ALCAMO'S MICROBES AND SOCIETY

FOURTH EDITION

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Glendale Community College

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Brief Contents

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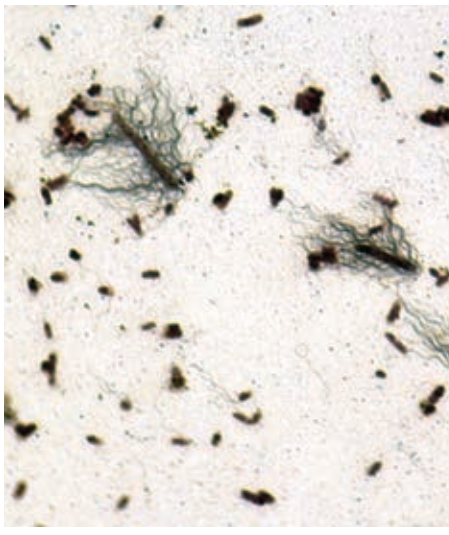

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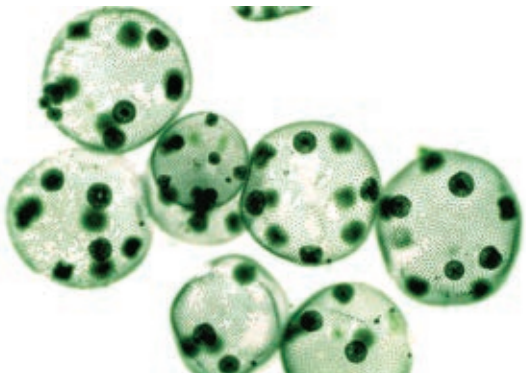

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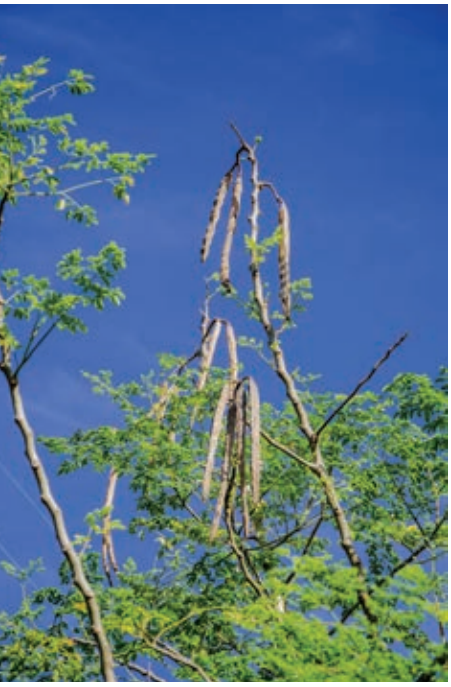

Courtesy of Dr. Rodney M. Donlan and Janice Carr/CDC

Preface

When I was approached by Jones & Bartlett Learning to become the new author of *Alcamo's Microbes and Society, Fourth Edition*, I was delighted. Why? It certainly wasn't because I was looking for more to do. With authoring other college textbooks and having a full-time faculty teaching position at Glendale Community College, I am plenty busy. The actual reason was that I saw this as an opportunity to convey the excitement and wonder of microbes to college students not majoring in the sciences, and to the public.

Today, hardly a day goes by when a story about microorganisms (microbes) does not appear in a newspaper, magazine, or on the TV news. 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.

It is an exciting time in microbiology, so I see my charge as one to capture that excitement, and transform the reader into a knowledgeable and scientifically literate citizen in today's society. This is not to make you into a science nerd, although there is nothing wrong with that, but rather to illustrate how the science of microbiology affects all of us in tremendous ways. As citizens of the world, we need to understand how the science operates, the challenges it faces, and the discoveries being made. Today, microbes are important to our lives, our good health, our society, and the daily operation of the world around us.

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

Audience

Alcamo's Microbes and Society, Fourth Edition is written to the nonscience undergraduate and inquiring citizen of the 21st century. 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 wellbeing. The book also examines the problem of antibiotic resistance, discusses the problems of nosocomial infections, and surveys several microbial diseases of history and contemporary times. 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. The book assumes little or no science background, and it should accommodate one-quarter or one-semester courses.

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. And importantly, microbes are at the center of all of these. 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.

What of today? 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 show you how microbes have had a significant impact on history. We shall study, for example, how microbes changed the course of Western civilization, how microbes stopped Napoleon's conquest of Russia, how microbes influenced the way 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.

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

Alcamo's Microbes and Society, Fourth Edition contains two parts. Part I introduces the microbial world over the span of 11 chapters. Individual chapters explore the bacteria, viruses, fungi, protists, and other microbes; 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 fit best. 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.

The Student Experience

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

Each chapter begins with a section titled "**Looking Ahead**" to let students know what they should take away from the chapter. The reading then opens with an engaging story to set a tone for the pages that follow. Key terms in the chapter appear in bold to draw the attention of readers, and organism pronunciations (sometimes appearing to be tongue twisting names) appear in the chapter margins along with the definitions of some more specialized terms (see margin). In addition, a pronunciation guide has been added as an Appendix.

12 Microbes and Food: A Menu of Microbial Delights

Many food and beverage products we consume and enjoy every day are either created by certain species of microbes or they are part of the production process in making the commercial product.

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Looking Ahead

Although we often think of microbes as food contaminants, many species actually play vital roles in producing the foods we enjoy, as we will discover in this chapter.

On completing this chapter, you should be capable of:

- Describing the process of wine fermentation.
- Comparing the roles of microbes in the fermentation processes for olives and cheese making.
- Explaining the role of yeast in bread making.
- ining the fermentation process for sausages and sauerkraut.
- ussing the process of brewing beer.

he decades, many food-related microbes have received bad
umerous disease outbreaks associated
although no trace

have been
en received
this nega-
microbes
associated
ondemn-

Bacillus
bā -cil'lus

Clostridium
klos-tri'dē-um

rem (Roentgen Equivalent in Man): A measure of radiation dose related to biological effect.

Endospores

A few bacterial species, particularly members of the genera *Bacillus* and *Clostridium*, have the ability to produce an extraordinarily resistant structure called the **endospore** (FIGURE 5.13). This structure is usually formed when nutrient stress is encountered in the environment. The spore is formed during an involved process during which the mother cell produces an internal spore (i.e., endospore) that contains a complete set of genetic information surrounded by a very thick peptidoglycan set of walls. Once formed and mature, the dormant spore is released with the death of the mother

Endospores are probably the most resistant biological
Desiccation has little effect on the spore. By contain
are heat resistant and undergo very few chemi
them difficult to eliminate from contaminated
For example, endospores can remain viable in
When placed in 70% ethyl alcohol, endospores h
can barely withstand 500 rems of radiation, but e
rems. In this dormant condition, endospores ca
centuries.

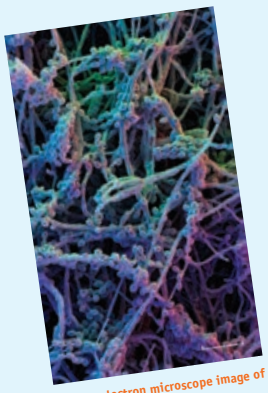
240 CHAPTER 11 Controlling Microbes: From Outside and Within the Body

A CLOSER LOOK 11.4

Hiding a Treasure

Their timing could not have been worse. Howard Florey, Ernst Chain, Norman Heatley, and others of the team had rediscovered penicillin, purified it, and proved it useful in infected patients. But it was 1939, and German bombs were falling on London. This was a dangerous time to be doing research into new drugs and medicines. What would they do if there was a German invasion of England? If the enemy were to learn the secret of penicillin, the team would have to destroy all their work. So, how could they preserve the vital fungus yet keep it from falling into enemy hands?

Heatley made a suggestion. Each team member would rub the mold on the inside lining of his coat. The *Penicillium* mold spores would cling to the rough coat surface where the spores could survive for years (if necessary) in a dormant form. If an invasion did occur, hopefully at least one team member would make it to safety along with his "moldy coat." Then, in a safe country, the spores would be used to start new cultures and the research could continue. Of course, a German invasion of England did not occur, but the plan was an ingenious way to hide the
red organism.
well told in *The Mold in*
Dr.



False-color scanning electron microscope image of *Penicillium* spores and hyphae. (Bar = 10 um.)

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A Final Thought

When one of us (J.P.) was a young assistant professor of biology, the question of whether viruses are "alive" came up for discussion at an informal social gathering. As several people had had some beer to drink, the conversation became quite animated supporting one or the other viewpoint on viruses being alive. Perhaps one of the best answer was, "Who cares! We treat viral diseases the same way regardless of whether they are alive or not."

But the question has continued to pique my interest philosophically to this day. And now I put it to you. Are viruses alive? Although this textbook often refers to viruses as microbes for the sake of convenience, we have avoided references to "live" or "dead" viruses. Instead, we have used the words "active" for replicating viruses and "inactive" for viruses not replicating. Perhaps we should consider viruses to be inert chemical molecules with at least two properties of living organisms—the ability to replicate and adapt. Thus, viruses are neither totally inert nor totally alive, but somewhere on the threshold of life. Your thoughts?

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.

The chapter concludes with **A Final Thought**, a set of **Questions to Consider** that provide challenging opportunities to apply what has been learned, and a **Key Terms** list for review. Students may 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.

Even many of the paragraphs are about the same size (there should be a rhythm in reading). The ultimate goal has been to provide a thorough and balanced presentation of microbiology within an enjoyable context.

What's New in This Edition?

Microbiology is a dynamic science and so this fourth 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 paradigms 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 is:

- Updated coverage of microbes and new information on the human microbiome (Chapters 1 and 2).
- Revised coverage of microbial molecules (Chapter 3).
- Clearer descriptions of genes and the science of genomics (Chapter 4).
- New information on viruses and all microbial groups (Chapters 5–8).
- Revised descriptions of bacterial growth and metabolism (Chapter 9).
- Current applications of genetic engineering and biotechnology (Chapters 10 and 14).
- New discussions on bacterial resistance to antibiotics (Chapter 11).
- Expanded coverage of food microbiology, safety, and prevention. (Chapters 12 and 13).
- Expanded coverage of vaccines and their importance to human health (Chapter 14).
- New data on microbes in agriculture and the environment (Chapters 15 and 16).
- Clearer discussions of the immune system function (Chapter 17).
- More concise descriptions of viral and bacterial diseases (Chapters 18 and 19).

FIGURE 1.5 **The Human Microbiome Sites.** This image identifies the body sites that were examined and sampled from 244 volunteers for the Human Microbiome Project.

Courtesy of NIH Medical Arts and Printing.

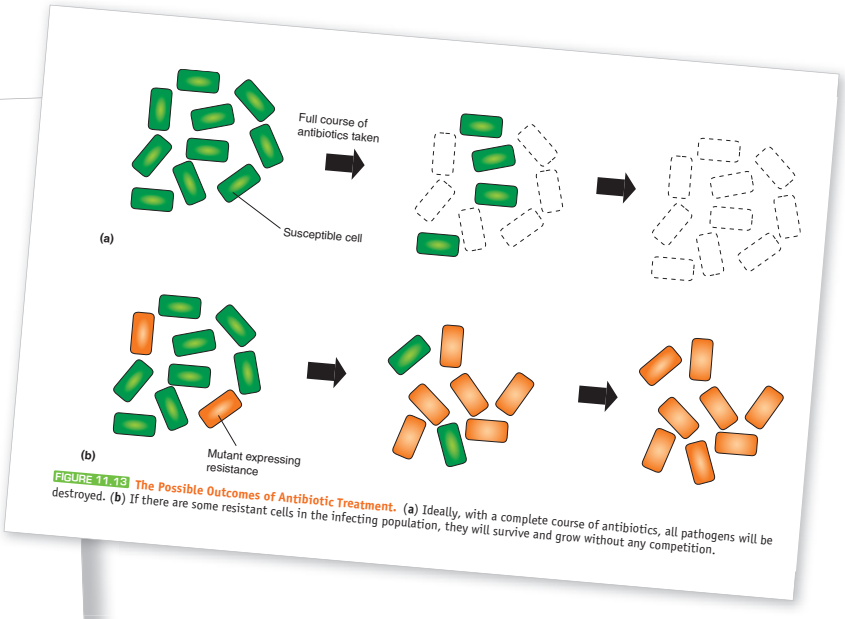

FIGURE 11.13 **The Possible Outcomes of Antibiotic Treatment.** **(a)** Ideally, with a complete course of antibiotics, all pathogens will be destroyed. **(b)** If there are some resistant cells in the infecting population, they will survive and grow without any competition.

All chapters have a small number of special topics boxes that are interesting, intriguing, and often important to us, and society as a whole. Some of these boxes have been updated or replaced. Among the new boxes are:

1.3 Antibiotics in the Feedlots	The abuse of antibiotics in fattening up livestock
2.4 Size Matters	Cell size is critical for proper nutrient transport
3.3 Microbes to the Rescue!	Microbes help clean up the *Deepwater Horizon* oil spill
4.2 The Tortoise and the Hare	Personalities affect the search to identify the structure of DNA
5.4 The Blood of History	Microbes have caused some "bloody" miracles in history
6.4 The Power of the Virus	Engineered viruses help to cure genetic diseases
7.4 "Black '47"	A microbial plant disease changes history
8.3 The Work of the Devil	Fungal hallucinations were behind the Salem witchcraft trials
9.3 Microbes "Raise a Stink"	Microbes compete successfully by being offensive to others
10.2 Gene Swapping in the World's Oceans	Microbes undergo an amazing amount of gene recombination
11.3 Are Antibacterial Soaps Worth the Money?	Investigating the reported usefulness of antibacterial soaps
12.3 This hqt's for You!	Ancient beer making by the Egyptians
13.3 Keeping Microorganisms Under Control	Quizzing your food safety precautions at home
14.1 Tag Team Microbes	Microbes working together can produce successful results
15.2 Stilton Cheese—Slicing through a Microbial Community	Some bacteria and fungi are essential to making many cheeses
16.2 The Great Sanitary Movement	Edwin Chadwick and the birth of modern sanitation
17.1 Probiotics and Your Health	Bacteria, probiotics, and their role in human health
18.4 The HIV Hideouts	Where the AIDS virus can hide out in the body
19.1 The Killer of Children	Pneumonia is deadly to children in many developing nations

Teaching Tools

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

- Sample Syllabus
- Lecture Outlines
- 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 Specialist or by going to www.jblearning.com.

Jones & Bartlett Learning also publishes the following titles that may be of use for your microbiology course:

- Infectious Diseases: *The Guide to Infectious Diseases by Body System, Second Edition* is an excellent ancillary tool for learning about microbial diseases. Each of the fifteen body systems units presents a brief introduction to the anatomical system and the bacterial, viral, fungal, or parasitic organism infecting the system.
- Encounters in Microbiology: *Encounters with Microbiology, Volume I, Second Edition* and *Volume II* bring together "Vital Signs" articles from *Discover* magazine in which health professionals use their knowledge of microbiology in their medical cases.

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. *Alcamo's Microbes and Society, Fourth 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 (jeffrey.pommerville@gccaz.edu) 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.

Additional Microbiology Resources from Jones & Bartlett Learning

The following additional products are available to supplement your microbiology course. Our full catalog can be browsed at go.jblearning.com/Microbiology

- *Alcamo's Laboratory Fundamentals of Microbiology* is a series of 30 multipart laboratory exercises that provide basic training in the handling of microorganisms and help students understand the properties and uses of microbes.
- A two-volume anthology called *Encounters in Microbiology* brings together "Vital Signs" articles from *Discover* magazine in which health professionals describe in layman's terms their experiences with microbes and their knowledge of microbiology to solve medical mysteries.
- *Guide to Infectious Diseases by Body System, Second Edition* is an excellent tool for learning about microbial diseases. Each of the 15 body system units in the booklet presents a brief introduction to the anatomical system and a sampling of the bacterial, viral, fungal, or parasitic organisms that can infect the system.

Courtesy of Dr. Rodney M. Donlan and Janice Carr/CDC

Acknowledgments

Putting together a new edition of a textbook always requires the input of a whole team and so I must recognize everyone at Jones & Bartlett Learning who helped put together this new edition of *Alcamo's Microbes and Society*. I want to thank my editors Erin O'Connor and Matt Kane for giving me the opportunity to revise and update *Alcamo's Microbes and Society, Fourth Edition*, and for their support and encouragement throughout the process; and Audrey Schwinn for managing the process expertly, guiding the revisions, and keeping me on a timetable. I also want to thank Leah Corrigan for her expert work at the production end of the publication process, and to photo researcher Lauren Miller. Thanks also to Shellie Newell for copyediting the manuscript and to Jan Cocker for proofreading the text. It takes a team of talented and dedicated professionals to put together a text and the *Alcamo's Microbes and Society* team is stellar. I salute you all and am honored to work with you.

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Courtesy of Dr. Rodney M. Donlan and Janice Carr/CDC

About the Author

Courtesy of Dr. Jeffrey Pommerville

Today, I am a microbiologist, researcher, and science educator. My plans did not start with that intent. While in high school in Santa Barbara, California, I wanted to play professional baseball, study the stars, and own a '66 Corvette. None of these desires would come true—my batting average was miserable (but I was a good defensive third baseman), I hated the astronomy correspondence course I took, and I have yet to buy that Corvette.

I found an interest in biology at Santa Barbara City College. After squeaking through college calculus, I transferred to the University of California at Santa Barbara (UCSB), where I received a BS in biology and stayed on to pursue a PhD degree studying cell communication and sexual pheromones in a water fungus in the lab of Ian Ross. After receiving my doctorate in cell and organismal biology, my graduation was written up in the local newspaper as a native son who was a "fungal sex biologist"—an image that was not lost on my three older brothers!

While in graduate school at UCSB, I rescued a secretary in distress from being licked to death by a German shepherd. Within a year, we were married (the secretary and I). When I finished my doctoral thesis, I spent several years as a postdoctoral fellow at the University of Georgia. Worried that I was involved in too many research projects, a faculty member told me something I will never forget. He said, "Jeff, it's when you can't think of a project or what to do that you need to worry." Well, I have never had to worry!

I then moved on to Texas A&M University, where I spent 8 years in teaching and research—and telling Aggie jokes. Toward the end of this time, after publishing over 30 peer-reviewed papers in national and international research journals, I realized I had a real interest in teaching and education. Leaving the sex biologist career behind, I headed farther west to Arizona to join the biology faculty at Glendale Community College, where I continue to teach introductory biology and microbiology.

I have been lucky to be part of several educational research projects and have been honored, with two of my colleagues, with a Team Innovation of the Year Award by the League of Innovation in the Community Colleges. In 2000, I became project director and lead principal investigator for a National Science Foundation grant to improve student outcomes in science through changes in curriculum and pedagogy. I had a fascinating three years coordinating more than 60 science faculty members (who at times were harder to manage than students) in designing and field testing

18 interdisciplinary science units. This culminated with me being honored in 2003 with the Gustav Ohaus Award (College Division) for Innovations in Science Teaching from the National Science Teachers Association.

I am the Perspectives Editor for the *Journal of Microbiology and Biology Education*, the science education research journal of the American Society for Microbiology (ASM) and in 2004 was co-chair for the ASM Conference for Undergraduate Educators. From 2006 to 2007, I was the chair of Undergraduate Education Division of ASM. In 2006, I was selected as one of four outstanding instructors at Glendale Community College. The culmination of my teaching career came in 2008 when I was nationally recognized by being awarded the Carski Foundation Distinguished Undergraduate Teaching Award for distinguished teaching of microbiology to undergraduate students and encouraging them to subsequent achievement.

I mention all this not to impress but to show how the road of life sometimes offers opportunities in unexpected and unplanned ways. The key though is keeping your "hands on the wheel and your eyes on the prize"—then unlimited opportunities will come your way. And, hey, who knows—maybe that '66 Corvette could be in my garage yet.

Courtesy of Dr. Rodney M. Donlan and Janice Carr/CDC

To the Student—Study and Read Smart

When I was an undergraduate student, I hardly ever read the "To the Student" section (if indeed one existed) in my textbooks because the section rarely contained any information of importance.

This one does, so please read on.

In college, I was a mediocre student until my junior year. Why? Mainly because I did not know how to study properly, and, important here, I did not know how to read a textbook effectively. My textbooks were filled with underlined sentences (highlighters hadn't been invented yet!) without any plan on how I would use this "emphasized" information. In fact, most textbooks *assume* you know how to read a textbook properly. It is not like reading a fictional novel.

Reading a textbook is difficult if you are not properly prepared. So that you can take advantage of what I learned as a student and have learned from instructing thousands of students, I have worked hard to make this text user friendly with a reading style that is not threatening or complicated. Still, there is a substantial amount of information to learn and understand, so having the appropriate reading and comprehension skills is critical. Therefore, I encourage you to spend 20 minutes reading this section, as I am going to give you several tips and suggestions for acquiring those skills. Let me show you how to be an active reader.

Be a Prepared Reader

Before you jump into reading a section of a chapter in this text, prepare yourself by finding the place and time and having the tools for study.

Place. Where are you right now as you read these lines? Are you in a quiet library or at home? If at home, are there any distractions, such as loud music, a blaring television, or screaming kids? Is the lighting adequate to read? Are you sitting at a desk or lounging on the living room sofa? Get where I am going? When you read for an educational purpose—that is, to learn and understand something—you need to maximize the environment for reading. Yes, it should be comfortable but not to the point that you will doze off.

Time. All of us have different times during the day when we perform some skill the best, be it exercising or studying. The last thing you want to do is read when you are tired or simply not "in the zone" for the job that needs to be done. You cannot learn and understand the information if you fall asleep or lack a positive attitude. I have kept the chapters in this text to about the same length so you can estimate the time necessary for each and plan your reading accordingly. If you have done your preliminary survey of the chapter or chapter section, you can determine about how much time you will need. If 40 minutes is needed to read—and comprehend (see below)—a section of a chapter, find the place and time that will give you 40 minutes of uninterrupted study.

Brain research suggests that most people's brains cannot spend more than 45 minutes in concentrated, technical reading. Therefore, I have avoided lengthy presentations and instead have focused on smaller sections, each with its own heading. These should accommodate shorter reading periods.

Reading Tools. Lastly, as you read this, what study tools do you have at your side? Do you have a highlighter or pen for emphasizing or underlining important words or phrases? Notice, the text has wide margins, which gives you the space to make notes or to indicate something that needs further clarification. Do you have a pencil or pen handy to make these notes? Lastly, some students find having a ruler is useful to prevent your eyes from wandering on the page and to read each line without distraction.

Be an Explorer Before You Read

When you sit down to read a section of a chapter, do some preliminary exploring. Look at the section head and subheadings to get an idea of what is discussed. Preview any diagrams, figures, tables, graphs, or other visuals used. They give you a better idea of what is going to occur. We have used a good deal of space in the text for these features, so use them to your advantage. They will help you learn the written information and comprehend its meaning. Do not try to understand all the visuals, but try to generate a mental "big picture" of what is to come. Familiarize yourself with any symbols or technical jargon that might be used in the visuals.

Be a Detective as You Read

Reading a section of a textbook requires you to discover the important information (the terms and concepts) from the forest of words on the page. So, the first thing to do is read the complete paragraph. When you have determined the main ideas, highlight or underline them. However, I have seen students highlighting the entire paragraph in yellow, including every *a*, *the*, and *and*. This is an example of highlighting before knowing what is important. So, I have helped you out somewhat. Important terms and concepts in the textbook are in **bold face** followed by the definition (or the definition might be in the page margin). So, in many cases, you should only need to highlight or underline essential ideas and key phrases—not complete sentences. By the way, the important microbiological terms and major concepts also are in the **Glossary** at the back of the text.

What if a paragraph or section has no boldfaced words? How do you find what is important here? From an English course, you may know that often the most important information is mentioned first in the paragraph. If it is followed by one or more examples, then you can backtrack and know what was important in the paragraph.

Say It in Your Own Words

Brain research has shown that each individual can only hold so much information in short-term memory. If you try to hold more, then something else needs to be removed—sort of like having a full computer disk. So that you do not lose any of this important information, you need to transfer it to long-term memory—to the hard drive if you will. In reading and studying, this means retaining the term or concept; so, write it out in your notebook *using your own words*. Memorizing a term does not mean you have learned the term or understood the concept. By actively writing it out in your own words, you are forced to think and actively interact with the information. This repetition reinforces your learning.

Be a Patient Student

In textbooks, you cannot read at the speed that you read your text messages, email, or a magazine story. There are unfamiliar details to be learned and understood in a

textbook—and this requires being a patient, slower reader. Actually, if you are like me and not a fast reader to begin with, it may be an advantage in your learning process. Identifying the important information from a textbook chapter requires you to *slow down* your reading speed. Speed-reading is of no value here.

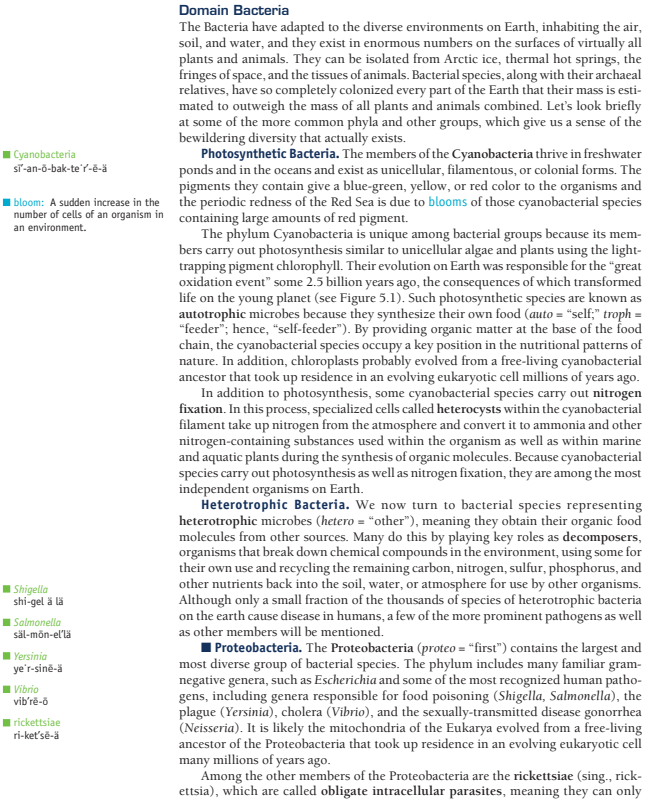
Know the What, Why, and How

Have you ever read something only to say, "I have no idea what I read!" As I've already mentioned, reading a microbiology text is not the same as reading *Sports Illustrated* or *People* magazine. In these entertainment magazines, you read passively for leisure or perhaps amusement. In *Alcamo's Microbes and Society, Fourth Edition,* or any other textbook, you must read actively for learning and understanding—that is, for *comprehension*. This can quickly lead to boredom unless you engage your brain as you read—that is, be an active reader. Do this by knowing the *what, why,* and *how* of your reading.

- *What* is the general topic or idea being discussed? This often is easy to determine because the section heading might tell you. If not, then it will appear in the first sentence or beginning part of the paragraph.
- *Why* is this information important? If I have done my job, the text section will tell you why it is important or the examples provided will drive the importance home. These surrounding clues further explain why the main idea was important.
- *How* do I "mine" the information presented? This was discussed under being a detective.

A Marked Up Reading Example

So, let's put words into action. Below is a passage from *Alcamo's Microbes and Society, Fourth Edition*. I have marked up (highlighted) the passage as if I were a student



Domain Bacteria

The Bacteria have adapted to the diverse environments on Earth, inhabiting the air, soil, and water, and they exist in enormous numbers on the surfaces of virtually all plants and animals. They can be isolated from Arctic ice, thermal hot springs, the fringes of space, and the tissues of animals. Bacterial species, along with their archaeal relatives, have so completely colonized every part of the Earth that their mass is estimated to outweigh the mass of all plants and animals combined. Let's look briefly at some of the more common phyla and other groups, which give us a sense of the bewildering diversity that actually exists.

Cyanobacteria
sī'-an-ō-bak-te´r'-ē-ä

bloom: A sudden increase in the number of cells of an organism in an environment.

Photosynthetic Bacteria. The members of the **Cyanobacteria** thrive in freshwater ponds and in the oceans and exist as unicellular, filamentous, or colonial forms. The pigments they contain give a blue-green, yellow, or red color to the organisms and the periodic redness of the Red Sea is due to blooms of those cyanobacterial species containing large amounts of red pigment.

The phylum Cyanobacteria is unique among bacterial groups because its members carry out photosynthesis similar to unicellular algae and plants using the light-trapping pigment chlorophyll. Their evolution on Earth was responsible for the "great oxidation event" some 2.5 billion years ago, the consequences of which transformed life on the young planet (see Figure 5.1). Such photosynthetic species are known as **autotrophic** microbes because they synthesize their own food (*auto* = "self;" *troph* = "feeder"; hence, "self-feeder"). By providing organic matter at the base of the food chain, the cyanobacterial species occupy a key position in the nutritional patterns of nature. In addition, chloroplasts probably evolved from a free-living cyanobacterial ancestor that took up residence in an evolving eukaryotic cell millions of years ago.

In addition to photosynthesis, some cyanobacterial species carry out **nitrogen fixation**. In this process, specialized cells called **heterocysts** within the cyanobacterial filament take up nitrogen from the atmosphere and convert it to ammonia and other nitrogen-containing substances used within the organism as well as within marine and aquatic plants during the synthesis of organic molecules. Because cyanobacterial species carry out photosynthesis as well as nitrogen fixation, they are among the most independent organisms on Earth.

Heterotrophic Bacteria. We now turn to bacterial species representing **heterotrophic** microbes (*hetero* = "other"), meaning they obtain their organic food molecules from other sources. Many do this by playing key roles as **decomposers**, organisms that break down chemical compounds in the environment, using some for their own use and recycling the remaining carbon, nitrogen, sulfur, phosphorus, and other nutrients back into the soil, water, or atmosphere for use by other organisms. Although only a small fraction of the thousands of species of heterotrophic bacteria on the earth cause disease in humans, a few of the more prominent pathogens as well as other members will be mentioned.

Shigella
shi-gel ä lä

Salmonella
säl-mön-el'lä

Yersinia
ye´r-sinē-ä

Vibrio
vib'rē-ō

rickettsiae
ri-ket'sē-ä

Proteobacteria. The **Proteobacteria** (*proteo* = "first") contains the largest and most diverse group of bacterial species. The phylum includes many familiar gram-negative genera, such as *Escherichia* and some of the most recognized human pathogens, including genera responsible for food poisoning (*Shigella, Salmonella*), the plague (*Yersinia*), cholera (*Vibrio*), and the sexually-transmitted disease gonorrhea (*Neisseria*). It is likely the mitochondria of the Eukarya evolved from a free-living ancestor of the Proteobacteria that took up residence in an evolving eukaryotic cell many millions of years ago.

Among the other members of the Proteobacteria are the **rickettsiae** (sing., rickettsia), which are called **obligate intracellular parasites**, meaning they can only

reading it for the first time. It uses many of the hints and suggestions I have provided. Remember, it is important to read the passage slowly, and concentrate on the main idea (concept) and the special terms that apply.

Have a Debriefing Strategy

After reading the material, be ready to debrief. Verbally summarize what you have learned. This will start moving the short-term information into the long-term memory storage—that is, *retention*. Any notes you made concerning confusing material should be discussed as soon as possible with your instructor. For microbiology, allow time to draw out diagrams. Again, repetition makes for easier learning and better retention.

In many professions, such as sports or the theater, the name of the game is practice, practice, practice. The hints and suggestions I have given you form a skill that requires practice to achieve and use efficiently. Change will not happen overnight; perseverance and willingness though will pay off with practice. You might also check with your college or university academic resource center or center for learning. These folks will have more ways to help you to read a textbook better and to study well.

Send Me a Note

In closing, I would like to invite you to write or email me. Let me know what is good about this textbook so I can build on it and what may need improvement so I can revise it. Don't be shy; let me know your thoughts. Also, I would be pleased to hear about any news of microbiology in your community, and I'd be happy to help you locate any information not covered in the text.

I wish you great success in your microbiology course. Welcome! Let's now plunge into the wonderful and sometimes awesome world of microorganisms.

—Dr. P
Email: jeffrey.pommerville@gccaz.edu
Website: http://web.gcca3.edu/~jpommerv/

Courtesy of Dr. Rodney M. Donlan and Janice Carr/CDC

A Tribute to I. Edward Alcamo

Courtesy of I. Edward Alcamo

Dr. Ignazio Edward Alcamo was a long-time Professor of Microbiology at the State University of New York at Farmingdale and the author of numerous textbooks, lab kits, and educational materials. He was the 2000 recipient of the Carski Foundation Distinguished Undergraduate Teaching Award, the highest honor bestowed upon microbiology educators by the American Society for Microbiology.

Ed Alcamo was educated at Iona College and St. John's University and held a deep belief in the partnership between research scientists and allied health educators. He sought to teach the scientific basis of microbiology in an accessible manner as well as to inspire students with a sense of topical relevance. Michael Vinciguerra, Provost at the SUNY Farmingdale wrote, "In 1970, when I joined the faculty as a chemistry professor, Ed's reputation as an excellent biology educator was already well known."

A prolific author, Dr. Alcamo produced a broad array of publications including several learning guides and textbooks—*Fundamentals of Microbiology* is now in its tenth edition. He also prepared the *Encarta* encyclopedia entry entitled "Procaryotes," as well as *The Microbiology Coloring Book*, and *Schaum's Outline of Microbiology*. His other books published within the past several years include *AIDS: The Biological Basis, DNA Technology: The Awesome Skill, The Biology Coloring Workbook,* and *Anatomy and Physiology the Easy Way*. In December 2002, after a six-month illness, Dr. Alcamo died of acute myeloid leukemia.

Dr. Alcamo's teaching career was dedicated to the proposition that emphasizing quality in education is central to turning back the tide of fear and uncertainty and enabling doctors to find cures for disease. In the early 1980s, when the early cases of an unknown acquired immunodeficiency syndrome were turning into a mysterious and intractable epidemic, Dr. Alcamo told this to his class:

> *One afternoon, about 350 years ago, in the countryside near London, a clergyman happened to meet Plague.*
> *"Where are you going?" asked the clergyman.*
> *"To London," responded Plague, "to kill a thousand."*
> *They chatted for another few moments, and each went his separate way.*
> *Some time later, they chanced to meet again. The clergyman said, "I see you decided to show no mercy in London. I heard that 10,000 died there."*
> *"Ah, yes," Plague replied, "but I only killed a thousand. Fear killed the rest."*