

formation stored in the network are specified as productions. The action components of productions can add structures to the network and activate nodes in the network. The conditions of all productions are matched against the activated part of the network. Those productions whose terms are satisfied by information contained in the activated portion of the network are executed.

*Language, Memory, and Thought* is a diverse book. It contains excellent summaries of previous theoretical work, discussions of the logic of theory construction and evaluation, and a detailed specification of the formal semantics of ACT representations. Of course, the author's primary objective is to describe ACT and to present various theoretical and empirical results that support the theory. Included are analyses of fact retrieval, inferential processes, encoding specificity, depth of processing, language comprehension, and induction of procedural knowledge. I give ACT high marks for generality; I was impressed by some of the theoretical analyses of various phenomena, finding them insightful and provocative.

Anderson is very much concerned with the problem of evaluating complex theoretical systems like ACT. He asserts, and I agree, that it is not possible to develop direct, decisive tests of such systems. One method of evaluation is to derive models of specific experimental paradigms from the general theory and to compare their predictions with empirical data. In ACT, such a model has two major components: (i) the subject's representation of the materials of the task in long-term memory is described in terms of the propositional network, and (ii) the processes by which the subject performs the task are described as a set of productions. The complete ACT theory, realized as a computer program, can be used to simulate performance. The theory includes activation-rate and storage parameters that would have to be estimated by Monte Carlo methods in order to fit empirical data. Unfortunately, Anderson does not show us any quantitative predictions obtained by simulation from the complete theory (he points out that the necessary Monte Carlo runs would be prohibitively expensive for a simulation program as complex as ACT). His predictions, which are calculated from approximations whose values are determined by the assumed network structure and the activation process defined on the network, are derived by ignoring the interactions and complex dynamics of the complete system. I don't want to leave

the impression that Anderson has not been able to provide strong empirical support for some of the basic mechanisms incorporated in ACT. In particular, I think the results of his fact-retrieval experiments give strong support for the hypothesized network structures and the activation process.

Some positions concerning memory representation that have been advanced with great vigor in recent years have not seemed worth pursuing because their proponents have not yet given us any reasonable explanation of how the proposed representations could be utilized. ACT, with its emphasis on detailed description of processes of utilization, makes a needed contribution to the field.

Anderson's analyses of various experimental paradigms provide another illustration of the utility of his emphasis on process. The production formalism in essence defined a programming language that reminds me of PLANNER or QA4 (D. G. Bobrow and B. Raphael, *Comput. Surv.* 6, 155 [1974]). A model of an experimental paradigm is a program that performs the task. Such programs make explicit the relationships between hypothesized structures and processes and subjects' performance. In addition, the analyses make clear the task-specific components of the psychological processes underlying performance in the particular paradigm.

Finally, some comments about the book itself. As I said earlier, it deals with a wide range of topics, from cognitive psychology and artificial intelligence to automata theory and model-theoretic semantics. Anderson gives his reader a good deal of assistance in detouring around those sections of the book that are not directly relevant to the development of ACT as a psychological theory. However, the reader is going to have to learn a new programming language, the production formalism. A word of warning to those whose knowledge of programming is limited to FORTRAN: All those nested parentheses are significant; you will have to understand what they mean. Here again, Anderson gives the reader a great deal of assistance in understanding the productions that make up a given model. This is a difficult but excellent book. Anderson's proposals concerning the processes that utilize stored knowledge are important developments. I strongly recommend this book to all students of language, memory, and thought.

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## Rain-Forest Prosimians

**Ecology and Behaviour of Nocturnal Primates.** Prosimians of Equatorial West Africa. PIERRE CHARLES-DOMINIQUE. Translated from the French by R. D. Martin. Columbia University Press, New York, 1977. x, 278 pp., illus. \$17.50.

This book is concerned with five little-known sympatric species of nocturnal prosimian primate indigenous to the equatorial rain forest of Central West Africa, one of the most complex of the world's ecosystems. The result of nearly 10 years of meticulous work involving direct observations by means of headlamps, trapping, marking, and releasing, and, more recently, radio-tracking, as well as ingenious experimental interventions under natural conditions, it goes well beyond mere description of behavior and related ecological factors to show how intricately and inextricably behavior and ecology are intertwined.

The species studied are Allen's bushbaby, the needle-clawed bushbaby, the dwarf bushbaby, the potto, and the angwantibo. For each there emerges a detailed picture of food preferences and feeding strategies, locomotor patterns, activity patterns, diurnal sleeping sites and habits, antipredator tactics, and, most important, aspects of social behavior, including complex repertoires of communication, social relationships, and territorial behavior.

The five species occur together in a single, complex ecosystem which contains, in addition, some 120 other mammalian species and well over 200 avian species. In these circumstances the primate species are potentially in competition with each other for space and available food resources. The author presents his subject in such a way as to show clearly how the five species manage to avoid such competition by fine adaptations to niches the others are unable to exploit. Each exploits a "precisely determined spectrum" of food resources in a specific and well-defined biotope. The five species occupy ecological niches not very different from those occupied by the earliest nocturnal primates at the beginning of the Tertiary.

Ecologically speaking the book brings out very clearly the difference between the nocturnal and the diurnal worlds, which require quite different means of, for example, communication and location of food. The author points out the importance of this difference both for the study of the evolution of social behavior and for the interpretation of many other

important biological features that are closely associated with the activity rhythm.

Although more detailed reconstruction of prosimian evolution will depend on synthesis of information from a wider range of biological disciplines, this book clearly demonstrates that detailed study of behavioral and ecological relationships can yield information of great significance for interpreting both the anatomical characteristics of extant species and past evolutionary trends. Although on first sight it might appear to be of interest only to the behavioral primatologist, the book has a far wider appeal. It is a model of behavioral ecology and as such will be welcomed by those interested in the interaction between animals and their environment.

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## Forams

**Recent Foraminifera.** ESTEBAN BOLTOVSKOY and RAMIL WRIGHT. Junk, The Hague, 1976. xviii, 516 pp., illus. Dfl. 125. Revision of *Los Foraminiferos Recientes*.

By virtue of their common occurrence in all marine environments—past and present—the shells of foraminifera have been utilized as stratigraphic and paleoecologic tools in petroleum exploration and, more recently, in the analysis of hundreds of Cenozoic and late Mesozoic sediment cores raised from the ocean basins by the Deep Sea Drilling Project. A foraminiferal organism may be considered to carry a paleobiological message within its shell that awaits decoding by the micropaleontologist, ecologist, cytologist, geochemist, and biochemist.

The results of investigations of Recent foraminifera from these diverse points of view are the subject of Boltovskoy and Wright's timely work, which fills a near-vacuum that exists in this field. Neither a treatise nor a textbook, it is rather a compendium, truly international in scope, of an astonishingly large number (1686) of publications.

The authors succeed in presenting an integrative summary of the burgeoning but widely scattered literature stemming from modern research on both planktonic and benthic foraminifera. They have brought together isolated observations and ideas under a series of wide-ranging headings, albeit the arrangement

is somewhat illogical. The chapters on sample collection and preparation are replete with a vast array of gear and methods, some of historical interest but bewildering to the initiate who is seeking a "standard" instrument or procedure.

The abundance and diversity of benthic foraminifera are clearly apparent from their occurrence in the entire spectrum of marine environments. Many species exhibit a wide range of morphological variability in response to a host of environmental factors, such as temperature, salinity, depth, food, substrate, and pH. The lack of agreement among contemporary workers on a single, world-wide depth zonation also reflects the complex interaction between highly diverse foraminiferal faunas and variable bottom conditions and substrates. Boltovskoy and Wright present tables of generalized depth distribution for 81 genera and of substrate preferences for 68 species, a bold attempt toward a synthesis.

The horizontal and vertical distributions of planktonic foraminifera are discussed succinctly, but the discussion suffers somewhat from a lack of critical assessment. Five schemes of biogeographic zonation are presented without evaluation. The importance of calcium carbonate and foraminiferal solubility on the deep-sea floor is obscured by the listing of incidental descriptive papers, which should have been replaced by a physical-chemical explanation.

Of particular interest are the many new and "forgotten" aspects of the living organism, its cytology, life cycle, symbiotic algae, shell structure and morphological variability, and chemical composition. A surprising omission in the encyclopedic coverage is that of a taxonomic scheme and criteria for identifying the major foraminiferal families and genera, with illustrations of at least the common species. Such information would have been helpful to beginning as well as advanced students in that the reader of the book would not be required to have prior knowledge of foraminiferal classification.

One might criticize some misspellings, omissions of references, the lack of evaluation, and occasional misinterpretations of published results. However, these defects are far outweighed by Boltovskoy and Wright's paramount success in synthesizing the problems and concepts in the mainstream of foraminiferal research.

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## Books Received

**Acoustical Oceanography.** Principles and Applications. Clarence S. Clay and Herman Medwin. Wiley-Interscience, New York, 1977. xx, 544 pp., illus. \$27.50. Ocean Engineering.

**Adult Learning.** Psychological Research and Applications. Michael J. A. Howe, Ed. Wiley, New York, 1977. xviii, 292 pp., illus. \$19.95.

**Air Pollution and Cancer in Man.** Proceedings of a meeting, Hanover, Germany, Oct. 1975. U. Mohr, D. Schmähl, L. Tomatis, and W. Davis, Eds. International Agency for Research on Cancer, Lyon, 1977 (U.S. distributor, WHO Publications Centre USA, Albany, N.Y.). xviii, 332 pp., illus. \$35. IARC Scientific Publications No. 16.

**Alternate States of Consciousness.** Papers from a conference, Apr. 1975. Norman E. Zinberg, Ed. Free Press (Macmillan), New York, and Collier Macmillan, London, 1977. x, 294 pp. \$14.95.

**American Urban Malls.** A Compendium. Roberto Brambilla, Gianni Longo, and Virginia Dzurinko. Institute for Environmental Action, New York, and Columbia University Center for Advanced Research in Urban and Environmental Affairs, New York, 1976 (available from the Superintendent of Documents, Washington, D.C.). xxii, 144 pp., illus. Paper, \$2.10. Footnotes Number Four. Stock No. 023-000-00376-7.

**The Futures Directory.** An International Listing and Description of Organizations and Individuals Active in Future Studies and Long-Range Planning. Compiled by John McHale and Magda Cordell McHale with Guy Streatfeild and Laurence Tobias. IPC Science and Technology Press, Guildford, Surrey, England, and Westview Press, Boulder, Colo., 1977. xii, 396 pp. \$38.50.

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**Growth Kinetics and Biochemical Regulation of Normal and Malignant Cells.** Papers from a symposium, Houston, 1976. Benjamin Drevwinko and Ronald M. Humphrey, Eds. Published for the University of Texas System Cancer Center by Williams and Wilkins, Baltimore, 1977. xxxviii, 900 pp., illus. \$45.95.

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**Introduction to Microprocessors.** D. Aspinall and E. L. Dagless, Eds. Pitman, London, and Academic Press, New York, 1977. viii, 162 pp., illus. Paper, \$9.50.

**Introduction to Semimicro Qualitative Analysis.** C. H. Sorum and J. J. Lagowski. Prentice-Hall, Englewood Cliffs, N.J., ed. 5, 1977. x, 310 pp., illus. Paper, \$8.95.