Physiology 435 team

PHYSIOLOGY OF CONSCIOUSNESS

Objectives:

- Define **consciousness** and explain the different **states** of consciousness.
- Explain what is meant by the " **Reticular Activating System** "(RAS)
- Define the **location** and **function** of the **Bulboreticular Facilitatory Area**.
- Describe how the **interaction** between the Bulboreticular Facilitatory Area, Thalamus and Cerebral Cortex subserves & sustains consciousness.
- Explain how a medical person can **differentiate between a conscious and unconscious** person by means of outward behavior as and physical signs.
- Describe the **role of EEG** and evoked potentials in differentiating between a conscious person, a sleeping person, a comatose patient and brain dead patient.

(Girls Slides Version)

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★ References:

- 435 girls slides and notes.

Color index: Important - Further explanation - Doctors Notes - Numbers.

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*Please check out this link before viewing the file to know if there are any additions or changes.

What is consciousness?

- The brain state in which a person is being **aware** of the self and surroundings. "وعيك بما حولك"
- Consciousness is a spectrum that ranges from low to high levels of awareness. "بمعنى أن مستويات الوعي متدرجة"
- It is a product of **electrical** activity of the brain. Meaning that a (flat EEG = unconscious). "EEG is an abbreviation of Electroencephalogram that will be discussed later." معلومة جانبية: في أمريكا ينطقونها إنْسِفَلُو قرام ولكن المملكة المتحدة ينطقونها إنكفلوقرام"

❖ Levels of Consciousness:

1) Normal Consciousness

- State of normal arousal, being fully awake and aware of the self and surroundings. In general we have Two awake states: relaxed awareness and awareness with concentrated attention.
  يعني الوعي والتنبّه نوعين، وعي الاسترخاء ووعي بتركيز، كما هو الفرق بين وعيك أثناء القيادة وأثناء المشي.

2) Clouded Consciousness وعي مشوّش

- The person is **conscious** but mentally **confused.** **Some examples include cases of:**
  - ★ **Drug\Alcohol intoxication.**
  - ★ **High fever (especially with cases of malaria, septicemia and dementia, etc.)**
- عشان كذا الطفل لما يكون عليه حرارة يسولف وتحس أنه مو مركز، الأمهات يعرفون اللي عليه حرارة من هذا الشيء (حاسة سادسة Go moms)

3) Sleep

- Person unconscious (in relation to the external world & surroundings) but is **arousable** (can be aroused). غير واعي بما حوله ولكن يمكن إيقاظه

4) Coma

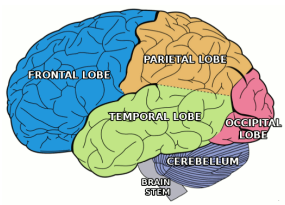
- Person unconscious and **not** arousable.
- GCS Glascow coma scale. Happens due to asc RAS or both cerebral hemispheres
- معلومة: عندنا مقياس يستخدم كثير بالمستشفيات لتقييم المريض واسمه "GCS Glascow Coma Scale" أقل نقاط فيه 3 وأعلاها 16 "يقيس ردود العين، الكلام، الحركة"

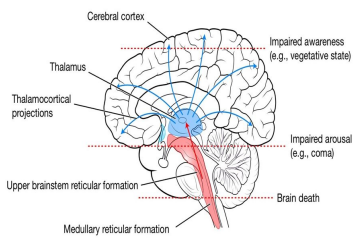
Glasgow Coma Scale

	1	2	3	4	5	6
Eye	Does not open eyes	Opens eyes in response to painful stimuli	Opens eyes in response to voice	Opens eyes spontaneously	N/A	N/A
Verbal	Makes no sounds	Incomprehensible sounds	Utters inappropriate words	Confused, disoriented	Oriented, converses normally	N/A
Motor	Makes no movements	Extension to painful stimuli (decerebrate response)	Abnormal flexion to painful stimuli (decorticate response)	Flexion / Withdrawal to painful stimuli	Localizes painful stimuli	Obeys commands

Brain Structures Involved in the Conscious State

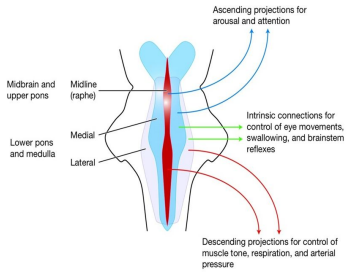
1- Reticular formation (In the brain stem).
2- Thalamus منطقة المهاد
3- Hypothalamus منطقة تحت المهاد
4- Ascending projection pathways.
5- Cerebral cortex (Widespread area).





❖ Brain stem Reticular formation:

- Set of **interconnected nuclei** that are located throughout the **brainstem** (Pons, Midbrain, Upper medulla), and the **thalamus**. مجموعة من الخلايا العصبية المتشابكة
- Connect the brainstem to the CC. "cerebral cortex."
- No clear anatomical boundaries. "Not in a specific place but more than one place in the brain."
- **Role in:** behavioral **arousal** AND **consciousness** (sleep/awake cycle).



Reticular Formation consists of 3 parts (from lateral to medial):

1) Lateral Reticular Formation "Parvocellular nuclei"

➔ Has **small** neurons.

Receives information from **ascending** tracts	for touch and pain.
Receives **vestibular** information	from median vestibular nerve.
Receives **auditory** information	from superior olivary nucleus
Visual information	from superior colliculus.
Olfactory information olfaction can trigger memories because it is sent to RF.	via medial forebrain bundle.

2) Paramedian Reticular Formation "Magnocellular nuclei" (direct connection to centres)

➔ Has **large** cells.

➔ Receives signals from lateral reticular formation.

➔ Contains:

- **Noradrenergic** (NA) neurons that projects onto ⟶ cerebral hemispheres.
- **Dopaminergic** (DA) neurons that projects onto ⟶ cerebral hemispheres.
- **Cholinergic** [1](Chl) neurons project onto ⟶ the thalamus.

3) Raphe nuclei (Median RF)

➔ In the **midline** of the reticular formation.

➔ Contain **serotonergic** projections to ⟶ the brain and spinal cord. "Raphe is the place of synthesis of the neurotransmitter **serotonin**."

❖ Functions of reticular formation:

1. Somatic motor control "Reticulospinal tracts"

The main pathway is (Motor area 4, premotor area 6, supressor area 4) ⟶ corona radiata ⟶ internal capsule ⟶ basal ganglia ⟶ brain stem. From the brainstem the reticulospianl tract is divided into medial excitatory pontine and lateral medullary inhibitory. Each receives from different places (motor tracts lecture). They affect gamma efferent and function in **maintaining tone, balance and posture.**

2. Cardiovascular control

Through **cardiac** and **vasomotor** centers of the **medulla** oblongata.

3. Pain modulation

- Pain signals from the lower body ⟶ RF ⟶ cerebral cortex. "بمعنى أن الألم يمر من الجسم وعبر الفورميشن حتى يصل لقشرة الدماغ"

[1] Neurons that use Acetylcholine as their main neurotransmitter

- RF is **origin of the descending analgesic** pathways (act on the spinal cord to block the transmission of some pain signals to the brain).

4. Sleep and consciousness.

5. Habituation

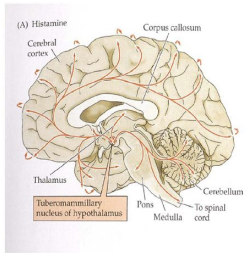
a process in which the brain learns to ignore repetitive stimuli while remaining sensitive to others. A good example of this is a person who can sleep through loud traffic in a large city, but is awakened promptly due to the sound of an alarm or crying baby.

→ Extra Explanation:

❖ **Clinical Significance:**

Mass lesions in the brainstem (especially pons and MO) cause severe alterations in level of consciousness (such as coma) because of their effects on the reticular formation.

❖ Thalamus

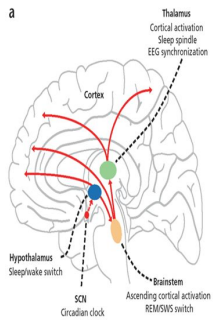


- **Located in:** the mid-part of the **diencephalon**.
- **Cholinergic** projections from the thalamus are responsible for:
  - **Activation** of the cerebral cortex.
  - **Regulation** of flow of information through other thalamic nuclei to the cortex via projections into reticular nuclei. (regulation of flow from RF to cortex)
- It is a relay station for impulses before reaching CC except for olfaction which goes directly to cortex.

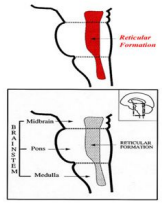
❖ Hypothalamus

Tuberomammillary nucleus in the hypothalamus (posterior third) that contains **histamine-releasing** neurons. It projects to the cortex and is involved in **maintaining the awake** state. "See the picture where the redlines are its projections"

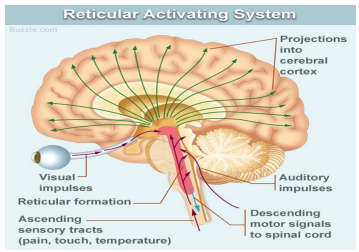
Anatomical components of RAS

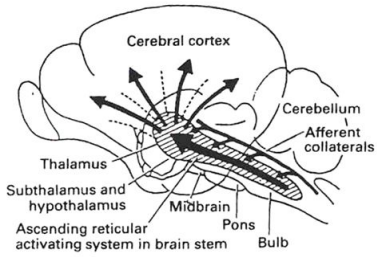


- The RAS is the system which keeps our cortex awake and conscious.
- The RAS is composed of several neuronal circuits connecting the brainstem to the cortex. Don't mix between RF and RAS. RF is the tracts only.
- **Originate in:** the upper brainstem reticular core and project through synaptic relays in the thalamic nuclei to the cerebral cortex.
- Clinical significance: individuals with **bilateral** lesions of **thalamic intralaminar** nuclei are **lethargic or drowsy.**
- **Pons (uppers & middle) and midbrain** are **essential** for wakefulness.
- Lesion in the mid-pons → unconsciousness → "coma due to the damage to RF"
- Please note: Bulboreticular = reticulospinal tract.
- The reticular **formation** has Excitatory + inhibitory areas.
- Excitatory area (Bulboreticular Facilitatory) = Medial pontine reticulospinal → Sends excitatory signals into Thalamus → thalamus excites almost all areas of the cortex.



- **Reticular Activating System (RAS) = The Bulboreticular Facilitatory (Excitatory) Area + Thalamus.**





❖ Functions of RAS:

1) Regulating sleep-wake transitions

- RAS **suppress as**cending **a**fferent activity to the CC ➞ leading to sleep.

2) Attention:

- RAS mediates transitions from relaxed wakefulness to of high attention. "هو الوسيط للتنقل مابين وعي عادي إلى وعي بتركيز ، على سبيل المثال كنت تتأمل السماء وفجأة مرّت كرة مسرعة (انتقلت من مرحلة استرخاء إلى تركيز على الكرة)"

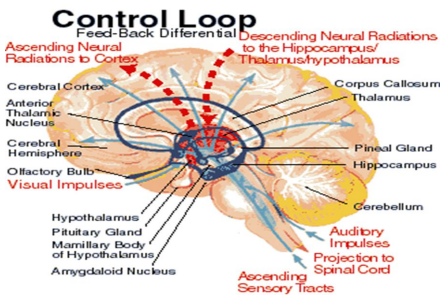
3) RAS and learning:

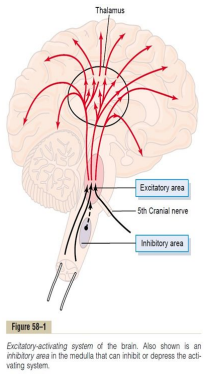
- The RAS is the center of balance for the other systems involved in learning, self-control or inhibition, and motivation. يفسر سبب بعد الحادث ممكن البعض يواجه صعوبة بالتعلم
- Provides the **neural connections** for processing and learning of information, **Selective attention** (to the correct task). مثل لما تركز على التلفزيون وما تنتبه للي حولك .. فديو ممتع هنا

❖ RAS dysfunction

If RAS is depressed	If the RAS is too excited
- An under-aroused cortex - Difficulty in learning - Poor memory - Little self-control - lack of consciousness or even coma.	- Over aroused cortex - **Hyper**-vigilance (sensory sensitivity) and the person is high alert for stimuli or threats. - Touching everything - Talking too much - Restless - Hyperactive

Sensory inputs to RAS:





Indices of Level of Consciousness: كيف تقيّم وعي المريض؟

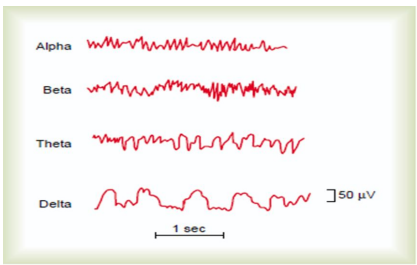
- **Appearance & Behavior:**
  - Posture (sitting, standing?) Open eyes? Facial expression?
  - Responds to stimuli (including the examiner's questions about name, orientation in time & place? & other general questions like who is the president?)
- **Vital signs:**

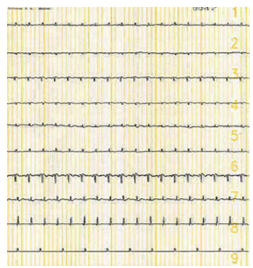
- Pulse, BP, respiration, pupils, reflexes, **particularly brainstem reflexes**, etc.
- EEG Each of these states (wakefulness, sleep, coma and death) has specific EEG patterns.
- Cortical **Evoked potentials** (in cases of Brain Death). "Shows in the EEG" This potential is activated by a stimulus whether it's auditory or visual (brainstem reflexes).

Electroencephalogram "EEG":

- An electroencephalogram (EEG) is a test that detects electrical activity in your brain using small, flat metal discs (electrodes) attached to your scalp. Your brain cells communicate via electrical impulses and are active all the time, even when you're asleep. The computer records your brain's electrical activity on the screen or on paper as wavy lines. Certain conditions, such as seizures and epilepsy, can be seen by the changes in the normal pattern of the brain's electrical activity. **Types:** Routine EEG, Sleep EEG, ambulatory EEG and video telemetry.
- Each brain wave has a certain range of frequencies. If it either increases or decreases you know there's something wrong in the brain.

Alpha waves	Beta waves	Theta waves	Delta waves
Recorded from the parietal & **occipital** regions. A: ارتاح	Frontal lobes. B: بركز	Temporal and **occipital**	From the cerebral cortex.
Normal in a person who is awake and relaxed+eyes closed. الشخص في حالة استرخاء أو بريك" بعد إكمال مهمة"	Produced by visual stimuli and mental activity شخص يلقي خطاب أو يفعل ما يتضمن نشاطًا من الدماغ	- Normal in newborns. - in adults indicate severe emotional stress.	- Normal in sleep and in an awake infants. - In an awake adult indicates brain damage
10 to 12 cycles/second. (Hz)	13 to 25 cycles/second. (Hz)"fastest"	5 to 8 cycles/second (Hz)	1 to 5 cycles/second (Hz) "slowest"





- Picture with **blue** background: Normal EEG (at normal magnification).
- Picture with **yellow** background: Brain Death (Flat EEG, at very high magnification).