Hutchinson (although MacArthur and Levins get a citation in Bartlett's bibliography). And if Murdie and Hassell's paper be excepted, the volume contains no reference to so diverse an array of people as Lotka, Volterra, Nicholson, Bailey, Watt, Holling, Odum, and Margalef. (The population geneticists, on the other hand, seem to have their Canonical Citation Abundance Distribution.) I could play a similar game with the subject index, but as the index is itself a bit capricious this would be cheating.

In short, this is a collection of interesting papers, including some useful reviews and some examples of mathematics well integrated with biology. In addition, the book serves a constructive purpose as an unconscious—and therefore all the more reliable—indicator of the strengths and (by omission) weaknesses of theoretical population biology in Britain.

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Philosophical Problems

The Many-Worlds Interpretation of Quantum Mechanics. A Fundamental Exposition. BRYCE S. DEWITT and NEILL GRAHAM, Eds. Princeton University Press, Princeton, N.J., 1973. viii, 253 pp. Cloth, \$12.50; paper, \$5.50. Princeton Series in Physics.

This book is a collection of papers concerned with the philosophy of quantum mechanics, and in particular the many-worlds interpretation of quantum mechanics. There are seven articles in the collection, the first by far the longest. I recommend to readers that they begin with articles 4, 3, and 2, in that order; they are not very lengthy and contain the heart of the material.

Philosophies of quantum mechanics are very personal matters; I approach this question as one who received a traditional physics education during the '50's and has been a practicing mathematical physicist ever since. By chance my personal view of quantum mechanics is close to that propounded in this book, here called the many-worlds interpretation. Preliminary to writing this review I recalled in my mind my past thoughts on the philosophy of quantum mechanics, and numerous past discussions with other physicists. I also undertook a casual survey of many of the other physicists at my present institution. It seems safe to say that the new breed of physicist has not thought much about philosophy, and feels that such questions of interpretation are irrelevant to his research. This insouciance is present to such an extent that certain misconceptions are commonly held, which I shall return to later. I would be among the last to urge scientists to read about interpretation of quantum mechanics as an aid to research. For those students, scientists, philosophers, and scientifically learned nonscientists who are in the process of puzzling about the connection between quantum mechanics and reality, I recommend the present book. If one wanted to read one and only one book on this subject—not at all a bad idea—this is a good book to read. We proceed to a brief discussion of the many-worlds interpretation.

In quantum mechanics a system is described by a vector (wave function) in Hilbert space, the time development of the system described by the time dependence of the vector. The vector in Hilbert space generally is a probability distribution for an infinite number of classical states of the system. Speaking simply, then, quantum mechanics can provide only a probability for a given occurrence, and not a deterministic prediction of a fixed outcome. Thus quantum mechanics is not a physical theory by the criteria physicists used to insist on. Einstein, for example, could not reconcile himself to it. At the opposite extreme, the prevalent view today is that a calculation of probabilities is all we ask of science.

One's first efforts to reconcile oneself to quantum mechanics often begin with the assumption that the wave function (vector) of the universe might be so peaked about a single classical state that the classical universe we live in could have its motion deterministically predicted by the wave function. Many physicists suffer this harmless delusion. As is discussed in the fourth article of the collection, the *Gedanken* experiment with Schrödinger's cat convinces us that this is impossible. Classical events, such as whether the cat lives or dies, or whether you buy this book or not, can be affected by quantum-mechanical-scale events. In the wave function of the universe—if one accepts quantum mechanics to this extent—there is a nonzero probability that you buy the book and a nonzero probability that you do not. There are two common philosophies to reconcile one with this unpleasantness, the Copenhagen view and the many-worlds view.

The first view essentially is that quantum mechanics is wrong. The equations are to be modified in some way so that the wave function always is peaked about a single classical state. Some mechanism "collapses" the wave function to a function peaked at a single classical state whenever it would "split" into a function peaked at a number of "classical" alternatives. There is a distinction, obscure to me, made between looking for a specific modification of the equations and merely postulating the "collapse." It should be emphasized that in any case such modification of quantum mechanics is real and would affect the results of experiments and calculations, although in a negligibly small way for realistic experiments.

I was one of those who embraced quantum mechanics bra, ket, and matrix. I believe there is a wave function of the universe satisfying some linear evolution equation, so I am in the many-worlds camp. The wave function describes a continuous infinity of classical states developing in time, "splitting" and "recombining"; God runs his finger along the function picking out our actual world. Hugh Everett III, in the second paper in the collection, has formalized such an interpretation of quantum mechanics. There is a continuous infinity of classical worlds coexistent at any time; we are in one nonexceptional member of this set. Although, as authors in the collection say, this seems "bizarre" and is "startling," in fact, it is the natural interpretation one is inescapably led to if one takes the view that quantum mechanics is the ultimate formulation of nature's laws; the universe is a vector in Hilbert space.

To those who immediately reject the many-worlds view in favor of the Copenhagen view, one should recall that the Copenhagen view has its own difficulties. All the processes that make up a classical object are described by quantum mechanics, but not the object itself. There is no natural scale at which objects become classical: When does the wave function collapse? How can one modify quantum mechanics to correctly collapse? Since the many-worlds view requires quantum mechanics and nothing more—no "collapse," no "hidden variables," no "classical observers"—it is the most conservative interpretation. The fact that most books on quantum mechanics do not present this view makes this book a desirable addition to the physics literature. Certainly in teaching quantum mechanics a number of articles in this collection are good references to give students desirous of some outside reading material on philosophy.

Having been entirely positive up to this point I would offer some criticism of the format of the present collection. There is no advice to the reader on how he might best read the seven articles collected. Certainly the first article presented is, by its length, the least palatable. I would have preferred an introduction and a different arrangement of the articles. In fact a textbook on the subject of the collection might be in order.

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Plant Biochemistry

Phytochemistry. LAWRENCE P. MILLER, Ed. Van Nostrand Reinhold, New York, 1973. Three volumes. Vol. 1, The Process and Products of Photosynthesis. xiv, 410 pp., illus. $22.50. Vol. 2, Organic Metabolites. xvi, 446 pp., illus. $24.50. Vol. 3, Inorganic Elements and Special Groups of Chemicals. xiv, 448 pp., illus. $24.50.

Despite the metabolic versatility of plants (over 1000 new compounds are reported yearly) broad-scale treatments of plant biochemistry are rare. This three-volume set is particularly welcome because its editor is knowledgeable, critical, and skillful as a writer. In the 36 chapters one finds some unevenness, but the editor has tried hard to keep differences in literary styles from causing the usual distractions. Differences in depth of coverage, however, cannot be glossed over.

While both primary and secondary biochemical activities are covered, most of the treatise is devoted to secondary plant compounds. Such compounds attract and hold interest for a number of reasons. There has been a marked increase in interest in compounds in plants from the vantage point of pure science. Perhaps it should have been expected that studies of the biogenesis of many "secondary" constituents would implicate them as intermediates in the biogenesis of metabolites of known importance. This is indeed coming to pass. Some of these compounds are also turning out to be important to the chemical taxonomist. A chapter is devoted to this rapidly growing aspect of systematics.

Most of the chapters are arranged in logical order except for the final volume. This volume has had to accommodate the late arrivals, and we find, for example, the chapter on respiration sandwiched between chapters on vitamins and endogenous plant growth regulators.

Volume 1 is about essentially what its subtitle leads one to expect: the process and products of photosynthesis. The chapter on the chloroplast in photosynthesis is somewhat restricted and seriously deficient in references since the mid-1960's. As a result important evidence of the nature of the two photosystems is missing. A modern treatment of the chloroplast membrane system is also lacking. There is a similar lack of use of concepts that came to the fore in the late 1960's in the chapter on photosynthesis. Thus one finds no mention of the inhibition of photosynthesis by oxygen—an old observation but one that is being reemphasized today.

A thoughtful treatment of the chlorophylls and their biosynthesis is provided. The pitfalls of measurement in solutions are pointed out, but there is no evaluation of Stacy French's important work on species of chlorophyll a. Techniques for the measurement of the chlorophylls in vivo now in use in several laboratories are not discussed. In the treatment of the control of chlorophyll biosynthesis no mention is made of the role of light. This is an important oversight. References after 1968 are sparse, and none appear beyond 1971.

The overview of the carotenoids is very compact but highly readable. An orderly and lucid though undetailed treatment has been provided for the mono- and oligosaccharides, though the sugar alcohols have been given only three pages. Because of the intensity of work on cell wall constituents, it is gratifying to see the much-needed treatment of hemicelluloses and gums. It is disappointing, however, to find no account of what is known of the biosynthesis of cellulose.

Volume 2 is devoted to organic metabolites. This is a big order. Once again the treatments are short and readable but often severely reduced in detail. This is true for the chapters on amino acids, proteins, purines and pyrimidines, alkaloids, steroids, terpenes, and rubber. The chapter on flavonoids is especially well done but lacking in findings of the current decade. The chapter on volatile plant products is encyclopedic to the point of being readable for reference only. One of the most important of the volatiles, ethylene, is not mentioned at all.

Volume 3 is devoted to the inorganic elements and special groups of chemicals. The chapter on the role of minerals in phytochemistry is almost exclusively devoted to the minor elements. The treatment of the halogens is perhaps the best available. A full chapter on the physiology of sulfur compounds is provided. But little is said about their biosynthesis. The treatment of organic acids is restricted to those known to be most active metabolically plus oxalic and tartaric acids. The latter compounds are considered because they are the most prominent acids found in plants. It is a genuine service to have the acetylenes introduced because this is a new area for biochemical exploration. Possibly these highly reactive compounds serve as primary precursors for substances of physiological significance. Some of them are antimicrobial and others are of pharmacological significance.

Lignin is inadequately treated. In view of their importance in the water relations of plants it is surprising that cutin, suberin, and surface waxes have been allotted so little space. The vitamins are treated in encyclopedic style with emphasis on animals. A thoughtful analysis and prediction of things to come appear at the end of the chapter on mitochondria and plant respiration. An overview of the naturally occurring plant growth regulators is followed by one of the most detailed treatments available on the chemistry and biochemistry of the gibberellins.

The treatise ends with a potpourri of chapters on molecular taxonomy, plant-derived drugs, and economically important plant products.

Although almost all the information in these volumes is available in other reviews, a distinct service has been performed for the discipline of plant biochemistry. This is a field with a steadily increasing number of practitioners and their need for a source book has been served.

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