CNS MODULE
PHYSIOLOGY (LECTURE 8)
CONSCIOUSNESS & SLEEP

PRESENTED BY

DR. FATMA FARRAG ALI

ASSOCIATE PROFESSOR OF PHYSIOLOGY

2023-2024

SLEEP

- **Definition:**
  - Sleep is a physiological state of temporary unconsciousness (from which the person can be aroused by proper stimulation; sensory or other stimuli).
  - It is to be distinguished from coma, which is unconsciousness from which the person cannot be aroused.

- **Duration:**

Its varies inversely with age (average):

  - 18 hours/day in infants.
  - 8 hours/day in adults.
  - 6 hours/day in old persons.

- **The sleep/wakefulness 24-hours rhythm:**

It is determined mainly by synchronization with the 24-hours light/dark cycle.

TYPES OF SLEEP

- There are multiple stages of sleep, from very light sleep to very deep sleep. Sleep researchers divide sleep into two different types of sleep that have different qualities.

Two Types of Sleep.

- During each night, a person goes through stages of two types of sleep that alternate with each other.
- They are called:

(1) Slow-wave sleep (SWS), because in this type of sleep the brain waves are very low frequency.

(2) Rapid eye movement sleep (REM sleep), because in this type of sleep the eyes undergo rapid movements despite the fact that the person is still asleep.

(A) Slow wave sleep (SWS) (= non-rapid eye movement, Non-REM sleep)

- This type is the first to occur when the person falls a sleep.
- It is characterized by slow EEG waves and absence of REM (= Rapid eye movements).
- EEG recording during this type show 4 stages that occur respectively as follows:

- **Stage 1:** in this stage, **sleep is very light** and the EEG shows a **slow theta wave** rhythm.
- **Stage 2:** in this stage, **sleep is light** and the EEG shows characteristic **sleep spindles** (= bouts of large alpha-like waves that superimpose on the theta rhythm, and each bout lasts for 1-2 seconds).
- **Stage 3:** in this stage, **sleep is moderately deep**, and the EEG shows delta waves at a frequency of about 3 Hz.
- **Stage 4:** in this stage, **sleep is deepest** and the EEG shows delta waves with maximal slowing (frequency = 1 Hz).

- During non-REM sleep, sleep talking and walking often occur.
- Although slow-wave sleep is frequently called “dreamless sleep,” dreams and sometimes even nightmares do occur but they are usually not remembered.

(B) Rapid eye movement (REM, or paradoxical) sleep

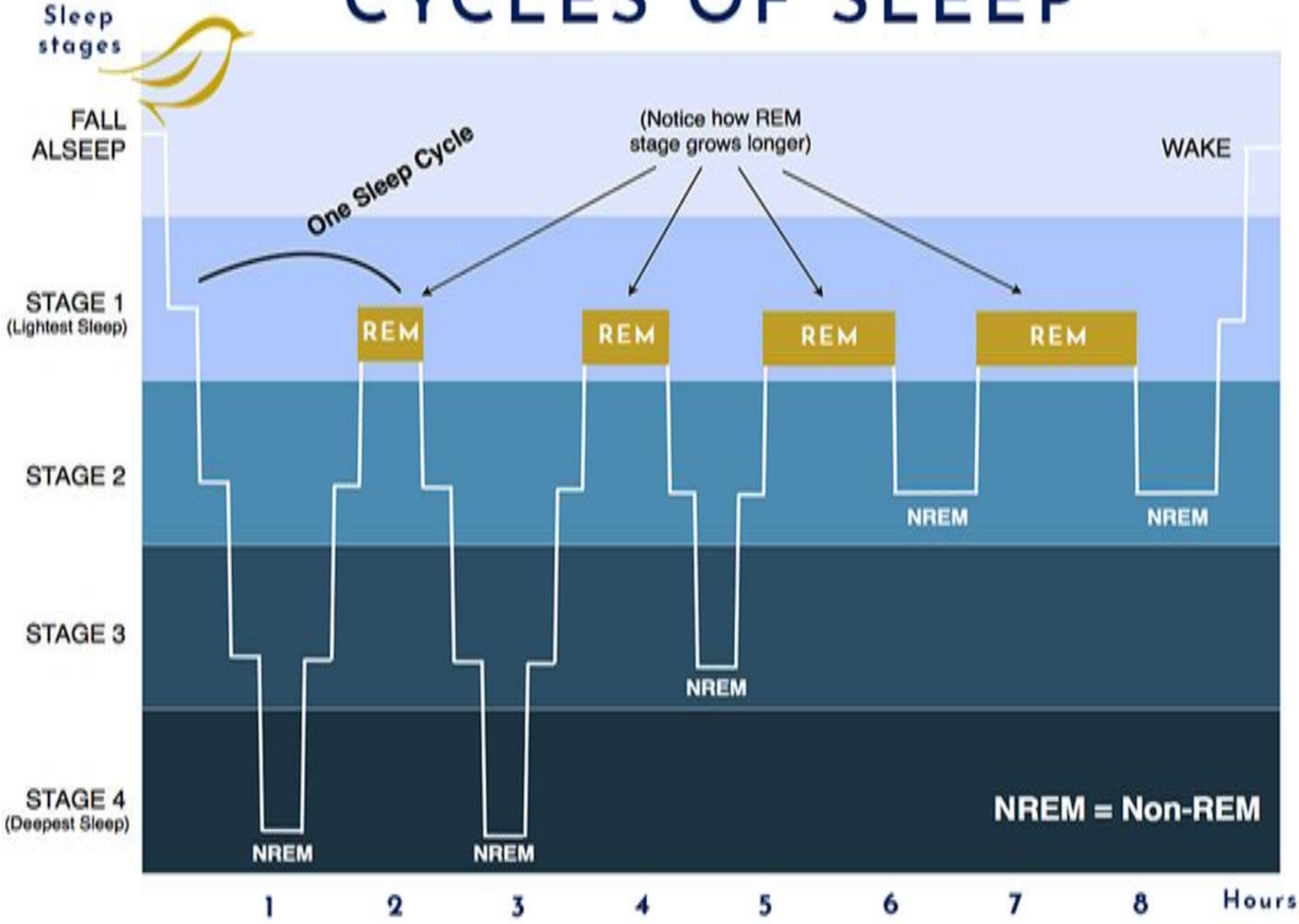
- This type is characterized by rapid eye movements, and it normally follows the slow wave sleep.
- The EEG shows desynchronized **beta rhythm** as that encountered in the arousal response. This indicates brain activity but , however, the person is still a sleep and the threshold for arousal is high (so it is also called paradoxical sleep).
- Active dreams that can be remembered frequently occur during REM sleep.

Sleep Cycles

Sleep starts normally by the **slow wave type (Non-REM)** for about 70-110 **(average 90) minutes**, then **REM sleep follows for about 20 minutes**, and this is repeated cyclically with gradual prolongation of the REM sleep periods. Thus, there are **4-6 sleep cycles during a single night**, and the **REM sleep constitutes about 20-25 % of the total sleep time**.

- Most sleep during each night is of the slow-wave variety; this is the deep, restful sleep that the person experiences during the first hour of sleep after having been awake for many hours.
- REM sleep, on the other hand, occurs in episodes that occupy about 20- 25 % of the sleep time; each episode normally recurs about every 90 minutes. This type of sleep is not so restful, and it is usually associated with vivid dreaming.

CYCLES OF SLEEP



	Non-REM sleep (Slow wave sleep; SWS)	REM (Paradoxical) sleep
1. Timing:	At the start of sleep	After the 4th stage of non-REM sleep
2. Duration/night:	75-80 % / sleep time	20 -25 %/ sleep time
3. Duration/cycle	Average 90 minutes	Average 20 minutes
4. Depth of sleep & EEG findings:	4 stages: *Stage 1 (very light sleep): Theta waves *Stage 2 (light sleep): Sleep spindles(bouts of large alpha-like waves that superimpose on theta waves) *Stage 3 (moderately-deep sleep):Delta waves (3 Hz) *Stage 4 (deep sleep): Delta waves with maximal slowing (1 Hz).	Small rapid irregular beta waves (like an alert person)
5. Eyes movements:	No rapid eye movements (deviate up)	Rapid eye movements
6. Dreams:	Absent (if present → not remembered)	Present & can be remembered
7. HR, RR, BP:	↓↓ (10-30%)	↑↑(may be irregular)
8. Muscles tone:	Slight ↓ (hypotonia)	Marked ↓↓↓ (Sleep paralysis)
9. Sleep talking & walking:	Present	Absent
10. Awakening:	Easy	Difficult (high threshold)
11. Brain activity & metabolism	↓	↑ (by 20%)

MECHANISM (THEORIES) of SLEEP

Sleep primarily results from depression of the cerebral cortex secondary to inhibition of the RAS activity, which can occur by either:

(1) Passive theory:

This assumes that **sleep occurs as a result of passive inhibition of the RAS**, which can be induced by either its **fatigue (after a period of wakefulness)** or by **decreasing its activity through elimination of its exciting stimuli e.g. the visual, auditory, painful and other stimuli**. However, absence of the exciting stimuli alone cannot lead to sleep, although it helps its onset.

(2) Active theory:

This **seems to be the real mechanism of sleep**.

It was found that **excitation of certain centers in the brain stem inhibits the RAS**, and it is believed that **sleep occurs as a result of active inhibition of the RAS by signals discharged from certain centers**. **Some of these ''sleep centers'' include the following:**

Stimulation of these nuclei depresses the RAS and **produces slow wave (non-REM) sleep**.

1- The Raphe nuclei in the lower half of pons and medulla.

The neurons of these nuclei release serotonin, so it is believed that serotonin induces sleep.

When a drug that blocks the formation of serotonin is administered to an animal, the animal often cannot sleep for the next several days. Therefore, it has been assumed that **serotonin** is a transmitter substance associated with production of sleep **(sleep hormone)**.

2. Stimulation of some areas in the nucleus of the tractus solitarius can also cause sleep (This nucleus is the termination in the medulla oblongata for visceral sensory signals entering by way of the vagus and glossopharyngeal nerves).

3. Stimulation of several regions in the diencephalon can also promote sleep, including **mainly the suprachiasmatic nucleus in anterior hypothalamus.**

- ✓ **The hypothalamic suprachiasmatic nucleus** is probably the **center that synchronizes the sleep/wakefulness rhythm with the 24 hours light-dark cycle**.

Possible Cause of REM Sleep.

- Why slow-wave sleep is broken periodically by REM sleep is not understood. However, drugs that mimic the action of acetylcholine increase the occurrence of REM sleep.
- The **large acetylcholine secreting neurons in the upper brain stem reticular formation** might, through their extensive efferent fibers, **activate many portions of the brain**. This theoretically could cause the excess activity that occurs in certain brain regions in REM sleep.

SLEEP CENTERS

	Non-REM sleep	REM sleep
Center:	Raphe nuclei (in lower pons & upper MO)	Cholinergic neurons of upper brainstem reticular formation (RF)
Chemical transmitter:	Serotonin	Acetylcholine (Ach)

(3) Metabolic theory of sleep:

- Experiments have shown that cerebrospinal fluid (CSF), blood and urine of animals kept awake for several days were found to contain substances that induce sleep if injected into the brain ventricular system of other animals.
- Many of such sleep inducing factors were identified (e.g. muramyl peptide which is a low-molecular-weight substance that accumulates in the CSF and urine in animals kept awake for several days. When only micrograms of this sleep-producing substance are injected into the third ventricle, almost natural sleep occurs within a few minutes, and the animal may stay asleep for several hours.
- Another substance that has similar effects in causing sleep is isolated from the blood of sleeping animals. And still a third sleep factor, not yet identified molecularly, has been isolated from the neuronal tissues of the brain stem of animals kept awake for days.
- It is possible that prolonged wakefulness causes progressive accumulation of a sleep factor or factors in the brain stem or in the CSF that lead to sleep.

Mechanism of Consciousness (Wakefulness)

- The initiation and maintenance of consciousness is the function of the reticular activating system (RAS).
- Activation of this system leads to consciousness through excitation of cerebral cortex by signals discharged either directly or via the reticulo-thalamo-cortical pathway.
- Consciousness is then maintained by a +ve feedback mechanism through re-excitation of the RAS by signals discharged from the activated cortex via the corticofugal fibers (which constitute a cortico-thalamo-reticular pathway).

The sleep/wakefulness cycle

- When the sleep centers are not activated, the upper pontine reticular activating nuclei (RAS) are released from inhibition, which allows the RAS to become spontaneously active.
- RAS in turn excites the cerebral cortex which sends numerous positive feedback signals back to RAS nuclei to activate them still further.
- Therefore, once wakefulness begins, it has a natural tendency to sustain itself because of all this positive feedback activity.
- Then, after the brain remains activated for many hours, even the neurons themselves in RAS presumably become fatigued. Consequently, the positive feedback cycle between the RAS nuclei and the cerebral cortex fades, and the sleep-promoting effects of the sleep centers take over, leading to rapid transition from wakefulness back to sleep.
- Then during the sleeping hours, the RAS gradually recovers its excitability, while the sleep centers become less excitable (because of their over-activity), so the RAS is released from their inhibitory effect and discharges excitatory signals to the cerebral cortex, leading to a new cycle of wakefulness.
- This overall theory could explain the rapid transitions from wakefulness to sleep and from sleep to wakefulness.

Physiologic Effects of Sleep

- ✓ Sleep causes two major types of physiologic effects: first, effects on the nervous system itself, and second, effects on other functional systems of the body.
- ✓ Lack of sleep certainly affects the functions of the central nervous system. Prolonged wakefulness is often associated with progressive malfunction of the thought processes and abnormal behavioral activities.
- ✓ In addition, a person can become irritable or even psychotic after forced wakefulness.
- ✓ Therefore, we can assume that sleep in multiple ways restores both normal levels of brain activity and normal “balance” among the different functions of the central nervous system.
- ✓ overuse of some brain areas during wakefulness could easily throw these areas out of balance with the remainder of the nervous system. We might postulate that the principal value of sleep is to restore natural balances among the neuronal centers.

SLEEP DISORDERS

1. Insomnia: (the commonest)

- Definition: Lack of sleep.
- Causes: Psychological (fear or anxiety) – Analeptic substances – Damage of sleep centers.

2. Hypersomnia: Prolonged sleep.

3. Non-REM sleep may be associated with:

- Sleep-talking.
- Sleep-walking (somnambulism).

4. REM sleep may be associated with:

✓ REM behavior disorder: No ↓ in muscle tone.

5. Sleep apnea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YOU