bilin or green" symbionts lead to cryptophytes, rhodophytes, euglenoids, chlorophytes, and higher plants, while also in this line are the higher animals, ascomycetes, and basidiomycetes. Provocative to the end, the authors suggest that these two lines constitute two kingdoms into which all eukaryotes could (should?) be classified.

Fascinating points occur throughout the book in relation to specific groups: 70 mutants of *Chlamydomonas* defective in wall synthesis, with most mutants differing from the wild type by a single gene and control of wall synthesis apparently extranuclear; production of scales of various types in Golgi systems and endoplasmic reticulum of prasinophytes, chrysophytes, and prymnesiophytes, providing keys to informational behavior of endomembranes and to cell wall origins; flagellar roots of bewildering complexity, all asymmetric and all of phylogenetic import, but all of unknown function in relation to locomotion or communication with organelles to which they attach (nuclei, chloroplasts, plasmalemma, eyespots); and so on. However, most of the authors consider their cytological, ultrastructural, and biochemical information phylogenetically, and their contributions lead naturally to the concluding chapter by Stewart and Mattox, where problems abound. What of the apparently genuine absence of flagella in red algae? What of suggestions that microtubules evolved first as cytoskeletal components of the eukaryotic cell and that 9 + 2 flagella are relatively recent? What is the functional difference between mitochondria with flat and tubular cristae that could determine which type of pigmented endosymbiont became incorporated into a cell as a chloroplast? (The authors do propose answers to these questions, for which see the book.)

No doubt the anti-endosymbiosis camp will be heard; no doubt others will revive ideas on origin of flagella from spindles rather than vice versa; no doubt further data will accumulate to support or modify the ideas presented here (one awaits detailed information on conservative proteins with impatience). In the meantime, this book contains much to educate and stimulate the phycologist, protozoologist, and general biologist who might not immediately think that the phytoflagellates are of much interest to him or her.

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Chaos and Strange Attractors

Nonlinear Dynamics. Papers from a conference, New York, Dec. 1979. ROBERT H. G. HELLEMAN, Ed. New York Academy of Sciences, New York, 1980. xii, 508 pp., illus. Cloth or paper, $98. Annals of the New York Academy of Sciences, vol. 357.

Nonlinear dynamics encompasses a wide variety of phenomena, from turbulence to interacting species and ecologies. In fact, any phenomenon whose evolution is governed by nonlinear rate equations could be given the nonlinear dynamics label.

From the older, more traditional problems such as turbulence, there have emerged new applications and some new and exciting ideas (with catchy names such as "chaotic flows" and "strange attractors") that have attracted many workers to the field.

The book edited by Helleman, containing 44 papers presented at a conference, attempts to summarize the state of numerous aspects of the subject as of late 1979, with chaotic behavior of nonlinear deterministic systems the underlying theme. The attempt succeeds admirably to say the least. The papers, almost without exception, are clear and readable even to the nonspecialist. They are mostly theoretical in nature, but there are a few interesting and delightful experimental papers on turbulence. There is even a list of introductory references for those who do not wish to plunge immediately into chaos.

The papers are ordered in the way they were presented at the conference and are grouped sensibly under the general headings of Turbulence, Ergodic and Integrable Behavior, (applications to) Physics and Chemistry, Chaotic Maps and Flows, Chemical and Fully Developed Turbulence, and Strange Attractors. The potential reader who has heard of and may wish to know more about chaos and strange attractors will find much of interest under these headings, including the exotic universal behavior of simple maps on an interval and its possible relevance to turbulence.

Within the aforementioned categories, the reader will find applications to ecology and epidemiology, astrophysics, statistical mechanics, plasmas, reaction-diffusion systems, turbulent convection and flows, and some other more specialized topics, as well as some papers on more mathematical aspects of the subject. In fact it is difficult to think of something nonlinear that is not at least touched upon in this book. Mathematical and physical practitioners will surely find something of interest in it and will be tempted to learn more, even if they are not nonlinear specialists.

The field is seeing renewed interest and contains exciting new ideas and some hints of major breakthroughs, and it is possible that much of the contents of this book will not stay current in the near future. It will, however, stand as a useful source of references to the state of the nonlinear dynamics art circa December 1979. It is to be hoped that the next conference proceedings on this subject will be as well organized and presented as its immediate predecessor.

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Denizens of the Amazon

The Fishes and the Forest. Explorations in Amazonian Natural History. MICHAEL GOULDING. University of California Press, Berkeley, 1981. xii, 280 pp., illus. $20.

Fish are a major food source in the Amazon Basin, and Goulding contends that many commercial species are almost as dependent on the Amazonian forest, and as vulnerable to deforestation, as the better publicized terrestrial fauna. The floodplains of most Amazonian lowland rivers are inundated annually, forming extensive varzea forests. In this popular account of his studies on the larger fishes of the Rio Machado and Rio Madeira in southwestern Brazil, Goulding argues that these forests are the ultimate base of the aquatic food chain.

Goulding convincingly shows that many common fishes move into inundated forests and eat large quantities of fruits and seeds, fattening up for the rest of the year. (Several of the larger characins break hard nuts with dentitions that seem nicely specialized for nut-cracking; some of the piranhas masticate seeds with dentitions that seem as fiercely specialized for flesh-eating.) During low water, the fish move into floodplain lakes or back into the main river and eat little. Throughout the year, insects, leaves, and detritus are also important varzea-derived food sources. Thus, the varzea is the direct food source for a number of commercial species and the indirect source for the numerous piscivorous fishes.

This is solid work, but Goulding concludes too much from it. He claims that

75 percent of the total commercial catch (of the total Amazon Basin?) is based on flooded forests, but his calculations are not given. The estimate is suspect, yet it is the sort of figure likely to become numerical folklore, increasingly quoted without qualification. In any case, data of this type can only suggest possible effects of deforestation. Goulding's current studies may provide direct confirmation, and this book may inspire new studies.

In addition to the data on stomach contents that are the basis for his conclusions, Goulding includes introductory chapters on the hydrology and fish fauna of the Amazon and gives accounts of the natural history and illustrations of each species of fish and food plant studied. Since Goulding's only other reference to this research is a technical report to the Brazilian Instituto Nacional de Pesquisas de Amazônia, this book is the only report most specialists will see; therefore, it must also be judged technically.

While few of Goulding's statements on food habits are novel, many of the previous reports on the subject have been anecdotal or based on hearsay. His observations are the most thorough and well-documented on Amazonian fishes published to date—based on year-round samples of large numbers of many species, identification of species of fruit or seed eaten, determination of viability of digested seeds by planting, and deposition of voucher specimens of both fish and plants. This thoroughness makes the general absence of data even more frustrating. Some of the most intriguing and original observations are of the migrations of the large characins—spawning movements from tributaries into and slightly down the main river at the onset of the floods, and nonspawning movements (the piracema) into and up the main river at low water. The nature and possible evolutionary causes of these movements are discussed, but the reader is referred to the INPA report for the evidence. The data on temporal patterns of fruit-eating are summarized too thoroughly, and no data on fat levels, gonadal development, distribution of catch within seasons, or fruiting times are presented. The format of the book seems ample, with sparse tables and wide margins, to have allowed inclusion of additional data. There are numerous minor discrepancies between data in the tables and those in the text.

Mercifully, Goulding doesn't force his data into supporting competitive exclusion, niche specialization during periods of scarcity, or other traditional theoretical suppositions. He concludes that most species specialize during high water, when food is abundant; congeners often overlap greatly; many species overlap with respect to what little is eaten during low water. Occasionally, Goulding reverts to completely speculative, competitive-evolutionary explanations (for instance that the characins "prevent—or better, have prevented, in the evolution of feeding behaviors—[the catfish] from making serious inroads into their food supply between sunset and sunrise"; p. 187). Old habits die hard.

The conflict between the demands of scientific presentation and those of popular writing has separated books of travels and natural history from scientific works. Goulding mars the presentation of some important work by trying to make this book a little of each. Nevertheless, the Amazon remains very poorly known, and this book stimulates both in what it can and in what it cannot answer. The effects of Amazonian deforestation on aquatic ecosystems are important, and Goulding's plausible argument deserves attention and further study.

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Vertebrate Physiology

Epithelial Transport in the Lower Vertebrates. Transports Epithéliaux chez les Vertébrés Inférieurs. Jean Maetz Symposium, Villefranche-sur-Mer, France, June 1978. B. LAHLOU, Ed. Cambridge University Press, New York, 1980. xiv, 366 pp., illus. $55.

This volume is the proceedings of a memorial symposium to Jean Maetz. A distinguished group of investigators has contributed 29 papers, five of them in French, dealing primarily with the structure and function of fish gills. Thus the title is misleading, since amphibians receive minor treatment and reptiles none. The papers are grouped into four categories, morphology, transport, biochemistry, and endocrine regulation.

The heavy reliance of this treatise on the study of fish gills illustrates a curious propensity of certain schools of comparative physiology to study a preparation despite its unsuitability for rigorous testing of hypotheses. Bentley (p. 7) acknowledges this problem in an amusing fashion: "Gills appear to have been designed to provide the ultimate intellectual exercise for those who wish to study epithelial membrane physiology." Everyone recognizes the importance of gills and the significance of understanding mechanisms of gill transport, but I would suggest that few basic principles of transport can be discovered in such complicated, heterogeneous structures. In any case, gills have been "fashionable" for some years now, and the work of Maetz and his followers is the best of the efforts devoted to this complex epithelial structure. I wish that a similar array of talent could be brought to bear on the study of elasmobranch, reptilian, and avian salt glands, which are virtually pure populations of specialized transport cells.

The present volume is, however, an excellent introduction to epithelial transport in fish and will be of interest to all physiologists who want to keep abreast of recent developments in the field. A wide variety of experimental approaches is utilized, and the papers are of high quality. I was especially interested in the work reported by Potts on the effect of low *p*H on gill potentials and sodium balance. This is a rather neglected phenomenon that has great practical significance in relation to acid pollution; development of nonlethal bioassays based on changes in gill sodium transport rates is possible. Hughes's paper on the functional morphology of gills also seems a particularly valuable summary. Several of the authors discuss isolated fish skin and sheets of opercular epithelium. These topics deserve further study.

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Books Received

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