

Preface

Anyone who has recently attended a conference on microbial ecology would agree that it is hard not to appreciate how much the field has evolved in the past few decades. We are gaining unprecedented insights in the lifestyles of microbes at different spatial levels. With molecular tools, we can study microbial communities at the level of single cell interactions while with remote sensing we can detect their presence and activity at a planetary scale. Nucleic acids and proteins can be sequenced from minute amounts of starting material and in just a few hours, giving us detailed descriptions of the diversity and activity of microbial communities. And using these techniques, everywhere we look, and as long liquid water is available, we are discovering new branches of the microbial tree of life. In seemingly inhospitable places, microbes are exploiting resources, cycling organic and inorganic compounds, fighting with each other and promiscuously exchanging massive amounts of genetic information. Extreme environments select for unique adaptations at the level of enzymes, compounds, and processes which are the future arsenal of biotechnology. The exploitation of these natural resources will require not only the development of new bioinformatic tools for data mining, but also new culturing techniques and systems biology approaches for environmental engineering.

This book is meant to provide a useful reference for those who want to start a research program in extreme microbiology and, hopefully, inspire new research directions. Assembling it has taken a long time. For one reason or another, there was always an excuse such as too much teaching or administrative duties or the lack of enough material or just procrastinating because of another grant deadline approaching. And it was just by chance that we ended up working at the same institution and found the time to convince enough experts in the field that it would be fun to write this book.

So here it is. The chapters are organized so that they roughly follow a vertical profile through the biosphere.

After a brief introductory chapter, we begin in the deepest depths of the Ocean with Chap. 2 comprehensively reviewing the phylogenetic diversity of cultured and uncultured piezophiles (pressure-adapted microbes) and discussing the need for a

better representation of piezophilic phylogenetic diversity in culture collections. We also discover how the genomic features of pressure-adapted microorganisms differ from those of close phylogenetic relatives from shallower waters.

The deep sea is further explored in Chap. 3, which goes into detailing the adaptations of motility and cell envelopes of piezophiles and Chap. 4, which explores the effects of hydrostatic pressure on extracellular electron transfer and how this might be ecologically relevant to environments with low energy input.

The following two chapters describe life in hot environments. Chapter 5 reviews the diversity and activity of microbial populations in many high-temperature habitats around the world. Thermophilic bacteria and archaea produce many enzymes which have biotechnological applications but proteins from thermophilic viruses might also have similar or even better potential. Chapter 6 describes the ecology viruses and the concurrent coevolution of CRISPR/Cas systems in hot springs.

The next two chapters take the readers to the opposite extreme of temperature. In Chap. 7, the diversity of bacteria in polar deserts is discussed in the context of their remarkable adaptations, while Chap. 8 looks at the ecological function of phages in high-latitude aquatic systems. A particular emphasis is devoted to phage–host dynamics and their relevance to the control of biogeochemical fluxes though the polar ecosystem.

Chapter 9 deals with solvent tolerance, which is important for many industrial processes. The chapter discusses the evolution of efflux pumps as a way to cope with solvent stress and how these can also provide resistance to antibiotics. Therefore, understanding solvent tolerance has implications in the control of infectious disease and human health.

And finally, Chap. 10 presents a comprehensive review of microbial life in clouds from their diversity to the adaptations to environmental challenges of living air.

This book only deals with a small subset of the extreme habitats of our biosphere. Notable omissions include extremes of pH or salinity on which other, more specific volumes have been written. One important point made by all authors is that the molecular and physiological basis of life at any extreme is still largely unknown and that a lot more work is needed to fully understand it. It is easy to see why, since most of the habitats are difficult to access. Yet, if technology keeps progressing at the same pace, it will not be long before we can answer many of the questions raised in this book about evolution, biogeography, and biodiversity.

And even if the study of microbes in extreme environments will remain challenging, hence not for the faint-hearted, the potential rewards are worth the effort.

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Microbial Ecology of Extreme Environments

Chenard, C.; Lauro, F.M. (Eds.)

2017, XV, 245 p. 17 illus., Hardcover

ISBN: 978-3-319-51684-4