come to the conclusion that it played a minor role in Einstein's thinking, yet says next to nothing about stellar aberrations or the Fizeau experiment, even though he characterizes Einstein's statement that these two results were sufficient for him as "*the most crucial statement Einstein ever made on the origins of the special theory of relativity*" (p. 117, his italics). More exasperating than puzzling is Pais's repetition of the old chestnut that the explanation of the "twin paradox" requires the general theory of relativity—especially since he misattributes this claim to Einstein (p. 145). I think his discussion of the two postulates of the special theory is also somewhat off the mark, largely owing to neglect of evidence that Einstein seriously considered an emission theory of light before adopting the second postulate.

Pais's discussion of the development of the general theory—in particular of the three-year delay between Einstein's adoption of the metric tensor in late 1912 and his discovery of the correct field equations in late 1915—is a careful reworking of what I may call the received version, filled in with many new details based on a careful reading of the relevant papers and correspondence in the Einstein Archive. This version attributes the delay (insofar as it was not due to external circumstances) to Einstein's failure to grasp certain elementary mathematical features of generally covariant equations. Unfortunately, Pais does not seem to have studied Einstein's notebooks from that period, also preserved in the Archive. One of these makes the received version simply untenable, as John Norton will soon show in a forthcoming paper. A number of minor features of Pais's account of the general theory and Einstein's ensuing quest for a unified field theory are slightly awkward, perhaps understandably given that he himself has not worked extensively in this area. In addition, he never explains why Einstein was so taken with the mathematical concept of displacement field or affine connection, on which he based most of his efforts at constructing a unified field theory after 1925. Einstein put it succinctly in 1954: "The essence of the general theory of relativity is to go beyond the inertial system . . . it [is] the displacement field which allows one to be freed from the obstacle of the inertial system." (The important letter to Besso in which this statement appears is translated in full in A. P. French, Ed., *Einstein: A Centenary Volume*, Harvard University Press, 1979, pp. 267–269.)

For me, the sections on statistical physics and quantum theory are the most successful in the book. Not only does Pais give an excellent presentation of Einstein's contributions to the development of quantum theory, he explains why Einstein felt that it never became a fundamental theory in his sense, even after the development of quantum mechanics. He makes clear the relationship between Einstein's critique of quantum mechanics and his search for a unified field theory: the non-singular solutions to the unified field equations were somehow finally to provide a fundamental explanation of the quantum riddle. His negative evaluation (p. 456) of the paper by Einstein, Rosen, and Podolsky, however, totally neglects the current discussion of nonseparability in quantum mechanics. There are some smaller weak points. For example, I do not feel the account of Einstein's work on "Gespensterfelder" and its influence on Born is adequate, nor does Pais explore the role of Einstein's challenge to reproduce his blackbody fluctuation formula on Jordan's work on the quantum theory of fields.

Other fascinating topics on which Pais expresses novel views that I don't have space to discuss include the reason for Einstein's fame (pp. 311–312), the interpretation of the concept of scientific revolution (pp. 29–30), and the concept of going beyond "the edge of history" in the analysis of individual creative acts (pp. 163–164).

This book is both unique and indispensable for any serious Einstein scholar, not least for its extensive documentation. May it serve not only as a source of profound insight and pleasure to many readers but as a further spur to the current renaissance of Einstein studies.

JOHN STACHEL
Einstein Project,
Princeton University Press,
Princeton, New Jersey 08540

Algology

The Biology of Seaweeds. CHRISTOPHER S. LOBBAN and MICHAEL J. WYNNE, Eds. University of California Press, Berkeley, 1981. xii, 786 pp., illus. $85. Botanical Monographs, vol. 17.

The Ecology of Algae. F. E. ROUND. Cambridge University Press, New York, 1981. viii, 654 pp., illus. $130.

The diversity of the algae is legendary. They consist of at least ten different phyla. Morphologically they range from single-celled organisms resembling bacteria to massive structures with complex anatomical and morphological differentiation. They are found in many different kinds of habitats, ranging from rocks in the Antarctic deserts through oligotrophic waters of open oceans to hot springs. Their physiological diversity extends to the most fundamental biochemical processes. The difficulties such diversity presents are often emphasized by apologetic authors, editors, and reviewers. Lines of demarcation that allow one to identify subject areas of manageable proportions must be drawn, but they frequently appear arbitrary and artificial. Two approaches are generally adopted; the one is to isolate a group (or groups) of the algae and consider all aspects of their biology, and the other is to identify one aspect of the biology and consider the entire range of algal types. The volumes reviewed here provide examples of these two approaches.

The editors of *The Biology of Seaweeds* wished to produce a book that "would deal with all three major divisions of marine macrophytes" and asked the contributors "to exclude material on freshwater algae and phytoplankton, as well as benthic marine diatoms and blue-green algae." In *The Ecology of Algae*, by contrast, Round set out to make "a first attempt to present a unified account of algal ecology without the artificial division into freshwater and marine communities."

The two volumes also present another opportunity for comparison, the one being a collection of contributions by different authors and the other a single-author book of possible appeal to students. The former genre offers the opportunity for expert treatment of particular subjects and comprehensiveness of coverage. The accompanying dangers include unevenness of presentation and lack of synthesis and integration. The latter allows for an integrated (albeit personal) approach but might suffer from superficiality and over-generalization. *The Biology of Seaweeds* has avoided most of the dangers of collective volumes, and the deficiencies of Round's treatment of his subject have little to do with superficiality.

The *Biology of Seaweeds* is a worthy addition to the series Botanical Monographs, which includes substantial contributions in many fields of study. The book is a work of scholarship that has much to offer to many people of diverse interests. It presents information that will delight and edify, and it contains myriad implicit (and sometimes explicit) suggestions for further work.

The editors have divided the subject into four broad sections: Structure and

Reproduction, Ecology, Physiology and Biochemistry, and Seaweeds as Resources. The sections each have brief introductions that, for the most part, provide valuable perspectives for the detailed chapters to follow. However, it must be admitted that the simplistic generalizations in the introductions to the sections on ecology and on physiology and biochemistry are not in keeping with the scholarly treatments that follow.

Almost 300 pages are devoted to structure and reproduction, with life histories separated from morphology and classification and the three taxonomic divisions (Chlorophyta, Phaeophyta, and Rhodophyta) treated separately. These chapters are not for the uninformed. They will be of interest to those who are familiar with the basic features of algal structure, life histories, and classification and who want to learn of the many doubts and controversies surrounding many of the generally accepted views. As with many books on algae, the level of detail and specialization involved in discussions of structure, reproduction, and classification is not paralleled in the considerations of such topics as ecology and physiology.

In *The Ecology of Algae*, Round has attempted a monumental task. In addition to addressing the complete range of habitats within which algae occur, he attempts integrated presentations of topics such as symbiosis, parasitism, and grazing (one chapter), annual succession and growth, energy flow and nutrient cycling, and paleoecology. Also, he aims "to lead the reader into the relevant literature by illustrating points with *quoted* examples [his italics] rather than generalized statements." Certainly the book abounds with detailed presentations of data (almost 40 percent of the pages are filled with figures and tables), and more than 2100 references are included. Although the author claims that emphasis is placed on recent literature, the relativity of the word "recent" is obvious, as in references to "a recent analysis (Stull, 1975)" and "the recent international study of the Indian Ocean . . . during the 1960's," and no paper later than 1978 is mentioned.

I wish I could say that the author's monumental task had been successfully accomplished. Round has certainly shown the extreme range of habitats within which algae may be found. Also he has provided many examples with which many readers may be unfamiliar. But the fascination of algae in nature and the intellectual excitement of studying them are buried beneath the mass of detail and obscured by the approach. For example, the attempts to classify and name habitats and communities—examples being "epipsammon," "endolithon," "epipelon," "pseudoplankton (=tychoplankton)"—appear contrived and pedantic. The strict correctness of the terms is not in question, but the emphasis given to them impedes rather than enhances our understanding of algae in nature. Similarly, the selection of data for detailed presentation appears more idiosyncratic than interesting. Finally, the length of treatment and the attempt at comprehensiveness ensure that the reader is not left with a clear view of present-day studies of algal ecology or with an awareness of the problems and concepts that are currently exciting scientists concerned with the relationships between algae and their environment. Round has written a lengthy statement of his own perspective that gives an unfortunate impression of self-indulgence. Pascal once apologized to a friend, "I have made this letter longer than usual because I lack the time to make it short." It is a sentiment of some relevance to this book.

IAN MORRIS

Center for Environmental and Estuarine Studies, University of Maryland, Cambridge, 21613

A Theory of Vision

Vision. A Computational Investigation into the Human Representation and Processing of Visual Information. DAVID MARR. Freeman, San Francisco, 1982. xviii, 398 pp., illus. $29.95.

When David Marr died last year at the age of 35, he had already become a legend among neuroscientists. His posthumous book, *Vision*, is a synopsis of the work that made his reputation—his computational theories of the human visual system.

When Marr visited the Artificial Intelligence Laboratory at MIT in 1973, it was already being suggested that experimental psychology might have much to gain from computational theories, but the idea of a computational theory was still foreign to neurophysiology (apart from one or two flashes of insight by Horace Barlow). Marr describes how the considerable momentum generated by the work of Hubel and Wiesel seemed to be decaying without having led to any clear idea of the processes that are involved in actually seeing things. Marr realized, and insisted, that any information processing theory of vision must be addressed to questions at several different levels of abstraction. Just as in computing systems one must distinguish between the logic of a program and the circuitry of the computer on which the program is running, so in human vision one must distinguish between the neurophysiology of the visual system and more abstract entities such as the Fourier spectrum of a retinal image or the disparities between corresponding points in two such images. But Marr insisted on the need to take a global view of visual information processing. What precisely was the task being executed by the system? On what properties of the world could a system performing this task be expected to rely? What general method or methods could be shown to be effective in the performance of the task? Given a particular method, what algorithm or algorithms could be devised for its implementation? Given a particular algorithm, what sort of neural circuitry would be required, or would suffice, to carry it out? Do any of the known components of the visual system answer to these specifications?

Marr's particular achievement was to force such questions on the attention of neuroscientists. If neurophysiology was a theoretical vacuum when he entered it, it is now seething with lively controversy about the validity of his ideas on the visual system.

Vision has seven chapters. The first begins with a historical survey and then outlines Marr's own philosophy and approach to the study of vision. There are sections on the understanding of complex information processing systems and on the necessity of adopting an appropriate representational framework. Chapter 2 is devoted to the way in which images are represented. In it Marr reviews his already well-known concept of the "primal sketch" and the steps by which it may be built up from elementary features of the image. He examines the nature of the processes that lead to the grouping of elements and distinguishes between the "raw" primal sketch and the "full" primal sketch in which groups of features are labeled as belonging together. Chapter 3 describes the processes whereby visual images are interpreted as arising from surfaces, and particular attention is paid to the clues that are supplied by apparent motion and by stereoscopic disparities. In the following chapter we meet the "2½-D sketch," in which the visual information is represented as arising from surfaces of specified slope and tilt relative to the line of sight. Chapter 5, on shape recognition, passes to the final