and certainly attempts to illustrate how different the country's problems are from those of other continents. This is of particular interest to American ecologists who want to understand different ecosystems and management techniques utilized on another continent.

The book has an optimistic objective, "not . . . to be simply a catalog of environmental degradation and disaster, but a positive attempt to learn from the mistakes and successes of the past." This is also a tall order. Australia is very different from northern temperate ecosystems: its soils are old and shallow, its climate is harsh and unpredictable, humans have introduced grazing animals in vast numbers, and it has suffered a disproportionate number of invading species in a short duration of European settlement. A relatively small number of people (15 million) have wrought extensive landscape degradation to a vast portion of the country, and restoration seems slow or nonexistent.

Many Australian ecosystems contrast greatly with their European and American counterparts, so the policies of conservation and land management that have been imported from outside Australia do not necessarily apply, and have had disastrous consequences in some cases. Different ecological principles and related management strategies have been worked out for Australian conditions, which the authors are careful to illustrate. For example, stocking rates and clearing regimes are required that take into account the greater erosion and drought suffered by arid grazing lands when grass and tree cover are removed.

The contributions in the book are extensive, but most pertain to three types of research: (i) basic biology of Australian ecosystems and organisms (for example, coastal marine ecology, Sydney's vegetation, rural trees and the dieback syndrome, biology of ants); (ii) management techniques as applied to Australian ecosystems (for example, revegetation in grazing lands, honey bee management, fire in relation to *Banksia* populations, utilization of satellite photographs, management of numbat populations); and (iii) development of conservation values (for example, genetic resources, concepts of land preservation in arid zones, "naturalness" in relation to disturbed land, and criteria for conserving land).

Most authors emphasize that many aspects of Australian ecology are unstudied and many questions are unanswered. Until the basic ecology is studied comprehensively (and normal fluctuations in ecosystems measured), scientists cannot hope to predict the effects of large-scale trends (such as global warming). This creates a pressure for Australian science to ask the right questions and answer them quickly.

The book is extremely useful for anyone who wants to understand the ecological issues of this island continent, or simply to gain insights into different systems. Unfortunately, it is priced fairly high and is too technical to reach the shelves of Australian landowners, who desperately need to know the problems facing Australian science with regard to land management decisions. In general, most authors cite the need for changes in aspects of Australian scientific research, including: more research on major ecosystems (for example, sandy beaches and mudflats); more use of the experimental ecological approach; increased research in restoration ecology of disturbed landscapes (such as grazing lands, reefs, or upland streams); and a stronger commitment on the part of ecologists to communicating their results to the general public. Regarding the last issue, the editors summarize the volume on this note:

> Ecologists can no longer remain in the background, researching issues in isolation from the community. We must venture into the arena where policies are fought out and see that our knowledge and understanding of the environment is properly used in making the decisions about the world in which we live.

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Sleeping and Dreaming

Thalamic Oscillations and Signaling. MIRCEA STERIADE, EDWARD G. JONES, AND RODOLFO R. LLINAS. Wiley, New York, 1990. xvi, 431 pp., illus. $115. A Neurosciences Institute Publication.

Brainstem Control of Wakefulness and Sleep. MIRCEA STERIADE AND ROBERT W. MCCARLEY. Plenum, New York, 1990. xvi, 499 pp., illus. $85.

Lying late at night in bed reading a highly technical monograph, one occasionally finds oneself becoming drowsy and falling asleep. If the previous nights were spent over grant proposals, letters of recommendation, and chapters long overdue, one may even after some time start to dream, imagining oneself in some mystical past where scientists were expected to search for the truth rather than to generate an endless number of documents.

These two monographs will go a long way toward explaining how such late-night behavior is controlled by the brain and how wakefulness, sleep, and dreaming are expressed at the level of single cells and neural networks. The two major actors represented in both books are the thalamus and parts of the brainstem. The thalamus is the principal gateway to the cerebral cortex: the visual, auditory, somatosensory, and gustatory pathways all pass through specific thalamic nuclei on their way to the cortex. Furthermore, cortical areas that receive input from specific thalamic nuclei also provide a massive projection back to the same nuclei. For example, about half of all synapses in the best-studied thalamic nuclei, the lateral geniculate nucleus (LGN), which is located halfway between the retina and the primary visual cortex, originate in the cortex, the remainder being derived from retina, local GABAergic interneurons, and the brainstem. Physiologists have long been puzzled about why afferent input does not project directly onto the cortex but passes through a relay station, particularly since the functional properties of thalamic cells appear to differ little from those of their input fibers.

One major clue to this mystery was discovered in the early '80s by Llinas, one of the authors of *Thalamic Oscillations and Signaling*. He and his coworkers showed that all thalamic neurons can be in one of two quite distinct electrophysiological states, depending on their membrane potential. At resting potentials more positive than minus 60 millivolts, cells respond to a current injection by a steady stream of fast action potentials. If the membrane potential shifts to minus 65 millivolts or less, a calcium conductance comes into play, resulting in a burst of two to four fast action potentials followed by a profound hyperpolarization lasting between 70 and 150 milliseconds. The cell repeats this basic pattern throughout the current injection. Thus, thalamic cells can be either in a "relay" or in an "oscillatory" mode.

Steriade, the first author of both monographs, has shown that these modes can be controlled by a diffuse projection to the thalamus from cholinergic neurons in the reticular formation in the brainstem as well as from noradrenergic neurons in the locus coeruleus. Furthermore, these modes relate to the gross behavioral states of wakefulness, rapid-eye-movement (REM) or paradoxical sleep, and non-REM or slow-wave sleep. Cholinergic brainstem neurons excite thalamic neurons during both wakefulness and REM sleep, both of them states in which the brain is highly active. On the basis of heroic intracellular recordings, it has been shown that activation of cholinergic brainstem neurons tonically shifts the membrane potential of thalamic relay cells toward more positive values and increases their spontaneous discharge frequency, switching these cells into the relay mode and leading to a desynchro-

nized electroencephalogram (EEG). These findings essentially vindicate the concept, postulated in the '50s, of a diffusely acting midbrain reticular activating system.

A second dominant feature of the REM phase is the so-called pontogeniculo-occipital (PGO) waves, fast electrical events in the field potential that begin about one minute prior to and occur during REM sleep. PGO waves precede and indicate the direction of rapid eye movements and have been related to gaze direction in dream imagery. Another group of cholinergic brainstem neurons initiates these waves by directly exciting LGN relay cells. A third very striking feature of REM sleep is the lack of major muscle movement during this phase of sleep (muscle atonia) despite our subjective experience of action and movement in our dreams and despite the high level of activity of neurons in motor cortex and other motor areas. This lack of movement is due to direct tonic hyperpolarization of the motoneurons, a synaptic action that originates from neurons in the pons, a part of the reticular formation.

A dominant feature of the transition from the desynchronized to the synchronized EEG, corresponding to the transition from wakefulness or REM sleep to deep, non-REM sleep, is "spindles," waxing and waning waves at a frequency of 7 to 14 hertz that are grouped in sequences lasting 1 to 2 seconds and recurring periodically every 5 to 10 seconds. These oscillations, not to be confused with alpha waves observed during states of restful wakefulness, originate in a thin layer of inhibitory GABAergic neurons surrounding most of the thalamus, called the reticular nucleus of the thalamus. These neurons, under modulatory control from the brainstem, can switch into the "oscillatory" mode. Reticular thalamic neurons therefore act as true pacemakers, imposing their rhythm onto thalamic neurons and thereby inhibiting the relay of specific information to the cortex. All of this—and much more—can be found in great detail in both volumes.

The two books essentially take the same approach, linking events at the level of the single cell, mainly changes in membrane potential or input conductance, to behavioral events such as spindles, sleep, or vigilance. The physiology is complemented by detailed anatomy of all the relevant structures down to the level of the morphology of cells identifiable through horseradish peroxidase injections. Accordingly, both books are lavishly illustrated with close to 400 stains, camera lucida drawings, and both intra- and extracellular recordings. Furthermore, both volumes provide long historical introductions, placing their contributions in proper perspective.

The books differ, however, in emphasis. *Brainstem Control of Wakefulness and Sleep* discusses primarily the contribution of networks in the brainstem to the expression of the sleep-wakefulness cycle with all of its attendant phenomena (muscular atonia, REM, spindles, synchronized and desynchronized EEG, and so on). In contrast, *Thalamic Oscillations and Signaling* focuses on the anatomy and electrophysiology of the thalamus and its relevance to the generation of the various forms of oscillatory and desynchronized EEGs. Despite its highly technical nature, *Brainstem Control* has a broader outlook, attempting to place its findings within the framework of clinical sleep disorders and dreams. Unfortunately, however, neither volume has much to say about the functional relevance of all of these phenomena or about the relevant experimental literature on sleep deprivation (Why do we dream? Why are there two, very different sleep phases?) Curiously, the most puzzling question of what is the function of the 50 percent of all synapses in the thalamus that originate in cortex is mentioned but once.

Neither book is for the faint-hearted. A background in biophysics and electrophysiology is strongly desirable for following the arguments fully. Abbreviations abound, and most figures are collages of numerous traces and graphs. Both books are landmarks in the field and are at the pinnacle of technical achievement. It is therefore all the more unfortunate that they are not readily accessible to a more general audience, such as cognitive psychologists, clinicians, or theoreticians.

The ultimate goal of the research effort represented in these books is the elucidation of a tight mapping between single neurons on the one hand and human behavior and its subjective correlates on the other. That this reductionist program will ultimately be successful is at present only a belief. It should be tempered by the words of H. Ellis, "Dreams are real while they last. Can we say more of life?"

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