Echoes of Life: What Fossil Molecules Reveal about Earth History

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Source: BioScience, 59(8) : 710-712

Published By: American Institute of Biological Sciences

URL: https://doi.org/10.1525/bio.2009.59.8.16
mechanisms of colonization and biologically invasion in view of a changing climate, readers who direct their attention to only selected chapters would benefit from the inclusion of the specific state of the environment, given the rapid changes in climate in polar regions.

The last chapter holds two particularly strong components of this volume: “Further Reading and Web Resources” and the extensive reference list itself. About 20 percent of the almost 600 citations in the reference list were published after 2005, which is commendable, given the historical nature of many of the chapters. The Web sites provide links to most of the major polar research programs as well as to sites on polar conservation and policy. This excellent compilation of references alone makes this book an invaluable source of information.

Moreover, this edition of *The Biology of Polar Regions* packs a plethora of information. The authors’ detailed comparisons of Arctic and Antarctic habitats generate a breadth of coverage that few books on polar environments offer. Despite the book’s minor idiosyncrasies, it was enjoyable to read, and it’s a superb starting point for those in search of information on virtually all topics in polar biology. Like other volumes in Oxford’s *Biology of Habitats* series, *The Biology of Polar Regions* should be on the shelf of students studying biological or environmental science, those beginning independent research, and professional biologists embarking on research in a new habitat. Astrobiologists who use life at Earth’s poles as an analog for the habitability of other icy worlds also will find this book to be a useful tool.

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**MOLECULES, MUD, MOON ROCKS, AND MICROBES**


In her first book, *Carbon Dreams* (2001), Susan Gaines combined fact and fiction to depict the life and struggles of a female geochemist as her career developed. The book portrayed the scientific world in both positive and negative ways by highlighting the passion that scientists have for their research, the difficulties and frustrations of finding funding, and the politics of scientific discovery. In her second book, *Echoes of Life*, with coauthors Geoffrey Eglinton and Jürgen Rullkötter, Gaines once again explores the trials and tribulations of scientific discovery, but this time the story is nonfiction, and the real-world context is the inception and growth of biomarker research and geochemistry.

The science of biomarkers evolved while oil exploration was in high gear, the oceans depths were being scoured, and interplanetary dust and moon rocks were a vast mystery. Throughout *Echoes of Life*, the science and the politics of research, as well as the collaborations and rivalries of researchers, are carefully portrayed. For example, the chapter “From the Moon to Mars” recounts how researchers receiving bits of the moon from NASA’s Project Apollo—and there were many of them—had to swear to secrecy about their results until 5 January 1970 (the first day of a NASA-convened Lunar Science Conference). The book also discusses the interest of oil companies and government agencies, in the United States and abroad, in funding biomarker research. Given recent negative social, economic, and political attitudes toward fossil fuels and oil companies, readers will be fascinated by the...
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The first few chapters introduce biomarkers and concentrate on Eglinton’s studies as a graduate student and postdoctoral researcher with Melvin Calvin. Calvin had received some of Earth’s oldest sedimentary rocks and needed them to be analyzed; Eglinton proved to be an eager colleague. Readers will be drawn in by the description of Calvin and Eglinton’s enthusiasm as they study Precambrian exudates and slowly figure out what compounds chromatograph and spectrometer peaks represent, and they will keep reading to discover, or rediscover, some of the primary literature cited throughout the text. For example, the Science article (Eglinton et al. 1964) on the identification of hydrocarbons from the Nonesuch shale, a classic that demonstrates the nascent of biomarker research at that time, merits reconsideration. One admires the researchers’ ingenuity as they propose and work through connections between pristine and phytane compounds and the digenesis of organic matter in oil.

Subsequent chapters highlight how biomarkers have grown in importance to different fields and enhanced the synergies between disciplines. For example, microbes are prominently featured throughout the text. Because of their small size, ancient bacteria and other microbes are not usually found as intact fossils. The chemical remnants of bacterial cell walls and exudates are proving to be strong signatures of the former presence of microorganisms. Coupling this information with molecular analyses, researchers have been able to hypothesize the structure as well as the function of microbial communities.

Biomarker research has also prospered from advances in technology, which in many cases occurred as a result of a particular researcher’s desire to isolate one compound. The importance of analytical instruments and technological innovation in the identification of key biological compounds will not be lost on anyone who has had private conversations with a gas chromatograph or mass spectrometer. When they reach the end of the book, readers are likely to have a strong appreciation for the importance of biomarkers, and, like the authors, an optimistic outlook for the science.
Those who are interested in geochemistry, and those who are looking to broaden their knowledge of the connections between chemical compounds and the diversity of life, will find *Echos of Life* well worth reading. Readers will come away with an understanding of what those compounds mean in a given time and place. Although the science Gaines and her coauthors present is sometimes difficult, the book nicely blends chemical structures with the researchers behind the discoveries.

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References cited


**NOT JUST CARBON BALANCE**


Plant carbon balance is a key interest of many modelers and ecologists because of its supposed role in limiting distributions. *Plants at the Margin* shows that carbon balance is not the only limiting factor for plants, and in many cases, not even a significant one. For people like me who never had enough physiology but have nonetheless attempted to model plants and environmental limits, it is a great book.

R. M. M. Crawford, author of *Plants at the Margin* and an emeritus professor at the University of St. Andrews in Scotland, is a specialist in the physiology of plants, especially those in northern and oceanic environments. He is perhaps best known for his work on root respiration and anoxia tolerance, and for his early insights into the physiological effects of climatic warming. *Plants at the Margin* is a scientific synthesis of Crawford’s life work, and thus covers a full range of marginal environments. The biological wisdom found in just the first few pages, and the concise way in which it is expounded, is remarkable.

The book comprises four sections: introductory chapters on the essence and biodiversity of marginal areas; two rigorous chapters on physiology and reproduction in marginal situations; six chapters treating particular marginal environments in more detail; and a final chapter called “Man at the Margins,” plus a short conclusion.

Habitats are marginal when survival is threatened, so limitation mechanisms should be sought in demography, physiology, and genetics. Plant species are seen as having similar resource requirements and differing mainly in their tolerance to adverse factors. Thus a species’ competitive success in good times, when resources are plentiful, matters less to its survival than its ability to utilize and exploit alternative resources in bad times. Crawford offers a good discussion of the significance of carbon balance to both plants and researchers, with recognition that it is the physiology of particular plant organs that may be critical.

In the second chapter, Crawford summarizes various measures of biodiversity, including genetic variation, and contends that variation between habitats (beta diversity) is more suitable for assessing biodiversity than is species richness. Several biodiversity hot spots, as well as dry lands and the Arctic, are described in some detail, with nice examples of remarkable species. This chapter in particular establishes some of the main themes found throughout the book: diversity includes genetic, morphological, and physiological aspects; marginal species often show surprising levels of diversity (which could provide biogenetic resources for restoration efforts); genetically diverse species in refugia may be especially vulnerable to extinction once the stability of the refuge changes; and marginal areas are prone to disruption, and may be stressed even more by global warming.

The second section of the book focuses on resource acquisition and reproduction. An important theme here is that adaptation to one extreme situation is usually maladaptive to others, as illustrated by the opposing strategies a plant needs for the reducing and oxidizing conditions at root surfaces in dry as opposed to flooded situations. The harm to root systems caused by warm periods during winter is very well explained, and discussions on life-history strategies, resource allocation, and shade tolerance are clear and understandable. The treatment of tolerance mechanisms is strong, acknowledging that avoidance strategies, rather than tolerance, obviate the need for specializing adaptations that lead to dependence on particular conditions. Portions of this section describe how some plants find alternative sources of light, water, nutrients, and carbon dioxide, and the summary on mycorrhizae and their significance in nutrient-poor habitats is well done. The reproduction chapter illustrates obstacles in marginal environments at all stages of a plant’s development, from flowering to final establishment. Genetic invasion and the high degree of hybridization in marginal areas are well explained, and the degree of invisibility is seen as a result more of resource fluctuations and disturbance than of diversity, productivity, or reproductive rates. Short sections follow on reproduction in particular environments, mast seeding, seed banks, and clonal growth, covering the advantages of asexual reproduction, dioecy, and longevity.

The six case studies go into more detail about the problems of tree lines, a warmer Arctic zone, coastal environments, flooding, woody plants at margins, and high-altitude environments. There is a good history of the tundra-taiga interface, including the idea that grazing by Pleistocene megafauna may have precluded tundra and created a subpolar steppe instead (cf. Zimov’s “Pleistocene Park”). Current warming and higher atmospheric carbon diox-