NAME: OMOGBEMEH FAITH ALENOSI
MATRIC NUMBER: 17/ MHS01/258
DEPARTMENT: NEUROPHYSIOLOGY

QUESTIONS

1) Discuss the physiology of sleep
2) Discuss the role of basal ganglia in coordinating movements

ANSWERS

1) PHYSIOLOGY OF SLEEP

Sleep refers to the state of unconsciousness from which the individual can be aroused by sensory or other stimuli. Sleep is usually associated with limited movement in humans. During sleep, the stimulus pulse transfer becomes less frequent between the reticular formation and cerebral Cortex. The depth of sleep is not constant throughout the sleeping period. It varies in different stages of sleep.

SLEEP-WAKE CYCLE

Sleep and wakefulness, like many of the body's regulatory mechanisms, have circadian rhythm of about 24hours. However average sleep requirement per day at different age groups is:

- Newborn infants: 18-20 hours
- Growing children: 12-14 hours
- Adults: 7-9 hours
- Old persons: 5-7hours

FACTORS AFFECTING SLEEP

Factors which minimise sensory stimulation and favour the onset of natural sleep are:

- ***Silence***:A noisy environment can impair sleep and increase arousal from sleep. The noise level that causes an individual to wake varies between people and also changes with age. A person is also more likely to wake up if the noise is significant to the person, the crying of an infant to its parents.
- ***Darkened room:*** Seasonal changes in the duration of daylight affect the sleep-wakefulness cycle. During sleep, 5-10% of light reaches the retina and light exposure can result in arousal from non-REM sleep. Light exposure during the day also increases alertness, motor function and mood, elevates body temperature and heart rate.

- ***Comfortable surroundings temperature:*** An ambient temperature of 18 °C is ideal for falling asleep and staying asleep. Increased and decreased temperatures result in disrupted sleep
- ***Physical and mental relaxation:*** Exercise promotes wakefulness during the activity and also for 3 hours after the activity. Exercise close to the time of going to bed can delay and decrease melatonin secretion. This is important as melatonin is a hormone produced by the pineal gland which promotes sleep.
- Consumption of a basic urge, such as hunger or sex:
- Low frequency stimulation, such as by knocking in a cradle or sitting in a moving vehicle.

The factors described above have a modest effect if any. The only behavioural factor that reliably and substantially increases sleep is prior sleeplessness. On the other hand, anxiety and emotional stimuli by release of epinephrine cause activation of RAS and make sleep more difficult.

PHYSIOLOGICAL CHANGES DURING SLEEP

During sleep, most of the body functions are reduced to basal level. These changes include:

I. BRAIN:

The brain is inactive during sleep. There is a characteristic cycle of brain wave activity during sleep with irregular intervals of dreams. Electrical activity in the brain varies with stages of sleep.

II. CARDIOVASCULAR SYSTEM

During sleep, the heart rate reduces. It varies between 45 and 60 beats per minute. Systolic pressure falls to about 90 to 110mmHg. Lowest level is reached about 4th hour of sleep and remains at this level till a short time before waking up. Then, the pressure commences to rise. If sleep is disturbed by exciting dreams, the pressures is elevated above 130mmHg.

III. RESPIRATORY SYSTEM

Rate and force of respiration are decreased. Respiration becomes irregular and Cheyne-Stokes type of periodic breathing may develop which may lead to sleep apnea.

IV. GASTROINTESTINAL TRACT

Salivary secretion decreases during sleep. Gastric secretion is not altered or may be increased slightly. Contraction of empty stomach is more vigorous.

V. PLASMA VOLUME. The plasma volume decreases by about 10 percent during sleep.

VI. EXCRETORY SYSTEM

Formation of urine decreases and specific gravity of urine increases

TYPES OF SLEEP

a) Rapid Eye Movement Sleep or REM sleep
b) Non Rapid Eye Movement Sleep or Non REM sleep

A) REM SLEEP

REM sleep is also called *PARADOXICAL SLEEP,* because even though a person is asleep and difficult to arouse, his or her EEG(electroencephalogram) pattern shows intense activity that is similar to that observed in the alert, away state. It is the type of sleep associated with rapid and conjugate movements of the eyeballs move, the sleep is deep.In fact, brain O2 consumption is higher during REM sleep than during the non REM or awake states. When awakened during REM sleep, subjects frequently report that they have been dreaming. This is true even in people who usually do not remember dreaming when they awaken on their own. It occupies 20-30% of the sleeping period. Functionally, it is very important because it plays an import want role in consolidation of memory.

B) NON REM SLEEP:

It is the type of sleep without the movements of eyeballs. It is also called *SLOW WAVE SLEEP*. Dreams do not occur in this type of sleep and it occupies about 70-80% of total sleeping period. Non REM sleep is followed by REM sleep.Cell division is more rapid during non-REM sleep and sleep has an important function on the immune system.

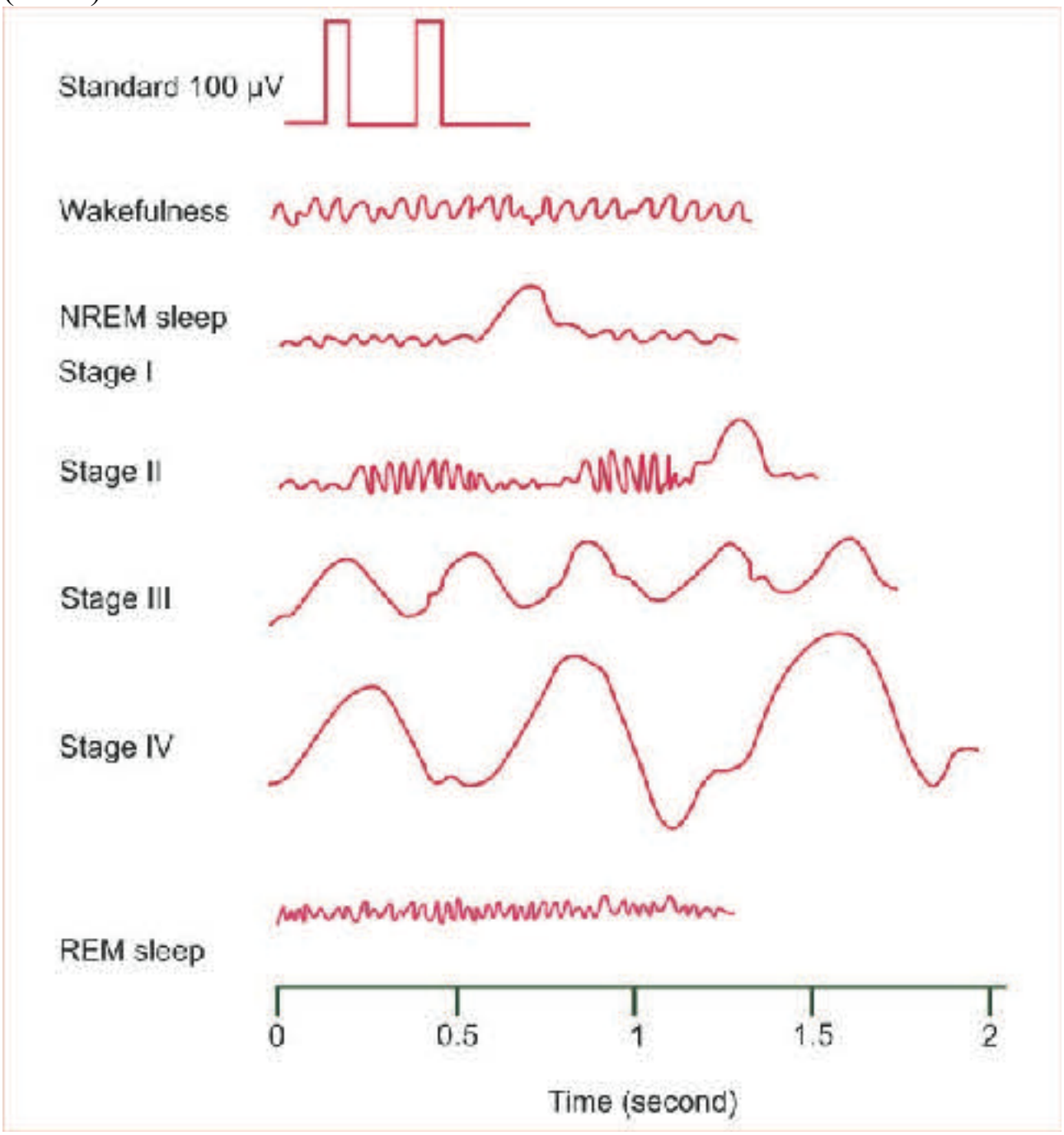
The initial phase of sleep—NREM sleep—is sub- divided into three stages. Each successive stage is characterised by an EEG pattern with a lower frequency and larger amplitude than the preceding one.

- *Stage 1 of non REM sleep(stage of very light sleep)*: In stage N1 sleep, theta waves begin to be interspersed among the alpha pattern. There is still considerable sensitivity to sensory stimuli. However, the mild to moderate stimuli are often able to produce a full arousal.
- *Stage 2 of non REM sleep(stage of light sleep)* : It is characterised by the appearance of sleep spindles. In stage N2, high- frequency bursts called sleep spindles and large-amplitude K complexes occasionally interrupt the theta rhythm followed by a brief 14Hz activity.

- *Stage 3 of non REM sleep (stage of moderate deep sleep)*: It is characterised by an EEG that display high maple slow(0.5-2Hz) waves called the delta waves
- *Stage 4 of non REM sleep(stage of deep sleep)*: It produces EEG pattern dome-like very slow, large waves called delta waves. Thus, the characteristic of deep sleep is a pattern of rhythmic slow waves, indicating marked SYNCHRONISATION.

NOTE: Sleep begins with the progression from stage N1 to stage N3 of NREM sleep, which normally takes 30 to 45 min. The process then changes; the EEG ultimately resumes a small-amplitude, high-frequency, asynchronous pattern that looks very similar to the alert, awake state. Instead of the person waking, however, the behavioural characteristics of sleep continue at this time, but this sleep also includes rapid eye movement

(REM).



Electroencephalogram during wakefulness, different stages of NREM sleep and REM sleep.
NREM- Non Rapid Eye Movement
REM- Rapid Eye Movement

PHYSIOLOGICAL IMPORTANCE OF SLEEP

a) Sleep may serve as a period of body's rest and metabolic restoration as evidenced by following physiological changes during non REM sleep:

- Pulsatile release of growth hormone and gonadotropins from the pituitary and

- Decrease in blood pressure, heart rate and respiration

b) Sleep is necessary for certain forms of learning: In experimental animals, learning sessions do not improve performance until a period of SWS or SWS plus REM sleep has occurred. However, it is not known why sleep is necessary and there is as yet no clinical correlate to this experimental observation.

c) REM sleep is necessary for mental well being: The correlateion between dreaming and REM sleep indicates that the brain is highly active at this time. This may allow for the expression through dreams, of concern in the subconscious and for long term chemical and structural changes that brain must undergo to make learning and memory possible.

d) REM sleep plays an important role in homeostatic mechanism: It is evident from the observation that when the experimental animals are completely deprived of REM sleep for long periods, they loose weight in spite of increased calleric intake and finally die

CLINICAL ANATOMY OF SLEEP

A) INSOMNIA:

It refers to the inability to have sufficient or restful sleep despite an adequate opportunity for sleep. It occurs due to systemic illness or mental conditions such as psychiatric problems, alcoholic addiction and drug addiction.

Insomnia is usually classified as one of three types:

- Chronic, which is when insomnia happens on a regular basis for at least one month.
- Intermittent, which is when insomnia occurs periodically
- Transient, which is when insomnia lasts for just a few nights at a time.

It can be relieved temporarily by sleeping pills, especially benzodiazepines. Prolonged use of these drugs can be habit forming and can compromise day time performance.

B) SLEEP APNEA:

It is the temporary stoppage of breathing repeatedly during sleeping.Sleep apnea syndrome is the disorder that involves fluctuations in the rate and force of respiration during REM sleep with short apneic episode. Apnea is due to decreased stimulation of respiratory centers, arrest of diaphragmatic movements, airway obstruction or the combination of all these factors. When breathing stops, the resultant hypercapnia and hypoxia stimulate respiration.

Sleep apnea syndrome occurs in obesity, myxedema, enlargement of tonsil and lesion in brainstem. Common features of this syndrome are loud snoring, restless movements, nocturnal insomnia, daytime sleepiness, morning headache and fatigue. In severe conditions, hypertension, right heart failure and stroke occur.

C) NARCOLEPSY AND CATAPLEXY

Narcolepsy is characterised by 'sleep attacks' during the day. This means that you will suddenly feel extremely tired and fall asleep without warning. The disorder can also cause sleep paralysis, which may make you physically unable to move right after waking up. Although narcolepsy may occur on its own, it is also associated with certain neurological disorders, such as multiple sclerosis.

Cataplexy is sudden outburst of emotion. Both the diseases are due to hypothalamic disorders.

D) NOCTURNAL ENURESIS

Nocturnal enuresis is the involuntary voiding of urine at bed. It is also called or bedwetting. It is common in children.

E) SOMNALBULISM

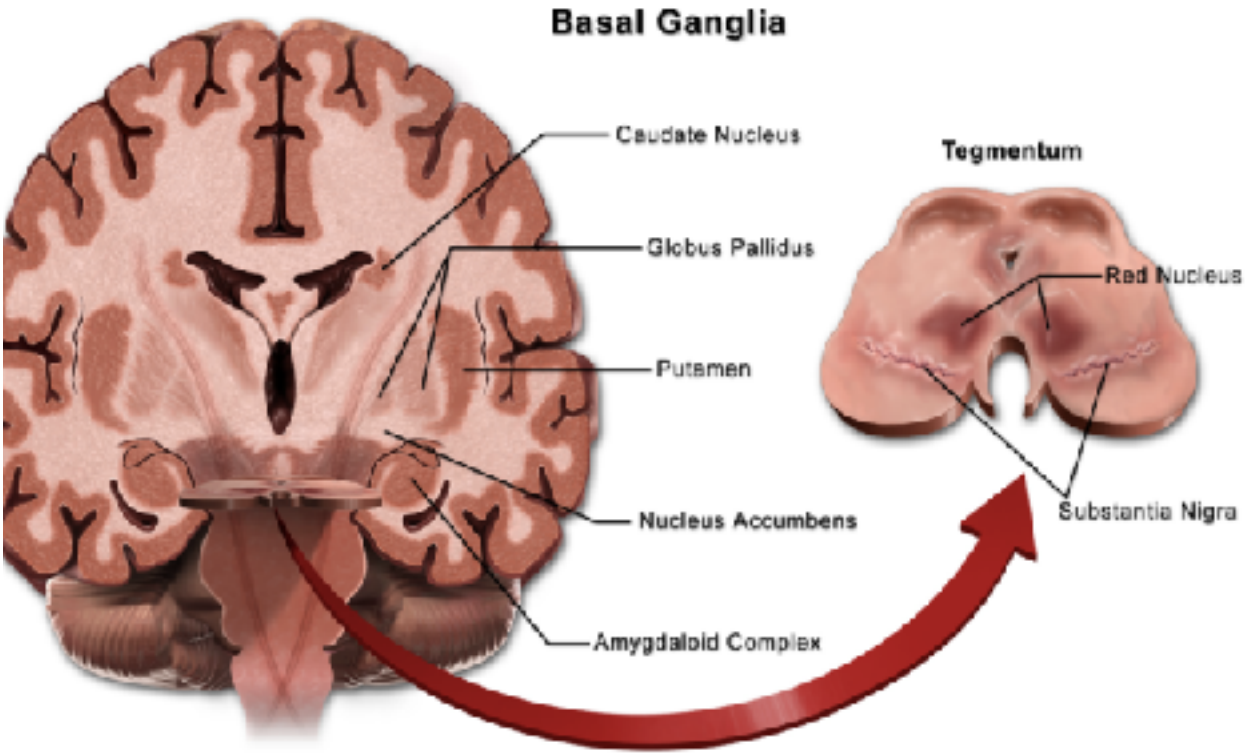
Somnambulism is getting up from bed and walking in the state of sleep. It is also called walking during sleep or sleep walking (somnus = sleep; ambulare = to walk). It varies from just sitting up in the bed to walking around with eyes open and performing some major complex task. The episode lasts for few minutes to half an hour. It occurs during non-REM sleep. In children, it is associated with bedwetting or night terror without any psychological disturbance. However, in adults it is associated with psychoneurosis.

2) **ROLE OF BASAL GANGLIA IN COORDINATING MOVEMENTS**

Basal Ganglia are a group of subcortical nuclei or bodies that together are primarily engaged in influencing motor(movement) control along with the motor cortex and the spinal cord.

Movement

In order to execute purposeful movements, a small number of motor plans in the brain need to be promoted and integrated, while others that impair or stop the execution of the desired movement must be suppressed. Action selection is facilitated by the nature of the parallel pathways, the number of neurons involved in the processing of information as it progresses



through the basal ganglia, and the manner in which these neurons are arranged. The input and output nuclei generally contain the largest and smallest numbers of neurons, respectively. As information progresses through the basal ganglia, each neuron integrates information that has been transmitted from many other neurons in preceding nuclei; hence, the signal becomes increasingly focused and specific as it passes through the basal ganglia. The process of determining which signals are promoted occurs early in the basal ganglia circuit—at the striatum; the neuromodulator dopamine plays a key role in signal promotion.

Parallel pathways within the basal ganglia circuits facilitate signal promotion and signal inhibition. Neighbouring pathways carrying information about elements of the same desired movement successively amplify the promoted signal as it progresses through the basal ganglia. More often, however, neighbouring pathways act to reduce unwanted signals, ensuring that an accurate, precise, and optimized action plan is developed. In the absence of action selection, all motor plans are promoted and many muscles around the body are activated, leading to a failure to execute desired actions.
Coordinating motivation with body movement. Specifically, the basal ganglia inhibits individual behavior in a complex social interaction and also inhibits small voluntary movement.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

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 characterised by a gradual loss of the ability to initiate movement, whereas Huntington's disease is characterised 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 subthalamic nucleus. Hemiballismus is characterised by violent and uncontrollable flinging movements of the arms and legs.

<u>Function in Eye Movement</u>

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.