

The background of the cover is a dark, reddish-brown color, overlaid with numerous microscopic images. These include several spherical viruses with distinct surface patterns (some with star-like or hexagonal arrangements), smaller dark granules, and larger, more complex cellular structures. The overall aesthetic is scientific and focused on microbiology.

FOUNDATIONS
IN

MICROBIOLOGY

KATHLEEN TALARO
ARTHUR TALARO

Second Edition

202226

FOUNDATIONS
IN

MICRO

BIOLOGY

S e c o n d E d i t i o n

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IN MEMORY OF OUR FRIEND AND FIRST
EDITOR, ED JAFFE. WE LOST THIS SPECIAL
MAN IN 1992, JUST WEEKS AFTER THE
PUBLICATION OF THE FIRST EDITION. HE
WAS THE SPARK BEHIND SEVERAL
SUCCESSFUL TEXTBOOKS AND A MAN OF
GREAT CHARACTER AND KEEN
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AND ONLY WISH HE HAD BEEN HERE FOR
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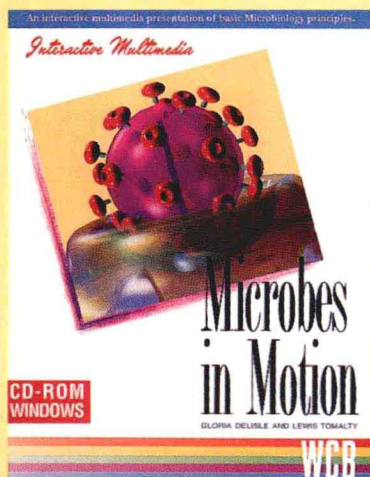
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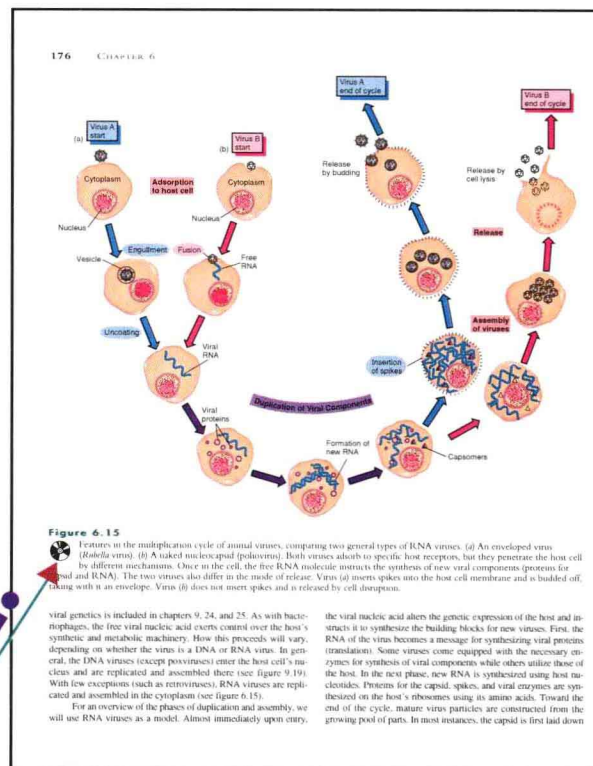
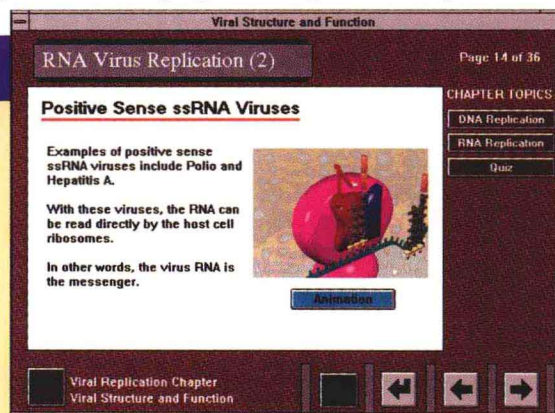
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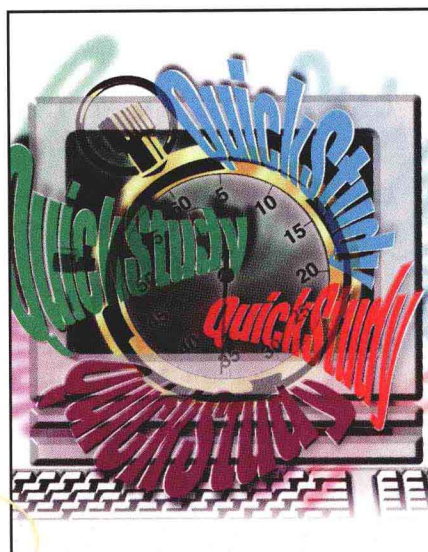
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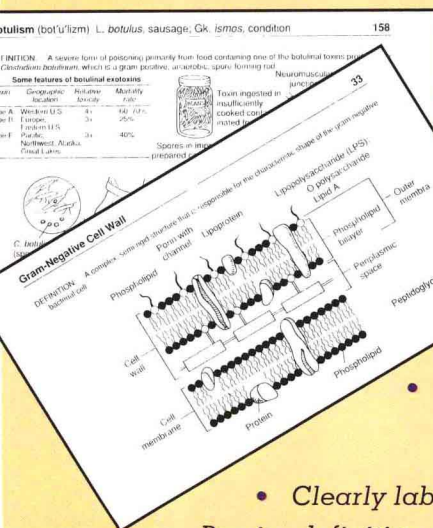
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PREFACE

IMPORTANCE AND IMPACT OF MICROBIOLOGY

Every semester or quarter, several hundred thousand students enroll in microbiology courses as a prerequisite for entering allied health professions, biotechnology fields, or to expand their science backgrounds. It is not uncommon for students to approach this course with some trepidation, because microbiology sometimes has an undeserved reputation for being difficult, incomprehensible, even a rite of passage to be survived or endured. Yet something magical invariably happens when students experience their first peeks into the world of microorganisms and begin to realize just how relevant this subject is to them. After a short time our students become transformed into enthusiastic, budding scientists, requesting extra time in the laboratory or spending late hours in the computer room using the study guides and other aids.

They have been captured just as we were many years ago by this unique and fascinating science. It has opened up lines of questioning as current as today's headlines. Students want to know: Will there be an AIDS vaccine? How are microbes involved in global warming? How did a bacterial infection cause my grandmother to go into shock? What do we know about the viral epidemic in Africa? Could we really clone dinosaurs? What is an oncogene? It becomes clear that this subject is required as part of a curriculum because it is the first step in training. This training extends far beyond your future professions—it extends into all areas of human endeavor. Microbiology offers something for everyone, and it cultivates informed citizens who can make perceptive decisions on important events.

The extent of the impact of microorganisms is very broad indeed. It includes not only their roles in disease, but in industry, ecology, and the very functioning of the earth itself. In the three years since our first edition, the field has continued to expand at a very rapid pace, necessitating hundreds of changes in this book and requiring updating right up to the time of printing. Such a huge volume of information is constantly emerging from the scientific literature that no elementary text can do it justice. Just in the past year, for example, the world witnessed several outbreaks of old and new diseases; the research community explored anatomy and physiology of microorganisms to an astounding depth; and new developments occurred constantly in the areas of bioengineering, immunology, and medical applications. The

rapid pace of discovery dictates a somewhat selective inclusion of new material. Overall, we have aimed to present a balanced coverage of traditional and “cutting edge” microbiology.

TEXT PHILOSOPHY AND ORGANIZATION

Our purpose in writing this text has remained unchanged from the original: to present microbiology in a dynamic, comprehensible way. It is our hope that it helps you learn the fundamentals of microbiology, and that it challenges you to expand and refine your knowledge as you progress from the earlier to later chapters. Along the way, we want you to appreciate its complexity and practical applications, but we also hope you have a little fun while you are at it.

The order and style of our presentation is fundamentally the same as the previous edition, but it incorporates numerous small and large changes. To list them all would require several dozen pages. We have extensively updated figures and statistics, and introduced pertinent events occurring since 1993. Owing to the current emphasis on molecular biology and the role of microbiology in medicine and industry, we added an entirely new chapter (10) on DNA technology, which follows the chapter on microbial genetics. We also recognized the importance of having a separate chapter on laboratory techniques for studying microbiology, and we placed this information, along with a section on media, in chapter 3. Several users suggested that we break certain longer chapters into two smaller ones. We divided specific mechanisms of immunity and applications of immunity into separate chapters (15 and 16), and the bacilli of medical importance into gram-positive bacilli (19) and gram-negative bacilli (20).

These changes added four chapters to the original 22, but without notably increasing the size of the text. We were able to make room for new text and visual aids by carefully rewriting for greater conciseness and by eliminating a few figures and the small boxes. This also made it possible to significantly redesign the text and reformat the headings, tables, and boxes to increase their readability.

We have retained many of the features that readers appreciated, such as same page call outs of terminology and pronunciation, readable writing style, chapter openers, boxed readings, and

end-of-chapter summaries and questions. We hope our light-hearted analogies, models, and figures continue to catch your attention and imagination and stimulate your learning.

OVERALL PLAN OF TEXTBOOK

- Outline
- 26 chapters
- Appendices A–F
- Glossary
- Index
- End sheets

OUTLINE

Two outlines are provided: a brief format that lists the chapters, and an expanded outline that contains the major chapter headings.

CHAPTER ORDER AND CONTENT

The order of chapters is arranged to build a foundation of necessary subject matter that prepares the students for multidisciplinary concepts in later chapters and in their professions. Most chapters provide bi-level coverage that allows an instructor to teach the topic at a generalized level and to include subordinate ideas if so desired. We spent considerable effort to present ideas in an order that naturally flows from one concept to the next.

The chapters are clustered together in related core groups. Chapters 1, 2, and 3 introduce and reinforce essential basics such as history, the scientific method, classification, chemistry, cells, laboratory techniques, and microscopy. The next three (chapters 4, 5, 6) introduce the structure, life cycles, and physiology of the major groups of microorganisms (procaryotes, eucaryotes, and viruses). Chapters 7, 8, 9, and 10 introduce the concepts of nutrition, metabolism, genetics, and genetic applications. Chapters 11, 12, and 13 deal with microbial control measures, chemotherapy, and host-parasite interactions and epidemiology. Chapters 14, 15, 16, and 17 cover host defenses and immunity, and range from general systems of immunity, specific mechanisms of immune reactions, applications of immunity (vaccination and immune testing), and diseases of the immune system.

The basic principles version of the text contains only the first 17 chapters. The complete version starts off the second major block of chapters with a section called “Introduction to Medical Bacteriology” that summarizes techniques in clinical identification and prepares the student for the subsequent chapters on major infectious diseases. The remaining chapters are organized according to major microbial groups. Chapters 18, 19, 20, and 21 cover the bacterial diseases; chapter 22 deals with the fungi; chapter 23 discusses the parasites (protozoa and helminth worms); and chapters 24 and 25 survey the DNA and RNA viral diseases. The final chapter (26) explores ecologic microbiology and the roles of

microorganisms in the natural world; and applied or industrial microbiology, which considers the uses of microorganisms in commercial production.

APPENDICES

The six appendices appearing in this edition include the following: appendix A, important charts; appendix B, exponents; appendix C, methods for testing sterilization and germicidal processes; appendix D, universal blood and body fluid precautions; appendix E, answers to the multiple choice questions; and appendix F: classification of major microbial disease agents by system affected, site of infection, and routes of transmission. Appendix F is new with this edition and has been added to the text in response to many requests. It is a series of color-coded tables that cross-reference the major bacterial, fungal, parasitic, and viral agents and diseases by affected system and mode of transmission.

GLOSSARY AND INDEX

The glossary includes about 650 entries that define the most prominent terms used in the text. The index is also an excellent tool for locating terms and concepts. With its >4,000 listings, it is an extensive and valuable tool.

END SHEETS

Inside the covers are end sheets with printouts from the Centers for Disease Control and Prevention (CDC). The front cover tabulates the latest summary data from 1994 for major reportable infectious diseases in the United States, listed by region and state. Since summary data from 1995 are not yet published, this is the most recent information available. The back cover presents a summary table of disease incidence in the United States from 1984 to 1993 and tables and graphs on AIDS and rabies.

CHAPTER ORGANIZATION

Each chapter is organized on the same master plan, as itemized below.

- Chapter opener (statement, figure, outline)
- Body of text with figures, A-B-C-D headings, tables, charts, microfiles, chapter checkpoints, and highlighted terms
- Chapter capsule summaries with key terms
- Questions section (four types of questions)

DETAILS OF CHAPTER STRUCTURE

Opening Page

The first page of each chapter lays out the primary content by means of a short opening statement, story, or description; it presents a photograph or drawing that focuses on an intriguing chapter topic; and it contains an outline of the major chapter headings.

Figures

The text was developed with a comprehensive, customized illustration program of over 650 drawings and photographs. About 100 of these are new additions to this edition. The majority of illustrations were originally designed by Kathy Talaro to complement the written text. The photographs and micrographs were chosen for their clarity and uniqueness. Considerable attention was given to the use of leader lines to highlight important points, to legends that support the text, and to careful use of color.

Multimedia-supported illustrations: Throughout the text the reader will find *illustrations* of microbiological concepts and processes that can be supplemented with full-color video, animations, or interactive screens from *Microbes in Motion* (0-697-24596-9), the interactive CD-ROM available from Wm. C. Brown Publishers. The reader will be able to easily recognize these figures, as the figure legends are preceded by a CD icon. Figure 5.22, page 143, is one example of such an illustration.

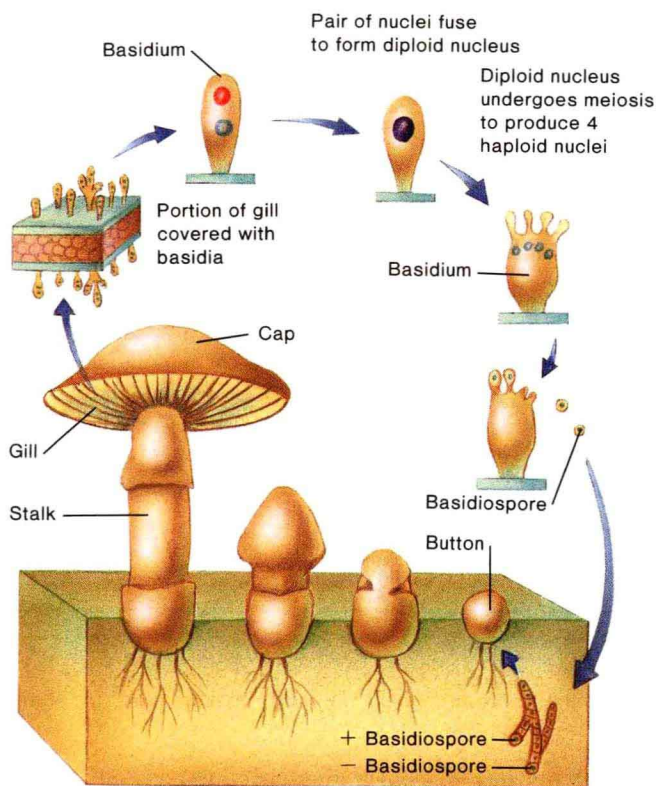


Figure 5.22



Formation of basidiospores in a mushroom.

Correlation guide to *Microbes in Motion*: To facilitate finding the corresponding information on the *Microbes in Motion* CD-ROM for the multimedia-supported illustrations described above, a correlation guide is provided following the preface. The *Microbes in Motion* CD-ROM is organized into 15 topical “books,” the books are divided up into “chapters,” and the chapters have numbered “pages.” For each multimedia-supported illustration the correlation guide directs the reader to the book,

chapter, and page on the CD-ROM where corresponding material can be found. The correlation guide entry is shown here for the multimedia-supported illustration, Figure 5.22, referred to earlier.

Figure 5.22 Fungal structure and function; Metabolism and growth/Fungal reproduction p. 22

Headings

The body of the text is organized into sections by means of headings. In keeping with our intention to lay foundations, levels extend from the major A and B headings in larger type that demarcate general areas of discussion to C and D headings in medium type that enlarge on essential details.

Tables and Charts

The text contains approximately 120 tables and charts. Some are formatted as summaries of support information and comparisons of processes or microbial groups. Notable examples include illustrated tables that combine pictorial analyses with data; micromaps, which present information in the form of flowcharts; and bulleted lists of important characteristics.

Microfiles

Boxed readings in this edition are called microfiles.* These are reports of special interest on topics that relate to the textual material. Your instructor may assign these to you as part of the information in the chapter or they may be considered enrichment readings of historic or current interest. Many of these are revised versions of feature boxes from the 1st edition; 20 of them are entirely new. The topics are organized by stylized icons into the categories of:



History



Immunology



Biotechnology



Spotlight



Genetics



General Topics



Medical Applications

*Please note that when spelled “microphile,” it means a person who loves microbiology!

Chapter Checkpoints

Each chapter contains several boxed synopses called chapter checkpoints that concisely state the most important ideas under major headings. These “rest stops” give the reader quick recaps of

what has been covered to that point and may be used with the chapter capsules as a general review. An example of a Chapter Checkpoint box from page 355 has been reproduced here.

Chapter Checkpoints

Antimicrobial chemotherapy involves the use of drugs to control infection on or in the body.

Antimicrobial drugs are produced either synthetically or from natural sources. They inhibit or destroy microbial growth in the infected host. Antibiotic drugs are the subset of antimicrobials produced by the natural metabolic processes of microorganisms.

Antimicrobial drugs are classified by their range of effectiveness. Broad-spectrum antimicrobials are effective against many types of microbes. Narrow-spectrum antimicrobials are effective against a limited group of microbes.

Antimicrobial therapy involves three interacting factors: the drug, the microbe, and the infected host.

Two genera of bacteria and two genera of fungi are the primary sources of most antibiotics. The molecular structures of these compounds can be chemically altered to form additional semi-synthetic antimicrobials.

Vocabulary

Biological sciences like microbiology require a strong grasp of terminology. This can be greatly reinforced by teaching elements of word origins and pronunciations. We present the principal vocabulary terms in boldface and italics. The first time a term appears, it is defined or used in context in the text itself. Most of these terms are denoted by asterisks or by numbered footnotes that describe word origins, pronunciation, or explanatory information. A guide to phonetic pronunciations with examples as used in this text is shown in the table on the right.

Chapter Capsules with Key Terms

Chapter content is condensed into columnar summaries called capsules. These encapsulate the main information in the chapter in the form of short statements and descriptions. This format places the key terms in context rather than merely listing them.

Self-test Questions

Each chapter concludes with an extensive section containing four types of questions. These are intended as a valuable means of self-study and self-testing. The number and types of questions are sufficient to allow your instructor to select and assign questions only from those areas he or she would like to emphasize. Questions that contain several parts are differentiated by letters so that all or part of a question may be answered. Due to space constraints, the text contains answers only to multiple choice questions (in appendix E). A guide for answers to all other questions will be made available to instructors.

GENERAL GUIDE TO PRONUNCIATION AS USED IN THE TEXTBOOK

| Letter | Pronounced | As in | Example in text |
|--------|---------------|-----------|--------------------------------|
| A | ah | fat | bacteria (1st a) |
| | ay | day | lipase |
| | uh | along | schistosoma, bacteria (2nd a) |
| AE | ee | | archaebacteria, salmonellae |
| C | see | cease | cellulase |
| cc | kay | cat | anaerobic, procaryote |
| | kay, then see | | vaccine, cocci |
| Ch | kay | chorus | chemotherapy, spirochete |
| | ch | chest | chickenpox |
| | sh | chevrolet | chancere |
| E | ee | discrete | nucleus, gangrene |
| | eh | bet | cestode, mesosome |
| Er | ur | finger | thermophile |
| Eu | oo | leukemia | <i>Pseudomonas</i> , pneumonia |
| | yoo | | eubacteria |
| G | j | geologic | appendage |
| | guh | growth | glycolysis |
| I | eye | bite | halophile, spirochete, lipase |
| | ih | bit | facultative, aerobic |
| | ee | nutrient | <i>Mycobacterium</i> |
| O | aw | body | optical |
| | oh | cold | saprotroph |
| OI | oh-ee | oil | ameboid |
| oe | ee | | <i>Entamoeba</i> |
| oo | oo | mood | zoonosis |
| ox | ocks | pox | toxemia |
| Ph | eff | phase | staphylococci |
| Ps | sick | Psalm | <i>Pseudomonas</i> |
| S | ess | sense | spirochete |
| | zee | pleasure | <i>Blastomyces</i> , plasmid |
| tion | shun | mention | sporulation |
| ture | chur | furniture | denature |
| U | yoo | uniform | papule |
| | uh | cup | coccus |
| UR | yur | cure | purine |
| Y | y | why | mycosis |
| | ee | wary | leprosy |
| | ih | synthetic | Chlamydiales |

Multiple Choice Questions

These are a common type of objective questions for class testing and standardized exams, and they can rapidly assess your grasp of selected vocabulary and concepts. Since they do not exhaustively cover every fact, you may want to obtain one of the student study guides keyed to the text that contains additional objective questions. In general, multiple choice questions have only one correct answer, and this answer may be surmised by a process of eliminating the incorrect answers, and narrowing the choices down to one. Be aware that questions may be answered by choosing "both a and b" or "all of the above."

Many chapters contain matching questions constructed with a list of words and a list of numbered descriptions. With single matching questions, you choose a single description that fits a given word, and with multiple matching questions, you choose all descriptions that fit the words in the list.

Concept Questions

These are more detailed in content and are suggested as a “writing to learn” exercise. In many academic settings it is increasingly important to demonstrate scholarly and communication skills by writing in depth about course content. In our classes, it is a requirement for any subjects that are being used for transfer credit. These questions are based on the premise that to write clearly about a subject, you must have some knowledge of it. Writing is an excellent way to develop a sense of vocabulary and usage, and this inevitably leads to greater understanding and ability in expression.

We suggest you compose a logical, complete answer to each question or section that properly explains, discusses, diagrams, or compares the assigned topic. The information and terminology to answer these questions can be found in the main body of the text, figures, tables, and microfilm readings. Complete coverage of most concept questions will require several paragraphs.

Critical Thinking Questions

These take the student to a higher level of analysis. They test the ability to reason and solve problems that were not specifically outlined in the text. They assume some understanding of information in that chapter and earlier chapters, and they expect the reader to interrelate, integrate, and apply these concepts to scientific studies, case studies, and everyday practical settings. Several questions suggest that you perform demonstrations and even use your imagination and intuition to come up with plausible explanations and develop models. Many selections allow more than one interpretation and way to solve the problem, and there may not be an exact “correct” answer.

SUPPLEMENTAL MATERIALS FOR STUDENTS AND INSTRUCTORS

LEARNING AIDS

Student Study Guide

A *Student Study Guide* was prepared by Jackie Butler of Grayson County Community College. It contains study objectives, questions, activities, and test-taking strategies. Answers to the objective questions are included.

Computerized Study Guide (QuickStudy)

A *Computerized Study Guide* written by Dale Deslauriers of Chaffey College is available for IBM and Macintosh computers. It contains questions and answers, and will create a study plan with page references for the questions missed.

Microbes in Motion Interactive CD-ROM

Microbes in Motion is an interactive CD-ROM for Windows that brings microbiology to life. This easy to use tutorial can go from the classroom to the resource center to your students' own per-

sonal computers. *Microbes in Motion* brings discovery back into the learning and education process through interactive screens, animations, video, audio, and hyperlinking questions. The applications of this CD-ROM are only as limited as your good ideas.

Microbiology Study Cards

A set of 305, three-by-five-inch *Microbiology Study Cards* prepared by Kent M. Van De Graaff, F. Brent Johnson, Brigham Young University, and Christopher H. Creek features complete descriptions of terms, clearly labeled drawings, clinical information on diseases, and much more.

Student Study Art Notebook

This art notebook contains the 200 illustrations from the transparency set. With this notebook students no longer have to worry about whether they will be able to see leader lines and labels in a large lecture hall.

TEACHING SUPPORTS

An Instructor's Manual with Test Item File

An Instructor's Manual with Test Item File was developed by Donna Merrill, Great Lakes Community College. It contains a chapter summary, chapter outline, chapter checkpoints, and topics for discussion for each chapter. A list of transparencies and sources of audiovisual materials is also included. The Test Item File contains true-false, multiple choice, matching, and short answer questions to be used in compiling exams.

Overhead Transparencies

A set of 200 four-color transparencies of the most requested figures is offered to all instructors who adopt the text.

Microtest

A computerized testing service is offered free upon request to qualified adopters of this textbook. A complete test item file is available on computer diskette for use with DOS, Windows, and Macintosh computers.

TO THE STUDENT

This book was written with you in mind. Even with all the ancillary and instructional material to aid in your study, there is still no substitute for time spent with the text in reading, careful observation, repetition, self-testing, cooperative learning with other students or tutors, and even an old-fashioned idea—preparing flash cards. A former student of ours made over 800 of these small index cards covering the terminology and primary concepts. Her experience has been repeated by many other students. Flash cards are valuable in at least three ways: they force you to write down and use the words and concepts; they provide a readily portable means of studying the subject matter in small bites, which is an excellent way to retain information; and they can be carried along

and used as a method of self-testing when a word or question is placed on one side of the card and the definition or answer is placed on the other side. Spending an hour every day with flash cards is a far more effective way of learning than trying to absorb three chapters of material in a single 10-hour marathon.

The subject matter in this text is basic, but this doesn't mean it is simple or easy. Some of you come to this course with a biology and chemistry background; others will have little or no preparation. The text is designed to meet the needs of both types of students. Even for students with a strong science background, there is far more information in a text this size than can be covered in most courses. It contains a wide scope so that instructors may pick and choose the areas they would like to emphasize. Let your instructor and course syllabus be your guide to the order and selection of topics. Your instructor will also give specific reading and question assignments that support the aims of your particular course.

inspiration for new figures, boxes, and information, and they have helped to shape this book and give it a personality. We owe a debt of gratitude for the special insights they brought to this project.

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CORRELATION GUIDE TO MICROBES IN MOTION TO FOUNDATIONS IN MICROBIOLOGY

This correlation guide was compiled in order to assist you in integrating the information from *Microbes in Motion*, the interactive CD-ROM developed and published by Wm. C. Brown Publishers, into the textual material presented in this second edition of *Foundations in Microbiology* by Talaro and Talaro.

Microbes in Motion is an interactive tutorial that can be used by professors and students alike. This highly visual tutorial brings the study of microbiology to life through use of animations, video, audio, music interactive screens, and quizzes. Your understanding of microbiological concepts will be enhanced using this CD-ROM tutorial. In some cases, the discussions on *Microbes in Motion* will be different in level, emphasis, or presentation than those found in this textbook but this can actually enhance understanding.

You will encounter a CD-ROM icon  in figure legends throughout the text. When you see a CD-ROM icon be sure to refer to this correlation guide for corresponding information on *Microbes in Motion*.

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