

Physiology of **Consciousness**

Consciousness

- Is the brain state in which a person is being aware of the self and surroundings
- It is a product of electrical activity of the brain
- (*flat EEG = unconscious*)

4 levels of consciousness

- 1- Normal consciousness
- 2- Clouded consciousness
- 3- Sleep
- 4- Coma

Level of Consciousness

- (1) Normal Consciousness
- (state of normal arousal , being fully awake and aware of the self and surroundings)



- **(2) Clouded consciousness :**
- person conscious but mentally confused
- e.g., in cases of drug or alcohol intoxication , High fever associated (malaria or septicemia , dementia , etc) .



- **(3) Sleep :**

- person unconscious (in relation to the external world & surroundings)
- but is arousable (can be aroused) .



- **(4) Coma :**

- ✚ person unconscious and not arousable



Brain Structures involved in the conscious state

- **Brain stem Reticular formation**
- **Thalamus**
- **Hypothalamus**
- **Ascending projection pathways**
- **Wide spread area in the cerebral cortex**

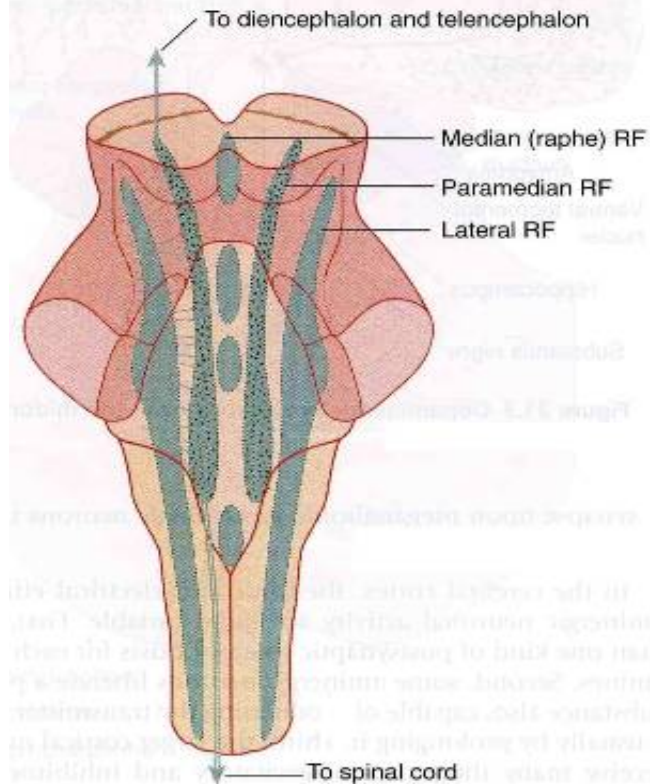
Reticular formation

Set of interconnected nuclei that are located throughout the brainstem (Pons, Midbrain, Upper medulla), and the thalamus

Role in behavioral arousal

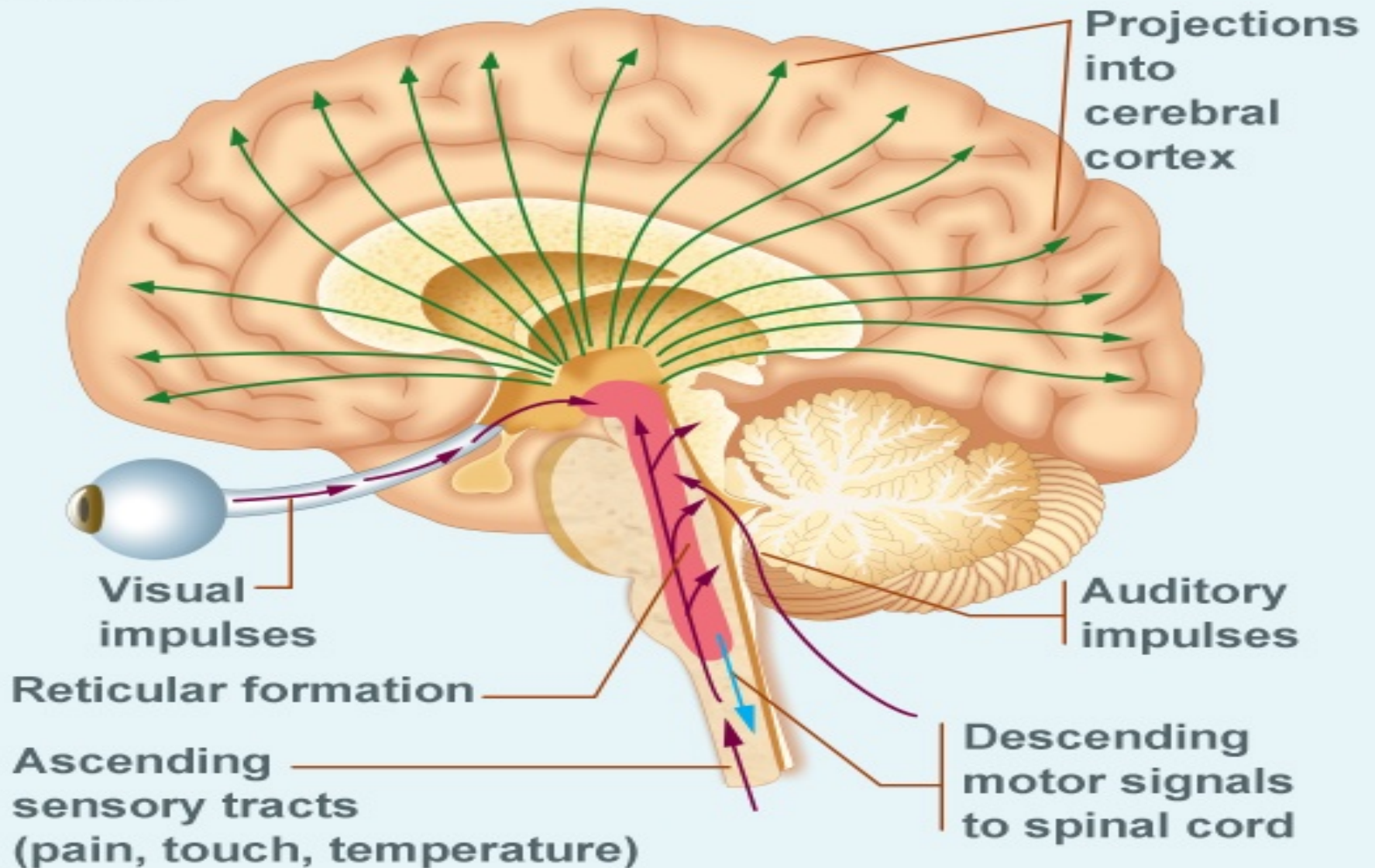
Role in consciousness (sleep/awake cycle)

Connect the brain stem to the CC



Reticular Activating System

Buzzle.com

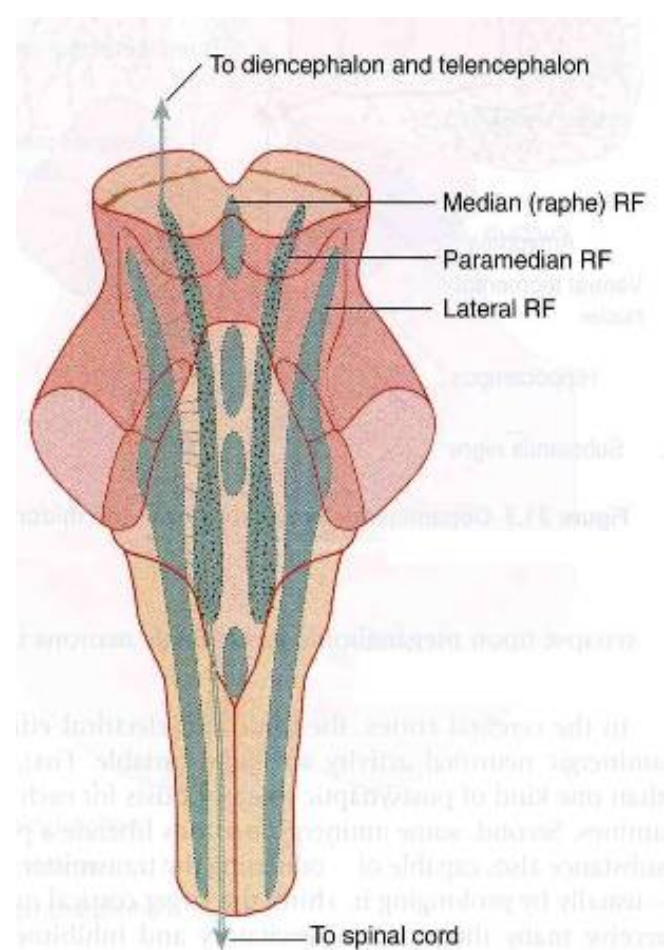


consists of 3 parts:

**Lateral Reticular
Formation**

**Para median Reticular
Formation**

Raphe nuclei (Median RF)



⊙ Lateral Reticular Formation

Has small neurones

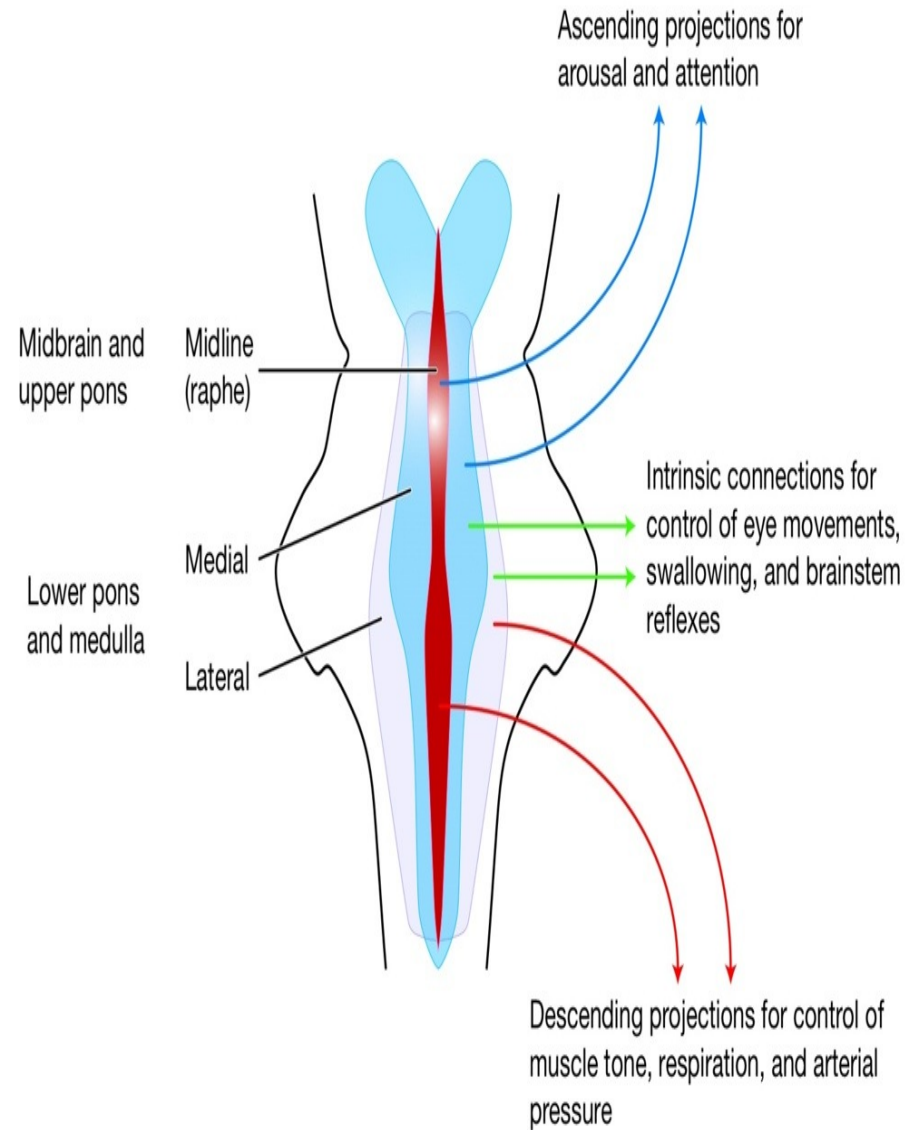
Receives information from ascending tracts for touch and pain.

Receives vestibular information from median vestibular nerve.

Receives auditory information from superior olivary nucleus.

Visual information from superior colliculus.

Olfactory information via medial forebrain bundle



Paramedian Reticular Formation

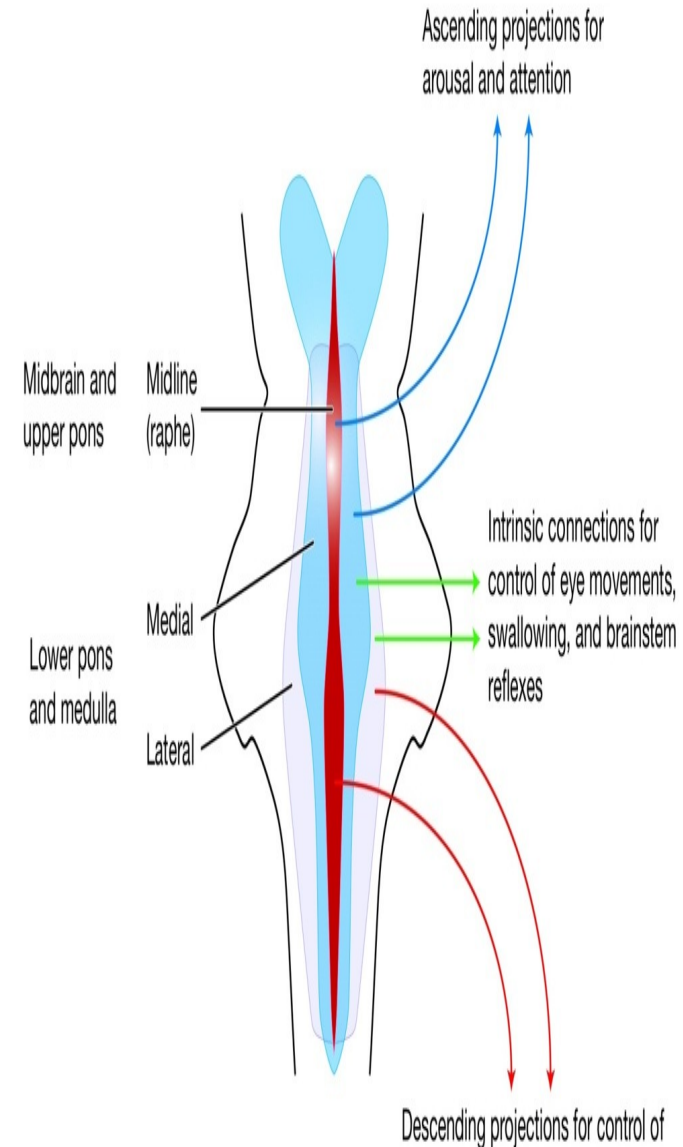
Has large cells.

- Receives signals from lateral reticular formation

- Nucleus ceruleus which located bilaterally and posteriorly at junction between pons and mid brain ,contains noradrenergic neurones and projects onto the cerebral cortex.

- Ventral tegmental nucleus contains dopaminergic neurones that project directly onto the cortex.

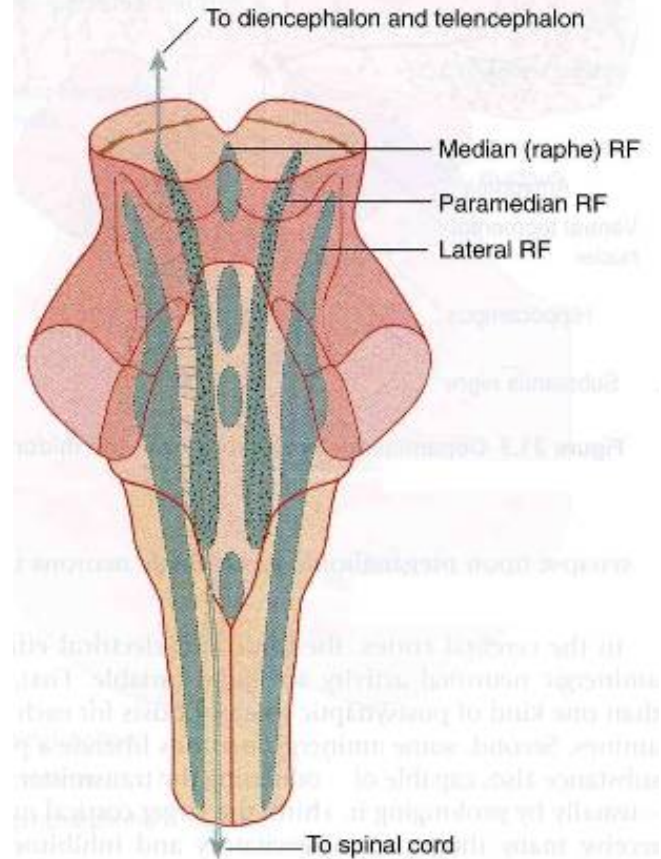
- Acetyl choline secreted by cholinergic gigantocellular neurones project onto the thalamus

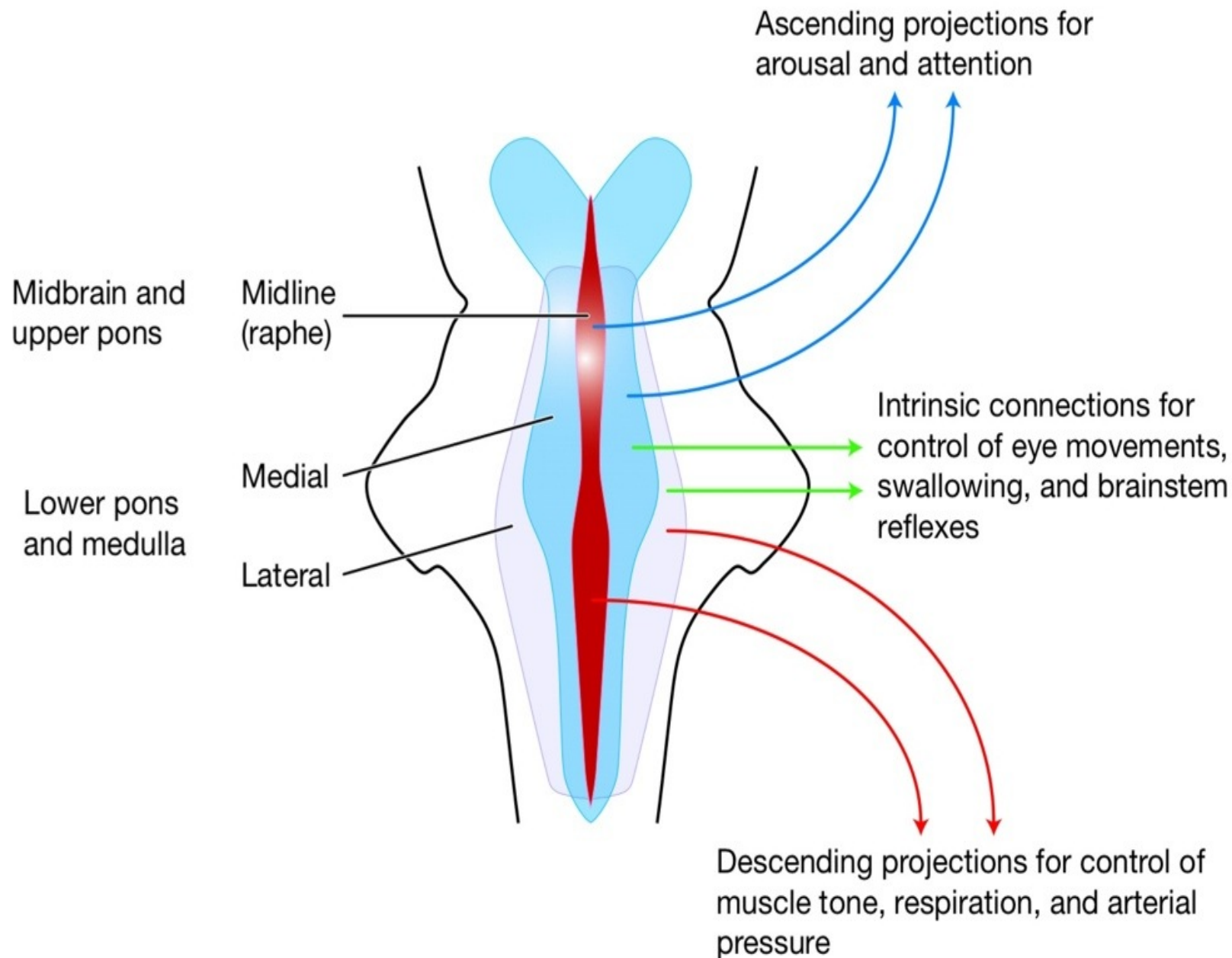


Raphe nuclei (Median RF)

In the midline of the reticular formation

Contain **serotonergic projections** to the brain and spinal cord.





Functions of reticular formation

- 1. **Somatic motor control** (Reticulospinal tracts)
- 2. **Cardiovascular control**
 - Through cardiac and vasomotor centers of the medulla oblongata
- 3. **Pain modulation**
- Pain signals from the lower body >> >> RF >> >> cerebral cortex
- RF is origin of the descending analgesic pathways
- (act on the spinal cord to block the transmission of some pain signals to the brain)

Functions of reticular formation, cont...

- 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 .

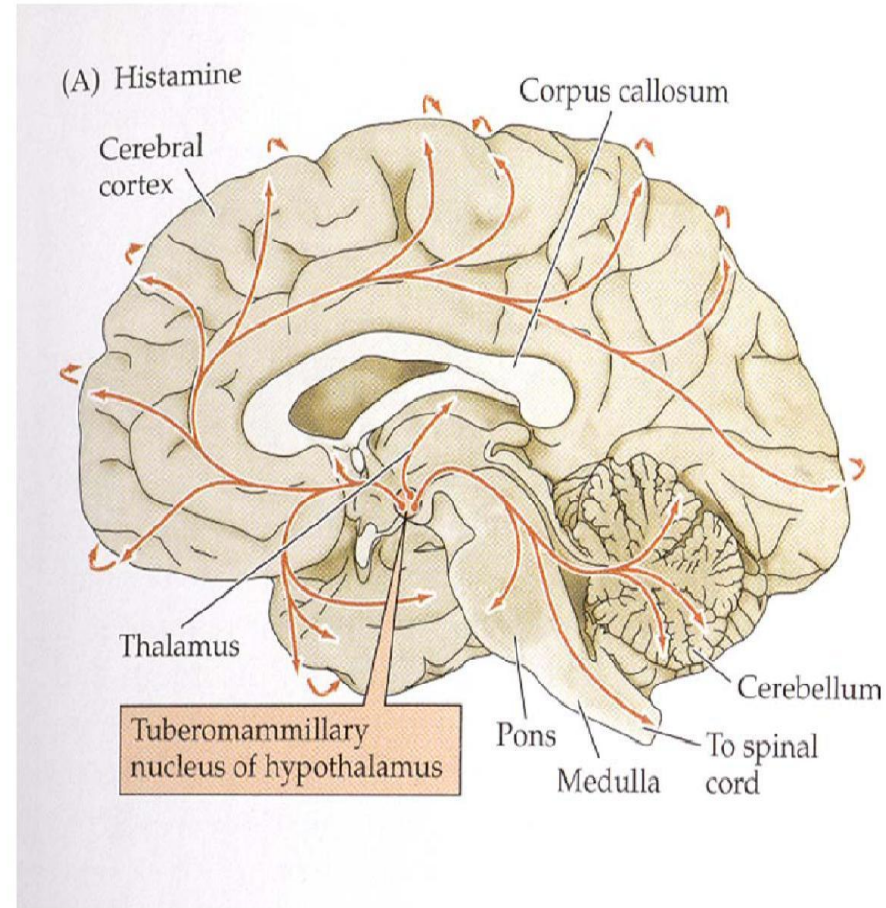
Thalamus

Located in the mid-part of the diencephalon

- Almost every area of the cerebral cortex connects with its own highly specific area in the thalamus .
- These functional segments are called Thalamocortical Sectors
- They are made of
 - Thalamo-cortical (TC) fibers
 - Cortico-thalamic (CT) fibers .
- These neural circuits between the thalamus & cortex are essential for determining the level of consciousness .

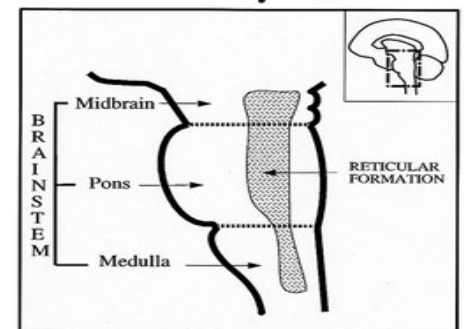
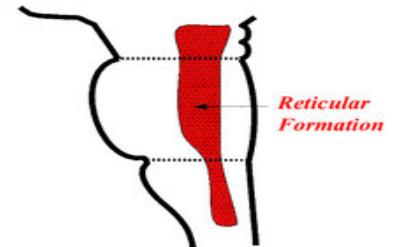
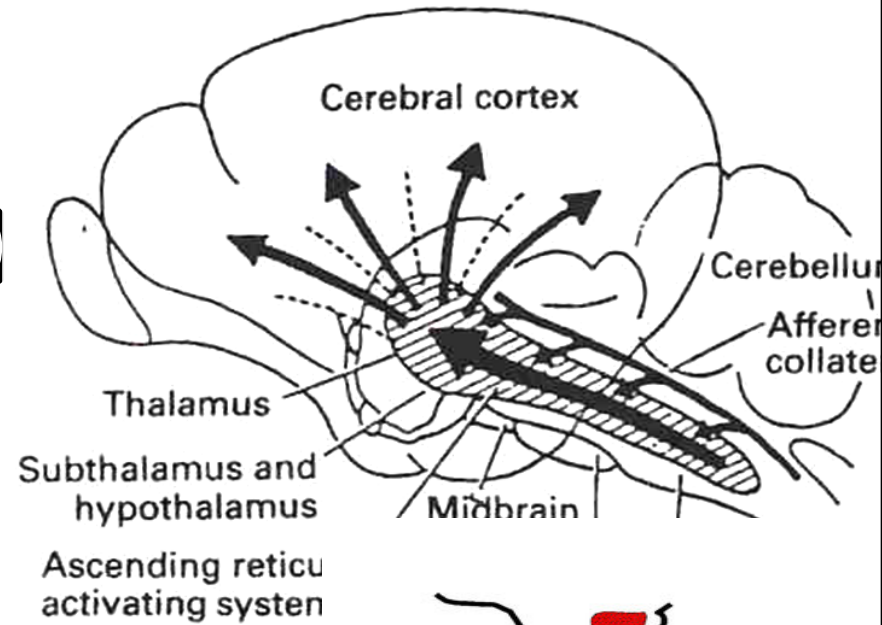
Hypothalamus

- **Tuberomammillary nucleus** in the hypothalamus which consists of histaminergic neurons projects to the cortex and is involved in maintaining the awake state



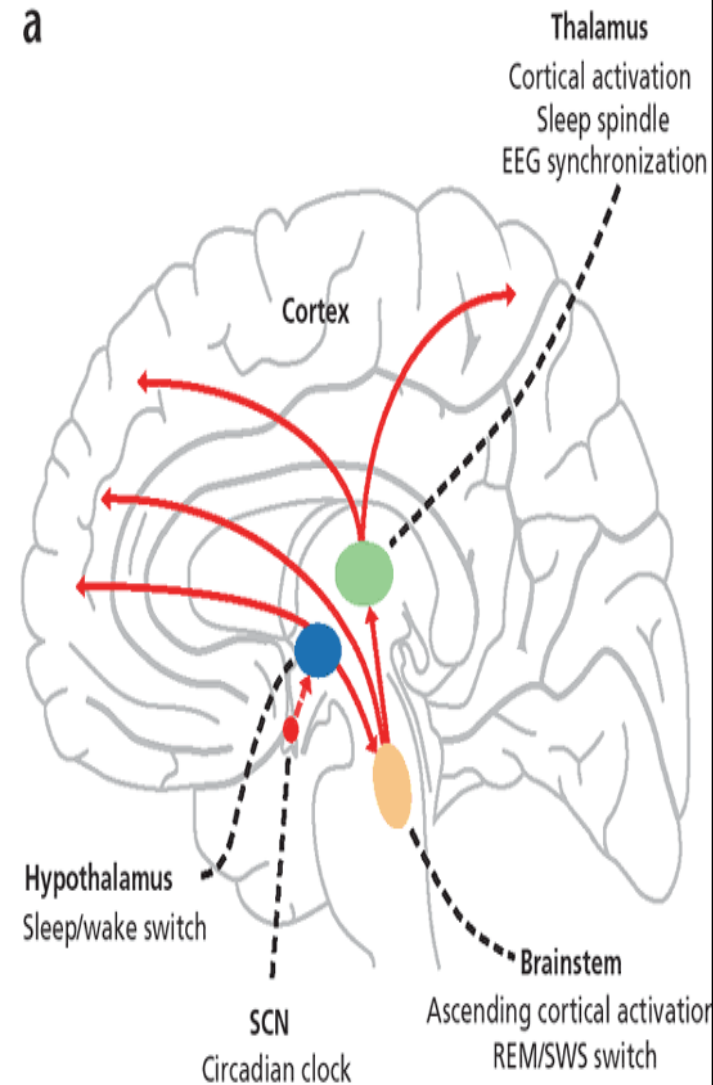
RAS

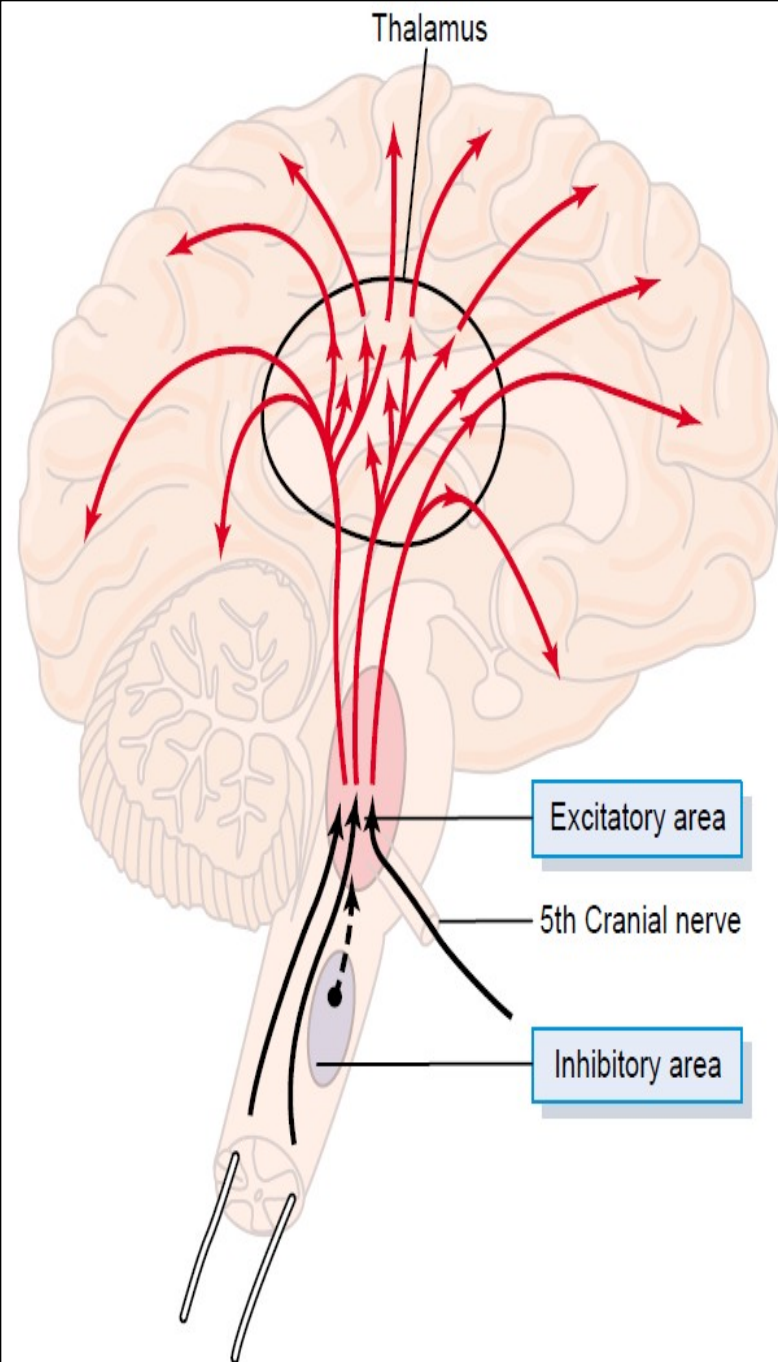
- Lesion in the mid-pons
>>>>>>unconsciousness
- Pons (uppers & middle) and midbrain are essential for wakefulness .



Anatomical components of RAS

- The RAS is composed of several neuronal circuits connecting the brainstem to the cortex
- Originate in the upper brainstem reticular core and project through synaptic relays in the thalamic nuclei to the cerebral cortex
- As a result, individuals with bilateral lesions of thalamic intralaminar nuclei are lethargic or drowsy





- **Bulboreticular Facilitory (Excitatory) = Reticular Excitatory Area of the Brain Stem**
- **Sends excitatory signals into Thalamus**
- **>>>> thalamus excites almost all areas of the cortex .**
- **The Bulboreticular Facilitory (Excitatory) Area + Thalamus =Reticular Activating System (RAS)**
- **The RAS is the system which keeps our cortex awake and conscious**

Sensory inputs to RAS

Control Loop

Feed-Back Differential

Ascending Neural Radiations to Cortex

Descending Neural Radiations to the Hippocampus/Thalamus/hypothalamus

Cerebral Cortex

Anterior Thalamic Nucleus

Cerebral Hemisphere

Olfactory Bulb

Visual Impulses

Hypothalamus

Pituitary Gland

Mamillary Body of Hypothalamus

Amygdaloid Nucleus

Corpus Callosum

Thalamus

Pineal Gland

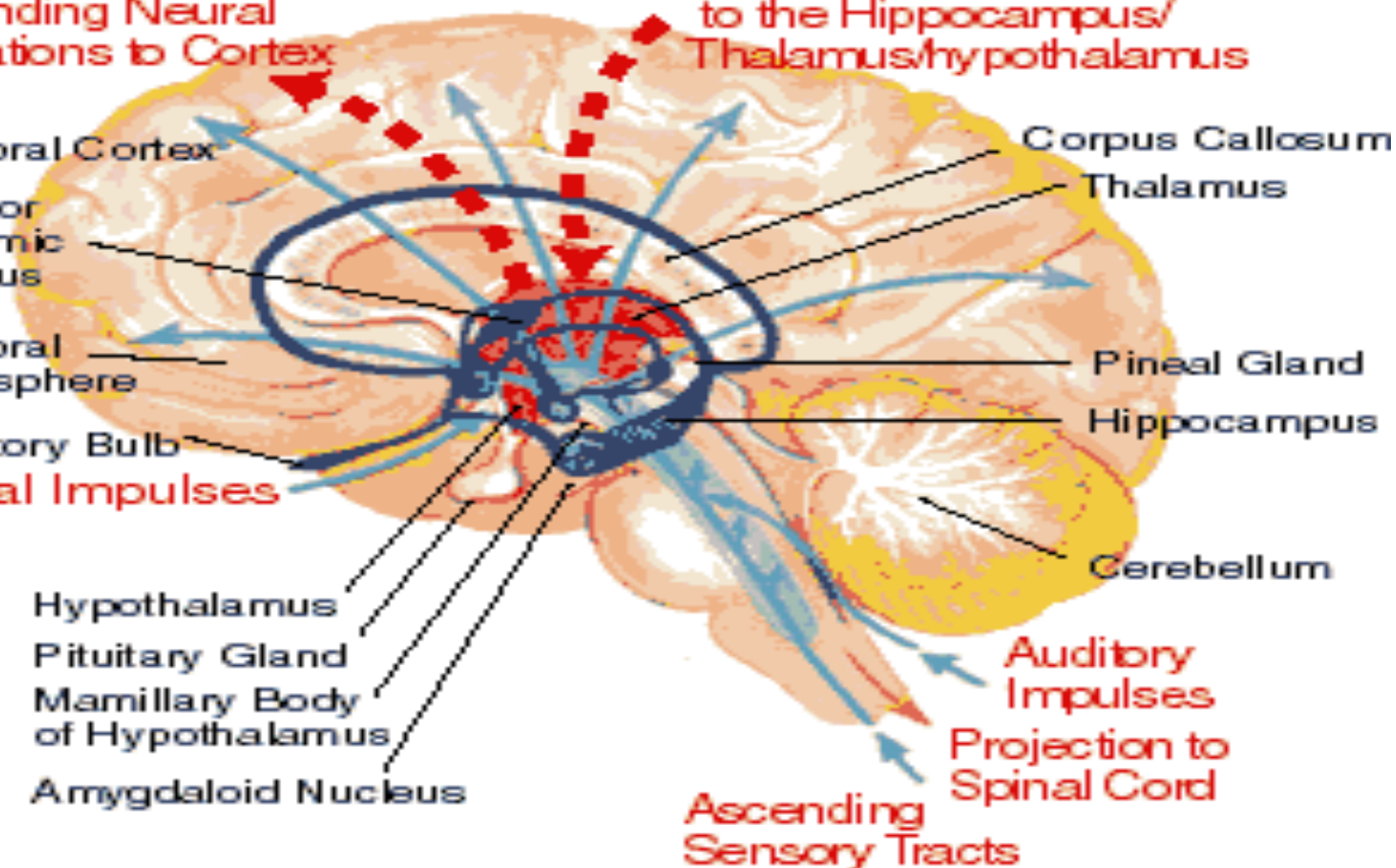
Hippocampus

Cerebellum

Auditory Impulses

Projection to Spinal Cord

Ascending Sensory Tracts



Functions of RAS

- 1- Regulating sleep-wake transitions
- If inhibitory area activity increase >>>>
reduce the activity of RAS >>>>> less
afferent signal to the CC >>>>> sleep

2-Attention

- RAS mediate transitions from relaxed wakefulness to of high attention.
- There is increased regional blood flow in the midbrain reticular formation (MRF) and thalamic intralaminar nuclei during tasks requiring increased alertness and 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 for processing and learning of information, , and the ability to pay attention to the correct task.

RAS dysfunction

If RAS is depressed:

- An under-aroused cortex
- Difficulty in learning
- Poor memory
- Little self-control
- lack of consciousness or even coma.

If the RAS is too excited,

- Over aroused cortex
- Hyper-vigilance (sensory sensitivity)
- Touching everything
- Talking too much
- Restless
- Hyperactive

Indices of Level of Consciousness

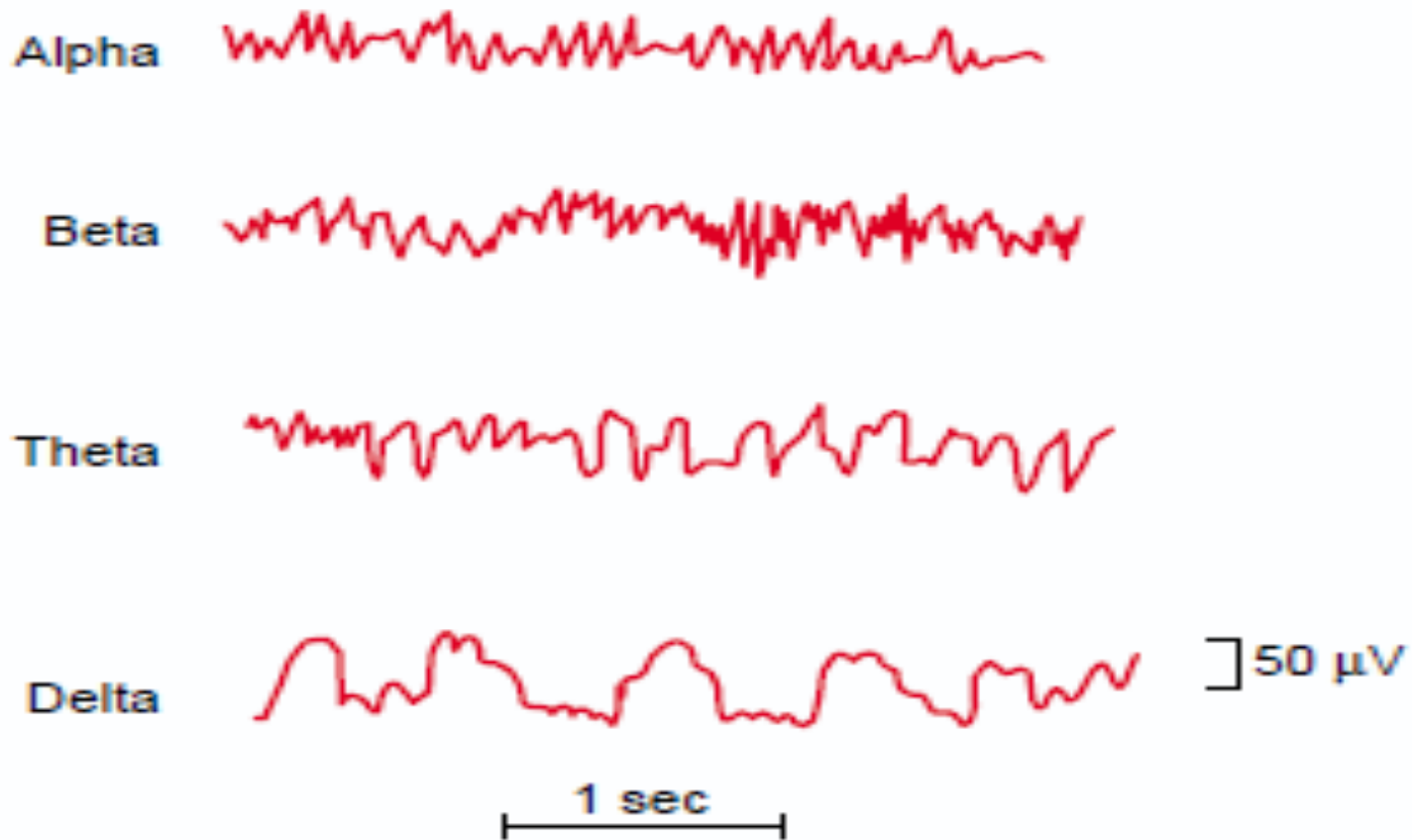
- Appearance & Behavior :

- 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 :

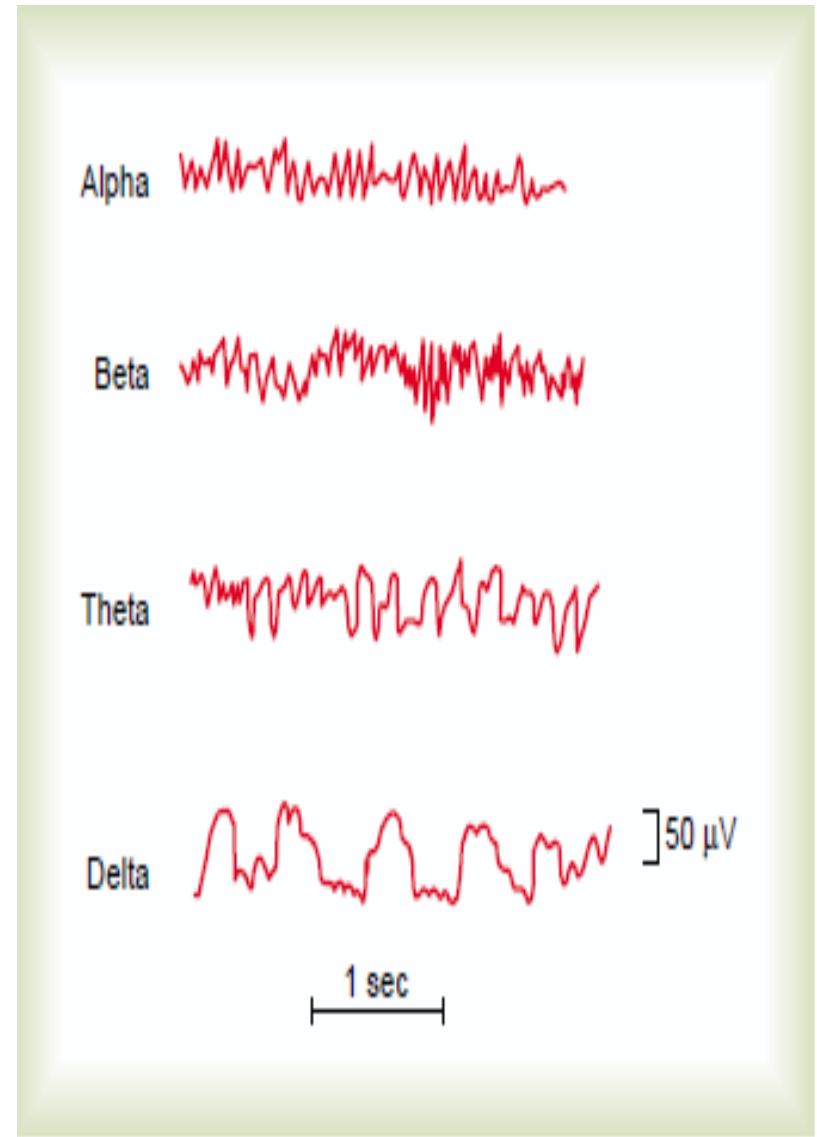
- Pulse , BP, respiration , pupils , reflexes , particularly brainstem reflexes , etc)
- EEG → Each of these states (wakefulness , sleep , coma and death) has specific EEG patterns
- Evoked potentials (in cases of Brain Death).
- (Stimulation of a sense organ can evoke a cortical response that can be recorded by scalp electrode over the primary receiving cortical area for that particular sense)

Electroencephalogram

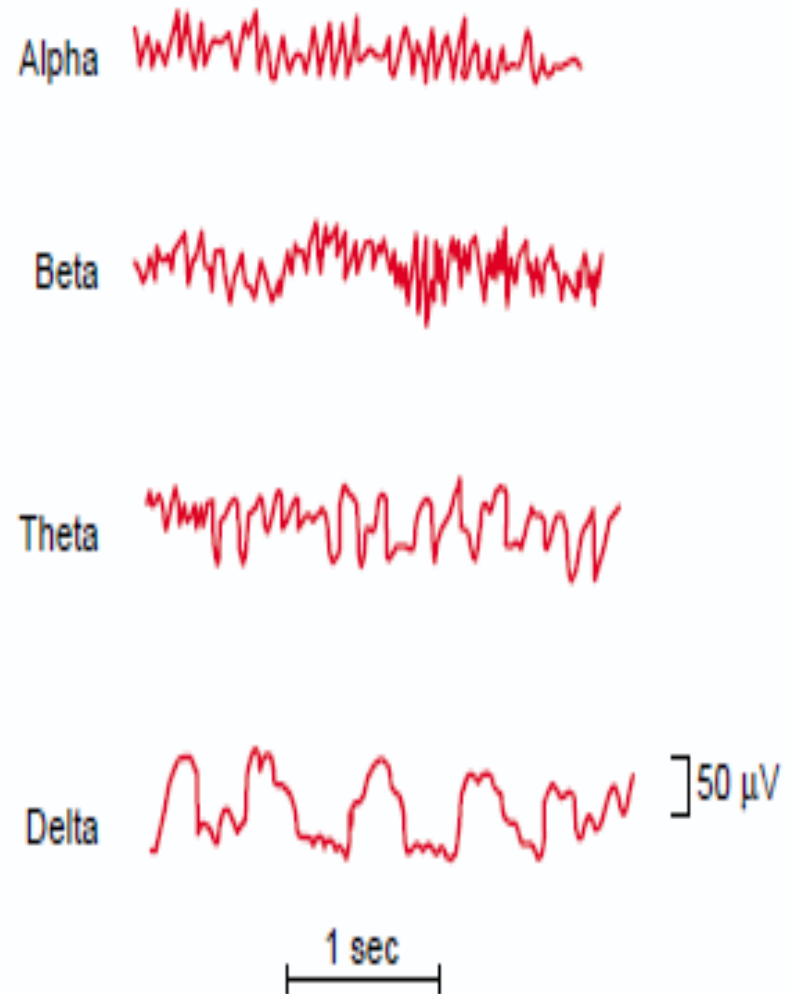


- Alpha waves:
- Recorded from the parietal & occipital regions
- Awake and relaxed + eyes closed
- 10 to 12 cycles/second.

- Beta waves:
- Frontal lobes
- Produced by visual stimuli and mental activity
- 13 to 25 cycles per second .



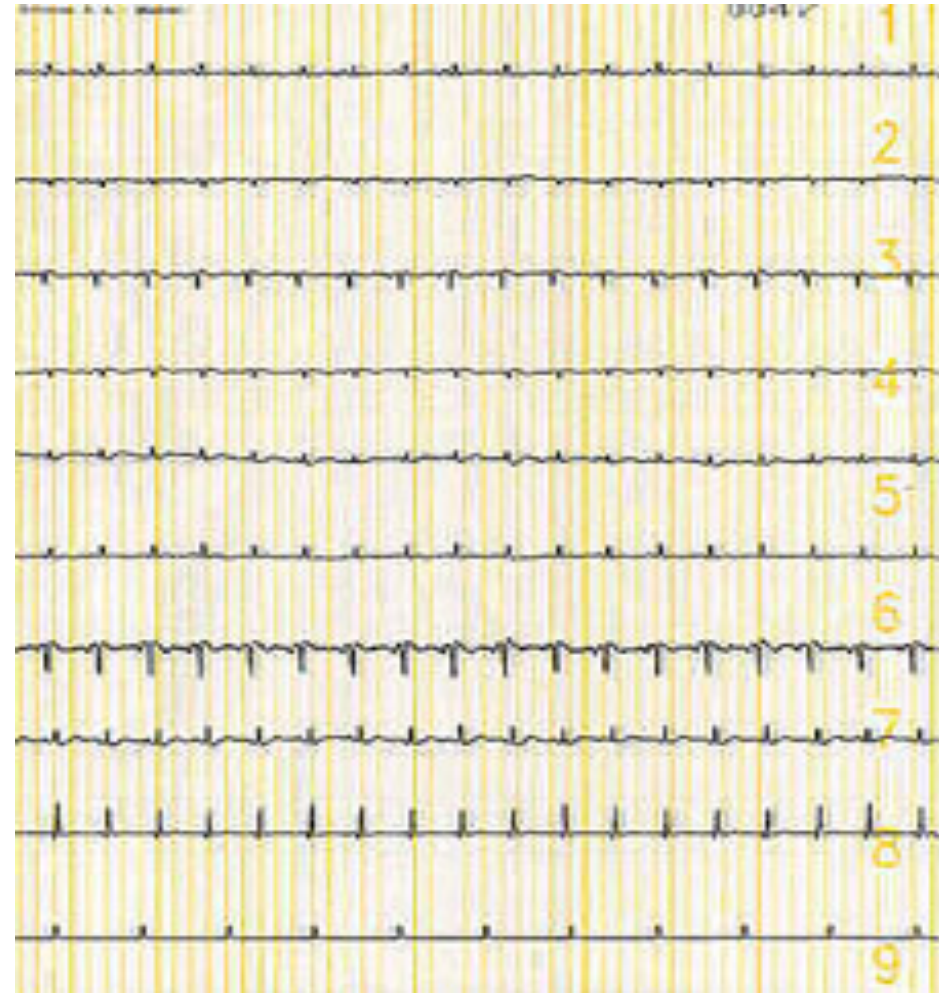
- **Theta:**
 - Temporal and occipital
 - 5 to 8 cycles/second
 - (newborn)
- Theta waves in adults indicates severe emotional stress
- **Delta:**
 - From the cerebral cortex
 - 1 to 5 cycles/second
 - Sleep and in an awake infant
 - In an awake adult indicates brain damage.



Brain Death Confirmatory Testing with EEG



Normal EEG (at normal magnification)



Brain Death (Flat EEG ,at very high magnification)

THANK YOU