foreign lands, beyond the limits of reliable government, requires a very particular kind of personality. Meyer, this book implies, was an archetype. From his youth he was introverted, sensitive yet taciturn, and could only achieve contentment, and then but fleetingly, in isolation and in continuous battle against fatigue, danger, filth, and the unpredictability of other people.

Meyer's life could lend itself either to an adventure story for a general readership or to a carefully documented history for professionals. Unfortunately, Meyer apparently left too little record for either to be fully achieved. Whereas his British contemporaries Wilson, Farrar, and Kingdon-Ward clearly delighted in recounting their seemingly more modest exploits in yarns that remain rollicking to this day, Meyer shrank at writing, and his diaries are so terse that they give little information to the plant scientist or the biographer. He rarely, it seems, described the geology or the geomorphology of the areas he visited, or even the plant communities from which he collected, beyond brief and generalized statements. Neither do we have a penetrating portrait of any of his companions. We are left, then, with what patently was uppermost in his mind: his triumph over mud, cold or heat, the appalling conditions in the inns, transport difficulties, and the unpredictability of the people of the country he lived in for over seven years but whose lingua franca, Mandarin, he never brought himself to learn. Also, we learn of the tedious weeks that Meyer spent in recording, labeling, packing, and transmitting his tons of collected material. In this Meyer was the master, and the first to successfully transmit scion material from China to the United States. It is not surprising to learn that the destruction of one of his major collections in a hurricane after its arrival at Galveston had a permanent effect on him. We end, then, with admiration for the extraordinary courage of the man and for his considerable attainments, and a deep sympathy for the unhappy condition that drove him on. But we have no clear picture of the land he explored, of its people or their customs, or of the terrain, the vegetation, or the growing conditions in which his introductions had flourished in nature.

The book, nonetheless, has indeed been written principally as an adventure story for the general reader. For reasons beyond the biographer's command, it has only partially succeeded. More use might perhaps have been made of Meyer's photographic archive, now at the National Arboretum, to elaborate the text. More regrettably, though, only a general documentation of Meyer's lasting contribution to agriculture, forestry, and horticulture has been provided. Of particular value, for instance, would have been a list of potentially important discoveries that failed to make it to the United States or to survive here and of the localities where they might yet persist. The main account of Meyer's journeys does make mention of outstanding plants as they were discovered or collected, and a useful chapter describes the more successful of his introductions in the United States. Also, one appendix provides a sample list of Meyer's introductions with his own brief annotations; and a second attempts to record the whereabouts of known survivors of those species that have never entered general cultivation. The author explains that a comprehensive dossier would be impracticable. Why? Have the record-keepers really done such disservice to the work of this brave man? If so, here is an object lesson in the unreliability of ex situ conservation, either of whole plants or of seed banks, and of the importance of nature preserves in agricultural development.

Frank Meyer in a "veritable jungle of *Tamarix* bushes," Chinese Turkestan, 18 February 1911. [From *Frank N. Meyer: Plant Hunter in Asia*; U.S. Department of Agriculture collection, National Arboretum]

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## Biogeochemistry

**Microbial Geochemistry**. W. E. KRUMBEIN, Ed. Blackwell Scientific, Palo Alto, Calif., 1983. xii, 330 pp., illus. $60.

Microbial geochemistry is the branch of microbial ecology concerned with the elemental cycles of the biosphere. Though the origins of the subject can be traced to Winogradsky and Beijerinck early in this century, it is only relatively recently that great progress has been made in assessing rates of microbially mediated processes in natural habitats. The result is the development of microbiogeochemistry into a mature interdisciplinary field.

In prefatory and introductory chapters Krumbein develops the philosophical basis for the study of biogeochemistry. The heart of the book contains more pragmatic information on elemental cycles. Blackburn emphasizes the process of organic nitrogen mineralization in his treatment of the nitrogen cycle. He notes that the nitrogen, sulfur, and carbon cycles are intimately related to one another in anaerobic sediments. Nitrate serves as an oxidizing agent for sulfide and sulfate serves as an oxidizing agent for methane but not for ammonium. The ultimate result in marine sediments is the oxidation of organic carbon to carbon dioxide accompanied by the accumulation of ammonium.

A chapter on the sulfur cycle by Jørgensen also emphasizes marine sediments. From a microbiological perspective the sulfur cycle is particularly fascinating because of the tremendous diversity of the bacteria that utilize sulfur in its various oxidation states. Jørgensen suggests that such bacteria may rapidly oxidize sulfur to the elemental ($S^0$) state. Elemental sulfur is not chemically oxidized and can be stored internally or externally by cells and subsequently oxidized as an energy source when sulfide has been depleted.

The well-balanced and thorough chapters on iron and manganese geochemistry by Nealson are especially pleasing. As Nealson notes, iron occurs largely in the oxidized state in most nonsedimentary parts of the biosphere. It is an essential element for virtually all living organisms (with the interesting exception of the lactic-acid bacteria), but, because of the low solubility of the oxidized form, microbes have evolved specific biochelating agents (siderophores) for capturing and taking it up into the cells. Utilization of reduced iron as an energy source appears to be a rare event confined to certain acidophilic iron bac-

teria. Reduced manganese occurs more commonly in aerobic portions of the biosphere than reduced iron, and it is a potential energy source for lithotrophic organisms, though there is now no incontestable case of manganese lithotrophy.

In an excellent review of the involvement of microorganisms in weathering processes, Berthelin discusses microbial mechanisms that influence weathering processes, the importance of microbial weathering in soil formation, plant growth, and leaching, and laboratory and field methods for the measurement of weathering.

I was somewhat surprised by the attention given to evolution in the book. Much of a chapter on carbon cycling by Krumbein and Swart is devoted to the topic, and the concluding chapter by Knoll and Awramik discusses ancient microbial ecosystems.

The book was conceived as a textbook, although, as Krumbein notes, it is not a comprehensive treatment of the subject. It would be most appropriate for those who already have a background in microbiology.

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## Oxygen Metabolism

**The Biology and Chemistry of Active Oxygen.** J. V. BANNISTER and W. H. BANNISTER, Eds. Elsevier, New York, 1984. xiv, 262 pp., illus. $55. Developments in Biochemistry, vol. 26.

The editors have used the term "active oxygen" in the title of this book to signify the dichotomous nature of the molecule, a sine qua non for the existence of most organisms and a potential toxicant for all forms of life. The molecular mechanisms involved in the uptake and utilization of oxygen in its beneficial role have been extensively studied, generating a vast body of sometimes controversial information. On the other hand, the basis for deleterious effects of oxygen has only recently been amenable to systematic study and is now the subject of scientific debate, and sometimes of impassioned polemics. The most crucial recent development in the field of oxygen metabolism has been the discovery of the enzyme superoxide dismutase, an event that created widespread interest in the study of the radicals generated in the process of oxygen metabolism. In view of this, and of the involvement of the editors in investigations of the chemistry and biology of superoxide dismutase, it is no surprise that oxygen radicals and superoxide dismutase are the focal points of the book. Subserving this theme are chapters on such topics as the binding of oxygen to hemoglobin, oxygen-using enzyme systems, and the possible role of radicals in disease. Most of the chapters are in the style of synopses of the history, chemistry, and biology of the topics being discussed. For example, the chapter on hemoglobin, by Brunori, Giacometti, and Giardina, starts off with the early studies of Hill and Adair, presents brief descriptions of the models for cooperativity and the phenomenology of regulation of oxygen binding, and concludes with a short section on the comparative aspects of the biology of hemoglobin. This is a very good summary indeed, but it is likely to be old hat for those actively working on the subject.

The chapters on oxygen-using reactions include descriptions of cytochrome *c* oxidase, eicosanoid production, and mono- and dioxygenases. It would appear that the main purpose of these chapters is to provide a backdrop for the ensuing coverage of superoxide dismutase and oxygen radicals. It is therefore surprising that the hydrogen peroxide–producing oxidases such as flavoproteins and metalloenzymes, which are the most likely candidates to generate superoxide radicals, have been completely ignored. Ironically, xanthine oxidase, which was the first enzyme shown to produce superoxide, has often been invoked as an in vivo generator of the radical. The editors have also chosen to ignore catalases and peroxidases, which are ubiquitous and have important biological functions.

The major part of the book deals with the biological effects of reduced oxygen species and the role of superoxide dismutase in protecting against oxygen toxicity. An impressive body of arguments is presented here to support the contention that the superoxide ion is capable of initiating cell damage, often by leading to the formation of the hydroxide radical. Though it is probably true that many intracellular macro- and micromolecules are impervious to the superoxide ion, the catalyzed formation of the hydroxide radical from superoxide and hydrogen peroxide is currently the favored mechanism for explaining the toxicity of oxygen metabolites. Those who would contend that the superoxide radical is innocuous will find little comfort here.

The highlight of the book is a chapter by J. V. Bannister and G. Rotilio summarizing a decade of research on superoxide dismutase, with 291 references. The only shortcoming of this chapter is that it was completed about two years ago, and thus does not cover the results from the recent crystallographic and topological studies that provide an esthetically pleasing idea of the structure-activity correlations of superoxide dismutase.

Despite some shortcomings, this book can be a useful acquisition for those working on oxygen metabolism. With oxygen radicals being implicated in an ever-increasing number of biological pathways, some functional and others detrimental, the audience for a book like this must be quite large indeed.

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## Theoretical Seismology

**Seismic Wave Propagation in Stratified Media.** B. L. N. KENNETT. Cambridge University Press, New York, 1983. x, 342 pp., illus. $59.50. Cambridge Monographs on Mechanics and Applied Mathematics.

Several excellent books in theoretical seismology have in recent years attempted to assume the mantle of Ewing, Jardetzky, and Press's *Elastic Waves in Layered Media* (1957), which played a key role in initiating and disseminating the ideas that now form the theoretical basis for much of seismology. The great expansion of theoretical seismology, associated with the extensive application of wave propagation theory to numerical modeling and inversion, has made the idea of a single successor book to Ewing, Jardetzky, and Press seem quite impractical, however, and recent books by Aki and Richards, Pilant, and Ben-Menahem and Singh have undertaken systematic expositions of wave propagation theory from quite distinct points of view. The sheer volume of material now available makes it necessary for the apprentice seismologist to receive substantial guidance from an experienced professional.

In spite of the number of other books available, the new contribution by Brian Kennett is welcome and fills a significant niche. By restricting the discussion to media with properties depending only on one space variable, Kennett can bring us a systematic, monographic approach while offering informal discussions of the physical significance of the material. The conventional approach to this material involves a rather immiscible combination of scalar wave propagation theory, vector wave theory, and the theory