

Preface

I am excited about the new fifth edition of *Microbes and Society*. Why? This new edition reflects the current state of the science of microbiology and stresses more than ever the roles microorganisms play in society and in human health. Enthusiastic responses from students and faculty have helped shape this edition into a form that fits the evolving needs of today's students. It emphasizes how microorganisms are connected to our lives every day, and the textbook highlights many microbial interactions that most of us would not realize occur. It shows the connections of science with other fields, including the social sciences and humanities.

Both our own health and the health of the planet depend on the interactions with microorganisms. When we see or hear a report on a disease outbreak, the discovery of some new and often exotic microorganism, or a news story about how microorganisms influence our good health and the environment, many students and the public in general often do not have the background to properly evaluate many of the statements or claims made. After reading *Microbes and Society,* all that will change.

Studies have reported that the use of more readable textbooks in college often is correlated with better grades. Therefore, the chapters of *Microbes and Society, Fifth Edition*, have been either completely rewritten or heavily edited to limit the volume of information. In addition, unfamiliar science vocabulary can be challenging, as the number of technical terms can be overwhelming. To be a science-literate student in today's society, some mastery of scientific jargon is necessary. However, the mass of technical terms has been reduced by almost 10 percent. Consequently, *Microbes and Society, Fifth Edition* presents a balanced approach by providing a sufficient volume of information and introducing enough vocabulary to promote effective learning and communication. In the end, students will be more science and biology literate, which is essential in today's world.

So, welcome to the world of microbiology! I hope you find the journey exciting, fun, informative, and fascinating.

Audience

Microbes and Society, Fifth Edition is written for the nonscience undergraduate and inquiring citizen of the 21st century. The textbook assumes little or no science background, and it should accommodate a one-quarter or one-semester course. Students will find that understanding microbes will help them do well in such fields as business, sociology, food science, pharmaceutical and health sciences, economics, and agriculture. It discusses such topics as the place of microbes in ecology and the environment, the use of microbes in biotechnology, the role of microbes in food production, and the numerous other ways that microbes contribute to the quality of our lives and our well-being. The book also examines the problem of antibiotic resistance, discusses the importance of vaccines, describes the intimate association of microorganisms in our gut, and surveys several microbial diseases of historical and contemporary times.

Objectives

The 21st century is destined to be the Century of Biology. In future decades we can anticipate new products of biotechnology, new ways of preserving and protecting our environment, new methods in agriculture, new practices to maintain human health, and new technologies not yet even in the idea stage. Microbes are at the center of all of these happenings. They are the hammers and nails of genetic engineering, the worker bees for purifying polluted water, the sources of imaginative insecticides and pesticides, our internal guardians protecting us from disease and helping keep us healthy, and the jumping off points for futuristic technologies. Knowing the microbes is essential to knowing the future. Helping you to know the microbes is the first major objective of this book.

Rarely does a day go by when we do not enjoy a "microbial food;" each time we put out the garbage, we assume that microbes will break it down; whenever we take a breath, we inhale oxygen that microbes have put into the atmosphere; and each time we cover a sneeze, we try to stop the spread of microbes. Helping

you to understand the places that microbes occupy in our day-to-day existence is this book's second major objective.

But what would the present and future be without the past? The third major objective is to provide some examples of how microbes have had a significant impact on history. We shall study, for example, how plague changed the course of Western civilization, how malaria influenced the building of the Panama Canal, how microbes influenced the way human cultures arose, and how microbes made much of the current work in biotechnology possible. Few groups of organisms have played such a rich and powerful role in history and society.

I hope you will enjoy your education in microbiology and come to understand the influence of microbes on our society today, in the past, and in the future.

Organization

Microbes and Society, Fifth Edition contains two parts. Part I introduces the microbial world over the span of 11 chapters. Individual chapters explore the bacteria, viruses, fungi, and protists. Other chapters describe how these microbes grow and reproduce, the unique genetic patterns they display, and the methods used to control them.

Part II moves to the practical applications of microbiology. We visit a restaurant for a microbial meal, we wander through a research facility and see microbes at work, we stop at various locations in the environment and observe microbes acting on our behalf, and we examine their place in disease. The bottom line is that microbes are relevant.

Must the chapters be studied in sequence? Absolutely not. Time constraints often prevent courses from using the entire book, so instructors and students are invited to "cherry pick" those topics that best fit their situation. To encourage flexibility, each chapter has been written independently of the others, and each section in a chapter stands alone. Instructors may, therefore, design their own approach to microbiology according to their students' needs. Instructors seeking additional information on creating a custom textbook for their course should contact their Jones & Bartlett Learning Account Manager at go.jblearning.com/findmyrep.

The Student Experience

Approaching a course in microbiology can be an anxious undertaking. There are new insights to learn, new concepts to understand, and an entirely new vocabulary to master. To help smooth over the bumps, this book incorporates several features that should help increase students' comfort level as they read *Microbes and Society, Fifth Edition.*

Students might note that all chapters are about the same length. This was done purposefully to provide a symmetrical framework in which students can learn. Each chapter has several sections and numerous smaller subsections to accommodate limited study times. The ultimate goal has been to provide a thorough and balanced presentation of microbiology within an enjoyable context.

Each chapter begins with an engaging story that helps set a tone for the pages and topics that follow. A section titled **"Looking Ahead"** indicates to students what they should take away from the chapter.

LOOKING AHEAD

After reading and completing this chapter, you will be able to:

- **2.1** Compare the contributions to microbiology that were made by each of the four pioneers.
- **2.2** Write correctly an organism's scientific name.
- **2.3** Explain the differences between (a) the light microscope and the electron microscope (EM) and (b) the transmission EM and scanning EM.
- **2.4** Identify the general characteristics of the microbes and viruses.
- **2.5** Describe the tree of life, and assess its significance to microbiology and the evolution of life.

Special topics boxes in each chapter (**"A Closer Look"**) encourage a moment of relief from the rigors of study, and present a historical insight, an interesting aside, or a health issue. Most figures are presented in full color, and special attention has been given to setting them close to their text reference. In the chapter margins of each page, definitions to some scientific terms and organism pronunciations (sometimes appearing to be tongue twisting names) are presented. In addition, a pronunciation guide has been added as an Appendix. The chapter topics conclude with **A Final Thought**

At the end of each chapter are the **Chapter Discussion Questions**. This includes **What Was He Thinking** that has the student think about the most important information presented in the chapter. The **Key Terms** again appear and provide the vocabulary to answer the **Questions For Discussion**.

Even many of the paragraphs are about the same size (there should be a rhythm in reading).



CHAPTER 15

Microbes and Agriculture: No Microbes, No Hamburgers

The Man from Delft

He stood in front of the assembled farmers and made an outrageous proposal: "Don't plant your crops in the same field as last year," he said. "Leave the field alone and let the clover grow for the next year."

The year was 1887; the man was Martinus Willem Beijerinck; the country was The Netherlands. Because agricultural land was scarce in his small country, his proposal was outrageous.

"But Martinus. We cannot afford to let the field remain empty for a whole planting season. It will bankrupt us!" several farmers shouted.

Beijerinck was a local bacteriologist from Delft, Holland. While his colleagues in France and Germany were investigating the germ theory of disease and its implications Beijerinck was out in the agricultural fields. He noticed the land was very productive when it was freshly cleared of brush and trees and ... after several years of use. Moreover, the fields ... let the field lie unplanted for a couple ... the answer to these mysteries.

... ur fear. But you need to let the fields ... crops," Beijerinck explained. "Plant ... hen you do replant, your crop yield will ...

... t, to be sure, but he also had a solid back- ... ospheric nitrogen gas (N_2) was essential

Beijerinck: BY-yer-ink

Sebaceous Skin Sites

Bacterial diversity appears lowest at sebaceous (oily) sites, such as the forehead and back. *Propionibacterium acnes* inhabits hair follicles at these sites and can metabolize the **sebum** into products that are toxic to many other bacterial species including pathogens. In higher numbers, some *P. acnes* strains are associated with skin conditions like acne.

Moist Skin Sites

Moist sites on the skin, such as the navel, groin, sole of the foot, back of the knee, and the inner elbow, are dominated by *Staphylococcus* and *Corynebacterium* species. Processing of sweat by the staphylococci and corynebacteria produces the characteristic body odor associated with sweat.

Propionibacterium pea-OHN-ee-bak AK-nees

Sebum: An oily s... the sebaceous gl... keeps the skin an... moist.

Staphylococcus: staff-ih-...

A CLOSER LOOK 5.4

"The Work of the Devil"

As an undergraduate, Linda Caporael was missing a critical history course for graduation. Little did she know that through this class she was about to provide a possible answer for one of the biggest mysteries of early American history, the cause of the Salem Witch Trials. These trials in 1692 led to the execution of 20 people who had been accused of being witches in Salem, Massachusetts (see **FIGURE A**).

Caporael, now a behavioral psychologist at New York's Rensselaer Polytechnic Institute, in preparation of a paper for her history course had read a book where the author could not explain the hallucinations among the people in Salem during the witchcraft trials. Caporael made a connection between the "Salem witches" and a French story of ergot poisoning in 1951. In Pont-Saint-Esprit, a small village in the south of France, more than 50 villagers went insane for a month after eating ergotized rye flour. Some people had fits of insomnia, others had hallucinogenic visions, and still others were reported to have fits of hysterical laughing or crying. In the end, three people died.

Caporael noticed a link between these bizarre symptoms ... those of Salem witches, and the hallucinogenic ... derivative of ergot. Could ...

FIGURE A A witch trial in Massachusetts, 1692.



sensations on the skin, and a host of other symptoms—all of which, Linda Caporael found in the records of the Salem witchcraft trials. Ergot thrives in warm, damp, rainy springs and summers, which were the exact conditions Caporael says existed in Salem in 1691. In addition, parts of Salem village consisted of swampy meadows that would be the perfect environment for fungal growth. And because rye was the staple grain of Salem, it is not a stretch to suggest that the rye crop consumed in the winter of 1691–1692 ... been contaminated by large quantities of ergot.

A Final Thought

The diversity of life has astounded scientists and explorers for centuries. The challenge of naming and categorizing this vast array of organisms is nowhere more complicated than it is with the microbial world. With so many new species being discovered every year, scientists today are dependent on different forms of microscopy and various biochemical, genetic, and molecular tools to set organisms apart from one another. The fruits of this labor have resulted in the three-domain system and the TOL, which visibly describe the various forms of microscopic life. The history of taxonomy, from Linnaeus to Woese, is a magnificent study of the evolution of life and one that continues to challenge the thinking about the basic nature of life itself.

What's New in This Edition?

Microbiology is a dynamic science and so this fifth edition reflects many of these advances as they pertain to humans, the environment, and society. The textbook also

features new and improved schematics to represent essential concepts and patterns of thought in a more accurate and approachable way.

Each chapter has been revised based on the most current and significant knowledge available. New to this edition:

- All chapters have been extensively edited and rewritten
- Many chapters have been shortened
- Improved readability based on the Flesch Reading Ease Test and the Flesch-Kincaid Grade Level Test
- Almost 10% fewer scientific terms
- New organism pronunciation guide throughout the text

Detailed chapter-by-chapter updates include:

Chapter	New Features and Content
Chapter 1	■ Chapter completely rewritten to emphasize the connections between microbes and society ■ 16 new figures
Chapter 2	■ Chapter restructured for information flow ■ New end-of-chapter questions ■ 14 new figures
Chapter 3	■ New end-of-chapter questions ■ 1 modified figure ■ New "A Closer Look"
Chapter 4	■ Former Chapter 5 in previous edition ■ New chapter opener ■ New end-of-chapter questions ■ 3 modified figures ■ 11 new figures
Chapter 5	■ Chapter 5 combines (and condenses) Chapters 7 and 8 ■ New end-of-chapter questions ■ 4 modified figures ■ 16 new figures
Chapter 6	■ Chapter placement re-sequenced for better understanding after the discussion of prokaryotes and eukaryotes (Chapters 4 and 5) ■ New chapter opener ■ New end-of-chapter questions ■ 5 modified figures
Chapter 7	■ Chapter rewritten for better clarity and understanding ■ New end-of-chapter questions ■ 6 new figures ■ 6 modified figures
Chapter 8	■ Former Chapter 4 in previous edition ■ New chapter introduction ■ New end-of-chapter questions ■ New A Closer Look ■ 7 new figures ■ 3 modified figures ■ 1 new table

Chapter 9	■ Former Chapter 10 in previous edition ■ 4 new figures ■ Extensive revision of 7 figures ■ New end-of-chapter questions
Chapter 10	■ Former Chapter 11 in previous edition ■ 6 new figures ■ Revisions to 5 figures ■ 1 new table ■ New end-of-chapter questions
Chapter 11	■ New chapter covering microbial social behavior through biofilms and the human microbiome. ■ 18 new figures ■ 2 new A Closer Look boxed features ■ 9 new end-of-chapter questions
Chapter 12	■ Former Chapter 13 in previous edition ■ 11 new figures ■ 1 new table ■ 8 new end-of-chapter questions
Chapter 13	■ Former Chapter 12 in previous edition ■ New chapter opener ■ 7 new figures ■ 3 new A Closer Look boxed features ■ New end-of-chapter questions and modifications
Chapter 14	■ New chapter opener ■ 6 new figures ■ Revisions to 7 figures ■ 1 new A Closer Look boxed feature ■ New end-of-chapter questions and modifications
Chapter 15	■ 14 new figures ■ Revisions to 2 figures ■ 1 new A Closer Look boxed feature ■ New end-of-chapter questions and modifications
Chapter 16	■ 14 new figures ■ New chapter opener ■ New end-of-chapter questions and modifications
Chapter 17	Chapter has been completely rewritten and immune system material is much more approachable for students. Vaccines and vaccine safety have been added to this chapter. ■ 9 new figures ■ Revisions to 5 figures ■ New end-of-chapter questions and modifications
Chapter 18	Information on viral diseases updated ■ 8 new figures ■ Information on Zika virus disease added
Chapter 19	■ 12 new figures ■ Revisions to 4 figures ■ 2 new A Closer Look boxed features ■ New end-of-chapter questions and modifications

Teaching Tools

The following resources are available to instructors to assist with course preparation:

- Sample Syllabus
- In-depth Lecture Presentations in PowerPoint format that feature art from the book
- Test Banks
- Image Bank of figures from the book
- Answers to the end-of-chapter questions from the book

Qualified instructors can obtain this material by contacting their Jones & Bartlett Learning Account Manager or by going to www.jblearning.com.

For instructors who offer a lab component with their course we have the following resources:

- *Laboratory Fundamentals of Microbiology, Eleventh Edition* is the completely modernized lab manual revolution built for today's learners, focusing on the student's experience in the lab. Lab activities in this new, full-color resource have been expanded and reorganized into new sections, such as "Laboratory Safety," "Population Growth" and "Immunology." Access to over 100 minutes of 34 instructor-chosen, high-quality videos of actual students performing the most common lab skills, procedures, and techniques is included with each new copy.
- Access to the *Fundamentals of Microbiology Laboratory Video Series* is also available for purchase as a subscription if your students do not require a printed lab manual.

Contact your Jones & Bartlett Learning Account Manager at go.jblearning.com/findmyrep for more information on bundle pricing if you plan to use more than one of these resources in your course.

Note to Instructors

Microbiology embodies the beautiful and ugly, the simple and complex, and the big and the small of life, and in this regard is a fascinating, useful, and approachable topic for non-science majors to learn. Because of the real value of microbes to the quality of human life, the environment, and society, as well as their ability to cause disease, I saw the need for a course in microbiology for the non-science major. *Microbes and Society, Fifth Edition* is written and designed to support such a course; I hope you find it to be a useful tool in your pedagogical mission.

Please feel free to email me (jeffpommervillephd@gmail.com) anytime with questions, comments, ideas, and/or suggestions that you believe could strengthen this text and make it an even more exciting learning experience for students.