and the influence of this proximity and of the social sciences on the questions being investigated. These thoughtful chapters deal with topics that have been of considerable interest in experimental studies conducted in captivity, and the restriction of the volume to field studies was wisely relaxed somewhat more in this section than in the previous ones. Still, coverage of work done with captive rather than free-living primates is less complete. That truncation is unfortunate but understandable. We will be blessed if in the near future another volume of equal quality and scope brings us a different balance from this one's.

Part 5, the final one, is entitled The Future, and the first chapter deals briefly with the critical state of tropical conservation; on the outcome of this complex story hinge our hopes for the very survival of most primate species as well as any possibility of gaining a deeper understanding of their lives. Even species that do not disappear entirely may soon live only in small isolated populations or inhabit greatly altered environments in which their futures are tenuous and their behavior is greatly compromised. In recognition of the centrality of conservation concerns, the editors and authors of this volume are contributing their royalties to a conservation fund, and an increasing number of researchers are involved in facilitating educational opportunities for those in tropical countries who will ultimately be the ones to resolve the complex issues.

Primate Societies is not free from the unevenness of style and quality that is virtually inevitable in a multi-authored volume, but these are balanced or muted by the differing strengths of the many authors and the benefits provided by the editors, who possessed a clear vision of the whole. In addition to the roughness, there are gaps in information and in satisfactory explanations and insights. To some extent the level of conceptual insight and synthesis reflects the cost of having a tightly edited multi-authored volume with ambitious goals for conveying the large, scattered body of recent data, but what we miss in the book also reflects the state of the field. Throughout the book, and in the final chapter, the editors and authors explicitly point out what we don't know, and in doing so they communicate the searching, alive, active state of field, the opportunities and possibilities, the studies that still need to be done.

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Dreams as Behavior

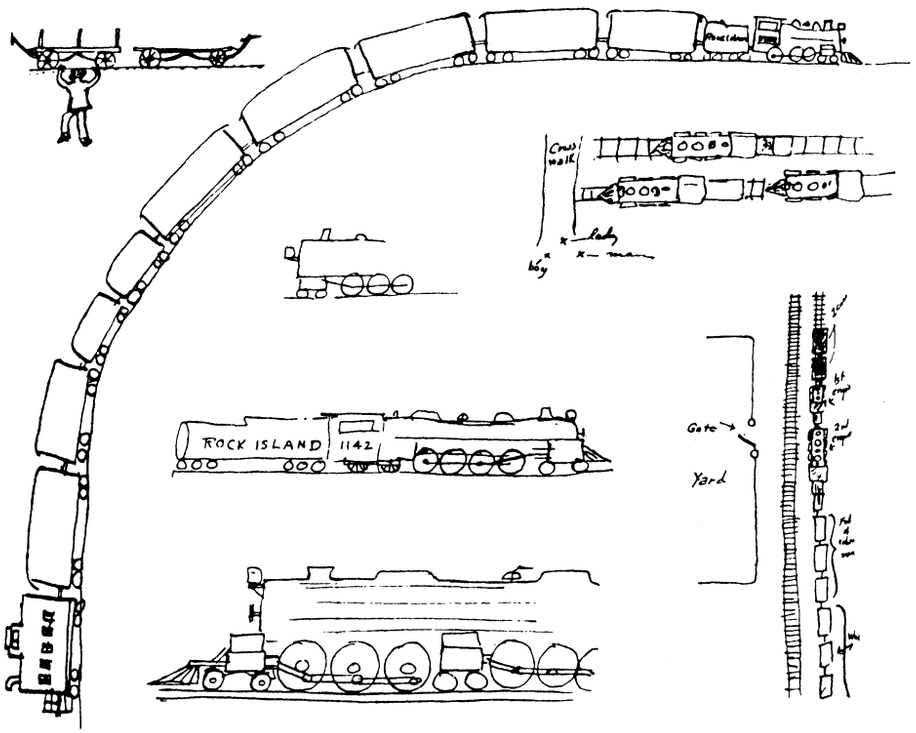
The Dreaming Brain. J. ALLAN HOBSON. Basic Books, New York, 1988. xvi, 319 pp., illus. $22.95.

Sleep is, arguably, the most consistent feature of animal and human behavior in that both its timing and the structure of the behavior are relatively stereotyped. Nonetheless, the major biological questions concerning sleep, its adaptive significance and the mechanisms by which it is produced, remain largely unanswered. In this book, Hobson analyzes that component of sleep behavior that is the least stereotyped and the most challenging and intriguing, dreaming. His thesis, simply stated, is that dreams are what they seem to be, fragments of mental activity that occur during sleep. Mental activity, in Hobson's view, is equivalent to the physiological activity of the nervous system. To make this clear, he states, "I use the hybrid term *brain-mind* to signal my conviction that a complete description of either (brain or mind) will be a complete description of the other (mind or brain)." Thus the proper path to analyzing and understanding dreaming as a behavior lies in identifying and characterizing the neural mechanisms associated with it. Obviously this is an enormously difficult task; the substantial progress that has been made is recounted in the book. Hobson's approach is historical, and this is both effective and engaging. Early attempts at a scientific analysis of dreaming were undertaken in the 19th century by a number of investigators, including Helmholtz and Wundt, and were driven by the view that dreams should be analyzed as brain functions. The work was primitive, however, and, as is the case inevitably in science, progress awaited the development of appropriate methodology. This began to appear over the early decades of this century, but as these developments emerged, a powerful voice arose that carried dream analysis in another direction for many years.

Sigmund Freud, a Viennese neurologist who developed an interest in hypnosis and psychopathology, concluded that the content of dreams provided a rich insight into understanding human behavior and, in particular, pathological behavior. Hobson correctly concludes that the consequence of Freud's development of psychoanalysis was to abort the emerging experimental tradition in sleep research. He spends some time in debunking the psychoanalytic approach, but his criticism of this and other early behavioral approaches to the analysis of dreams is reasoned and dispassionate. Dispassion is appropriate, as psychoanalysis, at least in the strict interpretation of that term, has largely disappeared from American psychiatry, and we are in a period in which the biological analysis of behavior and its disorders is in ascendance.

The chronology continues with a review of the development of modern neurobiology, from the neuron doctrine to early neurophysiology. The development of technology to record the electrical activity of the nervous system led to the discovery of what remains the principal tool in the study of sleep and dreaming, the electroencephalogram. The EEG records activity only from the surface of the brain, essentially from superficial cerebral cortex, but it is a reliable indicator of behavioral state, clearly distinguishing sleep and waking. As this distinction became evident, a series of other observations contributed immensely to our understanding of the localization of brain structures critical to the generation of sleep and wakefulness. The crucial observation was that of Moruzzi and Magoun, who demonstrated that the integrity of the upper brainstem reticular formation is essential to the maintenance of wakefulness. At almost the same time, Kleitman and his associates demonstrated that the sleeping EEG has two distinctive components. One is characterized by relatively slow, high-voltage activity and is designated slow-wave sleep. The other is characterized by more rapid, low-voltage activity similar to waking, with associated changes in muscle tone and very dramatic rapid eye movements, which led to its designation as REM sleep. Subsequently, Kleitman and Dement demonstrated that nearly all dreaming is associated with REM sleep.

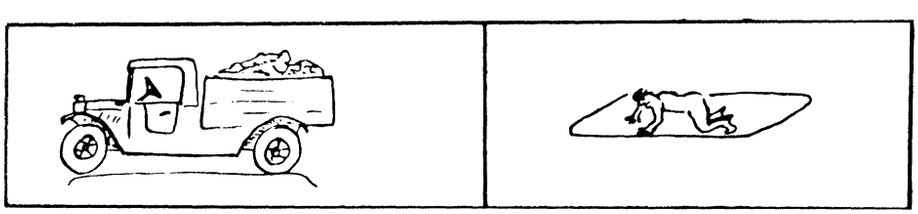
From this background, Hobson and his associates, and other workers, have carried on an extensive investigation of the neurophysiology of REM sleep. This has led Hobson to advance what is termed the "activation-synthesis hypothesis." In this formulation, structures in the reticular formation of the brainstem interact so that the forebrain is intermittently activated into a state similar to waking but receives no sensory input and has no motor output. The forebrain, thus activated, synthesizes its ongoing activity to produce a dream. The nature of the dream will reflect the physiological processes activated. Although the formulation is complex and difficult, the hypothesis permits Hobson to begin to ac-



Drawing from a dream journal obtained by the author of *The Dreaming Brain*. According to the dreamer (shown, upper left, "hanging perilously from the tracks"), Rock Island locomotive 1142 (center) "has an engineer who speaks only French and therefore (*sic*) denies passengers permission to ride in the engine." [From *The Dreaming Brain*]

count for the major features of dreams, their apparently hallucinatory or delusional content, their disorientation and alteration of emotional content, and, finally, the amnesia that occurs unless wakefulness supervenes. The activation-synthesis hypothesis is interesting and provocative, but it is worth noting that we know much more about the physiology of activation than we do of synthesis. Indeed, Hobson is presented with the same nearly overwhelming problem that confronts any neurobiologist who wishes to understand human cognitive function. The complexity of the processes appears to transcend our current capacity to analyze them in a reductionist framework. Hobson clearly understands this, and he proposes a formal behavioral analysis of dreams as one beginning to the effort to attack the problem.

In my view this is both an interesting and an important book. It is the only detailed attempt to use an experimental analysis to deal with dreams as behavior reflecting the function of the nervous system. In it Hobson makes four important contributions. First, he traces the development of our knowledge of sleep and dreaming in a cohesive and comprehensible account. Second, he shows how the techniques of modern neurobiology can be applied to behavior analysis by beginning the explication of the physiology of dreaming as a mental activity. Third, he removes dreams from the realm of mystery, particularly from the mystification of psychoanalytic dogma. This is not to state that he believes dreams are meaningless. Indeed, he clearly recognizes that dreams are meaningful behavior and that, in some circumstances, they can be employed to the dreamer's advantage. Finally, he provides a basis for a formal analysis of dreams as behavior that is not only valuable as a contribution to the field but is critical if we are to proceed in the principal challenge of neurobiology, the understanding of the human mind.



"Commonplace and exotic vehicles" (truck and flying carpet) shown in the dream journal. A high proportion of the drawings depict modes of conveyance. [From *The Dreaming Brain*]

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Learning in Simple Systems

Memory Traces in the Brain. DANIEL L. ALKON. Cambridge University Press, New York, 1988. x, 190 pp., illus. $39.50; paper, $14.95.

The search for memory traces in the brain has challenged researchers in the neurobiology of learning and memory. The difficulty of locating traces for specific memories has prevented most serious attempts at attacking the question of the nature of the memory trace itself. Nevertheless, RNAs and proteins have been successively proposed to be memory molecules, and ingenious theories have been devised to account (in general poorly) for the properties of memory processes. The failures of biochemists to identify clearly the chemical nature of memory traces have been attributed to the impossibility of accomplishing the double task of measuring necessarily small correlates of a specific memory and proving the specificity of any change large enough to be measurable. In the '70s, a number of laboratories decided that an alternative and more promising strategy with which to search for the "engram" was to study "simple systems," be they simple because they involve a small number of neurons or because the nature of the "learning" is (or appears) simple. The hope in pursuing such a strategy was to be able to describe the wiring diagram of the systems in such detail as to predict where the memory trace was most likely to be found, then to follow the molecular and cellular events occurring at that location during the different phases of the learning process. Although most researchers were aware that the price of such an approach was that the relatively limited behavioral repertoire restricted the memory ensemble of these systems, it was assumed that the richness of human memory was the result more of quantitative than of qualitative differences.

Memory Traces in the Brain comes out of this tradition and describes the patient and meticulous search that Daniel Alkon and his co-workers at the National Institute of Neurological and Communicative Disorders and Stroke and the Marine Biological Laboratory at Woods Hole have conducted for the last 10 years using a marine mollusk, *Hermissenda crassicornis*, as a simple system. In