MICROBIOLOGY

CARPENTER

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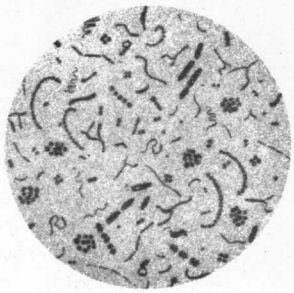

PREFACE

THE DISCOVERY of microorganisms initiated a period of description and classification, during which the separate sciences of protozoology, bacteriology, mycology, algology, and virology flourished and were jealously nurtured by their disciples. Physiologic studies then revealed fundamental similarities among microorganisms, and these discoveries gradually broke the barriers that had separated the various disciplines. Differences between groups of organisms became less significant, except for taxonomic purposes; it soon became evident that microorganisms possess the same physiologic and genetic mechanisms as higher plants and animals.

The interrelationships among microorganisms and between them and their living and nonliving environments are an important part of the science of microbiology, whose status was recently elevated by the decision of the Society of American Bacteriologists to change its name to American Society for Microbiology.

It will be apparent to the discerning reader that the author was indoctrinated as a bacteriologist in the premicrobiologic era. He hopes, however, that his interest in microorganisms generally will also be apparent. It is impossible to do justice to the entire realm of microbial life in a book designed for a one semester course.

The plan is, therefore, to devote approximately equal space to: (1) a general survey of microorganisms; (2) a detailed study of the biology of bacteria—their metabolism, growth, death, and genetics; (3) the ecologic relationships and roles of microorganisms in natural or controlled environments such as soil, water, foods, and milk, and in industry; and (4) the interactions of pathogenic microorganisms and their animal or plant hosts. This treatment will orient the student within the world of microorganisms, impress upon him the basic unity of vital processes, and point out the interplay among microscopic organisms and between them and macroscopic organisms.

The author believes that there is no virtue in presenting an unduly complicated picture, particularly in an introductory book. It should, however, be strictly accurate. He has therefore tried to provide a concise but readable, straightforward account with a minimum of factual detail to be memorized but with illustrative material to emphasize principles and general concepts. A background that includes a year of biology and a year or more of chemistry is presumed. For the benefit of those who do not readily visualize chemical relationships and reactions, a graphic presentation has been used whenever possible.

This book should provide a foundation for study in the medical professions or in the various specialties such as pathogenic bacteriology, sanitary, soil, or industrial microbiology. It should also be suitable as the only experience in the field for students of home economics, agriculture, liberal arts, teacher education, pharmacy, and preclinical nursing.

There are many whom I would like to thank publicly for their assistance in converting the first rough draft into published form. First and foremost, my patient wife, Helen Carpenter, typed and retyped the manuscript more times than she should have to remember, but always with cheerful devotion to the dictates of accuracy and grammatical expression. The staff of the W. B. Saunders Company were extremely helpful throughout. Part or all of the text was read by Dr. Reino Kallio and by Dr. Maurice Green, and their many suggestions are gratefully acknowledged. The author, however, accepts full responsibility for all errors of commission or omission that remain. Various individuals and companies kindly supplied photographs and other illustrative material as noted. Dr. George B. Chapman, especially, went to considerable trouble to prepare prints of some of his excellent electron photomicrographs. My sincere thanks go to all persons, named or unnamed, who helped in any way.

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An Open Letter to Students

BEFORE you read the first chapter I would like to welcome you to a new field of study and to wish you pleasure and profit from it. I would also like to give you a bird's-eye view of what is ahead and offer a few suggestions that may help you get the most from your study.

Microbiology is not just a book or a course in college. It is the study of small organisms, which have many of the same attributes as other forms of life. By learning from test tube experiments how microorganisms behave we can learn many things about how other organisms function.

No doubt you know that several kinds of organisms comprise the subject of this book: protozoa, algae, yeasts, molds, bacteria, rickettsiae, and viruses. To begin, therefore, you will look at the various groups of microscopic organisms, both individually and as members of the plant or animal kingdom, concluding with a fairly detailed study of bacterial cells. Bacterial "anatomy," if you please, has been actively reinvestigated during the past ten or fifteen years by new microscopic methods.

Next you will learn about the growth and death of bacteria and some of the metabolic processes that accompany growth and the search for energy. I hope you will be able to appreciate the simplicity and beauty of the schemes by which, one step at a time, living cells

bring about seemingly complicated chemical changes. You will also learn that bacteria behave genetically like many other organisms; they undergo mutation, and some can apparently conjugate in a pseudosexual manner.

With the background you have at this point the section on applied microbiology will be a logical application of facts and principles already encountered. The kinds and numbers of microorganisms and their activities in natural and controlled environments can often be predicted from knowledge of their physiologic characteristics.

Lastly, you will make an excursion into pathogenic microbiology: infection, resistance and immunity, chemotherapy, and the ecology of infectious disease, with a few illustrations of bacterial, fungal, or viral infections of plants or animals.

When you study, get an overall picture of the subject first by skimming the subheadings within each chapter. Write a *brief* topic outline of a chapter or subject. Don't memorize a lot of details first; they never make sense by themselves, but if you know the general outline, the details fit into place without much conscious effort. Learning details without knowing how they are connected with one another is like looking at a large portrait only a few inches away; all you see is an eye or a foot, and your impression of the picture is distorted and incomplete until you back away and look at it as a whole.

Many of your fellow students approach microbiology with dread, expecting to be required to memorize long lists of names or other terms that seem to mean nothing. Naturally, there are unfamiliar terms in any new subject, but, as you read, hear, *and use* them, they soon become familiar. Moreover, the words do mean something, as you can learn with only a little trouble. You will note that there is no glossary in this book. Instead, the index contains boldface references to pages where terms are explained. It will be more work, but if you look up a term in the text and read a few sentences about it, the word will mean more to you, and you will remember it longer.

There are study questions after most chapters. Some are "fact" questions; some call for thought. If you cannot answer them, review the chapter and think about it, or look up some of the supplementary readings. Specific page references to the books listed at the end of each chapter have been omitted; decide from the comments which book contains the information you desire, and then use its table of contents or index.

If you are interested in still further information on some topic, there are many periodicals that publish the results of research. The *Journal of General Microbiology,* for example, is a British publication with excellent papers on the biologic activities of the various microorganisms. Its closest American counterpart is the *Journal of Bacteriology. Applied Microbiology* publishes papers on antibiotics, fermentations, enzymes, and the microbiology of manufactured products. The *Journal of Infectious Diseases* contains articles on the causes, pathogenesis, host response, and laboratory diagnosis of diseases caused by microorganisms. Papers surveying recent work on a topic are found in *Bacteriological Reviews.* Students who wish to try their facility in French will find interesting papers in the *Annales de l'Institut Pasteur,* which is similar to the *Journal of Infectious Diseases* but emphasizes immunization against bacterial and viral infections. The German equivalent is the *Zentralblatt für Bakteriologie, Parasitenkunde, Infektionskrankheiten und Hygiene.* A translation of the Russian *Mikrobiologiia* is now available, so it is not necessary to know this language in order to read some of the Russian literature.

A book such as this doesn't "happen" overnight. More than five years will have elapsed between the day "Chapter One" was written on the first page of rough draft and the day the first student opens the cover. Several chapters were completely rewritten during the last few months before publication because so many recent advances had been made. What is written today may not appear true tomorrow, but if you know what is *believed* today, you can better evaluate the discoveries of tomorrow.

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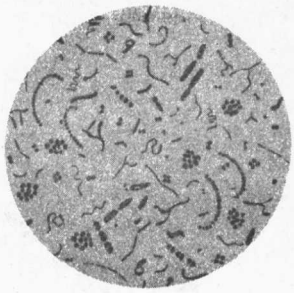
MICROORGANISMS



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The World of Microorganisms

MICROBIOLOGY is the study of organisms that are for the most part too small to be seen with the naked eye. The existence of microorganisms was suspected long before they were first seen. Proof that they existed required the invention of a suitable microscope, and that did not occur until about three hundred years ago. Leeuwenhoek, although not the inventor of the microscope, made the best early microscopes; he is usually given credit for the discovery of protozoa and bacteria, two of the seven principal types of microorganisms, sometime about 1683.

Microorganisms include, in addition to protozoa and bacteria, the algae, molds, yeasts, rickettsiae, and viruses. Most of these are unicellular organisms or, in some cases, aggregates of independent cells showing little if any specialization of function. A characteristic common to microorganisms, along with their small size, is relative simplicity of structure. Structural simplicity does not, however, necessarily imply physiologic simplicity. Microorganisms perform the same fundamental activities within their single cells as "higher organisms" do within their many-celled structures: utilization of food and energy, formation of new protoplasm, reproduction. It is important to remember that microorganisms are essentially the same biologically as other organisms.

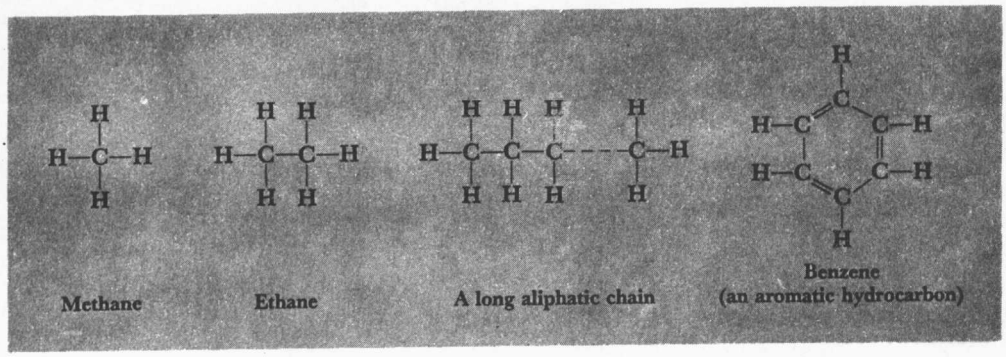

Fig. 1-1. Short and long chain and cyclic hydrocarbons.

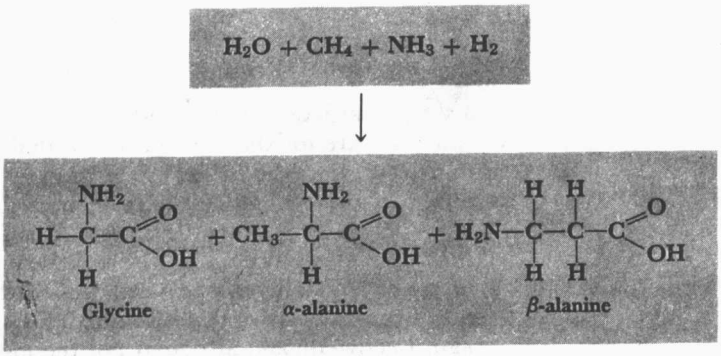

Fig. 1-2. Formation of amino acids by electric discharge from gases present in the prehistoric atmosphere.

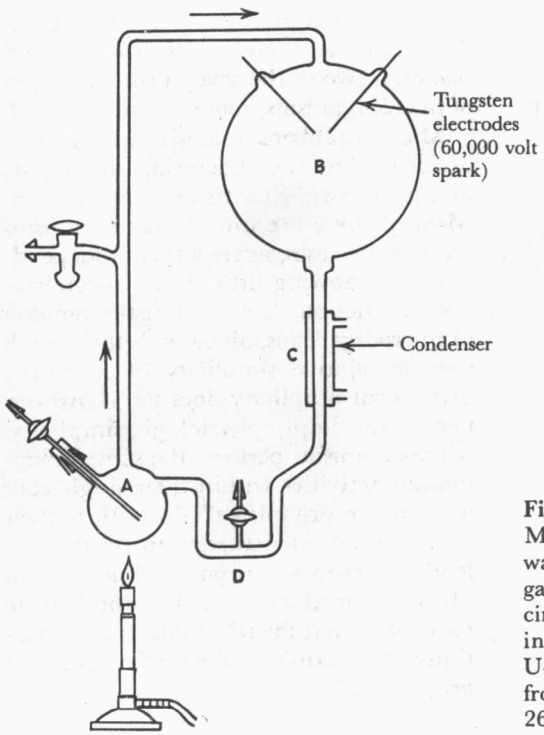

Fig. 1-3. Spark-discharge apparatus used by Miller to produce organic compounds from water vapor, hydrogen, methane, and ammonia gases. The water in flask *A* is boiled to promote circulation. Products formed by the discharge in *B* are condensed at *C* and return to *A* via U-tube, *D*, which prevents backflow. (Redrawn from Miller: Ann. New York Acad. Sc., *69:* 261, 1957.)