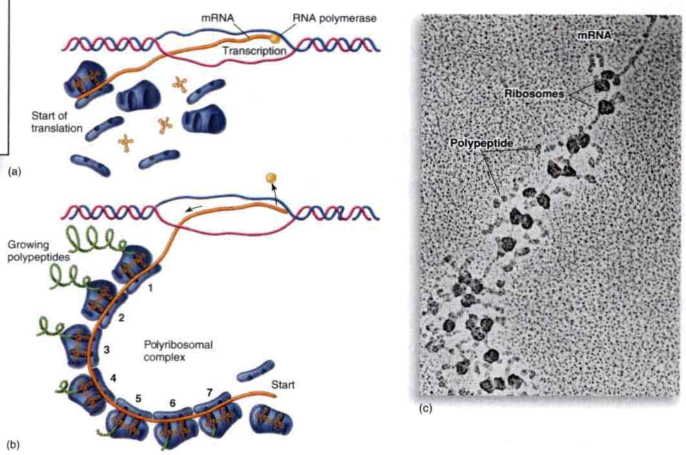
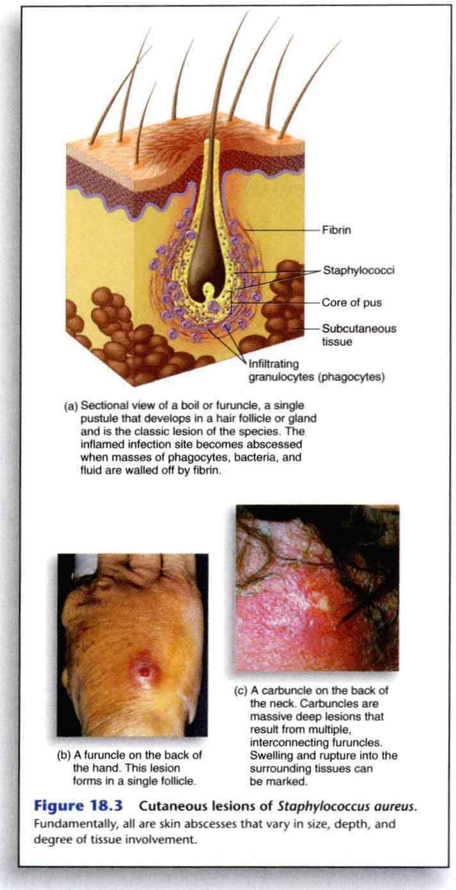


Figure 9.16 Speeding up the protein assembly line in bacteria.
(a) The mRNA transcript encounters ribosomal parts immediately as it leaves the DNA. **(b)** The ribosomal factories assemble along the mRNA in a chain, each ribosome reading the message and translating it into protein. Many products will 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 (30,000×).

Combination Figures

Line drawings combined with photos give students two perspectives: the realism of photos and the explanatory clarity of illustrations. The authors chose this method of presentation to help students comprehend difficult concepts.



(a) Sectional view of a boil or furuncle, a single pustule that develops in a hair follicle or gland and is the classic lesion of the species. The inflamed infection site becomes abscessed when masses of phagocytes, bacteria, and fluid are walled off by fibrin.

(b) A furuncle on the back of the hand. This lesion forms in a single follicle.

(c) A carbuncle on the back of the neck. Carbuncles are massive deep lesions that result from multiple, interconnecting furuncles. Swelling and rupture into the surrounding tissues can be marked.

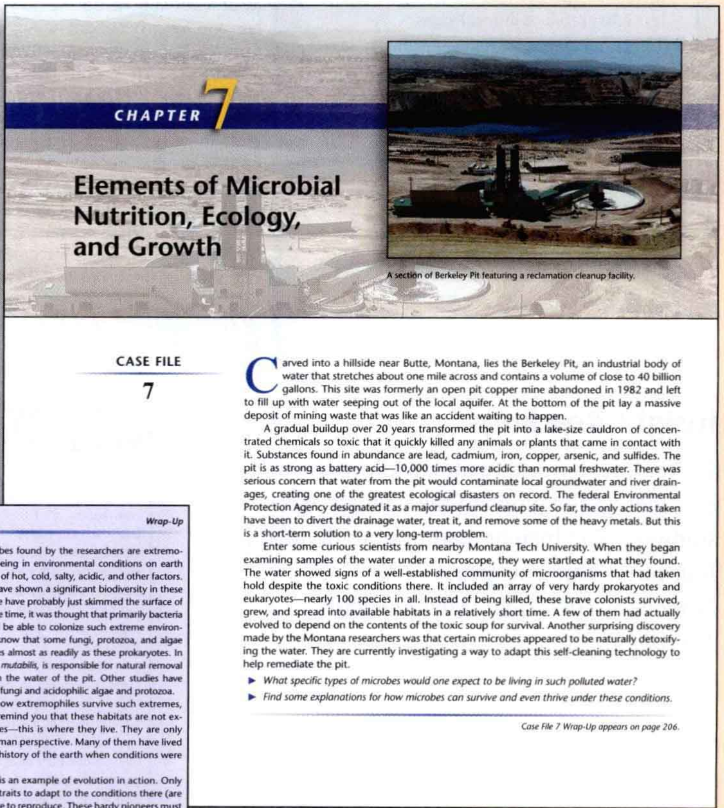
Figure 18.3 **Cutaneous lesions of *Staphylococcus aureus*.** Fundamentally, all are skin abscesses that vary in size, depth, and degree of tissue involvement.

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.

Overview Figures

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



A section of Berkeley Pit featuring a reclamation cleanup facility.

CASE FILE 7

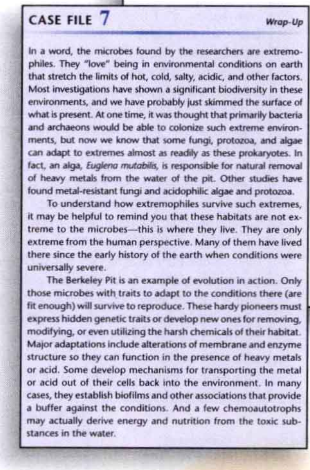
Carved into a hillside near Butte, Montana, lies the Berkeley Pit, an industrial body of water that stretches about one mile across and contains a volume of close to 40 billion gallons. This site was formerly an open pit copper mine abandoned in 1982 and left to fill up with water seeping out of the local aquifer. At the bottom of the pit lay a massive deposit of mining waste that was like an accident waiting to happen.

A gradual buildup over 20 years transformed the pit into a lake-size cauldron of concentrated chemicals so toxic that it quickly killed any animals or plants that came in contact with it. Substances found in abundance are lead, cadmium, iron, copper, arsenic, and sulfides. The pit is as strong as battery acid—10,000 times more acidic than normal freshwater. There was serious concern that water from the pit would contaminate local groundwater and river drainages, creating one of the greatest ecological disasters on record. The federal Environmental Protection Agency designated it as a major superfund cleanup site. So far, the only actions taken have been to divert the drainage water, treat it, and remove some of the heavy metals. But this is a short-term solution to a very long-term problem.

Enter some curious scientists from nearby Montana Tech University. When they began examining samples of the water under a microscope, they were startled at what they found. The water showed signs of a well-established community of microorganisms that had taken hold despite the toxic conditions there. It included an array of very hardy prokaryotes and eukaryotes—nearly 100 species in all. Instead of being killed, these brave colonists survived, grew, and spread into available habitats in a relatively short time. A few of them had actually evolved to depend on the contents of the toxic soup for survival. Another surprising discovery made by the Montana researchers was that certain microbes appeared to be naturally detoxifying the water. They are currently investigating a way to adapt this self-cleaning technology to help remediate the pit.

- *What specific types of microbes would one expect to be living in such polluted water?*
- *Find some explanations for how microbes can survive and even thrive under these conditions.*

Case File 7 Wrap-Up appears on page 206.



CASE FILE 7 *Wrap-Up*

In a word, the microbes found by the researchers are extremophiles. They "love" being in environmental conditions on earth that stretch the limits of hot, cold, salty, acidic, and other factors. Most investigations have shown a significant biodiversity in these environments, and we have probably just skimmed the surface of what is present. At one time, it was thought that primarily bacteria and archaeons would be able to colonize such extreme environments, but now we know that some fungi, protozoa, and algae can adapt to extremes almost as readily as these prokaryotes. In fact, an alga, *Euglena mutabilis,* is responsible for natural removal of heavy metals from the water of the pit. Other studies have found metal-resistant fungi and acidophilic algae and protozoa.

To understand how extremophiles survive such extremes, it may be helpful to remind you that these habitats are not extreme to the microbes—this is where they live. They are only extreme from the human perspective. Many of them have lived there since the early history of the earth when conditions were universally severe.

The Berkeley Pit is an example of evolution in action. Only those microbes with traits to adapt to the conditions there (are fit enough) will survive to reproduce. These hardy pioneers must express hidden genetic traits or develop new ones for removing, modifying, or even utilizing the harsh chemicals of their habitat. Major adaptations include alterations of membrane and enzyme structure so they can function in the presence of heavy metals or acid. Some develop mechanisms for transporting the metal or acid out of their cells back into the environment. In many cases, they establish biofilms and other associations that provide a buffer against the conditions. And a few chemoautotrophs may actually derive energy and nutrition from the toxic substances in the water.

Pedagogical Aids Promote Active Learning

Foundations in Microbiology organizes every chapter with consistent pedagogical tools. These visual and content-related elements enable students to develop a consistent learning strategy and learn in more than one way, creating a higher retention rate. Let's look at the pedagogical features within each chapter:

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. These relevant "stories" pique interest and help students understand just how important it is to learn and retain the chapter's content.

"I really like the illustrations in this chapter. They are clearly tied to the text and are effective in presenting the information. I found them easy to understand. The photographs are great too."

—Carola Wright, Mt. San Antonio College

CHECKPOINT

- Exoenzymes, toxins, and the ability to induce injurious host responses are the three main types of *virulence factors* pathogens utilize to combat host defenses and damage host tissue.
- Exotoxins and endotoxins differ in their chemical composition and tissue specificity.
- Characteristics or structures of microbes that induce extreme host responses are a major factor in most infectious diseases.
- Patterns of infection vary with the pathogen or pathogens involved. They range from local and focal to systemic.
- A mixed infection is caused by two or more microorganisms simultaneously.
- Infections can be characterized by their sequen[…] secondary and by their duration as either acute o[…]
- An infectious disease is characterized by both ob[…] subjective symptoms.
- Infectious diseases that are asymptomatic or sub[…] less often produce clinical signs.
- The portal of exit by which a pathogen leaves its […] not always the same as the portal of entry.
- The portals of exit and entry determine how path[…] population.
- Some pathogens persist in the body in a latent st[…] long-term diseases called *sequelae.*

Checkpoints

Major sections within the chapters end with a summary of the significant concepts covered. In the disease chapters (18–27) the Checkpoints summarize important pathogens. Students can use these Checkpoints to review while reading and as study tools before exams.

A NOTE ABOUT VIRUSES AS NORMAL FLORA

The role of viruses as normal residents is complicated by their usual reputation as infectious agents. In addition, they are harbored inside cells, which makes them very different from most resident flora. But we now know that they can be harmless and even beneficial inhabitants of the body. Discoveries from the human genome sequencing project have shown that about 8% to 10% of the genetic material consists of endogenous retroviruses (ERVs). It has been postulated that these ERVs started out as ancient infections, but through coevolution, the virus established a mutualistic existence with the human genetic material. In time, the viruses may have become an important factor in the survival of their hosts.

Evidence for this sort of effect has been found in studies with sheep. In these mammals, some ERVs are needed for the healthy development of placentas and embryos. It also appears that some of these viruses help to defend against other viruses that are pathogenic to the host. There is little doubt that similar effects on development and gene expression in humans will be discovered as human genome studies continue.

Notes

"Heads-up" type material appears, when appropriate, letting students know about various terminologies, exceptions to the rule, or to provide clarification or further explanation of the immediate subject.

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.*

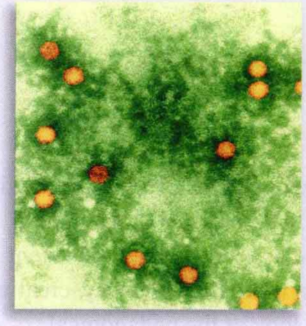
INSIGHT 6.2 *Discovery*

Artificial Viruses Created!

Newspapers are filled with stories of the debate over the ethics of creating life through cloning techniques. Dolly the cloned sheep and the many other animals created since have raised ethical questions about scientists "playing God" when they harvest genetic material from an animal and create an identical organism from it.

Meanwhile, in a much less publicized event, scientists at the State University of New York at Stony Brook succeeded in artificially creating a virus that is virtually identical to natural poliovirus. They used DNA nucleotides they bought "off the shelf" and put them together according to the published poliovirus sequence. They then added an enzyme that would transcribe the DNA sequence into the RNA genome used by poliovirus. They ended up with a virus that was nearly identical to poliovirus (see photograph). Its capsid, infectivity, and replication in host cells are similar to the natural virus.

[…]us was greeted with controversy, particu[…] […]otentially devastating to human health. The



scientists, who were working on a biowarfare defense project funded by the Department of Defense, argued that they were demonstrating what could be accomplished if information and chemicals fell into the wrong hands.

In 2003, another lab in Rockville, Maryland, manufactured a "working" bacteriophage, a harmless virus called phi X. Their hope is to create microorganisms from which they can harness energy—for use as a renewable energy source. But the prospect of harmful misuse of the new technology has prompted scientific experts to team with national security and bioethics experts to discuss the pros and cons of the new technology and ways to ensure its acceptable uses.

What basic materials, molecules, and other components would be required to create viruses in a test tube? *Answer available at http://www.mhhe.com/talaro7*

TABLE 4.2 Comparison of the Two Spiral-Shaped Bacteria

	Overall Appearance	Mode of Locomotion	Number of Helical Turns	Gram Reaction (Cell Wall Type)	Examples of Important Types
Spirilla	Rigid helix (Spirilla)	Polar flagella; cells swim by rotating around like corkscrews; do not flex; have one to several flagella; can be in tufts	Varies from 1 to 20	Gram-negative	Most are harmless; one species, *Spirillum minor,* causes rat bite fever.
Spirochetes	Flexible helix (Curved or spiral forms: Spirillum/Spirochete)	Periplasmic flagella within sheath; cells flex; can swim by rotation or by creeping on surfaces; have 2 to 100 periplasmic flagella	Varies from 3 to 70	Gram-negative	*Treponema pallidum,* cause of syphilis; *Borrelia* and *Leptospira,* important pathogens

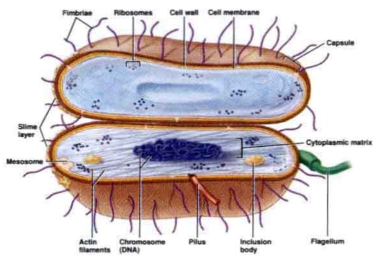
Tables

This edition contains numerous illustrated tables. Horizontal light lines set off each entry, making them easy to read.

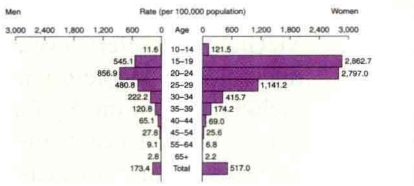
GUIDED TOUR

Visual Understanding

1. From **chapter 4, figure 4.1.** Locate all structures that could function in adhesion of a pathogen to its host cell.



2. From **figure 13.20*b*.** What are some obvious trends in the rates of chlamydiosis with regard to age and sex?



(b) Chlamydia — Age- and sex-specific rates: United States, 2006

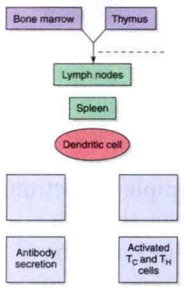
New! Visual Understanding Questions

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.

Concept Mapping

Appendix E provides guidance for working with concept maps.

1. Supply your own linking lines, as well as the 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 links and the linking words between each pair of concepts.

active immunity
passive immunity
natural immunity
artificial immunity
innate immunity
vaccines
interferon
inflammation
memory

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.

Footnotes

Footnotes assist the reader with additional information about the content.

4. The letters correspond to Greek letters gamma, alpha, mu, delta, and epsilon, which are also used to designate the structure of their constant regions.

Terminology

Learning the terminology of microbiology can be a daunting task. To assist the reader, key words are denoted with an asterisk to provide the pronunciation and understanding of the term at the bottom of the page.

Chapter Summary with Key Terms

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

Multiple-Choice Questions

Students can assess their knowledge of basic concepts by answering these questions. Other types of questions and activities to follow build on this foundational knowledge. Answers can be found in Appendix F.

Writing-to-Learn Questions

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

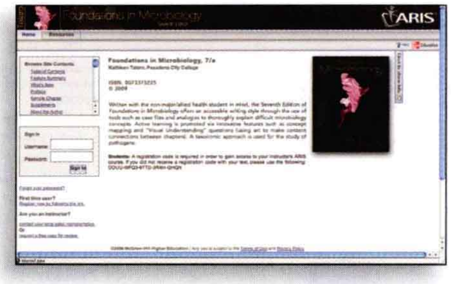
Internet Search Topics

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.

Teaching and Learning Supplements

McGraw-Hill offers various tools and technology products to support ***Foundations in Microbiology* 7/e.** Instructors can obtain teaching aids by calling McGraw-Hill's Service Department at 1-800-338-3987, visiting our Microbiology catalog at **www.mhhe.com/microbiology**, or contacting their local McGraw-Hill sales representative.

ARIS Website



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 and can also edit questions, import their own content, and create due dates for assignments. ARIS offers automatic grading and reporting of easy-to-assign homework, quizzing, and testing.

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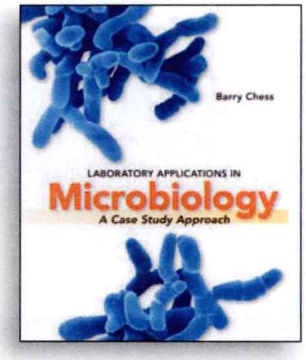
Electronic Images and Assets for Instructors

Part of the ARIS Website, the digital library contains photos, artwork, animations, PPTs, and other media resources that can be used to create customized lectures, tests and quizzes, and design course websites or printed support materials. All assets are copyrighted by McGraw-Hill Higher Education but can be used for classroom purposes. The resources in this collection include:

- **Art** Full-color digital files of all illustrations in the book can be readily incorporated into lecture presentations.
- **Photos** Key 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 instructional use.
- **Animations** Full-color animations illustrating important microbial or physiological processes are also provided.
- **Lecture Outlines** Build your own lecture outline or use one already prepared for you, with embedded animations!

Laboratory Manuals



McGraw-Hill offers several microbiology laboratory manuals, including a new one by Barry Chess that focuses on a case study approach. Use the relevancy of a case study to get your students to read the lab exercises beforehand, and be comfortable in a lab setting. Contact your sales representative for packaging options with any of our microbiology lab manuals.

Computerized Test Bank Online

Test questions are provided within a computerized test bank powered by McGraw-Hill's flexible electronic testing program. EZ Test Online allows instructors to create tests or quizzes in an easy-to-use program, without installing the testing software. Visit: **www.eztestonline.com** to learn more about creating and managing tests, online scoring, and support resources.

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e-Instruction with CPS

The Classroom Performance System (CPS) is an interactive system that allows instructors 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 more clarification is needed. Specially designed questions for e-Instruction are provided through this book's website.

Course Delivery Systems

Instructors can 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 student tracking features are readily available for use within these or any other HTML-based course management platforms.

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