Microbiology

with Diseases by Taxonomy

FIFTH EDITION

Robert W. Bauman

Pearson

Invest in your future:

Microbiology Matters

Engage with compelling healthcare applications

NEW! Micro Matters

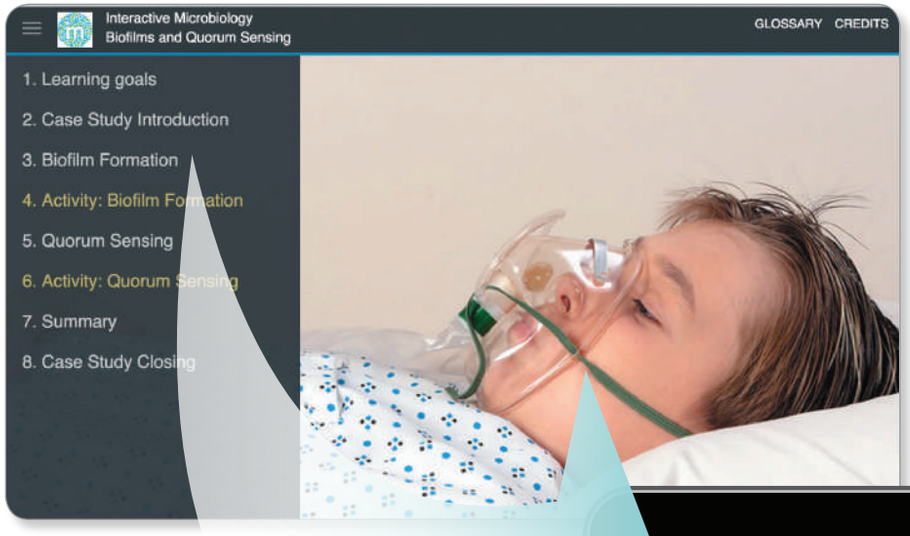
Video Cases animate and connect concepts across chapters and emphasize the clinical importance of foundational material. Micro Matters videos are accessible via QR codes in select chapters and are also assignable in MasteringMicrobiology.

MICRO MATTERS

Make the connection between Chapters 11, 12, and 13. Scan this QR code to see how *Micro Matters*.

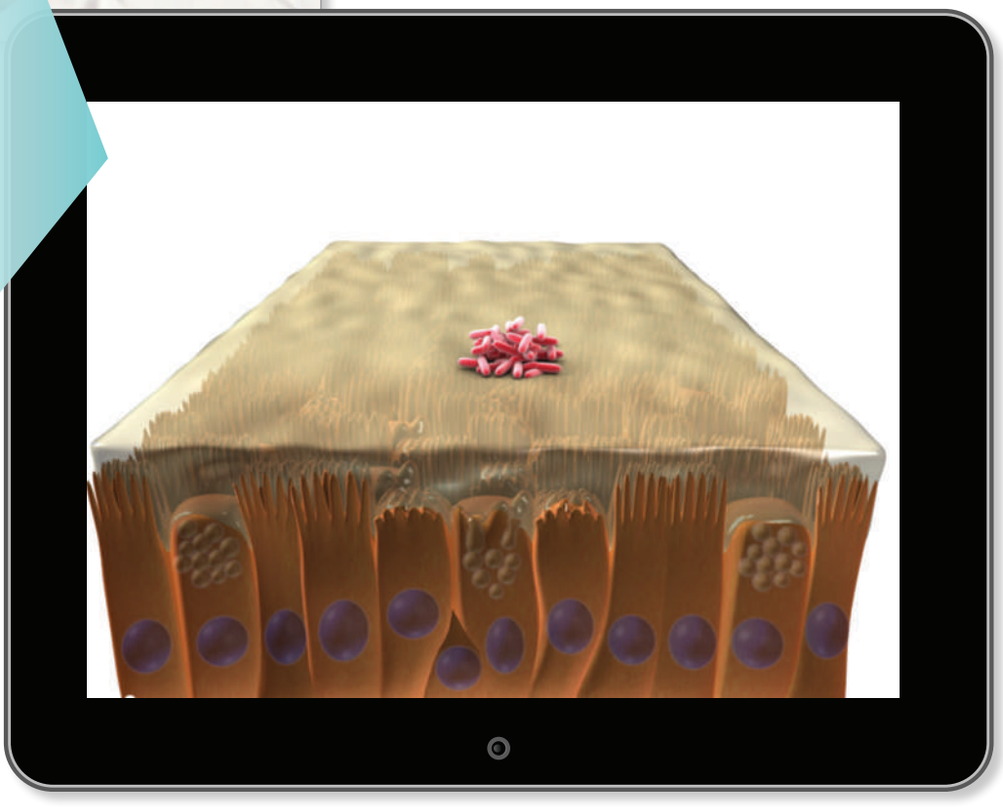
Visit the **MasteringMicrobiology Study Area** to challenge your understanding with practice tests, animation quizzes, and clinical case studies!

MasteringMicrobiology®

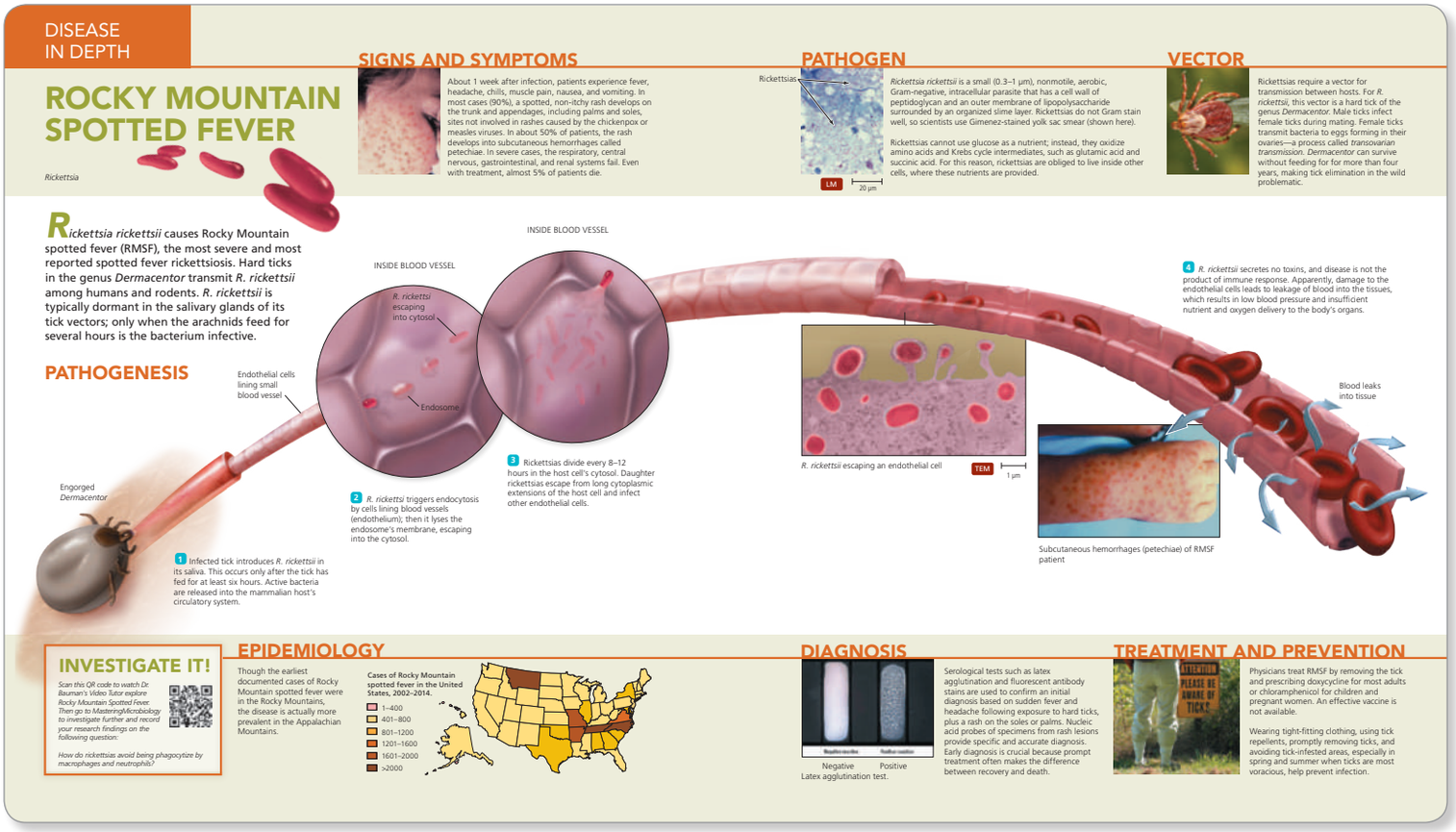


NEW! Interactive Microbiology

is a dynamic suite of interactive tutorials and animations that teach key concepts in microbiology including Operons; Biofilms and Quorum Sensing; Complement; Antibiotic Resistance, Mechanisms and Selection; Aerobic Respiration in Prokaryotes, and more. Each tutorial presents the concept within a real healthcare scenario and allows you to learn from manipulating variables, predicting outcomes, and answering assessment questions.



NEW! Disease in Depth One- or two-page spreads feature important and representative diseases. These highly visual spreads contain illustrations, micrographs, and infographics, providing in-depth overviews of selected diseases for comprehensive study and review.

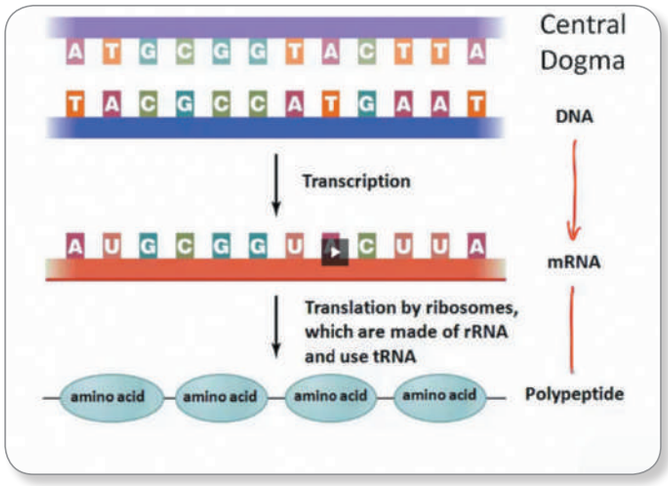


Disease in Depth Video Tutors walk through the presented disease, concluding with an "Investigate It!" question for independent research, furthering your understanding of microbiology's relevancy and importance. Dr. Bauman also includes video tutors to coach students through key process art figures in the book.

MasteringMicrobiology®

NEW! Disease in Depth Coaching Activities feature personalized hints and feedback and provide guidance through each disease, prompting students to explore further with independent research.

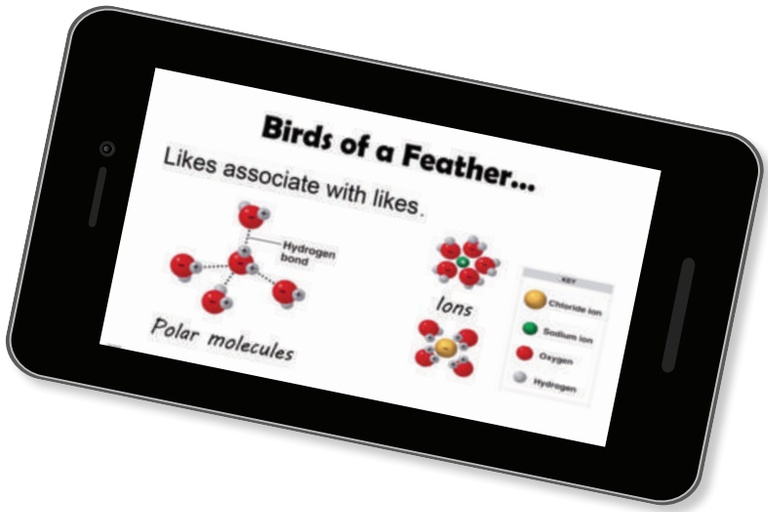
NEW! Connecting Concepts Coaching Activities reinforce a "big picture" understanding of microbiology by showing how concepts in a particular chapter connect across other chapters in the text.

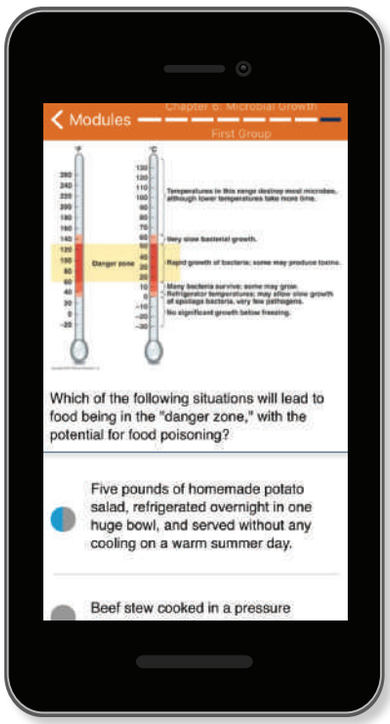


Master Microbiology **at your own pace**, wherever you go!

MasteringMicrobiology®

NEW! MicroBoosters offer a mobile-friendly way for you to review (or learn for the first time) foundational concepts that are important in order to understand Microbiology, including Study Skills, Basic General and Organic Chemistry, Cell Biology, and more. MicroBoosters can be assigned through MasteringMicrobiology and are available for self-study as Dynamic Study Modules.





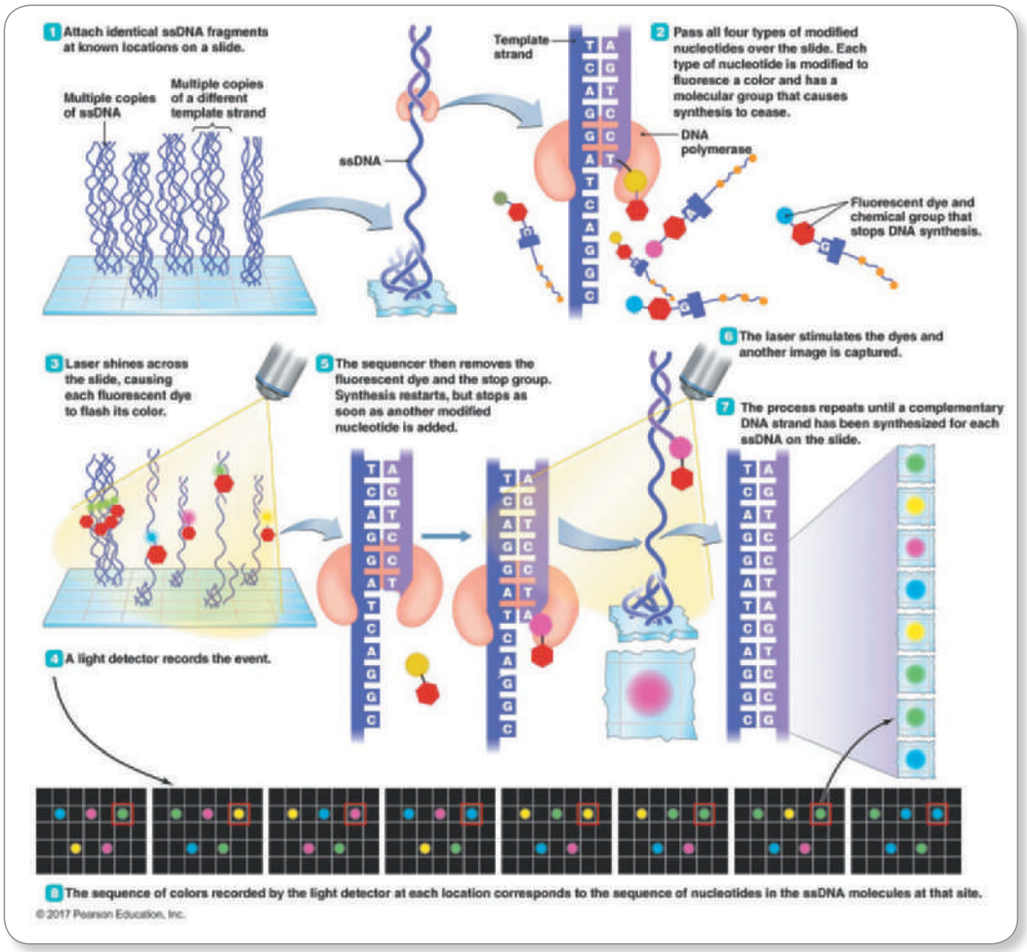
NEW! Mobile-friendly Dynamic Study Modules help students acquire, retain, and recall information faster and more effectively than ever before. These flashcard-style modules are available as a self-study tool or can be assigned by instructors.

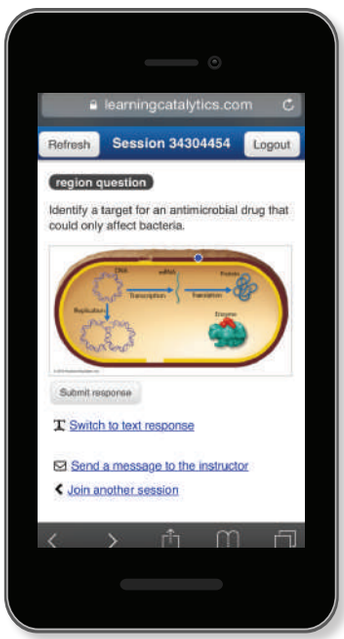
NEW! Adaptive Follow-Up Assignments in MasteringMicrobiology are based on each student's performance on the original homework assignment and, when assigned, provide additional coaching and practice.

EXPANDED! Dr. Bauman's Video Tutors, developed and narrated by the author, carefully teach key concepts using textbook art, bringing the illustrations to life and helping you visualize and understand complex topics and important processes. The Fifth Edition includes new video tutors on key concepts as well as the Disease in Depth overviews. You can quickly access the video tutors by scanning QR codes with a mobile device for on-the-go tutoring; instructors may also assign them as coaching activities in MasteringMicrobiology.

Learn how **today's microbiologists think.**

UPDATED! Every chapter has been revised to reflect the current **State of the Science**, including the latest research and technology. Highlights of content updates include extensive discussions on the impact of genomics in understanding disease diagnosis and treatment options.





Develop **higher-level thinking skills** and conceptual understanding

MasteringMicrobiology®

NEW! Learning Catalytics is a "bring your own device" (laptop, smartphone, or tablet) classroom system for student engagement and assessment. With Learning Catalytics, instructors can assess students in real time using open-ended tasks to probe student understanding.

NEW! ASM Curriculum Guidelines pre-test and post-test assessments are assignable in MasteringMicrobiology to facilitate efficient and customizable assessment of the six underlying concepts and 22 related topics of lasting importance in undergraduate microbiology courses as determined by the American Society of Microbiology.

Connect Lecture and Lab

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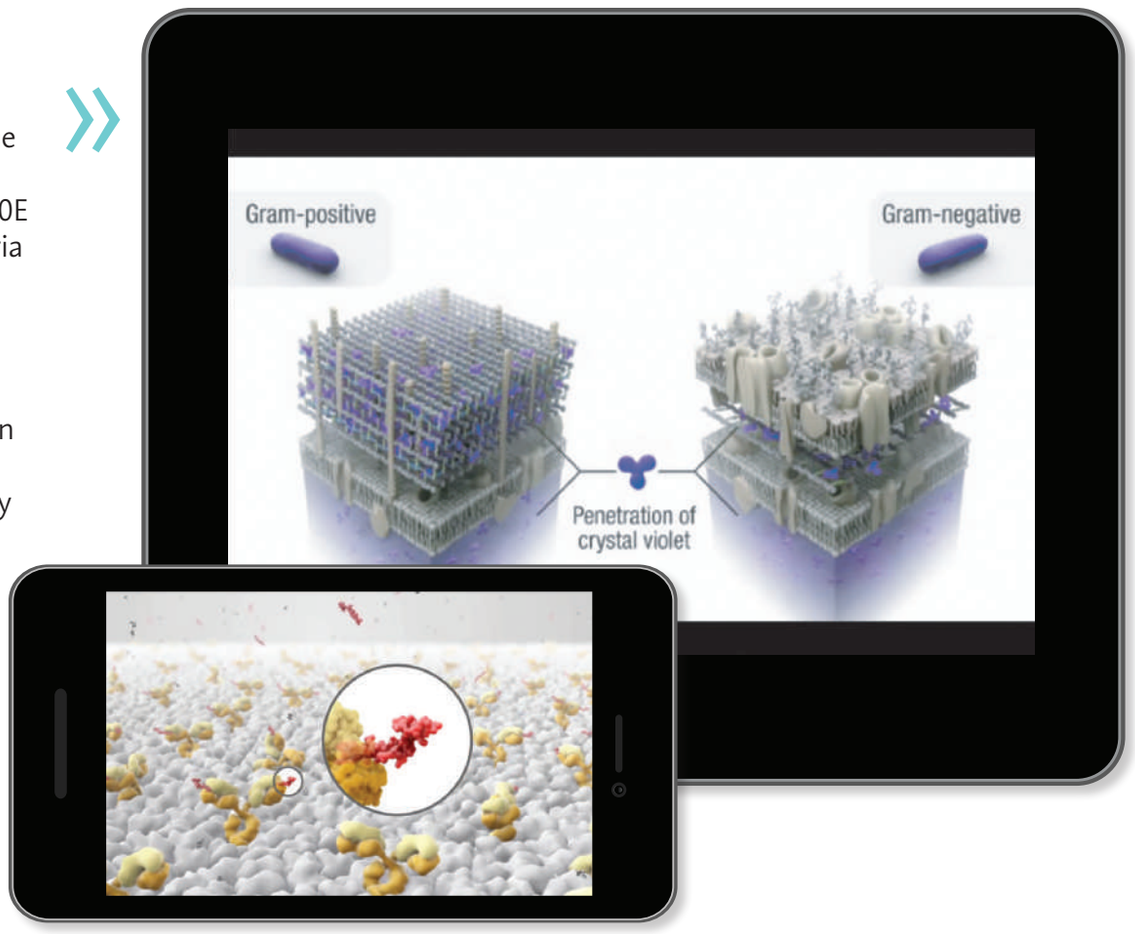
MicroLab Tutors help instructors and students get the most out of lab time and make the connection between microbiology concepts, lab techniques, and real-world applications.

These tutorials combine live-action video and molecular animation with assessment and answer-specific feedback to coach students in how to interpret and analyze different lab results.

MicroLab Tutor Coaching Activities include the following topics:

- Use and Application of the Acid-Fast Stain
- Multitest Systems—API 20E
- Aseptic Transfer of Bacteria
- ELISA
- Gram Stain
- Use and Application of Microscopy
- Polymerase Chain Reaction (PCR)
- Safety in the Microbiology Laboratory
- Quantifying Bacteria with Serial Dilutions and Pour Plates
- Smear Preparation and Fixation
- Streak Plate Technique
- Survey of Protozoa
- Identification of Unknown Bacteria



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Lab Technique Videos give students an opportunity to see techniques performed correctly and quiz themselves on lab procedures both before and after lab time.

Lab Technique videos can be assigned as pre-lab quizzes in MasteringMicrobiology and include coaching and feedback on the following techniques:

- **NEW!** The Scientific Method
- **NEW!** How to Write a Lab Report
- Acid-Fast Staining
- Amylase Production
- Carbohydrate Catabolism
- Compound Microscope
- Differential and Selective Media
- Disk-Diffusion Assay
- ELISA
- Gram Stain
- Hydrogen Sulfide Production
- Litmus Milk Reactions
- Negative Staining
- Respiration
- Serial Dilutions
- Simple Staining
- Smear Preparation
- Structural Stains
- Safety in the Microbiology Laboratory

Also Available for the Microbiology Lab Course

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The Eleventh Edition of this popular laboratory manual has been thoroughly revised with easy-to-adapt Lab Reports and the latest protocols from governing agencies including the EPA, ASM, and AOAC, along with two new lab exercises: one on Food Safety, and another covering the BSL 1 Biological Safety Level.

Techniques in Microbiology: A Student Handbook
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MasteringMicrobiology is the most effective and widely used online homework, tutorial, and assessment system for the sciences, delivering self-paced tutorials that focus on your course objectives, provide individualized coaching, and respond to your students' progress.

Instructor's Resource Material

The Instructor's Resource Material offers a wealth of instructor media resources, including presentation art, lecture outlines, test items, and answer keys—all in one convenient location. These resources help instructors prepare for class—and create dynamic lectures—in half the time! The Instructor's Resource Materials include:

- All figures from the text with and without labels in both JPEG and PowerPoint® formats
- All figures from the book with the Label Edit feature and selected "process" figures from the text with the Step Edit feature in PowerPoint format
- All tables from the text
- PowerPoint lecture outlines, including figures and tables from the book and links to the animations and videos

All items provided on the IRC can also be downloaded from the "Instructor Resources" area of MasteringMicrobiology, which also includes: Video Tutors, MicroFlix™ Animations, Microbiology Animations, Microbiology Videos, Lab Technique Videos, and more.

NEW! Learning Catalytics is a "bring your own device" (laptop, smartphone, or tablet) classroom system for student engagement and assessment. With Learning Catalytics, instructors can assess students in real time using open-ended tasks to probe student understanding.

Test Bank (Download Only)

by Robert W. Bauman, Nichol Dolby

The Fifth Edition Test Bank includes hundreds of multiple choice, true/false, and short answer/essay questions that are correlated to the book's Learning Outcomes and Bloom's Taxonomy rankings. Available electronically in the "Instructor Resources" area of MasteringMicrobiology, in both Microsoft Word® and in TestGen formats.

Instructor's Manual (Download Only)

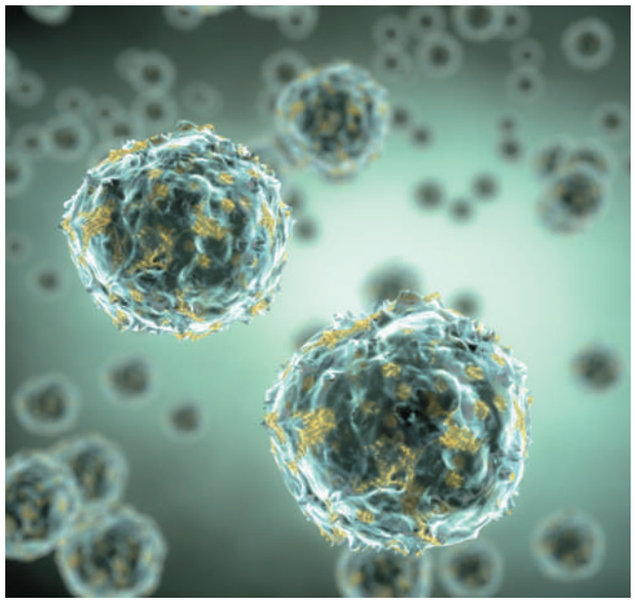
by Robert W. Bauman, Nichol Dolby

This guide can be downloaded from the "Instructor Resources" area of MasteringMicrobiology and includes a detailed chapter outline and summary for each chapter as well as answers to in-text Clinical Case Studies, "Tell Me Why" questions, Critical Thinking questions, and end-of-chapter Questions for Review.

FIFTH EDITION
GLOBAL EDITION

MICROBIOLOGY

WITH DISEASES BY TAXONOMY



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To Michelle:
My best friend, my closest confidant, my cheerleader, my partner, my love. Thirty-four years! I love you more now than then.

—Robert

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ISBN 10: 1-292-16076-4
ISBN 13: 978-1-292-16076-4

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

10 9 8 7 6 5 4 3 2 1

Typeset by Lumina Datamatics, Inc.

Printed and bound in Malaysia

About the Author

ROBERT W. BAUMAN is a professor of biology and past chairman of the Department of Biological Sciences at Amarillo College in Amarillo, Texas. He has taught microbiology, human anatomy and physiology, and botany. In 2004, the students of Amarillo College selected Dr. Bauman as the recipient of the John F. Mead Faculty Excellence Award and he has been nominated for the one-time award every year since. He received an M.A. degree in botany from the University of Texas at Austin and a Ph.D. in biology from Stanford University. His research interests have included the morphology and ecology of freshwater algae, the cell biology of marine algae (particularly the deposition of cell walls and intercellular communication), environmentally triggered chromogenesis in butterflies, and terrestrial oil pollution remediation by naturally occurring bacteria. He is a member of the American Society of Microbiology (ASM) where he has held national offices, Texas Community College Teachers Association (TCCTA) where he serves in a statewide position of leadership, American Association for the Advancement of Science (AAAS), Human Anatomy and Physiology Society (HAPS), and The Lepidopterists' Society. When he is not writing books, he enjoys spending time with his family: gardening, hiking, camping, rock climbing, backpacking, cycling, skiing, and reading by a crackling fire in the winter and in a gently swaying hammock in the summer.

TODD P. PRIMM (contributor) is an associate professor at Sam Houston State University, where he teaches pre-nursing microbiology. He also serves as Director of the Professional and Academic Center for Excellence, which focuses on improving teaching and learning on campus. In 2010, he was Distinguished Alumnus of the Graduate School of Biomedical Sciences of Baylor College of Medicine, where he earned a Ph.D. in Biochemistry in 1997. He received a B.S. from Texas A&M University in 1992. He is very active in the American Society for Microbiology and received the Texas Branch 2015 Faculty Teaching Award. He was chair of the organizing committee for the 2013 ASM Conference for Undergraduate Educators, participated in the 2012 Research Residency of the ASM/NSF Biology Scholars Program, and currently serves on the editorial board for the *Journal of Microbiology and Biology Education*. He is also an affiliate staff member with the international organization Cru. He loves teaching and mentoring students and spending time with his wonderful wife of 23 years and four children.

About the Clinical Consultants

CECILY D. COSBY is nationally certified as both a family nurse practitioner and physician assistant. She is a professor of nursing, currently teaching at Samuel Merritt University in Oakland, California, and has been in clinical practice since 1980. She received her Ph.D. and M.S. from the University of California, San Francisco; her BSN from California State University, Long Beach; and her P.A. certificate from the Stanford Primary Care program. She is the Director of Samuel Merritt University's Doctor of Nursing Practice Program.

JEAN E. MONTGOMERY is a registered nurse formerly teaching in the associate degree nursing program at Austin Community College in Texas. She received her MSN from the University of Texas Health Science Center at San Antonio, Texas.

Preface

The reemergence of whooping cough, mumps, and measles and the emergence of snail fever, spotted fever rickettsiosis, Middle East respiratory syndrome, and other diseases; the cases of strep throat, MRSA, and tuberculosis; the progress of cutting-edge research into microbial genetics; the challenge of increasingly drug-resistant pathogens; the continual discovery of microorganisms previously unknown—these are just a few examples of why exploring microbiology has never been more exciting, or more important. Welcome!

I have taught microbiology to undergraduates for over 27 years and witnessed firsthand how students struggle with the same topics and concepts year after year. To address these challenging topics, I have created 14 new Video Tutors: three in addition to those already incorporated into the first 18 chapters of the text and 11 that cover the Disease in Depth features. The Video Tutors and Disease in Depth features walk students through key concepts in microbiology, bringing the art of the textbook to life and important concepts into view. In creating this textbook, my aim was to help students see complex topics of microbiology—especially metabolism, genetics, and immunology—in a way that they can understand, while at the same time presenting a thorough and accurate overview of microbiology. I also wished to highlight the many positive effects of microorganisms on our lives, along with the medically important microorganisms that cause disease.

New to This Edition

In approaching the fifth edition, my goal was to build upon the strengths and success of the previous editions by updating it with the latest scientific and educational research and data available and by incorporating the many terrific suggestions I have received from colleagues and students alike. The feedback from instructors who adopted previous editions has been immensely gratifying and is much appreciated. The Microbe at a Glance features have been widely praised by instructors and students, so I, along with art editor Kelly Murphy, developed 11 new Disease in Depth features, most as two-page spreads, that use compelling art and photos to provide a detailed, visually unsurpassed overview of a specific disease. Each Disease in Depth feature includes an Investigate It! question with a QR code directing students to a Video Tutor that explores the topic and encourages further, independent research. These activities are assignable in MasteringMicrobiology®. Another goal for this edition was to provide additional instruction on important foundational concepts and processes. To that end, I developed and narrated three new core concept Video Tutors, accessible via QR codes in the textbook and assignable in MasteringMicrobiology.

The result is, once again, a collaborative effort of educators, students, editors, and top scientific illustrators: a textbook that, I hope, continues to improve upon conventional explanations and illustrations in substantive and effective ways.

In this new edition:

- **NEW Disease in Depth** features highlight important and representative diseases for each body system, extending the visual impact of the art program as well as the highly praised Microbe at a Glance features. Each of these 11 visual features contains infographics, provides in-depth coverage of the selected disease, and includes a QR code and Investigate It! question that directs students to a Video Tutor exploring the topic and prompting further inquiry and critical thinking.

New assignable Disease in Depth coaching activities in MasteringMicrobiology® encourage students to apply and test their understanding of key concepts.

- **NEW Video Tutors** developed and narrated by the author walk students through key concepts. New to this edition are Video Tutors on glycolysis, protein translation, and antigen processing. These Video Tutors bring the textbook art to life and help students visualize and understand tough topics and important processes. Thirty-two video tutorials are accessible via QR codes in the textbook and are accompanied by multiple-choice questions, assignable in MasteringMicrobiology®.
- **NEW Tell Me Why** critical thinking questions end every main section within each chapter. These questions strengthen the pedagogy and organization of each chapter and *consistently* provide stop-and-think opportunities for students as they read.
- **NEW Expanded coverage of helminths** is provided in new Highlight features, and an **emphasis on virulence factors** is included the Disease in Depth features.
- **The genetics chapters (Chapters 7–8)** have been reviewed and revised by genetics specialists. These now reflect the most current understanding of this rapidly evolving field, including new discussion of next-generation DNA sequencing.
- **Over 330 NEW and revised micrographs, photos, and figures** enhance student understanding of the text and boxed features.
- **NEW and EXPANDED MasteringMicrobiology** includes new Interactive Microbiology animations and tutorials; new MicroBooster remedial video tutorials; new Disease in Depth coaching activities; new Video Tutors with assessments; new MicroCareers and Clinical Case Study coaching activities; and a plethora of microbiology lab resources. **NEW** Interactive Microbiology is a dynamic suite of interactive tutorials and animations that teach key concepts in the context of a clinical setting. Students actively engage with each topic and learn from manipulating variables, predicting outcomes, and answering formative and summative assessments. Topics include Operons; Complement; Biofilms and Quorum Sensing; Antibiotic Resistance, Mechanisms; Antibiotic Resistance, Selection; Aerobic Respiration in Prokaryotes; and Human Microbiota. **NEW** MicroBoosters are a suite of brief video tutorials that cover key concepts that students often need to review, including Study Skills, Math, Basic Chemistry, Cell Biology, Basic Biology and more! The Micro Lab resources include MicroLab Tutors, which use lab technique videos, 3-D molecular animations, and step-by-step tutorials to help students make connections between lecture and lab; Lab Technique Videos and pre-lab quizzes to ensure that students come prepared for lab time; and Lab Practical and post-lab quizzes to reinforce what students have learned.

MasteringMicrobiology offers students access to Dynamic Study Modules to help them acquire, retain, and recall information faster and more efficiently than ever before with textbook-specific explanations and art. Dynamic Study Modules are available for use as a self-study tool or as assignments. Instructors also now have the option to give Adaptive Follow-Up assignments that provide student-specific additional coaching and practice. These question sets continuously adapt to each student's needs, making efficient use of homework time.

MasteringMicrobiology also includes Learning Catalytics—a "bring your own device" student engagement, assessment, and classroom intelligence system. With Learning Catalytics, instructors can assess students in real time using open-ended tasks to probe student understanding using Pearson's library of questions or designing their own.

The following section provides a detailed outline of this edition's chapter-by-chapter revisions.

Chapter-by-Chapter Revisions

CHAPTER 1 A BRIEF HISTORY OF MICROBIOLOGY

- Added three Tell Me Why critical thinking questions to text
- Added three new photos (chapter opener, Fig. 1.6b, Highlight box on MERS)
- Updated map showing countries having transmission of variant Creutzfeldt-Jakob disease (vJCD)
- Added CDC-preferred term "healthcare-associated infection (HAI)" (formerly nosocomial infection)
- Added introductory coverage of normal microbiota and of agar in micro labs
- Clarified the use of *controls* in Pasteur's experiment to disprove spontaneous generation
- Clarified industrial use of microbes in making yogurt and pest control
- Introduced the success of gene therapy to treat several inherited immune deficiencies
- Updated box: "The New Normal": The Challenge of Emerging and Reemerging Diseases to include Middle East respiratory syndrome (MERS), Ebola, chikungunya, and measles
- Added to list of current problems in microbiology: biofilms, tests for infections, and persistent antimicrobial-drug resistance
- Added three critical thinking questions to Emerging Disease Case Study: Variant Creutzfeldt-Jacob Disease
- New end-of-chapter, short-answer question on healthcare-associated (nosocomial) infections
- Added fill-in Concept Map over types of microbes and some of their major characteristics

CHAPTER 2 THE CHEMISTRY OF MICROBIOLOGY

- Added five Tell Me Why critical thinking questions to text
- Eleven figures revised for better pedagogy (Figs. 2.2, 2.3, 2.6, 2.11, 2.15, 2.17, 2.19, 2.21, 2.22, 2.23; amino group in Table 2.3)
- New Learning Outcomes concerning terms regarding elements, valence electrons and chemical bonding, organic compounds, contrasting ionic and covalent bonds, and lipids
- New figure legend question for enhanced pedagogy (Fig. 2.3)
- Expanded coverage of term "nucleoside" because nucleoside analogs treat many diseases
- Added fill-in Concept Map over nucleotide structure and function

CHAPTER 3 CELL STRUCTURE AND FUNCTION

- Added 12 Tell Me Why critical thinking questions to text
- Two new photos (Figs. 3.5b, 3.8a)
- Revised and enhanced artwork in 14 figures for enhanced pedagogy (Figs. 3.4, 3.8b, 3.9, 3.12, 3.14, 3.15, 3.17, 3.18, 3.19, 3.20, 3.21, 3.22, 3.24, 3.35)
- Added one new figure (structure of glucose versus NAG and NAM) (Fig. 3.13)
- Enhanced discussion of flagella and cilia structure and function, comparison and contrast between the outer and cytoplasmic membranes of Gram-negative cells, and movement across cell membranes

CHAPTER 4 MICROSCOPY, STAINING, AND CLASSIFICATION

- Added four Tell Me Why critical thinking questions to text
- Revised two figures for enhanced pedagogy (Figs. 4.4, 4.6)
- Revised Learning Outcome regarding simple stains, which now include Gomori methenamine silver stain and hematoxylin and eosin stains
- Added fill-in-the-blank Concept Map about Gram stain and cell wall structure to end-of-chapter review
- Revised coverage of history of taxonomy
- Expanded discussion of resolution, immersion oil, mordants, definition of microbial species, and role of George Fox in the discovery of the archaea and three domains of life
- Revised section on microbial taxonomy to more fully address genomic techniques in taxonomy
- At request of reviewers and instructors, removed detailed figures for dark field, phase, and scanning electron microscopy so as to reduce complexity and chapter length
- Added three critical thinking questions and a new photo to Emerging Disease Case Study: Necrotizing Fasciitis

CHAPTER 5 MICROBIAL METABOLISM

- Added six Tell Me Why critical thinking questions to text
- Added two new figure questions (Figs. 5.4, 5.13)
- Added one new end-of-chapter fill-in-the-blank question
- Revised 14 figures for greater clarity and better pedagogy (Figs. 5.5, 5.6, 5.10, 5.11, 5.12, 5.13, 5.14, 5.16, 5.17, 5.18, 5.19, 5.26, 5.30; end-of-chapter critical thinking question 1)
- Clarified and expanded discussion of enzymatic activation through allosteric sites and competitive and noncompetitive inhibition of enzyme activity
- Added fill-in Concept Map over aerobic respiration

CHAPTER 6 MICROBIAL NUTRITION AND GROWTH

- Added three Tell Me Why critical thinking questions to text
- Revised five figures for greater clarity and better pedagogy (Figs. 6.7, 6.8, 6.9, 6.17, 6.20)
- Added two new photos (Figs. 6.13, 6.24b)
- Expanded discussion of singlet oxygen and superoxide radicals as oxidizing agents
- Clarified the method of counting microbes using a cell counter
- Added fill-in Concept Map over culture media

CHAPTER 7 MICROBIAL GENETICS

- Added four Tell Me Why critical thinking questions to text
- Upgraded 20 figures for greater clarity, accuracy, ease of reading, and better pedagogy (Figs. 7.1, 7.5, 7.6, 7.7, 7.9, 7.10, 7.11, 7.13, 7.20, 7.21, 7.22, 7.23, 7.26, 7.27, 7.28, 7.30, 7.34, 7.35, 7.36, 7.37)
- Updated text to discuss the smallest cellular genome at 112,091 bp (candidatus *Nasuia deltocephalinicola*)
- Included recent discovery that chloroplast chromosomes are linear rather than circular
- Increased discussion of use of RNA as enzymes (ribozymes)

- Expanded table comparing and contrasting DNA replication, transcription, and translation
- Discussed codon and tRNA for 21st amino acid, selenocysteine
- Enhanced and clarified discussion of *lac* and *trp* operons and of the action of cAMP and CAP as activators
- Expanded and reorganized discussion of DNA repair systems
- Clarified and updated information on the events in conjugation, particularly with Hfr cells
- Expanded coverage of nucleotides and pyrophosphate (diphosphate)
- Added critical thinking questions to Emerging Disease Case Study: *Vibrio vulnificus* Infection
- Revised the chapter to better explain differences between archaeal, bacterial, and eukaryotic genetics
- Added fill-in Concept Map over point mutations

CHAPTER 8 RECOMBINANT DNA TECHNOLOGY

- Added five Tell Me Why critical thinking questions to text
- Added six Learning Outcomes concerning uses of synthetic nucleic acids, PCR, fluorescent *in situ* hybridization (FISH), functional genomics, Sanger sequencing, and next-generation sequencing
- Added one new figure (Fig. 8.10)
- Modified Fig. 8.7 for better pedagogy
- Deleted figures for Southern blots and Sanger automated DNA sequencing as these techniques are historical and less-commonly used today
- Added discussion of real-time PCR (RT-PCR), Sanger sequencing methods, next-generation DNA sequencing (NGS), including pyrosequencing and fluorescent methods, functional genomics, microbiomes, and biomedical animal models
- New Highlight boxes: How Do You Fix a Mosquito? on controlling dengue and The Human Microbiome Project

CHAPTER 9 CONTROLLING MICROBIAL GROWTH IN THE ENVIRONMENT

- Added four Tell Me Why critical thinking questions to text
- Revised five figures for better accuracy, currency, and pedagogy (Figs. 9.2, 9.7, 9.13, 9.15, 9.16)
- Two new photos (Fig. 9.9, Beneficial Microbes)
- Updated techniques for deactivation of prions, coverage of thimerosal in vaccines, and activity of AOAC International in developing disinfection standards
- Added three critical thinking questions to Emerging Disease Case Study: *Acanthamoeba* Keratitis
- Added critical thinking question concerning salmonellosis pandemic from smoked salmon
- Added fill-in Concept Map over moist heat applications to control microbes

CHAPTER 10 CONTROLLING MICROBIAL GROWTH IN THE BODY: ANTIMICROBIAL DRUGS

- Added four Tell Me Why critical thinking questions to text
- Updated and revised tables of antimicrobials to include all new antimicrobials mentioned in disease chapters, including carbapenems and capreomycin (antibacterials); enfuvirtide (newly approved anti-HIV-1); ciclopirox (antifungal); and bithionol (anthelmintic); updated sources of drugs, modes of action, clinical considerations, and methods of resistance
- Updated adverse effects of aminoglycosides
- Updated the mechanism of resistance against quinolone antibacterial drugs
- Removed amantadine as a treatment for influenza A
- Revised seven figures for greater clarity, accuracy, ease of reading, and better pedagogy (Figs. 10.2, 10.3, 10.6, 10.8, 10.13, 10.15; map of worldwide, community-associated MRSA)
- Three new photos (Highlight, Fig. 10.10, Clinical Case Study)
- Added three critical thinking questions to Emerging Disease Case Study: Community-Associated MRSA and updated map with newly published data

CHAPTER 11 CHARACTERIZING AND CLASSIFYING PROKARYOTES

- Added four Tell Me Why critical thinking questions to text
- Six new Learning Outcomes (for proteobacteria, including newly discovered zetaproteobacteria)
- Thirteen new photos (Figs. 11.1, 11.2a, 11.5, 11.7, 11.11a, 11.16, 11.17, 11.19, 11.21, 11.22, 11.23, 11.24b, 11.27b)
- Ten revised figures for better pedagogy (Figs. 11.1, 11.3, 11.4, 11.6, 11.10, 11.14, 11.17, 11.21, 11.26, 11.27)
- Clarified and expanded coverage of (1) "snapping division," which is a distinctive characteristic of corynebacteria, including *C. diphtheriae*, (2) floc formation and its use in sewage treatment, and (3) methicillin-resistant strains of *Staphylococcus aureus*
- Updated with new discoveries in bacterial and archaeal systematics: six classes of proteobacteria rather than four and five phyla of archaea (rather than two)
- Removed box on Botox and box on the possible link between cyanobacteria and brain disease to make room for new material
- Three new critical thinking questions over pertussis as a reemerging disease
- Added fill-in Concept Map over domain Archaea

CHAPTER 12 CHARACTERIZING AND CLASSIFYING EUKARYOTES

- Added six Tell Me Why critical thinking questions to text
- Eight new photos (Figs. 12.11, 12.12a and b, 12.13c, 12.14, 12.20, 12.25, 12.27)
- Seven revised figures for more accurate and lucid pedagogy (Figs. 12.1, 12.3, 12.7, 12.8, 12.17, 12.23; map for aspergillosis)
- As reviewers requested, shortened chapter by eliminating detailed discussion and artwork of ciliate (*Paramecium*) conjugation and of sexual reproduction by zygomycetes, ascomycetes, and basidiomycetes
- Updated algal, fungal, protozoan, water mold, and slime mold taxonomy
- Clarified and expanded coverage of (1) meiosis, (2) alveoli in protists, and (3) use of radiation as an energy source for some fungi
- Added new critical thinking questions: three about the emerging disease aspergillosis and two at end of chapter about genomics in relationship to metabolism in various environments
- Added fill-in Concept Map over eukaryotic microorganisms

CHAPTER 13 CHARACTERIZING AND CLASSIFYING VIRUSES, VIROIDS, AND PRIONS

- Added four Tell Me Why critical thinking questions to text
- Four new photos (Figs. 13.1b, 13.21, 13.24; bacteriophage box)
- Upgraded eight figures for better pedagogy and currency (Figs. 13.5, 13.8, 13.12, 13.13, 13.14, 13.16, 13.18, 13.22)
- One new figure showing prion templating (Fig. 13.23)
- Two new Learning Outcomes concerning (1) structures of viruses and (2) control of prions
- Updated viral nomenclature to correspond to changes approved by the International Committee on Taxonomy of Viruses (ICTV) in 2014

- Added discussion on the benefits and costs to a virus of having an envelope versus being naked
- Clarified and expanded text concerning lytic cycle of phage replication; use of phage typing; replication of animal viruses, particularly ssDNA viruses; link between viruses and human cancers; viroids; and prions
- Updated techniques for deactivation of prions and treatment of prion disease
- Updated Emerging Disease Case Study: Chikungunya; added three critical thinking questions to the discussion

CHAPTER 14 INFECTION, INFECTIOUS DISEASES, AND EPIDEMIOLOGY

- Added eight Tell Me Why critical thinking questions to text
- Changed eight figures for better pedagogy, timeliness, or clarity (Figs. 14.3, 14.4, 14.5, 14.9, 14.10, 14.14, 14.16, 14.20)
- Revised and updated coverage of (1) number of human cells in a body and the number of cellular microbiota, (2) microbiome, and (3) symbioses (added terms *symbiont* and *amensalism*)
- Updated to replace term *nosocomial* with *healthcare-associated* (in all chapters)
- Updated epidemiology charts, tables, and graphs
- Updated list of nationally notifiable infectious diseases
- Three new critical thinking questions added to the discussion of *Hantavirus* as an emerging disease
- Added fill-in Concept Map over transmission of diseases

CHAPTER 15 INNATE IMMUNITY

- Added two Tell Me Why critical thinking questions to text
- Modified nine figures for enhanced clarity and better pedagogy (Figs. 15.4, 15.6, 15.7, 15.8, 15.9, 15.11, 15.12, 15.13, 15.14)
- Three new photos (Figs. 15.1, 15.5b)
- Updated and expanded coverage of the action of antimicrobial peptides (defensins), Toll-like receptor 10 (TLR10), complement activation, complement cascade, and membrane attack complexes
- Expanded and clarified discussion of inflammatory mediators

CHAPTER 16 SPECIFIC DEFENSE: ADAPTIVE IMMUNITY

- Added three Tell Me Why critical thinking questions to text
- Revised and clarified (1) function and structure of tonsils, (2) flow of lymph, and (3) mucosa-associated lymphoid tissue
- Reordered the discussion of topics in adaptive immunity to better align with the way events occur; for example, MHC and antigen processing are discussed before T cells and cell-mediated immunity, which are discussed before B cells and antibody-mediated immunity
- Removed discussion of T-independent antibody immunity as it was too advanced for beginning students
- Revised three pieces of art for enhanced pedagogy (Figs. 16.2, 16.3, 16.10)
- Added three critical thinking questions and updated incidence map for the discussion of microsporidiosis
- Added fill-in Concept Map over antibodies

CHAPTER 17 IMMUNIZATION AND IMMUNE TESTING

- Added a Tell Me Why critical thinking question to text
- Updated to newly revised CDC 2015 vaccination schedule for children, adolescents, and adults
- Updated table of vaccine-preventable diseases in the United States
- Enhanced discussion of development of attenuated viral vaccines
- Added two points to chapter summary about recombinant gene technology and vaccine production and about vaccine safety
- Revised five figures for better pedagogy (Figs. 17.2, 17.3, 17.6, 17.11, 17.14)

CHAPTER 18 HYPERSENSITIVITIES, AUTOIMMUNE DISEASES, AND IMMUNE DEFICIENCIES

- Added three Tell Me Why critical thinking questions to text
- Revised one figure for greater clarity and accuracy (Fig. 18.7)
- Expanded coverage of type III hypersensitivity, the relationship between hypersensitivities and autoimmune disorders
- Removed figure and text for a very rare disease, immune thrombocytopenic purpura, to make room for new material in Chapter 19

CHAPTER 19 PATHOGENIC GRAM-POSITIVE BACTERIA

- Added nine Tell Me Why critical thinking questions to text
- Added three Disease in Depth visual presentations of disease: necrotizing fasciitis, listeriosis, and tuberculosis
- Twenty-five new photos (Figs. 19.1, 19.12, 19.17, 19.19, 19.20, 19.21)
- Seven revisions to figures for consistency, currency, accuracy, and better pedagogy (Figs. 19.5, 19.23; Disease in Depth: Necrottizing Fasciitis, Listeriosis, and Tuberculosis; Microbe at a Glance: *Streptococcus* and *Clostridium*)
- Updated all diagnoses and incidence data
- Revised two Learning Outcomes for better pedagogy (19.10, 19.13)
- Revised Chapter Summary for better pedagogy (for *Staphylococcus*; *Streptococcus*; *Enterococcus*, *Bacillus*; *Clostridium*; *Listeria*; *Mycoplasma*; *Corynebacterium*; *Mycobacterium*)
- Updated definitions for multi-drug-resistant (MDR) and extensively drug-resistant (XDR) tuberculosis
- Updated treatment regimen for inhalation anthrax, bioterrorist anthrax, botulism, tetanus, listeriosis, mycoplasmal pneumonia, nongonococcal urethritis, and tuberculosis
- Updated and enhanced discussion of mycolic acids, role of *Streptococcus mutans* in tooth decay, and anthrax vaccine
- Added a figure question regarding snapping division in corynebacteria
- Added three critical thinking questions and updated incidence maps for the discussion of Buruli ulcer
- Added Clinical Case Study regarding tuberculosis

CHAPTER 20 PATHOGENIC GRAM-NEGATIVE COCCI AND BACILLI

- Added three Tell Me Why critical thinking questions to text
- Added one Disease in Depth visual presentation of disease on urinary tract infections
- Updated all diagnoses and incidence data, including maps
- Updated to replace term *nosocomial* with *healthcare-associated*
- Revised Chapter Summary for better pedagogy (Pathogenic, Gram-Negative, Facultatively Anaerobic Bacilli; Pathogenic, Gram-Negative, Aerobic Bacilli; Pathogenic, Gram-Negative, Anaerobic Bacilli)
- Updated treatment regimen for gonorrhea, meningococcus meningitis, bubonic plague, bartonellosis, brucellosis, and Legionnaires' disease
- Added one new figure (Fig. 20.1) and figure question on the potential effects of lipid A
- Revised nine figures for better pedagogy (Microbe at a Glance: *Neisseria gonorrhoeae;* Figs. 20.2, 20.3, 20.14, 20.18, 20.19, 20.22, 20.23, 20.28)
- Added three critical thinking questions and updated incidence maps for the discussion of melioidosis

CHAPTER 21 RICKETTSIAS, CHLAMYDIAS, SPIROCHETES, AND VIBRIOS

- Added three Tell Me Why critical thinking questions to text
- New Disease in Depth: Spotted Fever Rickettsiosis
- Updated all diagnoses and incidence data
- Modified/updated nine figures (Figs. 21.1, 21.2, 21.3, 21.5, 21.8, 21.12, 21.13, 21.17, 21.20)
- Two new photos (Figs. 21.11, 21.19)
- Updated treatment regimen for rickettsial spotted fever (Rocky Mountain spotted fever, RMSF), murine typhus, scrub typhus, human monocytic ehrlichiosis, anaplasmosis (formerly called human granulocytic ehrlichiosis), lymphogranuloma venereum, trachoma, cholera, and gastric ulcers
- Updated and expanded coverage of epidemic typhus, murine typhus, scrub typhus, spotted fever rickettsioses (RMSF), ehrlichiosis, anaplasmosis, lymphogranuloma venereum, urethritis, yaws, *Borrelia*, and cholera

CHAPTER 22 PATHOGENIC FUNGI

- Added five Tell Me Why critical thinking questions to text
- Added new Disease in Depth: Candidiasis
- Updated all diagnoses and incidence data
- New Learning Outcomes: antifungal vaccines, mycetomas
- Added one new photo for enhanced pedagogy (Fig. 22.19)
- Updated treatment regimen for paracoccidioidomycosis, *Pneumocystis* pneumonia, candidiasis, aspergillosis, *Malassezia* infections, mycetoma, and sporotrichosis
- Enhanced discussion of dearth of antifungal vaccines
- Added three critical thinking questions and updated incidence maps for the discussion of blastomycosis
- Added fill-in Concept Map over systemic mycoses

CHAPTER 23 PARASITIC PROTOZOA, HELMINTHS, AND ARTHROPOD VECTORS

- Added four Tell Me Why critical thinking questions to text
- Added two new Disease in Depth spreads: Giardiasis and Malaria
- Rearranged the chapter to cover vectors first; expanded coverage of vectors
- New Learning Outcomes: parasitology, definitive versus intermediate hosts, biological versus mechanical vectors, ascariasis, hookworm infestations, pinworms, anisakiasis
- Updated all diagnoses and incidence data
- Updated treatment regimen for *Acanthamoeba* keratitis, leishmaniasis, trichomoniasis, malaria, *Cryptosporidium* enteritis, and infestation with *Fasciola*
- Added mention of emerging human pathogen of malaria: *Plasmodium knowlesi*
- Updated stages in life cycle of *Toxoplasma*
- Simplified discussion of life cycles of *Trypanosoma cruzi* and of *T. brucei*
- Added roundworm *Anisakis* and its disease anisakiasis at teachers' requests
- Twenty-four new, more engaging photos (Figs. 23.2, 23.10, 23.12, 23.13, 23.18; Disease in Depth: Giardiasis; Disease in Depth: Malaria; Emerging Disease Case Study: Babesiosis)
- Eight revised, updated, enhanced, and pedagogically more effective figures (Figs. 23.1, 23.3, 23.5, 23.6, 23.9, 23.14, 23.17, 23.24)
- Added three critical thinking questions and updated incidence maps for the discussions of babesiosis and of schistosomiasis
- Added fill-in Concept Map over intestinal protozoan parasites

CHAPTER 24 PATHOGENIC DNA VIRUSES

- Added five Tell Me Why critical thinking questions to text
- Updated all diagnoses and incidence data
- Updated treatment regimen for shingles, history of smallpox vaccination, and the effect of adenovirus 36 on obesity
- Four new photos (Figs. 24.3, 24.15, 24.16c, 24.22)
- Reformatted one figure for better pedagogy (Fig. 24.21)
- Added three critical thinking questions and updated incidence maps for the discussion of monkeypox
- New Disease in Depth: Papillomas with three new photos and three new figures

CHAPTER 25 PATHOGENIC RNA VIRUSES

- Added six Tell Me Why critical thinking questions to text
- Updated all diagnoses and incidence data
- Updated treatment regimen for colds, hepatitis E, hepatitis C, AIDS, measles, respiratory syncytial virus infection, and Lassa hemorrhagic fever
- Updated, revised, and expanded discussion of coronavirus respiratory syndromes, Nipah virus encephalitis, hepatitis E virus, and respiratory syncytial viral disease
- Clarified definition of zoonosis
- Added Learning Outcome about mumps
- Sixteen figures revised, updated, or enhanced for better pedagogy (Figs. 25.2, 25.9, 25.10, 25.11, 25.12, 25.14, 25.17, 25.18, 25.19, 25.21, 25.23, 25.24, 25.26, 25.28, 25.29, 25.36)
- Thirteen new photos (chapter opener; Figs. 25.1, 25.7, 25.16b, 25.22b, 25.27, 25.30, 25.32; Highlight box on bats and Nipah virus)
- New Microbe at a Glance box on measles virus
- Two new Emerging Disease Case Study boxes on norovirus gastroenteritis and tick-borne encephalitis
- Two new Disease in Depth features on Ebola hemorrhagic fever and influenza
- Added three critical thinking questions to the box on influenza H1N1

CHAPTER 26 INDUSTRIAL AND ENVIRONMENTAL MICROBIOLOGY

- Added four Tell Me Why critical thinking questions to text
- Added Learning Outcome on eutrophication
- Three figures revised, updated, or enhanced for better pedagogy (Figs. 26.6, 26.8, 26.15)
- Revised and clarified water contamination and water pollution
- Updated list of bioterrorist threats to include the additions to category C
- New Emerging Disease Case Study regarding primary amebic meningoencephalitis (*Naegleria fowleri* infection)

Reviewers for the **Fifth Edition**

I wish to thank the hundreds of instructors and students who participated in reviews, class tests, and focus groups for earlier editions of the textbook. Your comments have informed this book from beginning to end, and I am deeply grateful. For the fifth edition, I extend my deepest appreciation to the following reviewers.

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Acknowledgments

As has been the case with all previous editions, I am ever more cognizant that this book is a team effort. I am deeply grateful once again to Kelsey Churchman of Pearson Science and to the team she gathered to produce the fifth edition. Kelsey, dedicated project manager Lauren Beebe, and invaluable program manager Chriscelle Palaganas helped develop the vision for this fifth edition, generating ideas to make it more effective and compelling. As project manager, Lauren also had the unenviable task of coordinating everything and keeping me on track—thank you, Lauren, for being understanding, patient, and lenient, especially when I misplaced a deadline. Kari Hopperstead was invaluable in developmental editing. I am grateful.

Thank you to Barbara Yien, project editor of the first two editions, for years of support and for introducing me to chocolate truffles. I am excited for your growing family and new responsibilities! I am grateful to Frank Ruggirello for his unflagging encouragement and support of my work and this book; enjoy your new adventures! I am also indebted to Daryl Fox, whose early support for this book never wavered.

Anita Wagner Hueftle—the eagle-eyed—edited the manuscript thoroughly and meticulously, suggesting important changes for clarity, accuracy, and consistency. The incomparable Kelly Murphy did a magnificently superb job as art development editor, helping to conceptualize new illustrations and suggesting ways to improve the art overall—thank you, Kelly for taking the original art of my friend Ken Probst and enhancing this book's amazingly beautiful biological illustrations. My thanks to Lachina for rendering the art in this edition. Andrea Stefanowicz and Lumina Datamatics expertly guided the project through production. Andrea, thank you for meticulously improving the text. Maureen "Mo" Spuhler remains the most amazing photo researcher. I am in your debt, "Molybdenum." Rich Robison and Brent Selinger supplied many of the text's wonderful and unique micrographs. Emily Friel created the beautiful interior design and the stunning cover.

Thanks to Michéle Shuster and Amy Helms for their work on the media and print supplements for this edition. Special thanks are due to Lauren Beebe and Andrea Stefanowicz for managing the supplements, to Kyle Doctor in production for his work on the Instructor's Resource DVD, and to Joe Mochnick for his management of the extraordinary array of media resources for students and instructors, especially MasteringMicrobiology®. Thanks also to Jordan Roeder, RN, and Nan Kemp and for their administrative, editorial, and research assistance. I am grateful to Neena Bali and now Lauren Harp in Marketing; they lead the amazing Pearson sales representatives to do a terrific job of keeping in touch with the professors and students who provide so many wonderful suggestions for this textbook. As always, I am humbled, inspired, and encouraged by the sales representatives; your role on the team deserves more gratitude than I can express here or with citrus fruit.

I am especially grateful to Phil Mixter of Washington State University, Mary Jane Niles of the University of San Francisco, Bronwen Steele of Estrella Mountain Community College, Jan Miller of American River College, and Jane Reece for their expertise and advice.

I am further indebted to Sam Schwarzlose for his excellent work on the Video Tutor assessments and to Terry Austin for lending his technical expertise to the project.

On the home front: Thank you, Jennie and Nick Knapp, Elizabeth Bauman, Jeremy Bauman, Larry Latham, Josh Wood, and Mike Isley. You keep me even-keeled. My wife Michelle deserves more recognition than I can possibly express: "Many are noble, but you excel them all." Thank you.

Robert W. Bauman
Amarillo, Texas

The publishers would like to thank the following for contributing to and reviewing the Global Edition:

Dhriti Bhattacharyya

Sumitra Datta
Amity University Kolkata

Rajeev Kaul
University of Delhi

Gopalakrishnan Menon
Tomsk State University

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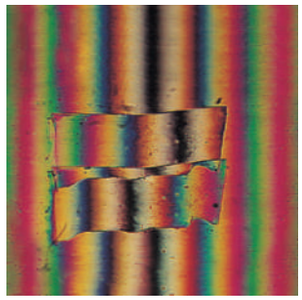

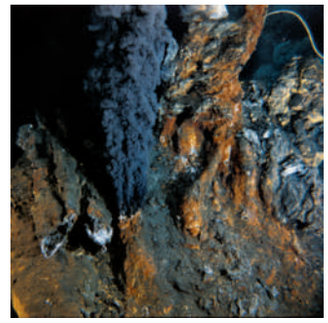

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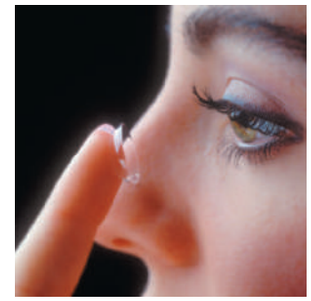

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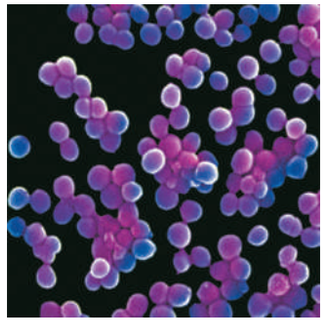

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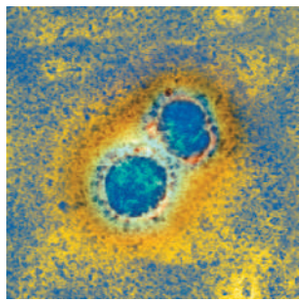

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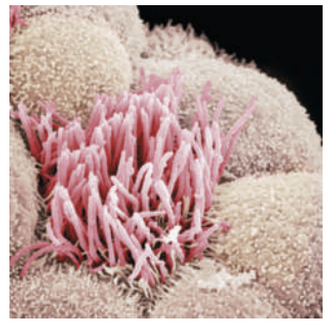

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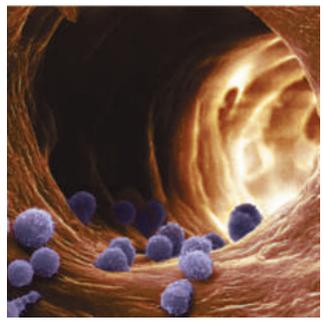

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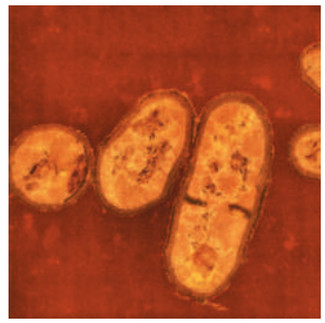

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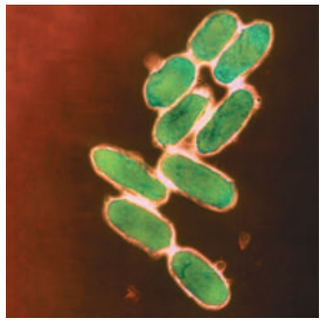

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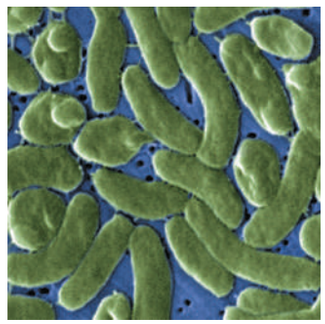

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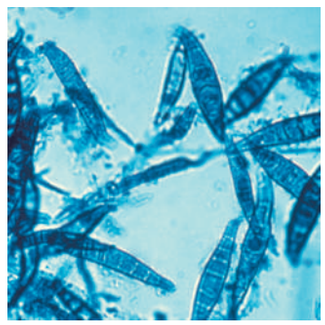

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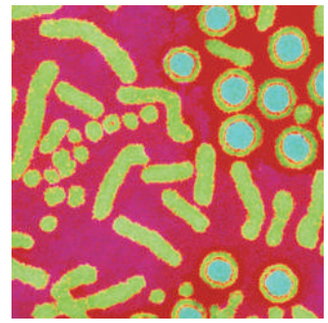

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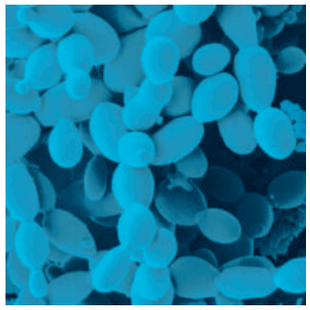

Feature Boxes

BENEFICIAL MICROBES

HIGHLIGHT

EMERGING DISEASE CASE STUDY

CLINICAL CASE STUDY

MICROBE AT A GLANCE

DISEASE IN DEPTH