Dr Steven Lin – The Functional Dentist

The Five Stages of Sleep & Brain Wave Cycles

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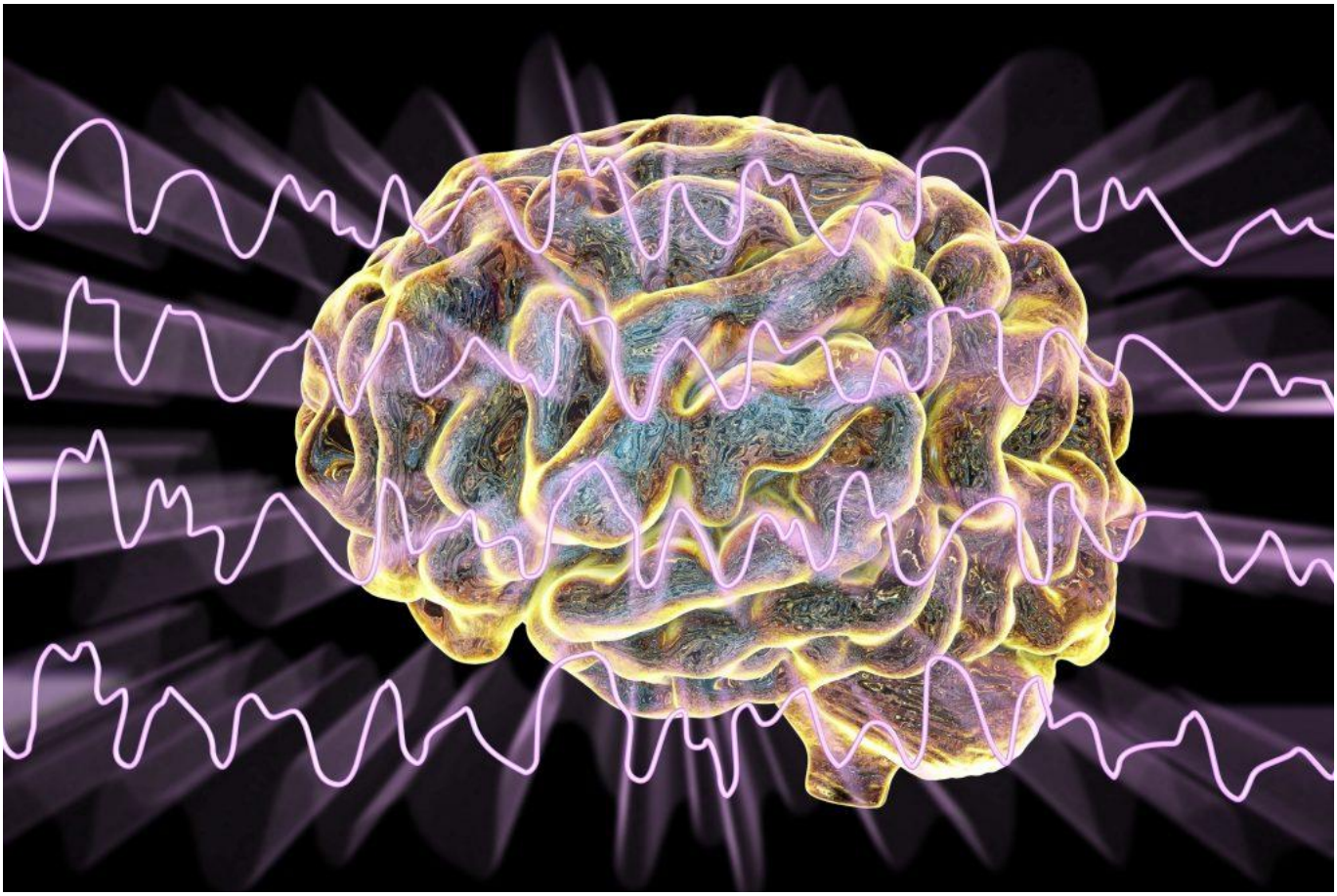

Over an entire night your brain needs to move through the various stages of sleep

In recent years we've seen a big increase in our understanding of the role that better sleep plays in health. Sleep is a critical component of brain health, yet many people don't really know what happens in the brain during the **stages of sleep**.

For a long time, it was thought the brain was inactive during sleep, but today, neuroscience has discovered that human sleep is a far more

complex process. The complex human brain needs to replenish nightly, and brain diseases like Alzheimer's and dementia are linked to poor sleep.

During the evening, the brain proceeds through the different stages of sleep. To do so, your body needs the right environment: a cool, calm, dark room with deep, restful breathing. Breathing controls the autonomic nervous system, guiding how the brain relaxes and enters deeper states to allow rapid eye movement (REM) sleep.

You may be surprised to read that REM sleep isn't the deepest stage of sleep. During the sleep stages, different brain waves guide the states of sleep consciousness. For example, lucid dreaming happens during REM stages. We'll be looking at these stages in three parts:

- **Part I: The Five Stages of Sleep**
- **Part II: Brain Waves & Sleep Stages**
- **Part III: Sleep Cycles, Light and Deep Sleep**

Sleep is a critical part of a healthy brain and body – let's understand the stages of sleep and how brain waves relate them.

Part I: The Five Stages of Sleep

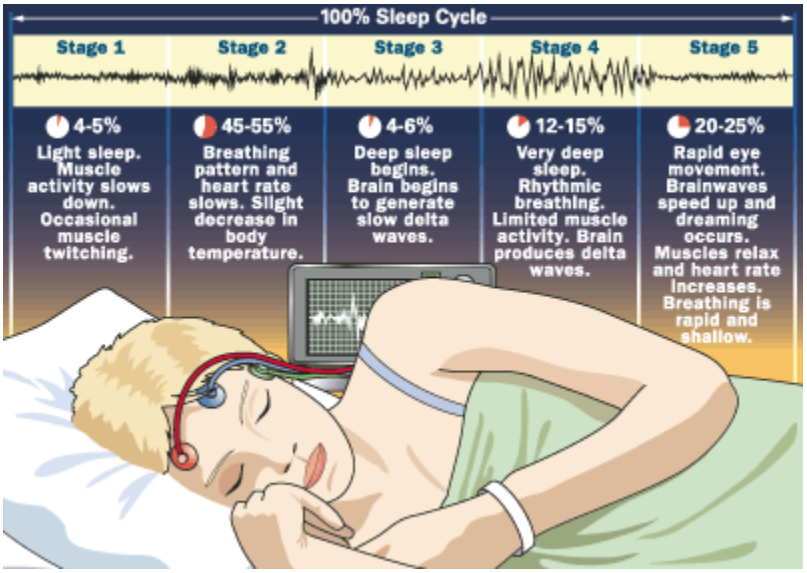

Image: The five stages of sleep and changing brain wave frequencies Source

What is the Ideal Sleep Cycle?

Eight hours sleep is the most common sleep recommendation, however, it's well reported that you should get between 7 and 9 hours sleep. One sleep cycle equates to roughly 90 minutes. During this period your brain goes through five stages of sleep.

How Many Cycles of Sleep do we Need?

During an entire night of sleep, the brain goes through a number of sleep cycles. The first four stages of sleep are called non-rapid eye movement (NREM). After two stages of light sleep in which the body is drifting and transitioning into dormancy, deep sleep arrives.

The fifth stage of sleep is called rapid eye movement (REM)**.** The body experiences bursts of rapid eye movements, and brain waves change to those we experience while being awake.

What is the Most Important Stage of Sleep?

All of the four stages of sleep are important. Sleep is a cycle, and your brain must complete each to get the full benefit. However, how much light sleep you get doesn't seem to impact how tired you feel when you wake; how much deep sleep or REM sleep you get is more vital for feeling well rested and replenished.

What are the Four Phases of Sleep?

From stage 1 to stage 4 of NREM we move down to a very deep sleep.

NREM Sleep Stages

Stage 1: is the lightest stage of NREM sleep. Often defined by the presence of slow eye movements, it's a drowsy level of sleep that can easily be disrupted, causing awakenings or arousals.

Muscle tone throughout the body relaxes and brain wave activity begins to shift from that of the waking state. People may

experience hypnic jerks (abrupt muscle spasms.) Others report a feeling of drifting or falling when moving in and out of stage 1.

Characteristics of Stage 1 NREM Sleep:

- Waking up feeling like you didn't sleep at all.
- Muscles are not inhibited yet: the eyes roll a little bit and eyelids may be slightly open.
- Breathing slows down and your heartbeat becomes regular.
- Blood pressure and brain temperature decrease.
- Some suggest the feeling of drifting may be an evolutionary hangover from when our ancestors lived in trees that prevented them from falling out of them.

Stage 2: is the first deep stage of NREM sleep. Awakenings or arousals do not occur as easily as in Stage 1 sleep, and slow moving eye rolls stop. Brain waves slow with specific bursts of rapid activity known as sleep spindles, intermixed with sleep structures known as K complexes. Both sleep spindles and K complexes are thought to protect the brain from awakening from sleep.

Characteristics of Stage 2 NREM sleep:

- Lasts about 20 minutes.
- A slowing heart rate and a decrease in body temperature. Cell activity reduces to prepare you to go into a deep sleep.
- Blood pressure decreases and other metabolic functions slow down too.
- It becomes harder to wake up.
- Your brain starts to emit slower, larger brain waves.
- The first two stages of NREM sleep together are often referred to as light sleep.

Stages 3 & 4: are known as deep NREM sleep. These are the most restorative stages of sleep. Stage 3 NREM sleep consists of delta waves or slow waves.

Awakenings or arousals are rare and often it is difficult to wake up someone in Stage 3 sleep. Sleep conditions like parasomnias (which can include sleepwalking, sleep talking and night terrors,) occur during the deepest NREM stage of sleep.

Characteristics of Stage 3 & 4 NREM sleep:

- Starts 35-45 minutes after falling asleep.
- Brain waves slow down and become larger delta waves.
- People sleep through most disturbances (such as noises and movements) without reaction.
- Waking during this stage brings a high probability of feeling disoriented for the first few minutes.

REM Sleep

Rapid eye movement, or REM, is the stage of sleep in which most dreaming occurs. The eyes are not constantly moving but they do dart back, forth, up and down. These eye movements may be related to visual images of dreams, however, the full reason for rapid eye movements are still a mystery.

The core muscles that run the heart and diaphragm continue, and while the eyes move rapidly (hence the name), other muscles are paralysed. Awakenings and arousals can occur more easily in REM;

being woken during a REM period can leave one feeling groggy or overly sleepy.

Characteristics of Stage 5 REM Sleep:

- Eyes move rapidly in all directions.
- The deepest and powerful dreams usually occur.
- This stage is also characterized by an increase in heart and respiration rates, and their rhythms may become irregular.
- REM stages typically get longer and longer as the night goes by, and the last REM stage can last an hour.
- Brain waves are smaller, like those experienced in waking periods.
- Sleepwalking may occur in these episodes.
- Bed wetting may happen because a larger percentage of REM sleep makes it difficult for the brain to tune into the bladder's night-time signals. Children often mention that they had a dream about urinating while this is going on.

How Long is Each Sleep Stage?

While we have defined four stages of sleep, defining their length is a bit more complicated. Typically, sleep cycles begin every 90-120 minutes, resulting in four to five cycles per sleep period.

The sleep cycle does not proceed directly from NREM to REM sleep, it progresses through the stages of NREM sleep from light to deep sleep, then reverses back from deep sleep to light sleep, then goes into REM sleep, before starting over in light sleep again.

We'll revisit this cycle again in Part III, but first, we'll look at an overview of the different brain waves and sleep.

Part II: Brain Waves & Sleep Stages

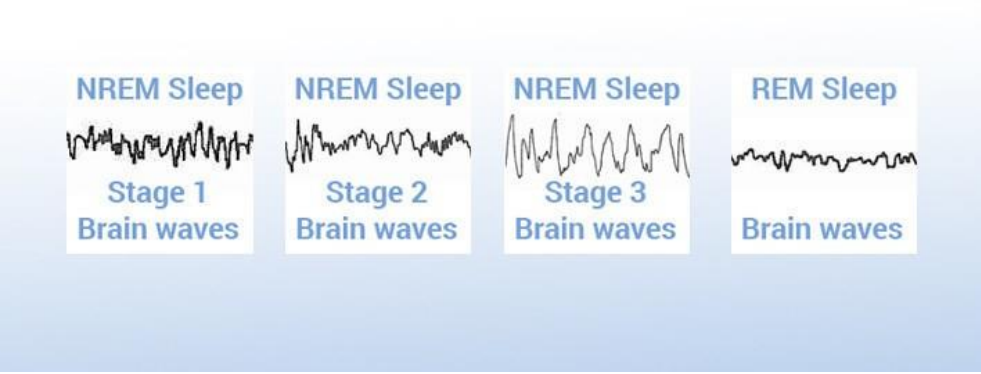

Image: Types of brain waves during stages of sleep.

Which Brain Waves are Best for Sleep?

Sleep science is still a relatively young field. Researchers did not discover REM sleep until 1953 when new machines were developed to monitor brain activity. Before then it was thought the brain was completely inactive during sleep. Today we know that different frequencies of brain waves are active during the different stages of sleep.

Types of Brain Waves

- **Alpha Waves**: At 8 to 12 Hz, alpha waves are involved in how we think, feel, communicate, sleep and generally function.
- **Delta Waves:** At 0.5 to 3 Hz, delta waves are the slowest brain waves and occur in the deepest states of sleep.
- **Theta Waves:** At 3 to 8 Hz, theta waves also occur during sleep, and have been observed in very deep states of meditation.

- **Beta Waves:** These are the most common daytime brain waves, with a rhythm of 12 to 30 Hz. They are dominant in normal wakeful states, and when you're focused on cognitive tasks, such as problem-solving or decision making.
- **Gamma Waves:** These are the fastest of the brain waves, with a rhythm of 25 to 100 Hz. They process information from various brain areas and are responsible for conscious perception.

EEG Recording Brain Waves During Sleep

Electroencephalogram (EEG) is a method used to measure the electrical activity of the brain by tracking and recording brain wave patterns. Small metal discs with thin wires (electrodes) are placed on the scalp, and then send signals to a computer to record the results.

Brain Waves during REM and NREM sleep

Each stage of sleep has a purpose. For example, scientists have disproven the idea that deprivation of REM sleep can lead to insanity. However, lack of REM sleep can contribute to clinical depression, but we still don't know why. Recent theories link REM sleep to learning and memory.

Brain Waves During the Sleep Cycle

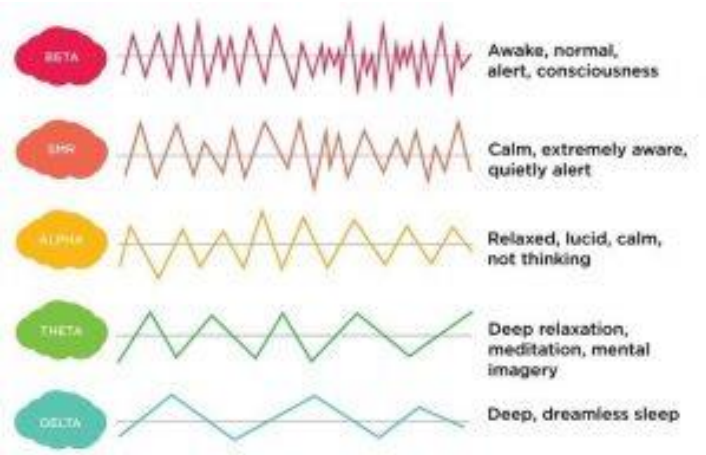

Image: The different brain waves and their relationship to wakefulness or sleeping.

Awake vs. Sleep Brain Wave Comparison

STAGE	FREQUENCY (HZ)	AMPLITUDE (MICRO VOLTS)	WAVEFORM TYPE
Awake	15-50	<50	Beta
NREM Stage 1	8-12	50	Alpha
NREM Stage 2	4-8	50-100	Theta

NREM Stage 3	4-15	50-150	Spindle Waves
NREM Stage 4	1-4	100-200	Spindle Waves & Slow Waves
REM	15-30	<50	Delta

As you can see, being awake and REM sleep share a similar frequency of brain wave activity. Now we've seen the different brain waves during sleep, let's look at how sleep cycles guide the stages of sleep.

Part III: Sleep Cycles, Light and Deep Sleep

What's the Difference Between Light and Deep Sleep?

At night your body cycles through different sleep stages. It moves from light to deep sleep, back to light, then into REM. Sleep cycles also vary naturally.

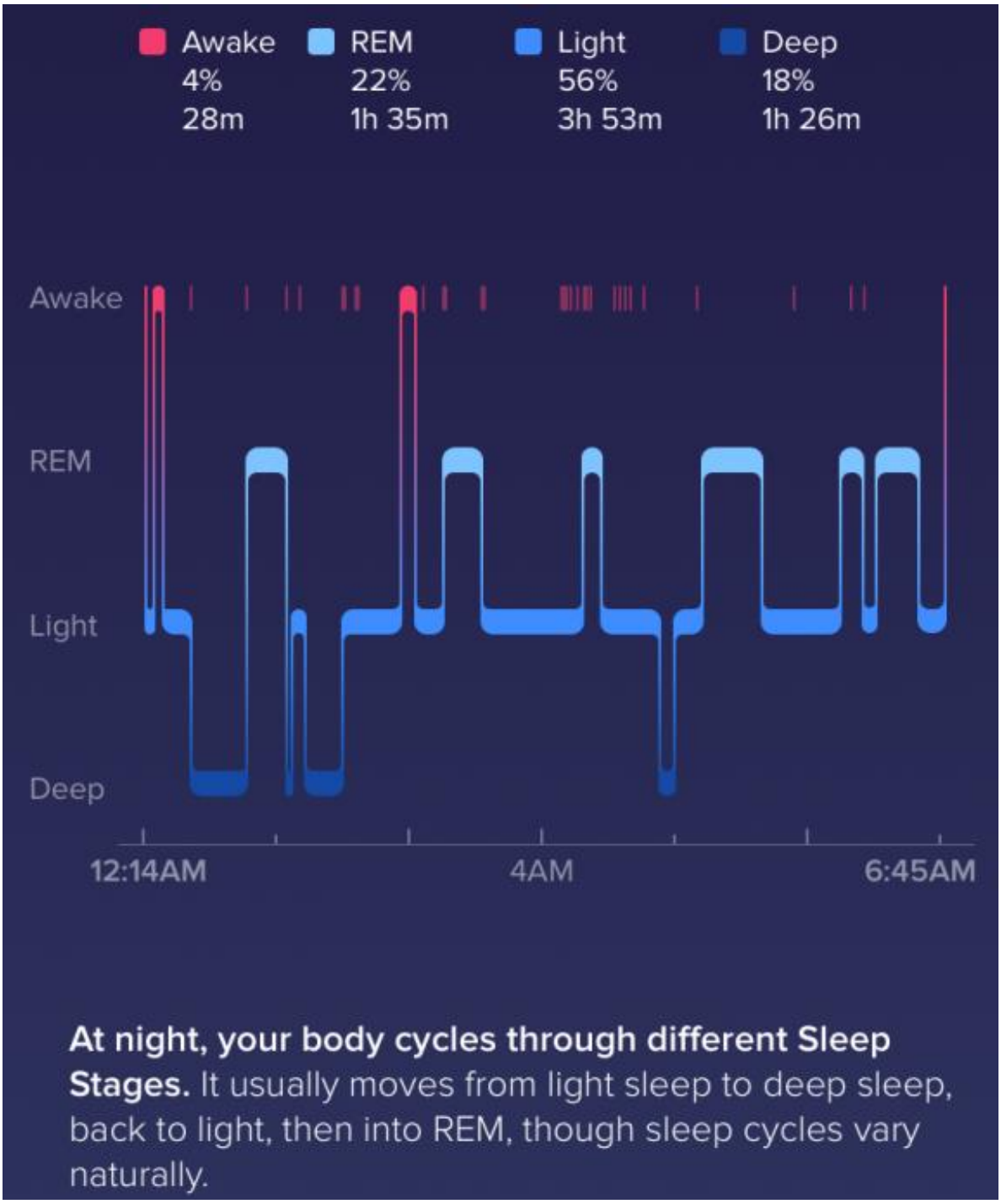

Image: Sleep cycles from light to deep to REM sleep. Source: Fitbit

Light Sleep vs. Deep Sleep

Now we'll look at each stage in terms of what changes over a sleep cycle.

Stage 1 NREM: This is the sleep that's a little more choppy, shallow, and not restful. It's usually just a quick transition, so you're not in it for very long. You still hear things in your environment and have a sense of awareness, and your brain dips into sleep, but it doesn't feel like true sleep.

Stage 2 NREM: Usually referred to as light sleep, you can still be easily awoken in this stage. However, stage 2 sleep is *not* shallow. Light sleep takes up more than half of the night. The brain processes memories and emotions and your metabolism regulates in NREM stage 2.

A lot of body maintenance occurs compared to other stages of sleep. The digestive system in particular undergoes maintenance. Breathing and heart rate typically decrease slightly during this stage.

Deep Sleep

Stage 3 NREM Sleep: During deep sleep, the brain becomes less responsive to outside stimuli. Breathing slows down, your muscles relax, and your heart rate usually becomes more regular. Deep sleep is very much about the body. The thinking parts of the brain are mainly

offline and no dreaming occurs at all during this time. Throughout the body, rebuilding and repairing is occurring.

The body also secretes growth hormone in the deep sleep stage, which is associated with cellular rebuilding and repair, and digestive and immune regulation happen during this phase.

REM Sleep

While deep NREM sleep is about the body, REM sleep is about the brain. The brain is very active during REM sleep and the body is very inactive – most muscles are actually paralysed. REM sleep is when most dreaming happens, and the eyes move rapidly in different directions. Heart rate increases and breathing becomes more irregular.

REM sleep has been shown to be important for emotional regulation and memory. The brain is cleared of things that aren't needed. However, it's also important for the body; in REM sleep, peak protein synthesis at the cellular level keeps many processes in the body working properly.

How Light and Deep Sleep Cycles Work

The brain cycles each stage of sleep at multiple times in the night, and spends a different amount of time in each of them. Each cycle lasts 90 minutes on average, while some cycles can be as short as 50 minutes and as long as 100 minutes or more.

Sleep Cycle 1

During light sleep you'll dip into stage one and transition into stage two. Then it's a quick move into deep sleep. You stay in deep REM sleep for about 10 minutes. It's very hard to wake up from deep sleep; the body tries to get it over with as quickly as possible, and halfway through the night, you've already been through deep REM sleep.

Sleep Cycle 2

More light sleep happens as well as a lot of deep sleep, (but less deep sleep than in stage 1.) More REM sleep begins to occur.

Sleep Cycle 3

Less deep sleep, and more REM sleep happens in this stage. On average, light sleep will take up about 50 to 60 percent or more of your night, deep sleep takes up 10 to 25 percent (depending on your age) of sleep, and REM makes up about 20 to 25 percent of your nightly sleep. REM sleep mostly takes place in the second half of the night. During the second half of the night, sleep cycles break down as your body alternates between light sleep and REM for the rest of the night.

How Much Deep Sleep do we Need?

There’s no real way to get too much deep sleep. The body has its own natural drive for deep sleep, and once it gets enough and the need for it decreases, the body just goes into REM and light sleep. Listen to your body; if you get too little deep sleep you won’t feel refreshed when you awaken.

The two main things that can lead to less deep sleep are:

- Age: people naturally get less deep sleep as they get older.
- Sleep interference: like pain, medical issues, sleep apnea, and other sleep disorders.

Disorders can keep you out of deep sleep and make sleep a little shallower. Your body wants to get into deep sleep at night, and it wants to avoid deep sleep during the day. There is a natural delay of how long it will take you to get into it.

How Much REM Sleep do you Need?

Too little REM sleep can leave you feeling groggy, less focussed, and with memory problems. That’s why it’s important to get enough sleep after learning something new or before taking an exam. Some

medications can also block REM sleep by half (such as anti-depressants).

Too much REM could also create problems; more than 25% of REM sleep can cause too much brain activation, leaving you angry, irritable, and may contribute to the symptoms of depression and anxiety.

Sleep Cycles During an Entire Night

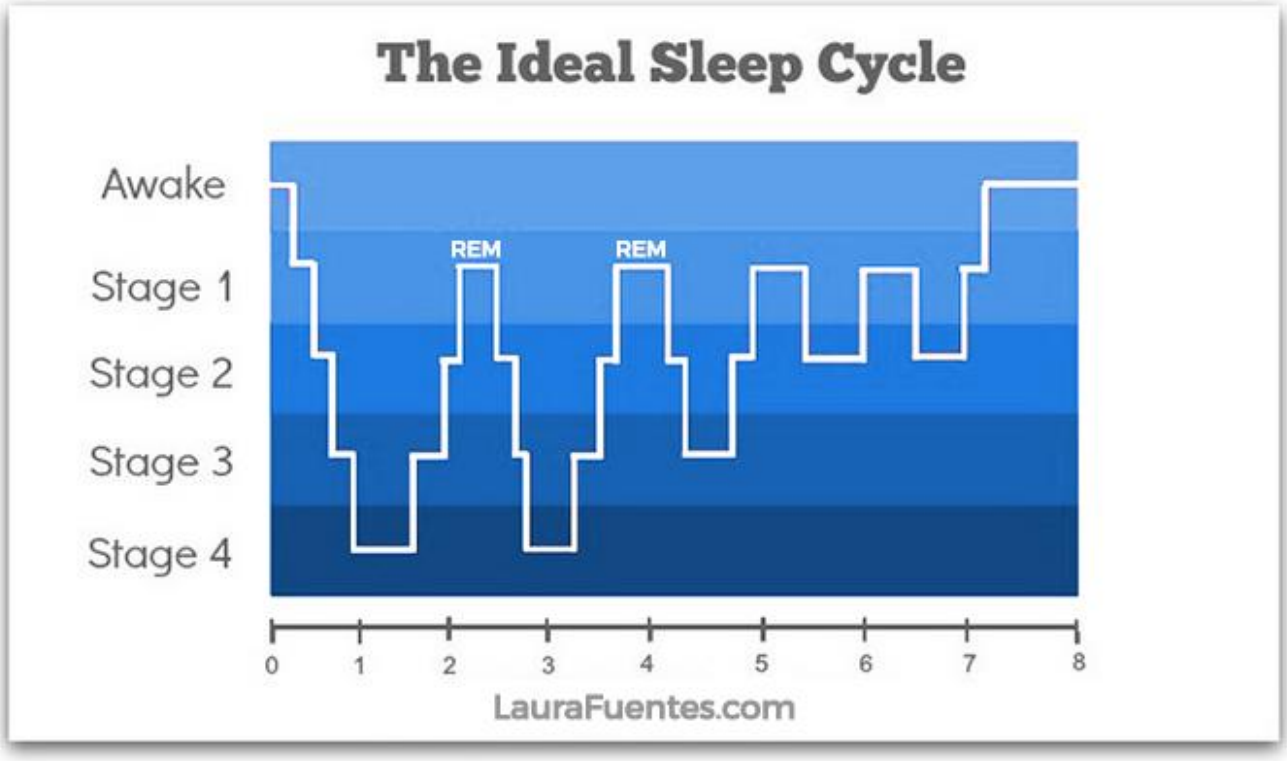

Image: REM sleep increases as sleep cycles progress over a night. Source: LauraFuentes.com

What happens over the course of a night of typical sleep? As the night progresses, the amount of time we spend in a particular stage of sleep shifts. How much NREM and REM sleep is not just based on where

we are in our nightly sleep, it also depends on what time of day (or night it is).

Regardless of the time taken to fall asleep, people tend to experience more NREM sleep in the earlier hours of the night, between 11pm and 3am. More REM sleep happens in the later hours of the night, between 3am and 7 am.

People known as ‘night owls’ get more REM sleep overall than the early-to-bedders. The need for all this complexity in our sleep cycles is still a mystery.

Changes in Sleep According to Age

A typical adult sleeps about 8 hours per night (with lots of variability). Some deal with 6 to 7 hours, while others say they need 9 to 9.5 hours of sleep. Teenagers in particular tend to need 9 or more hours of sleep a night to be optimally alert the next day.

Our age also helps determine what *type* of sleep we get. From childhood to adulthood, there is a reduction in how much deep sleep we get (NREM stages 3 – 4). This change takes place primarily in adolescence when about 40% of NREM stage 3 – 4 sleep is replaced by stage 2 sleep. In addition to losing our deep sleep, we also cut back on REM sleep as we age.

Newborns spend half their total sleep time in REM sleep, but by two years old that is down to only a quarter (and remains that way).

Babies also sleep on shorter cycles of only 50–60 minutes, and can fall straight into REM sleep.

Newborn Sleep (0–4 months)

Newborn sleep has no distinctive sleep waves. Sleep is categorized as “Active”, “Quiet” and “Indeterminate”. Active sleep is the equivalent of REM sleep and quiet sleep is equivalent to non-REM sleep. Newborns mostly experience active sleep which allows for frequent arousals or awakenings, this is necessary for regular periods of feeding.

Infant Sleep (4 months–1 year)

A standard sleep stage distinction is now apparent. Sleep becomes stages and routines can be developed. Sleep length is typically 10-13 hours per 24 hour period, including two to three daytime naps.

Toddlers sleep (1 year–3 years)

Now fully developed sleeping patterns appear. Children spend about 25% of their sleeping hours in stage 3 deep sleep, and almost an equal amount of time in REM. Sleep length is roughly 9.5-10.5 hours per 24 hour period. They require only one nap per day, most likely occurring early in the afternoon to allow enough time later for proper night-time sleep.

Pre-School sleep (3–6 years)

Sleep time is similar to that of toddlers, with about 9-10 hours per 24 hour period. Afternoon naps usually stop around the age of 3-4 years for a majority of children. Stage 3 sleep still takes up a high percentage of their total sleep time.

School Age sleep (6 years–12 years)

Sleep time for school aged children remains at 9-10 hours per 24-hour period. Stage 3 remains approximately 20-25% of total sleep time. Restorative sleep is important for growth and development.

Adolescent sleep (12 years and beyond)

Sleep time for adolescents is approximately 9-9.5 hours per 24 hour period. There are physiological changes in circadian rhythm that occur, causing sleep onset to be later. This internal shift is the cause of many teenagers going to be later and their desire to sleep in during mornings. As a person ages and becomes an adult, the circadian rhythm shifts back, and sleep takes up approximately 6.5-8 hours per 24 hour period.

What are the Benefits of Naps?

In Western Society we tend to sleep in one big chunk at night, but some researchers question whether our bodies were designed to do this. Some traditional cultures are known to sleep in two phases; six hours at night, and a one and a half hour nap in the afternoon. Mediterranean cultures are known for their mid-afternoon “siestas.”

If you’ve experienced a post-lunch low, it could be the body craving this cycle, (although it’s equally likely to be the food you’ve eaten.) This type of sleep schedule may fit better with our circadian rhythms, which tend to experience a drop around 2pm.

How Napping Helps the Brain

For recovering from fatigue, a 15-20 minute nap is ideal. Some research suggests a nap as short as 5 minutes could be beneficial. Napping has been shown to help integrate memories and skills.

Napping to increase memory may require a full sleep cycle (90 minutes), which can also help you retain a certain skill you’ve just learned. However, after these periods, you may feel groggy or experience sleep inertia. The farther along you are in your sleep cycle when you wake, the harder it is to get over grogginess.

Conclusion

The stages of sleep are a complex function of the human brain, and while we don't fully understand how the cycles of sleep work, we do know they're crucial to our wellbeing and the health of our brains. During this series we'll be referring back to these stages of sleep. Next we're going to take a look at insomnia, other sleep disorders, and how breathing can help you get a better night's sleep.

Further Reading

http://healthysleep.med.harvard.edu/healthy/science/what/sleep-patterns-rem-nrem