

## Outward Searchers

**SETI Pioneers.** Scientists Talk about Their Search for Extraterrestrial Intelligence. DAVID W. SWIFT. University of Arizona Press, Tucson, 1990. xiv, 436 pp., illus. \$35.

Are we alone? The question of extraterrestrial life is at once one of the oldest and one of the most profound. It is only in the present generation, however, that planetary exploration, radio astronomy, studies of the origin of life, and electronics have synergistically matured and produced at their confluence a scientific community interested in the Search for Extraterrestrial Intelligence (SETI). The first milestone occurred in 1959 with the seminal article of Philip Morrison and Giuseppe Cocconi pointing out that radio communication between the stars was possible with our present technology and that the 21-centimeter wavelength emitted by hydrogen provided a preferred channel. At the same time, Frank Drake independently came to similar conclusions and carried out the first radio search for extraterrestrial life. The book *Intelligent Life in the Universe* (1966) by Carl Sagan and Iosef Shklovskii had an enormous effect on both professionals and laypersons, as did the NASA *Project Cyclops* report (1971) by Bernard Oliver and John Billingham. As SETI gained some respectability, further radio searches were carried out on a small scale in both the United States and the Soviet Union. This led by the mid-1970s to a push within NASA for a long-term SETI project, one that has only in the past year received a green light—first observations are planned for the Columbian quincentennial in 1992.

It is this pioneer epoch in the development of SETI that David Swift, a sociologist at the University of Hawaii, has sought to capture in his book. The format is highly unusual—with the exception of short introductory and concluding sections, *SETI Pioneers* consists solely of transcripts of interviews with 17 of the key persons in the field. One might think this a deadly formula, but in fact the interviews are smoothly transcribed and Swift in most cases has skillfully remained in the background and let the interviewees speak for themselves. Thus he allows some of the most imaginative scientific thinkers of our time to hold forth on

their views regarding SETI and extraterrestrial life and on how the field has developed. On the other hand, substantial editing of these interviews would have improved the ratio between questions and answers that are meaty and intriguing and those that are routine, repetitive, or uninteresting. Furthermore, there appears to have been little if any checking of the accuracy of the interviewees' statements. There are many basic errors (historical and otherwise) and in several cases inconsistencies between interviews. Nor does Swift supply any footnotes or cross-references at points where the non-expert could have used assistance in understanding an allusion or a technical term (although there is a brief glossary).

Swift's goal in presenting complete transcripts was to create an unbiased text from which readers could directly learn about individuals' ideas and personalities. Indeed, the book's great strength is that one meets fascinating characters—insightful, erudite, and even witty—and is exposed to a host of provocative scientific, political, and philosophical views (many having little to do with SETI). Oliver likens the Galactic Club of technical civilizations to the National Academy of Sciences: both organizations spend most of their time deciding about new members. Morrison describes congressmen as Aristotelian in the sense that they assume that Earth is the center of the universe and that we need to clear up problems here before finding out about other worlds. Charles Seeger describes the entire history of life on Earth as only "one powerful datum" and says we need to find more such "data." Billingham describes the troubles a SETI project has had fitting into NASA's usual style: "The contrast couldn't be more extreme between SETI and sending a spacecraft that you know will land on Mars within three seconds of four o'clock in the afternoon on a certain day in August 1994." Melvin Calvin gives the views of a biochemist. Freeman Dyson suggests looking for telltale radio emission from the "skid marks" of a braking interstellar spacecraft. Jill Tarter and Paul Horowitz give the views of a later generation. Interviews by Oliver with three Soviet SETI practitioners are also included. The most interesting of these is with Nikolai

Kardashev; for instance, we learn of the influence in the 1950s of one Professor Tihov in Kazakhstan who demonstrated that plant life existed on Mars in his laboratory of "extraterrestrial botanics."

These relatively raw transcripts thus have their positive aspects, but they also mean that *SETI Pioneers* fails as a scholarly work. I would have been far more satisfied if Swift had given us a book analyzing in detail (and quoting interviews to support arguments) the kinds of questions raised in the preface and discussed in the brief conclusions: Who were these scientists who became involved in what at first was very much a fringe enterprise? What was in their personal and professional backgrounds that might have led them toward SETI? How were they viewed by their colleagues? Swift points out that all the SETI pioneers have been highly respected in their primary disciplines, but nevertheless are willing to spend a small (in most cases) fraction of their time in this type of speculative exploration. Almost all are from urban centers of high technology or prestigious universities, with Cornell University and Silicon Valley playing major roles. Swift also discusses how the astronomer Otto Struve was an important catalyst in the early development of SETI and uncovers the remarkable statistic that the SETI pioneers are without exception first-born sons or only children. But this type of discussion and analysis makes up only 5% of the book.

*SETI Pioneers* is thus a problematic book of unusual format about fascinating people engaged in an exciting endeavor. It has notable strengths and glaring weaknesses. I suspect that readers will react with a range of opinions as broad as those concerning the likelihood of success in SETI itself.

WOODRUFF T. SULLIVAN III

Department of Astronomy,  
University of Washington, Seattle, WA 98195

## An Explanation of Behavior

**The Trilune Brain in Evolution.** Role in Paleocerebral Functions. PAUL D. MACLEAN. Plenum, New York, 1990. xxiv, 672 pp., illus. \$75.

Paul MacLean was one of the trailblazers of neuroscience whose work in the 1940s and '50s provided many of the insights into the functions of the brain upon which today's neuroscientists build. MacLean in particular made contributions that drew attention to the role of brain areas such as the amygdala, septum, and cingulate cortex in emotion and motivation. He introduced the encompassing term *limbic system* to recognize the functional interrelatedness of these brain

regions together with the hippocampus. Drawing on his own work and seemingly influenced by the prevailing view of brain evolution and the behavior of non-mammals (as reflected in the work of Elizabeth Crosby and C. J. Herrick), MacLean attempted to develop a comprehensive schema of brain function that would explain many major aspects of human behavior. This schema, which he set forth in the early '60s, was dubbed by him the triune brain because it involved the notion that the cerebral hemispheres of modern mammals, including humans, contain three distinct major regions—one inherited from reptiles, one inherited from early mammals, and one evolved in modern mammals. MacLean views each of these regions as controlling a specific set of behaviors. Hence he views the brain of modern mammals as exhibiting the sometimes unhappy cohabitation of an area with reptilian impulses (termed by him the reptilian or R-complex, which is often ignoble and always selfish), an area with early mammalian traits (termed the paleomammalian complex, which is emotional but often noble and gentle), and an area devoted exclusively to rational and intellectual processes (termed the neomammalian complex).

Since he first introduced the triune-brain concept, MacLean has devoted himself to promoting and to carrying out studies to support it. These efforts have been rewarded by the reception the idea has been accorded outside the field of brain research. For example, it was a centerpiece to Carl Sagan's ruminations about the evolution of human intelligence in the best-selling book *The Dragons of Eden*, and it is frequently the only discussion of brain evolution in psychiatry and psychology textbooks.

The reasons for the popular appeal of the triune-brain idea are easy to see. For one thing, it pinpoints "big" behaviors that we are all interested in and finds causes for them. Further, it takes the "bad" behaviors, the things that we humans would rather not take blame for, and attributes most of them to a nonhuman, non-mammalian part of us, the purported reptilian beast in us. It takes the "good" behaviors, such as parental behavior and the related altruism, as well as the endeavors of art, science, and philosophy, and makes us feel that they are part of us as mammals and humans. These ideas tie in well with a longstanding human interest (at least in Western civilization) in attributing wayward human behavior to some nonhuman source—either to the beast within or to humankind's fall from God's grace due to the serpent-induced dereliction (those reptiles again) in the Garden of Eden. MacLean's ideas are also appealing because they are simple; after a ten-minute exposition of

them one can feel equipped to explain much human behavior with the force of science behind one (those neighbors who always complain when the leaves from our trees fall in their yard are so reptilian in their territoriality).

The reception of the triune-brain idea among neuroscientists, however, has not been nearly so favorable. Since MacLean first introduced his ideas, neuroscience research has undergone tremendous growth, and knowledge about the brain, its functions, and its evolution has been greatly extended. As new information accumulated, it became clear that the older, simpler ideas about brain evolution and function upon which the triune-brain idea is based are fundamentally wrong. Neuroscientists, therefore, basically came to ignore the idea. Nonetheless, MacLean has continued to present it, focusing his efforts primarily on non-neuroscientists. The present book is his most recent and perhaps last great effort to advance the idea.

The first section of the book expounds the basic idea of the triune brain and why MacLean is interested in it. As he explains once more, MacLean believes that not much of note for the control of complex behaviors occurred during brain evolution among fishes and amphibians. Beginning with the appearance of reptiles, however, and progressing through early (now extinct) and modern mammals, MacLean says three areas of the cerebral hemispheres evolved in succession—the R-complex (that is, the basal ganglia) in reptiles, the paleomammalian complex (that is, the limbic system) in early mammals, and the neomammalian complex (that is, the neocortex) in modern mammals, with each being retained in the evolutionary progression.

The next section deals with the R-complex in more detail. MacLean presents his evidence that the R-complex in all amniotes plays a role in nonverbal behaviors of the type that reptiles, mammals, and birds all show—species-typical behavior involved in aggression, territoriality, dominance, and ritual displays. In his presentation on the R-complex, he labors for two causes important to his triune-brain idea—proving that reptiles and birds possess nothing like neocortex and proving that 150 years of study concerned with documenting the role of the R-complex in motor behavior have failed to reveal its functions. His proofs are bound to be inadequate given the preponderance of evidence on these matters. He then goes on to present experimental studies of his own on lizards and monkeys that he says fill the void in our knowledge about the R-complex. These studies, however, are limited in scope and questionable in their inter-

pretation. Despite this, MacLean asserts that his evidence shows that the R-complex controls all species-typical behavior. He even attempts to reinterpret the symptoms of Parkinson's disease and Huntington's disease in a way to suit his ideas about the functions of the basal ganglia, all the while ignoring the movement disturbances that occur in these disorders.

Next, MacLean moves on to the limbic system, presenting data on its anatomy and functions in order to support his idea that it plays a role in the motivation and emotion involved in feeding, reproductive behavior, and parental behavior. The specific behavioral functions he assigns to the individual parts of the limbic system seem to me not at all to derive unambiguously from the data he presents, and I remain largely unconvinced of the merit of trying to assign the control of one or two types of "big" behavior (that is, behavior consisting of a complex series of actions) to a single structure (parental behavior being assigned to the cingulate cortex, for example). Further, MacLean's presentation of the role of the hippocampus in limbic functions is not well reconciled with the current evidence that the hippocampus plays a role in memory. Next, MacLean moves on to presenting information on psychomotor epilepsy (sometimes termed temporal lobe epilepsy) in order to prove further that certain parts of the limbic system are involved in certain kinds of motivated behavior and emotion. I found the information interesting but not persuasive regarding his premise, because it is so hard to relate symptoms of epilepsy to the specific brain site that is producing them. The region producing the symptoms might not be the site at which the epileptic "storm" occurs, the symptoms may derive from the effects of the "storm" on a remote brain area. In the final section of the book, MacLean presents his ideas about the evolution of the neocortex, which he believes is involved in higher-order processes such as language (in humans), cognition, abstraction, and perception. Few neuroscientists would disagree with this last claim. In this section, MacLean also presents his thoughts on lobotomy, crying, laughter, handedness, and subjectivity, among other matters.

As intimated above, the triune-brain idea has a number of problems. Much as it excels at providing explanations for many things, it is far too loose to be considered a hypothesis from which falsifiable predictions can be derived. Nonetheless, one can find the idea itself false in that the story of brain evolution and function it tells is not consistent with current knowledge. For example, the R-complex is not a reptilian invention but seems to be present in vertebrates all the way

back to jawless fishes. Further, current research compellingly shows that the basal ganglia are involved in the initiation and control of voluntary movement, as evidenced notably by the movement disturbances in such diseases involving the human basal ganglia as Parkinson's disease and Huntington's disease. The basal ganglia may be involved in non-motor functions as well (no one denies this possibility), but I know of no one other than MacLean who now believes them to be the neural seat for the control of species-typical types of behaviors.

With respect to the limbic system, the evolutionary story MacLean tells is again wrong. The limbic system did not, for example, appear first in early mammals. Reptiles, birds, mammals, and amphibians all possess a septum, an amygdala, and a hippocampal complex (though the hippocampal complex in non-mammals looks very different from that in mammals). Further, reptiles, birds, mammals, and amphibians may all possess a cingulate cortex. The evidence is currently not decisive on this point, but MacLean's version of the story (namely that only mammals possess cingulate cortex) is not nearly as well substantiated as he makes it out to be. As to the functions of the limbic system, the evidence refutes MacLean's ideas that the amygdala is only involved in feeding, the septum in reproduction, and the hippocampus in the correlation of interoceptive and exteroceptive information. MacLean assigns to the cingulate cortex the functions of parental behavior, which he regards as uniquely mammalian. This ignores the fact that some reptiles, such as crocodiles, and all birds engage in parental behavior, not to mention the possibility suggested by paleontological data that some extinct reptiles, namely dinosaurs, also engaged in parental behavior.

Finally, MacLean is also not quite right in saying that neocortex first appeared with modern mammals. Evidence based on study of primitive mammals clearly suggests that neocortex was present in the earliest mammals. Further, even in non-mammals such as birds, reptiles, and bony and cartilaginous fishes there are parts of the cerebral hemispheres that are not part of the basal ganglia and are involved in such typically neocortical functions as perception, decision-making, learning, tool use, and concept formation (particularly in birds). In non-mammals, these cerebral areas do not have the same architecture as neocortex, which accounts for why they were not recognized for what they were until recently.

Apart from the problems with the triune-brain idea itself, what can be said about this book as such? In short, the ideas and data in it are outdated; only a handful of papers

from the '80s are cited. Further, the book is not entirely about the triune-brain idea. To be sure, that is the main story, but MacLean takes the opportunity to present his thoughts, conclusions, and speculations about a variety of topics related to human behavior. Consequently, we get his ideas about the evolution and neural basis of such things as conscience (it's in the prefrontal lobes), crying and laughter (he is not really sure, but he thinks it's limbic), and mathematical skill (he thinks the cerebellum could be involved). In many of his comments, MacLean criticizes other scientists for not pursuing the appropriate research questions or humankind in general for its foolish ways. On one matter I found my feelings quite in register with his—the blight that was prefrontal lobotomy as a therapeutic procedure.

One could also say that the book, both in its general tone and through the allusions to and quotations from the classics and philosophical works, clearly reveals MacLean to be a scholarly man with great interests in philosophy and the welfare of mankind. Nonetheless, there are some telling shortcomings in his scholarship. For example, in his presentation on the evolution of the R-complex, MacLean makes a comment that should leave Stephen J. Gould, not to mention all other students of evolution, aghast. Claiming that the concept of homology is confused and not clearly defined, he discards it in favor of what he regards as a much less equivocal term, namely correspondence. This is a very critical misjudgment to make in a work on evolution. MacLean also errs in his apparent sweeping acceptance of Haeckel's idea that ontogeny recapitulates phylogeny.

On a final note, although I strongly believe the triune-brain idea to be wrong, it would be myopic to overlook the positive value in what MacLean has ultimately been after. MacLean has been interested in the neural and evolutionary underpinnings of human behavior. He has wanted to see what makes people tick because he wants answers to some of the most basic questions about people. What are we? Where do we come from? How does our animal heritage affect our behavior? Why do we do the things we do? Why can we not live together more harmoniously? Although the questions are difficult to answer and in many senses religious and philosophical in nature, they are important questions that modern neuroscience research can shed light on, though perhaps not in as global and simple a way as MacLean has sought.

ANTON REINER

Department of Anatomy and Neurobiology,  
University of Tennessee,  
Memphis, TN 38163

## Some Other Books of Interest

**Ecological Concepts.** The Contribution of Ecology to an Understanding of the Natural World. J. M. CHERRETT *et al.*, Eds. Blackwell Scientific, Boston, 1989. viii, 385 pp., illus. \$92.95; paper, \$43.95. British Ecological Society Symposium 29. From a symposium, London, April 1988.

**Toward a More Exact Ecology.** PETER J. GRUBB and JOHN B. WHITTAKER, Eds. Blackwell Scientific, Boston, 1990. x, 468 pp., illus. \$92.95; paper, \$43.95. British Ecological Society Symposium 30. From a symposium, Oxford, U.K., Sept. 1988.

When in 1963 the British Ecological Society celebrated its 50th anniversary with a symposium, the organizers identified five "main areas of development" in the field—conservation ecology, quaternary ecology, production ecology, experimental and autecological studies, and the concept of community. For a second, two-symposium jubilee 25 years later, those responsible for the events began with an attempt to identify, through a survey of members, 50 "key concepts." In the opening chapter of the first of the volumes resulting from the symposiums, Cherrett presents the results of the survey. In short, the top five concepts are "the ecosystem," "succession," "energy flow," "conservation of resources," and "competition"; "r and K selection" comes in no. 33; and "the 3/2 thinning law" and "the guild" bring up the rear.

The remainder of *Ecological Concepts* is given over to invited essays on some of the concepts. In what is described as "a collection of personal views" 13 authors, not all of them British, give some history of the use of the concepts, discuss studies bearing on them, and assess their status. Ecosystems and their energetics are addressed by Waring, food webs by Lawton, the niche by Schoener, diversity and stability by Walker, predator-prey and host-pathogen interactions by Hassell and Anderson, population regulation in animals by Sinclair, competition by Law and Watkinson, life-history strategies by Caswell, optimization by Krebs and Houston, and levels of organization by May.

The choice of theme for the second volume represents a recognition, according to the editors, of the development of ecology from a largely descriptive enterprise to one with theoretical underpinnings supported by experimental evidence. The volume opens with an essay by Grubb expounding the issues of prediction in ecology and "exactness" in various approaches. The remaining papers are arranged according to theme: physiological processes in free-living orga-