

REGENERATION DURING SLEEP.

Being unconscious and defenseless for hours at a time poses a risk for every living creature. What makes sleep so important that it is worth taking the risk?



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Sleep is still one of biology's greatest secrets. It is well established that we regenerate both body and soul completely during the hours of unconsciousness. Researchers are engaged in unraveling this puzzle.

Bats, cats, chickens, elephants, horses, fruit flies and, of course, human beings all need sleep, but it has to be the right kind of sleep. Why humans and animals need to sleep has still not been fully explained, and it is one of the greatest unsolved puzzles in science today. It is highly risky for all creatures to spend several hours unconscious in the natural world. Despite this, sleep is so important that this is an acceptable risk. One thing is certain, skipping nightly rest for an extended period of time has serious consequences. Additionally, chronic sleep deprivation, or chronic sleep disorders, constitute an added risk factor for a number of conditions, such as influenza, epilepsy, Alzheimer's disease, obesity or stroke.

An energy boost to the brain

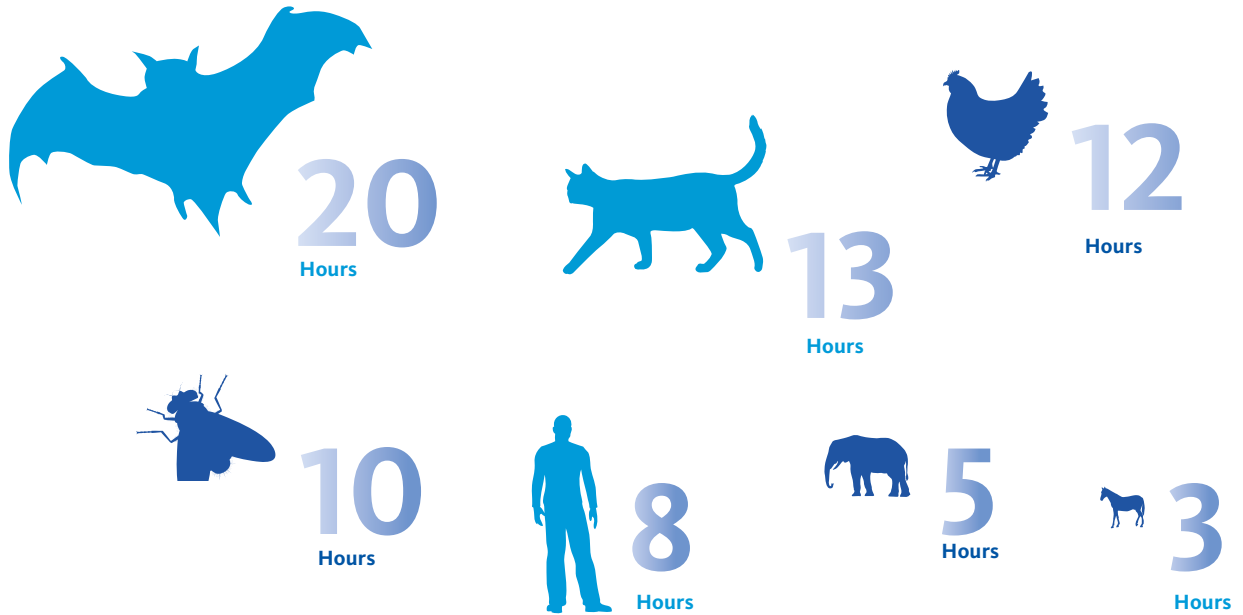
Falling asleep after an exhausting day and waking up in the morning fully refreshed can help one understand the benefits of sleep. The body regains energy and the mind is renewed with ideas. One theory about the function of

sleep proposes that it allows the brain to refill its reserves of energy. Researchers working with Radhika Basheer and Markus Dworak, at Harvard Medical School in Boston, have been able to establish that mice gain a powerful energy boost in the early phase of their sleep.¹ Interestingly, the energy boost is restricted to those areas of the brain which are only active in the waking state. The level of ATP (adenosine triphosphate) molecules increases significantly in those areas. ATP is the body's energy currency and is indispensable for most of its metabolic process. On the other hand, when mice were kept awake during the period they were normally asleep, no increase in ATP occurred. Once the mice were able to sleep, ATP functioned normally. This leads researchers to conclude that the supply is influenced by the time of day or by our "inner clocks." The question remains: why is it that such a supply of energy does not also occur in the waking state? Researchers have theorized that during our conscious state the brain is consistently engaged in energy-intensive nerve activity, and is careful to ensure the availability of adequate levels of energy.

Only through a particular signal, such as falling asleep, can these conditions be overcome. In recent years researchers have been able to measure how much less energy is consumed during sleep than in the conscious state². A medium sized body saves approximately 134 kilo-calories or 562 kilojoules by sleeping, compared to being awake. This may only correspond to the energy value of two slices of bread but the reduction in energy consumption may be the signal for refilling ATP reserves and producing certain biomolecules such as proteins or fatty acids, therefore regenerating the body.

Night-time cleaning service

Alongside the "energy question," in the last few years, scientists have hypothesized another potential physiological function of sleep. According to the results of a study conducted by Lulu Xie and her team at the University of Rochester, New York, harmful metabolites are cleared out of the brain during sleep.³ The brain has only a limited amount of energy available, which



is used for mental functions during the day. So that these functions are not negatively impacted, it reschedules its main cleaning regime to the after hours. The brain must decide between two functional states, says coauthor Maiken Nedergaard in the journal *Science*, “either it is awake and on the alert, or it’s asleep and can have a bit of a tidy up.” The so called glymphatic system, is particularly important for these nocturnal cleaning activities. The system is a network of tiny channels that transport cerebral fluid, in the cranium it replaces the lymph system, which is responsible for carrying waste products away from the rest of our body. These tiny drainage channels are not controlled by nerve cells but by glial cells, which carry out the actual protective and enveloping functions in the brain.

Gaps to allow drainage

In order to gain more knowledge about this drainage system, scientists injected

a colored dye into the cerebral fluid of sleeping mice. They were able to establish that it penetrated much more deeply into the tissue during sleep than in the conscious state. While the dye penetrated approximately ten times more effectively into the depths of the drainage system in sleeping animals, it was restricted to the surface of the brain in mice that were awake. At the same time, the researchers found that the nerve cells contract during sleep, creating gaps. The inter cellular space in the brains of rodents that were awake accounted for only 14 percent of the cerebral volume, while in sleeping animals it was 23 percent. Unusable proteins and other substances can drain away through these nocturnally-formed gaps, along with the cerebral fluid, into the bloodstream. These include β -amyloids that are associated with Alzheimer’s disease, for example. They were cleared away during sleep twice as quickly as during the conscious state. The neurotransmitter noradrenalin may play an important role in these contraction processes as its concentration is reduced in the

sleeping brain. The body needs an adequate amount of sleep in order to carry out this “cleaning service” efficiently. The American researchers suggest that if this is interfered with for any length of time, then substances hazardous to health can accumulate in the brain and create favorable conditions for diseases such as Alzheimer’s or Parkinson’s disease. Whether it is the replenishment of our energy reserves or the removal of harmful substances that is responsible for our need to sleep, a small miracle of regeneration takes place in our bodies every night.

Literature

- 1 Journal of Neuroscience, Bd. 30, Nr. 26, S. 9007
- 2 Journal of Physiology, Bd. 589, S. 235
- 3 Lulu Xie et al.: *Science*, DOI: 10.1126/science.1241224