with the history and potentialities of ichnology, the classification and preservation of trace fossils, and false traces. This section is largely review and will be of interest chiefly to those who are unfamiliar with the study of trace fossils. The second part deals with the geological significance of trace fossils. J. D. Howard's chapter on the sedimentological significance of trace fossils is an outstanding contribution. Howard ably demonstrates his assertion that trace fossils "often supply evidence of sedimentological conditions that is superior to information gained only by the study of physical structures." His model of trace fossils as indicators of general depositional processes under continuous and discontinuous deposition should receive wide attention from stratigraphers and paleontologists alike. It is simple, sensible, and useful.

The third part consists of papers dealing with selected groups of trace fossils, including plants, borers, and vertebrate tracks and burrows. W. J. Kennedy discusses trace fossils in carbonate rocks, a subject that has received little attention in the past although all trace fossil suites occur in carbonates and are as important for environmental interpretation, in carbonates as they are in other rocks. In another important chapter, R. G. Bromley describes distinct trace fossil assemblages associated with omission surfaces. If it wasn't before, it is clear from this paper that trace fossils will become increasingly important in assessment of the temporal continuity of any local stratigraphic sequence.

The fourth part is concerned with the traces of recent animals in aquatic, shallow marine, and deep-sea environments. J. Dörjes and G. Hertweck compare the living communities and trace assemblages at three places in the modern ocean, but with limited success. The only clear relation is no surprise—the highest degree of bioturbation coincides with the peak density of the biocoenoses. C. D. Hollister, B. C. Heezen, and K. E. Nafe describe animal traces on the deep-sea floor and illustrate them with new photographs. This area of research has become increasingly important as we recognize more and more deep-sea sediments in the fossil record. Trace fossils are often the only evidence of life preserved in these sediments.

The last part of the book deals with techniques in the study of traces. C. A. Elders's chapter is entitled "Experimental approaches in neoichnology" but is chiefly a systematic review of the method and mechanisms of burrowing. Perhaps this best illustrates the need for truly experimental research on the production and preservation of trace fossils.

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Bioenergetics

Electron Transfer Chains and Oxidative Phosphorylation. Proceedings of a symposium, Selva di Fasano, Italy, Sept. 1975. E. QUAGLIARIELLO, S. PAPA, F. PALMIERI, E. C. SLATER, and N. SILIPRANDI, Eds. North-Holland, Amsterdam, and Elsevier, New York, 1975. x, 452 pp., illus. $35.95.

At the descriptive level, there is no question that this proceedings volume provides an excellent, all-inclusive account of our present knowledge about the components of the complexes of the electron transfer chain and of the adenosine triphosphatase complex and about the pathways of electrons in the various complexes. It contains 56 articles, ranging in length from 2 to 16 pages. Some have the character of reviews or progress reports; quite a few present new material.

It might be useful to point up some decisive experimental developments to be found among the articles. H. Weiss *et al.* provide compelling evidence that cytochrome b in complex III is a dimeric unit of molecular weight 50,000 and not, as was previously thought, a monomeric unit of 25,000. The polypeptide chains of the unit are similar, but there are significant differences. The two spectral species of cytochrome b can now be satisfactorily rationalized in terms of a dimeric unit, the hemoprotein components of which are distinguishable spectroscopically. G. v. Jagow provides evidence that the interaction of antimycin with cytochrome b converts the cytochrome into a relatively inactive form that scarcely can exchange electrons with Q, durohydroquinone, and cytochrome c_1. In the form of its antimycin complex, cytochrome b behaves like a hydrogen carrier, that is, it accepts two protons and two electrons. W. A. Cramer *et al.* demonstrate that cytochrome b-559, which is intimately associated with photosystem I, exists in a high-potential form at neutral *p*H and in a low-potential form in acid. The oxidation-reduction potential of the protonated form is sufficiently low to permit it to be readily oxidized by photosystem I.

H. Beinert and F. Ruzicka give an incisive account of the role and function of the multiplicity of iron sulfur centers found in the various electron transfer complexes. They point out that the number of iron sulfur proteins counted now exceeds the number of cytochromes. This has become a source of embarrassment because no one has any idea why there should be three to four iron sulfur centers in a single complex such as complex I. The discovery that the flavoprotein that links the fatty acid oxidation system to the electron transfer chain is associated with an iron sulfur center is particularly noteworthy. H. Penefsky *et al.* have mastered the art of clearing F_1 of all bound nucleotides, and this has made it possible to determine how many binding sites for nucleotides there are in F_1 and which of the five polypeptides is concerned in the binding. In by far the most elegant article in the volume, S. J. Ferguson *et al.* trace the consequences of inactivating F_1 with a reagent that ties up one tyrosine group, inactivates adenosine triphosphatase, and eliminates the fluorescence induced by 1-anilino-naphthalene-8-sulfonate on addition of adenosine triphosphate (ATP). They conclude that the rate of probe response is not a bulk property of the membrane but is due to local causes, in line with the position of H. Baum *et al.* This result, Ferguson *et al.* emphasize, is hardly concordant with any of the current dogmas about the nature of the energized state. R. Bachofen *et al.*, from their studies of photosynthetic energy transduction, conclude that the energy-dependent release of bound ATP may be a side reaction with little relation to phosphorylation. It is this release that is the cornerstone of the Slater-Boyer conformational hypothesis.

A. Tzagoloff has initiated the construction of the first map of the structural and regulatory genes in mitochondrial DNA. From studies of mutants deficient in some facet of coupled ATP synthesis, he has been able to deduce the arrangement and role of some of the markers in the gene map. Y. Hatefi *et al.* have defined how one complex (complex I) can oxidize two substrates (reduced nicotinamide adenine dinucleotide and its phosphate) by similar yet not identical pathways and thus may have solved one of the long-standing puzzles of the mitochondrial electron transfer chain. A. Lehninger *et al.* have systematically tackled the problem of the number of protons formed during the passage of two electrons and two Ca^{2+} ions across the membrane. The number is four. It should be pointed out that if it were not, the prin-

ciple of electroneutrality would be violated.

When we turn from the articles that are merely descriptive to those that deal with molecular mechanisms and the driving forces in energy coupling, simplicity and clarity fade away. It becomes painfully obvious that the fundamental principles of energy coupling and the molecular mechanisms underlying electron transfer and oxidative phosphorylation are as far out of reach today as they were when oxidative phosphorylation was first discovered some 30 years ago, despite the tremendous increase in our knowledge of the structure of the mitochondrial transducing system. What can account for this lack of progress? The first and obvious explanation is that the theoretical cart has been put in front of the experimental horse. To understand the mechanism of electron transfer, we must at least know the internal structure of the complexes that carry out electron transfer. To understand the mechanism of coupled ATP synthesis, we must at least know the internal structure of the complex and the relationship among the parts that carry out the synthesis. That knowledge is still lacking. The second explanation is that the test of theory is not proficiency in debate but the solution of outstanding problems. If the chemosmotic model or the conformational model of energy coupling is valid, one of them should lead to the experimental resolution of all outstanding problems. Model builders are content to rest their case on argument and persuasion, and models become dogmas and not stepping-stones to wider experimentation.

It was a magnificent achievement to bring 100 or more participants from all parts of the world to have a three-day scientific dialogue in Selva di Fasano, and the concentration of talent in bioenergetics was at an all-time high at this conference. Yet there is a danger in this type of conference—the danger of perpetuating and reinforcing dogma. The powerful grip of dogma has all but strangled mitochondriology, and these continuing annual conferences supported by huge outlays of money have played a not inconsiderable part in bringing about this distressing situation.

As a summary of knowledge of the mitochondrial transducing system, this book can be recommended to all workers in bioenergetics. It will undoubtedly be one of the most referred to volumes in mitochondriology.

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Vertebrate Vision

Vision in Fishes. New Approaches in Research. Papers from a NATO Advanced Study Institute, Lennoxville, Quebec, Aug. 1974. M. A. ALI, Ed. Plenum, New York, 1975. xiv, 836 pp., illus. $62. NATO Advanced Study Institutes Series A, vol. 1.

The bony fishes and their allies constitute one of the three major vertebrate radiations, and in terms of number of species and ecological diversity they must also be considered the most biologically successful one. In most fishes vision is a prominent sensory modality utilized in complex behaviors such as predator-prey interactions, territoriality, dominance, pair bonding, and parental care. Long separated from the land vertebrates in evolution, the fishes offer biologists the opportunity to examine a vertebrate group that has solved a number of biological problems independently and often uniquely. An understanding of fish vision will add new information regarding a unique group of vertebrates and should also add greatly to our understanding of vertebrate vision in general. Any volume dealing extensively with vision in fishes should therefore be welcome.

This book includes 61 papers by researchers from seven countries. It is heavily slanted toward the organization of the eye proper, and the fish retina is used as a convenient model for the vertebrate retina in general. Only nine of the papers deal specifically with central nervous system aspects of vision. Unfortunately, it is impossible to gain from the 20 papers that touch on the subject any picture of the exact brain regions that receive primary retinal efferents. It is not even clear whether neurophysiological studies have characterized these primary retinal targets in a single fish, much less their possible variation.

Like most symposium volumes, this work falls short of its aims. One of its main purposes, according to the editor, was to focus attention on the significance of electrophysiological and visual pigment studies for revealing the life histories and habits of fishes. There are ten papers in the electrophysiology section, but only two (Schwassmann; Ali and Muntz) deal at all with variation in the visual systems of fishes or attempt to correlate that variation with habitat. Schwassmann clearly summarizes the available data concerning the spatial orderliness of the retinal projection onto the optic tectum of teleosts. This review reveals a puzzling phenomenon: in most freshwater fishes, even those with excellent vision, there is a linear projection of the retina onto the tectum, whereas most marine teleosts exhibit nonlinearity in the retinotectal map. These results suggest that most freshwater fishes do not have an "area centralis," whereas most marine fishes do.

The section on behavioral aspects also fails to make comparisons or to relate information about visually mediated behavior to the life history and ecology of fishes. The papers in this section deal, for the most part, with specific psychological techniques or results, with the exception of a broad outline compiled by Northmore and Yager of psychophysical methods utilized in work on fishes. The lack of any reference to the ethological literature (the most extensive literature on fish behavior) and to the importance of vision in much of the species-typical behavior of fishes is particularly glaring in a volume that purports to emphasize a broad variety of approaches.

The sections on optical and mechanical aspects, comparative and developmental aspects, and environmental aspects are the heart of this volume and contain a number of insightful and stimulating contributions. Papers by Schwassmann and by Sivak on accommodation and papers by Ali and by Easter on retinomotor responses are clearly written and provide excellent summaries of their subjects.

Sadoglu provides a particularly interesting paper, based primarily on her own work, on the genetic control of eye development in cave fishes. Her research may also prove to add considerable insight into the genetic control of eye development in vertebrates in general. Gruber provides a chapter summarizing what is known regarding peripheral vision in a nonteleost group, the elasmobranchs. One could wish that more such summaries had been provided.

Dartnall's analysis of visual pigments and their relationships to photic environments is a particularly effective review. His discussion of the sensitivity hypothesis of visual pigments—that these pigments have been selected to absorb the greatest number of quanta in a given photic environment—clearly reveals that we still do not know what visual surfaces fishes are scanning in most environmental circumstances. Muntz's contribution continues in a similar vein. He discusses variation in the visual pigments of fishes that most likely cannot be explained by the sensitivity hypothesis and emphasizes the need for more detailed information on the actual visual tasks that fishes perform.

Easter presents a concise and stimulat-