**ASSIGNMENT ON NEUROPHYSIOLOGY (PHS 305)**

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QUESTION 1:

Discuss the physiology of sleep.

Answer

**Sleep** is a naturally recurring state of mind and body, characterized by altered [consciousness](https://en.wikipedia.org/wiki/Consciousness), relatively inhibited sensory activity, reduced muscle activity and inhibition of nearly all [voluntary muscles](https://en.wikipedia.org/wiki/Voluntary_muscle) during [rapid eye movement](https://en.wikipedia.org/wiki/Rapid_eye_movement_sleep) (REM) sleep, and reduced interactions with surroundings. Sleep occurs in [repeating periods](https://en.wikipedia.org/wiki/Sleep_cycle), in which the body alternates between two distinct modes: Rapid Eye Movement ([REM](https://en.wikipedia.org/wiki/Rapid_eye_movement_sleep)) sleep and [Non-REM](https://en.wikipedia.org/wiki/Non-rapid_eye_movement_sleep) (NREM) sleep. A well-known feature of sleep is the [dream](https://en.wikipedia.org/wiki/Dream), an experience typically recounted in [narrative](https://en.wikipedia.org/wiki/Narrative) form, which resembles waking life while in progress, but which usually can later be distinguished as fantasy. During sleep, most of the [body's systems](https://en.wikipedia.org/wiki/Human_body) are in an [anabolic](https://en.wikipedia.org/wiki/Anabolic) state, helping to restore the immune, nervous, skeletal, and muscular systems; these are vital processes that maintain mood, memory, and cognitive function, and play a large role in the function of the [endocrine](https://en.wikipedia.org/wiki/Endocrine_system) and [immune systems](https://en.wikipedia.org/wiki/Immune_system).

**NREM** sleep is divided into stages 1, 2, 3, and 4, representing a continuum of relative depth. Each has unique characteristics including variations in brain wave patterns, eye movements, and muscle tone. A sleep episode begins with a short period of [NREM](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl82/) stage 1 progressing through stage 2, followed by stages 3 and 4 and finally to [REM](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl98/). However, individuals do not remain in REM sleep the remainder of the night but, rather, cycle between stages of NREM and REM throughout the night. NREM sleep constitutes about 75 to 80 percent of total time spent in sleep, and REM sleep constitutes the remaining 20 to 25 percent. The average length of the first NREM-REM sleep cycle is 70 to 100 minutes. The second, and later, cycles are longer lasting—approximately 90 to 120 minutes. In normal adults, REM sleep increases as the night progresses and is longest in the last one-third of the sleep episode. As the sleep episode progresses, stage 2 begins to account for the majority of NREM sleep, and stages 3 and 4 may sometimes altogether disappear.

**REM** sleep is defined by the presence of desynchronized (low-voltage, mixed-frequency) brain wave activity, muscle atonia, and bursts of rapid eye movements. During the initial cycle, the REM period may last only 1 to 5 minutes; however, it becomes progressively prolonged as the sleep episode progresses. There are numerous physiological differences between [NREM](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl82/) and REM sleep. Dreaming is most often associated with [REM](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl98/) sleep. Loss of muscle tone and reflexes likely serves an important function because it prevents an individual from “acting out” their dreams or nightmares while sleeping. Approximately 80 percent of vivid dream recall results after arousal from this stage of sleep. REM sleep may also be important for memory consolidation.

**Physiology during Sleep:**

Physiological changes also occur in the following systems;

* **Cardiovascular:** Changes in blood pressure and heart rate occur during sleep and are primarily determined by autonomic nervous system activity. For instance, brief increases in blood pressure and heart rate occur with K-complexes, arousals, and large body movements. Further, there is an increased risk of myocardial infarction in the morning due to the sharp increases in heart rate and blood pressure that accompany awakening.
* **Sympathetic-nerve activity:** Sympathetic-nerve activity decreases as [NREM](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl82/) sleep deepens; however, there is a burst of sympathetic-nerve activity during NREM sleep due to the brief increase in blood pressure and heart rate that follows K-complexes. Compared to wakefulness, there is a rise in activity during [REM](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl98/) sleep.
* **Respiratory:** Ventilation and respiratory flow change during sleep and become increasingly faster and more erratic, specifically during [REM](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl98/) sleep. Ventilation data during REM sleep are somewhat unclear, but they suggest that hypoventilation (deficient ventilation of the lungs that results in reduction in the oxygen content or increase in the carbon dioxide content of the blood or both) occurs in a similar way as during [NREM](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl82/) sleep. Several factors contribute to hypoventilation during NREM, and possibly REM, sleep such as reduced pharyngeal muscle tone. Further, during REM sleep, there is reduced rib cage movement and increased upper airway resistance due to the loss of tone in the intercostals and upper airway muscles. More generally, ventilation and respiratory flow show less effective adaptive responses during sleep. The cough reflex, which normally reacts to irritants in the airway, is suppressed during REM and NREM sleep. The hypoxic ventilatory response is also lower in NREM sleep than during wakefulness and decreases further during REM sleep. Similarly, the arousal response to respiratory resistance (for example, resistance in breathing in or out) is lowest in stage 3 and stage 4 sleep.
* **Cerebral blood flow:** [NREM](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl82/) sleep is associated with significant reductions in blood flow and metabolism, while total blood flow and metabolism in [REM](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl98/) sleep is comparable to wakefulness. However, metabolism and blood flow increase in certain brain regions during REM sleep, compared to wakefulness, such as the limbic system (which is involved with emotions), and visual association areas.
* **Renal:** There is a decreased excretion of sodium, potassium, chloride, and calcium during sleep that allows for more concentrated and reduced urine flow. The changes that occur during sleep in renal function are complex and include changes in renal blood flow, glomerular filtration, hormone secretion, and sympathetic neural stimulation.
* **Endocrine:** Endocrine functions such as growth hormone, thyroid hormone, and melatonin secretion are influenced by sleep. Growth hormone secretion typically takes place during the first few hours after sleep onset and generally occurs during [SWS](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl113/), while thyroid hormone secretion takes place in the late evening. [Melatonin](https://www.ncbi.nlm.nih.gov/books/n/nap11617/glossary/def-item/gl74/), which induces sleepiness, likely by reducing an alerting effect from the suprachiasmatic nucleus, is influenced by the light-dark cycle and is suppressed by light.

QUESTION 2:

Discuss the role of basal ganglia in coordinating movement.

Answer

The basal ganglia are responsible for voluntary motor control, procedural learning, and eye movement, as well as cognitive and emotional functions. The basal ganglia (or basal nuclei) are a group of nuclei of varied origin in the brains of vertebrates that act as a cohesive functional unit. They are situated at the base of the forebrain and are strongly connected with the cerebral cortex, thalamus, and other brain areas. The basal ganglia are associated with a variety of functions, including voluntary motor control, procedural learning relating to routine behaviors or habits such as bruxism and eye movements, as well as cognitive and emotional functions.

The basal ganglia are considered to be necessary for voluntary control of body movements. This idea is derived mainly from the clinical observations that lesions in the basal ganglia lead to movement disorders ranging from the inability to initiate a movement to the inability to suppress involuntary movements. Anatomically, the basal ganglia are the aggregate of nerve cell nuclei located at the base of the cerebrum. Although the basal ganglia have limited routes for their inputs and outputs, individual nuclei are often connected with each other, and therefore, it is difficult to understand, solely based on the known anatomical connections, how the information is processed in the basal ganglia. It is propose that the basal ganglia have two ways to control movements using two kinds of output: ***1*)** control over the thalamocortical networks and ***2*)** control over brain stem motor networks. However, there are different kinds of movements, such as *eye-head orienting, locomotion, mastication, and vocalization*. They are different from hand/arm movements in that their movement patterns are determined by specific neural networks in the brain stem or spinal cord. For hand-finger-arm movements, the pattern of movement is acquired largely with practice; for the brain stem-controlled movements, the pattern of movement is largely determined genetically. The outputs of the basal ganglia are directed to some of the motor networks in the brain stem. They include the projection to the superior colliculus (SC) (for eye-head orienting), the pedunculopontine nucleus (possibly for locomotion) and the periaqueductal gray (possibly for vocalization and autonomic responses).

The greatest source of insight into the functions of the basal ganglia has come from the study of two neurological disorders, Parkinson’s disease and Huntington’s disease. For both of these disorders, the nature of the neural damage is well-understood and can be correlated with the resulting symptoms. Parkinson’s disease involves the major loss of dopaminergic cells in the substantia nigra. Huntington’s disease involves the massive loss of medium spiny neurons in the striatum. The symptoms of the two diseases are virtually opposite: Parkinson’s disease is characterized by a gradual loss of the ability to initiate movement, whereas Huntington’s disease is characterized by an inability to prevent parts of the body from moving unintentionally. It is noteworthy that, although both diseases have cognitive symptoms, especially in their advanced stages, the most salient symptoms relate to the ability to initiate and control movement. Thus, both are classified primarily as movement disorders. A different movement disorder, called Hemiballismus, may result from damage restricted to the sub thalamic nucleus. Hemiballismus is characterized by violent and uncontrollable flinging movements of the arms and legs.

 

One of the most intensively studied functions of the basal ganglia is their role in controlling eye movements. Eye movement is influenced by an extensive network of brain regions that converge on a midbrain area called the superior colliculus (SC).The SC is a layered structure whose layers form two-dimensional retinotopic maps of visual space. A bump of neural activity in the deep layers of the SC drives eye movement toward the corresponding point in space. Saccadic eye movement is controlled by many brain areas. Drive for saccade originates largely from different cortical areas [frontal eye field (FEF), lateral intraperitoneal area (LIP), and supplementary eye field (SEF)], more or less independently. The basal ganglia work in a completely different way. They do not provide a drive, but select one that is appropriate, by exerting powerful tonic inhibition and removing it.

The basal ganglia are well-known role in skeletal movements as well.