

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