How can you tell when another person has crossed over from being awake to being asleep? Lying quietly with closed eyes is useful evidence, but it is the breathing pattern that usually gives it away. A change to very regular, shallow breaths typically accompanies sleep onset. (That is, unless the person’s upper airway has relaxed so much that tissues vibrate as air rushes by. The resulting snores confirm the sleeping.) One patient that I saw in our sleep clinic came in for evaluation because he was too sleepy during the daytime. He told me that his blind daughter always could tell when he was becoming drowsy while driving by the change in his breathing. I think that is a pretty scary scenario.

Early sleep researchers had to depend on direct observations of sleeping subjects. It was evident that people were not simply awake or asleep, but rather seemed to experience different levels or types of sleep. Typically, there are more movements during lighter sleep and greater irregularity in breathing during rapid eye movement (REM) sleep. The REMs beneath closed eyelids occurring during REM sleep usually are not so obvious in humans, but often they can be observed in dogs and cats. During deeper sleep stages people generally are less physically active and are less arousable by noises and other external stimuli. A person can make guesses about the depth of sleep or the sleep stage in other people and pets.

In sleep laboratories, researchers are now able to monitor sleep very precisely—determining exactly when people are awake and asleep—and they can categorize what type of sleep people are experiencing. The modern era of sleep research resulted from the invention of the electroencephalogram (EEG) in the 1920s. Hans Berger, a German psychiatrist, is credited with being the father of the EEG. The notion that electrical oscillations from the brain existed and that they could be amplified from scalp electrodes seemed highly improbable at the time. However, while Berger was carrying on his responsibilities as the chairman of psychiatry at the University of Jena, he secretly labored in his private laboratory in the attempt to perfect his methods of demonstrating the brain rhythms. He provided reliable evidence of what he defined as alpha and beta rhythms. Finally, in 1929, he published his findings in “On the Electroencephalogram of Man.”

The analysis of EEG patterns of the sleeping human brain must have been an irresistible research question. Within 5 years of Berger’s report of his discoveries, other research teams began to use his techniques to examine sleep. Most notable among these was the work of the private Loomis Laboratories led by wealthy American financier and amateur scientist Alfred Lee Loomis. Loomis and colleagues published a series of papers in the mid-1930s outlining the various patterns of electrical oscillations that they recorded during sleep. They developed an organization of sleep states and created many of the definitions of sleep characteristics still in use today. At that time, it was apparent that there was a relationship between the recorded brain oscillations and the observed depth of sleep with the lower frequencies (slow wave sleep) correlating with deeper sleep. What was missing from the Loomis system of sleep stages was the recognition of REM sleep, which was not reported until Aserinsky and Kleitman’s 1953 Science article. Kleitman’s student Dement helped to establish the relationship between REM sleep and the experience of dreaming. Soon a new organization of sleep stages based on the EEG, eye movements, and muscle tension...
was developed, incorporating the now familiar categories of REM sleep and the four stages of non-REM (NREM) sleep. The most recent categorization of sleep stages simplifies these into R, N1, N2, and N3, which correlate with the previous REM, NREM Stage1, NREM Stage 2, and NREM Stages 3 and 4.8

How closely does the “outside” objective representation of sleep relate to the “inside” subjective experience of sleeping? Sometimes it correlates very closely and sometimes it is widely divergent. For example, someone sleeping in a sleep laboratory may say that his or her sleep was uninterrupted for ~7 hours and the polysomnographic recording may reflect approximately the same amount of sleep. Although people may be able to describe how long it takes them to fall asleep, how much total sleep they experience, how many times they awaken, and the general quality of their sleep, they cannot reliably estimate how much time they are in different stages of sleep.

Often the correlation of recorded sleep and experienced sleep simply does not match very well. By its very nature, sleep is difficult to quantify. When I see patients for follow-up visits in our sleep clinic after their sleep laboratory studies, I always ask them about their experience sleeping during the test. It is not unusual for them to tell me that they barely slept at all or did not experience a moment of sleep. They then are incredulous when I provide evidence that they slept for 5–7 hours. Sometimes patients insist that the information is simply wrong and that they must have been confused with another patient.

The objective-subjective sleep disparity can occasionally be explained by poor quality sleep associated with sleep apnea or other sleep disorders. Sleep that has been unrefreshing may seem too short. Another explanation for the mismatch between these inside and outside perspectives of sleep might relate to the “connect the dots” of short awakenings interspersed with longer sleep episodes of REM sleep and the four stages of non-REM (NREM) sleep. The most recent categorization of sleep stages simplifies these into R, N1, N2, and N3, which correlate with the previous REM, NREM Stage1, NREM Stage 2, and NREM Stages 3 and 4.8

Among the most interesting patients with extreme inconsistencies of inside and outside sleep assessments have been the handful I have seen diagnosed with schizophrenia who firmly insisted that they did not sleep at all and had not done so for years. Invariably, family members would insist the opposite—that the patients slept through the night. Initially, I wondered whether this claim of complete sleeplessness represented a delusional symptom, but I have come to suspect that it actually might reflect a more fundamental aspect of schizophrenia—a dissociation of affective and cognitive experiences. One of these patients also insisted that he had a profound memory impairment and he consulted with numerous specialists in his search for a cure. On questioning, he was able to provide all of the details of what he “could not remember.” He explained that what was really missing were the feelings that should accompany the memories. His memories felt like empty shadows. Perhaps for him and these other patients with schizophrenia, sleeping no longer felt like sleeping.

I am certain that future research developments will narrow the gap of subjectively experienced sleep and objectively recorded sleep. The EEG is a very valuable tool, but defining sleep with this electrical representation of brain activity clearly has limitations. Advances in real-time brain imaging technology may provide a better understanding of the interactions of multiple brain regions and, perhaps, insights into how insomnia is experienced. New paradigms in the treatment of insomnia will likely follow. PP

REFERENCES