BASIC FACTS OF

MEDICAL MICROBIOLOGY

BROOKS

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PREFACE

This small work was designed to present the basic facts of *medical* microbiology to those preparing for professions which require an intelligent understanding of the subject. For some curricula, this will be the only course of its kind; for others, a foundation for advanced information. Since the author has, for the past five years, taught microbiology to student nurses, science instructors in the nursing area can rest assured that the text is well suited to their program. He has *not,* however, permitted the *standard theory* and *practices* of the "pure subject" to run secondary—in any segment of the text—to those procedures which the nurse performs at the clinical level or learns in other courses. Naturally, at the proper time and place implications and applications to the practice of nursing are pointed out. In the appendix, for example, the chief clinical applications of disinfection and sterilization are presented.

The plan of the text is simple and direct. Chapters 1 and 2 present a general discussion of microbes and infectious diseases, respectively. Chapters 3 to 9 present—in brief form—*all* the important diseases caused by *living organisms*. Although many works in microbiology do not cover *parasitic worms* and *ectoparasites* (lice, fleas and mites), these subjects are presented in some detail in this text. Chapter 10—Venoms—is, of course, an experimental inclusion. It is presented to justify the statement made above to the effect that this work covers *all* diseases caused by living organisms.

A great deal of thought was directed to the appendix. It is hoped that the student will find the information contained therein to be a succinct review of the material presented in the text. It is further hoped that the instructor will find the appendix a convenient way to draw to the students' attention those facts which are of special importance.

The same thought and hopes apply also to the glossary. The author's nonbiologist wife—who typed and read the entire manuscript—selected all the entries. Although her husband frequently exclaimed that the meaning of such and such a term was self-evident, she insisted that its inclusion in the glossary was essential for crystal clear exposition. Consequently, both student and instructor will discover that the glossary is extensive.

Little seems to be gained in an *introductory* course by presenting reference citations. It appears that the student is busy enough learning what the subject is about without encountering topics which are seldom

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appreciated by the beginner. From the many excellent standard texts available, the instructor can—if so desired—easily direct his class to more advanced topics.

During the writing of the manuscript an array of information sources were freely consulted. Among these, the standard works include: *Clinical Diagnosis by Laboratory Methods* by Todd, Sanford and Wells; *Textbook of Bacteriology* by Jordan and Burrows; *Zinsser's Textbook of Bacteriology* by Smith and Conant; *Medical Parasitology* by Sawitz; *A Manual of Tropical Medicine* by Mackie, Hunter and Worth; and *The Pharmacological Basis of Therapeutics* by Goodman and Gilman.

Once again, the author wishes to express his appreciation to the personnel of the W. B. Saunders Company for their fine work and friendly attitude. Also, he wishes to acknowledge the able assistance of Marie Litterer in the preparation of the illustrations. As far as the author's "poor wife" is concerned, what can be said? Not only does she put up with a husband who discusses the *Leptospira icterohaemorrhagiae* at the breakfast table, but also gives him the inspiration, strength and enthusiasm to run down to West Washington Square with a new manuscript.

STEWART M. BROOKS

CONTENTS

CHAPTER 1

GENERAL FACTS RELATING TO INFECTIOUS ORGANISMS

Microbiology is the science which deals with those organisms too small to be seen or studied without the aid of the microscope. Such organisms are accurately and aptly referred to as *microbes*. Contrary to popular belief, the overwhelming majority of the earth's microbes are our friends, not our enemies. As a matter of fact, man could not exist if it were not for the omnipresence of these one-celled benefactors. Not only do microbes make life possible for all higher forms (by virtue of their ability to convert dead organic matter into *essential* compounds, thus completing the "life cycle"), but they also aid man in the manufacture of an unbelievable number of diversified commodities of great import to his economy. Such unrelated commodities as beer, wine, vinegar, cheese and antibiotics are only a few products of microbial activity. It should be clear, therefore, that microbiology has wide application to man's welfare. Once the student of this science becomes conversant with the general facts

of the earth's microbial population, he is then prepared to go ahead and apply what he has learned to the field of his interest. Thus, the scientist who is called a "microbiologist" is almost always a specialist in a given area.

As the title of this work indicates, we are concerned with infectious organisms, i.e., *medical microbiology*. We must first, however, thoroughly digest and assimilate the cardinal biologic facts which apply to the microbes in general. Only in this way can we consider ourselves true students of the subject. These general principles are set forth in the present chapter. The student must acutely appreciate that the subsequent chapters are concerned with the *application* of these principles to medicine. At the proper time and place, however, additional applications, if of sufficient importance, will be presented.

For the sake of completeness, *all* organisms which infect man will be considered. This means that two categories of infectious agents of a *nonmicrobial* nature are included, i.e., *worms* and *ectoparasites* (viz., fleas, lice and mites). But even here, however, we shall discover that the microscope is an essential tool for study.

CLASSIFICATION OF INFECTIOUS AGENTS

It is essential for us to understand completely the various groups and subgroups into which infectious agents are placed. In this connection, we shall perhaps progress more rapidly if we first consider an elementary classification, employing terms which are no doubt familiar to many of us. From a medical standpoint, pathogenic organisms (*pathogens*) may be described under the following categories: *bacteria, fungi, rickettsiae, viruses, protozoa, worms* and *ectoparasites*. As we shall soon learn, these are broad and somewhat ambiguous terms. They are popularly used, however, and will serve as a stepping stone to a more elaborate analysis of the microbial world.

Although the following sections are by necessity rather technical in nature, they will be understood readily if the expositions are *closely correlated* with the accompanying figures.

Bacteria. *Bacteria are one-celled microbial plants without chlorophyll.* Being unicellular, they represent the simplest organisms of the plant world. As indicated above, most bacteria are our friends, not our enemies. It is a significant fact, however, that the bulk of the infectious diseases which plague man are caused by members of this category. For this reason, we shall study their classification in some detail.

Organisms of the plant world range in size from the giant redwoods of California to microorganisms. Their number and variety are beyond

the realm of man's imagination. Nevertheless, the botanist has discovered that all of them, on a basis of *morphology* (structure) and *physiology* (function), may be grouped into four botanical *Phyla* (singular, Phylum): *Spermatophyta, Pteridophyta, Bryophyta* and *Thallophyta;* (refer to Fig. 1 throughout this discussion). The Spermatophytes are the most advanced members of the plant world and include all *seedbearing* plants; the Pteridophytes include the *ferns* and their allies; the Bryophytes include the *mosses;* and the Thallophytes include all simple forms of plant life which do not have roots, stems and leaves. It is to this latter group that the unicellular plants, or bacteria, belong. The Thallophytes, in turn, are grouped according to the following *Subphyla: Algae, Lichens* and *Fungi.* Algae are simple, chlorophyll-bearing plants normally seen as pond scum and seaweed; fungi are Thallophytes *without chlorophyll;* and lichens, usually seen as a scale-like growth on tree trunks, are believed to be *symbiotic* combinations (mutually dependent) of algae and fungi. *All pathogenic plant microbes belong to the Fungi.*

The fungi are further grouped into three *Classes: Eumycetes, Schizomycetes* and *Myxomycetes.* The Eumycetes are referred to as the *"true fungi,"* the Schizomycetes as *bacteria* and the Myxomycetes as *slime molds.* In this work we are only concerned with the Eumycetes and Schizomycetes. The Eumycetes will be discussed under *fungi.* As shown in Figure 1, the Schizomycetes are divided into three *Orders: Eubacteriales, Actinomycetales* and *Spirochaetales.* Each of these orders will now be discussed in some detail.

EUBACTERIALES. This order contains the so-called "true bacteria." Its members cause the bulk of all bacterial diseases, indeed, the bulk of all infectious diseases. Of great aid to the student is the fact that the Eubacteriales, on a basis of *morphology,* fall into three categories: the *cocci,* or *oval* bacteria; *bacilli,* or *rod-shaped* bacteria, and the *spirilla,* or *curved-rod* bacteria. These three forms are shown in Figure 2. Although there are some species of Eubacteriales which are not perfectly round or perfectly rod-shaped, there are enough "pure types" to warrant great emphasis on this point. Many times all that the bacteriologist needs to know is whether a given organism is a *coccus, bacillus* or *spirillum.*

In spite of the diagnostic importance of these three morphologic categories, we must, however, for theoretical reasons, divide the Eubacteriales into *Families.* Throughout our study of the Eubacteriales (Chapter 3) we shall, when speaking in general terms, employ the family as our *unit.* The student who appreciates these facts and "knows" bacteria on a basis of classification, rather than rote memory, will be successful. As shown in Figure 1, we shall study the following families:

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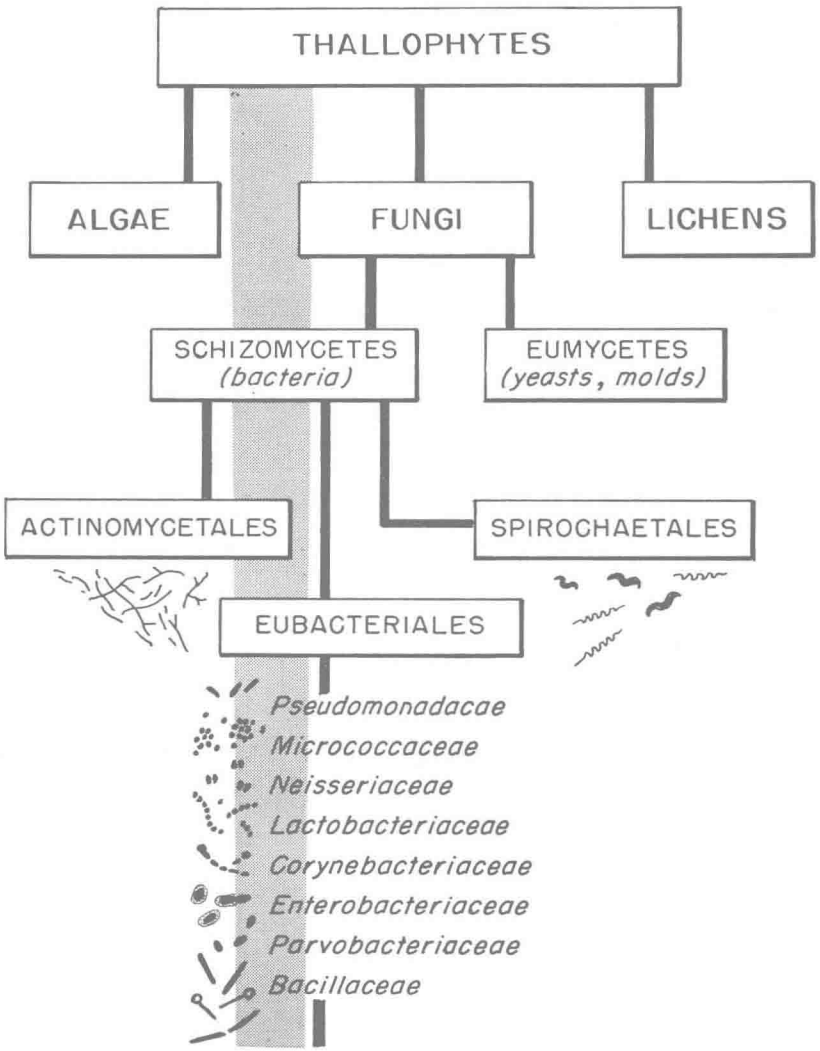

Fig. 1. Classification of the Thallophytes. All bacteria and fungi fall under the subphyllum *Fungi*. See text for detailed information concerning the Classes, Orders and Families thereunder.

Pseudomonadaceae, Micrococcaceae, Neisseriaceae, Lactobacteriaceae, Corynebacteriaceae, Enterobacteriaceae, Parvobacteriaceae and *Bacillaceae*. Actually, there are more families than these, but the ones cited are those which contain pathogenic members.

ACTINOMYCETALES. Members of this order (often referred to as *Actinomycetes*) are *moldlike* organisms having elongated cells, frequently *filamentous*, with a tendency to the development of *branching*. (See Fig. 3.) This order is characterized not only by pathogens, but

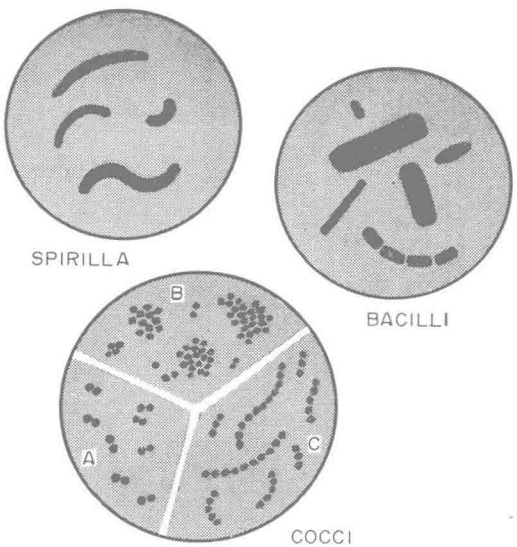

Fig. 2. Morphologic features of the Eubacteriales. *A*, Diplococci; *B*, staphylococci; *C*, streptococci.

also by organisms which produce the bulk of our most valuable *antibiotics* (viz., *Streptomycin, Neomycin, Aureomycin, Terramycin* and *Chloromycetin*). This is a good example of the fact that microorganisms are our *friends* as well as our enemies. All the pathogenic Actinomycetes belong to two families: the *Mycobacteriaceae* and the *Actinomycetaceae*. These two, and the family *Streptomycetaceae*, which produces antibiotics, will be discussed in Chapter 3.

SPIROCHAETALES. The members of this order (often referred to as *Spirochetes*) are slender flexuous spiral organisms which closely resemble the protozoa (p. 9). (For this reason, some authorities do not consider them as constituents of the plant world.) They do not contain a *nucleus*. (See Fig. 4.) The Spirochetes fall into two

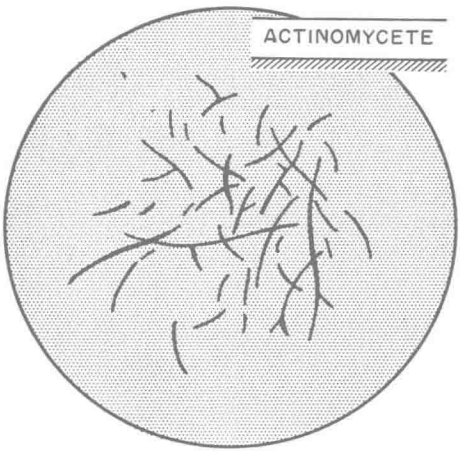

Fig. 3. General structure of an actinomycete.

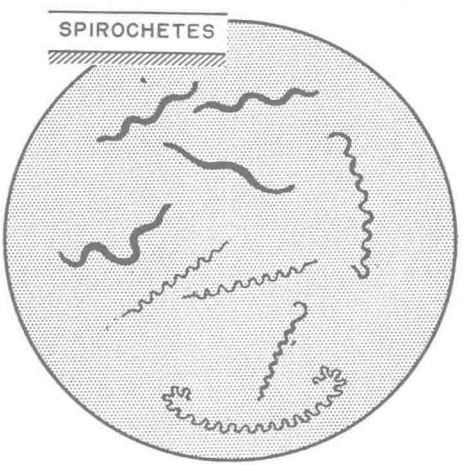

Fig. 4. Morphologic features of the spirochetes.

families: the *Spirochaetaceae* and the *Treponemataceae*. All the pathogenic members fall into the latter family. We shall discuss the pathogens in some detail in Chapter 3.

Fungi. The term *fungi*, in medical and popular usage, refers to any and all growths which—*to the unaided eye—look like a "mold."* This of course necessitates that we all agree on what a mold looks like. "Mold," in popular language, means any *fluffy and/or filamentous* growth upon dead or living organic matter (e.g., bread mold). When

such a growth is examined *microscopically*, however, one of three basic structures is seen: an *Actinomycete*, a *true mold* or a *yeast*. Thus, fungi (not Fungi) include the Actinomycetes (which, as we have already seen, are moldlike bacteria and formally classified as bacteria), yeasts (large unicellular plant organisms) and true molds (filamentous organisms with extensive branching). These three fungal forms are shown in Figure 5. The detailed morphology and physiology of these organisms will be thoroughly presented in Chapter 6 when we consider the fungi in detail.

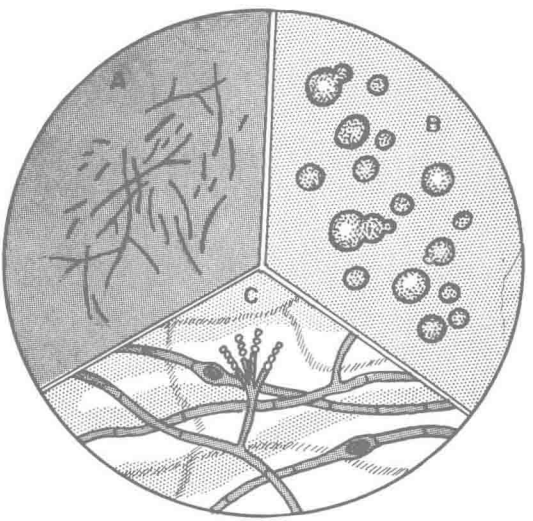

Fig. 5. General microscopic structural features of the fungi. *A*, An actinomycete; *B*, a yeast; *C*, a mold.

Rickettsiae. Rickettsiae (sometimes referred to as *rickettsial bodies*) were not discovered until 1909 (by Howard Taylor Ricketts). These organisms resemble bacteria in shape, but are considerably smaller. (See Fig. 6.) Although their exact nature is unknown, they are generally considered to be intermediate between the bacteria and viruses to which they are undoubtedly related. We shall, therefore, make no attempt at classification, if indeed, there be a satisfactory classification. In Chapter 4 we shall study in detail the rickettsiae and the diseases they incite.

Viruses. Every day the microbiologist and biochemist are recording new facts concerning the nature of viruses. It is safe to state, however, that we are still in the dark as to their true nature; indeed, we do not even know if they are a bona fide form of life. Perhaps the

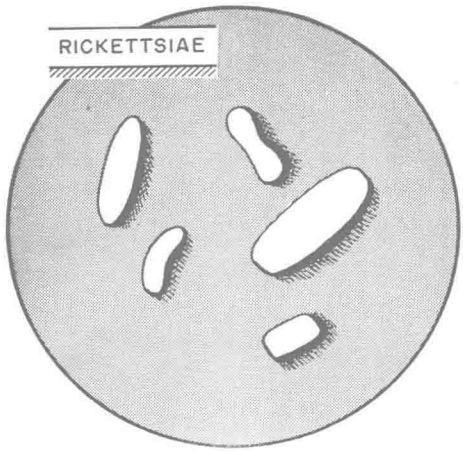

Fig. 6. Rickettsiae as they appear under the electron microscope.

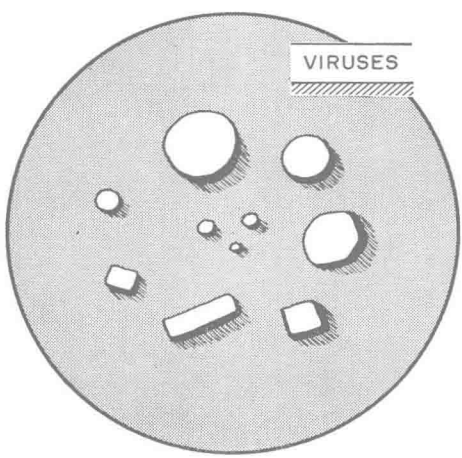

Fig. 7. Principal shapes of viruses as seen under the electron microscope.

virus represents a unique "state of matter" somewhere in the vicinity between life and nonlife. Viruses are the smallest microbes which confront the microbiologist. It was not until the advent of the *electron microscope* (which has a magnification about 100 times that of the optical microscope) that scientists were able to see and study them. Viruses range in size from almost invisibility (with the electron microscope) to about the size of the smallest bacterial cell. They appear as homogeneous bodies with spherical, rectangular or cuboidal shapes.

(See Fig. 7.) As with the rickettsiae, we shall not attempt to discuss the classification of these agents. In this connection, let us here be content with the fact that viruses are the simplest microbes that exist and may, for the present, be considered as intermediate between the rickettsiae and nonliving matter. The important physiological features of the viruses and the diseases they incite in man will be described in Chapter 5.

Protozoa. Protozoa are *unicellular animal organisms* with considerable diversification. (See Fig. 8.) They are much larger than the

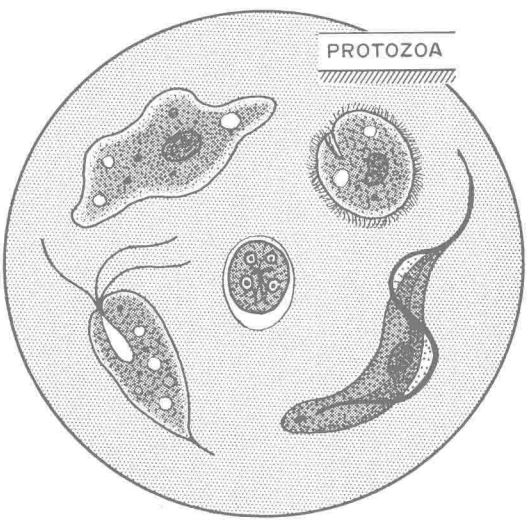

Fig. 8. Typical protozoans.

largest bacterium and possess well defined structures (viz., a nucleus and vacuoles). These organisms belong to the Phylum *Protozoa* (see Fig. 9) and are grouped thereunder (according to their mode of locomotion) into four classes: *Rhizopoda* (which move by means of pseudopodia), *Mastigophora* (which move by means of flagella), *Sporozoa* (which have no means of locomotion) and *Infusoria* (which move by means of cilia). Although most protozoa are harmless (indeed, helpful), a number of species produce severe infections. As a matter of fact, the most widespread infectious disease on earth, *malaria,* is caused by a protozoan.

Parasitic Worms. Worms, of course, belong to the animal kingdom. Unlike the members of the Phylum Protozoa, worms are *metazoans;* i.e., they are *multicellular.* Parasitic worms fall under the Phyla

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