Foreword

When we think of the ocean we might think of whales, waves, dolphins, fish, the smell of the sea, its blue color, and its vastness; most of us would not look out at the sea and think of marine microbes, nor did marine scientists for over a century. They sailed the seas and strenuously dragged plankton nets through the ocean's pelagial zone to capture what they judged would represent the marine biota. But they were unaware that the great majority of the biota, perhaps 99 percent, easily streamed through the holes of their nets; the holes were simply too big to capture these microbes. Even when membrane filters and microscopy were used, and they revealed great diversity of microplankton and nanoplankton, most microbes evaded detection. The view of the pelagic web of life that emerged, and became entrenched for a century, was then based on a tiny fraction of marine biota. As a result, fisheries scientists used models that did not include marine microbes, as did marine chemists and geochemists who studied how biological forces influenced the grand cycles of elements in the ocean. Much had to be revised as the major roles of the microbes were discovered, following the development of new concepts, incisive imaging, and molecular methods to observe and study marine plankton.

Munn enthusiastically and persuasively tells the story of the dramatic transformation of marine microbiology since the mid-1970s ("one of the most important advances in modern science"). The essence of it is that literally a billion (per liter of seawater) previously unsuspected picoplankton and ten-times more abundant and diverse femtoplankton (viruses) account for much of the marine biodiversity, abundance, and metabolism. It is not just the enormous numbers that are remarkable (a billion times more microbes in the sea than all the stars in the known universe, quotes Munn) but the microbes' metabolic capabilities. For instance, in 1988 a 0.6 μm marine photosynthetic bacterium *Prochlorococcus marinus* was discovered. We now know this is the most abundant photosynthetic organism on Earth, and is responsible for a large fraction of marine, and indeed planetary, photosynthesis. In pelagic ecosystems a microbial web of life forms the fine fabric on which macrobial life is visibly embroidered. The story of marine microbiology is truly exciting, and it is still unfolding. Munn captures the excitement of this dynamic field of marine microbiology and conveys it lucidly, insightfully, and in an engaging and accessible manner.

A distinct strength of the book is that it conveys the basic information on marine microbes and their ecophysiology in a highly accessible narrative; detailed and well-referenced discussions are placed in boxes that read like mini-reviews (and they are remarkably up to date and well-referenced including some 2010 citations.) Bacterial physiology and biochemistry is streamlined and marine examples are used, so the relevance to ocean processes is always maintained. Many currently topical research questions are also presented and discussed, including some hypotheses ripe for testing. A prominent feature of marine microbiology is that it is expanding rapidly to create new interdisciplinary interfaces. As we face complex environmental issues, so marine microbiologists need to work with ecologists, geochemists, fisheries and conservation biologists, climate scientists, biomedicine

researchers, and epidemiologists to incorporate a microbial perspective into studies of ocean and Earth systems. Munn's book should be of much value not only to students of marine microbiology but also to scientists from related disciplines, and could foster interdisciplinary research.

Munn reflects the times and the environmental concerns, returning over and over again to the theme of global climate change. He is passionate and creative as he debates the geoengineering proposals to sequester atmospheric CO_2 (he expresses strong reservations on geoengineering) and the environmental threats to coral reefs. In the "good old days" marine microbes (and microbiologists) were not included in such weighty issues. So, this is a relatively new arena for marine microbiologists. We have made impressive progress in uncovering microbial diversity, spatial and temporal dynamics, and have predicted metabolic capabilities for interactions with ocean systems. However, we are only beginning to understand how marine microbes influence system *variability* in an ecosystem context. For example, what regulatory mechanisms underlie the variability in the microbial carbon cycling in the ocean? How would they respond, for example, to climate change or geoengineering? These questions involve regulatory interactions among diverse microbes, from molecular and microspatial to an ocean-basin scale. Munn pays considerable and deep attention to the microspatial context for microbial biogeochemistry. After all, *this* is the realm of the microbe and the scale at which the individual microbes minutely structure the ecosystems and respond to global change. Their strength lies in their incredible diversity and intense activity, which still evade the casual observer of the sea.

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