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# The Theories of the Sleep Regulation in the Human Organism

**Janos Vincze, Gabriella Vincze-Tiszay**
Health Human International Environment Foundation, Budapest, Hungary
ndp@t-online.hu

**Abstract.** Sleeping is accompanied by a physiological narrowing of consciousness, during which the central nervous system and the whole body can relax and regenerate. Ever since human consciousness was formed during the process of becoming a human being, but also from infancy to the early stages of the development of consciousness, humans have known the fact of sleeping and its necessity for the body to rest and "be reborn". A seventy-year-old human spends approx. twenty years, or one-third of their life, asleep. During sleep, their connection with the outside world is more or less lost, but in the meantime they experience exciting dreams that are difficult for rational thinking to grasp. Are different theories of the sleep: Pavlov's conception, Hess Conception, instinctive action, biological clock.

**Key words**: sleep, EEG, sleeping phases, REM

## Introduction

Sleep is an indispensable requirement of the human organism. Man spends a third of his life in a stale of periodically recurring sleep. The most constant and essential symptoms of sleep are a decline in the activity of the nervous system, in particular of the cerebral cortex, and suspension of contacts with the surroundings. [1] The breaking of the organism's contact with the outside world usually occurs quickly, as though suddenly, and is just as quickly replaced by wakefulness, i.e. by resumption of the activity of the nervous system and normal contact with the environment. Very sharp changes occur in higher nervous activity and in the sensomotor sphere during sleep. [2]

There are characteristic alterations in the electro-encephalogram during sleep. The transition from wakefulness to sleep is accompanied, as a rule, with a slowing of the cortical rhythms, and the appearance in the EEG of high-amplitude alpha-, theta-, and delta-waves instead of the quick beta-rhythm characteristic of the waking state. [3]

Table 1. Frequency of EEG waves

| EEG waves | Frequency (Hz) | Tension (μV) |
|---|---|---|
| Alfa (α) | 8 – 12 | 30–50 |
| Beta (β) | 13 – 30 | < 20 |
| Gamma (γ) | 30 –75 | < 10 |
| Delta (δ) | 0,5 – 5,5 | 100–200 |
| Theta (θ) | 4 – 7,5 | < 30 |

Forms of a deep sleep, however, have recently been described in which slow EEG rhythms are replaced by low-amplitude, high-frequency waves like those observed in the waking state. These are supposed to be associated with dreams. [4]

There are characteristic alterations in the electro-encephalogram during sleep. The transition from wakefulness to sleep is accompanied, as a rule, with a slowing of the cortical rhythms, and the appearance in the EEG of high-amplitude alpha-, theta-, and delta-waves instead of the quick beta-rhythm characteristic of the waking state. The EEG curve is a measure of the event-dependent potential measured on the scalp. The mechanism of potential formation is as follows: the apical (peak) dendritic membranes of pyramidal cells are depolarized upon stimulation, positively charged ions flow into the cell from the extracellular space, where currents are formed due to changes in ion distribution. Because the current flows through a small resistor, the voltage is also low, on the order of microvolts. The formed synchronized currents (which are synchronized by the afferents of the thalamus) can be measured by adding them up. As a result of synchronization, measurable EEG waves are created. EEG waves are classically grouped according to frequency and amplitude.

**Nerve centers responsible for sleeping**

Localization of brain centers that regulate sleep is the subject of intensive research around the world. The regulation of paradoxical sleep is relatively clearer; in the brainstem, more precisely in the bridge, the groups of neurons involved in the creation of the paradoxical phase have been delineated. [5] Today, we are also aware of the brainstem nuclei responsible for muscle tone, physique eye and muscle movements.

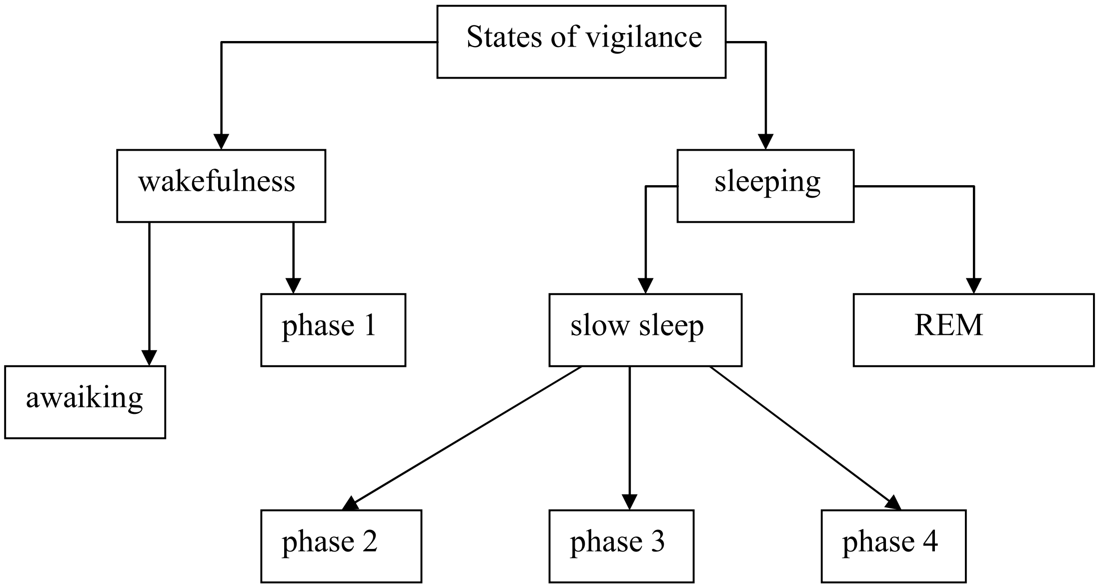
Fundamentally new findings were made by Nobel Laureate (1949) Walter Rudolf Hess, a physiologist from Zurich, who discovered that there are areas in the brain the electrical stimulation of which in the EEG causes slow waves, sometimes real sleep. The novelty in these experiments is that there are areas the increased activity of which leads to sleep. Hess believed he found this sleeping center in the thalamus. Since then, we know that the thalamus is really necessary to create the so-called sleep spindles, however, the lack of thalamus does not inhibit sleep. [6] The next area that arose as a sleep center is located in the lower part of the elongated brain. However, even this area plays only a subordinate role in the onset of sleep. To the best of our knowledge, the area that controls complex sleeping behavior, sleep as an instinctive action, is located on the lower surface of the brain, in the anterior part of the hypothalamus, and in the areas in front of that, the so-called preoptic region, secondary olfactory cortex, and orbital cortex. Stimulation of these areas induces inhibition with a delay of a few seconds, the animal lies down and falls asleep. If this sleep center is severely and extensively injured, insomnia leading to death occurs.

**The sleeping phases**

Slow-wave sleep, as its name implies, is caused by slow waves occurring in increasing numbers and at lower and lower frequencies in the EEG, as well as periods of 2–3 seconds consisting of more frequent waves, being characterized by the so-called “sleep spindles”. Based on the electrical activity of the brain, several stages of slow-wave sleep can be distinguished, e.g. four sleep states are usually defined from EEG curves, denoted by numbers 1–4 from superficial sleep to deep sleep. Although the different origins of each stage arise from time to time, slow-wave sleep is mostly considered qualitatively one, with each stage denoting different sleep depths. [7]
Characteristics of each phase:

1. NREM phase: forms a transition between wakefulness and sleep, the feeling of drowsiness increases. Brain waves and muscle activity slow down.
2. NREM phase: a light sleep period during which eye movement stops, brain waves slow further, heart rate and body temperature decrease.
3. NREM phase: characterized by extremely slow brain waves. Blood pressure drops and breathing slows down.
4. NREM phase: the phase of the deepest sleep, the brain produces the slowest waves. There is no eye movement, but the limb muscles are still able to move. Waking up someone is the most difficult at this stage. Phases 3 and 4 are essential for restoring the body’s energy, and this is when growth hormones are released as well.

5. REM phase: characterized by strong brain activity, this is when we dream. The motor muscles are temporarily paralyzed.




Under normal conditions, electrical activity in the brain follows the development of sleep well. Sleep progresses from stage 1, i.e., from the most superficial stage, to stage 4, then its depth decreases again, and – before another stage 1 occurs – paradoxical sleep appears. Sleep is deepest in the first half of the night, especially in the first sleep cycle. In later cycles, the amount of stage 4 is less and less, towards the morning the slow-wave sleep does not even go beyond stage 2.

Paradoxical sleep is a qualitatively different state from slow-wave sleep. Cerebral electrical activity is characterized by vigorous, rapid activity, which can sometimes exceed wakefulness activity. The muscles relax completely. [8] Sometimes, however, stormy movements occur, but they are always limited to a specific group of muscles: the wrist moves, one finger bends, and so on. Occasionally, high-amplitude eye movements are very common and are often accompanied by blood filling of the genitals, resulting in erection of the penis or clitoris in women. The heartbeat suddenly increases and then decreases, blood pressure fluctuates sharply, breathing may become irregular, and even temporary complete respiratory arrest may occur. [9] Respiratory arrest in infants can sometimes be fatal. During paradoxical sleep, the thermoregulation is switched off, but since the length of each paradoxical phase is 6–15 minutes, no significant cooling can occur on the covered person. The amount of paradoxical sleep is highest in newborns, reaching up to 70% of total sleep time. This drops to about 20% in adulthood.

**Theories of sleep**

Common sense dictates that sleep is simply perceived as rest, regeneration. However, it is easy to see that the body does not need sleep to rest. Is it about resting the brain? However, the regeneration of nerve cells is a very quick process, it is believed that the neurons controlling the heartbeat or breathing rest during the interval between two consecutive breaths or heartbeats.

Pavlov evolved a consistent theory of sleep, according to which it is the same process as internal inhibition. [10] In his view, sleep is a widespread, irradiated inhibition extending over the entire cerebral cortex and descending to the subcortical ganglia, between-brain and mid-brain. His conclusion was prompted by experiments which showed that repeated application of various conditioned inhibitory stimuli induced somnolence in dogs, and in some cases a deep sleep attended with complete relaxation of the musculature.

Sleep performs an important protective function, defending the cortical cells against the emaciating influence of stimuli. The need for this protection is linked with the fact that they are in a continuous state of activity involving the breakdown of phosphorus compounds rich in energy, and of proteins and amino acids. Lengthy activity leads to changes in ion balance (accumulation of sodium ions in the protoplasm and loss of potassium ions), with resulting alterations in the resting potential, the level of excitability, and the amplitude of synaptic and action potentials.

Hess's findings agreed well with the observations of neuropathologists, and the findings of histological studies of the brain of victims of lethargic encephalitis (which is characterized by sleep disorders expressed either in pathological sleep lasting for days or in pathological wakefulness). Economo, studying the histological picture of brain lesions, discovered changes in the posterior wall of the third brain ventricle and the walls of the Sylvian aqueduct in cases of encephalitis accompanied with pathological sleep, i.e. changes in the region along the boundary between the diencephalon and mesencephalon. He considered the centre regulating sleep to be localized in this area. Anteriorly to the sleep centre lay a region that Economo considered the centre of wakefulness, or insomnia. [11]

More recently, the notion that classifies sleep as an instinctive action has become widespread. Instinctive actions are species-specific, genetically coded, rather rigidly precise behaviors that satisfy an important biological need, and which are under the control of a certain internal driving force – the so-called motivation. Motivation is called hunger in the case of the eating instinct and drowsiness in the case of the sleep instinct. In this view, the sleep instinct would provide some sort of energy storage and processing process. [12]

Another view sees sleep simply as a manifestation of the biological clock. Indeed, disruption of the well-known circadian rhythm of sleeping-wakefulness can cause symptoms similar to sleep deprivation. The alternation of sleeping-wakefulness in many species shows a definite relationship with the alternation of bright-dark times of day. Humans sleep at night and they are awake during the day.

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