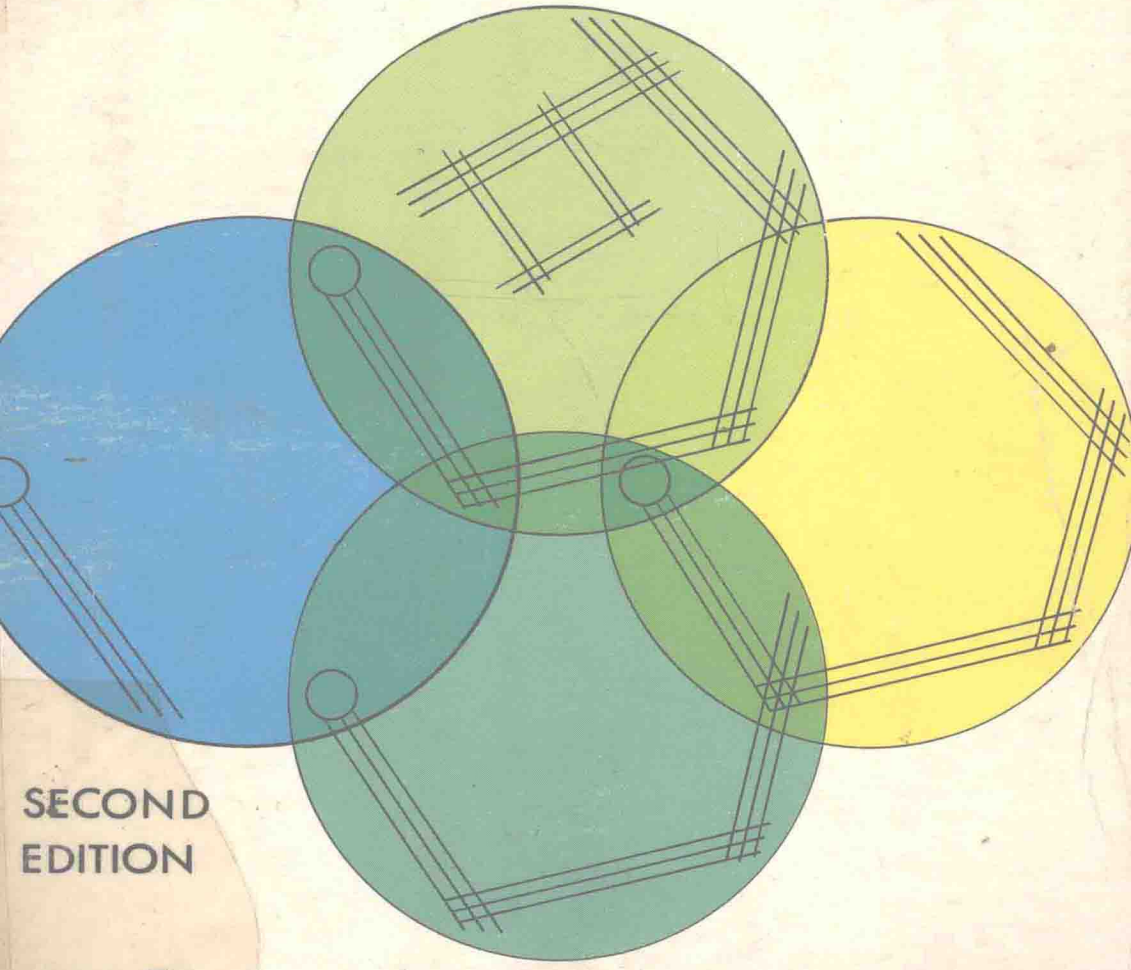
Microbiology

for the allied health professions



SECOND EDITION

Adrian N.C. Delaat

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for the Allied Health Professions

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Adrian N. C. Delaat, A.R.T.

Coordinator, Laboratory Medicine Education
Provincial Laboratory and X-Ray Services Division
Manitoba Health Services Commission
Winnipeg, Manitoba, Canada

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PREFACE

Choosing a microbiology text for students of the allied health professions is not an easy task. Although various books are available on the subject, none seems to fulfill the particular needs of the allied health professionals. Many microbiology texts offer an array of general information useful to the average undergraduate who has not yet selected a specialty, but mention little of the information most pertinent to health professionals. Other texts are directed to the medical student, who is more interested in clinical data than in technique, and consequently, these books contain much about disease syndromes and their management but little about the technical aspects of microbiology. Finally, there are several highly specialized texts that go far beyond the needs and comprehension of the average student of the allied health field.

The primary purpose of this book is to present the practical and elementary theoretic aspects of medical microbiology to the average high school graduate. As such, it offers a gentle exposure to what is often considered to be a difficult subject. I sincerely hope that it will whet the students' appetite for this fascinating subject, nourish them to the extent that they develop a healthy attitude toward microbiology, yet not stifle their enthusiasm with a diet too rich in content.

The first edition of this book was well received by members of the allied health professions. This response confirmed my belief that a book of this depth and breadth filled a need of these professionals. Thus, the second edition has been prepared with the same goals in mind as the first edition, but with the benefit of adding up-to-date information and culling out the inevitable mis-

takes. The classification of bacteria and the chapter organization in this edition have been completely rearranged to conform with that of the eighth edition of *Bergey's Manual of Determinative Bacteriology*. Such an arrangement should assist serious students in following up laboratory work related to identifying bacteria. New tables and charts that provide guides to the identification of organisms appear throughout the text; these revisions were made necessary by the new approach to classification and by the development of new information and techniques.

Compared to the first edition, more emphasis has been placed on the pathogenicity of various microbes. The information contained in the chapter on "Diseases Caused by Microbes" in the first edition has been enlarged to the extent that it now constitutes two substantial chapters: "Infectious Diseases" and "The Control of Infectious Diseases." The chapter on "Quality Control" was changed dramatically to reflect more clearly the current practices in that field. Outdated methods have been deleted and new ones incorporated.

Many contributed to the compilation of this book. I invite criticism and comment. Credit must go to my students who emphasized the need for a book such as this and who helped me to bring the various aspects into proper perspective, and to several colleagues who gave freely of their time and talents to critique early drafts and manuscripts. Dave Morrissey did the drawings for Chapter 22 and several others, Dorothy DiRienzi of Lea & Febiger was a most competent copy editor, and my wife Louise continued in her willing support.

Winnipeg, Canada — Adrian N. C. Delaat

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Part I
GENERAL MICROBIOLOGY

chapter 1

Introduction

"Read not to contradict and confute, nor to believe or take for granted, but to weigh and to consider."

These words by the sixteenth century philosopher, Sir Francis Bacon, aptly describe what should be the credo of the modern microbiologist. Few branches of the natural sciences have seen such rapid change as has the discipline of microbiology. The literature on hand, therefore, is full of apparent contradictions. Although the student may be baffled by such contradictions, he should not be alarmed by their existence. When he realizes that such contradictions stem from the rapid evolution of the discipline of microbiology, the keen student will welcome them as necessary evils, and will soon learn that the discipline is an interesting and rewarding area of study. Only recently has microbiology begun to emerge as a true and undisputed science. Before it reaches the stage of an exact science, many more contradictions will be committed to print. Therefore, if some statements in this text appear strange in comparison with other texts, please do not discard the statement as a fallacy. Consider: Is the statement of an earlier or later vintage than the one it contradicts? What is the context in which the statement is used? Does only hypothesis, or do proven experimental data back up the statement? Finding answers to such questions will not always be easy. By attempting to understand the

principles involved rather than by memorizing the facts as stated, the student will soon find his way through the maze of statements and be able to sort out the proven fact from the postulated hypothesis. Only by raising further questions will the student become a participant in, rather than a spectator of, the discipline under study.

At the outset of your study of microbiology, I would like to allay two widespread misconceptions: First, not all microorganisms are harmful. On the contrary one only has to think of those organisms responsible for the making of cheese, wines, drugs, and many other useful products to refute this common belief. In fact, the beneficial microorganisms far outnumber the harmful ones.

Secondly, working with microorganisms, even with pathogens, is far less hazardous than driving a car. Of course, we must learn to respect certain dangers that are inherent in working with infectious material, just as drivers have to respect and obey traffic laws to ensure safety on the road. Most traffic accidents are caused by careless drivers and not by road hazards; so too, careless workers cause most accidents in the laboratory.

Your instructor will undoubtedly brief you on safe practices in the laboratory. It is your task to heed his instructions in order to protect yourself, your fellow workers and your community.

The simplest definition of microbiology is: "the science that studies microscopic organisms." This definition, of course, is too general and requires further clarification. By microscopic organisms we mean all living things that cannot be seen by the unaided eye. Microbiology involves a study of many aspects of the other life sciences. Because of its tremendous scope, various branches of microbiology have developed, each serving a specific interest. Bacteriology is the study of bacteria and rickettsiae; virology, the study of viruses; mycology, the study of yeasts and molds; parasitology, the study of parasitic animals.

These specialties have been subdivided even further. Many specialities devote most of their efforts to small groups of special organisms or to a certain area of study. For example, a plant bacteriologist limits his main interest to bacteria associated with plants; a veterinary virologist studies viruses that cause diseases in animals; and a brewmaster specializes in the study of yeasts related to the fermentation process. We could go on and on.

As a member of the allied health professions, you would, of course, be mainly interested in those organisms that cause disease in man—the pathogens. This area of microbiology is known as medical microbiology. Medical microbiology can be defined as the

study of infectious diseases and their laboratory diagnosis. As such, medical microbiology includes the study of the treatment, control and prevention of infectious diseases. This elaboration brings us to two other sciences, immunology and epidemiology. Immunology is the study of the mechanisms by which the body reacts to "foreign" invaders. Epidemiology is the study of the distribution, spread and control of diseases.

By now you realize that medical microbiology is an extremely diverse field. In order to guide you through the maze of information about this subject in an intelligent and orderly fashion, this book has been divided into four parts.

Part I provides an introduction to the basic principles, theories and terminology of microbiology in general.

Part II deals specifically with various groups of microbes that are of medical interest. This systematic presentation allows you to study the microbes piecemeal, so to speak.

Part III introduces you to diagnostic microbiology, which involves the collection and analysis of specimens in order to detect and identify microbes. Because it is impossible to present a diagnostic approach that suits every need, this section should be considered a general guide rather than a blueprint.

Part IV presents the specific methods, media and reagents that are referred to in the preceding chapters.

To further develop your interests, you should seek to coordinate your studies with practical exercises. Practice these exercises shortly after you have studied each area. This will help you to understand the subject better and will also make you appreciate the difficulties constantly encountered by all microbiologists.

FURTHER READING

1. Stanier, R. Y., Doudoroff, M., and Adelberg, E. A.: *The Microbial World*, 3rd ed., Englewood Cliffs, N. J.: Prentice-Hall, 1970.
2. Wolk, C. P.: Physiology and cytological chemistry of blue-green algae, Bact. Rev., 37:32–101, 1973.

chapter 2

Brief History of Microbiology

It is difficult to state when microbiology actually began. Did it begin with the first description of microbial disease? If so, we must go back to the early Chinese scriptures. Did it begin with microscopy? Then, we must go back to the earliest lens grinders. We shall elect the latter as the beginning of microbiology.

2-1 THE DEVELOPMENT OF MICROSCOPY

Roger Bacon, a Franciscan monk, was the first to use two or more lenses as an aid to magnification in 1267. His lenses were reportedly of poor quality. During the middle of the sixteenth century, Hans Jansen perfected the art of lens making. Somewhat later, Robert Hooke brought lenses into practical use although it was not until late in the seventeenth century that anything resembling a microscope was devised. Antony van Leeuwenhoek, caretaker of the city hall in Delft, Holland, fancied the grinding of lenses as a hobby, and he built them into delicate instruments.

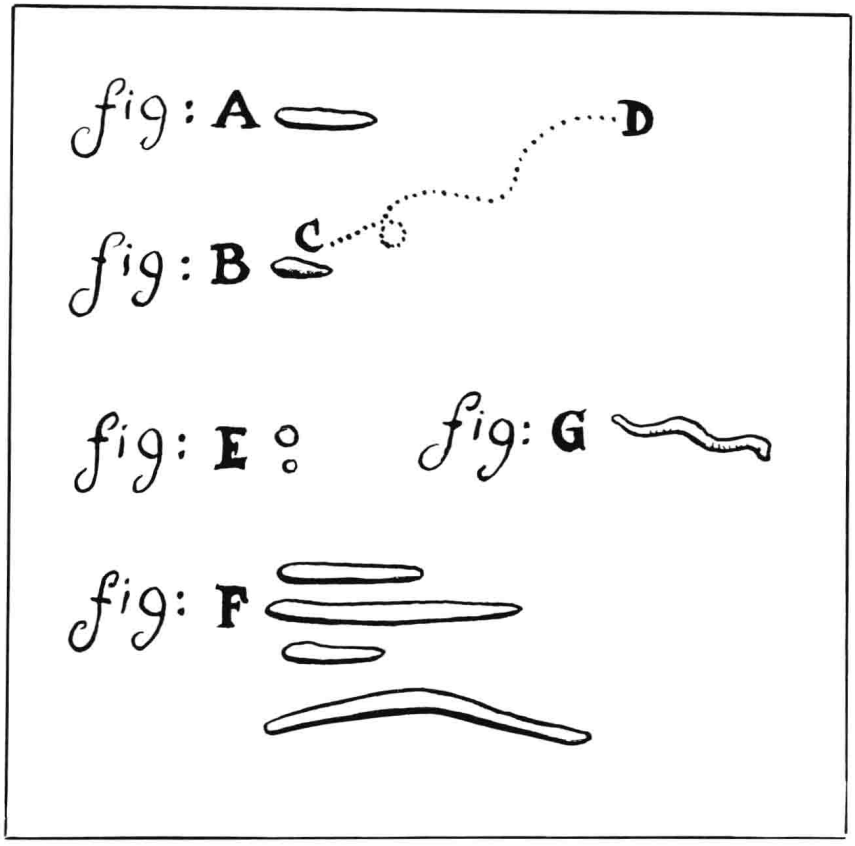

Fig. 2–1. These drawings of microorganisms from the human mouth were made by Antony van Leeuwenhoek in 1683. The dotted line, *C–D*, depicts the path of motion of the organism shown in drawing *B*.

Furthermore, he utilized these instruments to study an almost unlimited variety of specimens (see Fig. 2–1), and thus he discovered microbes of all descriptions. Moreover, he devised a few simple experiments to prove that hot water killed some of his "little beasties." Leeuwenhoek lived from 1635 to 1723, perfecting his microscopes so that the best would magnify up to 270 times.

In the following century, Ernst Abbe (1840–1905) developed a useful condenser, and Edison invented the electric light. Utilization of these two developments allowed magnifications of up to 1200 times, which is still the limit of the modern compound microscope utilizing ordinary light. During the 1920s, the use of ultraviolet light permitted slightly higher levels of magnification.

The greatest stride forward in microscopy, however, came in the 1930s with the invention of the electron microscope. Perfection of this instrument presently allows us to utilize working magnification of 30,000 to 90,000 times.

2-2 THE ORIGIN OF LIFE

Around 350 B.C., Aristotle wrote: "Animals sometimes arise in soil, sometimes in plants, and sometimes in other animals." Even today, some tribal cultures still believe that bees originate from the horns of bullocks buried in the mud. In the second half of the seventeenth century, Redi set out to prove that all living things have parents and that the theory of spontaneous generation was false. Redi simply covered spoiling meat with cheesecloth, thereby preventing flies from depositing eggs on the meat and hence the emergence of flies from the meat. While Redi's experiment refuted the belief that flies could originate spontaneously from putrid meat, it far from destroyed the idea of spontaneous generation altogether. Surely, proponents of that theory claimed, the microbes originate spontaneously.

Lazarro Spallanzani (1729–1799), on reading about Redi's work, was one of the few who believed that all living things, even the microbes, must have parents. In order to prove his belief, Spallanzani carried Redi's experiment one step further. He boiled mutton gravy and showed that, as long as the boiled gravy was kept sealed from the air, no microbes would originate from it.

A controversy developed between Spallanzani and an Irish priest named Needham who, together with Count Buffon, claimed that Spallanzani's experiment had destroyed a "vegetative force" and "elasticity of air" which were necessary for the appearance of microbes. The notions of vegetative forces and air elasticity were finally disproved in similar experiments by Schroeder and von Dush in 1854, who used cotton plugs, and by Louis Pasteur, who used swan-neck flasks.

The important thing to remember is that even today many "facts" are derived from hypothetic statements that have little or no supportive evidence. Even if it is derived from careful experimentation and brilliant deduction, any scientific "fact" may be refuted in time by the emergence of new evidence.

2-3 THE DISCOVERY OF THE NATURE OF FERMENTATION

Charles Caignard la Tour, 1777-1859, was the first person to detect budding yeasts in ferments. He referred to them as living