

ESSAY REVIEW

A Treatise on Limnology, v. II—introduction to lake biology and the limnoplankton; by G. Evelyn Hutchinson. P. xii, 1116, 253 figs. New York, 1967 (John Wiley & Sons, \$39.00).—To review a book it is desirable to know something of the person who wrote it, desirable also to be empathetic with him and, if possible, to understand him. For a simple naturalist, which I am, it is easy to be empathetic with G. Evelyn Hutchinson, whom I have known for many years. To understand him is quite another matter. His awesome scope and erudition are baffling enough, but now after it has been generally agreed for a century or more that scientific knowledge has outgrown the individual's capacity to master it, Hutchinson's command of biology, physics, chemistry, geology, and mathematics—in topical, regional, and historical depth—persuades one to believe that he has, in fact, assimilated virtually all of it! Accepting that accomplishment, surely the labor could have left no time for anything else. But he has written not less than 185 papers and 7 books. These are not mere digests but in the main represent original research or original deduction based on synthesis and analysis of available data, and in addition he has devoted more time to his classroom and students than do most teachers, has been a devotee of the arts, and has been a hardworking member of countless committees and councils. As if this weren't enough, he has, withal, an attitude of unhurried, contemplative reflection that permits him to inquire into all sorts of things that interest and delight the mind no matter how far they may lie from the major tasks. He must operate with incredible speed and efficiency. Indeed, he can have no pool of entropy. All must be finely ordered and efficiently tuned to work without friction or heat loss. How can one understand such a man?

The fact remains, that the second volume of his *Treatise on Limnology* has appeared and the third (and final?) volume is on its way.

This second volume of the treatise has a rather simpler structure (half the number of chapters, 18 through 26) than the first volume. The first two chapters, 18, The Nature and Origin of the Fresh-water Biota, and 19, The Structure and Terminology of the Lacustrine Biological Community, together make up more than one quarter of the book. Obviously, they are so comprehensive and so general they serve not only as a foundation for the rest of this volume, and volume III, but also as guides for almost any limnological work that involves the biota. An important contribution made in this chapter is the illuminating analysis of the physiological differences between marine and freshwater organisms and the bearing these have on the mechanisms that permit some to adapt to marked changes in salinity whereas others cannot. A feature of the first, long chapter (225 pages) that will appeal to the geologically-minded is the repeated reference to precursors of various groups of organisms from the geologic record. These records are evaluated and related to the elements of the physiology that shed light on the evolutionary paths and on whether a group originated in the sea or not. After re-

viewing an enormous array of evidence he concludes, "There is nothing in the empirical evidence to support the oft-repeated dictum that life began in the sea".

This long, general first chapter could well stand on its own feet as a separate book. Indeed, it would be hard to find, for the non-biologist, a more illuminating orientation to the fresh-water biota and its forbears. It is even possible that it would receive wider notice as a book than it may as a part of the treatise.

Chapter 19, the shortest, is as general as the first and deals wholly with the terminology and definitions of lacustrine communities. The concepts expressed are either those used in ecology or have been adapted from them. As in ecology, or any science dealing with a bewildering complexity of things in a space of endless variety, one comes inevitably to deal with these problems with differing degrees of arbitrariness.

All the rest of the book is devoted to the plankton. The author is remarkably successful in keeping the focus so sharply on the plankton and its problems. The temptation to become involved with the various influences of the littoral, and benthic communities, and with the nekton, must have been strong indeed. These, however, he promises to treat in volume III.

Hutchinson's treatment of the hydromechanics of the plankton (chapter 20) is reminiscent of his chapter on the hydromechanics of lakes in the first volume. All the properties of plankton plants and animals that determine whether they float or sink, even including how much energy a typical small plankter may use to keep out of the hypolimnion, are treated mathematically. It is a sink or swim chapter. The mathematically minded may swim. To those of us who are not he offers this solace, "The nonmathematical reader wearied by the analyses of the present chapter will probably find this result intuitively obvious". To be fair, he intended this remark to apply only to the influence of gelatinous sheaths on sinking rates. It would be misleading, however, to give the impression that the analyses and conclusions of this valuable chapter are expressed only in equations—the text is satisfyingly full and comprehensible. Among other things he reaches the conclusion that a form favoring efficient uptake of nutrients may be more significant than one that determines the slowest settling velocity. The remarkable silicone fluids were not, of course, available to earlier investigators of the settling rates of micro-organisms. But future investigators may find them useful. These come in a wide range of specific gravities and an enormous range of viscosities and certainly will be free of any osmotic effects.

The dominant photosynthetic base for all the rest of the plankton, that is, the phytoplankton, is treated in three chapters (21-23), which aggregate less than 100 pages. Only the more significant algae are considered and figured for the benefit of the zoological or geological reader. Perhaps others than I have missed the very interesting fact that the strictly phototrophic algae may derive part of their carbon source not

only from CO_2 in solution, H_2CO_3^- , and $\text{CO}_3^{=}$, but also from a combination of amino acids and carbon dioxide, the carbamino carboxylic acid complexes. These are stable in the pH range ordinarily found in hard water. Possibly these carboxylates explain why soil extracts have been found so generally useful in growing algae *in vitro*.

Because all the other organisms in a lake, excluding some bacteria, are dependent on the phytoplankton, Hutchinson devotes a chapter to the complex relations, and interrelations, of the phytoplankton associations. The phytoplankton is not a wholly autonomous part of the lacustrine community and for that, and other reasons, never reaches a state of equilibrium. Hutchinson expresses the competitive complexity and uncertainty thus: "The condition in a lake, however, is always starting time on a race course in which it is never finally decided whether horses or racing oxen, carrier pigeons or human runners are to provide the sport. The competitors of a given genus or other higher taxon are from time to time lined up, and sometimes the race begins, but, as it might be in the works of Lewis Carroll, the event is always called off before it is completed and something entirely different is arranged in its place".

Apropos of the annual changes in phytoplankton the author makes this surprising, and characteristically astute, observation: "It is probably a mistake to regard the annual changes in phytoplankton as comparable to the aspektion of vegetation on land. In some respects the changes are more like the responses to large scale climatic change in the postglacial of the terrestrial flora". This follows from the fact that the microorganisms experience twenty to several hundred generations a year. During just that part of a year between the spring phytoplankton bloom and midsummer almost the whole stationary nutrient supply of the lake may be almost exhausted. This is probably a much greater change than in the soil chemistry of an untouched terrestrial habitat during several millenia.

The seasonal succession of the phytoplankton and the factors that govern, or modify, is the subject of another chapter. One of these factors of unusual interest is the antibiotic effect of metabolic products, which may inhibit competition, especially in large populations. Long chain fatty acids are thought to be implicated. If Ca and Na ions are present in the lake one wonders if it might not be the soaps of these acids that are toxic rather than the acids themselves. As Hutchinson indicates, additional research in this area is needed. The factors that govern the seasonal succession of plankton algae are numerous, interrelated, and commonly much more complex than they may appear.

The longest chapter of the book (235 p.) is given over to the nature and biology of the zooplankton. Like the first chapter this could well stand as a separate book, and a valuable item it would be. If the trophic and spatial relationships of the phytoplankton are complex, their complexity pales in comparison with the comparable aspects of the zooplankton. Similarly, the taxonomy of the two categories differs with the zooplankton weighing down its end of the beam.

Because the zooplankton of lakes is made up predominantly of three large groups of animals: the free-living, nonphotosynthetic Protista, the Rotifera, and the Crustacea, this chapter is subdivided into three parts. The remaining animals, which aggregate a much smaller number of both species and individuals, include coelenterates, flatworms, gastrotrichs, mites, and larval insects. One reason this chapter is so long is that it not only treats in detail the biology and ecology of each kind of animal, but it critically reviews the research that has been done on the animals in each of these groups, and also treats the population dynamics and seasonal cycles of the various groups. Problems that need additional research are identified.

The thoroughness with which these three dominant groups of plankton animals is treated and, quite incidentally, the whole purpose of the book are revealed in the following three sentences from the mid part of this chapter. "It is reasonably certain, from Price's (1958) study of *Acanthocyclops vernalis* and its allies in North America, in which six non-interbreeding species almost or entirely devoid of any distinguishing morphological characters appear to exist, that in certain cases nature has split species far more than any taxonomist. Though ecologists are, as amateur taxonomists, almost always lumpers, for the discussion of ecological problems the more finely drawn professional taxonomy of the splitter frequently gives greater clarity and insight. This is particularly true of a book such as this which attempts to present the limnology of the earth as impartially as possible without undue preference for particular continents".

The chapter on the vertical migration and horizontal distribution of the zooplankton is predominantly a review of the numerous observations on the diurnal movements, mostly of the Crustacea, made in the field and in the laboratory. However, it contains one typical Hutchinsonian touch. In response to one investigator's expressed astonishment at the great amount of energy expended in vertical migration, Hutchinson makes a "rough calculation" and shows that even assuming an efficiency of the organism as low as one percent, "less than one two-hundredth of the organic matter of the body would be oxidized in performing the ascent. This would not appear to be a very serious drain on the biochemical economy of a migrating organism eating its body weight of food each day. A relatively small advantage conferred by vertical migration would in fact make that process an economically significant one, favored by natural selection".

The last chapter on cyclomorphosis is another long one; long primarily because it provides the only adequate review of an enormous volume of scattered work on the subject. Hutchinson points out that cyclomorphosis although a part of limnology also has a potential value in research on morphogenesis in general and in evolutionary genetics. Cyclomorphosis in the Cladocera and the Rotifers is something of a mystery. Cyclomorphosis in the diatoms, however, is determined largely

by the geometry of their frustules. Geologists will be interested to learn that several investigators, notably Nipkow of Zurich, shed much light on the sequence of form changes over long intervals of years by isolating the spring, summer, autumn diatoms from the easily datable varves in the bottom sediments of the Lake of Zurich and Baldeggersee.

The two volumes of the treatise invite comparison as books. As in volume 1, each chapter of volume 2 has an excellent summary. The second volume has more illustrations than the first, as might be expected, and a considerable number of the illustrations have the unusual feature of being continued over on to the next page, or even the one after that. The enormous bibliography of volume 1 (66 p.) is matched by that of volume 2 (65 p.). Hutchinson has given the bibliography of this second volume the same unusual feature he gave to that of the first; namely, for each reference he has added in bold type the page numbers in his book whereon the reference is mentioned or discussed. The list of symbols in volume 1 runs 9 pages and only 5½ in volume 2. In volume 2 the general index runs 22 pages whereas in volume 1 it is only 15 pages.

Superficially the two books appear to be identical products of the bookmaker's art. But the resemblance is regrettably superficial. The first volume shows all the signs of excellent bookmaking, the second volume reveals the earmarks of bad bookmaking. I happen to know that the author found the publisher unresponsive to repeated requests that errors be rectified. Setting aside the author's responsibility entirely, the publisher of such a book owes it to himself as well as to the public to insist on good copy editing. But misspellings of common words are conspicuously common. Much more annoying are the inaccurately labeled illustrations. Identifying letters are left off or wrongly placed on a number of figures. One figure has 4 out of 13 identifying letters wrongly placed. Another figure has proper identifying letters but one letter and its accompanying explanation are omitted entirely from the explanation. Bar scales are omitted. In the bibliography one entry is 6 places away from its proper alphabetical position.

The second volume of the *Treatise* is a worthy companion for its distinguished predecessor. It is a shame that the author has not been more appropriately served by his publisher.

W. H. BRADLEY