

Preface

In 2013, Dirk Wagner invited me to edit a new topical volume in the De Gruyter book series *Life in Extreme Environments*, after Diana Northup recommended me for the project. The volume title, "Microbial Life of Cave Systems," excited me. No books on this topic had been published, despite the noticeable increase in peer-reviewed literature describing cave microbiology over the past 30 years. A book like this would be the first authoritative, comprehensive account of the microbiology of caves, and potentially draw in new researchers, from students to academic and technology professionals. I was humbled by the invitation and grateful for Diana's recommendation.

As is true for all subsurface habitats, cave habitats are naturally bound on all sides by rock, and darkness is the most ubiquitous feature. However, nearly all of the chapters in this book reveal how pervasive extreme environmental conditions are to cave habitats. I do not mean extreme in the context of the customary microbiology definition, being conditions that humans consider abnormal. I mean extreme in the context of drastic variability. Differential movement of water and air through rock, sometimes quickly in conduits or fissures or slowly through the rock matrix, and the nature of hydrological connection to the surface or proximity to groundwater, affect the availability of organic substrates and nutrients needed for energy and metabolism. For some types of caves, organic matter and nutrients can be abundant and accumulate over time because decomposition rates are slower than deposition. In other types of caves, organic carbon and inorganic nutrient limitation is evident, but microbial activities associated with nutrient acquisition and cycling, degradation of organic matter, the production of new organic matter in the absence of photosynthetically-derived material, and induction of mineral precipitation can overcome those limitations and serve to sustain biologically diverse ecosystems. Water and air movement through rock also affects environmental conditions like salinity, temperature, and pH, which all can, and often do, span a full range of conditions. Many cave systems take thousands to millions of years to form, and as their environmental conditions stabilize over time, the endemic organisms adapt to those conditions. As such, it is clear that cave habitats are particularly susceptible to disturbance. Human-induced disturbances, like contamination events or even converting a cave into a tourist attraction, significantly alter environmental conditions and change the metabolic foundation and evolutionary trajectory of a cave ecosystem. Microbes have evolved strategies to survive through and compete in extreme environmental conditions, and may also evolve strategies to survive disturbances. These strategies can be explored for biotechnology potential, a theme that resonates throughout the book. Collectively, the book chapters build a complex picture of cave habitat extremes and of the multifaceted roles of microbial life in caves.

I am thankful to all the enthusiastic, contributing authors. As I discuss in the introductory chapter, many of us are kindred spirits who came into the science as part of a

few original teams. We are passionate about the subject matter and about caves, which might seem 'extreme' to those outside of this research area! What should become clear from each chapter in the book is that none of the research would be possible if someone had not ventured into the darkness to study the microbiology of caves or if we had not convinced others to explore with us. In many ways, our ability to enter caves makes our research unique from the types of work done in most other subterranean habitats, excluding artificial tunnels and mines, that must be accessed from wells and boreholes. Chapter by chapter, the research not only brings to focus the caves, and the microbiology of caves, but also emphasizes the collegiality of cavers.

"If it form the one landscape that we, the inconstant ones,
Are consistently homesick for, this is chiefly
Because it dissolves in water. Mark these rounded slopes
With their surface fragrance of thyme and, beneath,
A secret system of caves and conduits; hear the springs
That spurt out everywhere with a chuckle,
Each filling a private pool...; when I try to imagine a faultless love
Or the life to come, what I hear is the murmur
Of underground streams, what I see is a limestone landscape."

— W. H. Auden, excerpt from *In Praise of Limestone*

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