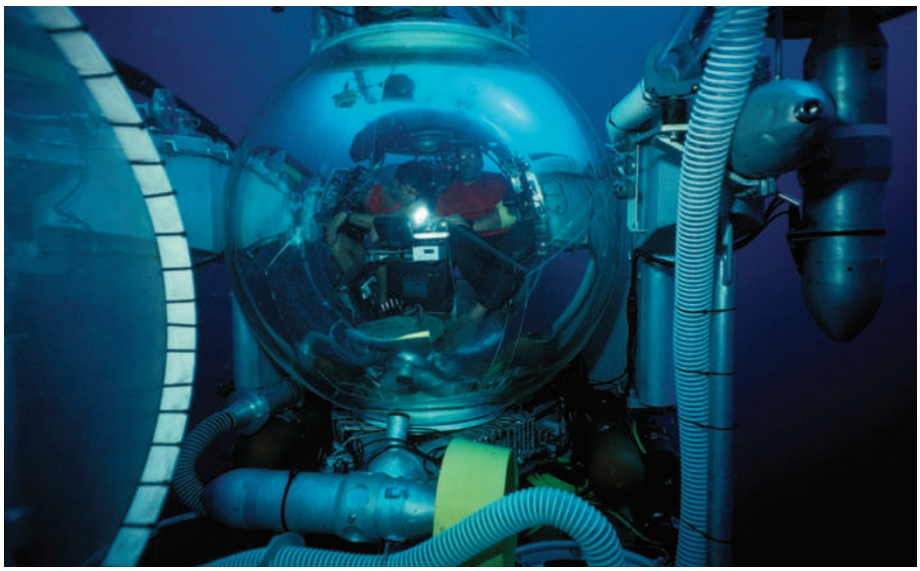
BOOKS & ARTS

The otherness of the oceans

As scientists discover more about the genomes of marine microorganisms, new views of their physiology and ecosystem networks are opening up, explain **Alexandra Z. Worden** and **Darcy McRose**.

Alien Ocean: Anthropological Voyages in Microbial Seas
by Stefan Helmreich
University of California Press: 2009.
464 pp. $60.00, £42.95



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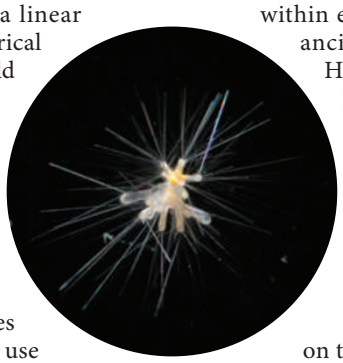
Deep-sea exploration may look otherworldly, but the ocean's tiny inhabitants — such as the foraminifer *Hastigerinella digitata* (below left) — are no more alien than the microbes in our guts.

In 1913, the French essayist Marcel Proust mused that "in certain climes whole tracts of air or ocean are illuminated or scented by myriads of protozoa which we cannot see". Proust's reflections perhaps resulted from his hypochondriac perception that nature and his personal well-being were in conflict. A century later, anthropologist Stefan Helmreich examines in his new book how modern microbial oceanographers experience oceans and the diverse microbial communities that dwell within them. He proposes that microbial ocean life is 'alien' to wider society and that this 'otherness' shapes our stewardship of nature — or lack thereof.

Alien Ocean focuses on current research in marine microbiology and the social and political contexts in which it takes place, with a particular focus on metagenomics, the study of genetic material from uncultured microorganisms. Helmreich offers vignettes from his voyage through specialized research labs, conferences and oceanographic expeditions. He discusses marine biotechnology, including 'bioprospecting' for commercially valuable compounds, and social quandaries surrounding intellectual-property rights.

The book is perhaps best read as a collection of essays rather than a linear progression. It is not a historical account of the burgeoning field of microbial oceanography; for instance, the discovery of SAR11, the most abundant group of heterotrophic bacteria in the ocean surface, slips by in a single sentence. This discovery, by Stephen Giovannoni of Oregon State University and his colleagues in 1990, helped usher in the use of the polymerase chain reaction as a tool for exploring marine microbial diversity. It engendered the idea that we could, and should, pursue genetic information even in the absence of lab cultures of microbes — a central goal of the metagenomic work discussed at length in the book.



Helmreich literally dives into his research, working with remotely operated vehicles that access the deep sea as well as participating in lab work. He offers a unique glimpse into the lives of environmental scientists, whether through his underwater trips in the tiny bathysphere *Alvin* or his adventures sploshing through salt marshes with legendaries such as biologist Lynn Margulis, a proponent of the Gaia concept of linked Earth systems, who also championed the idea that mitochondria and chloroplasts within eukaryotic cells arose from ancient endosymbiotic events. Helmreich's immersion allows him to capture sentiments that are absent from publications or formal interviews. He relays scientists' fears that the cumulative damage of human interaction with the oceans will result in our own demise.

At times, Helmreich's reliance on the perspectives of his interviewees precludes achieving a balanced point of view. For example, the work of controversial biologist Craig Venter, and seemingly his personality, is attacked in a chapter formulated from interviews with Venter's critics. This is out of character with the rest of the book — the author rarely provides critical evaluation of other scientists' research, and Venter himself does not seem to have been interviewed. Helmreich also states which US labs supposedly lead the field of marine microbiology — a surprising statement, given that he does not present a comprehensive or objective evaluation of the field.

The strength of *Alien Ocean* is its innovative analysis of the ways in which oceans are alien to humans. Helmreich likens marine microbial research to voyages in outer space, but this is not always the perception among the researchers interviewed. Many of them consider the ocean and its microbial flora and fauna to be no more alien than the enormous microbial community housed within the human gut. Helmreich points out that most of society perceives things differently. For some, "the alien ocean is a medium … dense in its darkness, crushing in its pressure, suffocating in its substance", even though it hosts creatures "whose very otherness is crucial to human life support".

He drives home the point that environmental destruction by humankind is tied to this perception; the sense of oceans as being separate from our everyday lives colours our ability and willingness to defend the natural world. Thus, he warns that, "alienated from the ocean, humanity may be destined to damage it". If he can bring this conundrum into the general consciousness, it will have profound effects on how society and policy-makers interact with the oceans.

Ever present in the book is the promise microbial oceanographers place in environmental genomic sequencing. Researchers hope that this technique will lead to an "understanding [of] the genetic control of the physiology of the sea". One scientist interviewed puts forth the idea that one-third to one-half of microbial genomes might represent 'ecology genes' — genes that could explain the dynamics and interactions of organisms.

Scientists also discuss in the book how the ocean may operate as a network of genes, an increasingly popular perspective. The gene-network concept is a helpful framework for considering interactions over long timescales. But if taken too literally, its value is less clear, especially over the shorter time frames of anthropogenic perturbations. It is a microbe's entire gene complement that shapes its overall physiology, response capabilities and interactions with other life forms — not just a single gene or gene set. Hence, simply probing the oceans for genes will not necessarily provide the organism- and genome-specific context probably needed to understand microbial dynamics.

Helmreich mentions the problem of deciphering meaning from the vast amounts of information being produced at increasingly rapid rates. This disconnection between information, inference and true function really is the 'elephant in the laboratory'. How do we move beyond gene sequences to understand cell physiology, functional roles, rates, activities, trophic linkages and global biogeochemical cycles?

As much as *Alien Ocean* captures the excitement and crucial nature of oceanographic research, the field still faces the grand challenge of advancing from sequence information to a functional understanding of the system. Although proper experimental design and a statistically appropriate depth of sequencing have yet to be achieved in marine metagenomic studies, there are more fundamental issues at hand. Many 'genes' sequenced in environmental metagenomic studies, or indeed in complete genome sequences of marine bacteria, archaea and unicellular eukaryotes, are still of unknown function. Stories are woven from those genes we can name, but other genes that might render insights into how a microbe wrangles with its environment remain untouched.

Gaps in our knowledge have led to raging disputes among microbiologists about whether common measures of microbial biodiversity reflect functional divergence. The state of the field is reminiscent of periods in medical research when inferences were made about the existence and roles of particular genes and molecules, such as the tumour suppressor p53, before concrete data were available. Reactions to such inferences propelled the field forwards. In the case of microbial oceanography, a tangible forward step would be to elucidate gene function and links to physiology. This would go a long way towards moving from sequence space to ecosystem-level understanding. Perhaps *Alien Ocean* will inspire the next generation to fulfil the promise of environmental genomic sequencing. ■

Alexandra Z. Worden and **Darcy McRose** are at the Monterey Bay Aquarium Research Institute, Moss Landing, California 95039, USA.
e-mail: azworden@mbari.org

See Editorial, page 140.

Ecology lost and found

Paradise Found: Nature in America at the Time of Discovery
by Steve Nicholls
University of Chicago Press: 2009.
536 pp. $30

Albert Bierstadt's 1864 work portrays the idyll of Yosemite before European settlers reached the American West.

MUSEUM OF FINE ARTS, BOSTON, 2009/BRIDGEMAN ART LIBRARY

"We don't need history," I recently heard a conservation scientist tell a group of students. He was being provocative, targeting those ecologists who treat the past as a baseline to which we should return. The world has changed too much and is changing too fast, he argued, for history to serve as a useful measure for restoring nature. The questions that animate conservation today do not ponder what we have lost or how we can get it back. The past is another world, and that world is gone. The questions now are: what kind of world do we want? And how can we create it?

In this context, Steve Nicholls's *Paradise Found* seems quaintly historical. The book is a cornucopia overflowing with the abundance of nature long gone. In this history, no species simply existed in the past. In early North America, Nicholls writes, "the fertile coasts teemed with fish and marine mammals … prairies were a carpet of wildflowers" and the mountains were "clothed in forests".

This is history written as if the past were a spectacular nature documentary. This comes as little surprise when you learn that the author has been a producer of nature shows for television for the past 25 years, as he frequently reminds readers. The book even calls to mind historical re-enactments, as Nicholls asks his audience to imagine themselves with the eleventh-century Norsemen settlers in fabled Vinland; fishing for cod with the fifteenth-century explorer John Cabot; or sitting under a tulip poplar as a flock of passenger pigeons burdens the boughs overhead.

Nicholls laments species that have been driven to extinction, but his real concern is a decline in the abundance of animals. By this he seems to mean wildlife spectacles that would be suitable for television. But Nicholls engages an important historical and ecological argument here, too. "An accurate picture of the past is important," he writes, as "a baseline to judge how effective conservation measures are."

A debate is raging among historians and ecologists regarding 'shifting baselines', a concept developed by marine biologist Daniel Pauly to describe how people often assess environmental decline only in the context of their own lifetimes. The sentiment is familiar: "When I was a kid, fish were everywhere — and this big! Now they're much harder to catch, and smaller." Each generation begins with a diminished baseline. This insight has led to massive efforts to find an accurate baseline for the natural world — what Nicholls calls 'paradise found' — by enlisting historians to scour records such as letters, diaries and ships' logs, which were also used by Nicholls to construct his narrative.

Although Nicholls acknowledges that early Native Americans often had a major impact on species and ecosystems, such as their hunting of bison in the Western grasslands, he portrays North America before its discovery by Europeans as Eden before the Fall. This is a common move in such accounts. But Nicholls seems to have