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EDITORIAL

Advances in Vent, Seep, Whale- and Wood-Fall Biology

The study of chemosynthetic ecosystems as an interdisciplinary, global endeavor

The first deep-sea chemosynthetic ecosystem was discovered just 30 years ago at the Galapagos Rift (Corliss & Ballard 1977; Lonsdale 1977; Corliss *et al.* 1979; Grassle 1986). Two years later, cold seeps were discovered on the California margin at the San Clemente Fault Zone (Lonsdale 1979), although at the time they were thought to be hydrothermal vents. Not until 1984 were cold seeps recognized as a different habitat from vents, with discovery of chemosynthetic communities on the Florida Escarpment (Paull *et al.* 1984). Shortly thereafter (1987), the first whale-fall chemosynthetic assemblage was found (Smith *et al.* 1989). Over the past 20 years the discovery of new chemosynthetic ecosystems has burgeoned worldwide, and our understanding has deepened and matured.

The overlapping environmental conditions, and in particular the faunal reliance on reduced compounds such as sulfide and methane, stimulated our collation of papers on different chemosynthetic environments into a single volume. Animals inhabiting wood, whale, seep and hydrothermal vent ecosystems are faced with both similar and different challenges. Their nexus is an array of adaptations to decouple survival from the sinking rain of organic debris in favor of specialized microbial symbioses to exploit less conventional energy sources. In all of these systems there are endless discoveries: new species, new species associations, novel roles for microbes, and unusual integration with the geochemical environment.

The articles within this volume reflect the diversity of settings that support chemosynthetic communities, the highly multidisciplinary nature of our explorations, the broad range of organisms associated with these systems and the breadth and complexity of questions being addressed. A wealth of biological disciplines is represented in these papers, from natural history to molecular microbial ecology, from reproduction, parasitology and population genetics to physiology, behavior, experimental ecology, biogeography and paleoecology. Symbiont-bearing organisms feature prominently throughout. In some cases, biology is interpreted with data from other disciplines, such as geochemistry. The fact that exciting questions can be addressed in all of these fields, while focusing on tiny patches of chemosynthetic sea floor, reflects the amazing role of these ecosystems in the modern realm of biological discovery.

The papers advance our understanding in multiple arenas, and illustrate clearly that the study of chemosynthetic ecosystems has entered the eras of experimentation and 'better living through chemistry.' We are shown the possibility of rearing vent and whale-fall animals, and of creating replicate whale-fall chemosynthetic habitats on the seafloor (Miyake *et al.*, Fujiwara *et al.*). We learn that bivalves grow rapidly (Barry *et al.*) and tubeworms grow very slowly (Cordes *et al.*) at methane seeps. Animal physiology reveals novel adaptations to metal and sulfide toxicity (Company *et al.*; Gonzalez Ray *et al.*; Brand *et al*), and communities are found that can live in nearly complete anoxia (Seergeva *et al.*) or derive nutrition from wood (Pailleret *et al.*). Chemical cues feature prominently in driving animal associations at seeps (Dattagupta *et al.*; Van Gaest *et al.*; Olu *et al.*) but structural attributes are important in chemosynthetic ecosystems as well (Govenar *et al.*). Symbioses are ubiquitous but offer continual surprises at vents: the first protozoan–bacterial symbiosis (Kouris *et al.*), multiple symbionts within tubeworms (Moyer *et al.*), as well as mussels involved in relationships with parasitic polynoids (Britayev *et al.*) and fungal disease (Van Dover *et al.*). Animal utilization of chemosynthetic food sources at vents and seeps is complex, with multiple pathways revealed by lipid (Colaco *et al.*) and stable isotope (Levin & Mendoza) markers. We glimpse predation in the fossil record (Amano & Jenkins), find unexpected levels of population differentiation in *Riftia* (Shanks & Halanych), unusual reproductive modes in copepods (Ivanenko), phylogenetic constraints on reproduction in bivalves (Jarnegren *et al.*), and continue to discover remarkable new species and adaptations in chemosynthetic ecosystems such as whale falls (Fujiwara *et al.*).

Papers in this volume span research from the North, West and East Pacific Ocean, as well as from the Atlantic Ocean and from the Black Sea. Contributors to this volume were from 11 countries and in many cases authors from multiple countries contributed to a single paper. Thus, the volume reflects the extent to which the study of chemosynthetic ecosystems is truly an international endeavor. The discipline has become highly collaborative on a global scale in recent years, due partly to increases in national and private (e.g., Census of Marine Life) funding for workshops and meetings that promote dialogue and kindle collaboration among scientists. But we still need to deepen our understanding of the ecological and evolutionary interactions among different chemosynthetic ecosystems. We hope that you, the reader, will find this volume stimulating and that it promotes cross-fertilization of information and ideas among researchers working in vents, seeps, whale- and wood falls.

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