PREFACE

The prokaryotes are a diverse assemblage of organisms that consists of the bacteria (also called eubacteria) and the archaea (also called archaebacteria). The text provides an updated account of the major aspects of the prokaryotes, such as cell structure, metabolism, developmental biology, adaptation to environmental changes, and biofilm formation. The text also covers cellular signaling pathways that allow individual bacterial cells to sense and respond to the environment, and also to signal each other so that they can respond as a cooperating population of organisms. It is written primarily for advanced undergraduate and beginning graduate students, and those who teach them. Topics include the structure and function of the prokaryotic cell (Chapter 1), growth and cell division (Chapter 2), membrane and cytosol bioenergetics (Chapters 3 and 7), electron transport and photosynthetic electron transport (Chapters 4 and 5), metabolic regulation (Chapter 6), intermediary metabolism (Chapters 8, 9, and 12–14), the metabolism of DNA, RNA, and protein, as well as how chromosomes are segregated during the cell cycle (Chapter 10), cell wall, capsule, and polysaccharide biosynthesis (Chapter 11), homeostasis (Chapter 15), solute transport (Chapter 16), protein export and secretion (Chapter 17), adaptive and developmental changes, multicellular behavior, and the signaling that underlies these events (Chapter 18), and how bacteria respond to environmental stress (Chapter 19). The text emphasizes the underlying principles of chemistry and physics in explaining the various physiological and metabolic features of prokaryotic cells, and thus provides the background for further advanced studies in this area.

To help students learn the material and prepare for examinations, each chapter ends with a summary and study questions, as well as a section of references and notes. The literature cited can be consulted for more data supporting the conclusions stated in the text and the notes expand on topics mentioned in the text. The notes are particularly important. Not only do they contain references to review articles and research papers, but they also have vital background information as well as detailed explanations of text material, including descriptions of experimental approaches. Students are therefore urged to examine the notes, particularly when the text directs them to do so.

This third edition of the text also contains boxes, which offer interesting historical perspectives on earlier discoveries that established the central tenets of biochemistry from the end of the nineteenth century into the 1960s, and the people who made these discoveries. From this material, the reader should gain an appreciation of the life-long effort of the many people who have contributed to our understanding of the biochemical bases of how cells function. Other boxes explain in more detail topics discussed in the text. See the listing of boxed material following the Table of Contents.

Most of the metabolic pathways that exist in the prokaryotes are the same as those in all living organisms, reflecting a unity in biochemistry dictated by principles of chemistry and (with respect to bioenergetics) physics. On the other hand, there is also a great deal of physiological diversity. The diversity of the prokaryotes is in part due to adaptations to the different habitats in which they grow. The habitats range in pH from approximately 1 to 12, temperatures from below 2 °C to over 100 °C, pressures as great as several thousand atmospheres (at the bottom of the oceans), habitats without oxygen, and habitats with salt concentrations that can reach saturating levels.

The physiological types among the prokaryotes mirror the diversity in the habitats and the sources of nutrient. Thus there are aerobes, anaerobes, and facultative anaerobes; heterotrophs, autotrophs, phototrophs, and chemolithotrophs; and alkaliphiles (alkalophiles), acidophiles, and halophiles. Some of these physiological types are found only among the prokaryotes, with rare exceptions. For example, among microorganisms that have been cultured in the laboratory, the ability to live indefinitely in the absence of air (anaerobic growth) is confined almost entirely to prokaryotes. Also, growth using the energy extracted from inorganic compounds (lithotrophy) seems not to have evolved in the eukaryotes and is restricted to certain groups of prokaryotes. The same can be said about the ability to reduce nitrogen gas to ammonia (nitrogen fixation), although this characteristic is more widespread among the prokaryotes than is lithotrophy. Another typically prokaryotic capability is the use of inorganic compounds such as nitrate and sulfate as electron acceptors during respiration (anaerobic respiration).

The organization of the text is according to topics rather than organisms, although the physiology of specific groups of prokaryotes is emphasized. This pattern of organization lends itself to the elucidation of general principles of physiology, metabolism, responses to environmental challenges, and cellular/multicellular development.

Most of the carboxyl groups are drawn as nonionized and the primary amino groups as nonprotonated. However, at physiological pH these groups are ionized and protonated, respectively. The names of the organic acids indicate that they are ionized (e.g., acetate rather than acetic acid).

There are two distinct evolutionary lines of prokaryotes commonly referred to as eubacteria and archaebacteria. However, this terminology implies a specific relationship between eubacteria and archaebacteria, whereas at the molecular level, the archaebacteria are not any more related to the eubacteria than they are to the eukaryotes. In recognition of this fact, Woese et al. suggested that the eubacteria be referred to simply as bacteria and that the archaebacteria be called archaea.[1] That terminology is followed in this text.

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REFERENCE

1. Woese, C. R., Kandler, O., and M. L. Wheelis. 1990. Towards a natural system of organisms: proposal for the domains Archaea, Bacteria and Eucarya. *Proc. Natl. Acad. Sci. USA* 87:4576–4579.