startling examples of the use of visual imagery in mathematics), they are almost overshadowed by Cooper and Shepard's elegant 100-page study of mental rotation, which goes far beyond Shepard's earlier and already influential work. Among its findings are that subjects cannot rotate an abstract frame of reference, but only an image of a concretely specified form; that certain well-defined circumstances yield nonlinear rotation-time functions; and that people can be induced to rotate a mental image continuously at a regular rate, with predictable effects if a comparison stimulus suddenly appears in the field. At all levels—ingenuity of design, sophistication of analysis, thoughtfulness of presentation—this is an outstanding piece of research.

The book offers two other very competent papers, both using judgment latencies to analyze complex processes. Posner continues to develop his notion of internal "codes," or modes of representation; Clark, Carpenter, and Just study the verbal statements which people find acceptable as descriptions of schematic drawings. In summary, whatever doubts one may have about the ultimate future of experimental psychology, there is no doubt that this volume includes some impressive examples of the present state of the art.

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A.I. in EASEy

Pattern Recognition, Learning, and Thought. Computer-Programmed Models of Higher Mental Processes. LEONARD UHR. Prentice-Hall, Englewood Cliffs, N.J., 1973. xxii, 506 pp., illus. $13.95. Prentice-Hall Series in Automatic Computation.

No matter what its ultimate definition, in practice "artificial intelligence" (A.I.) deals with computer programs that can be said to learn, recognize patterns, and solve problems. One usually teaches A.I. by discussing programs that appear to be especially good examples of machine thought. A few authors have tried to develop general principles about the capabilities of classes of algorithms used in A.I. Here Leonard Uhr, one of the major contributors to A.I. research, has tried yet another approach, a guide to the creation of A.I. computer programs. To be sure, Uhr interleaves mentions of general problems with his discussion of specific programming examples, but he usually does not go much beyond a brief aside on a general problem that a sample program illustrates. His asides are not reasoned arguments; his programs are.

Uhr discusses four subfields of A.I.: pattern recognition, game playing, problem solving, and learning. In each case he first presents a rudimentary program to do a simple illustrative task and then complicates it in order to execute more complex varieties of "intelligent action." There are numerous asides about the programs but, as noted, no formal analyses. Neither is there very much coverage of the literature, although there is a good bibliography, divided into topical sections. The programs themselves are written in EASEy, a simplification of the SNOBOL programming language, which Uhr hopes can be read like text. Fortunately, Uhr also offers clear English-language précis of the various EASEy programs. He seldom uses flow charts, and I, for one, missed them.

In evaluating Uhr's work we must distinguish both how well his aims are met and how well they have been chosen. Uhr himself says that the book is unevenly written. The discussion of pattern recognition is quite good, both in the choice of programming examples and the philosophical asides. I recommend this section to anyone who must actually program a pattern recognizer. The chapters on game playing do not contain clear-cut discussions of the various algorithms that have been developed for board games. Uhr has chosen to spend a great deal of time on a general discussion of the game GO, rather than the much more studied chess; his discussion is interesting, but it shortchanges the student who has not already examined the uncited literature. In discussing problem solving Uhr does not explain the basic ideas behind the resolution principle and graph searching. Finally, the most difficult section to evaluate is the one on learning. The examples of learning programs appear, at first glance, to be a collection of useful but ad hoc tricks. Uhr clearly feels that they represent much more. Unfortunately, his failure to carry his asides to the point of formal analysis leaves me unclear about the real implications of the programming devices illustrated. Uhr certainly recognizes the need to trace a connection between learning and pattern-recognition programs. He tries to do this by cross referencing from a discussion of learning to pattern-recognition programs presented earlier, but the effort seems to me to be of limited success.

Uhr's approach to instruction via programming example will probably be very useful in engaging the beginning student in a concrete discussion of A.I. This is good pedagogy and, especially at the undergraduate level, it should be much more effective than reliance upon the more formal, analytic, "removed from the real computer" approaches taken in several other texts. The disadvantage is that students may learn to plunge forward with clever programming solutions without analyzing their algorithms in any formal way. This encourages the software-engineer approach to A.I.—"can I program the machine to solve the problem at hand right now?"—and discourages the search for *proven* general solutions, even though Uhr stresses the need for such solutions in his discussion. The student is likely to heed the examples more than the cautions.

This book is an interesting adjunct to other A.I. texts. At the least it could serve as a second text in a course in which students discussed general principles and, using Uhr's book, worked on concrete programming problems. (A revised edition, written specifically for this purpose, could be much shorter.) A Compleat Artificial Intelligencer will have to contain serious discussions in mathematics, engineering, psychology, and programming. Only the last is given here. Uhr, too, is human. To give four would be divine.

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The Physics of Bonding

Bonds and Bands in Semiconductors. J. C. PHILLIPS. Academic Press, New York, 1973. xii, 288 pp., illus. $18.50. Materials Science and Technology.

During the past six years, J. C. Phillips has worked on modernizing and generalizing the outlook on chemical bonding begun by Linus Pauling, now possible because of the immense increase in factual knowledge about covalently bound solids. The theoretical calculations of conventional solid state theory can be long on computer time

and short on insight. In addition such calculations do not describe with useful accuracy important properties such as the relative energy of two alternative crystal structures or the electro-optic constants. The object of this modern outlook on bonding is to try to isolate the physics of bonding and to characterize empirically the unknown parameters and functions of this description. It has proved possible to find quantitative relations with predictive power for many important physical and chemical properties of a broad class of semiconductors. Two-thirds of *Bonds and Bands in Semiconductors* is a monograph on this subject, presenting work by Phillips (and by others he has strongly influenced) and the background necessary to explain and develop this frankly empirical outlook toward bonding and properties of solids. The remaining third is chiefly an exposition of conventional one-electron theory of band structure and optical spectra to connect the "bonding" ideas with energy bands in solids.

The professional materials scientist will find the monograph stimulating and informative. It discusses the relations between properties and materials in a way which brings many new insights to a reader who previously had some grasp of the theoretical constructs and the chemical systematics of the properties of solids. For such a reader, the book is relatively easy reading, chiefly because the author has attempted to present the subject as physically as possible and in as elementary a fashion as is consistent with describing the empirical phenomenology. Large sections of the book are material the professional knows, but often described from an unusual viewpoint. As a monograph, the book is at its best as a presentation of a coherent set of useful empirical relations. Chemists, engineers, and physicists interested in new electronic materials will find a working familiarity with this book a great asset. They will find the lack of detailed references to the original literature on experimental results and theoretical approaches annoying; the author gives only a few references at the end of each chapter, and those often to secondary sources.

The preface of the book suggests that the level is "typical of many introductory books on solid state physics." Many discussions are begun at a level which presumes considerably less knowledge than the usual reader of monographs has at his disposal. Since, to my knowledge, no existing textbook gives adequate coverage to the interdisciplinary area of this book, it is worth asking whether this book might itself be a useful text for a graduate course in chemistry, physics, or materials science. Unfortunately, the prerequisites for such a course would include a Kittel-level course on the phenomenology of solid state physics, some knowledge of the quantum theory of solids, and some understanding of conventional chemical theories of bonding. The book makes no pretense at a balanced view of important concepts—for example, in talking about effective charge without a discussion of the shell model of lattice vibrations it omits a major insight into the meaning of e^*. Chapters of the book are interrelated, and the student will not find it a book that can be studied sequentially. Finally, he will miss detailed references to partially covered subjects. Fortunately, these weaknesses for textbook use do not diminish the interest of this volume to those having a working familiarity with solids and semiconductors.

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Insect Physiology

The Physiology of Insecta. Vol. 1. MORRIS ROCKSTEIN, Ed. Second edition. Academic Press, New York, 1973. xvi, 512 pp., illus. $38.

To an ever increasing extent insects are being utilized to study basic questions in biology. This increased attention undoubtedly stems in large part from the facts that the genetic approach to the development and behavior of eukaryotes is gaining in popularity and that *Drosophila* is genetically the best known of all eukaryotes. With the influx of new researchers comes a demand for a ready source of information on the basic biology and physiology of insects. *The Physiology of Insecta* edited by Morris Rockstein, which first appeared in 1964, helped to satisfy this demand.

Now the series is being completely reworked. Besides an updating of the information, there will be an expansion of the treatise to six volumes. Chapters on bioluminescence, photoperiodism and circadian rhythms, pheromones, and other new topics are to be included in the new edition.

Each chapter presents a detailed overview of a particular aspect of insect physiology by an authority in that field and is written so as to be comprehensible to people outside the field. Thus, the chapters are generally not as inclusive or as critical as specialized review articles. Yet each includes an extensive list of references. These lists would have been even more valuable if the titles had been included. The lack is only partially overcome by having an author index for all works cited in the text.

The first volume to appear deals with the ontogeny of insects. J. de Wilde and A. de Loof begin with two chapters on reproductive processes. A rich variety of phenomena ranging from parasitic castration to traumatic insemination are concisely described, and the authors present succinctly the diverse endocrine mechanisms that regulate insect reproduction. The difficult subject of the biochemistry and physiology of embryonic and postembryonic development is covered by I. Agrell and A. Lundquist. In many instances they refer the reader to earlier reviews on one or another aspect of embryonic development, but unfortunately the most up-to-date reviews on those subjects (*Developmental Systems: Insects*, S. J. Counce and C. H. Waddington, Eds., Academic Press, 1972) were apparently not available to the authors and have not been included in the references. L. Gilbert and D. King present an excellent, thoughtful review of the endocrine aspects of insect development with a detailed summary of the chemistry of ecdysone and juvenile hormone. The last subject—insect aging—is one that has suffered from a lack of workers. This is very apparent from the article by Rockstein and J. Miquel. However, the physiological, biochemical, and ultrastructural data they present may help to direct work in this field of increasing relevance.

The upcoming volumes will consider "the insect and the external environment" and "the insect and the internal environment." In its new edition this series will be of value to researchers and students in all areas of insect biology.

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