the values of preservation, such as esthetic and recreational benefits and the scientific value of a more complete natural laboratory or genetic stock, are not as readily observable as the value of exploitation. Second, because the assumption of reproducibility holds for the products of only one of the alternatives (exploitation) a decision in favor of it forecloses future choice in favor of the other (preservation), and so the elimination of options must in itself be regarded as a cost associated with the former. Third, the impact of technological advance adds further asymmetry: it tends to increase the supply and lower the cost of producible goods but not of natural environments, for which only the demand increases as a result of population and income growth.

This third phenomenon, especially, is the subject of investigation in several of the essays in the volume under review. Preservation of wilderness is not the most pervasive of environmental concerns; nor, probably, is it the most crucial for the future well-being of society. Indeed, nature preserved in its pristine condition is almost a North American luxury; and, if we follow the analysis of one of the contributors to this volume, the benefits will be enjoyed largely by purists who are also among the most affluent. Nevertheless, in an atmosphere of rapidly growing public concern for wilderness protection, as reflected, for example, in the recent Wilderness Act and the Wild Scenic Rivers legislation, and in the context of highly politicized confrontations of preservationists, industrial developers, and governments, these studies offer the first real promise for a rigorous analytical approach to decisions involving environmental modification.

All but one of the nine studies are products of research sponsored by or undertaken at Resources for the Future, in Washington, D.C., where a group under John V. Krutilla has been pursuing empirical and theoretical investigations of a conclusion he tentatively reached in an analysis published six years ago—that private market processes are likely to preserve less than the optimum amount of natural environment and that the optimum amount is likely to increase. The book is an impressive statement of the progress of research since then. The most important papers report on economic studies, but three final papers offer a biologist's exhaustive review of numerical methods of classifying inland waters, a landscape architect's somewhat mechanical discussion of wildland typology, and a brave attempt by a psychologist to develop objective (or, more correctly, consistent) assessments of esthetic features of landscapes.

Like most compendia of conferences, the level and quality of presentation vary, the more so in this case because of the multidisciplinary nature of the subject matter coupled with the intradisciplinary specialization of the contributors. Hence, the audience that will appreciate the full range of the essays—from the highly esoteric economic analysis of decisions involving irreversible environmental modification to limnological taxonomy—will not be large. And, as in any new research field, we must be patient with sophisticated proofs of the obvious, such as a highly theoretical paper demonstrating that (with reasonable assumptions about the stability of consumer tastes) technological advance which enhances the production of some goods but not of others will cause the relative price of the latter to rise.

But it is the uncompromising disciplinary rigor of the studies that is the strength of the volume. In setting a high objective standard for further investigations in this contentious area of public policy the volume is a landmark in research on wilderness preservation.

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Entomologists on Their Past

History of Entomology. RAY F. SMITH, THOMAS E. MITTLER, and CARROLL N. SMITH, Eds. Published in cooperation with the Entomological Society of America by Annual Reviews, Palo Alto, Calif., 1973. viii, 518 pp., illus. $12.

The entomologists of today generally pride themselves on their biological professionalism; it would be interesting to know how many of the authors of this volume would resent being described as amateurs in their capacity as annalists and historians. The relative roles and interrelations of amateurs and professionals in the development of the subject, and the effect on it of the increasing professional dominance in the present century, are topics which none of the contributors consider specifically. However, the 25 authors, representing Australia, Austria, Britain, Canada, Denmark, France, Germany (both east and west), Israel, Japan, Sweden, the United States, and the Soviet Union, among them deal more or less authoritatively with many aspects of entomological history, and almost any entomologist with historical interests can hope to learn something new and interesting from the book. Particularly interesting to this reviewer were Günter Morge's account of Greco-Roman and medieval European entomology, Tuxen's "Entomology systematizes and describes," and Richard on the behavior of insects; others with more professional tastes might prefer Spencer Brown's "Genetics—the long story," or Wigglesworth on insect physiology. There are articles on early entomology in East Asia (by the Japanese Konishi and Itô) and in the Middle East (by Harpaz from Israel) which have ideological and religious resonances lacking in the rest of the volume.

With so many authors writing independently, there is inevitably a fair amount of overlap in coverage; thus von Frisch's work on *Apis* behavior is considered at some length in the article on apiculture as well as in the one on insect behavior, and early silk cultivation is discussed under entomology in the Far East as well as under sericultural science. Another inherent drawback of this type of treatment is that individual specialists, writing about the history of their own field, will tend to present it as leading to and culminating in their own theories, even where (as for example in the article by Andrewartha and Birch) these are controversial. The editors themselves admit that some aspects of entomology are not covered in this book, and they promise an attempt to remedy some of its omissions in future volumes of the *Annual Review of Entomology*, of which this book might well be considered a special issue.

It is a temptation any reviewer would find it hard to resist to suggest further topics that should be considered in this connection. One has already been suggested, the role of amateurs in the development of the science; two more that I think deserve consideration are the development and changing roles of entomological societies, which would involve some consideration of national schools and traditions in the subject, and the history of entomological publication, with particular reference to scientific periodicals and to faunal works.

In fine, this is a useful and interesting work, and, apart from Essig's

recently reprinted *A History of Entomology*, which deals only with American entomology, there is nothing else currently in print which deals at all extensively with its subject matter. The price being reasonable, many individual entomologists, as well as libraries, should find it a worthwhile buy.

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Botanical Symbiosis

Ectomycorrhizae. Their Ecology and Physiology. G. C. MARKS and T. T. KOZLOWSKI, Eds. Academic Press, New York, 1973. xvi, 444 pp., illus. $28.50. Physiological Ecology.

This book is a collection of papers concerned with the ecology of mycorrhizae. The authors interpret "ecology" very broadly, as is useful in view of the fact that the morphology, chemical composition, physiology, genetics, geographical distribution, and classification of mycorrhizae are not well enough known to provide an adequate foundation for the study of their ecology. Structure and morphogenesis are discussed by Marks and Foster, classification by Zak, distribution in forests by F. H. Meyer, growth of ectomycorrhizal fungi around seeds and roots by Bowen and Theodorou, mineral nutrition by Bowen, carbohydrate physiology by Hacskaylo, hormonal relationships in mycorrhizal development by Slankis, the rhizosphere of mycorrhizae by Rambelli, mycorrhizae and feeder root diseases by Marx, and applications in forestry by Mikola. The authors are currently publishing on mycorrhizae so their work has already been critically considered. They take some pains to review the literature, and in this they are aided by the publication within the last decade of at least nine symposia or texts on mycorrhizae.

A real difficulty in many studies of mycorrhizae is lack of identification of the fungi involved. Although this book contains author and subject indexes, it lacks an index to species. Successful application in forestry practice, such as the Austrian planting of *Pinus cembra* in timberline situations for avalanche control, has been much aided by Moser's careful mycological work.

The individual papers are careful, thoughtful presentations. Meyer's covers the widest intellectual range. Bowen brings in many ideas from the field of plant nutrition and attempts to make his discussion rigorous. Classification, as noted above, is simply unsatisfactory, a situation that certainly is no fault of Zak's. Slankis extends and defends the very interesting pioneering work he began long ago. The other papers illustrate nicely the extreme complexity of the subject and the many ways in which it cuts across conventional lines between plant-oriented disciplines. Could this latter account for the small representation of university researchers among the contributors?

Considerable emphasis is on forestry aspects of mycorrhizal problems, and this is no fault. Possibilities of application keep research and conclusions reasonable and testable. The heavy emphasis on a few tree species is disadvantageous, however, if mycorrhizal investigators allow themselves to be confined by their experimental material as plant physiologists have done with a very limited repertoire of crop plants. Mycorrhizae are of wide occurrence in natural vegetation, and noneconomic plants may be excellent experimental material. The investigators represented here are well aware of the importance of competition between plants, so their physiology is not automatically inapplicable, and they fulfill their aim of elucidating the ecology of mycorrhizae.

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Subunit Associations

Protein-Protein Interactions. Proceedings of a colloquium, Mosbach, Germany, Apr. 1972. R. JAENICKE and E. HELMREICH, Eds. Springer-Verlag, New York, 1972. viii, 464 pp., illus. $24.80.

This volume is the proceedings of a meeting that attempted to present an overview of molecular interactions in protein molecules. Out of this broad area of research, the colloquium concentrated on the functional advantages of multisubunit structures, with the emphasis on the nature of quaternary structure. The self-assembly and symmetry of these biological "supramolecular assemblies" are presented as a natural prerequisite for the development of diverse cooperative effects that are utilized in oligomeric proteins. These interactions often endow oligomers with increased stability or functional capability, improved efficiency, and the possibility for the control mechanisms essential for complex biological systems. Understanding the way such cooperative effects are mediated through intra- and intermolecular subunit contacts is of central importance in biology.

The symposium consisted of 20 invited papers which illustrate the diversity of solutions that nature has evolved to meet her needs in the hierarchy of molecular organization. The importance of quaternary structure in proteins is represented by the relatively simple tetrameric hemoglobin molecule, which remains a standard in the understanding of biological function on chemical and physical principles. The emphasis here and throughout is on the nature of the subunit associations and the resultant cooperative effects. Aspartate transcarbamylase, which consists of 12 polypeptide chains, is presented as one example of organization of a regulatory enzyme that uses separate catalytic and regulatory chains. Multienzyme complexes are one example of heterologous protein interactions. Besides profiting from quaternary structure in all ways accessible to monofunctional oligomers, multienzyme complexes have an additional inherent advantage of spatial organization for promoting efficiency of catalysis. Tryptophan synthetase is a small multienzyme complex which may be regarded as a dimer, $\alpha_2\beta_2$, of functional $\alpha\beta$ dimers. Although the individual subunits α and β_2 have distinct catalytic functions, the formation of the $\alpha_2\beta_2$ complex leads to large increases in the catalytic efficiencies of the partial reactions. Evidence is presented to indicate the formation of a composite active site where the preexisting sites in the α and β_2 subunits are brought into direct contact. Other topics include the protein assemblies in muscle, antigen-antibody interactions, the self-assembly of viruses, and the relevance of cell-cell interactions. In addition, there are papers on the nature of molecular forces involved in protein-protein interactions and on the importance of self-assembly and symmetry, and repeated examples of how experimental techniques of electron microscopy, x-ray diffraction, chemical and spectral probes, and others have been combined to elucidate the properties of complex biological systems to make a colloquium of this sort possible.

The book presents a broad yet cohesive summary of the recent developments in this area. The numerous high-quality figures and the inclusion of discussions enhance its value. Most of the