MICROBIOLOGY

by

FLORENE C. KELLY, M.S., Ph.D.

Professor of Bacteriology, The University of Oklahoma School of Medicine

and

K. EILEEN HITE, Ph.D., M.D.

Associate Attending Physician, Division of Pulmonary Disease, Montefiore Hospital, New York, and Associate Physician in Charge, Montefiore Hospital, Westchester Division, Bedford Hills, New York; Formerly Assistant Professor of Bacteriology, The University of Chicago

Foreword by

G. M. DACK, Ph.D., M.D.

Professor of Microbiology, The University of Chicago

SECOND EDITION

NEW YORK

APPLETON-CENTURY-CROFTS, INC.

Copyright, © 1955, by
APPLETON-CENTURY-CROFTS, INC.

All rights reserved. This book, or parts thereof, must not be reproduced in any form without permission of the publisher.

Library of Congress Card Number
55-8365

Copyright, 1949, by Appleton-Century-Crofts, Inc.

Printed in the United States of America

Affectionately

dedicated

to

E. F. K.

and

D. B. H.

"... Modern science is physics, while medieval science was something at once less potent and more important, ethics. With ethics alone, man may love the good, but never find it; with physics alone he may gain the whole world, and lose his own soul."

—Randall: *Making of the Modern Mind, Houghton Mifflin Company.*

此为试读，需要完整PDF请访问：www.ertongbook.com

PREFACE

This textbook is intended for the student who will require a comprehensive knowledge in the fields of general and pathogenic microbiology. An effort has been made to present established facts and current theories conservatively and simply but adequately to permit a basic understanding of the subject and to be of practical value. The text progresses in two parts from a general discussion of the microscopic world to a presentation of microbial disease and the pathogenic microorganisms. The first part emphasizes the phylogenetic groups and the biology, physiology and control of microbial populations; the second part treats of parasitism and disease, immunity, the unicellular pathogens, community health and preventive microbiology.

Since publication of the first edition in 1949 advances in the field of microbiology have occurred rapidly. These advances include increased knowledge of bacterial genetics, cellular structure, biochemistry, metabolism, immunology, bacterial viruses, and previously known pathogens; as well as descriptions of new disease agents and antibiotics. An attempt has been made to incorporate this material in the present edition in order to maintain vitality of the subject and interest of the student. The general organization and conservative attitude have been retained since it is our conviction that controversial material may best be presented at the discretion of the instructor.

The authors continue to be grateful to those who helped in so many ways in preparation of the first edition, and are appreciative of all the expressions of interest, suggestions and criticisms that have helped in preparation of this revision. They are particularly indebted to Dr. G. M. Dack of the University of Chicago who has contributed the Foreword and Mr. G. A. McDermott of Appleton-Century-Crofts, Inc.

Florene C. Kelly
K. Eileen Hite

FOREWORD

Microbiology is a rapidly expanding field and profoundly affects people in all walks of life. With the discovery of the sulfonamide drugs and more recently the antibiotics, an added impetus has been given to determine the mechanisms of action of these drugs. The use of bacteria in assaying food products for certain vitamins and amino acids has stimulated interest in the physiological aspects of bacteriology. The relation of bacteria to food spoilage is a subject which is increasingly occupying the attention of bacteriologists. In addition to these developments many new discoveries have been made in the field of virology. Consequently, the demand for microbiologists has increased as a result of this newly acquired knowledge. Since microbiology has such widespread application in so many fields of specialization it is important that the beginning student first consider microorganisms in large groups and gain an understanding of their potentialities. This has been admirably accomplished in the first half of the book.

The second half of the book is devoted to pathogenic microorganisms. A point of view is presented which is conservative, yet does not bewilder the student with controversial issues. The epidemiology and control of diseases are presented from the point of view of the means of transmission. The relationship of pathogenic microorganisms to other microorganisms as well as to the host tissues is emphasized.

The authors are particularly well qualified for the preparation of this book. Dr. Kelly has had many years of experience in teaching general college students, nurses and medical students. Dr. Hite has for several years been interested in medical bacteriology and public health from the standpoint of teacher and research worker in both the laboratory and clinical phases. The professional training of each of the authors complements that of the other and adds value to the book. This book is particularly well adapted to courses of general and pathogenic microbiology.

G. M. Dack

Director, Food Research Institute
Professor of Microbiology
The University of Chicago

MICROBIOLOGY

CONTENTS

Contents

1

DEVELOPMENT AND SCOPE OF MICROBIOLOGY

Microbiology is the study of living organisms invisible to the unaided eye. It is the curtain raiser to a world beyond the sphere of human sight, a microcosm in which the vital drama of the familiar visible world is repeated on a microscopic stage. Two hundred and seventy-five years ago the smallest creatures known to man were tiny insects, intimate little animals like the body louse and their kin, the mites that crawled through the cheese, riddled the grain barrel and caused the itch. The day in 1676 when a Dutchman named Antony van Leeuwenhoek * peered through a magnifying lens and saw living creatures "so small . . . that even if 100 of these very wee animals lay stretched out one against another, they could not reach to the length of a grain of coarse sand," he found the key to age-old mysteries of decay, disease and the nature of the living world. But another 150 years and more passed before the significance of his discovery was realized and these mysteries began to unfold.

Some of Leeuwenhoek's "little animals" were just that, microscopic animals now known as **protozoa,** while others, the incredibly small creatures "that shot through the water (or spittle) like a pike" or "hovered so together that you might imagine them to be a big swarm of gnats or flies," were really **bacteria.** Modern microbiology is concerned with all kinds of microscopic plants and animals as well as certain agents of disease, the rickettsiae and viruses, which do not qualify as either plants or animals. The great majority of microorganisms (popularly known as microbes or germs) are harmless, and indeed many are essential to the survival of other forms of life on earth. Considering the enormous numbers and varieties of microorganisms in the world, relatively few are dangerous to human welfare, but from man's standpoint these are the criminals in microbic society, for they are the cause of infectious disease.

Knowledge of microbiology in general, and especially bacteriology, developed as a result of efforts to find the answers to these three questions: Can plants and animals spring to life spontaneously from inanimate matter?

* For the story of "the father of protozoology and bacteriology" the reader is referred to the fascinating biography *Antony van Leeuwenhoek and His Little Animals* by Clifford Dobell. See reference list at end of chapter.

此为试读，需要完整PDF请访问：www.ertongbook.com

What happens to bring about fermentation and putrefaction? What is the cause of disease—particularly epidemic disease? *

Spontaneous Generation. Through the ages men have pondered on the origin of life. To the ancients not only was the beginning of all life on the earth a riddle, but more specifically they theorized on the origin of lowly creatures which appeared seemingly from nowhere. The popular belief,

Fig. 1. Antony van Leeuwenhoek (1632–1723), discoverer of the world of microscopic life. (From Woodruff, *Foundations of Biology,* The Macmillan Co.)

supported by Aristotle and the Bible, was that such plants and animals could arise spontaneously; for example, that decaying bull's flesh generates bees, that fish and eels come from mud and that mice can spring full grown from rags and grain. Despite the arguments of occasional skeptics and the demonstration by Redi in 1668 that maggots in meat are produced from

* A chronological table of important events which laid the foundations of modern microbiology is presented in the Appendix.

flies' eggs, the theory of spontaneous generation persisted. With the discovery of microscopic organisms it rallied with renewed vigor, for who could explain the source of these "animalcules" that suddenly appeared in pure rain water and in infusions of seeds, meat and other organic matter when none were visible originally?

Many ingenious experiments were performed in an attempt to settle the argument one way or another. In 1749 Needham, an Irish priest, supported the theory of spontaneous generation by demonstrating that microorganisms developed in infusions inside cork-stoppered flasks which had been exposed to boiling water. In Italy, Abbé Spallanzani took up that challenge, for he believed that the animalcules were in the air and dropped into the infusions. He repeated and refined Needham's experiments with different results. After hermetical sealing and prolonged heating no living creatures appeared —unless new air was admitted. But Needham picked flaws in this procedure, pointing out that such excessive heat destroyed the "vegetative force" of the infusion. And so the debate went on for years.

The final proof that microorganisms are generated by similar, previously existing microorganisms, *i.e.*, that microbes have parents,* was furnished by the work of Pasteur in France and Tyndall in England between 1860 and 1877. In a series of clever experiments Pasteur used flasks devised to admit air but not dust, and he showed that heated infusions in these flasks remained free from microorganisms. The physicist Tyndall fashioned an enclosed cabinet in which the air was free from floating particles as shown by a powerful beam of light directed across the chamber. Heated open tubes of infusion developed no life although exposed for months to the "optically empty" air of the cabinet. This convincing demonstration sounded the death knell of the theory of spontaneous generation and at the same time heralded the fight to prove another theory—the germ theory of disease.

Fermentation and Putrefaction. In 1663 Robert Boyle predicted that the nature of certain diseases would never be explained without an understanding of ferments and fermentation. Until the nineteenth century, however, the forces at work in the production of bread, beer and wine were matters of speculation. The chemists of that time claimed that fermentation was due to an internal motion of particles of unstable matter, a physicochemical phenomenon, and microscopic globules (yeasts) which appeared in fermenting solutions were thought to be nothing more than a chemical substance. Then within a year three scientists (Cagniard-Latour, 1836; Schwann, 1837; Kützing, 1837) working independently came to practically the same conclusions as to the nature of yeast. Their findings indicated that yeast is a living organism, a fungus plant that reproduces by budding, and that it is the cause of fermentative changes in sugar solutions and grape juice. This idea was greeted by ridicule and energetically denounced by investigators who contended that fermentation was not a vital process. It

* See the chapter entitled "Spallanzani: Microbes Must Have Parents" in Paul De Kruif's enthusiastic book *Microbe Hunters* listed with other references at the end of this chapter.

was soon after this that the French chemist Louis Pasteur became interested in fermentation and started studies on the subject which he continued for twenty years (1857-1877). In that period he substantiated the germ theory by research on lactic and butyric acids as well as alcoholic fermentations, on the production of vinegar, and finally by studies on wine and beer. Not only did he prove that yeast is a living organism which splits sugar into alcohol, carbon dioxide and other products, but also that different types of fermentation are caused by different microorganisms; decomposition of organic matter by putrefaction is the work of living organisms; the "diseases" of wine are due to the introduction of foreign microorganisms and spoilage can be prevented by heating the wine; fermentation is the result of microbic life without air. For the yeasts and bacteria which live without air he coined the name **anaerobe**, in contrast to those which require air, the **aerobes.**

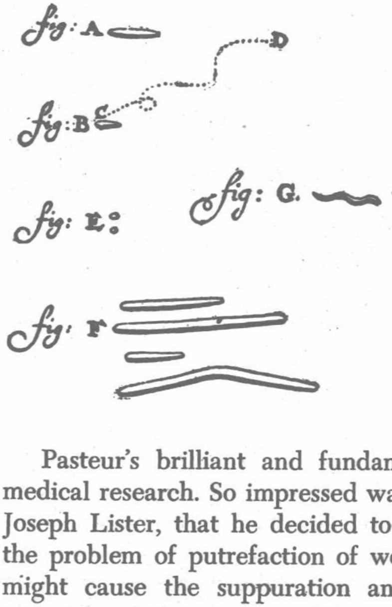

Fig. 2. Leeuwenhoek's drawings of bacteria from the human mouth. Published in *Arcana Naturae,* 1695. (From Smith and Conant, *Zinsser's Textbook of Bacteriology,* 10th ed., Appleton-Century-Crofts, Inc.)

Pasteur's brilliant and fundamental work had far-reaching effect on medical research. So impressed was the English surgeon and bacteriologist, Joseph Lister, that he decided to apply the principles of fermentation to the problem of putrefaction of wounds. He reasoned that microorganisms might cause the suppuration and putrefaction which usually attended surgery, and that these conditions might be avoided by killing the organisms in wounds by a chemical agent. The success of Lister's **antiseptic** surgery and how it paved the way for modern surgery is described in a later discussion on medical and surgical asepsis.

Microorganisms and Disease. Men recognized the contagious nature of certain diseases long before they had any knowledge of their cause. Various theories of disease were popular in different eras and civilizations. Ancient references to disease as punishment inflicted by wrathful gods illustrate the supernatural theory which lasted for centuries. Natural, earthly and cosmic phenomena, especially changes in the atmosphere, were believed by the early medical authorities of Greece and Rome to be responsible for the ills that affected mankind. Aristotle was convinced that bodily health was impaired when the air was tainted with **miasms** (a term derived from the

Greek word for **stain**). The miasmic theory of disease is still reflected in the name of the disease **malaria** and in certain superstitions. That disease can pass from one individual to another was recognized by the Hebrews of biblical times in the case of leprosy, and was demonstrated repeatedly by the great epidemics that swept over Europe in the Middle Ages. In 1546 Fracastorius, an Italian physician, published his observations on epidemic disease, particularly plague, syphilis and typhus fever, in three books on *De Contagione*. He described the agents of communicable diseases as *seminaria*

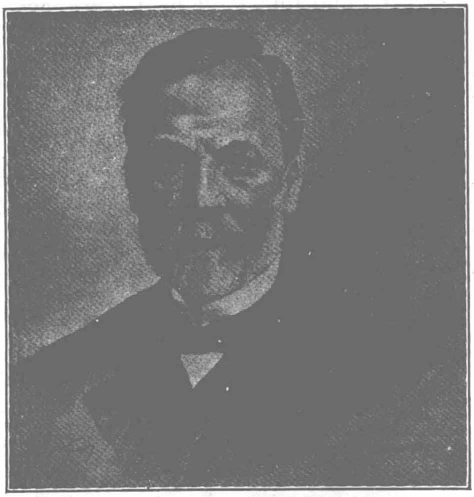

Fig. 3. Louis Pasteur (1822–1895). (Courtesy Central Scientific Co.)

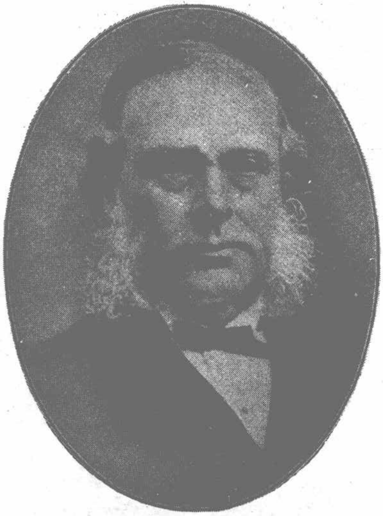

Fig. 4. Joseph Lister (1827–1912). (Courtesy Ethicon, Inc.)

(seeds or germs) that may be transmitted in three different ways, by direct contact with the diseased individual, by touching inanimate objects (fomites) and by air. Fracastorius could give no clear idea of the nature of *seminaria,* and his doctrine of *contagium animatum* (living contagion), although it was proved to be correct three hundred years later, had little influence at the time.

It was not until 1834, over one hundred and fifty years after the discovery of the "little animals," that a microorganism was first associated with disease. At this time Bassi demonstrated that a contagious disease of silkworms was caused by a mold. The first bacterium to be related to disease was the anthrax bacillus. Motionless little rods were observed in the blood and spleen of diseased animals by Pollender (1849) and later by Davaine and other French researchers. Davaine succeeded in transmitting anthrax in a series of animals by introducing a drop of blood from a diseased sheep into a normal sheep, but he could not eliminate the possibility that some invisible agent in the blood and not the bacterium might give rise to the disease. In 1876 Robert Koch, a German physician, demonstrated the results of four years' investigation which definitely established the bacillus as the cause of anthrax and introduced exact methods that soon changed the study of microbes from guesswork to a science. He perfected a technic by which the little rods from the diseased animal were cultivated outside the body, and he produced the disease by injection of a culture in which the anthrax bacillus was unaccompanied by other microorganisms or body fluids from the diseased animal. From this remarkable achievement Koch went on to devise procedures for the microscopic study of bacteria including staining technics and ways of isolating and growing bacteria in the laboratory. In 1881 he introduced a practical method for obtaining pure cultures by the use of nutrient gelatin and other solid media and thus gave to bacteriology the tools which permitted the exhaustive study of individual bacteria. The climax of Koch's career came in 1882 with his discovery of the tubercle bacillus and publication of a set of rules, now known as Koch's postulates, for determining the cause of an infectious disease (see page 266).

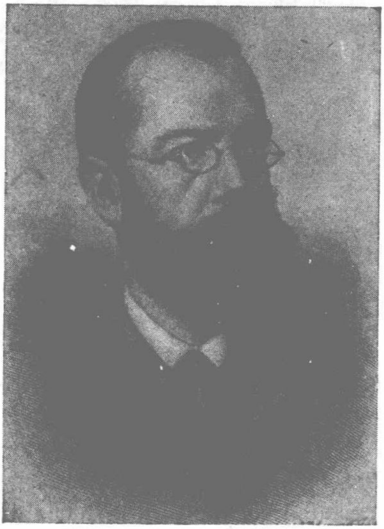

Fig. 5. Robert Koch (1843–1910).

Fig. 6. Edward Jenner (1749–1823). Marble statue at Geneva by Monteverde.

Prevention of Infectious Disease. Pasteur (1877) entered the field of infectious disease with studies on anthrax which confirmed Koch's conclusions. Being convinced that microorganisms cause diseases of man and animals, the practical Pasteur then turned his efforts toward their prevention. He had as his guide and stimulus the history of vaccination against smallpox. The oriental practice of deliberately inoculating healthy susceptible persons with materials from smallpox pustules had been introduced into England in 1721. It had as its purpose the production of a mild case of the disease and the protection of the individual against a second attack. The courage needed to submit to this inoculation must have been surpassed only by fear of the dread disease itself, for severe and even fatal cases sometimes resulted. The observation that milkmaids who had suffered an attack of cowpox, a mild disease in man, did not contract smallpox led Jenner (1796) to try an experiment. He inoculated a boy with material taken from cowpox lesions on a milkmaid's arms, and six weeks later subjected the youngster to a smallpox inoculation. When no reaction followed, Jenner was certain of the value of his **vaccination** (*L., vacca,* cow) method.

Vaccination against smallpox was a well established and widespread custom when Pasteur set out to learn methods of protective inoculation against other diseases. In experiments on chicken cholera (1880) in which he inoculated cultures of the bacterial agent into fowl, Pasteur observed that the disease-producing power or **virulence** of the organism varied and that it became weaker as the culture aged. Fowl inoculated with such weakened or **attenuated** organisms later safely withstood injections of the fully active, **virulent** organism. On the principle that inoculation of a living attenuated organism protects against subsequent attack by the same organism, Pasteur soon developed methods of prophylactic vaccination for anthrax, swine erysipelas and rabies. The next advance in preventive inoculation was the discovery by Theobald Smith and Salmon (1886) in America that heat-killed cultures of the hog cholera bacillus protect against that disease. With all possibility of the danger that attends the injection of any living organism removed, the foundation was laid for modern control of infectious disease by vaccination.

Now the study of resistance to disease or **immunology** was well on its way to becoming a science in its own right. Investigators sought an explanation of the susceptible and resistant states. Metchnikoff (1884) discovered body cells, the **phagocytes,** that devour invading microorganisms and foreign particles. The discovery that certain bacteria produce posions or **toxins** (Roux and Yersin, 1889) led to the recognition of neutralizing substances or **antitoxins** in the blood of immune animals (Behring and Kitasato, 1890), and the treatment of clinical cases with immune serum, or **serum therapy,** was begun. Studies of reactions between immune serums and the bacteria, bacterial products or other foreign material which had been inoculated to produce immunity revealed other types of immune substances besides antitoxins. Further knowledge of the immune process offered explanations of the hypersensitive state, of allergy and anaphylaxis.

Further Developments. In the period dominated by Pasteur and Koch (1876-1890), the so-called Golden Age of Bacteriology, investigators were speedily and richly rewarded for their efforts in the new and fertile field. By this time many protozoa, molds and yeasts as well as bacteria were incriminated as the causes of certain diseases. The simultaneous perfection of the compound microscope allowed accurate observation and facilitated the identification of microorganisms. The foundations for laboratory diagnosis of many infectious diseases were well established. The influence of

此为试读，需要完整PDF请访问：www.ertongbook.com