minology; it is well supported with line drawings. The classification scheme does not follow the 1991 Round, Crawford and Mann tome exactly, but it is hard to fault this since there is no consensus among diatomists regarding classification. A key to the genera is presented for families, and a key to the included species is provided for genera. The chapter contains both figures and plates that are interspersed, and this sometimes proves confusing. Not all species are illustrated, but tables of pertinent information are provided in many cases. The biogeographical information is very general, consisting of three regions (northern cold water, southern cold water, warm water); certainly, much more information is available in the literature but the authors did not compile this for the readers. The book does include some benthic as well as planktonic forms, but this treatment is haphazard. It also has material on the collection and preparation of samples, new nomenclatural combinations, a list of synonyms and an index to the taxa. The literature cited is extensive (23 pp.), including the important older literature; however, recent papers are less well represented.

The third chapter, by Karen A. Steidinger and Karl Tangen, is devoted to the dinoflagellates. The chapter covers the same topics as before, and these are well prepared. Like chapter two, figures and plates are interspersed. The classification of dinoflagellates is currently in flux, with molecular phylogenies in conflict with traditional plate-based phylogenies. The authors have, perhaps wisely, avoided this discussion, and simply present a classification as a framework for the chapter. They mention the growing controversy over what constitutes a species, making it clear that further research is necessary to determine whether cryptic species or subspecific complexes are present in certain cases. Unlike earlier chapters, some genera are not illustrated; the treatment is dominated by the armored taxa. A number of species are designated as toxic but almost no further information is provided. It would have been very helpful if the type of toxin was specified, and if there were some brief discussion of the various toxins in the introductory material. Also, some taxa designated ‘‘toxic’’ are only presumed to be toxic, and this could be misleading. Finally, literature citations regarding toxins are never provided, and one is left wondering where to go to get more information. Data on geographic ranges are very good, perhaps the best of all chapters. Like the other chapters, it concludes with preservation and preparation techniques, nomenclatural synonyms, an index of names, and literature citations.

Book three (the only one still in print) was formed by combining books one and two. Most of the errors in books one and two are corrected in book three but no attempt was made to update the earlier books. Thus, even though book three was published in 1997, literature citations end with 1992 for the phytoflagellates and coccolithophorid chapters. Furthermore, molecular systematics have dominated phytoplankton systematics during the 1990s but this topic is not even mentioned. The book is published with a paper cover and it is unlikely that it will withstand heavy use. It seems incredible to me that the book does not have a comprehensive index of species names.

In summary, I am ambivalent about these books. On one hand, there was a serious need for books like these. They are already on the shelves of most phytoplankton taxonomists and are being used extensively. On the other hand, they could have been much better. The use of electron microscopy, especially for the flagellate and coccolithophorid chapters, is sorely lacking. Throndsen pioneered the use of electron microscopy for flagellates, and it is baffling to find them missing from his chapter. The division/class-level classification scheme is woefully out of date, and molecular systematics is completely neglected. And for the oceanographer, perhaps the most glaring omission is the lack of attention to the coccoid picoplankton. How can one write books on the marine phytoplankton and not include *Prochlorococcus*, putatively the most abundant organism on the planet? The authors have made a great step forward in producing these books, and we can hope (even beg!) that the revised editions will be more comprehensive.

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Limnol. Oceanogr., 44(1), 1999, 233–234

FENCHEL, T., G.M. KING, AND T.H. BLACKBURN. 1998. **Bacterial biogeochemistry: The ecophysiology of mineral cycling**. Academic Press, San Diego. ISBN 0-12-103455-0. 307 p. $64.95.

Only three books on my science shelves were published 20 years ago or more: Paul de Kruif’s ‘‘Microbe Hunters’’ which was originally published in 1926 (I don’t know when I picked up my used paperback edition, dated 1954, but I paid $1.65), a chemistry textbook from my first year in college (enough said), and ‘‘Bacteria and Mineral Cycling’’ (published in 1979) by Fenchel and Blackburn, the predecessor to the book reviewed here. In spite of becoming dated over the years, I have read and have made students read ‘‘Bacteria and Mineral Cycling’’ because it clearly describes bacterial physiology and biogeochemical cycles mediated by bacteria, all in a mere 225 pages (counting the index). ‘‘Bacterial Biogeochemistry’’ adds Gary King as an author and 75 more pages of text, and its cover says it is a second edition of ‘‘Bacteria and Mineral Cycling’’. I suppose the claim is not mere advertisement hype, as the two books do share some things in common. But as the preface mentions, ‘‘all chapters have been completely rewritten as a consequence of many advances and discoveries during the past 20 years.’’ Indeed.

The 20 years since publication of ‘‘Bacteria and Mineral Cycling’’ have witnessed an explosion of research on bacteria and their roles in all ecosystems. The start of ‘‘bacterial biogeochemistry’’ (to use Fenchel et al.’s somewhat redundant title) can be assigned various dates (e.g., the late 19th century of Winogradski), but the exponential phase of the microbial revolution clearly began a few years after publication of ‘‘Bacteria and Mineral Cycling’’. During the early 1980’s, many papers appeared about the ‘‘microbial loop’’, the pathway for carbon from phytoplankton to bacteria via dissolved organic carbon (DOC), which is described in Chapter 3 (‘‘The water column’’) of ‘‘Bacterial Biogeochemistry’’. As Fenchel et al. point out, however, we knew much about the microbial loop before 1980; Krogh suggested back in 1934, for example, that DOC is the largest pool of carbon in the sea. Estimates of DOC concentrations have fluctuated a bit over the years (a story not mentioned by Fenchel et al.), but even at its current ebb, DOC looms large in carbon budgets. More importantly, several studies appearing since ‘‘Bacteria and Mineral Cycling’’ have shown that DOC fluxes are high and that a large fraction of primary production is somehow routed through the DOC pool, then processed by heterotrophic bacteria, and so on.

Soil microbiology has also probably progressed much over the last twenty years, although many of those advances are far from my interests and of most L&O readers. Perhaps because of that, I learned much from reading Chapter 4 ‘‘Biogeochemical cycling in soils’’, which is wedged between the water column chapter and a separate chapter on aquatic sediments. After an excellent summary of soil physics, Chapter 4 discusses how the biochemical composition of land plant detritus greatly impacts nutrient cycles and microbial assemblages in soils. Unique features of land plants such as high C:N ratios and lignin content are major factors that distinguish terrestrial element cycles from those in aquatic systems. Although the isolated biochemical facts come as no surprise, the chapter succeeds in drawing out the ecological (''ecophysiological'') implications and made me think differently about aquatic processes I thought I knew well.

One reason why many are interested in microbes is that several biogeochemical reactions mediated by bacteria affect atmospheric gases and thus perhaps climate. Microbial ecologists are not going to ''solve'' the greenhouse problem, but we need biology and especially microbial ecology if we are to understand what's going to happen as atmospheric CO_2 and other greenhouse gases continue to increase during the next fifty years. Chapter 9 ''Microbial biogeochemistry and the atmosphere'' should be required reading for all working on climate change. Perhaps some can skip the introduction to atmospheric science (microbial ecologists shouldn't), but everyone should read the sections discussing how microbes can affect atmospheric concentrations and fluxes of oxygen, methane, nitrogen gas and nitrous oxide. The chapter has a nice summary of the dimethyl sulfide story, although the Gaia hypothesis is mentioned in another chapter. Even many microbial ecologists will be surprised to learn about the degradation of anthropogenic gases such as hydrochlorofluorocarbons (HCFCs) introduced to replace ozone-destroying chlorofluorocarbons. HCFCs are greenhouse gases, albeit ozone-friendly, so any degradation by microbes is noteworthy.

Over the last twenty years—really the last five years or so—we have found that bacteria are the most numerous organisms in nature, occurring in just about every conceivable nook and cranny of our planet. Chapter 8 (''Biogeochemistry and extreme environments'') briefly discusses bacteria in marine sediments $>$500 m deep and in other subsurface environments such as Cretaceous period shales isolated from the surface for 10,000 years. Because it is difficult to cleanly sample bacteria in rocks and deep sediments and because of possible recent exchange with surface communities, reports of bacteria in deep and old subsurface environments have been questioned; nevertheless, evidence is growing that somehow some cells survive out of contact with surface sources of energy and carbon for thousands of years or longer. Much of the research in these and other extreme environments has been motivated by practical problems (e.g., what to do about radionuclide wastes leaching into groundwaters) and by promises of microbial gold (e.g., an enzyme from a Yellowstone hot spring bacterium, originally isolated by L&O author T. Brock, has spawned several million dollar industries and has revolutionized much of biology and some of ecology). But work in extreme environments also touches on questions asked long before the advent of biotechnology: How did life begin? Is life present on other planets? The book ends with a chapter ''Origins and evolution of biogeochemical cycles'' where you can read about prebiotic earth and how cells perhaps first started off on bits of clay or pyrite.

It is not hard to find fault with any book trying to cover all of biogeochemistry in 307 pages—that total includes an appendix, index, and many pages of quite up-to-date references. My main complaint is that sometimes the book reads like a textbook, other times not, although arguably it is the best we have to date. The textbookish appendix is an excellent introduction to microbial thermodynamics, and Chapter 1 ''General considerations'' has the basic facts about bacteria, such as a nice little table about how much energy is expended on various biosynthetic processes (protein synthesis is the most costly at 61% of the total). But the chapter is not light reading and much of the book is perhaps not for beginning students. The section on ''Dissimilatory metabolism'', for example, starts off with an introduction to ATP but then precedes to march through virtually every type of bacterial metabolism in about 30 (small) pages. The sheer density of facts will make it difficult for students to follow.

Fortunately the book is usually much more than a textbook. Rather than listing facts, what the book does is present the authors' view of how the biogeochemical world works. The authors could not cover all biogeochemistry in 307 pages and so choices had to be made. While no reader is likely to agree with all choices, many sections of the book will stimulate if not educate all readers. ''Bacterial Biogeochemistry'' is a worthy successor to ''Bacteria and Mineral Cycles'' and stands a good chance of being found on my shelves of scientific books twenty years from now.

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Limnol. Oceanogr., 44(1), 1999, 234–235

PATTERSON, D. J. Drawings by S. HEDLEY. 1996. **Free-living freshwater protozoa—a colour guide.** John Wiley & Sons, New York. 223 p. $49.95. ISBN 0-470-23567-5.

Protozoa, the animal-like protists, are found essentially anywhere there is water—from damp soil and mosses to lakes, estuaries, and the open ocean. Despite their near ubiquity and the fact that they are seen by every student learning to use a microscope, protozoa have been often overlooked in aquatic studies. However, this disregard is rapidly changing. For anyone interested in this group—including people brought to the study of protozoa for professional reasons as well as amateurs captivated by their first microscopic observations of protists—*Free-Living Freshwater Protozoa* will be a valuable reference. This informative, easy-to-use book fulfills its stated aim of making the study of protozoa accessible to the non-protozoologist, and it deserves a broad audience. Although targeted at nonspecialists, professionals will want to have it in their libraries; it will be extremely useful as a teaching aid. Further, despite its title, it will also be useful to marine biologists because many of the genera it describes are represented in brackish waters.

Essentially, this book is a guide to the identification of protozoa at the level of genus based on the attributes of living cells observed with light microscopy (rather than on characters that require specialized techniques of staining or preservation that are often required for species identification). Excellent color photomicrographs are presented in combination with equally good annotated line drawings of each micrograph, and the figure legends often provide ecological information about habitat or feeding behavior. The dichotomous key is unlikely to overwhelm the novice with unfamiliar terminology, and a useful glossary of terms is provided for quick reference. Other details that add to the book's ease of use include having the figures for a genus on the same page as their endpoint in the key and having each step of the key indicated at the outside margin of the page on which it occurs.

Introducing the bulk of the book, which consists of the key and figures, there is a chapter that describes microscopical and collecting methods; it also includes a general classification scheme of protozoa. The author appropriately includes descriptions and illustrations of microorganisms that fall outside of a strict interpretation of the term "protozoa." Some unicellular algae are included with the heterotrophic flagellates, and there is a short section on microorganisms that overlap in size with the protozoa—rotifers, gastrotrichs, and flatworms—all of which bear cilia and are often confused with protists. Several short sections in the final chapter characterize general protistan communities (e.g., plankton, benthos, and sewage