SCIENCE NEWS OF THE WEEK

Identifying the Switches of Sleep

Although an incredible amount of research has been conducted on sleep, scientists have made little progress in identifying what starts and stops it, and how people move from one phase of sleep to another. For instance, areas of the brain that are known to influence sleep have been identified as the brainstem, the thalamus, the basal forebrain and the hippocampus. But which neurons and nerve chemicals in these areas do the controlling?

A major step toward answering this question is reported in the July 4 Science by J. Allan Hobson, Robert W. McCarley and Peter W. Wyzinski of Harvard Medical School. These neurophysiologists have found that two kinds of neurons in the brainstem fire reciprocally during the waking-sleep cycle and also during the transition from one stage of sleep to another, suggesting that the neurons may be switches that turn sleep and sleep stages on and off. What's more, they've devised a mathematical model for sleep cycle control based on the reciprocal firing between these neurons. The model is explicit and testable, opening the door to confirming the neurons as the switches of sleep and discovering precisely how they work.

First the Harvard team found that neurons known as FTG cells in the brainstem fire significantly more during the desynchronized state of sleep than during the synchronized stage of sleep. Desynchronized sleep, characterized by low-voltage, high-frequency brain waves and rapid eye movements, is the stage associated with dreams. Synchronized sleep, characterized by high-voltage, low-frequency brain waves, includes the delta phase of sleep which tends to be deep and to occur in the early part of the night.

Then they found that other neurons in the brainstem known as LC cells do just the opposite: They fire more during synchronized sleep and less during desynchronized sleep. So Hobson and his colleagues tested their hypothesis that these two kinds of cells might fire reciprocally throughout the wake-sleep cycle.

They chose as subjects 25 male cats, explored their brainstems with microelectrodes and measured the firing of individual neurons in the brainstem during waking and sleep states. They found that the rate of firing of LC cells decreased moderately in the transition from waking to synchronized sleep and fell even more sharply in desynchronized sleep. The FTG neurons showed opposite, nearly equal trends—a moderate increase in firing in the transition from waking to synchronized sleep and an even greater increase in firing in desynchronized sleep.

These findings, Hobson and his colleagues conclude, are a strong argument that reciprocal firing between these two kinds of brainstem neurons serves as switches between the early, heavy stage of sleep and the later dream stage of sleep, and possibly as switches between waking and sleeping because, as Hobson explained to Science News, "the evidence was really strongest for control of the in-sleep cycle."

Other investigators, in fact, have also found that the FTG and LC cells are somehow implicated in sleep-waking states and that FTG and LC cells are in close physical contact. This led Hobson and his coworkers to arrive at a sleep control theory: FTG cells and LC cells are able to interact with each other, thereby controlling each other's firing rates, and this reciprocal interaction, or firing, controls the transition from one sleep stage to another, and possibly also the transition from waking to sleeping.

The mathematical model the Harvard investigators have devised for this sleep control theory makes predictions that can be tested experimentally. The model, for example, predicts that suppression of LC cell activity will augment FTG cell activity and hence lead to more dream sleep. It predicts that stimulation of LC cells results in less FTG cell activity and less dream sleep. And so on.

If such predictions are experimentally confirmed, they will go a long way toward documenting the FTG cells and the LC cells as crucial switches between heavy sleep and dream sleep, and possibly also as crucial switches between waking and sleeping. Many other questions, of course, will remain to challenge sleep researchers, such as nerve-transmitting chemicals these neurons secrete, how the chemicals influence reciprocal firing between the neurons, and how the neurons communicate with neurons in those other areas of the brain which also seem to have an input into sleep. □

The discreet charm of decaying psi's

One of the charming things about contemporary particle physics is the constant flux-and-reflux relation between theoretical hypothesis and experimental behavior. The oscillation rate at which hypotheses are taken up, doubted and taken up again does not quite approach that of eyeblinks, but it sometimes seems in danger of getting there.

One such reverberating question is whether the newly discovered, heavy, oddly behaving particles called psi's (or sometimes J's) are evidence for the existence of a property (quantum number) called charm (SN: 1/25/75, p. 58). Charm is important because its existence opens a new chapter in the theory of how particles are structured as well as closing some holes in the old one.

At first quite a number of theorists saw the psi's as evidence of charm. But then it began to seem suspicious. If charm was correct, there ought to be more than two psi's, and searches did not find any. Now there may be evidence for a new psi.

The same occurrence has been seen in two experiments (at least). Both are continuing searches for whatever may happen when electrons and positrons collide. One is run by an international European group of physicists at the Deutsches Elektronen-Synchrotron's DORIS storage ring in Hamburg; the other is operated by a collaboration of physicists from the Stanford Linear Accelerator Center and the Lawrence Berkeley Laboratory at SLAC's SPEAR storage ring in Palo Alto, Calif.

The event observed in both places is a double-photon decay of the heavier known psi, the psi (3700). That is, the psi (3700) turns itself into the psi (3100), giving off two photons on the way. The simplest way to interpret this is as a two-step process: The psi (3700) decays first to a related particle with a mass somewhere between 3700 million electron-volts and 3100 million electron-volts; that particle then decays to the psi (3100). It seems the Hamburg group is claiming the existence of a new particle. The California workers are more cautious, saying in the person of Roy F. Schwitters that they have no *direct* evidence yet for a third psi.

If it turns out to be one, the charm business is likely to turn sweet again. Until something else happens. The connection between theory and behavior in particle physics seems a bit strained to some in the field. Victor F. Weisskopf, whose career has hardly ended with his recent retirement from Massachusetts Institute of Technology, tells the story of the Austrian timetable: Austrian trains are always late. A Prussian visitor asks why they bother to publish timetables. "If we didn't," says the Austrian conductor, "we wouldn't know how late the trains are. *Alle aufgestiegen!*" □