deed Nicolis himself remarks that "macroscopic order is sandwiched between equilibrium thermal disorder and turbulent disorder." It is likely that very special conditions are required to obtain biological order from physical chaos. A paper by P. Schuster describes recent investigations by Eigen, Schuster, and others along such lines on the origin of the genetic code. The key idea, that self-replicating macromolecules must cooperate rather than compete to develop more organization, seems very plausible. There is also an excellent review by S. A. Kauffman of the topic of pattern formation in developing organisms, one highlight of which has been the formulation of rules for the regeneration of limbs and the like by French, Bryant, and Bryant and another the application of Turing's theory of pattern formation in diffusion-coupled chemical reactions to development and regeneration. The Turing theory gives a plausible account of such processes, but once again the stability exhibited by living tissues seems to be considerably greater than that exhibited by simple chemistry.

The book contains a number of papers concerned with solitons, fluid dynamics, and plasmas and with nonlinear equations in general. There is a very useful paper on the numerical computation of nonlinear waves by B. Fornberg, for example, in which many different numerical algorithms are discussed. Nevertheless it is fair to state that applications to biological problems dominate the volume, so that it will be of most interest to mathematical biologists. The volume itself is well produced. There are almost no errors in the text, and the format makes it easy to read.

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Desert Biology

Biology of Desert Invertebrates. CLIFFORD S. CRAWFORD. Springer-Verlag, New York, 1981. xvi, 314 pp., illus. $39.30.

Deserts are hot, dusty, generally uncomfortable places to be, and biologists working in them must have surely wondered at times about the cost-benefit ratio involved in extracting information about desert life.

Yet deserts have a diverse biota that, living under conditions that are often very stressful, provides an excellent opportunity for studying how plants and animals adapt to ecological constraints. Such constraints may be seen in the physiology, behavior, life history, and community assemblages of desert organisms. Often the constraints may be expressed as ecological convergence in form and function, as is seen among the cacti of North America and the cactus-like euphorbs of the Old World.

Among desert organisms, the most numerous are the invertebrates. Commonly found in deserts are protozoans, nematodes, mollusks, arachnids, millipedes, centipedes, and a variety of insects. Many of these have a great impact on desert life. For example, termites in the Sonoran desert can consume over 90 percent of the dead wood that falls in one year.

Despite their importance to the dynamics of desert systems, finding information on the ecological, behavioral, and physiological roles of desert invertebrates has been difficult. A number of excellent studies of single species, or even groups of species, have been published in diverse journals, but the information has been difficult to piece together.

Crawford has made a major contribution toward our understanding of desert invertebrates by arranging the details into patterns. Without sacrificing the particulars, he has assembled information from many sources and organized it around the themes of behavioral and physiological adaptations, life history adaptations, and community roles.

Crawford has done an excellent job of putting things together, and perhaps just because of that I found myself wishing for somewhat more synthesis. There are questions that touch on some important concepts in ecology that are not addressed in the book. For example, how are communities of desert invertebrates structured—randomly, by competition, by predation, or by historical constraints? What is the role, if any, of competition in a stressful environment? In a harsh environment, how much leeway does selection have in affecting the physiology and behavior of an animal without colliding with phylogenetic inertia?

Crawford's book nevertheless represents an excellent start. Now that we have the particulars organized into comprehensible patterns, we can ask broader questions that before could not be asked intelligently.

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Bioenergetics

Chemiosmotic Proton Circuits in Biological Membranes. In Honor of Peter Mitchell. V. P. SKULACHEV and PETER C. HINKLE, Eds. Addison-Wesley Advanced Book Program, Reading, Mass., 1981. xviii, 634 pp., illus. $29.50.

This book consists of 39 papers covering a wide variety of topics in bioenergetics. The unifying theme connecting topics as seemingly disparate as oxidative phosphorylation, proton transport in the stomach, photosynthetic electron flow, catecholamine storage in the adrenal medulla, and the mechanism of flagellar motion and bacterial active transport is the central role of the electrochemical proton gradient ($\Delta\tilde{\mu}_{H}+$) in all these processes. Thus the book clearly fulfills its stated aim of honoring Peter Mitchell on his 60th birthday. For it was Mitchell who, some two decades ago, almost single-handedly focused the attention of workers in bioenergetics on the central role of the electrochemical proton gradient in biological energy coupling. As Racker, in the introduction to his paper, aptly says, "his conceptual contributions . . . have revolutionized our thinking as well as our experimental approaches." The level of the book is too advanced and in some papers too specialized to serve as a first introduction to this revolution. However, a moderately well informed reader will find the book provides a nice overview of the effects of these revolutionized approaches.

The book opens with an excellent introductory paper by one of the editors, Skulachev, outlining the central concepts of Mitchell's chemiosmotic hypothesis, the history of its grudging acceptance by the bioenergetics community, and the subjects of chief current concern to workers in the field. The review, although brief, will be of particular interest to those of my generation who as graduate students or young postdocs saw the chemiosmotic hypothesis greeted with something close to ridicule in the early 1960's and watched as acceptance of Mitchell's ideas culminated with the award of the Nobel Prize in Chemistry in 1978. Skulachev also succeeds in giving the reader a good feeling for the wide variety of biological energy transducing systems that have been successfully analyzed by means of the chemiosmotic hypothesis.

Next there are 21 papers describing systems the editors have described as "$\Delta\tilde{\mu}_{H}+$ generators." Two highlights of this section of the book are a fair discussion by McCarty evaluating the relative roles of intramembrane and transmembrane pH gradients and a lucid review by Schatz of the biogenesis of the mitochondrial electron transport chain. The section contains three papers on the light-driven ion pumps of *Halobacterium halobium*, a system that provided some of the most convincing evidence for the chemiosmotic hypothesis. A paper by Stoeckenius *et al.* provides an excellent summary of the photocycle of bacteriorhodopsin and attempts to measure the stoichiometry of proton pumping coupled to this photocycle. A paper by MacDonald on the *Halobacterium* light-driven sodium pump is also excellent and serves the useful function of reminding the reader that ions other than protons may be the primary species in chemiosmosis. The difficulties facing investigators as they try to extend the general concepts of the chemiosmotic hypothesis to specific mechanisms will become apparent to the reader who struggles through the intricacies of the Q-cycle and related models for energy coupling in the cytochrome b-c_1 region of the mitochondrial chain (four papers) or in the cytochrome oxidase region (two papers). Three papers on photosynthetic electron flow point out many of the similarities between proton-translocating electron transfer chains of photosynthetic and respiring systems.

The 16 papers that make up the second major section, entitled $\Delta\tilde{\mu}_{H}+$ Consumers, are uniformly of high quality and not only give the reader excellent coverage of the several systems discussed but also supply a good feel for the detailed molecular information that has become available recently. This information has been extended in some cases to include the identification of individual amino acid residues likely to be involved in H^+ movements through the protonmotive adenosine triphosphate (ATP) synthesizing enzyme of oxidative phosphorylation. Readers will find eight up-to-date papers on several aspects of ATP synthesis, two excellent ones (by West and Kaback) on possible mechanisms in bacterial metabolite transport, and some very nice ones on slightly more "exotic" topics, such as the role of $\Delta\tilde{\mu}_{H}+$ in heat generation and DNA transport.

The book concludes with a speculative essay by Peter Mitchell himself. Perhaps this is in response to the closing question in Racker's paper, "How about it Peter? Can you once again steer us to some new, exciting adventures?" Though it is far from easy reading, the essay provides a fine example of the Mitchellian style and serves as a perfect counterpart to Skulachev's opening chapter, the one pointing toward possible future directions, the other summarizing the enormous successes of the chemiosmotic approach over the past 20 years.

Despite the generally high quality of the individual papers and the skill of the editors in selecting the contributors, the book suffers from some of the problems to be expected of a volume of this nature. A few papers are far from lucid, and occasionally there are lapses when some of the authors seem to be conversing with a rather small fraternity rather than with a larger scientific readership. One also regrets the absence of discussion of certain topics, such as the overall energetics of mitochondria, including the chemiosmotic contributions to phosphate and adenine nucleotide transport. All things considered, however, the book will make a useful addition to the library of any biochemist interested in bioenergetics.

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Learning about Space

Spatial Representation and Behavior Across the Life Span. Theory and Application. LYNN S. LIBEN, ARTHUR H. PATTERSON, and NORA NEWCOMBE, Eds. Academic Press, New York, 1981. xvi, 404 pp., illus. Developmental Psychology Series.

There has been a growing body of work dealing with the ways in which people behave in, think about, and attach meaning to space. This book offers a set of reports centering on developmental studies of spatial understanding.

Herbert Pick and Jeffrey Lockman lead off with an essay on spatially coordinated behavior, "a young infant's getting its thumb into its mouth, . . . a preschool child's learning to throw a ball, an adolescent's hand-sewing of intricate stitches in a homemade garment." The chapter has surprising depth. Several elegant analyses are offered with little elaboration. Infants are good at object-body manipulations before they are good at object-object operations. This developmental sequence in manipulation looks like another found in locomotion. The toddler navigates at first egocentrically, by locating things relative to its body, and then later allocentrically, by locating things relative to an objective plan. Pick and Lockman argue that when children move from egocentrism to allocentrism they shift from locating objects on one frame of reference toward the coordinated use of reflections of the objects on several frames of reference.

Linda Acredolo presents work concerned with the relationships between children's dealings with small-scale and large-scale spatial arrangements. Psychological researchers commonly present children and animals with tasks in a bounded space-of-the-problem. The researcher ignores the room cues beyond as irrelevant, but small children and animals have a tendency to use all there is to be seen about them, and so misunderstandings crop up about what they do or do not understand. Given little maps or models that simulate larger spatial arrangements of things around them, children often seem to know things at one scale that they do not seem to know at another. Why? Conversely, in play or in classrooms, children often seem to use learning in miniature arrangements to potentiate adaptation to the larger geography. What transfers positively from one scale to another?

The central issue of the volume, as the reader will have gathered, is children's development of spatial understanding. In an interlude, Lauren Harris offers a scholarly review of the literature on male-female differences in spatial ability. He concludes, carefully, that "the sex difference on tasks collectively called 'spatial' is real, not illusory." Neurological and "socioexperiential" factors are both implicated. Harris concludes that the sex differences are nontrivial, but he is not able to be conclusive about their theoretical or practical significance.

Roger Downs, a geographer, and Alexander Siegel, a psychologist, are two of the leading researchers on human spatial knowledge. In this volume they explore, separately and together, some of the epistemological puzzles buried in "cognitive mapping" studies. People do not have cognitive maps in their heads, of course. (Edward Chace Tolman used the term "cognitive map" in a famous paper in 1948 and the term has stuck.) What *is* the form of spatial knowledge? When children develop spatial knowledge, are they learning the way space really is, or are they joining the community of adults in their use of shared cognitive mappings to jointly designate, mark off, and dimensionalize space? Downs and Siegel write a brief chapter called "On mapping researchers mapping children mapping space." To avoid some basic puzzles, you need at least