MICROBIOLOGY
Principles and Applications

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Preface

A glance at any newspaper confirms the central role of microbiology in all of our lives. Will there be a vaccine for AIDS? Can genetically engineered bacteria be put to work cleaning up oil spills, or making anticancer agents? Can we continue to develop antibiotics faster than bacteria can evolve with resistance to them? Will yeasts solve the food shortages of the next century? Will other scourges follow smallpox into the history books, leaving the human race finally free of major epidemics—or will new killer diseases appear to take their place?

Such questions demonstrate that today, microbiology remains one of the most relevant of the sciences—relevant to many of our most personal concerns as well as those of our society and era. Microbiology has long been intimately involved with matters of life and death, and this is no less true in the age of AIDS than it was more than a century ago, when Pasteur was developing the first modern vaccines. But microbiology today is also on the cutting edge of scientific advance, as it was in the seventeenth century when Leeuwenhoek was making his simple microscopes and glimpsing the microbial world for the first time. Genetic engineering, for example, was born in the laboratories of microbiologists and spent its youth there; now, microorganisms still play a key role, even in work directed toward human cells. In countless areas, from agriculture to evolution, from ecology to dentistry, microbiology is both contributing to scientific knowledge and solving human problems.

Style, Organization, and Currency

This book is written chiefly for students of the health sciences, but it contains more than enough information to meet the needs of students majoring in biology. We have designed the book to serve the needs of both audiences by using an abundance of clinically important information to amplify and illustrate a thorough treatment of the general principles of microbiology.

We have made this text truly "user-friendly," in the belief that students who enjoy a course retain far more of its content for a longer period of time than those who take the course like a dose of medicine. We want students to experience microbiology as an exciting, dynamic, rapidly changing field that is important to human welfare. The development of microbiology—from Leeuwenhoek's astonished observations of "animalcules," to Pasteur's first use of rabies vaccine on a human being, to Fleming's discovery of penicillin, to today's race to develop an AIDS vaccine—has been one of the most dramatic stories in the history of science. The growth of our knowledge in recent years has done nothing to diminish the drama; microbiology is as intriguing now as it has ever been. There is no reason for a book to be any less interesting than its subject.

This book has deliberately been written in a simple, straightforward, functional style. Our aim is to make information as accessible as possible to students, not to dazzle or intimidate them. Throughout, we have emphasized the connection between microbiological knowledge and the students' personal experiences and career goals. It is this aim, as much as the demands of the microbiology curriculum, that accounts for the special attention we have given to the *clinical aspects* of microbiology and to public health issues.

In a field that changes so quickly—with new research, new drugs, and (unfortunately) new diseases—it is essential that a text be as up to date as possible. We have tried to incorporate the latest information, not just on clinical practice, but on all aspects of microbiology. Special attention has been paid to such important, rapidly evolving topics as genetic engineering (Chapter 8), drug resistance (Chapter 14 in particular), and nosocomial infections (Chapter 16). Chapter 19 contains an expanded Essay on AIDS, and topics related to this disease are treated in several other chapters as well.

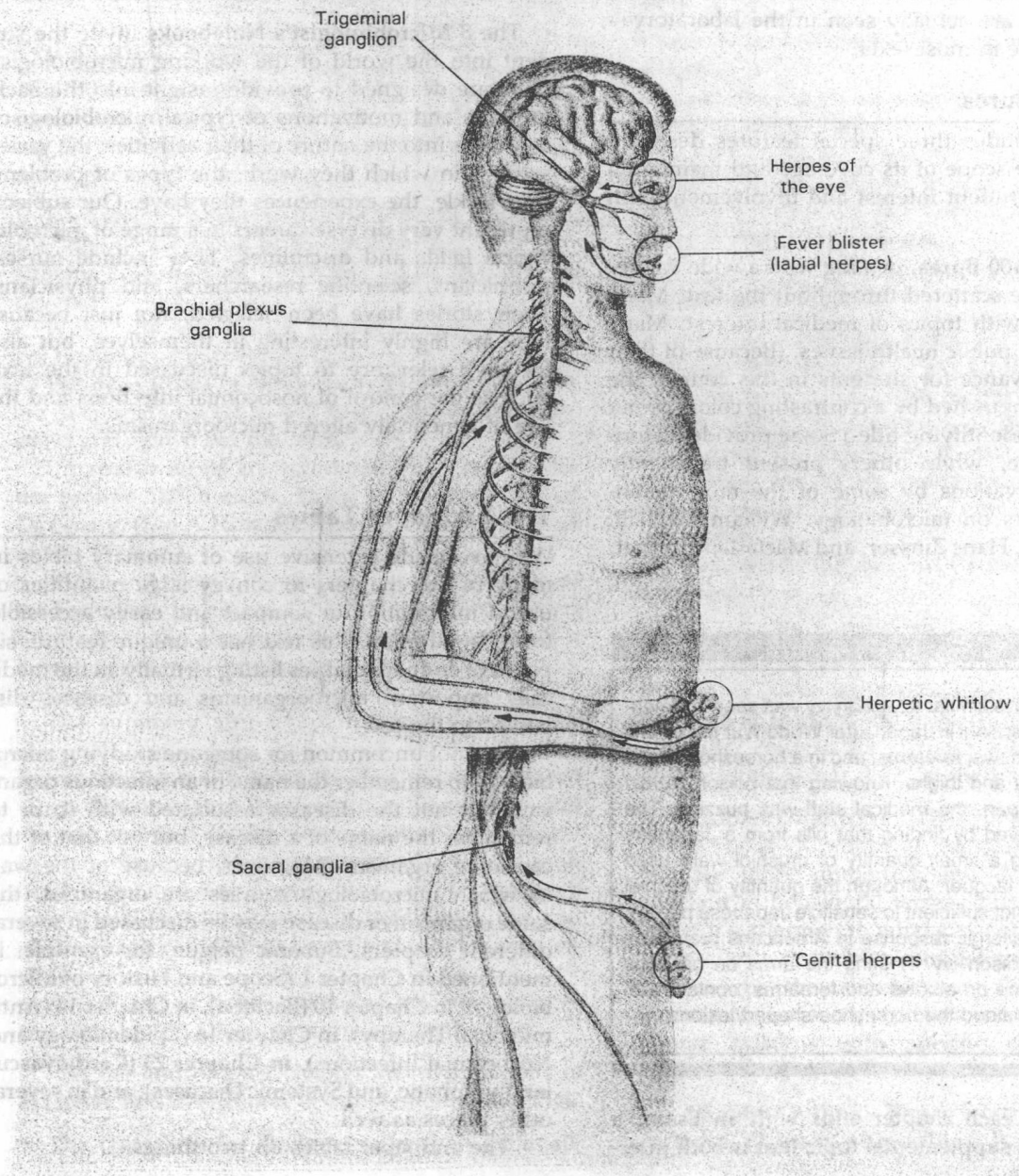
The organization of this text is designed to combine logic with flexibility. The chapter sequence is one that will be useful in most microbiology courses as they are usually taught. Nevertheless, it is not essential that the chapters be assigned in their present order; thus, it should be possible to use this book in courses organized along quite different lines. The first part of the book (Chapters 1–4) provides the basic information—on the nature of the microbiology, on chemistry, on microscopy, and on cells—that underlies the rest of the course. The second part (Chapters 5–8) deals with the metabolism, growth, and genetics of microorganisms. Including two chapters on genetics allows for a thorough treatment of such important topics as mutation and genetic engineering.

The third part (Chapters 9–12) comprises a survey of the major types of microorganisms, together with an introductory discussion of how they are classified.

The fourth part of the text (Chapters 13 and 14), devoted to control of microorganisms, includes material on physical control (sterilization and disinfection) and antimicrobial chemotherapy. The fifth part (Chapters 15–19) covers all aspects of the relationship between host and microorganism, including the disease process, epidemiology and nosocomial infections, nonspecific body defense mechanisms, and the immune system. Two chapters are allocated to immunology to permit a comprehensive discussion of immunization, immunologic tests, autoimmune disorders, and immunodeficiency diseases, including AIDS. The sixth part (Chapters 20–25) consists of a survey of infectious diseases, organized by the affected organ or system. Finally, the seventh part (Chapters 26 and 27) deals with environmental microbiology (including water pollution, water purification, and sewage treatment) and applied microbiology (including the microbiology of food).

The Art Program

Clear, attractive drawings and carefully chosen photographs can often make as great a contribution to the student's understanding of a scientific subject as the written text itself. We have been extremely fortunate to have the collaboration of an extraordinary artist,



William C. Ober, M.D., who has executed many of the illustrations for this text. Bill Ober combines technical skill with scientific understanding to a degree rarely found in even the best biological illustrators. The fact that all the drawings in this book are in full color has enabled us to make the maximum use of Bill's talents.

This book contains approximately 325 color drawings and some 500 photographs, the vast majority of them also in color. Throughout, color has been used, not just decoratively, but for its pedagogical value. For example, similar molecules or cellular structures are colored in the same way each time they appear, making them easier to recognize. The availability of color also makes it possible to present many subjects, such as staining reactions, more realistically—as they are actually seen in the laboratory—than is possible in most texts.

Special Features

This book includes three special features designed to broaden the scope of its coverage and maintain a high level of student interest and involvement with the material.

- More than 100 **Boxes**, dealing with a wide variety of subjects, are scattered throughout the text. Many of these deal with topics of medical interest. Many more focus on public health issues. (Because of their particular relevance for students in this course, the latter are distinguished by a contrasting color banner containing an identifying title.) Some provide historical perspective, while others present trenchantly phrased observations by some of the most distinguished writers on microbiology: William McNeill, Lewis Thomas, Hans Zinsser, and Macfarlane Burnet, among others.

Contact dermatitis similar to poison ivy was seen in American military personnel in Japan after World War II. Lesions appeared on elbows, forearms, and in a horseshoe shape on the buttocks and thighs. Knowing that poison ivy did not grow in Japan, the medical staff was puzzled. The puzzle was solved by finding that oils from a Japanese plant containing a small quantity of urushiol were used to manufacture lacquer. Although the quantity of urushiol in lacquer was not sufficient to sensitize Japanese people, it did elicit an allergic response in Americans previously sensitized to poison ivy. Resting the arms on bar tops explained lesions on elbows and forearms; contact with toilet seats explained the horseshoe-shaped lesions.

- The text of each chapter ends with an **Essay**, a discussion of a supplemental topic that is both interesting in itself and relevant to the content of the chapter. Some instructors may elect to treat these essays as integral parts of the text, while others may prefer to assign them as extra reading or make them optional for their students. Many of the essays deal with clinical subjects or public health issues ("Performing Multiple Diagnostic Tests," "Travel, Immigration, and Disease"); others develop chapter topics in greater detail ("More About Plasmids"); still others focus on current research or unsolved problems in microbiology ("Immunology of Cancer"). Chapter 19 contains a special extended essay on AIDS, which examines many aspects of the disease, including its epidemiology, the disease process and its clinical manifestations, the prospects for treatment or prevention, and the social, economic, and ethical problems that it has raised.

- The 8 **Microbiologist's Notebooks** invite the student into the world of the working microbiologist. They are designed to provide insight into the backgrounds and motivations of typical microbiologists, as well as into the nature of their activities: the varied settings in which they work, the types of problems they tackle, the experiences they have. Our subjects represent very diverse careers in a range of microbiological fields and disciplines. They include nurses, technicians, scientific researchers, and physicians. Their stories have been selected, not just because they are highly interesting in themselves, but also for their relevance to topics discussed in the text, such as the control of nosocomial infections and the use of genetically altered microorganisms.

The Endpaper Tables

We have made extensive use of summary tables in many of the chapters to convey large quantities of useful information in compact and easily accessible form. In addition, this text has a unique feature: six pages of **endpaper tables** listing virtually all the medically important microorganisms and diseases discussed in the text.

It is not uncommon for someone studying microbiology to remember the name of an infectious organism, but not the diseases associated with it; or to remember the name of a disease, but not that of the causative organism. Moreover, because of the way in which microbiology courses are organized, the same organism or disease may be discussed in several different chapters. Bubonic plague, for example, is mentioned in Chapter 1 (Scope and History of Microbiology), in Chapter 10 (Bacteria), in Chapter 14 (Antimicrobial Therapy), in Chapter 16 (Epidemiology and Nosocomial Infections), in Chapter 23 (Cardiovascular, Lymphatic, and Systemic Diseases), and in several other places as well.

The endpaper tables do two things:

- They reinforce the association between diseases and their causative organisms.
- They make it easy for a student to find the various sections of the text that deal with a particular organism or disease.

The front table lists all the major infectious diseases discussed in the text, their special features, the organisms that cause them, and the text pages on which each is discussed. The back table lists all the major organisms discussed in the text, classified by type (bacteria, viruses, etc.), with their distinguishing characteristics, the diseases that they produce, and the relevant text pages. These tables are a valuable learning tool in their own right, while also enhancing the usefulness of the text for students and instructors.

Pedagogical Apparatus

This book is designed, not simply as a vehicle for transmitting information, but also as a tool for learning. To that end, we have incorporated a set of coordinated pedagogical features.

- Each chapter begins with a list of **Focus Questions** that define the scope of the chapter and offers the student a preview of the major topics that will be covered.
- Within the text of each chapter, **important terms** are highlighted in boldface type.
- The **derivations** of terms are given whenever they are of special interest or will help students to understand and remember the term.
- Unfamiliar terms are accompanied by an easy-to-use **pronunciation guide**, based on *Stedman's Medical Dictionary*. (See A Note on Pronunciations at the end of this Preface.)
- At the end of each chapter, there is a concise **Chapter Summary.** Inclusion of the first- and second-level headings in the summary provides students with a quick overview of the chapter's structure, facilitating review.
- The summary also makes it easy to review the essential terminology introduced in the chapter. Terms that are boldfaced in the chapter are boldfaced when they appear in the summary. Those terms that are not included in the summary itself appear next to the relevant summary passage in the column headed **Related Key Terms.** Thus, all of a chapter's core vocabulary is repeated in boldface at the end of the chapter, visible at a single glance for easy review.
- Definitions of boldfaced terms are assembled in the alphabetical **Glossary** at the end of the text.

At the end of each chapter are two sections of exercises and a selection of supplemental readings.

- **The Questions for Review**—more than 700 in all, an average of more than 26 per chapter—are grouped into sections that correspond to the Focus Questions at the start of each chapter. They test the student's mastery of the factual information presented in the chapter.
- The **Problems for Investigation** typically call for more extended answers, often in the form of an oral report or an essay. They demand more thought and generally require the synthesis of information from several parts of the chapter, from several chapters, or sometimes from sources outside the text.
- The section called **Some Interesting Reading** lists books and articles that provide additional information about topics discussed in the chapter.

Four **Appendices** are provided to assist the student:

- a concise guide to the **metric system** and **scientific notation;**
- a summary of the standard **classification** of bacteria based on *Bergey's Manual;*
- a listing of **word roots** important for the student of microbiology, together with their meanings;
- guidelines for the safe collection and handling of **microbiological specimens.**

Instructor's Edition

A specially augmented **Instructor's Edition** of this text is available to enhance its usefulness as a teaching tool. For each chapter, the Instructor's Edition provides a wide range of supplemental material, designed (1) to assist the instructor in teaching the text, and (2) to allow for deeper and/or more extensive treatment of various topics should time and student interest permit.

Included in the material for each chapter are the following:

1. Chapter Overview The overview explains the organization of the chapter and summarizes its main themes. It is not a recapitulation of facts; rather, it is intended to place the material of the chapter into a broader context. Its purpose is to focus attention on the forest rather than on the trees.

2. Chapter Objectives These objectives are related to the Focus Questions at the start of each chapter, but are more numerous and detailed. They are couched in behavioral terms, thus directing the instructor's attention to what students ought to be able to *do* after successfully completing each chapter, as well as what they should know. (This feature is also a convenience for instructors who must prepare a course syllabus with specific chapter-by-chapter goals.)

3. Chapter Outline This is a complete outline that includes all levels of headings. It also indicates the

location of all Boxes, Figures, and Tables in the text for easy reference.

4. **Instructional Suggestions** A diversity of material is included in this extensive section:

- *Demonstrations* for class use;
- *Teaching Tips*, including suggestions for interesting examples and analogies, points to emphasize, questions and exercises for class use, effective ways to explain topics that students find especially difficult, and the like;
- *Discussion Topics* to stimulate student interest;
- *Library Assignments* suitable for student papers or oral reports;
- *Laboratory Correlations*, a list of those exercises from the Laboratory Manual that are relevant to the chapter material.

5. **Audiovisual Suggestions** This section includes lists of relevant films, videotapes, filmstrips and slides, and computer software.

6. **Review** This section contains complete and detailed answers to all end-of-chapter Questions for Review and Problems for Investigation.

Supplements

To supplement your needs—and theirs—the following materials are available:

- **Instructor's Edition** with the Instructor's Manual bound to the front cover. Includes outlines, objectives, suggestions, tips, activities, and answers to all text questions. Free upon adoption.
- **Test Item File** with approximately 1,000 questions—all referenced to chapter number and section. Free upon adoption.
- **Prentice Hall Data Manager**—the latest in state-of-the-art classroom management software. This complete instructor productivity package consists of three parts:

1. **Test Manager** allows you to both edit and add test questions to the Test Item File and assemble and save tests both manually and randomly. Additionally, two test-scrambling options combine to give you a virtually unlimited number of different scrambled versions of your tests. Available in both IBM and Apple versions.
2. **Grade Manager** is an electronic gradebook which merges flexibility, power, and ease-of-use. With it you can easily maintain and update class records, compute class statistics, print graphs, average grades, and sort by student name or grade. Available in IBM version only.
3. **Study Manager** draws questions from a computerized study guide bank so you can randomly create different quizzes every time it's used. Available for both IBM and Apple.

- **Telephone Testing Service** allows you to select questions from the Test Item File, call a toll-free number, and have the test prepared in-house at Prentice Hall with no additional charge. Within 48 hours, a professionally prepared test will arrive at your school, along with an answer key and answer sheets for your students. Up to two versions of a test will be furnished.
- **Laboratory Manual** to accompany *Microbiology*, prepared by Stephen A. Norrell. This manual contains practically every exercise that might be used in an intro lab (close to 30), and provides such extensive, clearly written background material and helpful pedagogical aids for each chapter that students do not have to consult outside sources during their lab work.
- **Instructor's Edition to the Laboratory Manual** with answers to all of the exercises.
- **Transparency Pack with 150 full-color acetates;** demo transparencies are available inside the Instructor's Resource Package. Free upon adoption.
- **150 full-color slides** from the book plus 50 other slides—25 gathered from outside sources and 25 of drawings from the book reproduced without labels for quizzing students. Demo slides are included inside the Instructor's Resource Package.
- **Study Guide** with chapter overviews, self-tests, key terms, and case studies.
- **Interactive Glossary** which drills students on vocabulary and word roots covered in the microbiology course; software is available for IBM and Apple computers and a demo is available from College Software and inside the Instructor's Resource Package. Free upon adoption.
- **Pronunciation Tapes** feature a review of key terms with their pronunciation and drills students on definitions of key terms.

A Note on Pronunciations

The scheme used for pronunciations is simple:

' is used for the main accent in a word;

" is used for the secondary accent, if any;

any vowel not followed by a consonant is assumed to be long;

any vowel followed by a consonant is assumed to be short unless it has a macron (bar) over it, in which case it is long;

syllables are separated by either a hyphen or an accent mark.

Acknowledgments

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Comments and suggestions about the book are most welcome.

J.G.C.
J.G.B.
V.E.D.

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