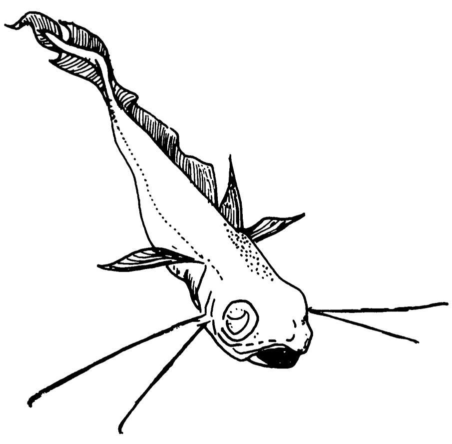
that the second Mayo trial was flawed, this time on biostatistical grounds. Pauling also succeeded in presenting his case to the new director of the National Cancer Institute, the funding power behind the two Mayo trials. It seems that Pauling in this director found a sympathetic ear and got some advice on how best to proceed in medically proving his case. A standard clinical trial was not suggested. The randomized controlled clinical trial, typically looking for relatively short-term and dramatic improvements, may not after all be the most suitable scientific method for assessing the efficacy of agents with moderate and long-term fortifying effects. A reconsideration of the standards of proof in medical research could turn out to be the most important outcome of the prolonged controversy about vitamin C and cancer.

ULLICA SEGERSTRÅLE
Department of Social Sciences,
Illinois Institute of Technology,
Chicago, IL 60616

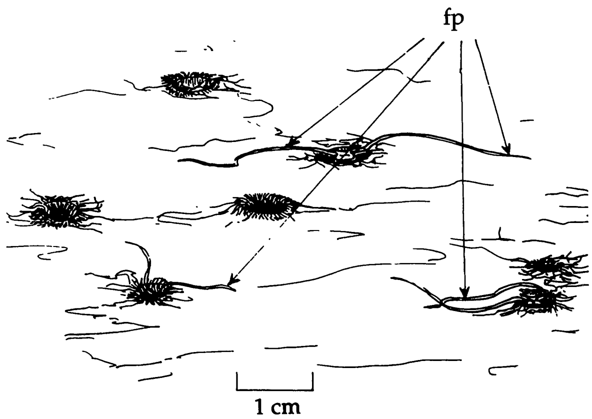
Life in the Abyss

Deep-Sea Biology. A Natural History of Organisms at the Deep-Sea Floor. JOHN D. GAGE and PAUL A. TYLER. Cambridge University Press, New York, 1991. xvi, 504 pp., illus. $135.

Sunlight at noon turns quickly to dusk as you descend beneath the surface of the open ocean. Continue your descent to the abyssal seafloor in the blackness of midnight, lit only by splashes of luminescent light as planktonic organisms are disturbed by your path through the water. Once on the bottom even your brightest lights won't penetrate very far. But under their spotlight you will find illuminated a minute patch of the largest, most inaccessible, and least understood ecosystem on our planet. You will see a world that is often more like the stage set of a science-fiction movie than anything familiar to most of us. You are likely to encounter fantastic creatures, like single-celled protozoans of grapefruit proportions, or giant stalk-borne tunicates looking like paper grocery sacks on sticks, or herds of sea cucumbers congregating on the tan muds of soft-sediment plains.



"Deep-sea morid fish probing the ooze for food with its long, sensitive pelvic fin rays." Some 50 species of deep-sea Moridae (cods) are known. . . . They often possess an elaborate light-producing organ . . . containing symbiotic luminous bacteria." [From *Deep-Sea Biology*; redrawn from B. C. Heezen and C. D. Hollister, *The Face of the Deep*, 1971]



"Surface-deposit feeding by the shallow-water, mud dwelling spionid *Malacoceros*; the paired, ciliated feeding palps (fp) select particles as they explore the sediment surface. . . . Deep-sea spionids probably feed in a similar manner, although they will rarely live at such high density as depicted; this foraging strategy becoming increasingly unable to provide resources at a rate sufficient to meet metabolic demands as food supplies become more sparse with increasing depth and distance from land." [From *Deep-Sea Biology*; drawing courtesy T. H. Pearson, SEAS Ltd., Oban]

Over the past 25 years there has been a major evolution in our thoughts about the nature of the abyssal seafloor environment. From a perception of the deep sea as a biologically sterile, spatially homogeneous, and temporally unchanging environment, we have come to know that life on the seafloor can in some places be abundant, sometimes spectacularly so. The diversity of the fauna of cold abyssal muds can be remarkably high, with species richness rivaling that of tropical rain forests. Spatial heterogeneity can be an important control of patterns in species abundance and diversity at centimeter, meter, and kilometer scales. And seasonal fluxes of phytodetritus to the seafloor provide the bass beat for the reproductive tempo of abyssal life in many regions.

Population genetics and molecular techniques are opening doors to an understanding of speciation and zoogeographic processes in the deep sea. Some of what were once believed to be cosmopolitan species are now appreciated as suites of multiple species, isolated by "invisible" barriers. Identifying these barriers challenges the imagination and entices even the novice into stimulating speculation. Like mountain ranges in terrestrial systems, are mid-ocean ridges that girdle the globe effective barriers to dispersal? What more subtle barriers might exist?

Advances in biochemical techniques are revealing surprising details about the life histories of many species. An intriguing strategy has been described in some mollusk species whose larvae leave the abyssopelagic realm entirely, ascending to near-surface waters where they feed and then descending back to the abyss to metamorphose and mature.

Of course, the event of the century in deep-sea biology was the discovery of hydrothermal vents at seafloor spreading centers where entire communities are fueled not by sunlight and photosynthesis but by geothermal processes and chemosynthesis. Symbioses between chemoautotrophic bacteria and invertebrate hosts dominate the biomass of most of these communities. Intensive investigations on the nature of hydrothermal vent communities have raised fundamental issues, including the role deep-sea vents played in the origin of life and as biotic refuges from the catastrophic extinctions that occurred in terrestrial and shallow-water environments, the thermal extremes at which life can exist, and the consequences of a geothermal source of light on the seafloor.

Deep-Sea Biology is a scholarly celebration of the growth of our knowledge about biological systems on the seafloor. Gage and Tyler initially engage us in a review of the natural history of deep-sea benthic organisms and proceed from there into discussions of patterns and rates and processes in space and time. Research of the past decade and a half is placed in its historical context, and many of the gaps in the depth and breadth of our understanding of the biology of the deep-sea are identified. The volume closes with a chapter that underscores the links between the seafloor environment, the world ocean, and world climate and provides a cautionary note to plans for exploitation of a great wilderness area still poorly understood and in many places still totally unexplored.

CINDY LEE VAN DOVER
Woods Hole Oceanographic Institution,
Woods Hole, MA 02543