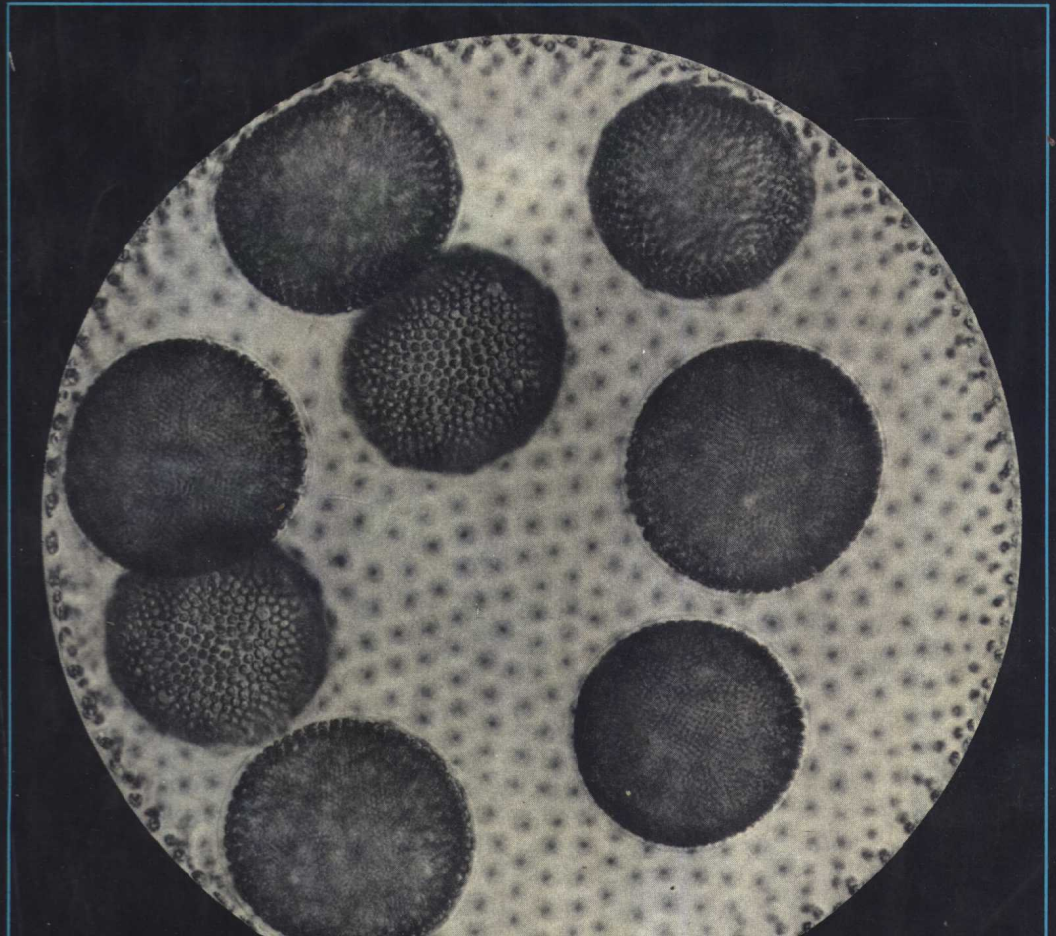
PAUL EDMONDS

MICROBIOLOGY

AN ENVIRONMENTAL PERSPECTIVE



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Preface

Environmental biology is one of many popular courses in environmental science programs that are being initiated and/or expanded on college campuses throughout the nation. Yet, there is a paucity of information in these programs that concerns the activities of microorganisms in nature. Traditional books on microbial ecology characterize these activities for microbiologists and students with advanced training in the biological sciences, but I know of no other book that has made this attempt for beginning students.

Microbiology: An Environmental Perspective is *not* intended to be a textbook for use in an introductory course for microbiology majors. The aim of this book is to provide students with an understanding of vital activities that microorganisms perform in nature. Although this book is written for the nonspecialist in microbiology, it is assumed that readers will have some command of basic biological concepts. In order to accommodate students with a diversity of backgrounds, the basic chemical concepts that are required for understanding environmental relationships are discussed in Chapter 2. The diversity of microbial habitats is discussed in Chapter 3, after which emphasis is placed on physiological activities of microorganisms in relation to broad-scale interactions that occur in natural ecosystems. Subsequent discussions deal with the epidemiology of some common human and animal diseases. Then, specific examples of influences that microorganisms have on the quality of the environment—human health, pollution (air, water, and land), and welfare (economic losses, etc.) are presented. The final chapter delineates specific roles that microorganisms play in polluted ecosystems and emphasizes the importance of controlling such activities.

I have taken a biased approach in the development of this book. It is not intended to be all-inclusive in the coverage of microbial activities in nature. Cell biology and basic physiology will be deemphasized except where necessary to clarify a functional concept. Also, culture methods and details of techniques used for studying microorganisms are deliberately omitted, because these aspects are covered thoroughly in many excellent general microbiology books.

In order to facilitate reading, a list of key words is provided at the end of each chapter. Pertinent periodicals and monographs are listed under

"Selected Readings" for those who may desire more details of a particular topic. A comprehensive glossary is provided at the end of the book.

I believe that *Microbiology: An Environmental Perspective* will provide the nonmicrobiologist with a broader dimension of organismic activities in the total ecosystem.

Finally, I wish to acknowledge my colleagues, friends, and relatives for their support during the preparation of this book. The names of those individuals who generously provided photographs for use as illustrations appear throughout the book in figure captions that acknowledge their contributions.

My special appreciations are expressed to those who read parts or all of the manuscript, and who took the time to offer constructive criticisms. Among this group are Dr. Daniel D. Burke, Department of Microbiology, University of Illinois, Urbana; Dr. Karl T. Kleeman, Department of Biology, California State University, Fresno; Dr. Michael G. Petit, Department of Microbiology, Colorado State University, Ft. Collins; Dr. Ramon J. Seidler, Department of Microbiology, Oregon State University, Corvallis; Dr. David L. Wright, Department of Biology, University of Wisconsin–Oshkosh, and my former students: Penny Schiller, Danielle Meyer, Kenneth L. Hobbs, and David M. Janssen.

Lastly, I wish to acknowledge the support of my family, and the cooperation of the staff at Macmillan Publishing Company. Without the courteous cooperation of Charles E. Stewart, Jr., Woodrow W. Chapman, Bruce Bumby, Mollie Horwitz, and Lola Peters this project could not have been completed.

Paul Edmonds

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Introduction

In this era of ecological awareness, maintaining the quality of the environment is a major concern of many college students. Yet, the techniques and approaches of separate disciplines among the physical, social, and biological sciences in our institutions are inadequate to deal justly with the complexity and magnitude of environmental problems. Environmental science programs are numerous, but too often students develop obscure views of the environment as a totality—a functional system of subunits that include physical, chemical, and biological components. Among the biological components, the activities of some microorganisms are vital to the functioning of the system as a whole and to the existence of all other biological species including human beings.

Microbiology: An Environmental Perspective introduces nonmajors in microbiology to the functional aspects of microorganisms in nature. Many individuals harbor vague concepts about microorganisms and recognize them as "germs" that function to produce discomfort and dreaded human diseases; others view them only as complex agents studied by highly trained scientists. Although both views are within the vast scope of microbiology, they fail to convey the broad spectrum of activities in nature that are mediated by microorganisms.

CHAPTER 1

Microbial groups

- **Historical perspective**
- **Living cells**
- **Procaryotic organisms**
  - *Bacteria*
  - *Blue-green algae*
  - *Mycoplasmas*
- **Eucaryotic organisms**
  - *Fungi*
    - *Yeasts*
    - *Molds*
    - *Slime molds*
  - *Algae*
  - *Protozoa*
  - *Isolated cells of multicellular organisms*
- **Viruses (noncellular agents)**
  - *Bacterial viruses (bacteriophages)*
  - *Animal viruses*
- **Key words**
- **Selected readings**

What are microorganisms? Unlike terms used to describe higher forms of life (plants and animals), the term *microorganism* does not describe a unified group or a single biological entity with similar structures and function. Microorganisms are highly diverse, but all are microscopic or submicroscopic, all are undifferentiated unicells, and all share a common feature – smallness. This does not mean that all microorganisms are of an equal size. The size variation will become evident as we examine the types of cells found within the various groups of microorganisms.

Historical perspective

From the earliest recordings of ancient civilizations through the Middle Ages, human infirmities were ascribed to demons, evil spirits, and retributive gods. Such views were inadequate to satisfy the curiosity of a few. Those curious-minded individuals probed into the mysteries of life by collecting and examining all types of living things. At that time the world of microscopic organisms was unknown.

Between the fourteenth and seventeenth centuries, the fields of chemistry, botany, zoology, and medicine evolved from superstitious arts, filled with uncertainty and chaotic techniques, into well-disciplined subjects based on scientific principles. A few workers in the medical profession postulated the existence of invisible agents of disease. For example, Girolamo Fracastoro (1483–1553) published a book in 1546 which described three ways for the transmission of infectious agents: by direct contact, by fomites (inanimate objects), and by the air. Later, the microscope emerged as an important instrument. Athanasius Kircher (1602–1680), Robert Hooke (1635–1703), and Marcello Malpighi (1628–1694) used magnifying lenses in their studies of a variety of biological specimens, but Anton van Leeuwenhoek (1632–1723) is recognized as the first person to see and accurately describe the invisible creatures of the microbial world. Unlike most scholars of that era, Leeuwenhoek was not a trained scientist, but ground lenses and assembled them into microscopes as a hobby. Sketches of creatures that he had observed in saliva, teeth scrapings, and a variety of other aqueous mixtures were presented to the Royal Society of London in 1674. His drawings were highly accurate, because morphological descriptions were made relative to items such as grains of sand and mustard seeds. As a result of such comparisons, some of the organisms that he described are now recognized as bacteria and protozoans.

Although many divergent views relative to the origin of life had been publicized in the scientific community, debate over that controversial issue was intensified by the discovery of microorganisms. Some leading scholars of that time ardently supported the "theory of spontaneous generation" and attempted to prove its validity through experimentation. As a result of much confusion and inaccurate interpretation of experimental data, controversial debate on this subject continued for many years. Finally, through a series of carefully planned experiments, Louis Pasteur (1822–1895) proved that "germs" did not originate spontaneously in sterile solutions, but developed from other "germs" that had entered his flasks on contaminated dust particles; thus ended the debate over the theory of spontaneous generation. This was only one of many great contributions that Pasteur made to science; others were the establishment of concepts for the "germ theory of disease," the characterization of life in the absence of air (anaerobic growth), the development of techniques for pasteurization, and the development of a vaccine for rabies.

While Pasteur's accomplishments in France were unprecedented in the scientific community, a young physician, Robert Koch (1843–1910), was making news in Germany. Koch established himself as a capable scientist at an early age and proved subsequently to be