



Physiology Team



Lecture : 10

Physiology of Consciousness

Done By: May H. Alorainy 🐾

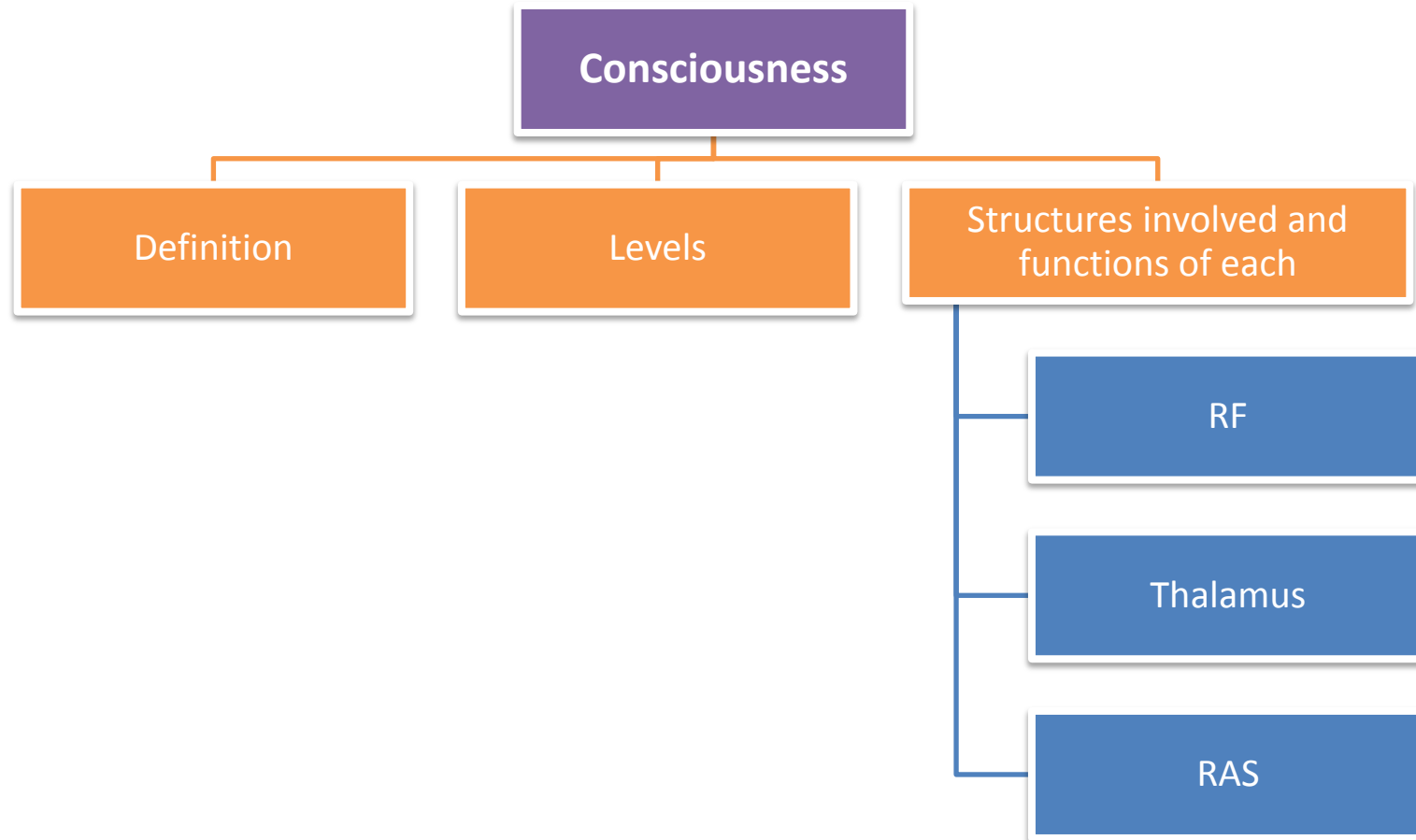
Reviewed By: Mohammed Al-Sari

OBJECTIVES

At the end of this lecture, student should be able to describe:

- Levels of consciousness/ definition
- Functional divisions of RF.
- Overview of functions of RF.
- Anatomical components of RAS.
- Connections of RAS.
- Neurotransmitters of RAS.
- Functions of RAS.

MIND MAP



What is Consciousness?

- Is the brain state in which a person **is aware of the self and surroundings**.
- It is a product of electrical activity of the brain → a person with a flat EEG can not be conscious!
- We have certain centers in our brain keeping us aroused → Thus, activation of these centers results in desynchronizing rhythm.
- How can you be aroused from your sleep? By applying a sensory stimuli → sends information to arousal centers in brain and activates them.

What are the levels of consciousness?

- 1-Normal Consciousness** → state of normal arousal , being fully awake **and aware of the self and surroundings**.
- 2-Clouded consciousness** → person is conscious but mentally confused (e.g., in cases of drug **or alcohol intoxication**, high fever associated with malaria or septicemia, dementia, etc.)
- 3-Sleep** → person is unconscious (in relation to the external world & surroundings) **but is arousable (can be aroused)**.
- 4-Coma** → person is unconscious and **not arousable**. On EEG: activity will appear as delta waves, while in brain death EEG will appear flat indicating absence of brain activity.

Cont.

The level of consciousness is influenced by:

- **Peripheral Sensory input:**

- Number and type of afferent signals that enter the CNS (Note: pain signals strongly excite the brain)

- **Thalamo-cortical sectors:**

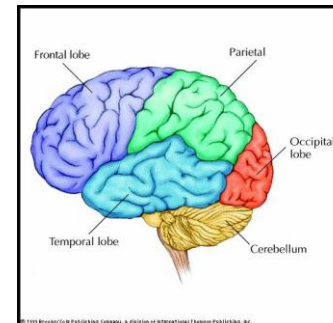
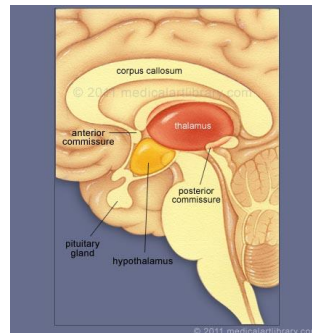
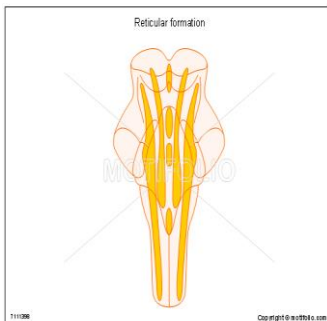
- Definition: areas of the cerebral cortex connecting with their own specific area in the thalamus
- Made of thalamo-cortical fibers & feedback cortico-thalamic fibers
- Excitatory signals pass to the cortex from RAS, also feedback signals return from the cortex back to the thalamus (part of RAS)
- These circuits are essential for determining the level of consciousness

Consciousness depends upon the interaction between

Reticular formation

Thalamus

Cortical association areas



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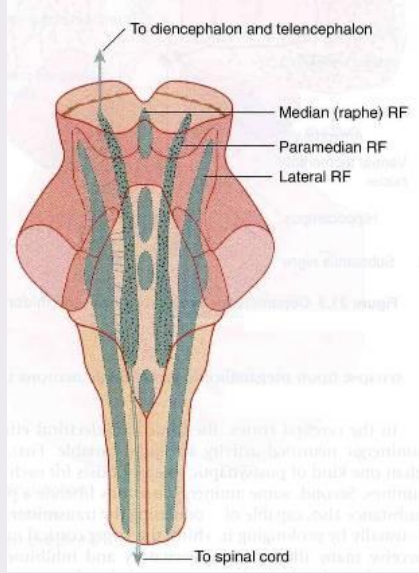
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Reticular formation

Important

| Lateral RF | Paramedian RF | Raphe nuclei (Median RF) |
|--|---|---|
| Has small neurones | Has large cells. | In the midline of the reticular formation |
| Receives information from ascending tracts for touch and pain. Y3ni if a person is sleeping and had a painful stimulus, he/she would be aroused → indicates severity of pain | Receives signals from lateral reticular formation. Lateral RF receives information then sends them to paramedian RF for analysis. | Contain serotonergic projections to the brain and spinal cord. Has upwards and downwards projections. |
| Receives vestibular information from median vestibular nerve. | Projects onto cerebral hemispheres. |  |
| Receives auditory information from superior olivary nucleus. If I want to wake someone up, I yell at them. | Nucleus coeruleus contains noradrenergic neurones and projects onto the cerebral cortex. | |
| Visual information from superior colliculus. If I want to wake a person up, I turn the lights on. | Ventral tegmental nucleus contains dopaminergic neurones that project directly onto the cortex. | |
| Olfactory information via medial forebrain bundle. | Cholinergic neurones project onto the thalamus. | |

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Functions of Reticular formation

1. **Somatic motor control** (Reticulospinal tracts)
2. **Cardiovascular control**: The reticular formation includes the cardiac and vasomotor centers of the medulla oblongata.
3. **Pain modulation**: Allow pain signals from the lower body reach the cerebral cortex. It is also the origin of the descending analgesic pathways. The nerve fibers in these pathways act in the spinal cord to block the transmission of some pain signals to the brain.
4. **Sleep and consciousness**: The reticular formation has projections to the thalamus and cerebral cortex . It plays a central role in states of consciousness like alertness and sleep. *Injury to the reticular formation can result in irreversible coma.*
5. **Habituation**: This is a process in which the brain learns to ignore repetitive, meaningless stimuli while remaining sensitive to others. A good example of this is when a person can sleep through loud traffic in a large city, but is awakened promptly due to the sound of an alarm.

Thalamus

(second level of analysis)

The thalamus is contained in the mid-part of the diencephalon and is split up into a number of different nuclei which perform **3 main tasks**:

- Cholinergic projections excite the individual thalamic relay nuclei which lead to activation of the cerebral cortex.
 - Cholinergic projections to the **intralaminar nuclei**, which in turn project to all areas of the cortex .
 - Cholinergic projections to reticular nuclei to regulate flow of information through other thalamic nuclei to the cortex.
- =>Cholinergic projections to the thalamus stimulate the cerebral cortex.
- Tuberomammillary nucleus in the hypothalamus projects to the cortex and is involved in maintaining the awake state.

Anatomical components of RAS

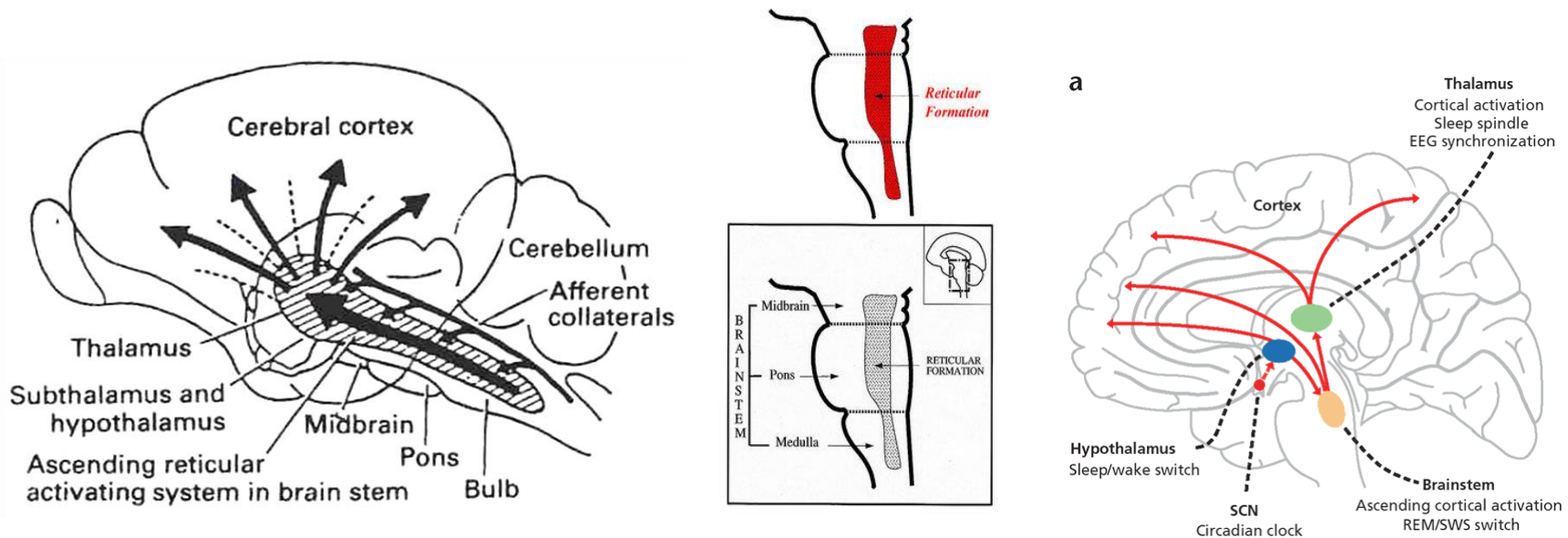
(reticular activating system)

- The RAS is composed of several neuronal circuits connecting the brainstem to the cortex. These pathways originate in the upper brainstem reticular core and project through synaptic relays in the rostral intralaminar and thalamic nuclei to the cerebral cortex. As a result, individuals with bilateral lesions of thalamic intralaminar nuclei are lethargic (sleepy or lacking energy).
- ***Several areas traditionally included in the RAS are:***
 - Midbrain Reticular Formation.
 - Mesencephalic Nucleus (mesencephalon)
 - Thalamic Intralaminar nucleus
 - Dorsal Hypothalamus.
 - Tegmentum.

Dr. Eman did not actually go through this slide at all but study it just in case!
:D

RAS

- Lesions in the mid-pons of an animal result in an irreversible coma
- This means that areas in the upper pons and midbrain are essential for wakefulness. That area called Bulboreticular Facilitory (Excitatory) Area of the reticular formation.



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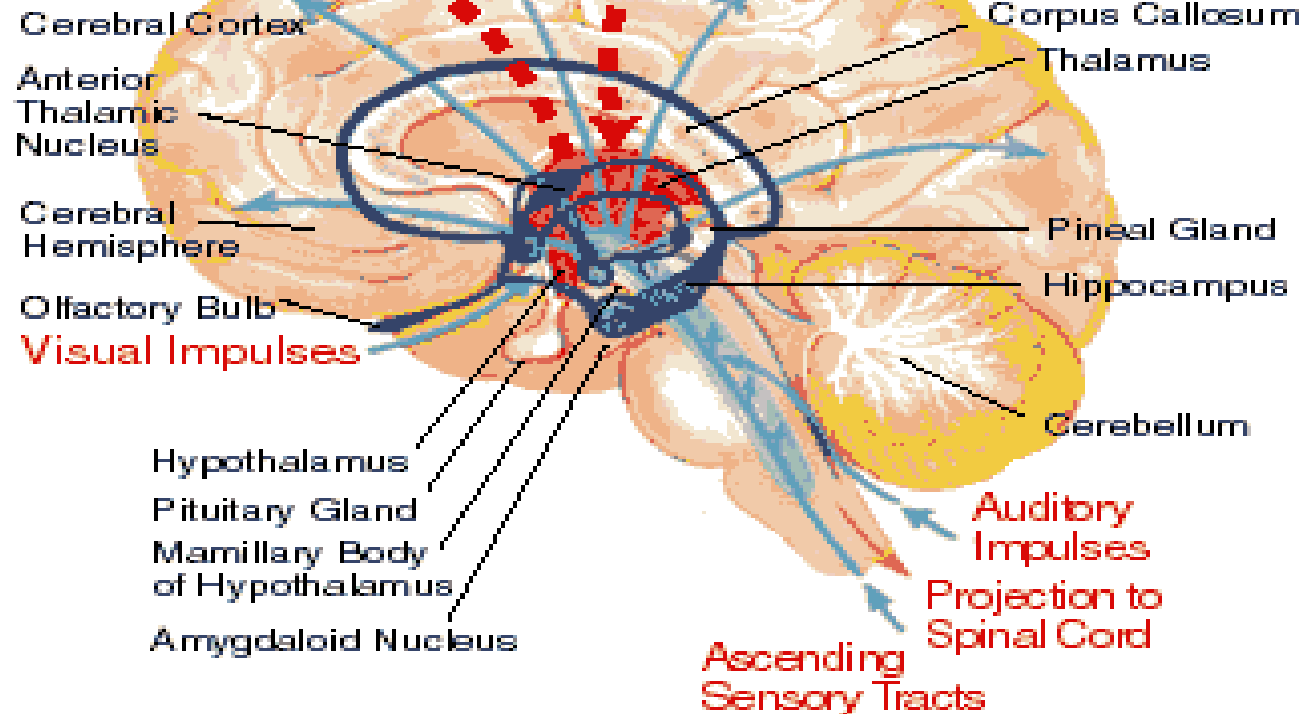
Sensory inputs to RAS

Control Loop

Feed-Back Differential

Ascending Neural Radiations to Cortex

Descending Neural Radiations to the Hippocampus/Thalamus/hypothalamus



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(1) Regulating sleep-wake transitions:

- The main function of the RAS is to modify and potentiate thalamic and cortical functions resulting in (EEG) desynchronization.
- Low voltage fast burst brain waves (EEG desynchronization) are associated with **wakefulness** and **REM sleep**,
- During non-REM sleep, neurons in the RAS will have a much lower firing rate large voltage slow waves .
- The physiological change from a state of deep sleep to wakefulness is reversible and mediated by **the RAS** via **acetylcholine & Norepinephrine**
- Stimulation of the RAS produces EEG desynchronization by suppressing slow cortical waves.
- **In order that the brain may sleep, there must be a reduction in ascending afferent activity reaching the cortex by suppression of the RAS.**

(2) Attention: The reticular activating system also helps mediate transitions from relaxed wakefulness to periods of high attention.

(3) RAS and learning:

- The RAS is the center of balance for the other systems involved in learning, self-control or inhibition, and motivation.
- When functioning normally, it provides the neural connections that are needed for the processing and learning of information, and the ability to pay attention to the correct task.

What happens if RAS is not working properly?

Important

If the RAS doesn't excite the neurons of the cortex as much as it ought to



Under-aroused cortex



-difficulty in learning
-poor memory
-little self-control

If RAS failed to activate the cortex at all



lack of consciousness or even coma.

the RAS was too excited, and aroused the cortex or other systems of the brain too much



excessive startle responses



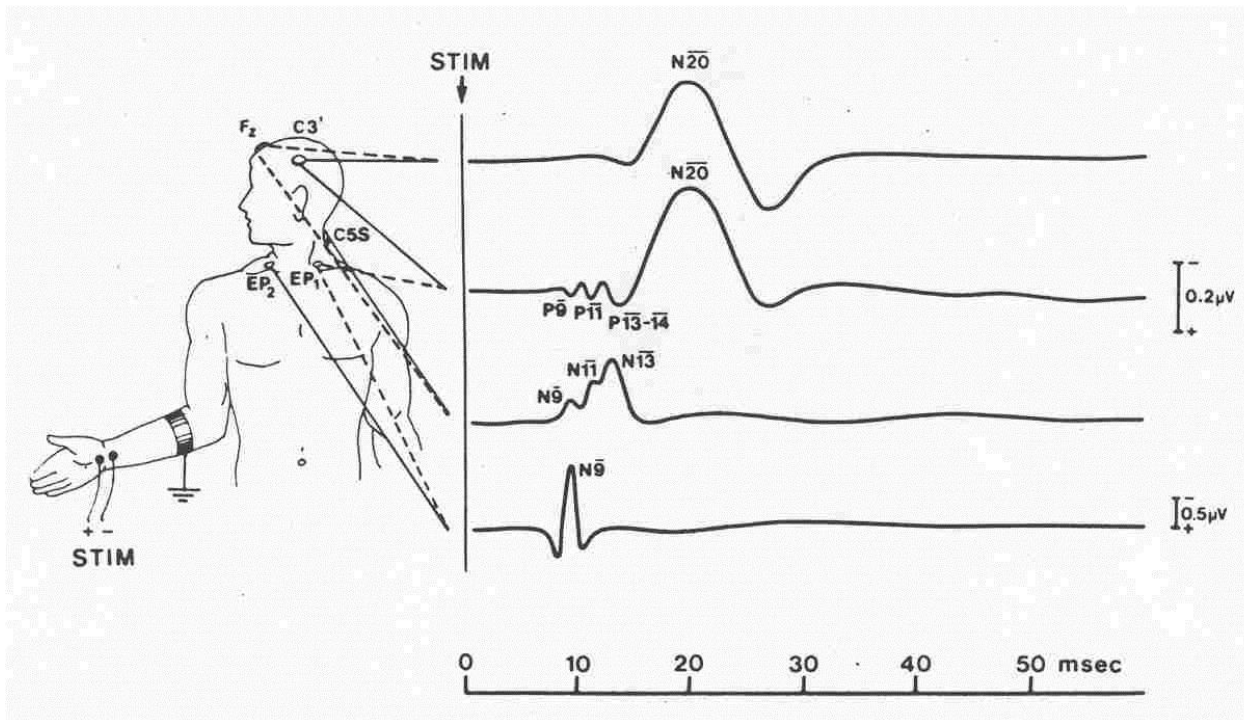
hyper-vigilance + touching everything + talking too much + restless + **hyperactive.**

Signs of Level of Consciousness

- **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 Qs like who is the president?).
- **Vital signs:** Pulse, BP, respiration, pupils, reflexes (particularly brainstem reflexes).
- **EEG:** Each of these states (wakefulness, sleep, coma and death) has specific EEG patterns.
- **Evoked potentials:** In cases of Brain Death. **If EEG waves appear abnormal or absent → we use evoked potential, in which we stimulate certain areas in scalp then see if the waves appear or not.**

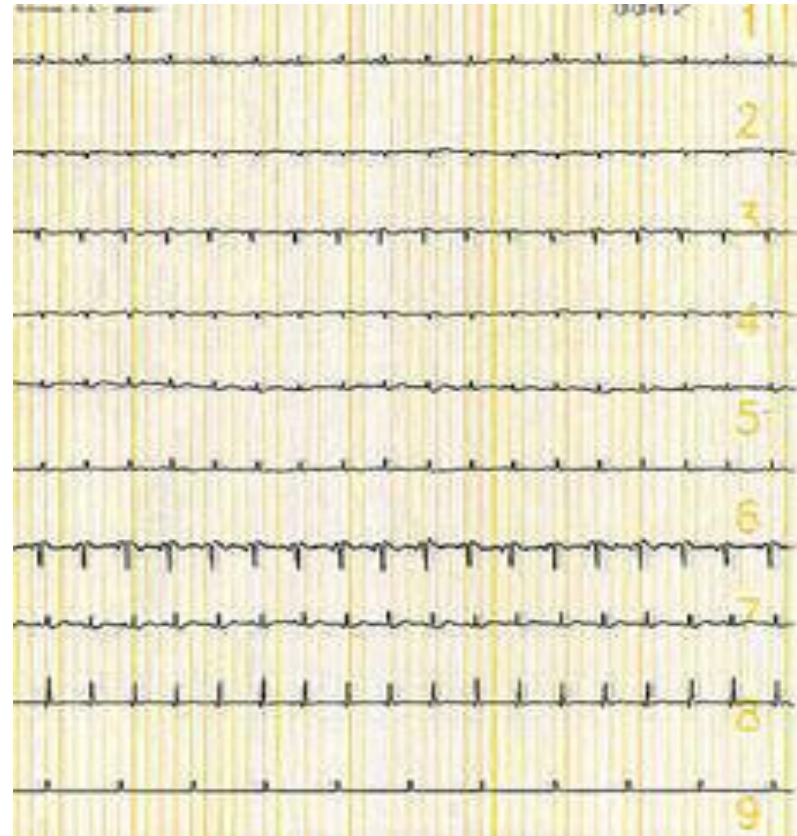
Brain Death Confirmatory Testing with Somato-sensory Evoked Potentials

- Stimulation of a sense organ can evoke a cortical response that can be recorded by scalp electrode over the primary receiving cortical area for that particular sense.





Normal EEG (at normal magnification)



Brain Death (Flat EEG, at very high magnification)

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SUMMARY

- Conciseness Is the brain state in which a person **is aware of self and surroundings.**
- **THERE ARE 4 LEVELS OF CONSCIOUSNESS:** 1-Normal, 2-Clouded, 3-Sleep, & 4-Coma.
- **Consciousness depends upon interaction between:** Reticular formation + thalamus + Cortical association areas.
- **RETICULAR FORMATION CONSISTS OF THREE PARTS:** 1-Lateral, 2-Paramedian & 3-Median.
- **RETICULAR FORMATION HAS 5 FUNCTIONS:** 1-Somatic motor control, 2-Cardiovascular control, 3-Pain modulation, 4-Sleep and consciousness & 5-Habituation.
- **THE THALAMUS IS CONTAINED IN THE MID-PART OF THE DIENCEPHALON AND IS SPLIT UP INTO A NUMBER OF DIFFERENT NUCLEI WHICH PERFORM 3 MAIN TASKS:**
 1. Cholinergic projections excite individual thalamic relay nuclei => activation of the cerebral cortex
 2. Intralaminar nuclei project to the entire cortex
 3. Reticular nuclei regulate information flow through thalamic nuclei
- **RAS HAS THREE MAIN FUNCTIONS:** 1-Regulating sleep-wake transitions, 2-Attention & 3-Learning.
- **IF RAS IS NOT WORKING PROPERLY IT COULD RESULT IN:** 1-Under-aroused cortex, 2-Lack of consciousness or 3-Hyperactivity.
- Appearance and behaviour, vital signs, EEG and evoked potential can indicate the level of consciousness.

QUESTIONS

Answers:

1:B

2:C

3:A

1. Desynchronizing rhythm appears in states of:

- a) Coma.
- b) Consciousness.
- c) Brain death.

2. Lesions in mid pons cause the person to be:

- a) Hyperactive.
- b) Under-aroused.
- c) Unconscious for the rest of her/his life.

3. Difficulty in learning, poor memory and little self-control are caused when:

- a) RAS doesn't excite the neurons of cortex as much as it's ought to.
- b) RAS fails to activate the cortex.
- c) RAS excites the cortex excessively.

THE END

**If there are any Problems or Suggestions,
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THANK YOU