Zoosemiotics: Juncture of Semiotics and the Biological Study of Behavior

A very rapidly expanding behavioral science has lately crystallized at the intersection of semiotics, the general theory of signs, and ethology, the biological study of behavior. Its subject matter is the ways whereby animals communicate with each other, a full understanding of which requires the cooperative attack of an exceptionally wide variety of scientific disciplines ranging from bioacoustics and biochemistry through anatomy to sensory physiology and neurophysiology, and from comparative psychology and zoology to anthropology and linguistics. In my own work, I have chosen to call this field "zoosemiotics," partly to avoid using an unwieldy phrase where a single term will do, but more positively, to emphasize its necessary dependency on a science which deals, broadly, with coding of information in cybernetic control processes and the consequences that are imposed by this categorization where a living animal is the transcoder in a biological version of the traditional information-theory circuit.

Animal Communication [Blaisdell (Ginn), New York, 1964. 216 pp. $2.50], by Hubert Frings and Mable Frings, is the first book-length appraisal of what is known about this emerging "formal entity in science," of which "even the definition and limits . . . are still uncertain" published since F. Kainz's compendium *Die "Sprache" der Tiere* (1961). Kainz is a Viennese philosopher whose monograph constituted a neat and serviceable terminal point of the classical period of animal communication research that began with Darwin's *The Expression of the Emotions in Man and Animals* (1872); it was at once a technical survey of pertinent theoretical considerations and a recital of facts as they appeared and could be evaluated toward the end of the last decade. By contrast, the Frings's book, which "is intended primarily for nonspecialists," reflects the authors' zoological training. Hubert Frings, who serves as General Secretary of the International Committee on Biological Acoustics, has previously published, with his wife Mable, a useful bibliography of sound production and sound reception by insects (1960), and the two of them have shared in a number of ingenious experiments involving communication signals in starlings, the herring gull, and species of crows.

There are both practical and fundamental reasons why scientists study animal communication systems, but a concerted exploitation of these mechanisms for the benefit of man remains a task for the future. Accordingly, the authors devote only one chapter out of 11 to utilitarian applications: in wildlife management, agriculture, and pest control; to supplement existing human information-handling devices; and in bionics, a term that designates efforts to convert living systems into mechanical and electrical analogues. Our knowledge of basic zoosemiotic processes is so rudimentary that, at this stage, the possibilities for practical uses can be but dimly perceived; for the would-be biological engineer, research in this area "should offer intellectual adventure of the highest order" in the not too distant future, yet his current attempts are also of value in that these may "catalyze an interest in pure research. . . ." The ultimate goal of zoologists is simply to understand animals better: are animals totally predictable machines, or are they complex organisms with elements of indeterminacy, especially in the central nervous system of the receiver of a signal? Linguists and psycholinguists who are concerned with animal communication are interested chiefly in disclosing the biological origins of human communication. They seek answers to particular questions such as these: what are the anatomical and physiological correlates of verbal behavior and what sensory and cognitive specializations are required for language perception; what motivates the onset and accomplishment of language learning in the development of infants; why do subhuman forms lack the capacity to acquire even the beginnings of language; how can present evolutionary theory account for the uniqueness of both form and behavior of language specialization in man; and what is the genetic basis for language propensity, man's species-specific biological endowment? This book offers no solutions, of course, but only some helpful signposts for the tyro traveler.

In their introduction, the authors grapple to define communication but arbitrarily limit the notion to relationships among members of the same species, a restriction they later partially abandon. They next survey the sensory channels used by animals, with vivid illustrations from the tactile, chemical, optical, and acoustical modalities, a subject that has recently been expounded, in more detail, in at least two other popular books: *The Senses of Animals and Men* (1962), by L. Milne and M. Milne, and *The Senses of Animals* (1963), by L. H. Matthews and M. Knight. The authors then discuss the two principal methods used in studying animal behavior: observation—of the sender, the message, and the receiver—and experiment—the use of synthetic signals, or of decoys, the alteration of structures or interference with the activities of senders and receivers, and still more elaborate laboratory procedures. (This might have been an appropriate context in which to allude to biotelemetric techniques that are increasingly employed in studies not only of animal physiology, but also of animal tracking, orientation, and ecology, and indeed, of social behavior.)

Most of the remainder of the book is devoted to what has actually been discovered about animal communication, which is not very much, especially when one considers the multiplicity of species—some 700,000 of them—left to study. In chapters 4 through 8, the material is organized and presented with explicit references to the users of the code, and by an analysis of the assumed designata of the displays. Approaches formulated thus in pragmatic and semantic terms,

rather than in terms of the syntactic properties of codes and messages, may be convenient now but are likely to be provisional.

Chapter 4 deals with species identification in aggregational systems (cellular, sessile, mobile, social, and interspecific) and dispersal systems (ritualized fighting, aggressive displays, and territorial behavior). Chapter 5 is devoted to social cooperation, involving such items of information as alarm signals (subclassified here as indicators of departure, distress, warning, and the like) and food signals; it also contains a summary of what is known about the chemical guidance system of ants and the dances of the honeybee, but there is no mention of information transmission in the honeybee by means of sound, certain uses of which have been amply demonstrated by H. Esch and by A. M. Wenner.

In chapter 6, the authors take up, channel-by-channel, signals involved in sexual attraction and recognition, remarking somewhat enigmatically that, "In these processes, communication reaches its highest development." In the next two chapters, they briefly consider signals to further courtship and mating in such taxa as annelids, molluscs, crabs, scorpions, insects, and several vertebrates, and in a lengthier excursus, displays used by spiders; then they take up some of the ways in which parent-young relationships entail communication.

Under the heading "Sources of error in animal communication," the authors discuss the development of dialects and of cross-reactivity, by which they mean the development of reactions by a receiver to signals other than those appropriate to the species for the temporal and spatial context in which they are observed. These are fascinating topics that yield different results depending on whether the problem of efficiency is approached from the point of view of the encoder's or the decoder's ensemble. In the human situation, for example, an individual is often capable of decoding more than one dialect of a language, but his capacity to encode is more likely to be limited to just one.

A sketchy outline of evolutionary theory leads to pertinent observations about the evolution of communication and reassertion of the ethological hypothesis that "communication signals usually originate as modified intention movements." The authors' intimations concerning the differences between human and animal communication underline the urgent need for a fresh approach, cutting across established academic disciplines, to the meaningful problems of zoosemiotics.

The value of this splendid little book is enhanced by nine pages of selected references, an index table of animal groups and systems of communication classified by function, and an index of subjects and names. There are also 24 illustrations, mostly line drawings.

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Plasma Physics

Plasma Kinetic Theory. D. C. Montgomery and D. A. Tidman. McGraw-Hill, New York, 1964. xii + 293 pp. Illus. $11.50.

This monograph is intended for the serious student or researcher in plasma physics and will serve as an excellent introduction to the subject for the student who is well grounded in the classical kinetic theory of neutral particles and the basic mathematics of theoretical physics. The authors do not pretend to discuss every topic that could conceivably be included under the title, but instead expend their energies and pages trying to give the reader a deeper understanding of some of the most widely discussed (and often, therefore, the most widely misunderstood) problems in the field. They make a great effort to point out which parts of the treatments must be taken as assumptions; then they try to give the reader a feeling for which assumptions are reasonable and which are made out of mathematical necessity rather than on the basis of well-founded physical facts. The authors apologize for their lack of emphasis on experiments, but continually demonstrate their awareness of the "unfortunate separation" between the theories of highly idealized models and experiments on extremely complicated natural or laboratory systems. Whenever they can, they point out paths that may eventually provide links between the two.

The book is arranged in three parts. In the first the authors discuss the aims and limitations of classical kinetic theory, beginning with an heuristic derivation of the Boltzmann equation, description of attempts to apply it to plasmas, and discussion of the Fokker-Planck equation. The BBGKY approach to kinetic theory and discussion of the Vlasov equation, the adiabatic assumption, the Balescu-Lenard equation, and statistical fluctuations in plasmas are presented in part 2. In part 3 the authors apply the formalisms to some wave and nonlinear phenomena, discuss attempts at fluid dynamic descriptions of plasmas, and treat certain radiation and electromagnetic wave scattering problems. The final chapter is reserved for comments on three experiments that the authors feel offer promise of bridging the "unfortunate separation"—the positive ion electrostatic oscillation experiments, the observations of incoherent backscatter from the ionosphere, and the computer "experiments" with simplified models of plasmas.

In my opinion, the book will prove quite useful to the student and to the researcher, both of whom should be much concerned with understanding the present state of plasma kinetic theory, particularly its limitations and weaknesses, and its relation to experiments.

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Chemical Engineering

Advances in Heat Transfer. vol. 1. Thomas F. Irvine, Jr., and James P. Harnett, Eds. Academic Press, New York, 1964. xi + 459 pp. Illus. $16.

The editors of this compilation of reviews of the current literature in six areas of heat transfer research have, for the most part, selected interesting and timely topics that should be of interest to those working in related areas as well as to the heat transfer specialist.

The sections on thermal radiation and electric and magnetic effects on heat transfer to electrically conducting fluids are novel and well done, while Luikov's review of heat and mass transfer in capillary porous bodies brings a large amount of Russian work to the attention of the English-speaking