

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.

ROBERT ROSEN

Departments of Biophysics and Mathematics, State University of New York at Buffalo, Amherst

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.

MERWYN S. GARBARINO

Department of Anthropology, University of Illinois at Chicago Circle, Chicago

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

Japanese communications about as fast as the Japanese themselves could. Although circumstances made it impossible to prevent or even attenuate the raid on Pearl Harbor, communications intelligence played a major role throughout the Pacific war. Admiral Chester Nimitz has described the battle of Midway Island as "essentially a victory of intelligence."

A long chapter is devoted to the National Security Agency and the current status of American cryptology. Kahn states that his manuscript was submitted to the Department of Defense before publication. I imagine that many people will be surprised at the amount of information he has been able to amass about this supersecret and hypersensitive branch of government. Much of it undoubtedly comes from the 90-minute press conference held in Moscow by W. H. Martin and B. F. Mitchell, NSA employees who defected to Russia in 1960. But much information is of a more recent vintage, and it is an interesting speculation how he came by it. Kahn also discusses the morality of cryptanalysis and the need for congressional surveillance of even the most secret government activities.

Only within the last 50 years could cryptology properly be called a science. The large number of distinguished mathematicians, here and abroad, who have made significant contributions in recent years to cryptology in general and cryptanalysis in particular attests to the changing nature of the subject. With the advent of large computers and delicate statistical tests to find hidden patterns submerged in a seemingly formless sea of cipher text, the need for intuition and inspiration has diminished, though not completely disappeared. In at least one college in the United States a course in cryptanalysis has been offered within the regular curriculum of the mathematics department.

But in no sense is this book a text. The weaknesses and strengths of numerous cryptological systems (including one that when properly used cannot be broken—the so-called one-time key) are fully described, and some cryptanalytic methods are mentioned though only sketchily illustrated. The reader who overcomes the temptation to skim over the more technical pages in favor of the abundant anecdotal material will certainly gain an understanding of the basic laws of cryptography. However, it is much more difficult to appreciate the subtleties (as either an art or a science) of cryptanalysis with-

out actually doing some. And the author does not provide the reader with an opportunity to get his hands dirty. He does, however, mention several elementary texts on cryptanalysis which are currently in print, including at least one in English (Helen F. Gaines, *Elementary Cryptanalysis*, 1939, reprinted as *Cryptanalysis*, Dover, 1956). For someone whose interest in cryptology is of a more passive nature, this book will provide many hours of pleasant reading.

MARTIN H. PEARL

*Department of Mathematics,
University of Maryland, College Park*

Practical Lore for Biologists

Methods in Developmental Biology. FRED H. WILT and NORMAN K. WESSELLS, Eds. Crowell, New York, 1967. xvi + 813 pp., illus. \$18.

The Materials and Methods section of the ordinary biological paper skims over the surface of a vast submerged mass of practical knowledge (not to mention belief, fashion, ritual, and magic) which is transmitted between practitioners mainly by apprenticeship, demonstration, and conversation. It can be troublesome for the outsider to break into such a predominantly oral tradition, and the publication of this volume of the practical lore of developmental biology comes at an opportune time. So many scientists from outside the subject are becoming attracted by its outstanding intellectual problems, and so many already at work in one of its branches are feeling the need to diversify their techniques. The 51 chapters of the book will give them a panorama of what can be done, and often in full detail exactly how to do it.

Many years ago a worried physicist, setting out to revolutionize biology (which he soon did), asked me to join his group as resident biologist with the anguished cry: "We've just got to have someone who can go out and catch the frogs." The role accorded the biologist lacked adequate dignity, but the problem expressed, how to choose, obtain, nurture, and prepare suitable living material so that the experiment may actually begin, can be formidable to the uninitiated. Nearly half the present volume is rightly given to the husbandry of the organisms, both plants and animals, that are known to be convenient for developmental studies.

Developmental biology is concerned with systems that are interacting in-

tensely at the cellular level, and, since so much analysis of this remains to be done, techniques of isolating and transposing cells and populations of cells by dissociation, culture, or grafting are of fundamental importance. A major section of the book covers such methods. In addition, plant growth substances (over a quarter of the book is devoted to plants), cell marking, nuclear transplantation, and miniaturized surgery have one or more chapters each. There are also important articles on the solution of the special problems posed by small size, by yoliness, and by other peculiarities of embryonic material, when one applies such standard procedures as the separation of cell organelles from homogenates, chemical determinations, or electron microscopy. But it is of course impossible to indicate the wealth of topics treated systematically or incidentally. The index, so important for a work of this kind, is efficient, averaging about 50 entries per article.

The editors have drawn from their contributors, many of whom are known as fastidious technicians, a rich output of experience, and they have tied it together with a valuable amount of cross-referencing between articles. They have taken the editorial task seriously. The practice of developmental biology will for a long time be in their debt.

MICHAEL ABERCROMBIE

*Department of Zoology,
University College, London*

Biological Phenomenon

The Contractile Process. Proceedings of a symposium sponsored by the New York Heart Association. Little, Brown, Boston, 1967. xii + 299 pp., illus. \$7. Also published as a supplement to the *Journal of General Physiology*, Vol. 50, No. 6, Part 2, 1967.

This symposium was organized into four sessions dealing in turn with the contractile process in macromolecules (two papers), the contractile process in striated muscle (three papers), comparative aspects of muscular contraction (five papers), and contractile processes in nonmuscular systems (three papers). The value of the published proceedings is greatly enhanced by the well-edited discussions following the papers and by a carefully prepared index.

The papers fall into two classes: one consists of reports of research unpublished at the time of, but largely pub-