

PREFACE

Unicellular microorganisms, and in particular prokaryotes, thrive in extremely diverse environments. In fact, the range of physicochemical conditions under which microbial life has been observed continues to expand as microbiologists explore more remote and hostile environments. Today, microorganisms have been described to occur in habitats spanning an extraordinary range of more than 120°C, 10 pH units, and millimolar to molar concentrations of solutes like NaCl. To grow under these extreme conditions, these microorganisms have evolved specific and unique adaptations, and the study of these provides interesting insights not only into microbial physiology but also into the most fundamental properties of living systems as compared to nonliving systems. Temperature, pH, and osmotic pressure are among the most-studied environmental parameters in microbiology, probably because they are easy to manipulate and because they are relevant in our daily life, for example, in food preservation. By comparison, much less is known about microbial adaptation to high pressure, although high-pressure environments are more widespread in nature than high-temperature, high- or low-pH, and high-osmolality environments. The compartment of the oceans 200 m below sea level constitutes more than 95% of the volume and represents 55% of the prokaryotic cells of all aquatic habitats on earth. Pressure levels vary 3 orders of magnitude, from 0.1 MPa at sea level to more than 110 MPa at the deepest point in the ocean, approximately 11,000 m deep. Besides the deep sea, the deep terrestrial subsurface is another enormous high-pressure habitat, probably the last large remaining unexplored habitat on the earth. Several piezophilic bacteria from the deep sea have been isolated and characterized today, but clearly, the full amplitude of microbial diversity in high-pressure habitats and the physiological adaptations in these organisms are only beginning to be unraveled.

Besides piezophiles, nonpiezophilic microorganisms are an object of study for investigators of high-pressure microbiology. The interest in studying the effects of high pressure on these organisms has been fueled by the development and commercial introduction since the 1990s of a food preservation technique based on high pressure without the need to apply heat. Large amounts of quantitative data on the high-pressure inactivation of food-borne pathogens and spoilage organisms have become available since then. The pressures used in these inactivation studies are typically in the range of 200 to 800 MPa, much higher than the pressures at any depth in the ocean. We have learned from these studies that sensitivity to heat and to high pressure are not necessarily linked and, most remarkably, that vegetative bacteria can acquire extreme resistance to high-pressure inactivation. The findings have, in turn, raised interesting fundamental questions about the actual molecular perception of high pressure, the nature of the cellular damage it causes, and more specifically the adaptations that render these cells high-pressure resistant. Adaptation to stress has always enjoyed a wide interest among microbial physiologists, and several bacterial stress responses are known in great molecular detail. High-pressure

stress has been largely neglected in this field, but in view of its unique effects on biomolecules and biomolecular assemblies, which are different and sometimes even opposed to the effects of heat, high pressure is likely to become a very useful addition to the "tool-box" available to microbial-stress investigators. High pressure has indeed been shown to induce some unique responses in nonpiezophiles, like *Escherichia coli*, and may thus help to uncover novel stress response pathways and adaptational mechanisms in bacteria that have thus far remained cryptic.

It is clear from the above that the field of high-pressure microbiology has evolved along two tracks and that both in the piezophile and in the nonpiezophile tracks, significant progress has been made in the description and understanding of high-pressure effects. Against this background, we endeavored to compile this book, which is probably the first to be entirely devoted to high-pressure microbiology. The objectives are to give an update on the progress in the field and to stimulate a cross-fertilization between the piezophile and the nonpiezophile high-pressure research fields. This approach is reflected in the structure of the book. While the first chapter introduces elementary thermodynamic principles related to high pressure and focuses on biomolecules and biochemical reactions, chapters 2 and 3 look at viruses and bacterial spores, respectively, and form the bridge to the cellular response and adaptation strategies of nonpiezophilic microorganisms, discussed in chapters 4 to 9. Chapter 10 closes the first section with an overview of food- and microbe-related features that affect the efficiency of high-pressure processing. The second section of the book (chapters 11 to 18) highlights different aspects of deep-sea microorganisms and deals both with their isolation, diversity, and ecology and with their physiological adaptations. We hope that this book will appeal to a large readership of microbiologists, not only those actively involved in high-pressure research but also those interested in microbial stress responses or more generally in microbial physiology.

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