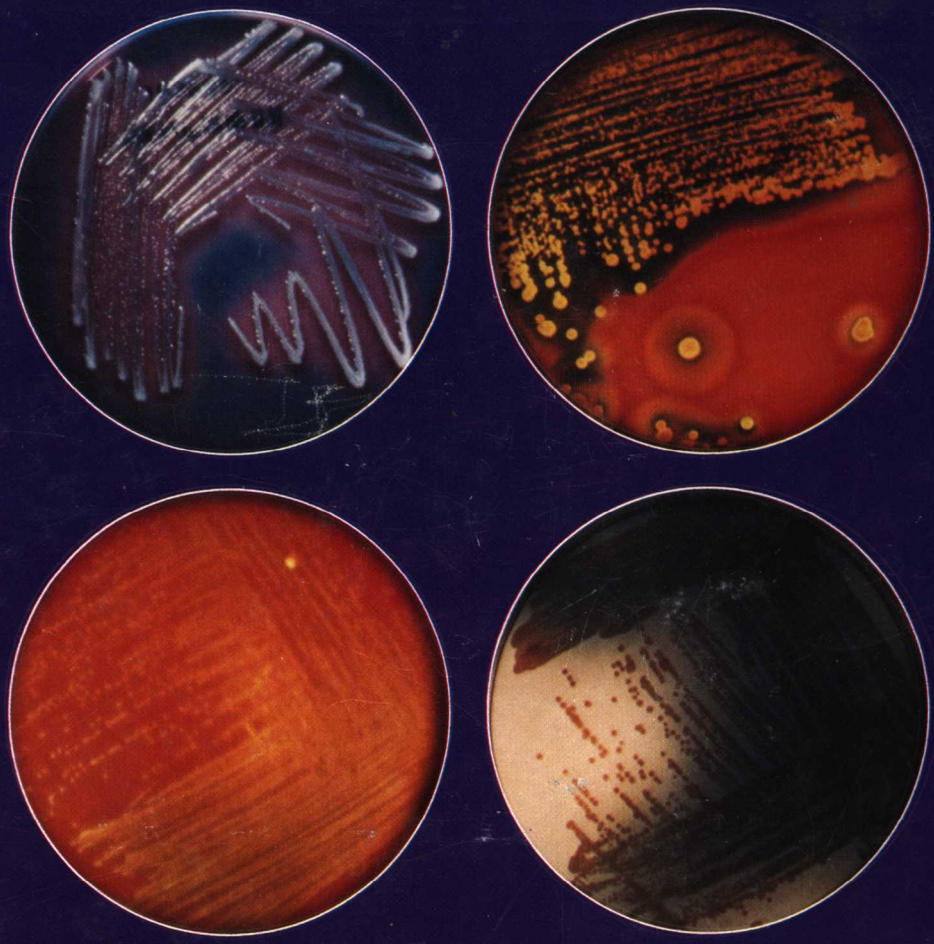

LARRY McKANE / JUDY KANDEL

# MICRO-BIOLOGY

## Essentials and Applications

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# MICRO-BIOLOGY

## Essentials and Applications

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# Preface

This book is intended for use by all undergraduate students, including those who plan to pursue careers in fields other than microbiology. We have therefore tried to write a book that is stimulating and enjoyable for students majoring in any aspect of science and the health-related fields. We feel this is best accomplished by following guidelines of clarity and brevity. Writing a short book is in many ways more difficult than writing a long one. The decisions to omit some material traditionally found in microbiology texts were often agonizing (it hurts to throw out one's microbiological pets). These decisions were carefully considered to avoid sacrificing the academic concepts necessary for thorough understanding and for practical implementation of microbiological principles. We tried to find a balance that will challenge the student without intimidating, thereby reducing anxiety and increasing learning efficiency. We hope this book generates sufficient interest that students will continue to informally study microorganisms long after they finish this class.

Our goals are to not only convey an important body of knowledge, but to share with the reader our fascination and excitement about microorganisms and the science that studies them. In this way we hope we can help students develop respect for microorganisms, for their vast number of beneficial activities as well as for their enormous potential to cause human suffering. This book should help students realize that, regardless of their career plans, microorganisms will continue to affect their lives in many notable ways. We have tried to create a book that helps students better recognize the problems created by the presence of microbes (as well as the solutions to these problems), and to personally modify their behavior as the result of intelligent consideration. Knowing the microbiological alternatives helps people make good decisions.

Such decision making is especially critical for students of health care. We hope to make these students realize that microbiology must be considered more than coursework. Effective medical professionals let their

knowledge of microorganisms determine their behavior in clinical settings. The student (and teacher) should be aware of the potential role of hospital personnel in the transmission of infectious diseases in the hospital. Lives depend on the knowledge and attitudes these students are acquiring right now in their introductory microbiology classes. Inadequate quality control in medical microbiology curricula often leads to grave consequences. The overriding goal of this text is to help medical professionals avoid becoming unwitting participants in the spread of disease.

Our presentation strategy is to initially guide students through the fundamentals of microbiology. In doing so, we decided not to defer the presentation of practical applications to the latter chapters, but rather discuss them in the same sections employed for presenting the conceptual information. This makes it easier for sudents to connect theory and practice. In the early chapters the reader receives an overview of the microbial world and an introduction to microscopy, laboratory cultivation, and other techniques for studying the microbes. The specifics of bacterial anatomy, physiology, reproduction, and growth are followed by chapters on the fungi, algae, protozoa, and viruses. The chemistry of life is presented in two chapters located late in the book's first half (Chapters 10 and 11). This way, students with no chemistry background won't have to surmount this hurdle until they have enough microbiological information to relate molecular concepts to principles they already understand. The same is true of Chapter 12 on microbial genetics, which cannot be fully appreciated before learning the biological importance of enzymes and metabolic reactions.



At this stage in the book, the student has acquired sufficient information about microbial fundamentals to understand fully how these processes may be intentionally impaired by physical and chemical agents for controlling microorganisms. A separate chapter is devoted to antibiotics and chemotherapeutic agents.

Except for the final chapter on microbial biotechnology, the remainder of the book is devoted to discussing the microbes as agents of infectious disease and the body's response to these intruders. We have attempted to paint an integrated picture of the infectious disease process, emphasizing the host-parasite relationship and the factors that distinguish colonization from infection, and infection from disease. Students become acquainted with the dynamic equilibrium between humans and potentially pathogenic agents and with the properties of host and parasite that are important in the development and clinical manifestations of infectious disease.

Separate chapters are devoted to concepts of disease pathogenesis, epidemiology, and clinical specimen collection. This unique triad is strategically located just before the chapters discussing the specific infectious diseases. These diseases are discussed according to the pathogen's portals of entry into the body. In this way the reader can better associate each disease with the most effective approaches for preventing the spread of infection to uninfected persons.

The book's final chapter deals with the modern "industrial revolution"

created by our increasing ability to harness the activities of microorganisms. Microbial biotechnology is providing new sources of important compounds, of food that may help relieve the world's hunger problem, and of modern weapons for fighting disease and human suffering.

Students will never fully appreciate the importance of microbiology, however, unless they are motivated to read about the microbes. For many, the subject itself will be of sufficient interest to keep them reading. We have incorporated several other features to capture the interest of students who may be either bored or intimidated by the sciences. Our diagrams are designed to suggest motion and draw attention to the important elements in the proper viewing sequence. We feel the use of our bold arrows helps change abstract concepts into easily comprehended physical images. To provide additional motivation, each chapter is supplemented with relevant asides enclosed in color boxes. These boxes enliven the text and better enable students to understand and appreciate the more human aspects of microbiology. Many of these boxed asides are provocative, others are historical, and still others help readers realize the personal intimacy of their own relationships with microorganisms.

Each chapter is preceded by an outline of the chapter contents and is followed by an overview, a list of key terms, and several questions that direct attention to the most important information.

To help reduce the continually growing incidence of nosocomial (hospital-acquired) infections, we have devoted a full chapter to this complex problem. Frequent references to these dangers are made during the discussions of concepts underlying growth, transmission, pathogenesis, epidemiology, and control of microorganisms and infectious disease. Although the importance of medical asepsis is stressed, the nosocomial infection problem cannot be solved by technique alone. This can be achieved only by an awareness of microorganisms and their influence on health and disease.

We would like to express our thanks for the many useful comments and suggestions provided by colleagues who reviewed this text during the course of its development, especially to Lucia Anderson, Queensborough Community College; David Campbell, St. Louis Community College, Meramec; Albert Canaris, University of Texas, El Paso; Garry J. Ciskowski, Indiana University of Pennsylvania; Elaine B. McClanahan, Crafton Hills College; Carolyn P. Eau Claire, Hackensack Medical Center; Cindy Erwin, City College of San Francisco; Richard Gross, Motlow State Community College; Joan Handley, the University of Kansas; John Hendry; Dean Hoganson, Drake University; Robert Janssen, The University of Arizona; Virginia C. Kelley, Auburn University; Leah Koditschek, Montclair State College; John Lancaster, the University of Oklahoma at Norman; William Lester, Humboldt State University; Lynne McFarland, University of Washington; William O'Dell, the University of Nebraska at Omaha; Rosemarie Palmer, Pennsylvania State University; Loy Pike, Indiana University at South Bend; Robert Quackenbush, the University of South Dakota; Mary Lee Richeson, Indiana University–Purdue University at Fort Wayne; War-

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**Larry McKane**
**Judy Kandel**

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OVERVIEW

Our world is populated by invisible creatures too small to be seen with the unaided eye. These life forms, the **microorganisms**, or **microbes**, may be seen only by magnifying their image with a microscope. Despite their small size, the effects of microbes on humans, and on the world in general, are critical for maintaining life on earth. It is therefore impossible, indeed undesirable, for people to avoid microorganisms or their influences. We should, however, understand the activities of microbes as well as their potential for enhancing or diminishing the quality of our lives. Such knowledge is instrumental for controlling microorganisms, minimizing their harmful effects, and maximizing their beneficial activities.

A few microorganisms are capable of growing in or on the human body. Some of these microbes are responsible for infectious disease, one of the great burdens people throughout history have had to endure. Until relatively recently, people were helpless when such diseases as smallpox, diphtheria, and typhoid swept through their communities. Controlling infectious diseases has saved millions of human lives. The cornerstone of this remarkable accomplishment is **microbiology**, the study of microorganisms.

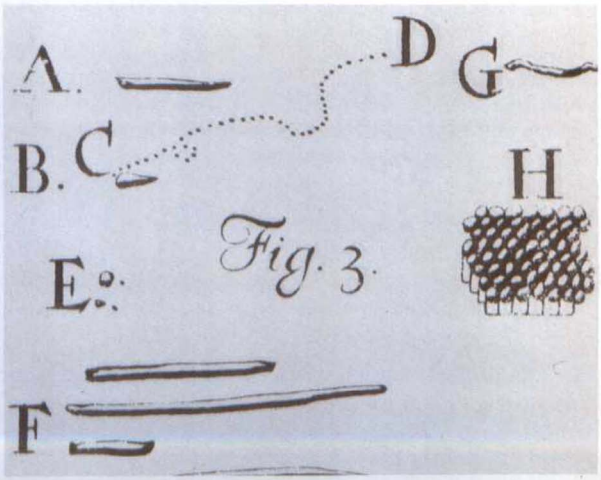
## BEGINNINGS OF MICROBIOLOGY



In 1674 Antoni van Leeuwenhoek, an amateur lens grinder of extraordinary skill and patience, looked through his simple microscope and discovered a new world (Fig. 1-1). The existence of this universe of microscopic inhabitants had been suspected by only a few insightful scientists. The "animalcules," as Leeuwenhoek called them in a series of letters to the Royal Society of London, were found in his mouth, stagnant water, and foods. Leeuwenhoek observed microbes in samples from nearly every environment he investigated. The animalcules seemed to be everywhere.

**FIGURE 1-1**

(*a*) Antoni van Leeuwenhoek with his simple microscope in hand. (*b*) Drawings from Leeuwenhoek's notebook of some of the microbes he observed.



## The Spontaneous Generation Controversy

Leeuwenhoek's discovery of microorganisms explains why many foods and drinks spoil. After sufficient time they simply become overgrown by microbes. Microbial proliferation is often evidenced by the cloudiness of a once-clear liquid. The origin of the microorganisms, however, was the subject of a scientific controversy that was finally resolved 200 years after Leeuwenhoek's findings. Some people suggested that nonliving substances were converted into living organisms; in other words, they believed in the **spontaneous generation** of life from nonliving materials. Opponents of this explanation supported **biogenesis**, a theory that all organisms arise only from other living organisms, and insisted that overgrown food has been "seeded" with at least one **viable** (living) parent microbe.

Spontaneous generation appeared to be disproved when it was demonstrated that beef broth that had been boiled to kill all the microbes in it remained **sterile** (free from all living organisms) as long as the container was plugged with a solid stopper. In response to criticism that air was necessary for spontaneous generation to occur, cotton plugs were substituted for solid stoppers. (Cotton filters remove suspended particles from air—microbes are among the suspended particles.) Broth that was protected from suspended particles remained sterile, demonstrating that the broth itself could not give rise to living organisms. Removing the cotton plug allowed microorganisms to enter and subsequently overgrow the liquid within 18 hours. Thus, boiling did not destroy the ability of the broth to support microbial growth. Biogenesis seemed to be the only logical explanation for such a phenomenon.



Many proponents of spontaneous generation, however, remained unconvinced. The controversy was finally resolved in 1861 by the powerful logic of Louis Pasteur. He designed swan-necked flasks that allowed the introduction of fresh, unaltered air but trapped dust particles and microorganisms in the curved neck, thereby eliminating the need for the cotton plug (Fig. 1-2). Broth that had been boiled in these flasks remained sterile. Thus, Pasteur proved that neither broth nor air could spontaneously produce microorganisms, since sterility was preserved in the presence of both. Furthermore, when the flask was tipped, allowing the liquid to flow into the neck, visible microbial growth developed within hours. He thus demonstrated that the agents responsible for spoiling the broth were the microbes trapped in the flask's neck.

In spite of his convincing experiments, a few scientists continued to reject biogenesis, and for good reason—their own experiments still failed to confirm Pasteur's claim. These investigators boiled and sealed liquid infusions of hay rather than beef broth. The hay infusions often became overgrown with bacteria, even when protected from all external sources of microbes. The conflicting results were due to the types of bacteria found in hay but rarely in beef. These bacteria form **endospores**, protective structures that are among the most heat-resistant forms of life on earth. Many endospores can survive several hours of boiling and then, at lower, more hospitable temperatures, germinate to an actively growing stage. Thus, the