while providing a readable general introduction to what has happened in the recent past in various areas of research on iron metabolism seems to be well satisfied by this treatise. Established authorities provide 20 chapters on all pertinent and currently active aspects of microbial iron metabolism studies, ably organized by the editor, who has contributed the introductory chapter on the general nature of biological iron and its participation in microbial physiology. A casual inspection of the chapters that follow, grouped under the headings of transport, biosynthesis and storage, iron enzymes and proteins, reactions of inorganic substrates, and medicine and chemotherapy, makes it clear that no one reviewer can comment authoritatively on how well the various contributors serve their particular fields. This reviewer, however, has received a generally favorable impression of the sections of the book that cover ground with which he is familiar and has derived considerable enlightenment from portions devoted to unfamiliar aspects. In general, each contributor—in addition to offering adequate factual coverage—has attempted to evaluate the status of his subject. Thus the statement on the jacket that this "is certainly a volume that points the way to future research" is accurate.

Whatever criticism there may be of this effort to present a complete picture of current and past research on iron in living systems must have more general than specific bases. Research on many relevant subjects—one may mention transport, biosynthesis, the iron-sulfur enzymes (such as ferredoxins, "HIPIP," nitrogenase, hydrogenase, and glutamate synthase), the prokaryotic cytochromes, and oxygenases—is in a state of rapid flux and development, and reviewers of such subjects can at best present progress reports with limited opportunity for systematic organization of material. Here and there one may also point to omissions or ask for further clarification. For example, in the introductory chapter, which contains a very brief presentation of inorganic iron chemistry, one might suggest that there be mention of phosphorus-containing ligands as iron chelates to go along with the excellent summary of ligand chemistry involving oxygen, nitrogen, and sulfur ligands. In the following treatment of iron-limited growth, no mention is made of studies on the interesting situations that arise in dealing with nutrition of photosynthetic bacteria wherein iron limitation places a unique stress on microorganisms faced with the necessity of reaction-center biosynthesis.

Sections that are particularly informative on topics of current interest are those on the genetics of nitrogen fixation, nonheme iron in respiratory chains, cytochromes, nitrogenase, and hydrogenase (all research areas of rapid growth and change).

The text is readable, and typographical errors are less frequent than is usual in a first edition. It is likely that the sections concerned with very active researches will experience rapid obsolescence, but there are major portions that probably will not require drastic updating for a reasonable time. This treatise should be a helpful source of information on all aspects of iron metabolism, not only for investigators interested in prokaryotic iron metabolism, but also for researchers looking for clues to the solution of problems involving the physiology of iron in eukaryotic systems.

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Studying Free Radicals

Microwave Spectroscopy of Free Radicals. ALAN CARRINGTON. Academic Press, New York, 1974. xii, 264 pp., illus. $12.50.

The author of this book successfully draws together the threads of a diverse subject. Microwave spectroscopy of stable gaseous molecules has been pursued actively by spectroscopists since the end of World War II (which gave birth to the klystron oscillator, the microwave spectroscopists' first practical energy source). Spectral transitions between angular momentum states of overall molecular rotation are interpreted to give precise information on molecular geometry. Similar studies on free radicals are of more recent vintage. With two exceptions (CF_2 and SiF_2), the free radicals discussed in this book are diatomic or triatomic open-shell molecules. The coupling of the electronic angular momentum contributed by the open shell structure with that due to nuclear rotation, vibration, and nuclear spin produces a molecule of delightful spectroscopic complexity. Only a few of the myriad of microwave transitions have been studied in any of the free radicals, yet a wealth of structural and dynamic information has been deduced. The spectroscopic investigation of free radicals in the laboratory should receive a major impetus from radioastronomers who have detected microwave emissions from radicals such as OH and CN, as well as from some as yet unidentified species, contained in interstellar gas clouds. Microwave spectroscopy of free radicals (which are nearly always unstable, transient species) in the laboratory is not trivial from the experimental point of view, and there is a distinct possibility that a large proportion of such measurements will be made in the near future with radiotelescopes.

After an introductory chapter in which the theoretical principles underlying microwave spectroscopy are reviewed briefly, the second chapter deals with experimental aspects of the various approaches to gas-phase free-radical microwave spectroscopy. An experimental approach that depends upon the molecular paramagnetism that arises from the open shell structure (developed largely in the author's laboratory) is particularly suitable for short-lived species. Magnetic tuning of the energy levels allows fixed microwave frequency operation in a compact resonant cavity. Also described are the recent uses of far-infrared lasers as energy sources, as well as microwave/optical double resonance methods. The theory of molecular energy levels is outlined in chapter 3, which includes a brief discussion of the various Hund coupling cases that is important for the later interpretation of free radical spectra. The final chapters of the book, 4 and 5, are devoted to the presentation and analysis of the spectra of diatomic and triatomic radicals, respectively.

This is not a heavily theoretical book; rather, it provides a good overview of the status of work in the field, as well as an introductory guide to gas-phase free-radical spectroscopy.

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Effects of Power Plants

Thermal Ecology. Proceedings of a symposium, Augusta, Ga., May 1973. J. WHITFIELD GIBBONS and REBECCA R. SHARITZ, Eds. U.S. Atomic Energy Commission, Oak Ridge, Tenn., 1974 (available as CONF-730505 from National Technical Information Service, Springfield, Va.). xvi, 672 pp., illus. Paper, $13.60. AEC Symposium Series, 32.

The rapidly expanding electric power industry, with its large steam generating stations that emit about two-thirds of the fuel energy into the environment as waste heat, has prompted concern for the thermal integrity of natural waters used for cooling. There has been an unprecedented rush to study power station effluents throughout North America, encouraged and often required by regulatory agencies. Largely

overlooked by many environmentalists have been the fairly well financed research and monitoring programs at certain Atomic Energy Commission (now the Energy Research and Development Administration) installations. These programs have contributed substantially to the art of assessing environmental impacts and recovery and have collected data related directly to solving problems of "thermal pollution." The symposium on which this book is based therefore seemed to serve two purposes: It brought together many researchers, especially from the southeastern United States, mutually involved in research on thermal effects; and it introduced to a wider audience the research program in thermal ecology at the AEC's (ERDA's) Savannah River Plant.

The book consists of 55 extremely diverse papers on physiochemical phenomena, physiological ecology, thermal tolerance and adaptation, population ecology, behavioral ecology, community ecology, productivity, diversity, and models. Eighteen of the papers report research at the Savannah River site; 33 report work from the Southeast. Other regions are sparsely represented. Reports of field studies predominate (38), but there are 14 reports of laboratory work and three reviews. Fish rate the most attention (19 papers), followed by invertebrates (12), algae and microorganisms (ten), reptiles and amphibians (six), terrestrial and emergent vegetation (three), birds (two), and parasites (one).

What information is new? Certainly there is much about the Savannah River Plant that was not heretofore available. The papers provide notable breadth of coverage of the various biotic components in the lake-swamp ecosystem. Some of this information is relevant to questions about electric power station effluents, but some is not. Temperatures produced by plutonium production facilities have exceeded those produced by conventional power stations, so several studies are useful mostly for defining effects of extremes. Most authors concentrate on reporting progress from their own programs. There is no attempt to synthesize the diverse information from the Savannah River Plant to give the reader an overall perspective on that work.

What is new in other reports depends upon the reader's background. There are no great revelations, in my estimation, but a number of good, solid points are made. Some examples from the first few papers are: Gas bubble disease of fish—long hypothesized as a secondary effect of heating water—is shown to be caused by supersaturated gases in the water; behavioral thermoregulation by fish at a power station on Lake Michigan is shown to be affected by fish moving in and out of the heated water, not simply by fish selecting their preferred temperature; weight loss by centrarchid fish in a North Carolina cooling pond at temperatures above 36°C—another hypothesized result of extremely high temperatures—is shown to be related both to metabolic demands of the fish and to the fact that the available food supply is drastically altered by the change in temperature. A striking attempt at synthesis of the ecological and social values related to a thermal discharge is made by H. T. Odum in the last paper. His bizarre energy diagrams and caloric calculations for a large portion of Florida attempt to relate nuclear power and its thermal effluents to the overall energetics of society.

The book has no real summary statement. Where is research on thermal effects going? What should we be doing? Are we near to answering major questions about the temperature dependence of ecological structure and function? Whereas in the preface (p. vii) the editors claim to seek "a reevaluation of approaches, a coordination of efforts, and a general consolidation of current findings," the book achieves no such synthesis.

I cannot provide the missing cohesion in a short review, but certain observations can be made. First, the ecological information related to the siting, design, and operation of conventional electric power plants is not synonymous with thermal ecology. There is much about effects of temperature that simply is not relevant to power stations: hot springs, decimated swamps, and laboratory tests that obscure the basic time-dependence of thermal tolerances of organisms, to name but a few. Second, and conversely, there are many nonthermal impacts of power stations that are of equal or greater importance to the analysis of environmental impact. Some papers in the book conclude as much.

Third, there ought to be some discussion about the ability of small research projects or reports to contribute meaningfully to advancement of ecological perception—especially in the face of a potentially large and pervasive modification of the environment such as a power station cooling system. It is difficult to assemble a pile of cogs into a gear wheel, so to speak. Synthesis ought to be part of the original blueprint. The Savannah River Plant has a real opportunity to direct a broadly integrated research effort on Par Pond, which, despite certain atypical features (the very hot canals leading to it and the exotic species, such as alligators, that live in it), could be an experimental model for a valuable closed-cycle cooling system managed for both its heat dissipation qualities and recreational fishing.

Finally, research approaches should be chosen with objectives in mind. I believe society would like ecologists to concentrate on the effort to provide the nation with reasonably inexpensive electrical energy with the least possible disruption of natural environments. This volume will be of interest to everyone who is involved in that effort.

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Geology and Oil

Petroleum and Global Tectonics. Papers from a meeting, Princeton, N.J., Mar. 1972. ALFRED G. FISCHER and SHELDON JUDSON, Eds. Princeton University Press, Princeton, N.J., 1975. xii, 324 pp., illus. Cloth, $16.50; paper, $8.95.

The papers in this volume were first presented at a conference held (in honor of H. D. Hedberg) in 1972. Hence, a number of the most current facets of the topic are not treated. In fact, the conference dates back to the time when the first full rush of new insights from plate tectonics had just struck the practice of petroleum geology. The strength of the published volume consequently lies in the breadth of the view taken by the dozen or so knowledgeable and thoughtful geologists who contributed to it. Each was evidently confronted with the task of preparing an initial summary of the impact of the new global tectonic theory on some particular aspect of geologic thinking related to petroleum accumulation. Under the circumstances, no one could offer fully integrated syntheses of the matters at hand, and the reader thus receives selected stimulation rather than full satisfaction from the collection of articles.

It seems clear that plate tectonic theory exerts three main types of leverage on plans for petroleum exploration: a fresh view of the causes and patterns of basin subsidence that allow the accumulation of sediment in which oil and gas deposits can be lodged; a fresh view of the reasons for and variations in the geothermal gradients that largely control the generation of hydrocarbons from initial organic precursors; and a fresh view of the tectonic deformation that underlies the conditions, favorable or unfavorable, for the subsurface migration and entrapment of fluid hydrocarbons.

Of these three factors, the first two embody the most straightforward corollaries of plate tectonics, and they are addressed in some detail by several authors. With re-