كلية الطب البشري
Faculty of Medicine

CNS Module-2021
Physiology Lectures
(Lecture 12)
Topic 6: Cerebral Cortex and Electrical activity of the brain

Electrical activity of the brain & Sleep

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Electrical activity of the Brain & Arousal response and sleep

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- **Two types of brain potentials can be recorded:**

I- Evoked potentials : **The electrical events that occur in the cortex after stimulation of a sense organ can be monitored with a recording electrode.**

Types of Evoked potentials :

1- Somatosensory stimuli → SSEP

2- Auditory stimuli → AEP

3- Visual stimuli → VEP

2- Spontaneous potential(Electroencephalogram)

the recording of the variations in brain potential. The EEG can be recorded with scalp electrodes through the unopened skull or with electrodes on or in the brain. The term electrocorticogram is used for the recording obtained with electrodes on the pial surface of the cortex.

(II) The Electro-encephalogram (EEG)

-The EEG is the record of the spontaneous electric activity of the brain.

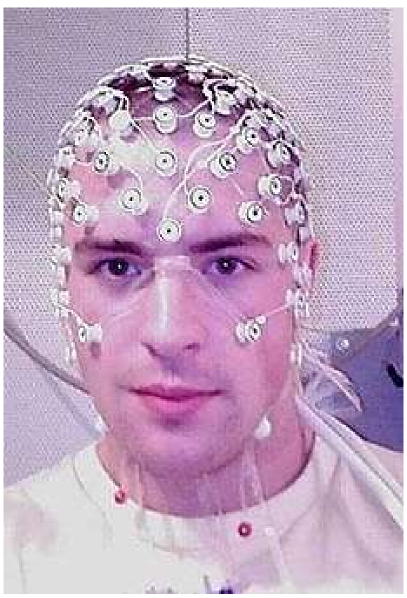
-It can be recorded by applying electrodes on the scalp of patient.

-The electric activity appears on a multi-channel recorder as waves of variable intensity (0-200 mV) and frequency (1-50 Hz).

Conditions Required :

1- Recording of EEG should be done in a calm room at a comfortable temperature

2- The subject should be in complete physical and mental rest.



-The electric activity appears on a multi-channel recorder as waves of variable intensity (0-200 mV) and frequency (1-50 Hz).

Alpha

- -8-13 Hz & 50 µv
- -Regular & rhythmic
- -Adult
- -Parito-occipital region.
- -Physical and mental rest
- -Awake but with eyes closed

Alpha

Beta

- -18-30Hz & 20 µv
- -Irregular & non-rhythmic
- -Adult
- -Frontal region
- -Intense activation of the CNS i.e. during thinking and tension

Beta

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Theta

4-7 Hz & 100 µv

Regular and large

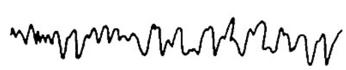
Parietal & Temporal

In Children

& in adult during light

Sleep and may be in adults during emotional disappointment

Theta



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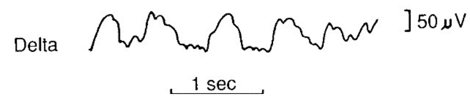
Delta

-1-3 Hz & 100 μv

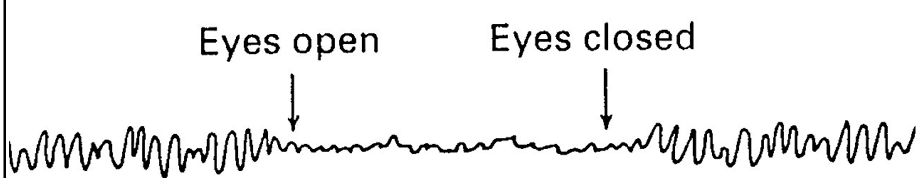
-Regular& high voltage

-Infants & in adults during deep sleep

coma, anasthtesia



Desynchronization :alpha block : Alert or Arousal response :



While the eyes are closed, synchronous discharge of many cerebral neurons produces alpha waves, but when the eyes are opened, faster low voltage irregular beta waves are recorded. This is known as "alpha block". It has also been called "de-synchronization" because it represents breaking up of the synchronized neural activity necessary to produce regular waves.

Clinical Uses of the EEG

1-Localizing brain tumors

2. Diagnosis of epilepsy

3.Diagnosis of sleep disorders.

4.Confirmation of brain death (flat EEG).

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Wakefulness And Sleep Cycle

sleep and wakefulness

= state-dependent behavior

Reflected by changes in cortical electrical activity: EEG changes

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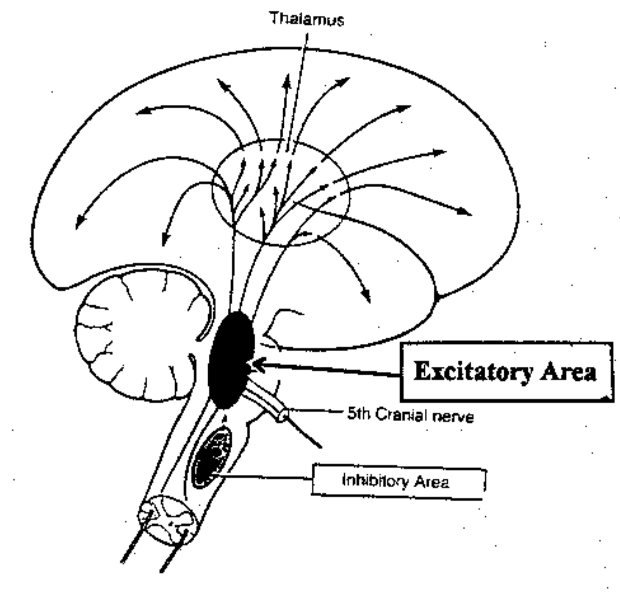

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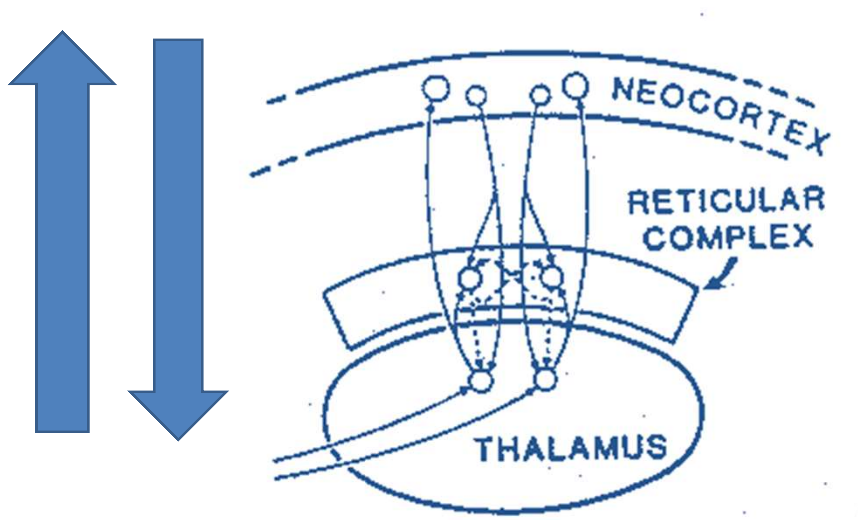
Positive feedback between the cortex and RF through the thalamus



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A. Factors that increase RAS activity:

1- The impulses from all the classical sensory pathways. Pain and proprioceptive stimuli are particularly effective and can arouse a person from sleep.

2- Descending impulses from the cerebral cortex have a strong excitatory effect on RAS. Emotions and voluntary movements help in keeping a person awake.

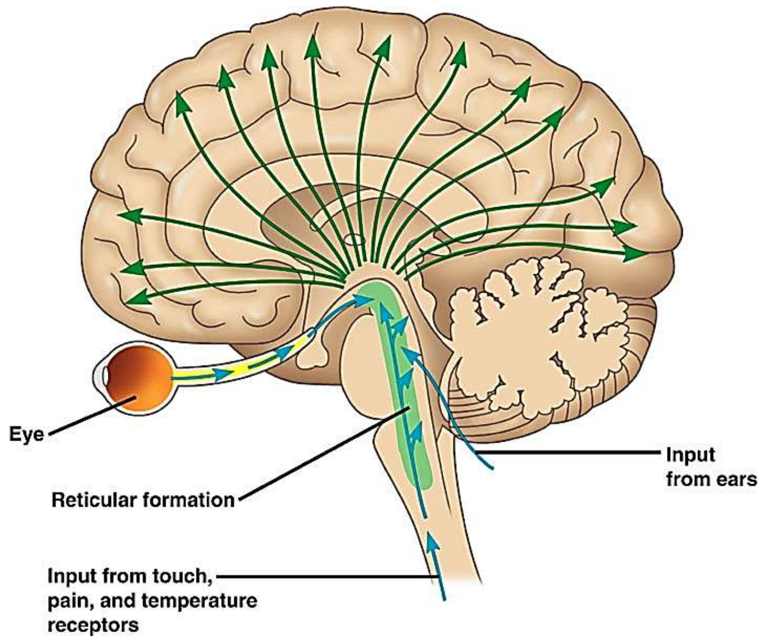
3-Epinephrine and norepinephrine secreted from the adrenal medulla produce alerting response.

B. Factors that decrease the RAS activity:

1- Impulses from the sleep-producing centers of the reticular formation.

2- Lesions that damage the brain stem cells e.g. vascular lesions, poisons, tumors and hypoxia.

3- Drugs e.g. barbiturates as they cause hyperpolarization of the neurons.



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Most, if not all, living cells in plants and animals have rhythmic fluctuations in their function on a circadian cycle. Normally they become entrained, that is, synchronized to the day–night light cycle in the environment. If they are not entrained, they become progressively more out of phase with the light–dark cycle because they are longer or shorter than 24 h.

The entrainment process in most cases is dependent on the suprachiasmatic nuclei (SCN). These nuclei receive information about the light–dark cycle via a special neural pathway, the retinohypothalamic fibers. Efferent fibers from the SCN initiate neural and humoral signals that entrain a wide variety of well-known circadian rhythms including the sleep–wake cycle and the secretion of the pineal hormone melatonin.

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-Sleep is a state of loss of consciousness from which a person can be aroused by proper stimuli.

-As the person falls asleep, different stages can be identified from an EEG recording.

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In mammals there are two sleep states:

- REM: rapid eye movement;
- NREM (non-REM)

Defined by:
• EEG
+ EOG, electroculography,
+ EMG, electromyography
(= polysomnography)

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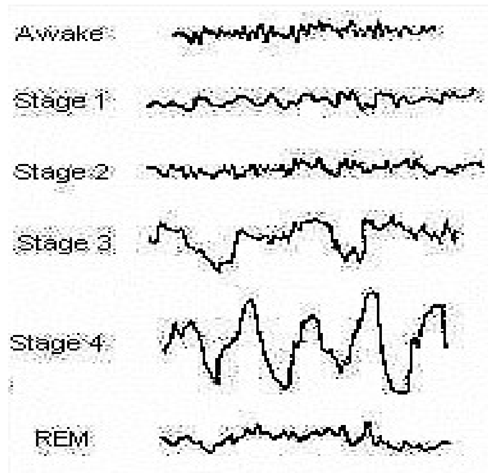
Slow-wave sleep (Non-Rapid Eye Movement):

- **Stage 1&2&3&4**
- **<u>Character</u>**

Theta → Theta with Sleep spindles → Theta → delta waves→delta max



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Non- REM

- Most of the sleep during the night occupies about 80% of sleep time.
- Eyes deviate up .
- Dreams are present, but are not remembered because they are not consolidated in the memory.
- Talking and walking are present
- HR&ABP&RR → decrease
- Ms Tone → Decreased

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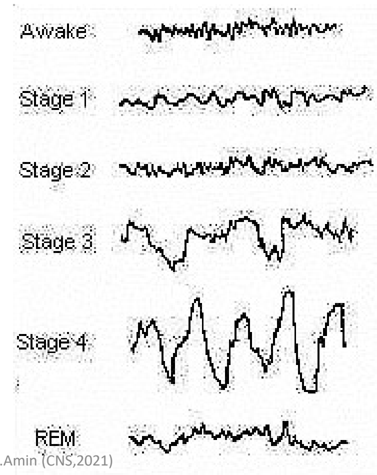
Rapid Eye Movement Sleep (REM sleep)

-Irregular low voltage, high frequency waves

-Resembles that seen in alert state (beta waves).

<u>REM sleep is also called paradoxical sleep.</u>



REM

-Occurs in episodes of 5-30 min, which recur about every 90 min of NREM sleep occupies

-20% of sleep duration.

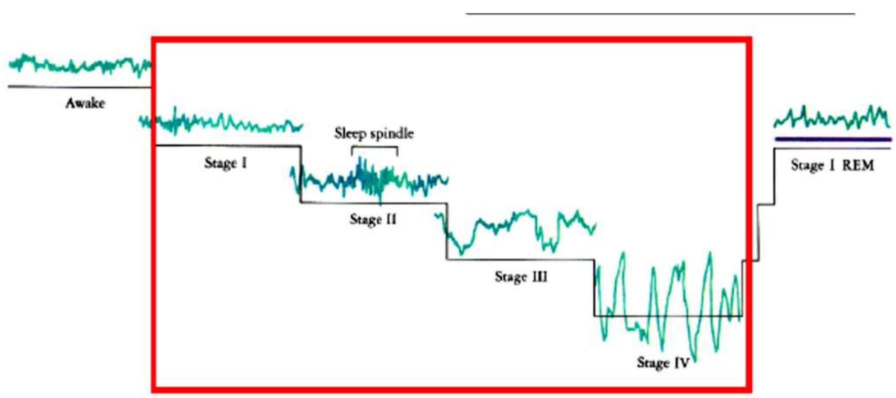
-Rapid eye movement

-Dreams which are remembered

-Increase : → HR & ABP & RR

-Marked hypotonia

-Beta waves → Irregular fast, low waves



Distribution of sleep stages

- In a typical night of sleep, a young adult first enters NREM sleep, passes through stage 1 and 2 and spends 70-100 minutes in stages 3 and 4. Sleep them lightens and a REM period follows. This cycle is repeated at intervals of about 90 min throughout the night.

Mechanisms of sleep

(1} Passive mechanism i.e. as a result of 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.

(2) Active mechanism : This is ***more accepted*** as a mechanism of sleep.

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Mechanisms of sleep

Active mechanism of sleep:

Transitions between sleep and wakefulness manifest a circadian rhythm consisting of an average of 6–8 h of sleep and 16–18 h of wakefulness. Nuclei in both the brainstem and hypothalamus are critical for the transitions between these states of consciousness.

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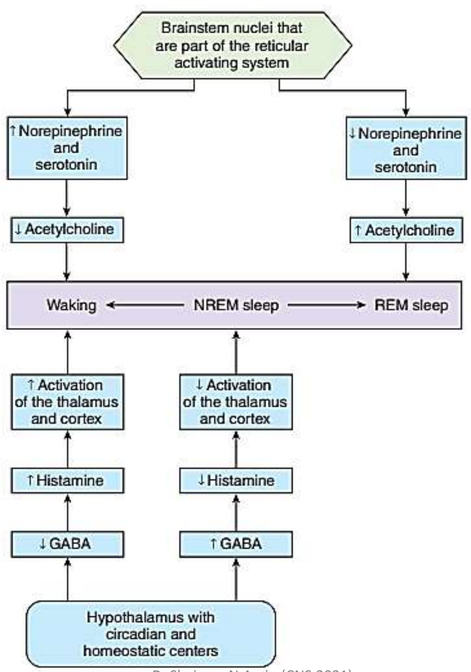
One theory regarding the basis for transitions from sleep to wakefulness involves alternating reciprocal activity of different groups of RAS neurons.

In this model, wakefulness and REM sleep are at opposite extremes. When the activity of norepinephrine- and serotonin-containing neurons is dominant, there is a reduced level of activity in acetylcholine-containing neurons in the pontine reticular formation.

This pattern of activity contributes to the appearance of the awake state. The reverse of this pattern leads to REM sleep.

When there is a more even balance in the activity of the aminergic and cholinergic neurons, NREM sleep occurs. In addition, an increased release of GABA and reduced release of histamine increase the likelihood of NREM sleep

The orexin released from hypothalamic neurons may regulate the changes in activity in these brainstem neurons.



Sleep disorders

1- Insomnia:

It is insufficient sleep that occurs in adults due to :

1- Psychological factors e.g. anxiety

2- Intake of analeptics e.g. coffee.

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2- Somnambulism:

"*sleep walking*"

-More common in male children.

-The person walks with eyes opened, and avoid obstacle and when awakened can not remember what he did.

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3- Narcolepsy:

Irresistible sleep during daytime activities which starts with sudden onset of REM sleep.

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Narcolepsy has a familial incidence strongly associated with a class II antigen of the major histocompatibility complex on chromosome 6 at the HLA-DR2 or HLA-DQW1 locus, implying a genetic susceptibility to narcolepsy.

The HLA complexes are interrelated genes that regulate the immune system Compared to brains from healthy persons, the brains of persons with narcolepsy often contain fewer hypocretin (orexin)-producing neurons in the hypothalamus.

It is thought that the HLA complex may increase susceptibility to an immune attack on these neurons, leading to their degeneration.

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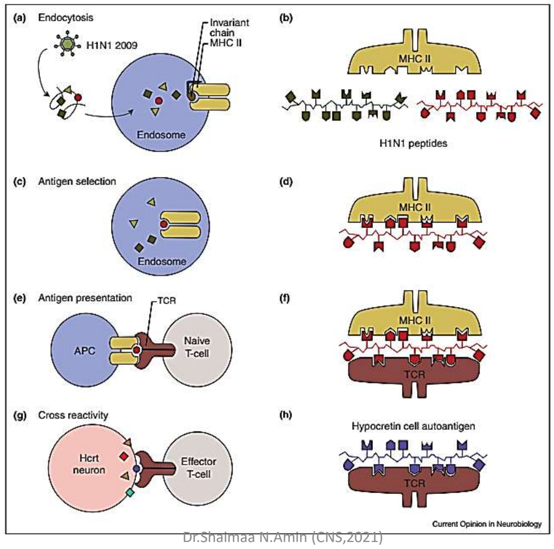
Autoimmune Basis of Narcolepsy



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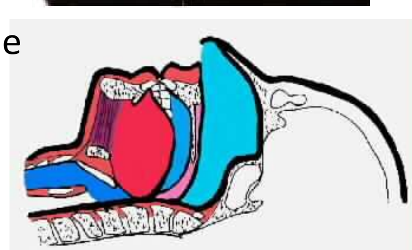
4- Sleep apnea:

-Caused by obstruction of the airways during sleep.

-Effort to overcome the obstruction awakens the person from sleep.



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Obstructive sleep apnea (OSA) is the most common cause of daytime sleepiness due to fragmented sleep at night and affects about 24% of middle-aged men and 9% of women in the United States. Breathing ceases for more than 10 s during frequent episodes of obstruction of the upper airway(especially the pharynx) due to reduction in muscle tone.

The apnea causes brief arousals from sleep in order to reestablish upper airway tone. An individual with OSA typically begins to snore soon after falling asleep. The snoring gets progressively louder until it is interrupted by an episode of apnea, which is then followed by a loud snort and gasp as the individual tries to breathe.

OSA is not associated with a reduction in total sleep time, but individuals with OSA experience a much greater time in stage 1 NREM sleep (from an average of 10% of total sleep to 30–50%) and a marked reduction in slow-wave sleep (stages 3 and 4 NREM sleep).

The pathophysiology of sleep apnea includes both a reduction in neuromuscular tone at the onset of sleep and a change in the central respiratory drive

<u>5- REM behavior disorder:</u>

- Hypotonia fails to occur.
- The patients with this condition act out their dreams, they even jump out of bed to do battle with imagined aggressors.

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