WHY DO WE SLEEP... AND WHAT HAPPENS IF WE DON'T?

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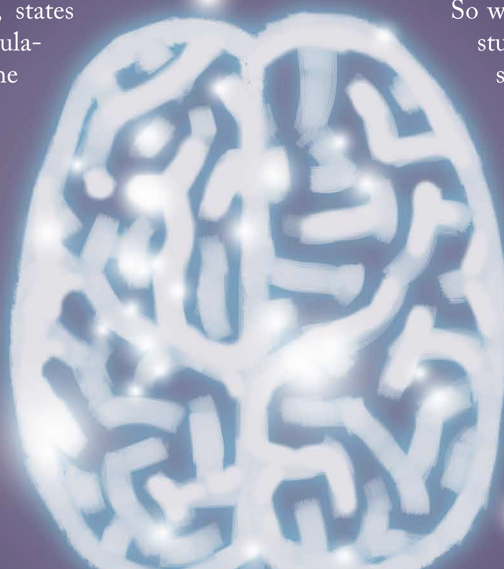

Sleep is a vital part of our routine and many of us can never seem to get enough of it. It is defined as a state of immobility with greatly reduced responsiveness that can be rapidly reversed.[1] However, the reason we sleep has yet to be elucidated by the scientific community. One possible explanation, the synaptic homeostasis hypothesis, states that sleep plays a role in the regulation of synaptic weight, which is the strength of connection between two neurons in the brain.[2] This hypothesis suggests that connection strength between neurons increases while we are awake and peaks right before we sleep. This is followed by a decrease in strength to a baseline level during sleep.[2] The process can be thought of as a cycle of "heating up and cooling down" in the brain to maintain homeostasis, allowing the brain to save energy, prevent synaptic overload, facilitate learning, form new memories.[2]

Evidently, brain activity does not cease during sleep. In the 1950s and 60s, the regular cyclic alternation between rapid eye movement (REM) and non-REM (NREM) during sleep was discovered.[3] REM sleep is associated with vivid dreaming, which indicates that the brain is highly active during sleep.[3] However, it was also noted that during REM sleep, sensory inputs and motor outputs are "shut off".[3] NREM sleep is characterized by a lack of dreams and a complete loss of consciousness, but some brain regions remain significantly active.[3] These discoveries indicate that sleep is a "reorganization", rather than a cessation, of neuronal activity.[3]

The cycle of NREM and REM sleep seems to be conserved in almost all mammals, suggesting that sleep may have a universally significant function.[3] In addition, all mammals and even individual humans differ in the amount and nature of their sleep, which are dependent with genetics, environmental factors, and diet.[1] Interestingly, some aquatic mammals, such as dolphins, have adapted a unique way of sleeping called unihemispheric sleep, in which they "shut off" only one hemisphere of their brain at a time.[1] The study of sleep in multiple species further supports the theories that sleep saves energy, keeps species from being inactive at inopportune times, and differs qualitatively across individuals and species.[1]

So what happens if we don't sleep? One study found that a night of sleep resulted in a 20% increase in motor speed without loss of accuracy.[4] Furthermore, a significant positive correlation was noted between the amount of NREM sleep and cognitive performance the following day.[4] Many studies show that sleep deprivation a negative impact on mood, cognitive performance, and motor function.[5] Lack of sleep also results in daytime performance deficits, which lead to significant social, financial, and human costs.[5] Accidents related to sleep deprivation have been estimated to have an annual economic impact of $43 billion to $56 billion.[5] Notably, lack of sleep has been shown to have similar impairments to those induced by alcohol consumption at or above the legal limit.[5] Overall, sleep deprivation has been linked with reduced cognitive performance, attention deficits, weaker immune responses, high blood pressure, and decline in normal human function.[5] ■

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HOW DO NEW SPECIES ARISE?

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A modern definition of "species" focuses on a shared gene pool and reproductive ability.[1] Based on this definition, in order to determine what mutations give rise to new species, we should consider what mutations cause reproductive isolation.

There are three main modes of reproductive isolation that could lead to speciation: allopatric, parapatric, and sympatric speciation. Allopatric speciation occurs when a species splits into two geographically isolated populations in a way that prevents genetic exchange.[2] First, a geographic barrier separates a species; this could be a result of continental movement, human activities, or formation of mountains, islands, and glaciers. Next, genotypic and phenotypic differences begin to arise due to mutations in the separate gene pools, divergence in selective pressures between the two populations, and genetic drift. These differences often gives rise to incipient species - species that may be infertile with each other but do not interbreed due to the geographic barrier.[3] If this barrier were removed, the previously isolated populations could mate and produce low-fitness hybrids, which could become their own species or be eliminated from the population through mate choice discrimination. Over time, speciation progresses to completion. An example of allopatric speciation is the separation of Darwin's finches in the Galápagos archipelago.[4] The archipelago was colonized from continental South/Central America, in which a breeding population was established. Individual finches eventually colonized neighbouring islands to establish new breeding populations. Ultiamtely, eleven species of finches in the Galápagos arose from allopatric speciation.[4]

Parapatric speciation is similar to allopatric speciation in that a geographic barrier separates a species, but interbreeding can still occasionally occur.[5] While allopatric speciation results in two distinct geographic populations, parapatric speciation results in a continuous or discontinuous environmental gradient of hybrids, creating distinct species over time.[5] Parapatric speciation usually occurs in marine environments due to the low probability of full geographic barriers. It is the primary mode of speciation in coral-reef fish. Although coral reef fish larvae do not disperse too far from their birthplaces and adults are predominantly sedentary, they can still be separated through the porous coral reefs. In addition, parapatric speciation can occur from the spatial and environmental heterogeneity of coral-reef habitats.[6]

Sympatric speciation is the most rare. It occurs when a new species evolves from an ancestral species in the same geographic population, usually resulting from polyploidy, a trait that describes organisms that inherit more than one homologous set of chromosomes.[7] These polyploids will be infertile with their parental species, consequently becoming reproductively isolated while remaining in the same geographic location.[7] The apple maggot fly *Rhagoletis pomonella* may currently be undergoing sympatric speciation. The native host of this maggot is the hawthorn, but over the past 200 years, *Rhagoletis pomonella* have been found in domestic apples, Furthermore, significant allele frequency differences have been observed between hawthorn maggots and apple maggots.[8]

Overall, the three modes of speciation discussed in this article can be summarized into two main events: anagenesis, which occurs when one species gradually accumulates enough genetic changes to become a new species, like in sympatric speciation, and cladogenesis, which occurs when gene pools split to result in two or more new species, like in allopatric and parapatric speciation.[9] ■

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