Although working at a large spatial scale has countless advantages, it requires acceptance of a substantial reduction in data quality in a field where several lifetimes could easily be devoted to the study of a single community. Adams acquired most of his data by surface survey and examination of air photographs. Uncertainty about the possibility of continuing fieldwork led him to employ a low-intensity survey method in order to maximize areal coverage. These data are supplemented by reference to the complex historical materials initially available from the early portion of the third millennium.

The sizes of the settlements occupied during the periods under consideration are the basic input to further analysis and interpretation. Adams reviews the many difficulties that beset estimation of areal, population, and functional size. These difficulties lead him to eschew utilization of a variety of location analytic techniques that have been applied by others to comparable data sets. He seems to be of two minds about the matter, however, in that he is willing to examine the implications of settlement rank-size distributions and other data manipulations that assume no lesser accuracy, or wishful thinking, in size estimation than do those he rejects as requiring greater data reliability than is currently available.

I suspect that this seeming analytical ambivalence is partially the product of a research strategy that focuses more on broad patterns of population aggregation and land use than on the organizational structure to which many location analytic techniques are sensitive. Yet it also reflects an unresolved problem in all studies of this kind. Regional-scale research is a comparatively new development in several fields of social science, and there is still little informed consensus on the constraints imposed upon analysis and interpretation by the necessary trade-off of data quality for spatial coverage. While some will find Adams's position on these matters to be fairly conservative, others are likely to think that he has already sorely strained the limits of reasonable interpretation.

Heartland of Cities is not a work without fault. Adams acknowledges that the organizing concept of urbanism he employs is of primarily descriptive utility. Systematic consideration of the organizational variables that facilitate or inhibit the integration of complex societies is notably lacking. Lesser matters that will be a source of specialist discussion abound, but this is inevitable in a study that ranges so widely. Yet for its scope in space and time, its synthesis of data from disparate fields, and its articulation of research problems and results that are critical to our understanding of the development of complex societies, this volume will be of interest far beyond the often parochial confines of Mesopotamian scholarship.

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Unicellular Eukaryotes

Phytoflagellates. ELENOR R. COX, Ed. Elsevier/North Holland, New York, 1980. x, 474 pp., illus. $50. Developments in Marine Biology, vol. 2.

Phytoflagellates are complex eukaryotic unicells, combining the common characteristics of photosynthesis by chloroplasts and motility by paired 9 + 2 flagella with a wide diversity of photosynthetic pigments, flagellar appendages, cell coverings, flagellar roots, cell symmetry, chromosomal and spindle organization, eyespots, photoreceptors, contractile vacuoles, chloroplast ultrastructure, storage metabolites, and Golgi and endoplasmic reticulum function, and having life histories involving spores, cysts, and a variety of sexual behavior.

These features are discussed for the major taxa of phytoflagellates by the contributors to this volume, with the main emphasis being placed upon ultrastructure in relation to cell function and phylogeny. The chapters on chlorophytes, prasinophytes, chrysophytes, xanthophytes, eustigmatophytes (the last two not phytoflagellate groups but included for their interest in relation to the others), prymnesiophytes, chloromonads, cryptophytes, and dinoflagellates provide modern reviews of the groups that will be valuable summaries for both teaching and research. The chapter on snow algae concentrates on ecological physiology, that on colonial chlorophytes surveys the group at the light-microscope level, that on euglenoids concentrates on research in progress on chloroplasts, eyespot pigments, and, especially, *Trachelomonas* envelopes, and most of the chapter on silicoflagellates is concerned with skeleton formation. Finally, the recurrent themes of origins, evolution, and relationships in the various groups are brought together in a concluding chapter by Stewart and Mattox on the phylogeny of phytoflagellates as a whole, and it is here that the most controversial ideas are to be found.

Utilizing the mass of comparative data summarized by the 12 preceding authors, Stewart and Mattox postulate that phytoflagellates derive from zooflagellates rather than from photosynthetic prokaryotes. Early phytoflagellates would have been large, complex, predatory, non-walled (naked or scaly), asymmetric organisms, with these and other "animal-like" attributes (trichocysts, rhizoplasts, flagellar pits) being retained in many present-day forms. Origin of chloroplasts by symbiotic incorporation of prokaryotes into predatory zooflagellates is supported and the classical concept of origin of zooflagellates from phytoflagellates rejected (where evolution of heterotrophic from autotrophic forms is known, loss of pigments but retention of plastids is often found). It follows that the relationship between any two phytoflagellate groups is that between their respective zooflagellate ancestors. The characters that must be examined to establish the latter are types of mitotic spindle, the flagellar apparatus (the 9 + 2 axoneme assumed to be of common origin, with variations arising in root systems and flagellar appendages), cell surface and coverings, and mitochondrial type, the last emerging as the somewhat surprising key to the authors' basic phylogenetic solution. Characters are listed that are found in cells with either flattened mitochondrial cristae or tubular mitochondrial cristae but not both, Stewart and Mattox pointing out that chloroplasts of phytoflagellates with flat cristae always contain phycobilins or chlorophyll *b* whereas those with tubular cristae always contain brown or yellow pigments and lack phycobilins and chlorophyll *b*. This correlation is suggested to indicate that the type of mitochondrion present in the zooflagellate ancestor influenced the kind of photosynthetic prokaryotic endosymbiont that could become reduced and integrated to the status of chloroplasts.

On this precarious base, the authors erect a bifid phylogenetic tree with an ancestral flagellate without mitochondria or chloroplasts giving rise to organisms with (i) mitochondria with tubular cristae derived from endosymbiosed prokaryotes or (ii) mitochondria with flat cristae similarly derived. The same steps of spindle evolution occur in both lines, but type of prochloroplast symbiont is restricted. In the first line, "brown" symbionts lead to dinoflagellates, diatoms, chrysophytes, brown algae, prymensiophytes, and xanthophytes, and the line also includes ciliates, myxomycetes, and oomycetes; in the second line, "phyco-

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