Forty Winks

Sleep research is expanding and attracting more and more attention from scientists. Understand sleep to fully understand the brain and its impact on our lives.

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Forty winks and Zzzzz. All point to sleep. Why forty and why z? There are no reasonable answers for that; a wink being the shortest type of sleep available and “forty winks” therefore gives an indication of an appropriate short sleep – with the hope that when you wake up everything will be fine. “Give him forty winks, and he’ll turn up as fresh as clean sawdust and as respectable as a new Bible” (Play “King’s Evidence”, at Act III).

On the other hand, Robert Heinlein says, “Happiness consists in getting enough sleep; just that, nothing more.” Dalai Lama too thinks sleep is the best meditation. It is a soothing balm alright for a tired body and an exhausted mind. What is more, we do not even think and realise that we are sleeping while we are asleep. On the other hand why does every household often complain of at least one “Kumbhkarna ki aulad” in the family?

So how much sleep is too much or how little is too little? Why do we all need to sleep at all in the first place? – Are the two big questions that have bothered scientists for long.

Although everyone sleeps, most people would find it hard to precisely define sleep. All organisms display daily patterns of rest and activity that resemble the daily sleep and wakefulness patterns seen in humans. Before going further – let us first see what sleep is. By observing changes in behavior and responses, the following features can be used to describe/define sleep:

- Sleep is a period of reduced activity.
- Sleep is linked with a typical posture – lying down with eyes closed in humans.
- Sleep is a minor response to external stimuli.
- Sleep is a state that is relatively easy to reverse (distinguishing it from other conditions such as hibernation and coma).

What else can you say about sleep? Your breathing, heart rate, body temperature and many physiological functions change...
during your sleep. When we are awake, our body temperature is regulated by processes such as sweating, shivering and changing blood flow to the skin – through thermoregulation – resulting in minimal fluctuations. Just before we fall asleep, our bodies lose some heat to the surroundings (actually helps to induce sleep). The resulting reduction of 1 or 2°F actually helps in energy conservation – leading to the hypothesis that this is the primary function of sleep.

When you are in your ZZZZs, you usually pass through four phases of sleep: stages 1, 2, 3 and REM (rapid eye movement) sleep. These stages progress in a cycle from stage 1 to REM sleep – lasting for 70-100 minutes, then the cycle starts over again with stage 1.

Stage 1 lasts for 5-7 minutes during which your eyes are closed and you are easily woken up. In stage 2 your breathing slows down and your body temperature drops – you are getting ready for deep sleep with occasional bursts of rapid waves called sleep spindles; lasts for 10-25 minutes. In stage 3 you are fast asleep, it is harder to rouse you and you are disoriented for a few minutes if woken up; lasts for 20-40 minutes. During this stage, your body repairs and rebuilds tissues, builds bone and muscle and strengthens your immune system. You get less deep sleep as you grow older.

Your REM sleep starts about 90 minutes after you fall asleep. Ten-minute stages progressively increase to the last phase lasting for about an hour. Your heart rate and breathing quickens. Your brain is more active and you dream intensely. Your body-temperature falls to its lowest point. This is when you curl up in bed under blankets to conserve heat during this potential risk without thermoregulation.

At the end of each cycle, we move toward wakefulness—and this is when people often wake up.

The average length of the first NREM-REM sleep cycle is between 70 and 100 minutes; the average length of the second and later cycles is about 90 to 120 minutes. We spend about 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, on the other hand, spend about half of their sleep time in REM sleep. Jet lag and shift work can upset these usual sleep patterns by compelling the body to be awake when it wants to be asleep.

Of mammals, birds and reptiles that spend life on land and not in water, only mammals and birds display REM and non-REM sleep; reptiles rotate between basking (relaxing) and short bouts of active behavior. REM sleep probably evolved from such short active bouts and slow-wave-sleep of the basking state.

Incidentally, REM sleep’s first documented observation was in the first century B.C., by the Roman poet Lucretius when he wrote of watching one of his hunting dogs twitch as it lay sleeping.

In general, many physiological activities are reduced during sleep. But some physiological processes may even be increased during sleep. For example, one of the vital changes induced by sleep is an increased release of growth hormone. Also physiological activities related to digestion, cell repair, and growth are greatest during sleep, suggesting that cell repair and growth could be an important function of sleep – “why do we all need sleep?” probably stands answered here.

When we are awake, we are learning all day. This toughens the synapses (connections between neurons) in our brains, but soon they reach saturation and need sleep to “reset”. Some data suggest that when our brains have learned enough (or too much), these neural circuits tell the body to shut down, or go to sleep.

Age and genetics are two factors that influence how long we sleep, when we want to go to bed and wake up, and how deeply we are able to sleep.

Similar sleep habits are seen in identical twins but not in fraternal twins. European researchers, Professor Till Roenneberg and Dr. Karla Allebrandt et al. have shown that a known genetic factor in heart disease and diabetes, ABCC9, also controls how long one needs to sleep. In a study involving about 4000 individuals, they have shown that those with two copies of this gene slept for fewer hours than those with other variant copies; presence of this gene was ascertained by scanning individual genomes. The ABCC9 gene is evolutionarily ancient, as a similar gene is present in fruit flies, telling us that the genetic control of sleep duration may depend on similar mechanisms in a wide range of highly diverse species.

In addition, two interacting systems – an internal biological clock and the sleep-wake homeostat (one of the first devices capable of adapting itself to the surroundings) also decide our sleep/wake alterations –typically staying awake during the day and sleeping at night. Light provides main clues about what time it is and even short pulses of light at the right time during the cycle can reset it. Modern man is often desynchronised from this internal clock due to shift work, long distance travel across several time zones and extensive indoor lighting.

The clock, actually called the suprachiasmatic nucleus or SCN is a pair of pinhead-sized brain structures that together contain about 20,000 neurons. Light that reaches photoreceptors in the retina creates signals that travel along the optic nerve to the SCN. 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 synchronizes body temperature, hormone secretion, urine production, and changes in blood pressure. Good sleep helps nearly everything else in our lives.

When you have difficulty falling asleep – when even counting sheep does not help, feel tired upon waking up or stay awake during the night and have trouble going back to sleep – you are probably suffering from insomnia that affects millions. You can understand the plight of people with total blindness who suffer from life-long sleeping problems because their retinas are unable to detect light. Insomnia is defined by the quality of sleep and how you feel after sleeping – and not by the number of hours you sleep or how fast you doze off. The legend goes that Napoleon slept for only four hours each day.

Insufficient sleep may contribute to the onset of emotional difficulties and can affect many human disorders. For example, problems like stroke and asthma attacks tend to occur more frequently during the night and early morning, perhaps due to changes in hormones, heart rate, and other characteristics associated with sleep.

Sleep debt is the effect of not getting enough sleep; a large debt causes mental, emotional and physical fatigue and can be cumulative. Humans are known to reach maximum sleepiness after 30 hours of waking. As the brain uses stored energy in the form of ATP – the molecule used as currency for energy – adenosine builds up increasing the sleepiness. Caffeine temporarily blocks the effect of adenosine, allowing it to build up further before the need for sleep reasserts itself.

For more than 50 years now scientists have known that the brain is highly active during sleep. Careful observations and technical innovations have helped us understand a great deal about what goes on when we sleep. EEG, magnetoencephalography (MEG), structural MRI and Optogenetics, where they use light to control neurons that have been genetically modified to respond to light, have made great strides. For example, during sleep, the brain was thought to block out external stimuli through a gating mechanism at the level of the thalamus, but Andrillon et.al. in Paris have shown that people continue to hear and process words during light non-REM sleep but not in non-REM (Stage 3) and in REM. Your brain may wind down when you are asleep, but does not lose all awareness.

In another study, Boyce et al. have shown that specific neuronal activity only during REM sleep is essential for normal memory consolidation. Mice were first trained to locate a novel object from a place as well as some techniques to fear-conditioned memory recall and then specific neurons were selectively silenced during REM sleep. They noticed a temporary reduction of the memory-associated theta rhythms in these mice; same procedure done outside REM episodes had no effect on memory. REM sleep is inconsistent in nature; causality between neural activity during REM sleep and memory consolidation has been possible only because of optogenetic techniques which allowed them to target a precise neural population and control their activity using light.

Another study focusing on slow-wave activity (N3-stage), which measures the depth of sleep, reports that during the first night in a new environment one hemisphere of the brain remains active – a night watchman so to say! That explains why people take longer to fall asleep and have poorer sleep quality the first night in a new place. This appears to be a very general phenomenon as marine mammals, like fur seals, dolphins and beluga whales and also some birds are known to sleep with one half of their brain awake.

According to some scientists, REM sleep may have been an evolutionary modification of a known defensive mechanism for survival – like ‘death feigning’ as an ultimate line of defense against an attacking predator. Several modern tools appear to confirm this observation. And that sums it all up – you need to sleep for your health, happiness and mere survival!

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