Book Reviews

A Means toward a New Holism

Systems Theory and Biology. Proceedings of the 3rd Systems Symposium, Cleveland, Ohio, Oct. 1966. M. D. MESAROVIĆ, Ed. Springer-Verlag, New York, 1968. xii + 403 pp., illus. $16.

The volume under review contains a majority of the papers presented at an unusually successful symposium entitled "Systems Approach in Biology." The structure of that symposium, and of the present volume, can best be summed up in the editor's words:

> The Symposium consisted of three parts: The first part was devoted to the basic conceptual question of the relations between systems theory and biology. It was concerned with an overview, and a general assessment of the two fields as they relate to each other. The second part contained critical reviews of some of the principal areas in biology in which the methods and techniques of systems theory have been applied. . . . The third part consisted of contributions considering specific biological problems ranging from the biochemical level up to the level of higher functions of the central nervous system. The objective here was to present problems which are (or could be) attacked via systems theory on different biological levels and in this way to show the fundamental impact which systems theory might have on the biological inquiry. This volume contains the contributions from the first and third part of the Symposium.

The reader will observe that, in addition to the usual didactic and reportorial elements customary at a scientific symposium, there is also a note of apologetics; of being at pains to explain the *relevance* of system-theoretic ideas to the familiar problems of biological activity, presently being probed by so many techniques less foreign to the average biologist. This apologetic note is expressed openly and forcefully in the paper of Mesarović:

> *The fundamental question for the community of biologists is whether an explanation on the systems theoretic basis is acceptable as a true scientific explanation in the biological inquiry.* . . . The dictum that the fact has been established scientifically only if it is based on measurements has to be interpreted to mean that the alternative appearances of the observed attributes have been identified and the relationships between them have been established on a formal, precise, but not necessarily numerical basis. In short, then, the non-numerical models and relations have to acquire equal status with the more classical numerical models and concepts.
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> If the answer to the question of the acceptance of systems-theoretic explanations in biology is in the affirmative (as I contend) then . . . [we will have] a field of *systems biology* with its own identity and in its own right.

There is no doubt that system-theoretic ideas seem somewhat strange, and perhaps just a little frightening, to the present generation of structurally oriented biologists. It is not without irony that these system-theoretic ideas actually mark a return to the holistic, functionally oriented view of organisms entertained by biologists prior to the emergence of biochemistry and molecular biology, a view which was displaced by the rapid growth of these fields. Indeed, the writings of early biochemists display the same defensive and apologetic note, of trying to explain the relevance of slushes and homogenates to the generation of biologists who looked with disdain upon such "worthless artifacts." Nevertheless, as we know, the biochemists ultimately prevailed, because (i) holistic biology could proceed no further with the tools then available to it, and (ii) the explosive development of biochemical techniques (and the reductionist ideas which lay behind them) offered the possibility of acquiring intimate knowledge of biological structures, and a subsequent hope for understanding of all biological activity in satisfying structural terms. Correspondingly, system theory is emerging as a force in modern biology because (i) extremely powerful new formal tools are now available for the study of functional activities (particularly regulation, control, and information processing) and (ii) the limitations of what we can really learn about basic biological problems in purely structural terms are rapidly becoming apparent.

The wealth of material to be found in the present volume should go part of the way toward making system-theoretic concepts, and their utility for understanding of biologically important problems, more accessible to the modern biologist. We are offered treatments of a great number of different kinds of biological systems, in which system techniques are made use of to a greater or lesser degree. These range from purely qualitative discussions of differentation in slime molds (Barbara Wright) and regeneration (Marcus Singer) through a semiqualitative review of control properties in enzymatic networks, particularly those involved in intermediate metabolism (Benno Hess); a number of separate discussions of the adrenocortical system (the most interesting being that of Yates *et al.*), and of the integrative activities of the reticular formation (Scheibel and Scheibel; Kilmer, McCulloch, and Blum). There are general discussions of the role of system theory in biology by a biologist (T. H. Waterman) and by a senior Russian physiologist (P. K. Anokhin). Bridging the gap between these "semiempirical" studies and the purely theoretical papers is a stimulating discussion of levels of explanation (D. F. Bradley). On the theoretical side, we find a discussion of the decomposition of complex systems into simple "goal-seeking" components (Mesarovic), a rather cryptic paper (Krohn, Langer, and Rhodes) dealing essentially with the ways in which state variables may conveniently be chosen so as to have desirable properties, and a brief discussion by Kalman of his important work on the construction of linear dynamical systems which realize a given input-output relation (transfer function). This last paper indicates some of the subtlety of system-theoretic investigations; the concepts of controllability and observability which Kalman has introduced are going to have to become part of the repertoire of system biology.

There are, however, numerous aspects of system theory which are not touched on in the present volume, some of which seem to the reviewer destined to have a major impact on biology, and on science at large. For one thing, system theory has an *introspective* character which is lacking in purely structural sciences. Thus, for example, the relation between system biology and purely structural, metric biology is legitimately part of system theory, and not of structural biology. Since system theory deals with *classes* of systems (the elements of such a class being *analogous* in that they all

share the same dynamic and organizational character but in general are totally diverse in physical structure), the possibility arises of realizing a particular functional system in a wide variety of different physical ways; this is touched on in the paper of Kalman mentioned above. Thus we may ask whether a biologically interesting system may be physically realized in ways different from the ordinary; for example, in engineering terms (bearing on bionics and biomedical engineering), in terms of different chemistry and energetics (bearing on exobiology), or in simpler terms than are currently known (bearing on origin of life). On a less speculative level, even quite simple system-theoretic considerations can demonstrate the pitfalls into which one may stumble in attempting to make simplistic identifications of functional units with the structural units we find it convenient to observe and measure. Finally, system-theoretic concepts will doubtless play a major role in the conceptual unification of theoretical biology, in a way analogous to, for example, the role played by variational principles in the conceptual unification of theoretical physics.

In all, there seems little doubt that system-theoretic concepts are destined to play a dominant role in future biological developments. Therefore it is important for biologists to have the opportunity to acquaint themselves with these concepts and with what they can do. Volumes like the one under review will do a great deal to make this possible.

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Indian Art, Early and Modern

American Indian Painting of the Southwest and Plains Areas. DOROTHY DUNN. University of New Mexico Press, Albuquerque, 1968. xxviii + 429 pp., illus. $25.

Dorothy Dunn's association with American Indians began when she established an experimental art class in the Santa Fe Indian School in the early 1930's and has continued to the present day. Her long contact with American Indian artists and arts has enabled her to write with understanding and appreciation, tracing the traditional bases of American Indian motifs and style from pre-Columbian times to the present. *American Indian Painting* is thus not only an art book but also, to a considerable degree, a culture history of the Southwestern and Plains Indians. As such it will have wide appeal.

The author's objective, to analyze modern Indian painting in light of Indian cultural heritage and ideology, has been effectively furthered by 33 color plates and 124 black-and-white figures of American Indian paintings. The color illustrations are published for the first time, and they are an impressive and interesting collection. For a book of this price the quality of the color reproduction is disappointing, however; one would expect better definition. It would also be desirable to indicate the size of the originals. Statements of original size are standard in any art book, and the omission here is puzzling and irritating since some of the reproductions are of murals and some are of much smaller paintings, but all are reduced to the same page size.

The book has two major divisions, pre-modern and modern painting, with "modern" being roughly defined as post-1885. The first section, dealing with the earlier art, presents historical and archeological data as well as some general statements on primitive art. The second section is more autobiographical, treating in large part of persons and events of which the author has had personal knowledge, and the material is handled with an enthusiasm that comes from personal involvement over a span of many years. Although the book will appeal to intelligent laymen, as well as to students and professionals, in its entirety, I found the last half more interesting and valuable, offering esthetic analysis and description of modern Indian art and some partial biographies of Indian artists, all unavailable elsewhere. For those interested in further study, there is a bibliography of 604 items (from which there is a surprising omission of *Indian Art in America* by Frederick Dockstader and *Southwest Indian Painting* by Clara Lee Tanner, both of which ought to have been cited if only as additional sources of reproductions). There is no other book with the scope of this one, and it is unlikely that it will have a rival in the near future.

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Ciphers and Deciphering

The Codebreakers. The Story of Secret Writing. DAVID KAHN. Weidenfeld and Nicolson, London; Macmillan, New York, 1967. xviii + 1164 pp., illus. $14.95.

Cryptology, the art and science of secret writing, encompasses two reciprocal aims. Cryptography strives to conceal the meaning of a message by rendering the text unintelligible to outsiders. Cryptanalysis endeavors to obtain both the original text of the message and the method of encipherment that was used. In this long, rambling volume, Kahn presents a panoramic history of cryptology, beginning with an incident mentioned by Homer in the *Iliad*, progressing through the early developments of the Middle Ages and the surprisingly sophisticated era of the late Renaissance to the black chambers of 19th-century Europe, and continuing to the present day. He also discusses in great detail a number of paracryptological topics—from the decipherment of the Rosetta stone in 1822 by Jean-François Champollion and of Minoan Linear B by Michael Ventris in 1952 to methods that might be used to communicate with other planets inhabited by intelligent beings. In addition there is a delightful chapter about the various attempts that have been made to find ciphers within the Shakespearean plays that would prove they were written by Francis Bacon. The story of William and Elizabeth Friedman's refutation (for which they won the Folger Shakespeare Library Literature Prize in 1955) proving that the plays were written by Theodore Roosevelt is alone worth the price of the book.

Most important advances in cryptology have been brought about in time of war, when the vast increase in communications is coupled with an intense need for secrecy. Indeed, a large portion of this book is devoted to the cryptanalytic successes and failures of the combatants in the major wars of the last 250 years. Although Kahn is careful to point out that cryptanalysis is only one form of intelligence gathering and that intelligence is only one weapon in the arsenal of war, he makes a good case for the overriding importance of communications security. He pays particular attention to the dramatic events leading up to the attack on Pearl Harbor in 1941. It is by now well known that American naval intelligence had succeeded in breaking virtually every Japanese cryptographic system in the prewar years and was able to read