foundly different from animals. Common experience tells us that in the world as we know it all human beings have language, no animals do. But it is easy to be blind to the special circumstances that bring about the seemingly god-given division between men and animals. It is not god-given, not even to the extent that god works through our genes: it is a product in large part of human culture. Take away culture, take away the privileges of human education, and man's mind, like his naked body, is not so different from an ape's. A man will not learn to speak unless he has been spoken to.

The corollary is shockingly simple: expose an ape's mind to human culture and it may begin to take on human qualities. Speak to an ape in the right way and perhaps it will speak back.

Yet the reality of the ape-to-human transformation continues to prove startling, as much to the chimpanzees' teachers as to the rest of us who read of their experiments. Even now, with the evidence of their own and the Gardners' success before their eyes, Premack and Rumbaugh express in their books astonishment at what they themselves have revealed. The folded paper flower has lain in the cupboard all these years: place it in a glass of water and it blossoms.

Premack's book provides a detailed history of his work with Sarah, corroborated by the evidence obtained with three less gifted chimpanzees. The focus of the book is on the development of a "reading" and "writing" system based on the use of plastic symbols stuck to a board; the author also describes important experiments, using more conventional techniques, designed to probe the ways in which chimpanzees conceptualize the world around them. The book edited by Rumbaugh reports the findings of the LANA project (LANA is an acronym for LANguage Analogue Project as well as the name of a young chimpanzee), whose aim was to develop a computer-based language system in which messages, formed as strings of ideograms, could be typed on a keyboard and read from a visual display.

In many respects the two books cover similar ground: both report an intensive study of a single chimpanzee that has been taught to communicate with human beings through the medium of an "artificial" visual language. Yet the two projects and the books describing them each have a very different feel. Premack's approach was from the start idiosyncratic and opportunistic—he followed his nose where the scent for a good problem led him. The LANA project, begun a few years later, was much more carefully planned. It was conceived as a piece of collaborative research bringing together the skills of linguists, computer programmers, and comparative psychologists in an attempt to provide optimum conditions for promoting linguistic interchange and for recording what occurred.

Anyone who finds both books on his desk and like me is inclined to taste the juicier-looking morsel first will probably turn first to Premack. A book called *Intelligence in Ape and Man*, written by a single author, promises to be more entertaining than a compilation of papers called *Language Learning by a Chimpanzee*. Such an assessment would be quite mistaken. While the story Premack tells is extraordinarily interesting he has not in fact succeeded in writing a good book. The book is unnecessarily wordy and its argument is in places hard to follow: too many raw data (ten trials on this problem, twelve trials on that), too much space given to inconclusive anecdotes, too much spoon-fed and sometimes almost force-fed interpretation. Given that so much of Premack's material is gold it is a pity that he has allowed himself to contaminate it with such a lot of baser metal. Many readers may be tempted to give up through sheer exhaustion. And if they continue to the end they may begin to suspect that the author himself has never read his book from cover to cover: I was a bit depressed to find the very same sentences repeated word for word on, for example, pp. 132 and 353.

It was with some relief that I turned to Rumbaugh's volume. Here, from the opening chapter onward, one is in a world not only of adventure but of careful scholarship. Whereas I had felt hustled by Premack, I now found myself being willingly seduced. The book develops as the project did, through a historical survey of theories about the origin of human language, followed by discussion of the meaning of communication and of the previously known potential of the ape, then on to an account of the "Yerkish" language with details of the computer programs and training methods; and so to the chimpanzee's linguistic achievements—including details of conversations, both spontaneous and manipulated, her system of color naming, and her elementary counting skills. The book, which is written as a series of essays by Rumbaugh and his colleagues, is as a whole fluent and rounded. The unity of purpose and thinking that characterizes the separate contributions must, I suspect, have been present in the day-to-day running of the project and have been responsible in large measure for its success.

The chimpanzee has been taught to use a verbal language. That fact in itself is remarkable. But if that was all there was to it the chimpanzee's achievement would stand as a fact to be recorded in the *Guinness Book of World Records* rather than as a major contribution to natural science. The real promise of these experiments lies in what they will tell—the chimpanzee itself will tell—about its conceptual model of the outside world. Through the use of symbolic forms the chimpanzee has been induced, albeit in a limited way, to give public expression to its thought processes—to reveal how it categorizes objects, how it perceives relations between events in space and time, how it thinks of agency and causation, how it conceives of its own body. Both Premack and Rumbaugh believe that the conceptual system they are beginning to uncover is essentially prelinguistic. The chimpanzee does not—as yet—"think in words" but rather uses language as a means of creating a symbolic map of the ideas that are already in its mind. The implications for understanding human preverbal and nonverbal thinking are profound.

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Comparative Studies

Evolution of Brain and Behavior in Vertebrates. Papers from a conference, Tallahassee, Fla., Feb. 1973. R. B. MASTERTON, C. B. G. CAMPBELL, M. E. BITTERMAN, and NICHOLAS HOTTON, Eds. Erlbaum, Hillsdale, N.J., 1976 (distributor, Halsted [Wiley], New York). xiv, 482 pp., illus. $29.95.

Evolution, Brain, and Behavior. Persistent Problems. R. B. MASTERTON, WILLIAM HODOS, and HARRY JERISON, Eds. Erlbaum, Hillsdale, N.J., 1976 (distributor, Halsted [Wiley], New York). x, 276 pp., illus. $14.95.

Although the fields of paleontology, comparative neurology, and comparative psychology have much to learn from one another, there has been far too little fruitful interaction. This pair of volumes should stimulate such interaction. Although most of the papers they include relate strongly to one of the three disciplines, the individual authors are clearly aware of the contributions of the other fields, and the papers are written for readers outside their authors' specialties. The first volume has four chapters on the origins and radiations of vertebrates, seven chapters on comparative anatomy, and eight chapters on learning, sensory abilities, and other aspects of behavior. The shorter, more theoretical second vol-

ume has four chapters dealing with the comparative method, three chapters on brain evolution, one chapter on the availability of various species of fish for research, and six chapters considering the persistent issue of the use of the terms homology, analogy, and homoplasy. Its final two chapters take up the difficult tasks of placing human language in an evolutionary perspective and relating invertebrate "intelligence" to vertebrate capabilities. In general, although there are a few chapters that are only superficially related to the main theme, the separate discussions coalesce into an interesting, informative, and useful survey of major theoretical positions and recent developments having to do with the behavioral manifestations of brain evolution.

One of the goals of the editors and contributors was to update the outstanding earlier volume on the same subject, *Behavior and Evolution*, edited by Roe and Simpson and published in 1958. The period between the Roe and Simpson volume and the present volumes has seen unprecedented development and progress in comparative neuroanatomy. As a result of the application of new and powerful anatomical and electrophysiological techniques long-standing basic concepts in the field have been challenged, in particular some that stemmed from the failure of early anatomical methods to reveal certain brain connections in nonmammals. For example, lack of evidence for thalamocortical connections led to the view that neocortex is phylogenetically "new" and restricted to mammals. The forebrains of nonmammals were also incorrectly thought to lack the somatic, auditory, and visual inputs that so clearly dominate the mammalian forebrain. Improved techniques have now demonstrated both sensory input from the major modalities to the forebrain and thalamocortical connections identifying "neocortex" in many nonmammals. In the first of these volumes the changes in outlook necessitated by these findings are discussed in chapters by S. Ebbesson and R. G. Northcutt on the brains of fish and amphibians and by F. Ebner comparing forebrain organization in reptiles and mammals. Similarly, C. B. G. Campbell, in a review of recent findings in primates, points out that new evidence contradicts the long-held view that primary sensory areas of neocortex neither send nor receive long corticocortical connections. In the same chapter, Campbell notes that primate brains are characterized by an increase in the extent and number of subdivisions of neocortex devoted to vision.

The major outlines of vertebrate evolution are reviewed by N. Hotton III and to some extent by others. Although M. McKenna contributes to the volumes, unfortunately he does not present his important revision of mammalian phylogeny here. Deductions about brain evolution from fossilized endocranial casts are presented by L. Radinsky in the first volume and by H. Jerison in the second. The information contained in endocasts is quite limited, especially for early vertebrates, where endocasts do not accurately indicate the shape and size of the brain. The material has been put to good use, however, and it has been possible to outline the time course of increases in relative brain size and to infer certain specializations by comparing features of the brain surface preserved in endocasts with similar features of demonstrated significance in extant mammals. A difficulty with the first volume is that the chapters on behavior do not satisfactorily relate to the diversity or the divergences of vertebrates and vertebrate brains. The discussions of animal learning, while dealing with issues that are important in themselves, are disappointing from the point of view of evolution.

Other chapters in the first volume caught my interest for a variety of reasons. A lengthy chapter by W. Welker includes an overview of basic concepts of neuroscience, as well as a catalog of types of mammalian forebrain specializations. An engrossing discussion by E. Wever of the origin and evolution of the inner ear includes both prevailing theories and arguments against them. A chapter on the eye by M. Glickstein includes such unusual tidbits as the observation that the ganglion cells of the retinas of elephants are of enormous size. Also, many will find the survey of primate tool use by J. M. Warren of interest, even though the discussion does not relate to evolution.

Much of the second volume is occupied by engaging, sometimes redundant, and occasionally conflicting discussions of the concepts of homology, analogy, and homoplasy. Of particular interest are chapters on homology and the evolution of behavior by W. Hodos and on homology and the nervous system by Campbell. The reader should, however, start with the clarifying chapter by J. Hailman, which classifies and evaluates various current issues and concludes that it is most logical to define homology as denoting common ancestry, analogy as common function, and homoplasy as common appearance. Hailman also defends, correctly in my opinion, the practice of homologizing behavior. He argues that the criteria of homology can, in principle, be applied equally to behavior and morphological structure, an argument reminiscent of Darwin's equal treatment of behavior and corporal structure. Finally, other chapters by Hailman and by Campbell, one a short essay on the comparative study of behavior and the other a discussion of the rationale for choosing particular species for comparative studies, deal with basic concepts that should be much more widely understood. It is to be hoped that these chapters will find their way onto reading lists for students in biology, psychology, and the neurosciences.

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The Play by Nature

The Selfish Gene. RICHARD DAWKINS. Oxford University Press, New York, 1976. xiv, 224 pp. $8.95.

This book should be read, can be read, by almost everyone. It describes with great skill a new face of the theory of evolution. With much of the light, unencumbered style that has lately sold new and sometimes erroneous biology to the public, it is, in my opinion, a more serious achievement. It succeeds in the seemingly impossible task of using simple, untechnical English to present some rather recondite and quasi-mathematical themes of recent evolutionary thought. Seen through this book in their broad perspective at last, these will surprise and refresh even many research biologists who might have supposed themselves already in the know. At least, so they surprised this reviewer. Yet, to repeat, the book remains easily readable by anyone with the least grounding in science.

Even without intention to be snobbish, reading a popular book in a field close to one's research interests almost forces one to tally errors: this example misapplied, that point left ambiguous, that idea wrong, abandoned years ago. This book had an almost clean sheet from me. This is not to say that there are no probable errors—that could hardly be the case in a work where speculation is, in a sense, the stock in trade—but its biology as a whole is firmly the right way up and its