

# Understanding Sleep

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Spring 2000

We spend approximately one third of our lives sleeping. During sleep, our eyes are closed; muscles are relaxed; and breathing is regular. Our body seems to be stopped. In reality, the brain is very active during sleep.

Sleep is a source of good health. The failure to get a good night's sleep is one of the most harmful enemies to health, both mental and physical. Getting adequate sleep makes a difference in your moods and your efficiency on the job and at home

Yet so many people take sleep for granted. Many people say they don't want to waste time sleeping. Too much work, study, family life, entertainment, to do. The fact is, everyone needs sleep. Without sleep, people are less efficient and more irritable. Sleep gives your body a chance to rest and make any necessary repairs, not just from illness and injury, but from the stress and strain of everyday life.

However, the majority of people suffer, to some degree, from sleep deprivation. As mentioned above, some of this may be by choice, from trying to combine a work schedule and social responsibilities to the loss of sleep.

## 1 Sleep and You

### 1.1 Falling Asleep

The average person takes about 10 minutes to fall asleep and sleeps about seven to eight hours a night. Babies sleep about 18 hours a day while adults may get along on six hours of sleep every night.

Sleep allows your body to recharge itself. While you sleep, your body gets rid of skin waste and circulates minerals, vitamins and hormones. It is also the time when your body produces the most amount of infection-fighting substances. That's why bed rest is so important when you have a cold.

### 1.2 Brain During Sleep

In the brain, there are nerve-signaling chemicals called "neurotransmitters." They control whether we are asleep or awake by acting on different groups of neurons. Neurons or nerve cells reside in the brainstem, constituting the brain, spinal column, and nerves, consisting of a nucleated cell body with one

or more dendrites and a single axon. Neurotransmitters such as serotonin and norepinephrine are produced. They keep some parts of the brain active while we are awake. Other neurons at the base of the brain begin signaling when we fall asleep. These neurons appear to “switch off” the signals that keep us awake.

Scientists record brain activity by attaching electrodes to the scalp and then connecting these electrodes to a machine called an electroencephalograph. The record of brain activity recorded with this machine is called the encephalogram (EEG). The wavy lines of the EEG are what most people know as “brain waves.”

## 2 Sleep Stages

Sleep involves two kinds of resting periods: quiet sleep (stage 1, 2, 3, and 4) and active sleep (rapid-eye-movement (REM) stage). Throughout the night, you shift from quiet sleep to active sleep and back to quiet sleep (Figure 1). This basic sleep cycle takes an average of about 90 to 110 minutes and occurs four to five times every night. The first sleep 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.

We spend almost 50 percent of our total sleep time in stage 2 sleep, about 20 percent in REM sleep, and the remaining 30 percent in the other stages. Infants, by contrast, spend about 50 percent of their sleep time in quiet sleep and 50 percent in REM. Elderly people spend less than 15 percent of their sleep time in REM stage.

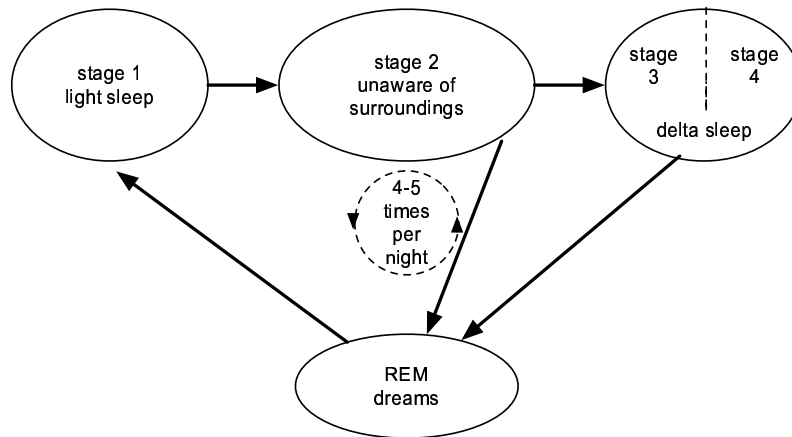


Figure 1: Normal sleep cycle. Throughout the night you shift from quiet sleep stages (1, 2, 3, and 4) to active sleep stage (REM), and back to quiet stages again.

During quiet, or non-REM, sleep, body functions start slowing down and brain wave activity becomes irregular. We have a uniform heart rate and breathing. The eyes move slowly. The body is not receiving instructions for movement. The quiet sleep has three phases:

## **2.1 Stage 1**

This is light sleep stage. As you fall asleep, your muscles begin to relax, your heart rate decreases and brain waves slow down and get more irregular. You are still aware of your surroundings. People awakened from stage 1 sleep often remember fragmented visual images. This stage lasts only a few minutes before you to into the next stage.

Many people experience sudden muscle contractions called “hypnic myoclonia,” often preceded by a sensation of starting to fall.

## **2.2 Stage 2**

Your body functions slow down even more and your thoughts become fragmented. Your eye movements stop and brain waves become slower. There may be occasional bursts of rapid waves called “sleep spindles.” Although you are unaware of your surroundings, you can awaken easily. This stage lasts from five to 20 minutes.

## **2.3 Stages 3 and 4 (Delta or Deep Sleep)**

Your brain is at its lowest state of consciousness. The term “delta” refers to extremely slow brain waves appearing in stage 3. Your muscles are relaxed and your body functions decrease. By stage 4, the brain produces delta waves almost exclusively. It is very difficult to wake someone during stages 3 and 4, thus these stages are together called “deep sleep.” There is no eye movement or muscle activity. People awakened during deep sleep often feel disoriented. Unless you have enough delta sleep at night, you will feel tired the next day; no matter how much stage 1 and stage 2 sleep you get.

## **2.4 REM stage**

After delta sleep, you may go into active sleep which is distinguished by rapid eye movement under closed eyelids that occur during this period. In REM sleep, your body experiences an increase in heart rate, blood pressure, gastric acid (in people with ulcers), body temperature, metabolic rate, blood flow in the brain, and glucose consumption. Because the heart becomes more vigorous, it might be one reason for the heart attacks which some people experience during sleep.

REM sleep periods last about 10 minutes. Research shows that it is the time when you dream the most actively. Studies of sleepers awakened during REM sleep show that subjects are able to vividly recall their dreams 80 percent of the

time. Sleepers awakened during quiet sleep remembered their dreams less than 10 percent of the time.

Our respiration rate varies according to the content of the dream; if we dream that we are running, we breathe rapidly. Our large muscles become very relaxed and, in a sense, paralyzed (sleep paralysis)—probably because those muscles cannot perform what we are dreaming. The sexual organs are stimulated. The body is more physiologically active during later REM periods than it is during the first period.

## **3 Amount of Sleep**

### **3.1 How Much Sleep We Need**

The amount of sleep each person needs depends on many factors, including age. Infants generally require about 16 hours a day, while teenagers need about nine hours on average. For most adults, seven to eight hours a night appears to be the best amount of sleep. Women in the first three months of pregnancy often need several more hours of sleep than usual. The amount of sleep a person needs also increases if he or she has been deprived of sleep in previous days. Getting too little sleep creates a “sleep debt.” Eventually, your body will demand that the debt be repaid. We don’t seem to adapt to getting less sleep than we need; while we may get used to a sleep-depriving schedule, our judgment, reaction time, and other functions are still impaired.

People tend to sleep more lightly and for shorter time spans as they get older, although they generally need about the same amount of sleep as they needed in early adulthood. About 50 percent of people over 65 have frequent sleeping problems. Deep sleep stages in many elderly people often become very short or stop completely.

Experts say that if you feel drowsy during the day, even during boring activities, you haven’t had enough sleep. If you routinely fall asleep within five minutes of lying down, you probably have severe sleep deprivation, possibly even a sleep disorder such as narcolepsy. Microsleeps are very brief episodes of sleep during a person’s waking hours; they are the sign of sleep deprivation.

### **3.2 Danger of Sleep Deprivation**

Sleep-deprived people who are tested by using a driving simulator or by performing a hand-eye coordination task perform as badly as or worse than those who are intoxicated. Sleep deprivation also magnifies alcohol’s effects on the body. Driver fatigue is responsible for an estimated 100,000 motor vehicle accidents and 1500 deaths each year, according to the National Highway Traffic Safety Administration. Driving while drowsy often lead to disaster. Caffeine and other stimulants cannot overcome the effects of severe sleep deprivation. The National Sleep Foundation says that if you have trouble keeping your eyes

focused, if you can't stop yawning, or if you can't remember driving the last few miles, you are probably too drowsy to drive safely.

## 4 Values of Sleep

### 4.1 Studies of Animal Lifetime

Animal studies show that sleep is necessary for survival. For example, while rats normally live for two to three years, average lifetime of those deprived of REM sleep is only five weeks, and of those deprived of all sleep stages live is only three weeks. Sleep-deprived rats also develop abnormally low body temperatures and sores on their tail and paws. The sores may develop because the rats' immune systems become impaired. Some studies suggest that sleep deprivation affects the immune system in detrimental ways.

### 4.2 Nervous Systems

Sleep appears necessary for our nervous systems to work properly. If we have too little sleep, we feel drowsy and unable to concentrate the next day. It also leads to impaired memory and physical performance and reduced ability to carry out math calculations. If sleep deprivation continues, hallucinations and mood swings may develop. Some experts believe sleep gives neurons used while we are awake a chance to shut down and repair themselves. Without sleep, neurons 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 important neuronal connections that might otherwise deteriorate from lack of activity.

### 4.3 Deep Sleep and Hormone

Deep sleep coincides with the release of growth hormone in children and young adults. Many of the body's cells also show increased production and reduced breakdown of proteins during deep sleep. Since proteins are the building blocks needed for cell growth and for repair of damage from factors like stress and ultraviolet rays, deep sleep may truly be "beauty sleep."

Activity in parts of the brain that control emotions, decision-making processes, and social interactions is drastically reduced during deep sleep, suggesting that this type of sleep may help people maintain optimal emotional and social functioning while they are awake. A study in rats also showed that certain nerve-signaling patterns which the rats generated during the day were repeated during deep sleep. This pattern repetition may help encode memories and improve learning.

## 5 Dreaming

We typically spend more than two hours each night dreaming. Scientists do not know much about how or why we dream. Psychologist Sigmund Freud believed dreaming was a “safety valve” for unconscious desires. When researchers first described REM in sleeping infants in 1953, serious and careful studies of sleep and dreaming began. Researchers soon realized that the strange, illogical experiences we call dreams almost always occur during REM sleep.

While most mammals and birds show signs of REM sleep, reptiles and other cold-blooded animals do not.

### 5.1 REM Signals

REM sleep begins with signals from an area at the base of the brain called the “pons” (see Figure 2). These signals travel to a brain region called the thalamus, which relays them to the cerebral cortex the outer layer of the brain that is responsible for learning, thinking, and organizing information. The pons also sends signals that shut off neurons in the spinal cord, causing temporary paralysis of the limb muscles. If something interferes with this paralysis, people will begin to physically “act out” their dreams - a rare, dangerous problem called REM sleep behavior disorder. A person dreaming about a ball game, for example, may run headlong into furniture or blindly strike someone sleeping nearby while trying to catch a ball in the dream.

### 5.2 REM Sleep and Learning

REM sleep stimulates the brain regions used in learning. This may be important for normal brain development during infancy, which would explain why infants spend much more time in REM sleep than adults. Like deep sleep, REM sleep is associated with increased production of proteins. One study found that REM sleep affects learning of certain mental skills. People taught a skill and then deprived of non-REM sleep could recall what they had learned after sleeping, while people deprived of REM sleep could not.

## 6 Body Clock

### 6.1 Circadian Rhythms

Circadian rhythms are regular changes in mental and physical characteristics that occur in the course of a day. Most circadian rhythms are controlled by the body’s biological clock. This clock, called the “suprachiasmatic nucleus” or SCN (see Figure 2), is actually a pair of tiny brain structures that together hold about 20,000 neurons. The SCN rests in a part of the brain called the hypothalamus. Light that reaches photoreceptors in the retina creates signals that travel along the optic nerve to the SCN.

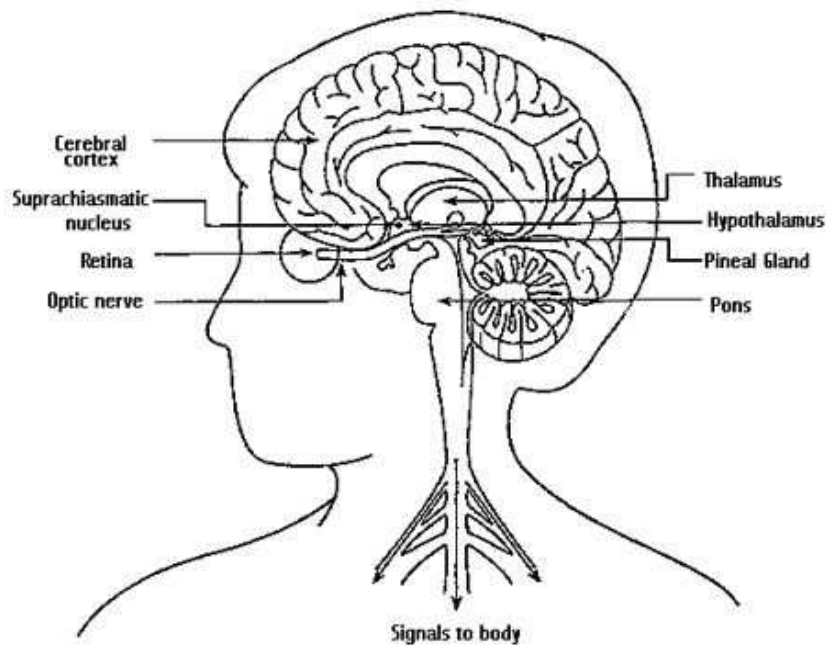


Figure 2: The parts of brain responsible for REM sleep. Signals sent from pons travel throughout various parts of the brain, creating REM stage.

Signals from the SCN travel to several brain regions, including the pineal gland, which responds to light-induced signals by switching off production of the hormone melatonin. The body’s level of melatonin normally increases after darkness falls, making people feel drowsy. The SCN also governs functions that are synchronized with the sleep/wake cycle, including body temperature, hormone secretion, urine production, and changes in blood pressure.

## 6.2 25-Hour Cycle

By depriving people of light and other external time cues, scientists have learned that most people’s biological clocks work on a 25-hour cycle rather than a 24-hour one. But because sunlight or other bright lights can reset the SCN, our biological cycles normally follow the 24-hour cycle of the sun, rather than our innate cycle. Circadian rhythms can be affected to some degree by almost any kind of external time cue, such as the beeping of your alarm clock, the clatter of a garbage truck, or the timing of your meals. These external time cues are called “zeitgebers” (German for “time givers”).

### 6.3 Jet Lag

When travelers pass from one time zone to another, they suffer from an uncomfortable feeling known as “jet lag.” When you move, your body clock does not immediately synchronize with the new local clock. It usually takes several days for your body’s cycles to adjust to the new time.

Light therapy can be used to manipulate the biological clock to reduce the jet lag effects. Patients are exposed to special lights for several hours near the time the subjects want to wake up. This helps them reset their biological clocks and adjust to a new time zone.

### 6.4 Shift Work

People who work nights or who perform shift work suffer from feeling like jet lag. They often become uncontrollably drowsy during work due to their schedules do not synchronize with time of day, and they may suffer insomnia or other problems when they try to sleep. Shift workers have an increased risk of heart problems, digestive disturbances, and emotional and mental problems. The number and severity of workplace accidents also tend to increase during the night shift. One study also found that medical interns working on the night shift are twice as likely as others to misinterpret hospital test records, which could endanger their patients.

It may be possible to reduce shift-related fatigue by using bright lights in the workplace, minimizing shift changes, and taking scheduled naps.

### 6.5 People with Blindness

Many people with total blindness experience life-long sleeping problems because their retinas are unable to detect light. These people experience permanent jet lag and periodic insomnia because their circadian rhythms follow their innate 25-hour cycle rather than a 24-hour one.

Melatonin may improve night-time sleep for such patients. However, long-term use of melatonin may create harmful side effects.

## 7 Sleep Disorders

At least 40 million Americans suffer from chronic sleep disorders each year, and an additional 20 million experience occasional sleeping problems. These disorders and the resulting sleep deprivation interfere with work, driving, and social activities. Doctors have described more than 70 sleep disorders, most of which can be managed effectively once they are correctly diagnosed. See Table 1 for number of US Population affected by some kind of sleep disorders. The most common sleep disorders include insomnia, sleep apnea, restless legs syndrome, and narcolepsy.



Disorder	US Pop Affected	% of Adult Pop Affected
Insomnia	60 millions	33
Sleep Apnea	18 millions	20
Restless Legs Syndrome	12 millions	10-15
Narcolepsy	136500	0.05

Table 1: US population affected by sleep disorders.

## 7.1 Insomnia

Almost everyone occasionally suffers from short-term insomnia. Insomnia is the inability to get adequate, restful sleep. Insomnia happens more in women than in men (at ratio about 4 to 3), and in older people than younger people. Factors such as stress, jet lag, and diet can cause insomnia.

Sleeping pills are usually prescribed to people with short-term insomnia. Long-term use of such pills, however, can actually interfere with good sleep. They can make it harder for you to fall asleep. They can be dangerous for people with certain illnesses. A better method for treating mild insomnia is practicing good sleep habits. For more serious cases of insomnia, researchers are experimenting with how to alter circadian cycles. One such method is light therapy.

## 7.2 Sleep Apnea

Sleep apnea is a disorder of interrupted breathing during sleep. It usually occurs in association with fat buildup or loss of muscle tone with aging. Sleep apnea is most common in adults over 60. We snore more as we get older because our muscles become increasingly flaccid with age. Gaining weight can increase snoring because fat accumulates in the airway tissues, narrowing the line of airflow. The person's effort to inhale air creates suction that collapses the windpipe. This blocks the air flow for 10 seconds to a minute while the sleeping person struggles to breathe (see Figure 3).

When oxygen level in blood falls, the brain responds by awakening the person enough to tighten the upper airway muscles and open the windpipe. The person may snort or gasp, then resume snoring. This cycle may be repeated hundreds of times a night. The frequent awakenings cause people with sleep apnea to feel sleepy. The lack of restful sleep may lead to irritability or depression. Oxygen deprivation can lead to morning headaches, a loss of interest in sex, or a decline in mental functioning. It also is linked to high blood pressure, irregular heartbeats, and an increased risk of heart attacks and stroke. Patients with severe, untreated sleep apnea are two to three times more likely to have automobile accidents than the general population. Sleep apnea may even lead to sudden death from respiratory arrest during sleep.

Patients with the symptoms of sleep apnea, such as loud snoring and excessive daytime sleepiness, should be treated with a test called "polysomnography." This test records the patient's brain waves, heartbeat, and breathing during an

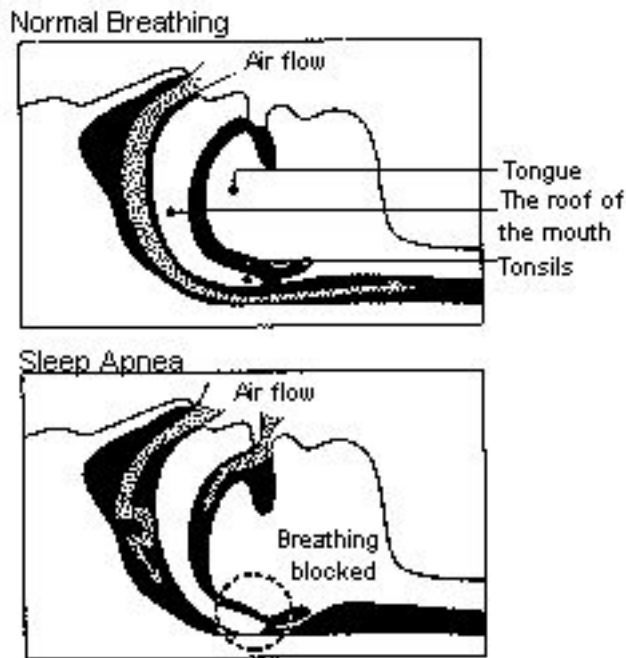


Figure 3

Figure 3: Obstructive sleep apnea. The windpipe collapses during breathing when muscles relax during sleep.

entire night. Several treatments for narcolepsy are available. Mild sleep apnea frequently can be overcome through weight loss or by preventing the person from sleeping on his or her back. In more serious cases, special devices or surgery may be needed. People with sleep apnea should never take sedatives or sleeping pills, which can prevent them from awakening enough to breathe.

### 7.3 Restless Legs Syndrome

Restless legs syndrome (RLS) is a disorder that causes unpleasant crawling, prickling, or tingling sensations in the legs and feet and an urge to move them for relief. This disorder is emerging as one of the most common sleep disorders, especially among older people. Almost half of patients over age 60 who complain of insomnia are diagnosed with RLS. RLS could be inherited from a close relative, most likely a parent.

Many RLS patients also have a disorder known as “periodic limb movement disorder” or PLMD, which causes repetitive jerking movements of the limbs,

especially the legs. These movements occur every 20 to 40 seconds and cause repeated awakening and severely fragmented sleep. In one study, RLS and PLMD accounted for a third of the insomnia seen in patients older than age 60.

RLS and PLMD often can be relieved by drugs that affect the neurotransmitter dopamine.

## 7.4 Narcolepsy

Narcolepsy is a neurological disorder. This serious disease involves the central nervous system. People with narcolepsy have frequent “sleep attacks” at various times of the day, even if they have had a normal amount of night-time sleep. People with narcolepsy also may experience cataplexy (loss of muscle control during emotional situations), hallucinations, temporary paralysis when they awaken, and disrupted night-time sleep.

The disorder is usually hereditary, but it occasionally is linked to brain damage from a head injury or neurological disease. Narcolepsy affects approximately the same number of people affected by Parkinson’s Disease. Narcolepsy usually begins in adolescence. Most people with narcolepsy go through their lives undiagnosed. It often takes years to obtain a correct diagnosis. Stimulants, antidepressants, or other drugs are used to help control the symptoms and prevent the effects of narcolepsy. See Table 2 for the drugs currently used in narcolepsy treatment.

Agent	Trademark	Function	Dose (mg/day)
Methylphenidate	Ritalin	Mild stimulant	10-60
Dextroamphetamine	Dexedrin	Stimulant	5-60
Methamphetamine	Desoxyn	Stimulant	5-60
Pemoline	Cylert	Mild stimulant	37.5-150
Mazindol	Mazanor, Sanorex	Stimulant	2-8
Imipramine	Tofranil	Antidepressant / anti-enuretic	25-200
Desipramine	Norpramine	Antidepressant	25-200
Protriptyline	Vivactil	Antidepressant	5-30
Nortriptyline	Pamelor	Tranquilizer / antidepressant	50-200
Fluxetine	Prozac	Antidepressant	20-80
Modafinil	Provigil	Stimulant	100-200

Table 2: Agents used in narcolepsy treatment.

Recently, a research team at Stanford University studied the Doberman Pinscher dogs that suffer from narcolepsy. After finding a defective gene responsible for canine narcolepsy, they identified an equivalent human gene. It is speculated that there may be additional genes involved. Understanding the exact relationship between the defective genes and the sleep system would be a major medical accomplishment and should yield new approaches in the preventing and curing of narcolepsy in humans. This may lead to a new understanding of how the brain regulates sleep and new ways of preventing or controlling narcolepsy.

## **8 Conclusion**

Sleep is a necessary part of life, like food and water. Your body refreshes itself during sleep, so it can work well during the day. Scientists now know that sleep is a dynamic state of brain and body. Understanding the factors that affect sleep will lead to revolutionary new therapies for sleep disorders.

Remember that getting a good night's sleep is the one of the best things you can do for yourself. Don't forget to do it tonight.

## **9 Disclaimer**

This work was part of my Physics 129W class at UC Irvine, and was more of a self reference (and education) than a true research paper. Facts and figures were gathered from many sources. Unfortunately I did not keep track of them.