

PREFACE

This is an exciting yet challenging time to be teaching and learning about microbiology. With the horrendous events of September 11, 2001, and the subsequent attacks of bioterrorism in the United States, the need to provide accurate and current information about the good and bad microbes seems greater than ever. Almost every day newspaper reports discuss the possibility of another attack using microbial agents or their toxins. Of equal interest, however, are the frequent articles that describe the discovery of microbes in an environment considered impossible to sustain life, the sequencing of another microbial genome, or the death of an individual from a rare infectious disease. Anyone glancing at the front page cannot help but realize the impact that microorganisms have in our daily lives. The announcements of the many scientific advances being made about the microbial world often bring with them vehement arguments related to the science. Are plants that contain genes of microorganisms safe to eat? Is it wise to put antimicrobial agents in soaps and animal feed? What agents of biological warfare might the citizens of the world face? Are we facing another flu pandemic? This book presents what we believe are the most important facts and concepts about the microbial world and the important role its members play in our daily lives. With the information presented, students should be able to form reasoned opinions and discuss intelligently their views on these questions.

An important consideration in revising this textbook is the diverse interests among students who take an introductory microbiology course today. As always, many students take microbiology as a prerequisite for nursing, pharmacy, and dental programs. A suitable textbook must provide a solid foundation in health-related aspects of microbiology, including coverage of medically important bacteria, antimicrobial medications, and immunization. An increasing number of students take microbiology as a step in the pursuit of other fields, including biotechnology, food science, and ecology. For these students, topics such as recombinant DNA technologies, fermentation processes, and microbial diversity are essential. With the search for the source of the anthrax preparation used in the bioterrorism attacks in the United States, the subject of techniques of microbial identification become more relevant. Microbiology is also becoming more popular as an elective for biology students, who are particularly interested in topics that highlight the relevance of microorganisms to shaping the biological world. Because of the wide range of career goals and interests of students, we have made a particular effort to broaden the scope of previous editions, providing a more balanced approach, yet retaining our strength in medical microbiology.

Diversity in the student population is manifested not only in the range of career goals, but also in educational backgrounds. For some, microbiology may be their first college-level science course; for others, microbiology builds on an already strong background in biology

and chemistry. To address this broad range of student backgrounds, we have incorporated numerous learning aids that will facilitate review for some advanced students, and will be a tremendous support to those who are seeing this material for the first time.

Preparing a textbook that satisfies such a broad range of needs and interests is a daunting task, but also extremely rewarding. We hope you will find that the approach and structure of this edition presents a modern and balanced view of microbiology in our world, acknowledging the profound and essential impact that microbes have on our lives today and their possible roles in our lives tomorrow.

Features of the Fifth Edition

Completely updated and including the most current topics in microbiology today, *Microbiology: A Human Perspective*, fifth edition, continues to be a classic. It has always been our goal to present sound scientific content that students can understand and rely upon for accuracy and currency, and thereby succeed in their preparation for meaningful careers. We have used constructive comments from numerous microbiology instructors and their students to continue to enhance the robust features of this proven text.

Expert Approach to Writing

We, as a strong and diverse team of scientists and teachers, solidly present the connection between microorganisms and humans. Because of our individual specializations and our research and educational backgrounds, we remain in the hub of the scientific community and can provide accurate and modern coverage spanning the breadth of microbiology. More importantly, as teachers, we constantly strive to present material that easily speaks to the students reading it.

We recognize that a textbook, no matter how exciting the subject matter, is not a novel. Few students will read the text from cover to cover and few instructors will include all of the topics covered in their course. We have used judicious redundancy to help present each major topic as a complete unit. We have avoided the chatty, superficial style of writing in favor of clarity and conciseness. The text is not “watered down” but rather provides students the depth of coverage needed to fully understand and appreciate the role of microorganisms in the biological sciences and human affairs.

“The writing style is very clear, precise, and student friendly. For example, the descriptions of innate and adaptive immunity, their roles and how they interact, are the best of their kind that I have encountered in any textbook.”
(Kim Burnham, Oklahoma State University)

"I loved the analogies and the simplicity of the writing."
(Kathleen Lauber, College of Southern Maryland)

Instructive Art Program That Speaks a Thousand Words

Microorganisms, by definition, are invisible to the naked eye. It becomes ever more important to allow students to visualize organisms as well as processes to reinforce learning. The art program continues as a key element of the learning process. Each figure in *Microbiology: A Human Perspective* was developed as the narrative was written and is referenced in bold in the supporting text. Colors and symbols are used consistently throughout the text. Legends are short, clear, and descriptive. Various types of art styles are used as needed to bring concepts to life.

Overview Figures simplify complex interactions and provide a sound study tool. **Image Pathways** help students to follow the progression of a discussion over several pages by highlighting and visualizing in detail each step of an overview figure.

Process Figures include step-by-step descriptions and include supporting text so that the figure walks through a compact summary of important concepts.

Combination Figures tie together the features that can be illustrated by an artist with the appearance of organisms in the real world.

Stunning Micrographs used generously throughout the text bring the microbial world to life. In the chapters presenting infectious diseases (chapters 22 to 29), micrographs are often combined with photographs showing the symptoms that the organisms cause.

Unmatched Clinical Coverage

Evans Roberts, Jr.—a member of the author team who is licensed and board certified in internal medicine by the American Board of Internal Medicine, and in public health and medical laboratory microbiology by the American Board of Microbiology—ensures that clinical coverage is accurate, modern, and instructive to those planning to enter health careers. The incomparable treatment of infectious diseases, which are organized by human body systems, is supported with generous photographs, summary tables, case histories, and critical thinking questions. Elements of the unparalleled clinical coverage include:

- Consistent coverage of all diseases, including individual sections that describe the symptoms, pathogenesis, causative agent, epidemiology, prevention, and treatment.
- Disease summaries that feature a drawing of a human showing symptoms, portals of entry and exit, location of pathology, and a step-by-step description of the infection process for each major disease.
- Case presentations of realistic clinical situations.
- Modern coverage of topics such as emerging diseases, new vaccines, and nosocomial infections.
- Dedicated chapters covering wound infections and HIV.

Learning System That Actively Involves Students

In today's classroom, it is important to pursue active learning with students. This edition of *Microbiology* challenges students to think critically by providing several avenues of practice in analyzing data, drawing conclusions, synthesizing information, interpreting graphs, and applying concepts to practical situations. These learning tools, developed by critical thinking expert Robert Allen, will benefit students pursuing any discipline.

What's New in This Edition?

We have added several pedagogical features that should reduce what may seem to be an information overload to some students. First, a list of key terms, with definitions, is provided at the beginning of each chapter. Second, carefully designed questions, termed focus points, target the key concepts of each major section. Knowing the answers to these questions ensures that students have grasped the important concepts in the text that follows. Finally, cartoons relevant to the presented material are interspersed throughout the text in order to lighten up the scientific contents.

All Chapters

- A list of key terms and their definition was added at the beginning of each chapter (the page following the chapter opener).
- Each section now begins with a list of Focus Points (learning objectives).
- Cartoons are scattered throughout the chapters.

Chapter 1

- New figure showing students in 1918 wearing gauze masks to protect themselves against influenza
- Updated figure on emerging diseases
- Eliminated figure showing various bacterial shapes
- Eliminated figure on a microfossil
- Updated story in the Perspective, including new photograph

Chapter 2

- Shortened A Glimpse of History
- All figures have brighter and more contrasting colors.

Chapter 3

- Small photos have been added to the table that describes the different types of microscopes.
- Improved EMs that show typical Gram-positive/Gram-negative cell walls
- New mention that the role of metachromatic granules might be more complex than originally thought; they appear to resemble eukaryotic acidocalcisomes.
- Mitochondria and chloroplasts are now described more completely in separate sections.

- Improved illustrations of eukaryotic cells and organelles

Chapter 4

- The chapter was rearranged to increase the emphasis on biofilms. The section that describes biofilms, "Bacterial Growth in Nature," is now the second section of the chapter. To maintain the flow, the section "Bacterial Growth in Laboratory Conditions" was also moved so that it still follows "Bacterial Growth in Nature."
- New EM that shows a biofilm
- Updated to include the current record-holder for highest temperature growth (121°C)
- Improved photos of a lactose fermenter on MacConkey agar and beta hemolysis on blood agar

Chapter 5

- Updated to include mention of alcohol-based antiseptic hand gels and silver-containing bandages
- The chapter has been reorganized so that the methods of physical control are covered in adjacent sections.
- New table that compares the various physical methods of microbial control
- New section that describes the use of high pressure to pasteurize foods such as guacamole
- New section on methods used by water treatment facilities to control microbial growth in drinking water; mentions amended regulations that require facilities to minimize the level of disinfection by-products and *Cryptosporidium* oocysts
- *Giardia* cysts and *Cryptosporidium* oocysts are now mentioned in the list of microbes that must be considered when selecting a disinfection procedure.
- Composition of the item to be sterilized is now listed in the factors to consider when selecting an appropriate germicidal chemical.
- The figure that shows the electromagnetic spectrum has been revised so that it is now easier to interpret.

Chapter 6

- Photos have been added to the figure that shows fermentation end products.
- Figure that illustrates oxidation-reduction reactions was revised for clarity.

Chapter 7

- Section on genomics has been moved to the end of the chapter.
- The three-dimensional structure of tRNA has been incorporated into the figures that illustrate tRNA and the process of translation.
- The figure that illustrates the replication fork has been revised for increased clarity.

Chapter 8

- Changed the story introducing the chapter from the rise of multiple antibiotic resistance after WWII to the story of the rise of methicillin- and vancomycin-resistant *Staph* today in the United States. The explanation of how *Staph* became resistant is discussed at the end of the chapter.

- Added section on how methylation of DNA is important in DNA repair
- Eliminated the section on conditional lethal mutants
- Added a section on how reactive oxygen damages DNA and how this damaged DNA can be repaired
- The section on conjugation now focuses on the transfer of plasmids and the discussion of chromosome transfer is greatly reduced.
- Barriers to gene transfer was moved to Chapter 13 (bacterial viruses).

Chapter 9

- New figure showing fluorescence *in situ* hybridization (FISH) result
- New figure showing the exponential amplification of the PCR product
- Information about genetic engineering of eukaryotic cells has been moved to the Web.

Chapter 10

- Increased emphasis on classification using rRNA sequences
- Details about numerical taxonomy have been moved to the Web.
- Outline of the 2nd edition of *Bergey's Manual of Systematic Bacteriology* is now included.
- Phylogenetic tree of the bacteria based on 16S rRNA comparisons is now included.
- Increased emphasis on the complications of lateral gene transfer in taxonomy, along with a new diagram that depicts the "shrub of life"
- Expanded the introduction to the section that describes methods used to characterize strain differences, pointing out the role these play in tracing sources of foodborne illnesses as well as forensic investigations of biocrimes. Decreased the detail about the specific methods.

Chapter 11

- The summary table now lists the phylum of each organism, in order to emphasize the phylogeny of the various prokaryotes described.
- A new section on the recently discovered *Nanoarchaea* has been added.

Chapter 12

- New A Glimpse of History, about the effect of the late blight of potatoes especially on the history of the United States
- New Perspective, about phytoplankton and global warming
- New Future Challenges, about developing malaria vaccines and new drugs

Chapter 13

- Eliminated tail fibers on phage lambda
- Corrected Figure 13.11
- Eliminated Figure 13.13 (restriction-modification of DNA)

Chapter 14

- Changed A Glimpse of History from the role of viruses in animal tumors to discovery of prions
- Moved the section on “Methods Used to Study Viruses” to end of chapter
- Eliminated Table 14.5 (relationship of virus size to dependency on host cell enzymes)
- Eliminated section on viruses and animal tumors
- Eliminated section on phenotypic mixing and the two correlating figures
- Expanded the discussion on prions

Chapter 15

- Moved the information on interferons into the section, “Sensor Systems”
- Rearranged the section on activation of the complement system so that the alternative pathway, which comes into play first and provides an essential “early warning system,” is described first
- Added NOD receptors to the section, “Sensor Systems”

Chapter 16

- Updated and simplified information on T_H cells
- Moved the section on T-cell activation; it now precedes the section that describes the roles of T cells.
- Revised general overview photo so that it now includes T-cell activation
- New table that summarizes the characteristics of cytotoxic T cells and helper T cells
- Revised detailed overview figure that is now larger and more engaging

Chapter 17

- Extensive revision of the section on immunological testing:
 - Some of the less common but historically important tests have been moved to the Web (such as complement fixation), increasing emphasis on the more routine tests such as ELISA and Western blotting.
 - The section is now divided into three general parts—Principles of Immunological Testing, Observing Antigen-Antibody Aggregations, and Using Labeled Antibodies to Detect Antigen-Antibody Interactions.
- Section on obtaining antibodies (for immunoassays) has been added to the section, “Principles of Immunological Testing”
- New figure that illustrates how immunoassays can be used to either identify an unknown antigen (using antibodies of known specificity) or identify specific antibodies in a patient’s serum (using known antigen)
- New photo showing latex agglutination results
- Photo of an Ouchterlony test is now included; the line drawing has been revised to correlate to the photo.
- New simplified line drawing of the radial immunodiffusion test
- Improved photo showing Western blotting results

Chapter 18

- New chapter opener showing asthmatic
- Added role of regulatory T cells
- Expanded and updated type 1 diabetes
- Added section on Graves’ disease
- Added leukocyte adhesion deficiency
- Added effect of feeding parasitic worms
- Revised figures 18.1, 18.3, 18.4, 18.5, and 18.7
- New photo of tuberculin test

Chapter 19

- Updated figure of a type III secretion system
- Simplified line drawing showing the role of Fc receptor pathogenesis

Chapter 20

- New figure shows the decline in infectious diseases in the century (CDC figure).

Chapter 21

- Added information about daptomycin
- Added information about echinocandins

Chapter 22

- Added section on cutaneous leishmaniasis
- Pediculosis and scabies cross-referenced
- Added importance of *P. acnes* sequencing
- Updated and clarified varicella
- Updated measles vaccination
- Added monograph on smallpox to OLC
- Revised figures 22.1, 22.3, 22.7, 22.10, 22.12, 22.14, and 22.15

Chapter 23

- Wound infections chapter moved next to skin infections chapter
- Replaced chapter opener with wound photo
- Updated vancomycin-resistant *Staphylococcus aureus*
- Updated invasive *Streptococcus pyogenes*
- Added *Pseudomonas aeruginosa* infections from ear piercings
- Updated neonatal tetanus
- Revised rat bite fever
- Updated *S. aureus*, Future Challenges
- Revised figures 23.1, 23.9, 23.10, and 23.15

Chapter 24

- New chapter opener showing strep throat
- Cross-referenced necrotizing fasciitis
- Added streptolysin and streptokinase importance
- Added importance of *S. pyogenes* genome sequencing
- Added *Moraxella* as cause of otitis media

- Added small effect of *H. influenzae* and *S. pneumoniae* vaccination on otitis media
- Updated pathogenesis of adenoviral infection
- Added mode of action of pneumolysin
- Updated anthrax by mail episode
- Added monograph on anthrax for OLC
- Updated pertussis in adults and increasing incidence
- Updated new pertussis vaccine
- Added worldwide importance of tuberculosis
- Updated tuberculosis pathogenesis and treatment
- Updated *Legionella* epidemiology, pathogenesis, and genomic studies
- Updated influenza virus cell entry
- Updated avian influenza
- Updated prevention of hantavirus infection
- Added section on SARS
- Revision of figure 24.3 (streptococcal surface antigens)
- New figure, a photo of pinkeye
- Revised figures 24.16, 24.17, 24.21, 24.22, and 24.23

Chapter 25

- New chapter opener: individual with jaundice
- Added cross-reference to pork tapeworm; refer to OLC for other helminths
- Updated norovirus name, symptoms, epidemiology
- Added green onion epidemic of hepatitis A
- Updated treatment of hepatitis B
- Added to *Giardia*: mitochondrial remnants, cysts infectious upon passage
- Replaced figure 25.3 (dental plaque)
- Updated map of hepatitis A, and incidence curves of hepatitis viruses

Chapter 26

- Updated pathogenesis of urinary tract infection
- Added photo of gonococcal urethritis
- Added description of Tuskegee experiment
- Added HPV vaccine in prevention of cervical cancer
- Revised figures 26.2, 26.7, and 26.21
- New photo of clue cell

Chapter 27

- Updated West Nile virus
- New Perspective (a rabies survivor)
- Updated poliomyelitis eradication
- New photo showing *C. botulinum* spores
- New map, West Nile infections in the United States
- New photo (animal with scrapie)

Chapter 28

- Updated arteriosclerosis and *Chlamydia pneumoniae*
- Added *T. whippelii* cultivation
- Updated clinical use of TNF inhibitors
- Inhalation tularemia symptoms, therapy, in Europe, and as a bioweapon
- *Brucella* as a bioweapon
- Updated treatment of plague
- ARIS, leishmaniasis
- Updated malaria prevention and treatment
- New photograph of individual with tularemia
- Updated map of yellow fever
- Updated map of malaria

Chapter 29

- Updated global AIDS distribution
- Updated cost of AIDS medications to the poor
- Updated failure of prime-boost AIDS vaccine
- Revised figures 29.5 and 29.6
- Revised figure (AIDS deaths in the United States)
- Revised figure 29.11 (mode of action of AZT)

Chapter 30

- New photo showing endo- and ectomycorrhizae

Chapter 31

- New figure that summarizes the steps of municipal wastewater treatment
- New photo showing municipal composting

Teaching Supplements

Digital Content Manager CD-ROM

This cross-platform CD-ROM is a multimedia collection of visual resources that allows instructors to utilize artwork from the text in multiple formats and create customized classroom presentations, visually based tests and quizzes, dynamic course website content, or attractive printed support material. The assets on this CD-ROM are organized by chapter within the following easy to use folders:

Art Library Full-color digital files of all the illustrations in the book, plus the same art saved in black and white versions, can be readily incorporated into lecture presentations, exams, or custom-made classroom materials. These images are also pre-inserted into blank PowerPoint slides for ease of use.

Photo Library Digital files of most of the photographs from the text can be reproduced for multiple classroom uses.

Table Library Every table that appears in the text is provided in digital form.

PowerPoint Lecture Outline Library Ready-made presentations that combine art and lecture notes are provided for each of the 32 chapters

of the text. These lecture outlines can be used as they are, or can be tailored to reflect preferred lecture topics and sequences.

Animation Library More than 50 full-color animations are available to harness the visual impact of processes in motion. Import these dynamic files into classroom presentations or online course materials.

TextEdit Art Library Every illustration from the textbook is provided in PowerPoint. Instructors may revise, move, or delete labels to create customized presentations and exams.

Video Library 36 dynamic motion sequences have been produced to bring microorganisms to life for students.



ARIS (www.mhhe.com/nester5) ARIS is a complete, online tutorial, electronic homework, and course management system, designed for greater ease of

use than any other system available. Available on adoption of any McGraw-Hill microbiology text, instructors can create and share course materials and assignments with colleagues with a few clicks of the mouse. All PowerPoint lectures, assignments, and quizzes are directly tied to text-specific materials in *Nester/Microbiology, 5/e*, but instructors can also edit questions, import their own content, and create announcements and due dates for assignments. ARIS has automatic grading and reporting of easy-to-assign homework, quizzing, and testing. All student activity within McGraw-Hill's ARIS is automatically recorded and available to the instructor through a fully integrated grade book that can be downloaded to Excel.

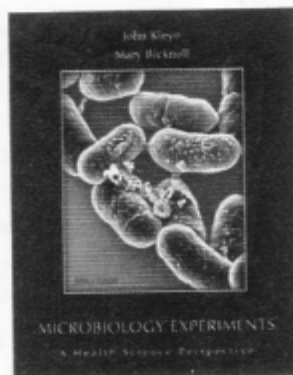
Instructor's Testing and Resource CD-ROM This cross-platform CD-ROM provides a wealth of resources for the instructor. Supplement features on this CD-ROM include a computerized test bank, utilizing testing software, to quickly create customized exams. This user-friendly program allows you to search for questions by topic, format, or difficulty level; edit existing questions or add new ones; and scramble questions and answers keys for multiple versions of the same test. Word files of the test bank are included for instructors who prefer to work outside of the test-generator software.

Other assets on the Instructor's Testing and Resource CD-ROM are grouped within easy-to-use folders. These resources include the Instructor's Manual and the Laboratory Preparator's Manual.

Instructor's Manual This valuable resource includes Learning Objectives keyed to the Student Study Guide, correlations to the multimedia resources available with the text, and answers to questions in the text.

Transparencies A set of 300 images from the textbook is provided for classroom projection.

Laboratory Manual The fifth edition of *Microbiology Experiments: A Health Science Perspective*, by the late John Kleyn and Mary Bicknell, has been prepared to directly support the text (although it may also be used with other microbiology textbooks). The laboratory manual features health-oriented experiments and endeavors also to reflect the goals and safety regulation guide-



lines of the American Society for Microbiology. Engaging student projects introduce some more intriguing members of the microbial world and expand the breadth of the manual beyond health-related topics. Newer experiments introduce modern techniques in biotechnology such as use of restriction enzymes and use of a computer database to identify sequence information.

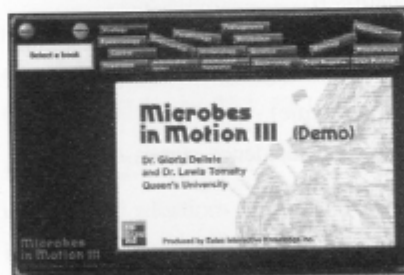
Preparator's Manual for the Laboratory Manual This invaluable guide includes answers to exercises, tips for successful experiments, lists of microbial cultures with sources and storage information, formulae and sources for stains and reagents, directions and recipes for preparing culture media, and sources of supplies. The Preparator's Manual is available to instructors through ARIS.

PageOut McGraw-Hill's exclusive tool for creating your own web site for your Microbiology course. It requires no knowledge of coding and is hosted by McGraw-Hill.

Learning Supplements

ARIS www.mhhe.com/nester5 Student resources on ARIS support each chapter in the text. Some of the features include:

- Self-quizzing with immediate feedback
- Animations of key processes with self-quizzing
- Electronic flash cards to review key vocabulary
- Additional clinical case presentations
- Web exercises encouraging practice of use of the Web to gather and evaluate information

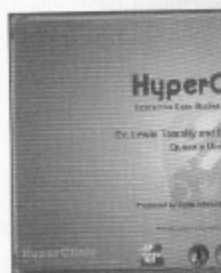


Microbes in Motion CD-ROM This interactive CD-ROM for both Windows and Macintosh brings microbiology to life through interactive video, audio, animations, and hyperlinks. This easy-to-use tutorial can go from the

classroom to the resource center to the student's own personal computer. Ideal for self-quizzing, class preparation, or review of microbiological concepts.

Hyperclinic CD-ROM Students will have fun with this interactive CD-ROM while learning valuable concepts and gaining practical experience in clinical microbiology. Packed with over 100 case studies and over 200 pathogens supported with audio, video, and interactive screens, students will gain confidence as they take on the role of the professionals.

Student Study Guide This valuable student resource goes beyond the standard multiple choice and true-false self-quizzing. T



authors have provided a wealth of study assets to help students truly master the material. In addition to unique learning activities, it includes key concepts, vocabulary review, self-tests, and more.

— Reviewers of the Fifth Edition —

Gene Nester, Evans Roberts, and Nancy Pearsall shared a vision many years ago to write a new breed of microbiology textbook especially for students planning to enter nursing and other health-related careers. Today there are other books of this type, but we were extremely gratified to learn that 85% of the students we surveyed intend to keep their copies of *Microbiology: A Human Perspective* because they feel it will benefit them greatly as they pursue their studies in these fields. We offer special thanks to the many students who used the fourth edition of *Microbiology: A Human Perspective* and who shared their thoughts with us about how to improve the presentation for the students who will use this edition of the text.

Rao Ayyagari's students at Lindenwood University

David Hurley's students at South Dakota State University

Steve Larsen's students at Indiana University–Purdue University at Indianapolis

Ellen Neidle's students at the University of Georgia

Jennifer Walker's students at the University of Georgia

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Lois C. Anderson, *Minnesota State University, Mankato*

Martha K. Bates, *Chattanooga State Technical Community College*

Barbara Beck, *Rochester Community and Technical College*

Benjie Blair, *Jacksonville State University*

Edward Braun, *Iowa State University*

Kathryn H. Brooks, *Michigan State University*

Alfred Brown, *Auburn University*

Katherine D. Buhrer, *Tidewater Community College*

Kim Burnham, *Victoria University*

Suzanne K. Butler, *Miami-Dade College*

Thomas R. Danford, *West Virginia Northern Community College*

Janet M. Decker, *University of Arizona*

Charles J. Dick, *Pasco-Hernando Community College*

Bob F. Drake, *Southwest Tennessee Community College*

Angela M. Edwards, *Trident Technical College*

Melissa J. Elliott, *Butler Community College*

Jeff S. Erikson, *Messiah College*

Teresa G. Fischer, *Indian River Community College*

Daniel C. Flynn, *West Virginia University*

Katherine Foreman, *Moraine Valley Community College*

S. Marvin Friedman, *Hunter College of CUNY*

Kathy Germain, *Southwest Tennessee Community College*

Ray Green, *Mercer University*

Michael T. Griffin, *Angelo State University*

Judy Haber, *California State University–Fresno*

Janelle M. Hare, *Morehead State University*

Margaret F. Hicks, *Pellissippi State Technical Community College*

Helmut Hirt, *Kansas State University*

James H. Holda, *University of Akron*

Robert D. Hunter, *Trident Technical College*

Ahmad Kamal, *Olive Harvey College*

Judith Marie Krey, *Waubunsee Community College*

Dawn Janich, *Community College of Philadelphia*

H. Bruce Joetston, *Fresno City College*

Karen Kendal-Fite, *Columbia State Community College*

Lee H. Lee, *Montclair State University*

Jeff G. Leid, *Northern Arizona University*

Leslie Lichtenstein, *Massasoit Community College*

Roger Lightner, *University of Arkansas at Fort Smith*

David Lipson, *San Diego State University*

William Lorowitz, *Weber State University*

Thomas J. Lynch, *University of Arkansas, Little Rock*

Barry Margulies, *Towson University*

Elizabeth F. McPherson, *University of Tennessee, Knoxville*

Pamela Moolenaar-Wirsiy, *Georgia Perimeter College*

Karen Grandel Nakaoka, *Weber State University*

Murad M. Odeh, *South Texas Community College*

Clark L. Ovrebo, *University of Central Oklahoma*

Gregory E. Paquette, *University of Rhode Island*

Marcia Pierce, *Eastern Kentucky University*

Nirmala Prabhu, *Edison College*

R. Prade, *Oklahoma State University*

Davis W. Pritchett, *University of Louisiana at Monroe*

Kathy Romero, *Greenville Technical College*

Todd Sandrin, *University of Wisconsin–Oshkosh*

David J. Schwartz, *Houston Community College, SW*

Timothy E. Scott, *Minnesota State University, Mankato*

Teri Shors, *University of Wisconsin–Oshkosh*

Timothy A. Steele, *Des Moines University*

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We would also like to thank Denise's husband, Richard Moore, who was “forced” to proofread and critique many of

the chapters. Although he has no formal scientific education, or perhaps because of that fact, his suggestions have been instrumental in making the text more "reader-friendly." Much to his own surprise, Richard has learned enough about the fundamentals of microbiology, and more recently immunology, to actually become intrigued with the subject.

Additionally, we would like to thank Joseph Gauthier, Elizabeth McPherson, and Donald Rubbelke for producing new media resources to support us and other instructors who lecture from our text.

We hope very much that this text will be interesting, educational for students, a help to their instructors, and will convey the excitement that we all feel for the subject. We would appreciate any comments and suggestions from our readers.

Eugene Nester

Denise Anderson

C. Evans Roberts, Jr.

Martha Nester