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

questionable statements are at least undogmatic. The author's modest assessment of his own ideas tends to disarm criticism, and here and there the reader finds himself flattered by a suggestion that he should work out a better model if he doesn't like the one given. That such an invitation can be made seriously in a popular book vividly reflects the newness of the subject matter. Strangely, there are indeed possibilities that simple ideas as yet untested may shortly resolve some old puzzles of evolution.

What, then, is this new face of evolution? To a certain extent it is like a new interpretation of Shakespeare: it was all in the script but somehow it passed unseen. I should add, however, that the new view in question was latent not so much in Darwin's script of evolution as in nature's and that our lapse of attention is more on the scale of 20 years than of a hundred. Dawkins starts, for example, from those variable helical molecules that we now know fairly well; Darwin knew not even about chromosomes or their strange dance in the sexual process. But even 20 years is quite long enough to cause surprise.

The first chapter broadly characterizes the phenomena the book seeks to explain and shows their philosophical and practical importance to human life. Some intriguing and alarming animal examples catch our attention. The second chapter goes back to the first replicators in their primeval soup. We see these multiply and elaborate. They begin to compete for substrates, to fight, even to lyse and eat one another; they hide themselves and their gains and weapons in defensive stockades; these come to be used for shelter not only from the tactics of rivals and predators but from the physical hardships of the environments that the replicators are increasingly enabled to invade. Thus they mobilize, settle, throw up bizarre farms, pour over the beaches, across land, and right on to deserts and eternal snows. Between such frontiers, beyond which, for long, life cannot go, the soup is poured and repoured millions of times over into an ever-stranger diversity of molds; at length it is poured into ant and elephant, mandrill and man. This second chapter concludes, concerning some ultimate descendant coalitions of these ancient replicators: "Their preservation is the ultimate rationale of our existence. . . . Now they go by the name of genes and we are their survival machines."

Forceful and provocative, the reader may think, but is it very new? Well, so far perhaps not, but of course evolution has not ended with our bodies. More important still, the techniques of survival in a crowded world turn out to be unexpectedly subtle, much more subtle than biologists were prepared to envisage under the old, departing paradigm of adaptation for the benefit of the species. It is this subtlety, roughly, that is the theme of the rest of the book. Take a simple example, birdsong. It seems a very inefficient arrangment: a naive materialist looking for the techniques by which a species of *Turdus* survives hard winters, food shortages, and the like might well find the flamboyant singing of its males as improbable as ectoplasm at a seance. (On further thought he might find the fact that the species has males at all equally improbable, and this indeed is another major topic of the book: as with that of birdsong, the function of sex has been rationalized much too facilely in the past.) Yet within any bird species a whole team of replicators has concerned itself to lay down an elaborate outline for this performance. Somewhere Dawkins cites the even more extraordinary song of the humpback whale, which may make itself heard over a whole ocean; but of this song we know even less than with *Turdus* what it is about and to whom directed. So far as the evidence goes it might actually *be* an anthem for cetacean unity against mankind—perhaps well for whales if it were. Of course, it is other teams of teams of replicators that now turn out symphony concerts. And these certainly do sometimes cross oceans—by reflection from bodies in space which themselves were made and orbited according to plans from even more complex teams. What conjurers do with mirrors is nothing to what nature, if Dawkins is right, does with no more promising a starting material than congealed primeval soup. It will serve to characterize the new look that biology has in this and some other recent books (such as E. O. Wilson's *Sociobiology*) to say that it shines with a hope that these farthest extensions of life may soon fit more comprehensibly, in essence if not in some details (religious persons and Neo-Marxists may reverse that phrase if it suits them better), into a general pattern that includes the simplest cell wall, the simplest multicell body, and the blackbird's song.

The impression should be avoided, however, that this book is some sort of layman's or poor man's *Sociobiology*. First, it has many original ideas, and second, it counterweights a certain imbalance in Wilson's massive tome by strongly emphasizing the game-theoretic aspect of social behavior, which Wilson hardly mentioned. "Game-theoretic" is not quite the right word, especially in the context of lower levels of social evolution, since the genes themselves don't rationalize about their methods of operation; nevertheless, it has become clear that at all levels there are useful similarities between the conceptual structures of game theory and those of social evolution. The cross-fertilization implied here is new and is still in progress: only recently, for example, I learned that game theory had already given a name ("Nash equilibrium") to a concept that corresponds roughly to the "evolutionarily stable strategy." Dawkins rightly treats the idea of evolutionary stability as all-important for his new overview of social biology. The gamelike element in social behavior and social adaptation comes from the dependence, in any social situation, of the success of one individual's strategy on the strategies used by his or her interactants. The pursuit of adaptation that gets the most out of a given situation regardless of the overall good can lead to some very surprising results. Who would have supposed, for example, that the weighty matter of why in fish, contrary to the case in most other animals, it is the male that usually guards the eggs and young if either sex does, might depend on such a trivial detail as which sex is constrained to release its gametes into the water first? Yet Dawkins and a coworker, pursuing an idea of R. L. Trivers's, have made a fair case that such a detail of timing, even if a matter of seconds, could be crucial for the whole phenomenon. Again, would we not expect that females of monogamous birds, blessed with the help of a mate, would lay larger clutches than females of polygamous species? Actually the reverse is true. Dawkins, in his somewhat alarming chapter on the "battle of the sexes," applies once more the idea of stability against exploitation (by the male in this case) and suddenly makes this odd correlation seem natural. His idea, like most of his others, remains unproven, and there may well be other, more weighty reasons; but the ones he gives, which are seen so easily from his new vantage point, demand notice.

In a textbook of game theory one sees no more of games than one sees of circles and triangles in a textbook of modern geometry. At a glance all is just algebra: game theory is a technical subject from the start. Thus it is certainly a literary feat to convey as much as this book does of even the outward feel and quality, let alone inward details, of game-theoretic situations without recourse to formulas. R. A. Fisher in his introduction to his great book on evolution wrote, "No

efforts of mine could avail to make the book easy reading." In that book, under a rain of formulas and of sentences as profound as terse, the reader is soon battered into acquiescence. Having read *The Selfish Gene* I now feel that Fisher could have done better, although, admittedly, he would have had to write a different kind of book. It looks as though even the formative ideas of classical population genetics could have been made much more interesting in ordinary prose than they ever were. (Indeed, Haldane did manage somewhat better than Fisher in this, but was less profound.) But what is really remarkable is how much of the rather tedious mathematics that comes in the mainstream of population genetics following the lead of Wright, Fisher, and Haldane can be bypassed in the new, more social approach to the facts of life. I was rather surprised to find Dawkins sharing my assessment of Fisher as "the greatest biologist of the twentieth century" (a rare view, as I thought); but I was also surprised to note how little he had to reiterate Fisher's book.

Finally, in his last chapter, Dawkins comes to the fascinating subject of the evolution of culture. He floats the term "meme" (short for "mimeme") for the cultural equivalent of "gene." Hard as this term may be to delimit—it surely must be harder than gene, which is bad enough—I suspect that it will soon be in common use by biologists and, one hopes, by philosophers, linguists, and others as well and that it may become absorbed as far as the word "gene" has been into everyday speech. I suspect, too, that this chapter will do much to stimulate interest in processes of cultural evolution per se.

"Meme," however, is hardly a sop likely to placate the guardians of the nurturist view of the human psyche (and already I seem to hear one nurturist idea whisper to another: "If it should be true that we are descended from Dawkins's memes, let us at least hope that it will not become generally known!"). What is perhaps a little more serious is that the book may fail to appeal to philosophers and others around the camp of the humanities, not so much because of its "memes" and other upstart ideas of insufficient pedigree as because of its general lack of a measured and academic tone. It lacks, perhaps, an air of mystery and romance commensurate with its profound theme—one wishes almost for a French translation by Malraux to be rendered again into English. Perhaps I myself felt a lack of romanticism and found the colloquial style occasionally jarring because I have always felt the play by nature which Dawkins re-presents to us to be at best a kind of Chekovian tragicomedy and certainly to have more of the spirit of *Hamlet* than of *As You Like It*.

Obviously that is just a feeling, unscientific; certainly it is no sound reason for suggesting that the book should have been written differently. Yet for me some of the strongest associations conjured up in musing on passages of this book were indeed from romantic poetry. In concluding this review I will make bold to cite two scraps that occurred to me, hoping that they may help to inspire Dawkins or someone else to take up the questions of consciousness and purpose where this book has lightly laid them down.

One is from A. E. Housman:

> From far, from eve and morning
> And yon twelve-winded sky,
> The stuff of life to knit me
> Blew hither: here am I.
>
> . . . . . .
>
> Speak now, and I will answer;
> How shall I help you, say;
> Ere to the wind's twelve quarters
> I take my endless way.

What "stuff," what "I" does Housman have in mind here, memes or genes?

The other quotation is from Wordsworth and about Newton. How easy, how reasonable, to imagine an ethnographic historian of the future writing of Newton,

> This man, although celibate and childless, made great intellectual contributions to the technology of his time, and this technology soon permitted its exponents, largely of the Caucasian race to which Newton belonged, to disperse and multiply all over the world on a scale that had no previous parallel.

And, of course, to multiply Newton's genes. Yet how indignantly, I suspect, Newton would have rejected this statement as representing the "ultimate rationale of his existence"; and how much, I suspect, he would have preferred the tribute of Wordsworth:

> Where the statue stood
> Of Newton with his prism and silent face,
> The marble index of a mind forever
> Voyaging through strange seas of Thought, alone.

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A Setting for Cultural Evolution

The Valley of Mexico. Studies in Pre-Hispanic Ecology and Society. Papers from a seminar, Santa Fe, N.M., April 1972. ERIC R. WOLF, Ed. University of New Mexico Press, Albuquerque, 1976. xiv, 338 pp., illus. $20. A School of American Research Book. School of American Research Advanced Seminar Series.

The Valley of Mexico, occupying 8000 square kilometers at an average elevation of 2200 meters, was a nuclear region for pre-Hispanic settlement and cultural evolution. In June 1960, with support from the National Science Foundation, Eric Wolf assembled a group of interested anthropologists for the purpose of planning future research in the valley. One of the most important results of that conference was a division of labor in which a group under the direction of René Millon studied the urbanization of Teotihuacán, pre-Columbian America's largest city, while a group under the direction of William Sanders studied prehistoric settlement patterns elsewhere in the valley. In April 1972, with support from the School of American Research, Wolf organized a second conference to see what had been accomplished in the intervening 12 years. To judge by this volume, an extraordinary amount had been learned.

There are several compliments that should be paid at the start of this review, the first of which goes to Wolf himself. In an age when anthropology is threatened by fragmentation and overspecialization, Wolf remains a generalizing ethnologist with a strong interest in archeology, as his two conferences demonstrate. Part of this interest results from Wolf's early association with archeologist Pedro Armillas, to whom the book is dedicated; if the authors of this volume reach high, it is partly because they stand on the shoulders of pioneers like Armillas. Second, this book is further proof that the School of American Research, under the direction of Douglas Schwartz, is running one of the most productive seminar series in anthropology today. Third, we must compliment Sanders for the extraordinary number of good young archeologists turned out by his project: of the nine authors, four (Barbara Price, Michael Logan, Richard Diehl, and Jeffrey Parsons) are former Sanders students, and one (Richard Blanton) is in turn a student of Parsons. This volume includes