

PREFACE

The *Archaea* are clearly recognizable as a unique and interesting group of organisms for many important reasons. They have distinct molecular characteristics that clearly distinguish them from the *Bacteria* and the *Eucarya*, and evolutionary studies highlight the quintessential role that the *Archaea* have played in shaping all life on Earth. Many archaea are extremophiles and have been responsible for rewriting the textbooks with regard to the degree that an organism can tolerate, or even thrive, in abiotic extremes. As a result, the combined implications of their evolutionary role and their capacity to thrive in environmental extremes have expanded the horizons for the astrobiology community in searching for extraterrestrial life. Properties that are characteristic of or unique to the *Archaea* span from fundamental biochemical signatures (e.g., the glycerol-1-phosphate lipid backbone) and metabolic pathways (e.g., methanogenesis) to fundamental properties of their "lifestyle" (e.g., no pathogenic archaea are known). While the *Archaea*, *Bacteria*, and *Eucarya* represent coherent lineages, they are also chimeric in part. Archaea tend to have information-processing systems (e.g., DNA replication, transcription, and translation) in common with eucarya, while they share other features (e.g., metabolism) with bacteria. These characteristics provide important fuel for debates about the course of evolution. They also offer practical benefits for advancing studies on eucaryal organisms, in particular, metazoans, which are often more complex and difficult to study, by providing analogous biological targets for a broad range of studies (e.g., protein X-ray structures for eucaryal homologs from archaeal hyperthermophiles).

Given their serious importance to biology, one might be surprised that surprisingly few books cover the biology of the *Archaea* to any real extent. The best introductory microbiology textbook that covers the *Archaea* is Brock: *Biology of Microorganisms*, in which

archaea are covered accurately, although necessarily briefly due to the scope of topics covered. *Archaea: Molecular and Cellular Biology* is pitched at practitioners in the field, and as a useful resource for those less familiar with the *Archaea* but who are charged with teaching the topic, and it is intended to be accessible to postgraduate and advanced level undergraduates who will, we might hope, be inspired to become the next generation of "archaeaologists." Each chapter covers essential background, focuses on the discoveries of the twenty-first century, and concludes with a view of what is expected to arise in the next five years. The book aims to be the authoritative reference source for the many disciplines interested in the *Archaea*.

In many fields, in particular, in the early years of growth, terminology is coined by different research groups and gradually evolves into a sea of descriptions. The development of the *Archaea* as a field of study is no exception. We have adopted the conventions proposed by Carl R. Woese, Otto Kandler, and Mark L. Wheelis in their article "Towards a natural system of organisms: proposal for the domains Archaea, Bacteria, and Eucarya," published in the *Proceedings of the National Academy of Sciences of the United States of America*, 1990 (87:4576–4579), and Norman Pace in his essay "Time for a change," published in *Nature*, 2006 (441:289). This avoids complications with the use of terms such as "archaebacteria" and "eubacteria," which in essence inappropriately describe two different forms of "bacteria," and the term "prokaryote."

While the *Archaea* have often been appreciated for the qualities listed above (e.g., their extremophilic nature), molecular ecological studies have highlighted the diversity and ubiquity of archaea on the planet. It may indeed be impossible to identify a type of habitat where archaea are completely absent. Traditionally, the taxonomy and physiology of the *Archaea* have

been described by referring to halophiles, hyperthermophiles, and methanogens. While this serves a purpose, members of the *Archaea* know no boundaries and are unified by their fundamental cellular properties. This book embraces this knowledge and is dedicated to fully describing the molecular cell biology of the *Archaea*.

The core of the book, Chapters 3 to 18, describes the key cellular processes such as DNA replication, transcription, translation, lipids, and metabolism, while including a depth and completeness that includes unique features of aminoacyl-tRNA synthesis, signal transduction, and posttranslational modification (to mention but a few of the topics). Chapter 2 is a large chapter that covers general characteristics and important model organisms. By broadly over-viewing the ecology and physiological diversity of the archaeal world, the chapter provides a reference point for contemplating the biology of the cell. Chapters 19 to 21 cover genomics, functional genomics, and molecular genetics. Although relevant aspects of these topics are integrated into preceding chapters, chapters 19 to 21 provide a depth and focus that highlight the evolutionary implications, the state-of-the-art, and the strengths and limitations of each of the fields. The book concludes with two chapters that cover biotechnological and biomedical applications of archaea and their cellular products.

Chapters 2 to 23 have been written and edited with the aim of capturing each author's individual expertise, while generating a reference text with a synthesized style and tone. It is indeed not merely a collection of conference proceedings. The exception to this general style is Chapter 1, a personalized account by Carl Woese of the "history of the *Archaea* movement." In his chapter, "The *Archaea*: an Invitation to Evolution," Carl offers a provocative and inspiring

account of how the *Archaea* were discovered, delves into the implications of archaeal distinctiveness for the origin and evolution of life, and describes the scientific and social hurdles that needed to be overcome to bring the field forward to where it is today, a time in which the *Archaea*, whose existence could not have been guessed only a short time ago, have come of age.

It is my hope that the many hours of effort that preceded the publication of this volume will have not been in vain, that the volume in hand will be the first place active researchers go to for information on the *Archaea*, and that the younger generation of biologists will be inspired to try their hand at these organisms, whose secrets we have only begun to unlock and which offer so much in the way of fundamental insights and practical benefits.

It would be ungracious of me not to acknowledge the help I have received along the way from the many people who provided assistance. It is impossible to cite everyone, but, in particular, I thank Greg Ferry for constructive and encouraging words (and great coffee) who helped to initiate the book and drive it along, and Kevin Sowers for supporting my efforts (in particular, with Guinness) during sabbatical in his laboratory. Interactions with authors have been uplifting experiences, which I think illustrates that those in the *Archaea* field share a common excitement and joy of discovery, and who certainly know how to pull together when it counts. Sincere thanks to Carl Woese for letting me see inside his world, and for not only sharing rare insight but timely, inspiring, and warm encouragement. Thanks to Greg Payne who has provided the critical and smooth link to the rest of the team at ASM Press—here's to you all, and to the first edition of *Archaea: Molecular and Cellular Biology*.

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