

An Intro to Sleep: What is Sleep?

Sleep is a physical and mental resting state in which a person becomes relatively inactive and unaware of the environment. In essence, sleep is a partial detachment from the world, where most external stimuli are blocked from the senses.

Normal sleep is characterized by a general decrease in body temperature, blood pressure, breathing rate, and most other bodily functions. In contrast, the human brain never decreases inactivity. Studies have shown that the brain is as active during sleep as it is when awake. Throughout an eight-hour sleep cycle, a normal adult alternates between two very different states, non-REM and REM (Rapid Eye Movement) sleep.

What is the Sleep Cycle?

Sleep is characterized by two distinct states, non-REM sleep and REM sleep. Non-REM and REM sleep alternate in 90- to 110-minute cycles. A normal sleep pattern has 4-5 cycles. The diagram and descriptions below illustrate the architecture of sleep. This explains why the cycles of sleep have been compared to going up and down a stairway.

The five-step sleep cycle repeats itself throughout a night of sleeping, much like a roller coaster. As a person drifts off, Stage 1 begins. After a few minutes, the EEG detects sleep. It may take anywhere from 30 – 40 minutes to cycle through Stage 2 through 4. Now, an individual backtracks through Stage 3, then Stage 2, and finally into REM sleep. This occurs 4 - 5 times per night.

Non-REM Sleep

Non-REM sleep consists of four stages that range from light dozing to deep sleep. Throughout this state of sleep, muscle activity is still functional, breathing is low, and brain activity is minimal. Approximately 75% of the sleep cycle is spent in non-REM sleep. Simple thought processes may be reported if a person is awakened in any stage of non-REM sleep; however, he or she will not usually recall any specific dream.

Wakefulness - This is a state of awareness in which an individual is conscious of his or her surrounding environment and has the ability to interact with it. In the period before sleep, wakefulness is described as quiet wakefulness, where the individual is resting in a relaxed condition with his or her eyes closed. This stage is characterized by alpha and beta waves activity.

Wakefulness is characterized by fast, low voltage EEG activity with both alpha and beta waves present. [Picture courtesy of Dr. Russell Rosenberg]

Stage 1

This stage could be termed the "dozing" stage. Only 5% of non-REM sleep is spent in Stage 1. It is the transitional period of very light sleep. Although the muscles and breathing rate begin to relax, the individual can still be awakened easily. It is during this stage that often, a sleeping individual may experience the sensation of falling and jerk suddenly into wakefulness. This is called a hypnic jerk. After this rush of activity subsides, the body begins to drift into a light slumber.

Stage 1 Sleep is a transition period from wakefulness to sleep. It is characterized by low voltage EEG and slow rolling eye movements. [Picture courtesy of Dr. Russell Rosenberg]

Stage 2

This stage is often considered the official onset of consolidated sleep. Approximately 45% of non-REM sleep is spent in Stage 2. Eye movements stop and brain waves become larger. Stage 2 Sleep is graphically defined with two distinct brain wave forms called sleep spindles and K-complexes. A sleep spindle is a pattern of EEG waves, consisting of a burst of 11 to 15 hertz waves that last for .5 to 1.5 seconds. A K-complex is high voltage EEG activity that consists of a sharp downward component followed by a slower upward component and lasts more than .5 second.

Stage 2 Sleep is characterized by a lack of eye movements, sleep spindles and K-complexes. Note the K-complexes and sleep spindles. [Picture courtesy of Dr. Russell Rosenberg]

Stage 3

As sleep advances progressively deeper, an individual becomes difficult to arouse. A person spends approximately 12% of non-REM sleep in this stage. Actual slow wave sleep begins as large and slow delta waves intermingle with smaller, faster ones. This stage of sleep is characterized by 20 to 40% of slow wave (delta) sleep.

Stage 4

Stage 4 is characterized by very deep sleep. Of the roughly 75% of non-REM sleep, approximately 13% is spent in this final stage. A person in one of the two latter stages, either 3 or 4, is harder to wake than a person in Stage 1 or 2. People who wake during deep sleep often feel groggy and disoriented for several minutes. By the time a person shifts into Stage 4, the brain produces delta waves almost exclusively.

Greater than 50% of Stage 4 Sleep is characterized by delta waves. Note that there are few graphical differences between Stage 3 and Stage 4. [Picture courtesy of Dr. Russell Rosenberg]

REM Sleep

Most dreaming takes place during REM (Rapid Eye Movement) sleep. Periodic eyelid fluttering, muscle paralysis, and irregular breathing, body temperature, heart rate, and blood pressure distinguish REM from non-REM sleep stages. REM sleep is also called "paradoxical" sleep because brain wave activity is similar to an awakened state. It is during REM sleep that the brain blocks signals to the muscles to remain immobile so dreams will not be acted out. Adults spend about 20 - 25% of their sleep cycle in REM sleep.

The EEG activity during REM sleep shows mixed frequency and low voltage with occasional bursts of "sawtooth" waves. Compare this EEG pattern with the wakefulness pattern. [Picture courtesy of Dr. Russell Rosenberg]

What Determines When We Sleep?

A major reason why humans sleep is due to circadian rhythms, also known as the biological clock. A cycle that lasts 24 hours is called circadian. Some physiological functions that are circadian include body temperature and certain hormone secretions. So too, humans have a natural cycle of approximately the length of one day. Small structures in the brain called suprachiasmatic nuclei (SCN) coordinate circadian rhythms. The SCN, in turn, is very sensitive to the presence or absence of light. This may explain why daytime sleep has been found to be less restful than nighttime sleep.

Sleep and wakefulness alternate, usually between night and day, respectively. For most people, sleepy peaks occur every 12 hours, at night, and around mid-afternoon. Through a complex process of hormonal and neurological changes, daylight naturally triggers periods of wakefulness. Studies have shown, however, that the absence of light does not disable our biological clocks.

The longer a person stays awake, the more sleep he or she requires; thus, the need to sleep accumulates throughout the time of wakefulness. This regulation is called homeostatic because it allows the body to reverse the effects of sleepiness by sleeping.

Normal peaks of alertness occur during daylight hours. The mid-afternoon dip, called a postprandial dip (after lunch), is caused by a natural decrease in body temperature. When our body temperature begins to drop, we are sleepier than when it begins to rise.

Why Do We Need Sleep?

Sleep is not a waste of time. Although researchers are not exactly sure why we need sleep, there are two basic theories:

- Restorative - Sleep enables the body and mind to rejuvenate, reenergize, and restore. As a person sleeps, it is thought that the brain performs vital housekeeping tasks, such as organizing long-term memory, integrating new information, and repairing and renewing tissue, nerve cells and other biochemicals. Sleep allows the body to rest and the mind to sort out past, present, and future activities and feelings.
- Adaptive - Sleep may have evolved as a protective adaptation-finding food in the daytime and hiding at night is easier. Nearly every animal sleeps to some degree. Thus, it only makes sense that predators sleep more than animals that are prey. For humans, the amount and quality of sleep achieved is directly proportional to the amount and quality of the next day's productivity.

Resource Materials from Healthy Start Fall Forum 2009
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Why is Sleep Important?

Sleep is a necessary and vital biological function. It is essential to a person's physical and emotional well being. Studies have shown that without enough sleep, a person's ability to perform even simple tasks declines dramatically.

The average sleep-deprived individual may experience impaired performance, irritability, lack of concentration, and daytime drowsiness. They are less alert, attentive, and unable to concentrate effectively. Additionally, because sleep is linked to restorative processes in the immune system, sleep deprivation in a normal adult causes a biological response similar to the body fighting off an infection.

Persistent sleep deprivation can cause significant mood swings, erratic behavior, hallucinations, and in the most extreme, yet rare cases, death. The jury is still out on the long-term effects of sleep deprivation on health. Current research in this area is examining the effects of sleep deprivation on the immune system.

A pioneer in sleep research, Dr. William Dement, noted that most undergraduates enter college with some knowledge of personal health, but little to no knowledge of the value of sleep. He suggests that all students should not only learn the importance of physical fitness and good nutrition, but healthy sleep, calling all three the "fundamental triumvirate of health."

What are the Consequences of Sleep Deprivation?

With today's increasingly on-the-go, around-the-clock society, more people than ever are sleep deprived. People need a wake-up call, literally, to become aware of how prevalent sleep deprivation is.

In fact, it is estimated that nearly 50% of the adult population in the United States is sleep deprived. This may be attributed to longer work hours and increased commute times. It appears the price of the boost in productivity is a reduction in sleep.

So, what is happening to all of these exhausted individuals? Many tragedies that have been linked to human error were due to exhaustion. Some historic examples of severe sleep deprivation include the Exxon Valdez oil spill, the NASA Challenger shuttle explosion, and the Chernobyl nuclear accident. Unfortunately, accidents can easily happen as the result of any amount of lost sleep.

The most common consequence of lost sleep has become a public health issue - sleeping behind the wheel. One third of all drivers will fall asleep while driving at least once in their lifetime. The monetary cost is estimated at more than \$30 billion annually and the human cost is roughly 100,000 crashes, 71,000 injuries, and 1,500 fatalities each year. These figures are probably very conservative due to inaccurate statistics. Moreover, this estimate does not account for other operators "behind a wheel", such as airline pilots, boat captains, and railway conductors.

What is Sleep Debt?

According to Dr. William Dement, sleep debt is created when personal sleep requirements are not met. This is especially true of students, medical residents, busy executives, shift workers, new parents, as well as most of the remaining population. The bad news is that sleep debt accumulates, builds quickly, and does not decrease spontaneously. The good news is that the old adage "You can't make up lost sleep" is not true. Repaying sleep debt requires extra-over and above the usual requirements. In most cases, sleep debt has a natural way of resolving itself. The homeostatic relationship between wakefulness and sleep discourages normal people from becoming dangerously sleep deprived. The body reacts to a lack of sleep by having daytime drowsiness such that an intense desire to sleep induces the person to either go to sleep early or sleep in late.

How Much Sleep Do We Need?

Six to eight hours per day is the average amount of sleep a person needs. That's about one-third of a lifetime! As a population, we sleep about 1 to 1.5 hours less than we did 100 years ago.

Sleep requirements vary from person to person-some people are naturally short or long sleepers. Thomas Edison, Martha Stewart, and Jay Leno have remarked that they sleep less than five hours a night. In contrast, Albert Einstein and Calvin Coolidge claimed they needed ten or more hours per night. Other well-known people such as Ronald Reagan and Winston Churchill took naps throughout the day.

Some experts suggest that the best way to determine personal sleep requirements is by waking up without an alarm clock. The amount of time spent sleeping would be the personal requirement. Other experts suggest that an ideal amount of sleep is the amount needed to feel refreshed and well rested in the morning and alert all day. Contrary to popular belief, the amount of sleep a person needs does not decrease with age. The reality is that sleep patterns and circadian rhythms change as one ages. Infants spend 50% of their sleep time in non-REM sleep and 50% in REM sleep; it has been shown that deep sleep coincides with the release of growth hormones, necessary for growing children. Adults spend approximately 20% in REM sleep, while elderly people may spend

only 15% in REM sleep. Older adults tend to spend most of their sleep time in Stage 1 of non-REM sleep. Consequently, they have less REM sleep and report frequent awakenings.

How is Sleep Measured? How are Sleep Disorders Diagnosed?

In the past forty years, sleep research has become viewed as valuable and pertinent. The American Medical Association only recently acknowledged sleep medicine as a specialty. Advances in sleep medicine are occurring at an unprecedented rate. Using the machines and tests described below, sleep researchers have been able to study the sleep cycle and sleep-related disorders.

The initial approach that sleep specialists and researchers use to accurately diagnose sleep disorders includes a physical examination, medical history, and multiple questionnaires.

Devices such as the electroencephalogram (EEG), electrooculogram (EOG) and electromyogram (EMG) are used to measure sleep patterns. An EEG records brain wave activity. Sensors, placed on both sides of the temple, are wired to a polygraph machine that displays brain activity. An EOG is a device that traces eye movements, which are particularly active during REM sleep. Muscle tension is measured using an EMG. Typical areas where EMG electrodes are placed are under the chin and on the legs.

A polysomnogram, also called a PSG, is another word for a sleep study. A PSG is a comprehensive and non-invasive test that records vital signs and physiology during a night of sleep. The study includes results from an EEG, EMG, and EOG. It also measures respiratory airflow, blood oxygen saturation, pulse rate, heart rate, body position, and respiratory effort. The information is recorded and gathered throughout the night in order to evaluate sleep disturbances.