A three-part series exploring the mechanisms of sleep and its effect on the body.

The Biology of Sleep

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For many people with CFS, the lack of sound slumber makes sleep a high-priority topic. The next four issues of the CFIDS Chronicle *will explore the biology of sleep, trying to understand its effects on the human body and possible implications in people with CFS. In this first installment, we cover the basic mechanisms of sleep and the critical functions it serves.*

Sleeping is something many people take for granted—something we all do without taking stock of the reasons it occurs or the purposes it serves. Obviously sleep must be a vital function since nearly every living organism requires it. Certainly the disruption of sleep can contribute to a host of physical problems, as anyone with CFS-related sleep dysfunction can attest. But what exactly is sleep and why is it so important to proper functioning?

Until the 1950s, most people thought of sleep as a passive, dormant part of our daily lives. We now know that our brains are very active during slumber. Sleep affects our daily functioning and our physical and mental health in a multitude of ways that we're just beginning to understand.

Falling asleep

Our bodies provoke us to sleep according to a *circadian rhythm*—an inner, time-governed mechanism that controls body temperature and the release of certain hormones. These circadian-driven changes in mental and physical attributes occur over the course of each day (*circadian* is Latin for "around a day".) Most circadian rhythms are controlled by the body's biological clock (the *suprachiasmatic nucleus* or SCN)—a pair of tiny structures in the brain that together contain about 20,000 neurons.

Sleepiness occurs as the circadian mechanism, primarily driven by light-induced cues from the SCN, causes the release of the hormone *melatonin* and a gradual decrease in core body temperature. This is all part of the process called *sleep initiation*.

In another sleep-related chemical process, *adenosine*—a neurotransmitter that dampens many of the bodily processes that make us feel awake—helps prepare the body for rest. Adenosine is produced throughout the day as our cells create the power needed for us to move and function. As the level of adenosine builds up in our brains, we feel sleepier. Along with corresponding messages from the circadian clock, this alerts our bodies that it's time to sleep.

In sleep science, *sleep latency* is the length of time that it takes to go from full wakefulness to falling asleep. During daytime, a sleep latency of 15-25 minutes is considered normal. Shorter sleep latency is a likely sign of recent or ongoing sleep deprivation. Longer sleep latency could be a sign of *sleep onset insomnia*.

The stages of sleep

What happens during that time between when we close our eyes at night and when we wake up the next day? As it turns out, a lot. As we sleep, our brains initiate a repeating cycle of graduated changes in the mind and body. This is called the sleep cycle, and disruptions or impediments to this cycle plague many people with CFS. Let's look at how the normal sleep cycle progresses.

Prior to starting the sleep cycle, we first spend a few moments in a state of "relaxed wakefulness." Most people stay in this state for up to 10 minutes before entering the first stage of sleep. Problems with sleep latency can affect the amount of time spent in this presleep state.

Stage 1 (drowsy sleep): During stage 1, also known as somnolence, we drift in and out of sleep and can be awakened easily. Our eyes move very slowly and muscle activity slows. People awakened from stage 1 sleep often remember fragmented visual images. Many also experience sudden muscle contractions called *hypnic myoclonia*, preceded by a sensation of falling. This stage of sleep normally lasts just 5 or 10 minutes.

Stage 2 (light sleep): When we enter stage 2 sleep, our eye movement stops and our brain waves (fluctuations of electrical activity) become slower, with occasional bursts of rapid waves called *sleep spindles*. Awareness of the external environment ceases.

Stages 3 and 4 (deep sleep): As our bodies enter deeper sleep, also known as slow wave sleep, our brains begin producing delta waves. The primary difference between stages 3 and 4 is the amount of delta wave activity, which grows to account for more than 50 percent of brain wave activity in stage 4 sleep. During stages 3 and 4 we are difficult to awaken and, if awakened, may not adjust immediately, feeling groggy and disoriented. These are also the stages of sleep where sleepwalking or night terrors occur.

REM sleep (dream sleep): At about 70-90 minutes into the sleep cycle, we experience REM (rapid eye movement) sleep. When we switch into REM sleep, our breathing becomes more rapid, irregular and shallow, our eyes jerk rapidly in various directions and our limb muscles are temporarily shut down. Heart rate increases and blood pressure rises during this cycle. This is the state where most dreaming occurs.

Throughout the night, the body moves through several of these sleep cycles. A complete sleep cycle normally takes about 90-110 minutes. The first cycles each night contain relatively short REM periods and long periods of deep sleep. As the night progresses, REM sleep periods increase in length while deep sleep decreases. By morning, people spend nearly all their sleep time in stages 1, 2 and REM. The inability to complete a full sleep cycle or to return to sleep after a cycle is interrupted is called *sleep maintenance insomnia*—another sleep disturbance experienced by a number of people with CFS.

Each stage of sleep offers benefits to the sleeper. However, REM sleep and deep sleep appear to be more vital because, when we're deprived of sleep, our brains will attempt to recover REM and deep sleep the next time we slumber.

For instance, if REM sleep is disrupted one night, our bodies don't follow the normal sleep progression the next time we doze off. Instead, we often go through extended periods of REM until we "catch up" on this stage of sleep. If deep sleep and REM sleep have both been lost, our brain attempts to catch up on the deep sleep stages first. In fact, the brain will try to make up all of the deep sleep it has lost and only half of the REM sleep.

When it comes to sleep and CFS, research has shown that the characteristic delta waves of deep sleep may be intruded upon by bursts of alpha waves more common to wakefulness. A 2008 study in the *American Journal of Physiology* also suggests that the transitions between sleep stages may be altered in people with CFS, particularly in light sleep and REM sleep.

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The purpose of sleep

Although scientists are still trying to learn exactly why people need sleep, numerous studies show that sleep influences many body functions and, in fact, is necessary for survival. Animal studies show that, while rats normally live for two to three years, those deprived of REM sleep survive only about five weeks on average, and rats deprived of all sleep stages live only about three weeks.

Research is also uncovering the ways that sleep may help to restore and rejuvenate many body functions:

Nervous system: Some sleep experts suggest that neurons used during the day repair themselves during sleep. Without sleep, these nerve cells may become so depleted in energy or so polluted with byproducts of normal cellular activities that they begin to malfunction. Sleep also may give the brain a chance to exercise connections that might otherwise deteriorate from lack of activity.

Cell maintenance: Many of the body's cells show an increase in protein production and a reduction in the breakdown of proteins during deep sleep. Since proteins are needed for cell growth and repair, deep sleep may act as a "pit stop" for cellular maintenance to occur. In another maintenance-like process, during deep sleep, blood flow redirects itself towards the muscles, possibly rejuvenating physical capacity.

Memory and learning: Studies in both humans and animals are providing evidence that sleep assists some types of memory and learning, allowing the brain to process newly learned information and to better retain memories of it.

Immune system: Sleep appears to have close ties to the immune system. Without adequate sleep, immune function weakens, and the body becomes more vulnerable to infection and disease. Studies also show that sleep deprivation can impede wound healing and reduce the amount of white blood cells circulating in the body.

The outlook

Clearly sleep is a dynamic state that greatly influences our waking hours and is key to maintaining important body functions. So it's not surprising that poor sleep or too little sleep can negatively affect our health—something that people with CFS can scarcely afford to experience.

Growing evidence suggests that a lack of sleep increases the risk for a variety of health problems, including diabetes, cardiovascular disease, stroke, depression, high blood pressure, obesity and infections. But help may be on the horizon.

Sleep research is expanding and attracting more attention from scientists. Brain imaging technology is helping researchers understand how different brain regions function during sleep and how particular activities and disorders affect the process. At the same time, sleep research on people with CFS is starting to uncover specific anomalies that occur within this group. As knowledge from this exploration evolves and converges, better therapies are likely to emerge for the sleep disorders that so many people with CFS experience.

Next up: How poor sleep can affect the body's regulatory systems. Plus tips for sleeping better!

EVALUATING YOUR SLEEP FUNCTION

CFS and poor sleep often seem to go hand-in-hand. That can make it challenging to sort out how much pain, cognitive problems and exhaustion are a result of sleep dysfunction versus the effects of CFS.

One way to start unraveling the mystery is to evaluate your sleep function. Two common sleep studies used to help diagnose sleep-related problems are *polysomnography (PSG)* and the *multiple sleep latency test (MSLT)*.

Polysomnography records the physical changes that occur while you sleep. Usually conducted at a sleep center, the test records brain activity, eye movements, heart rate and blood pressure. It also records the amount of oxygen in your blood and any changes in your breathing. The results are used to help diagnose insomnia, sleep apnea, narcolepsy, sleep-related seizure disorders and parasomnias (such as sleepwalking).

The **MSLT** evaluates how quickly and effectively you're able to fall alsleep. It's a daytime test, typically done the day after a sleep study. You relax in a quiet room for 30 minutes while brain activity is monitored. The MSLT can help diagnose sleep disorders such as narcolepsy, idiopathic hypersomnia (excessive sleeping) and circadian rhythm disorders. The test is repeated three or four times because your ability to fall asleep can vary at different times of the day.

Adequately addressing sleep problems can often improve some of the symptoms of CFS. Armed with the results of one or both of these tests, you and your doctor may be able to better manage any sleep-related issue you may be experiencing.