

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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