sion by McCarty evaluating the relative roles of intramembrane and transmembrane *p*H 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 $\Delta\bar{\mu}_H+$ 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 $\Delta\bar{\mu}_H+$ 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

elements of a "supermap" representing in the same symbolic space adult schematizations, the several childhood schematizations arising in development, and the mapping tasks that researchers create as they try to get people to "externalize" their cognitive maps.

Two chapters round out the group of developmental chapters that talk to one another. Roger Hart reviews findings from his longitudinal study of the ways in which children experience and know a New England town. Hart argues that the miniature studies that make up the bulk of the research literature must be supplemented by studies of how children know the real world around them. His work as presented here makes this obvious.

Seymour Wapner, Bernard Kaplan, and Robert Ciottone of Clark University try in 30 pages both to set forth a radically different framework for the understanding of human development, Genetic-Dramatism, and to review the findings of a series of studies in which people in transition—freshmen entering college, American children beginning an extended visit to Holland, elderly people moving into an old-age home—represent themselves in the context of the places and spaces around them. The chapter is clumsy because too many messages are crowded into it, but it may be useful in outlining a change in a well-known research program.

Clark University has been a creative center for the work represented in this volume. Much early work on cognitive mapping grew out of a kind of developmental psychology established by the late Heinz Werner at Clark, the comparative-developmental approach, whose theoretical influence stands second only to that of Piagetian genetic epistemology in Geneva. A weakness of the Clark theorizing has been that it has never had a data base that was adapted to it and suitable for the elaboration of the position. Piaget invented his own research tradition—first the "clinical method," then the "revised clinical method"—providing a comfortable ground on which his theory could be explored and elaborated. Werner and some of his collaborators were aficionados of experimental psychological work. They produced many interesting findings and many findings that were consistent with their theoretical position, but they did not seem able to produce a synergy between their theory and their data. This chapter may signal the development of theory and a data base in communication with one another.

Finally, the volume contains a chapter by Irwin Altman and Mary Gauvain outlining a "cross-cultural and dialectic" analysis of homes. Dwellings embody mythological and dramaturgical statements about the dilemmas and oppositions that have to be reconciled in human existence. A chapter by Walsh, Krauss, and Regnier presents data from a study under way dealing with how a sample of aged people in Los Angeles understand and use the urban terrain around them.

There are nine substantive chapters in the book—six of them good chapters that together make up a connected symposium on the development of spatial representation, one of them a useful review of male-female differences in spatial ability, two of them a little at loose ends in relation to the others. The editors have embedded these nine substantive chapters in five chapters of commentary. There are an overall introduction, a commentary chapter after each set of three substantive chapters, and finally an overall review. Some excellent people wrote those commentary chapters. But the five chapters seem to offer more reflection and commentary than a volume of nine substantive chapters needs or wants, particularly when a number of the substantive chapters achieve a rather high plane of scholarship and sophisticated discussion.

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The Importation of a Science

Bringing Aerodynamics to America. PAUL A. HANLE. MIT Press, Cambridge, Mass., 1982. xvi, 184 pp., illus. $20.

For reasons that are still only partly understood, the invention of the airplane by the Wright Brothers in 1903 did not foster the study of aeronautics as an exact science in this country. Rather, Germany, followed by France and England, took the lead in establishing the science of flight as an academic discipline. Aeronautical research and development at Göttingen University, in particular, stressed theoretical and experimental research, whereas the solution of similar scientific problems on this side of the Atlantic emphasized empirical methods.

America's second-class standing in aeronautics led Daniel Guggenheim, in 1926, to set up a $2,500,000 fund that was used to establish seven aeronautical schools in the United States, including one at the California Institute of Technology. The success of Pasadena's program depended critically on Robert Millikan's ability to lure Theodore von Kármán, Göttingen Ph.D., class of '08, away from his post as head of the Aerodynamics Institute at the Technical University of Aachen. By the mid-1920's, the accomplished physicist, aerodynamicist, and applied mathematician had built up an aeronautics establishment second only in importance to Ludwig Prandtl's at Göttingen. Then came von Kármán's association with Caltech, a watershed in the history of American aviation, Hanle argues, because the Hungarian-born scientist brought with him "the organization and personality of Göttingen-style applied science."

As the title suggests, this book is primarily about the transmission of theoretical aerodynamics, the hallmark of Göttingen's aeronautical curriculum, from the Old World to the New. Writing with the fervor of a true believer, Hanle traces German aeronautics, particularly theoretical aerodynamics, from the mathematician Felix Klein's success in creating a school of applied mechanics and mathematics at Göttingen to Theodore von Kármán's first visit to the United States in 1926, under the auspices of the Daniel Guggenheim Fund for the Promotion of Aeronautics, and concludes that von Kármán's appointment figured prominently in Millikan's plan to turn Caltech into another Göttingen. This is an interesting idea, although Hanle doesn't cite any primary source material to support his claim. Millikan believed that the modern world was basically a scientific invention, that science was the mainspring of the 20th century, and that America's future rested on promoting pure science and its applications. Caltech, in Millikan's view, existed to provide America's scientific leadership. If Göttingen did indeed provide the inspiration, so surely did Zurich's Eidgenössische Technische Hochschule, Pisa's Scuola Normale, and Paris's Ecole Polytechnique also.

Hanle is on much surer ground when he writes about the Klein-Prandtl-von Kármán alliance in Germany. He gives a good account of Ludwig Prandtl's role in reforming the technical education of engineers, following his Göttingen appointment in 1904. Prandtl's scientific contributions to aerodynamics are underlined, starting with his pioneering work on the flow of fluids around a body, which emphasized the need to study the region near the object's surface ("the boundary