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

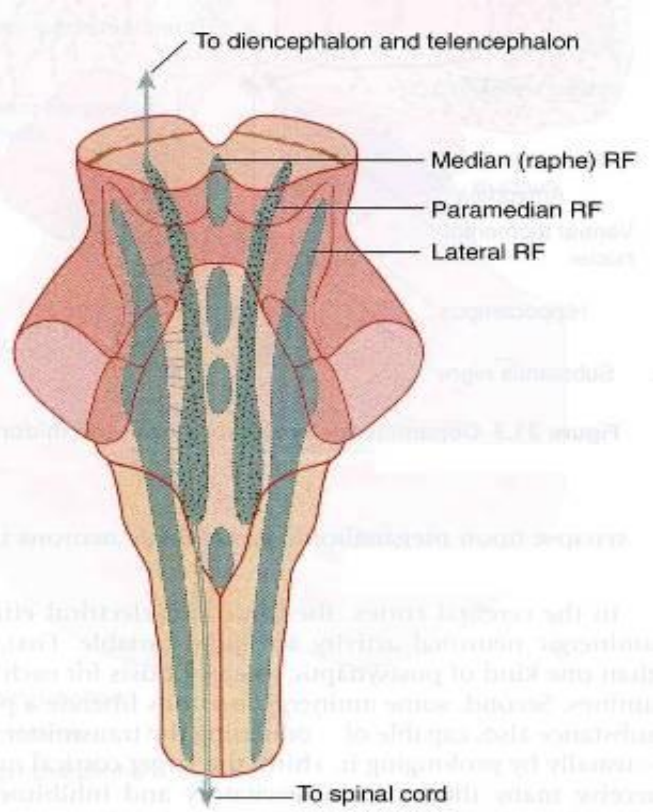
Reticular formation

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

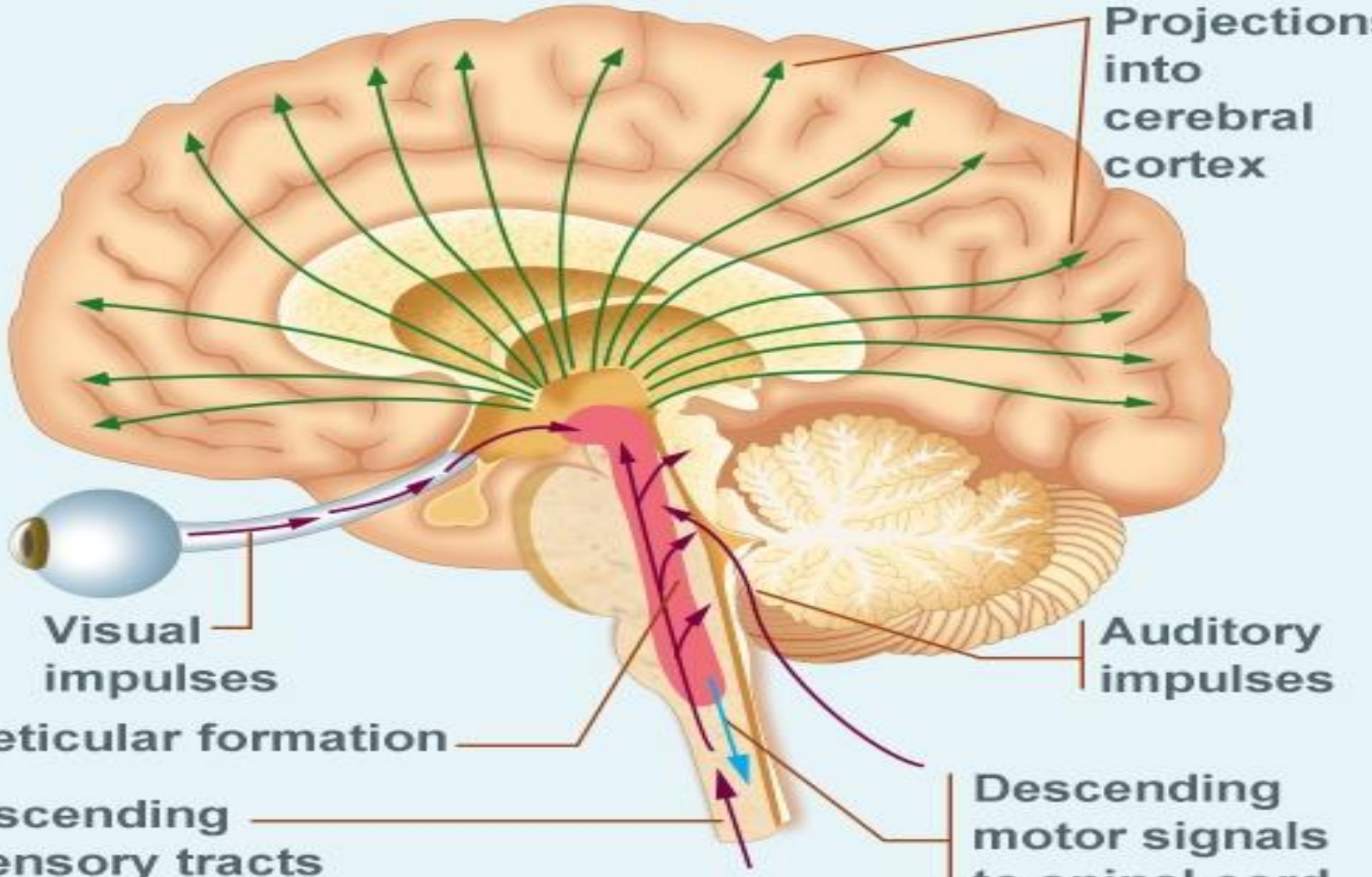
Role in behavioral arousal

Role in consciousness (sleep/awake cycle)

Connect the brain stem to the CC



Reticular Activating System

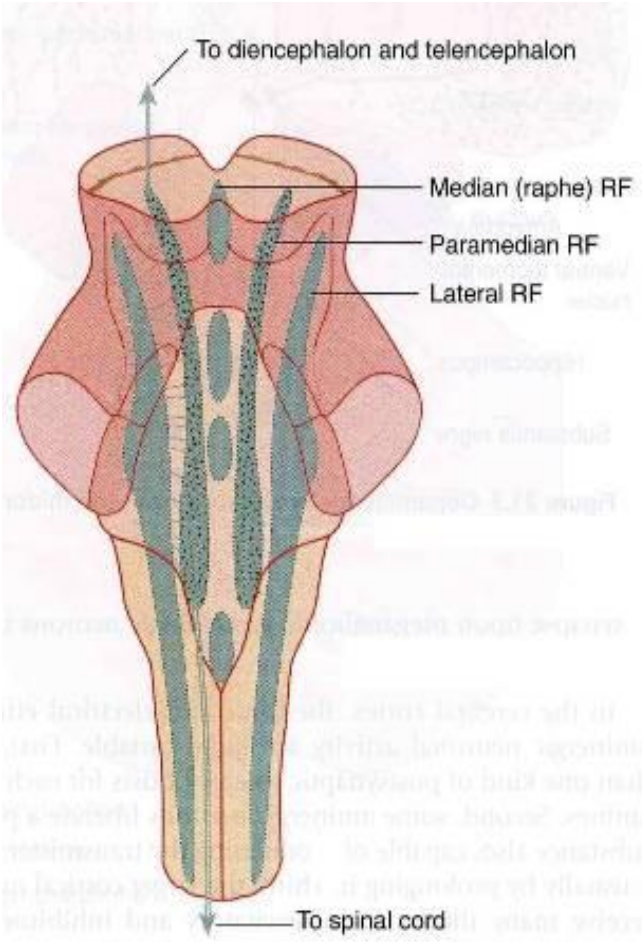


consists of 3 parts:

Lateral Reticular Formation

Para median Reticular Formation

Raphe nuclei (Median RF)



⊙ Lateral Reticular Formation

Has small neurones

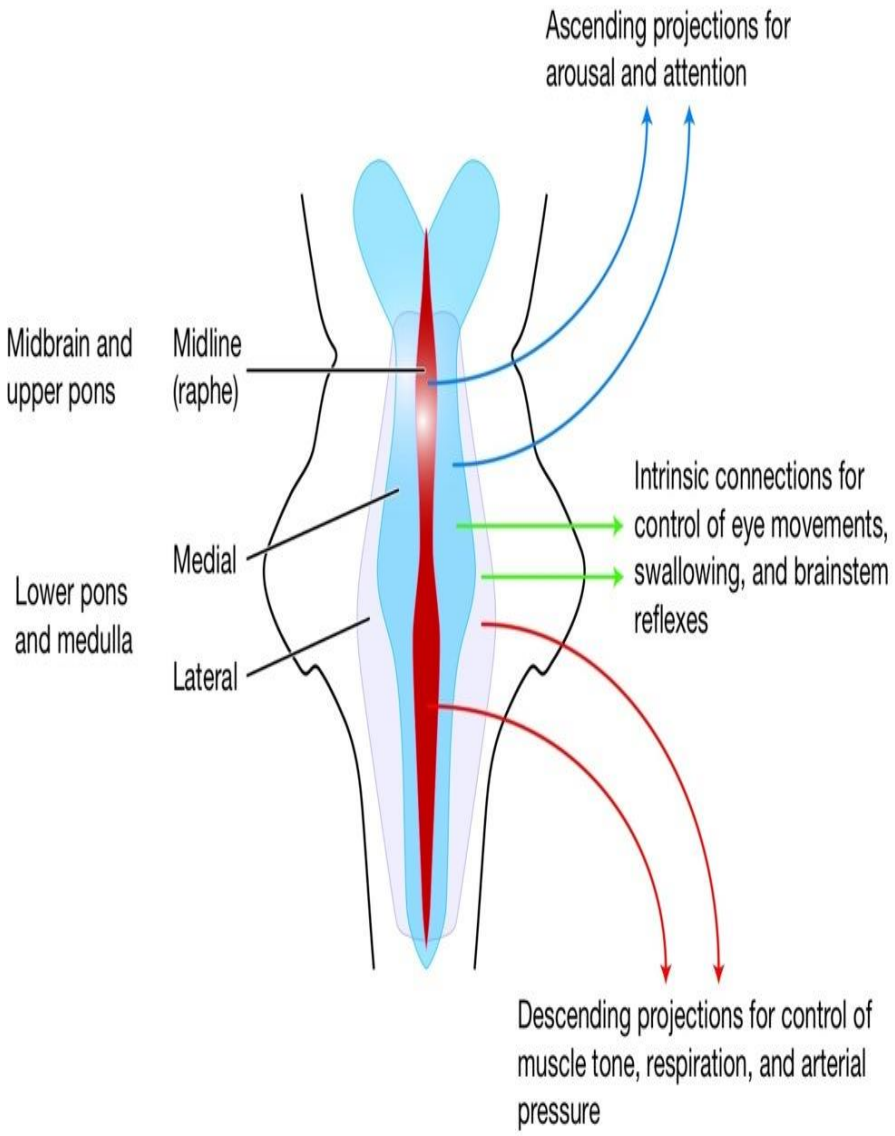
Receives information from ascending tracts for touch and pain.

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

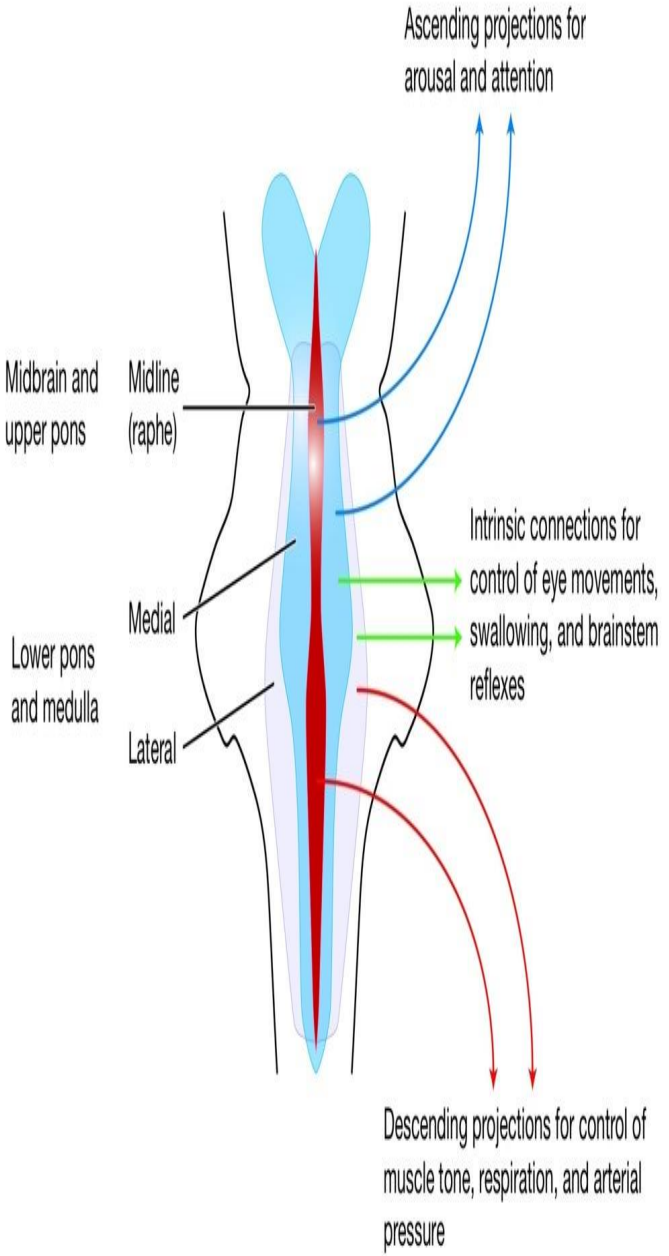
Has large cells.

-Receives signals from lateral reticular formation

-Nucleus ceruleus contains noradrenergic neurones and projects onto the cerebral cortex.

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

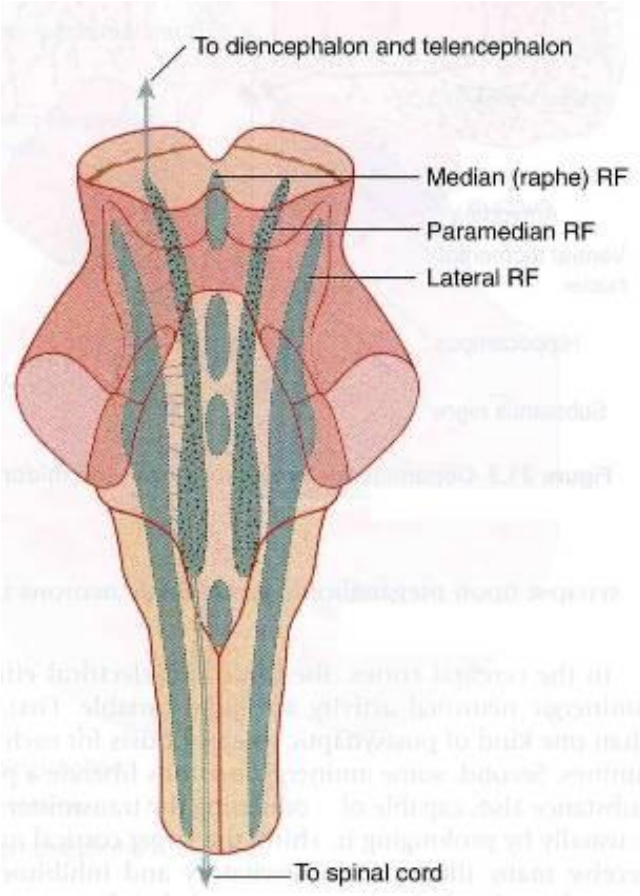
-Cholinergic neurones secreted by gigantocellular neurones project onto the thalamus

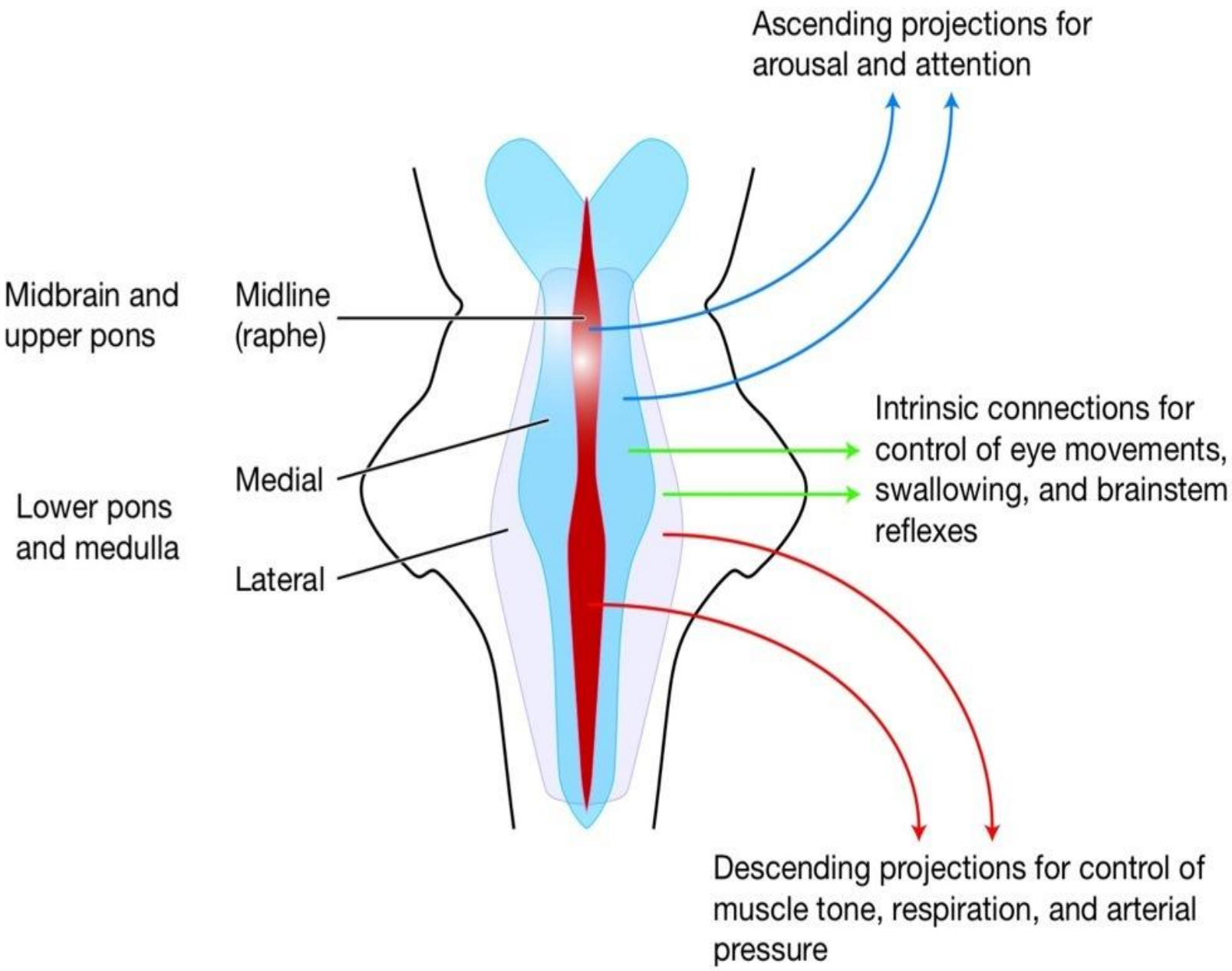


Raphe nuclei (Median RF)

In the midline of the reticular formation

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




Ascending projections for arousal and attention
Midbrain and upper pons
Midline (raphe)
Intrinsic connections for control of eye movements, swallowing, and brainstem reflexes
Medial
Lower pons and medulla
Lateral
Descending projections for control of muscle tone, respiration, and arterial pressure

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

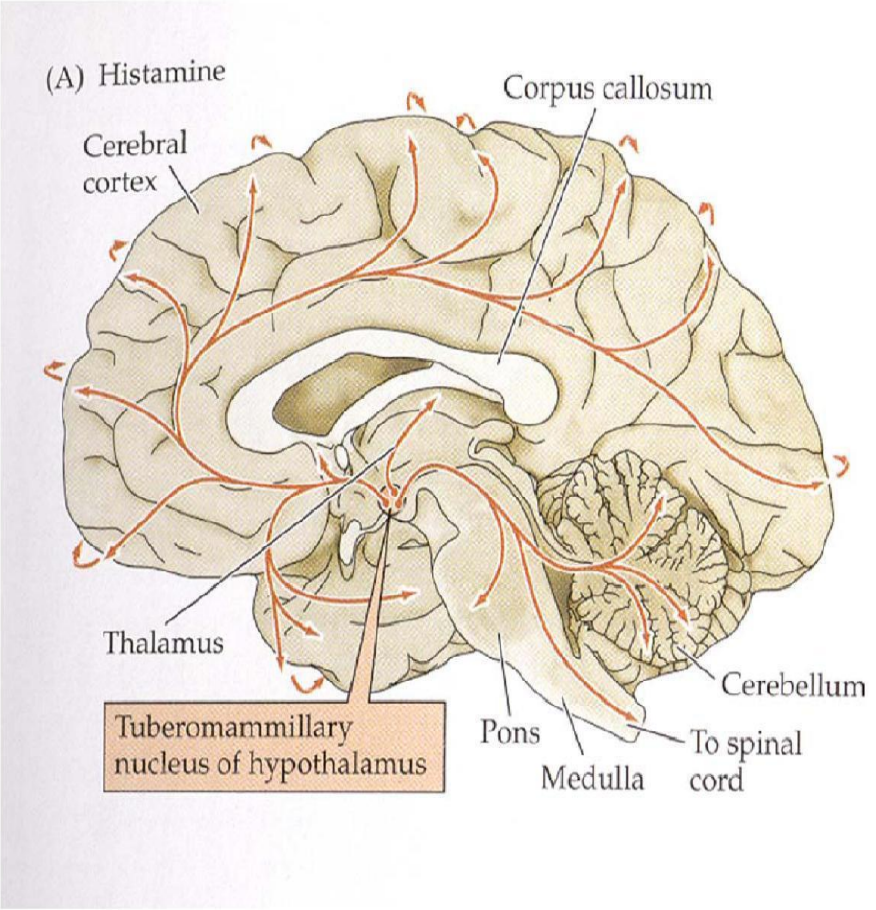
Located in the mid-part of the diencephalon

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.

Hypothalamus

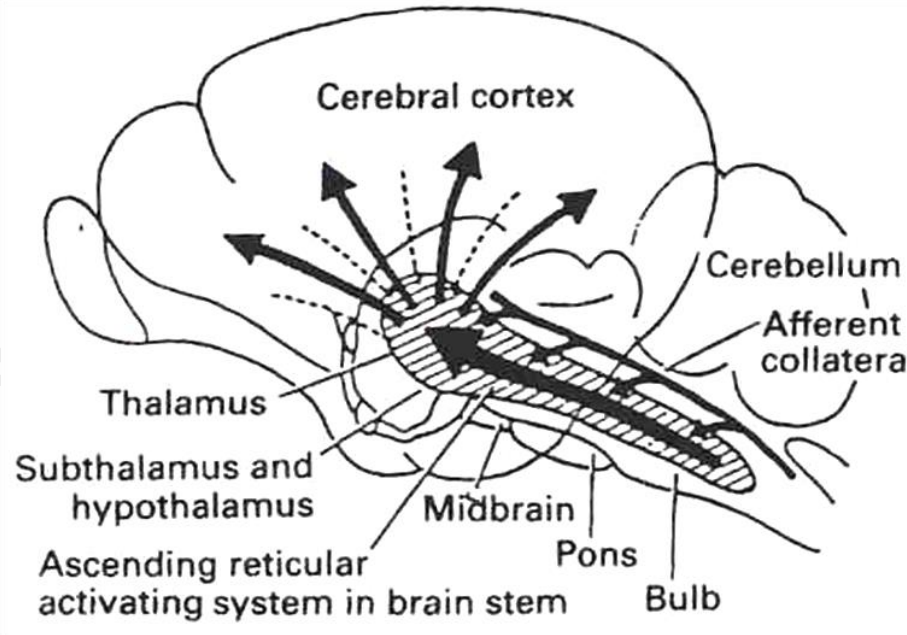
- **Tuberomammillary nucleus in the hypothalamus projects to the cortex and is involved in maintaining the awake state**

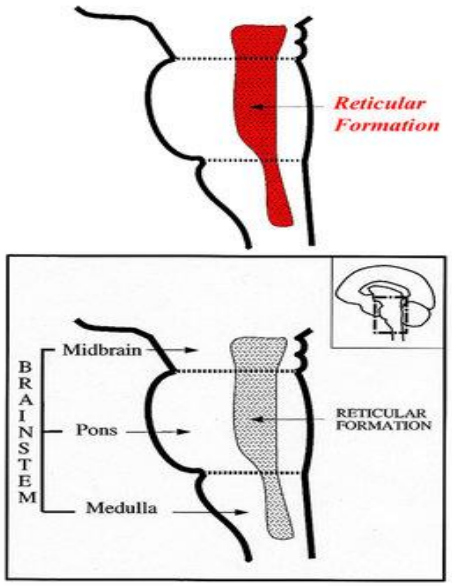


RAS

- Lesion in the mid-pons >>>>>>>unconsciousness

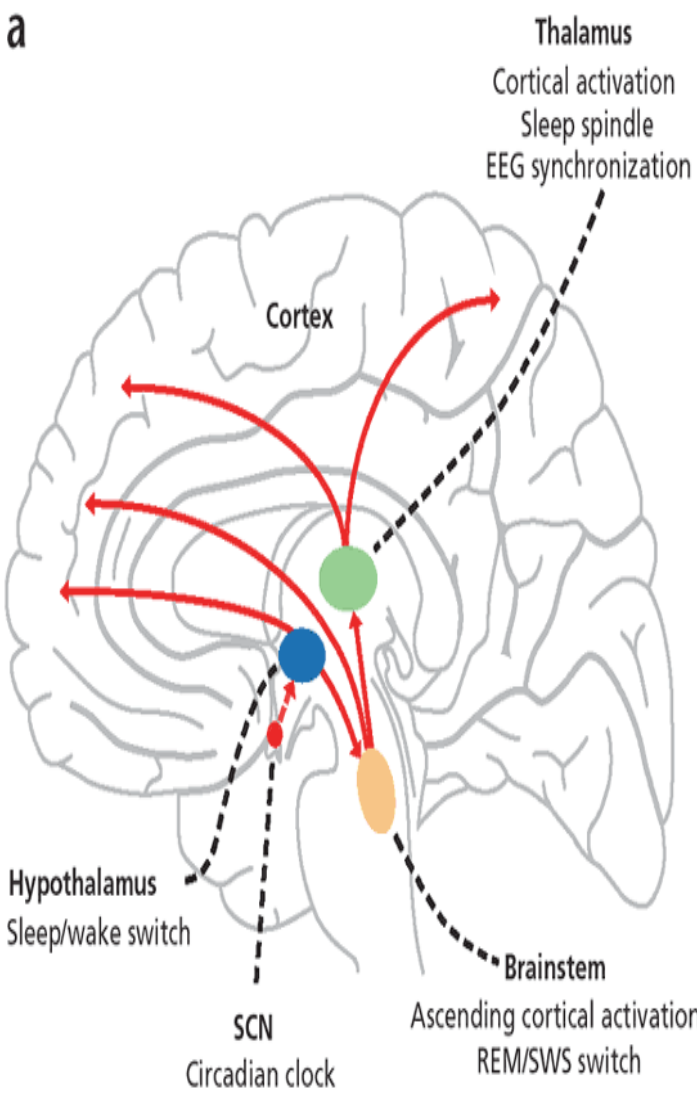
-Pons (uppers & middle and midbrain are essential for wakefulness .





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



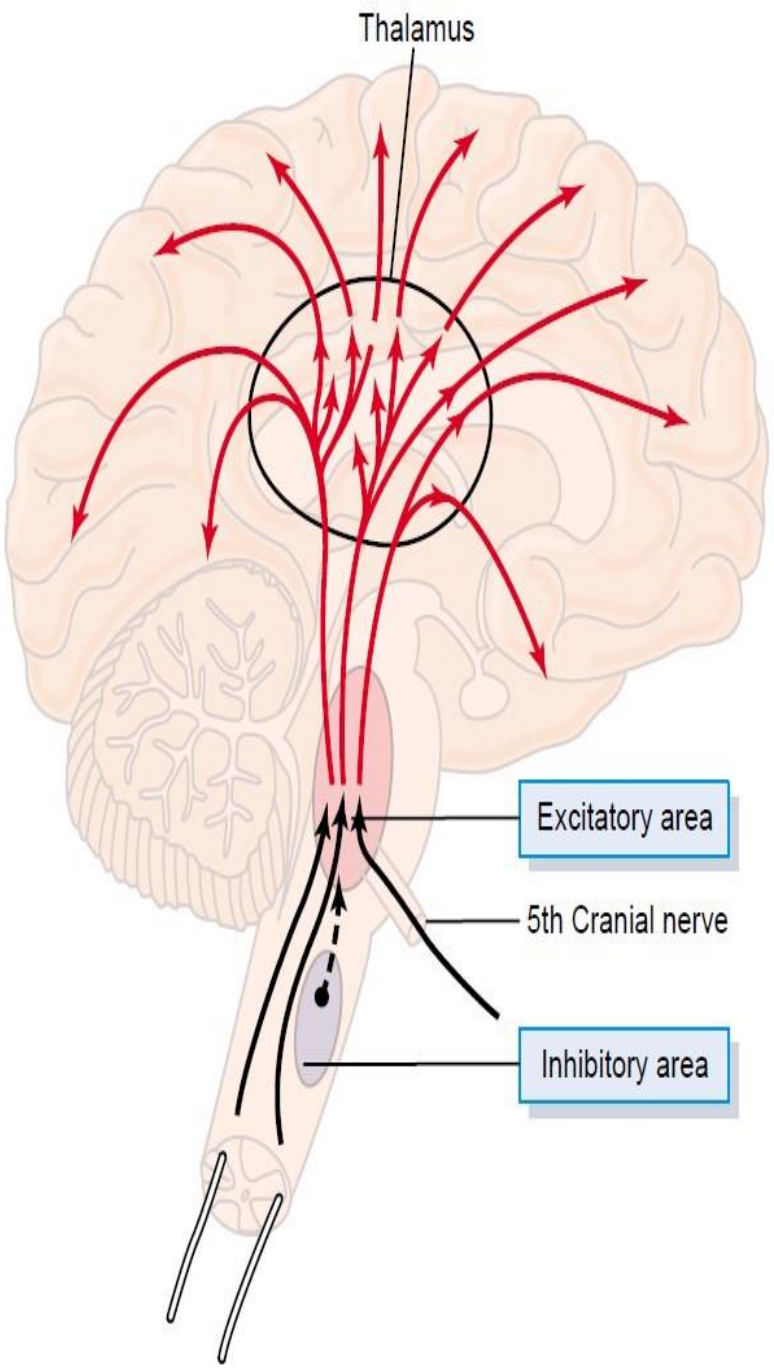
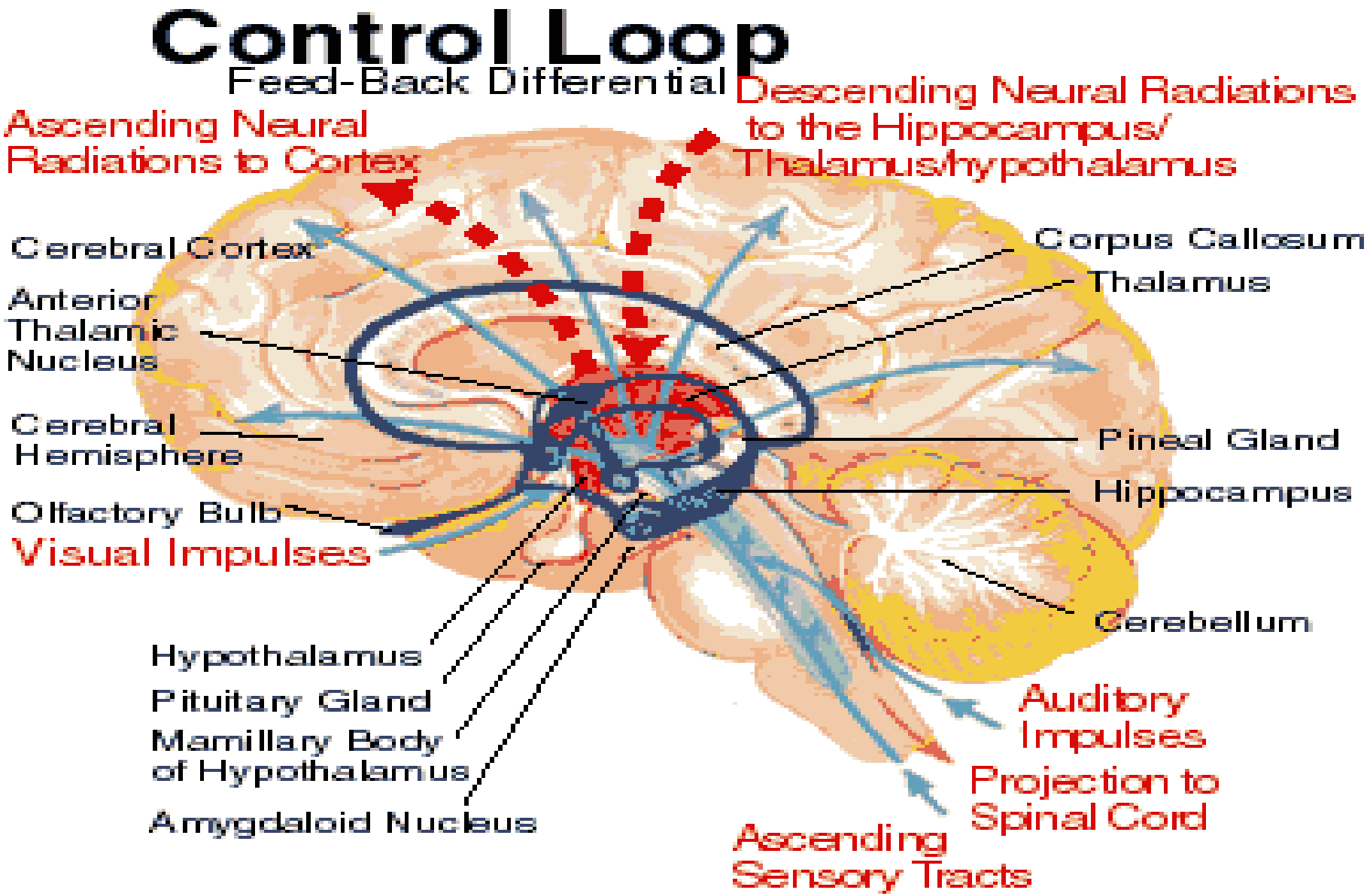


Figure 58–1

- 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



Functions of RAS

- 1- Regulating sleep-wake transitions
- RAS suppress ascending afferent activity 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 dysfucntion

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,

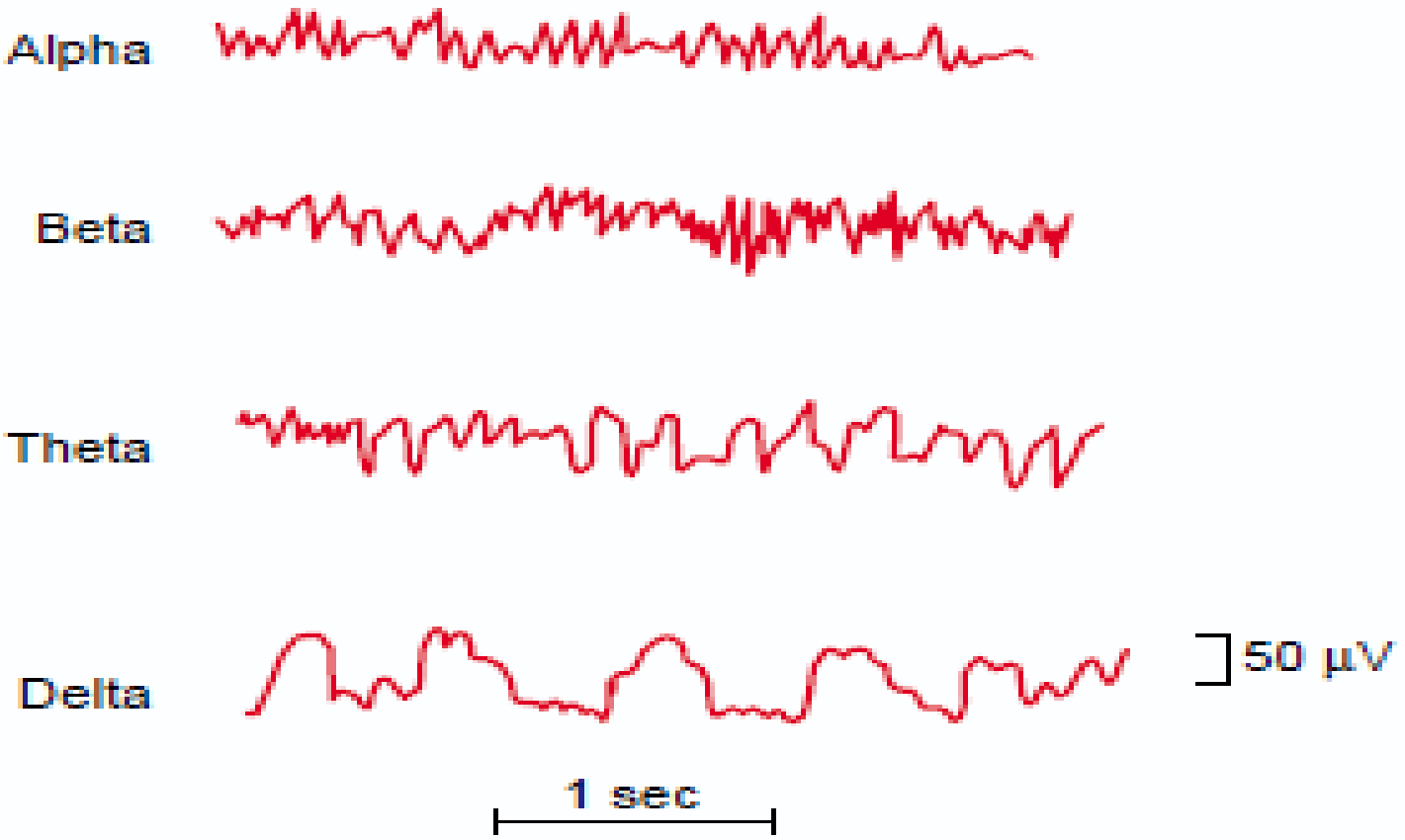
- Over aroused cortex
- Hyper-vigilance (sensory sensitivity)
- Touching everything
- Talking too much
- Restless
- Hyperactive

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 ?)

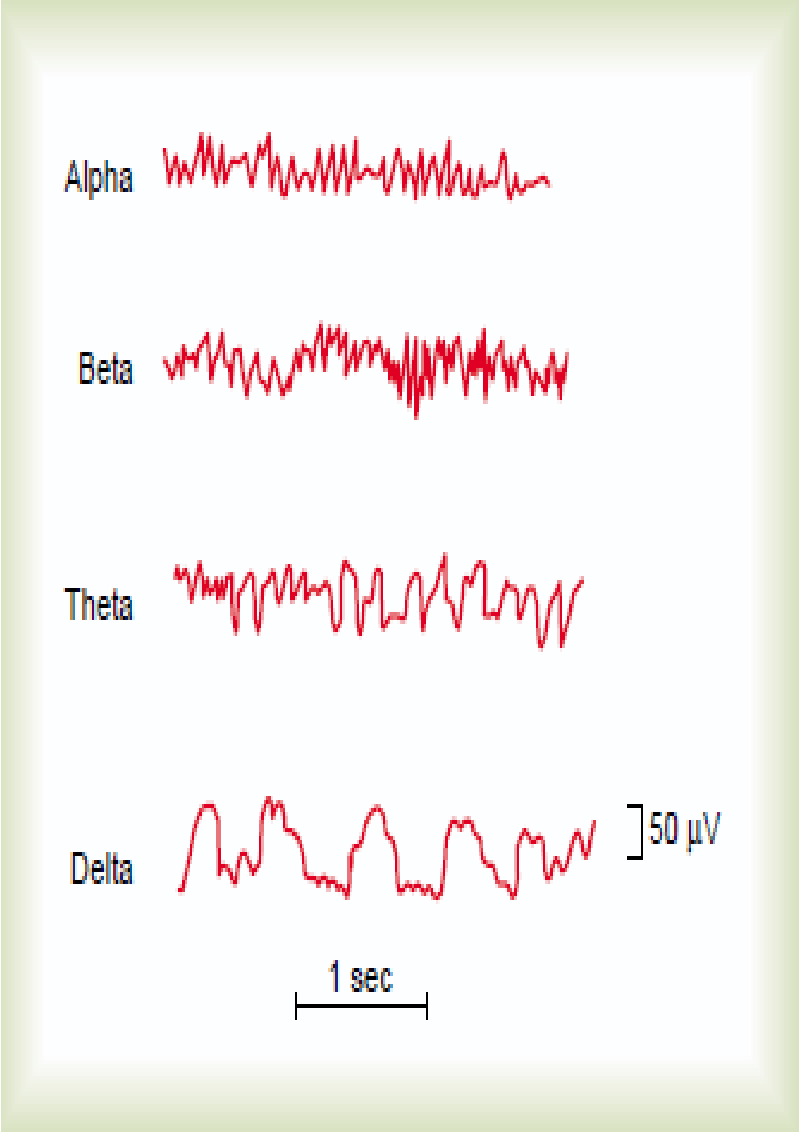
- **Vital signs :**
- Pulse , BP, respiration , pupils , reflexes , particularly brainstem reflexes , etc)
- **EEG** → Each of these states (wakefulness , sleep , coma and death) has specific EEG patterns
- **Evoked potentials** (in cases of Brain Death).

Electroencephalogram



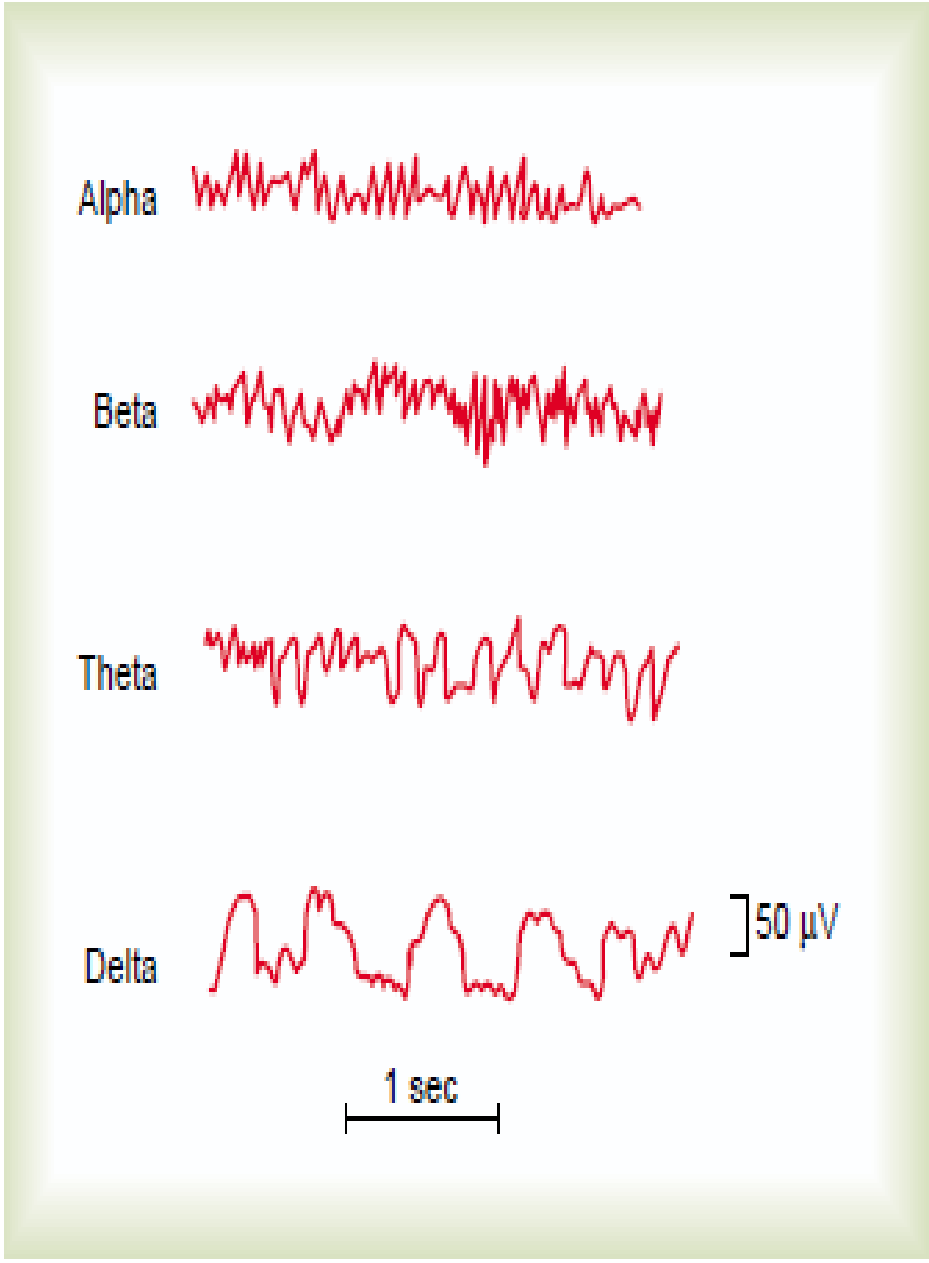
- Alpha waves:
- Recorded from the parietal &occipital regions
- Awake and relaxed+ eyes closed
- 10 to 12 cycles/second.

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



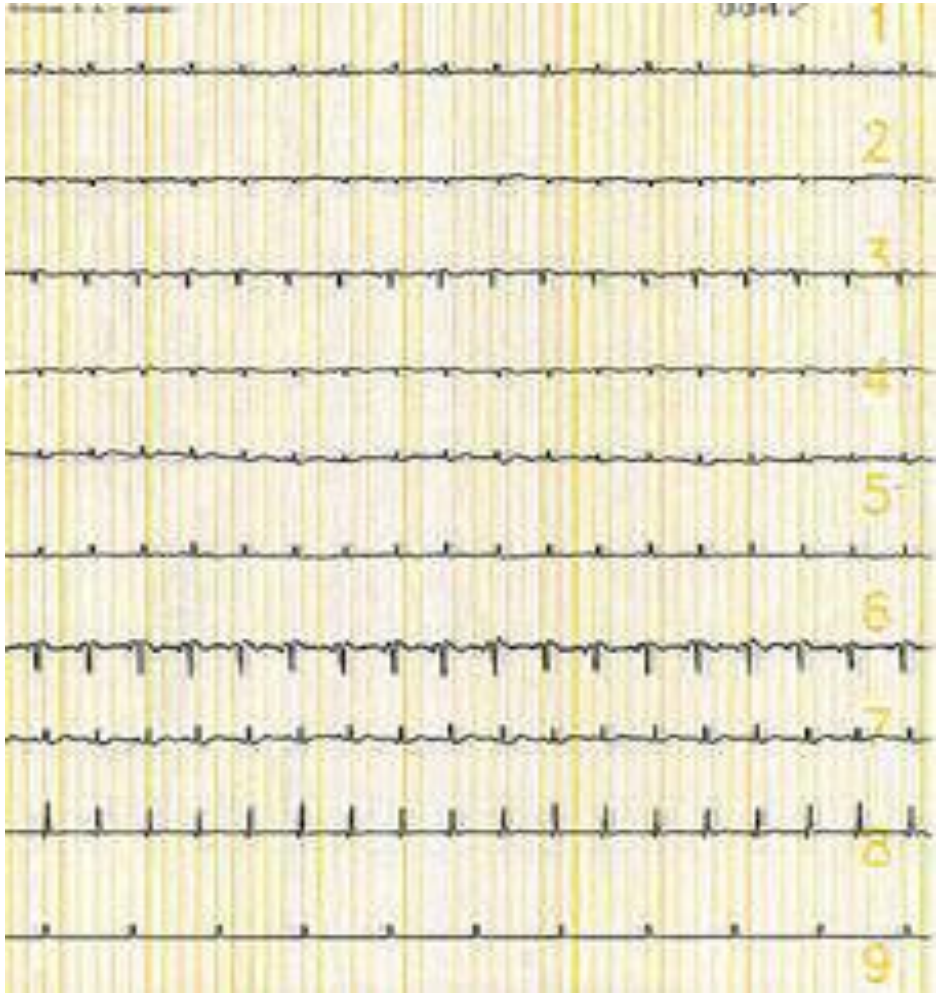
- **Theta:**
  -Temporal and occipital
  -5 to 8 cycles/second
  -(newborn)
- Theta waves in adults indicates severe emotional stress

- **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

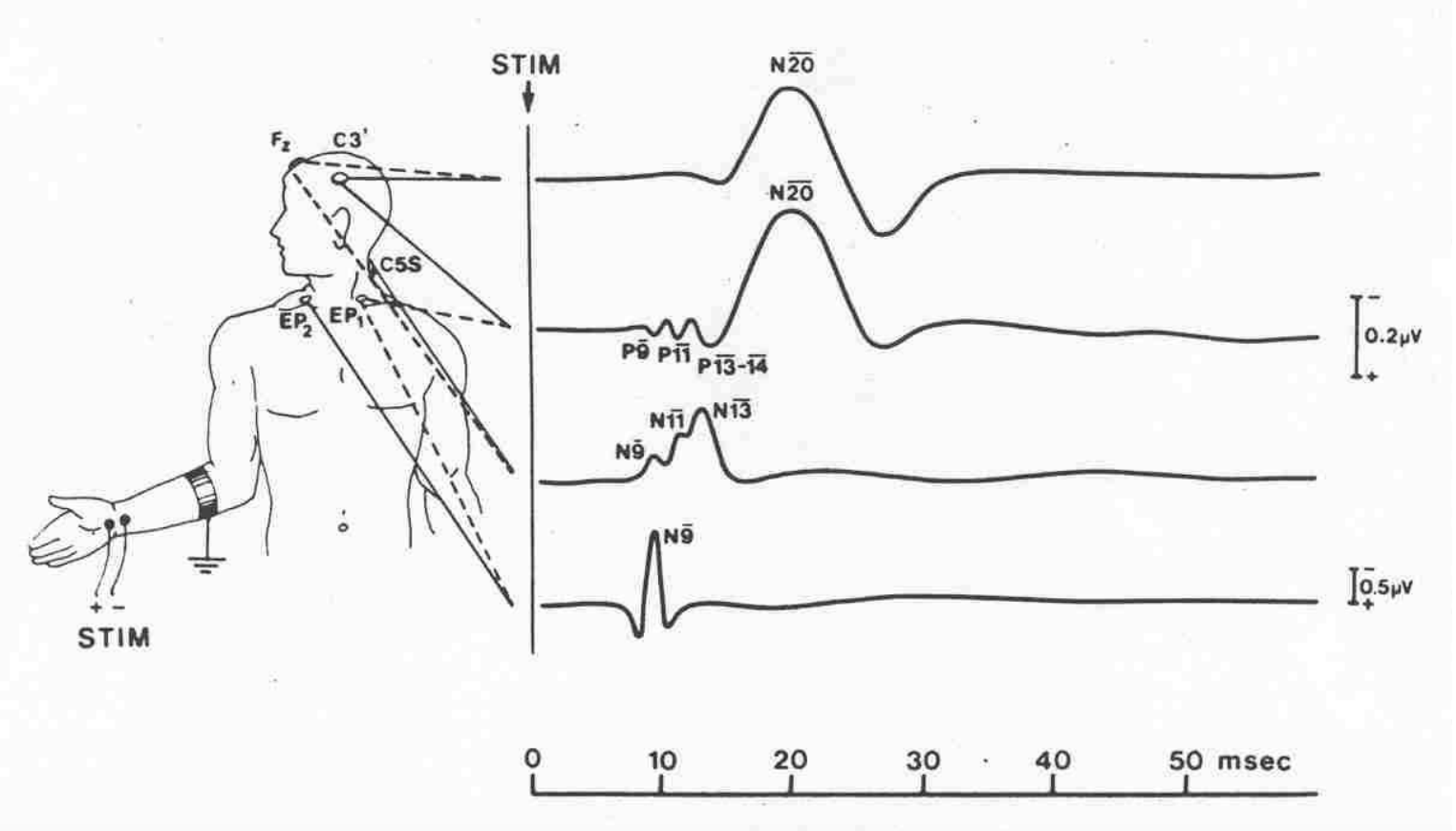
Normal EEG (at normal magnification)

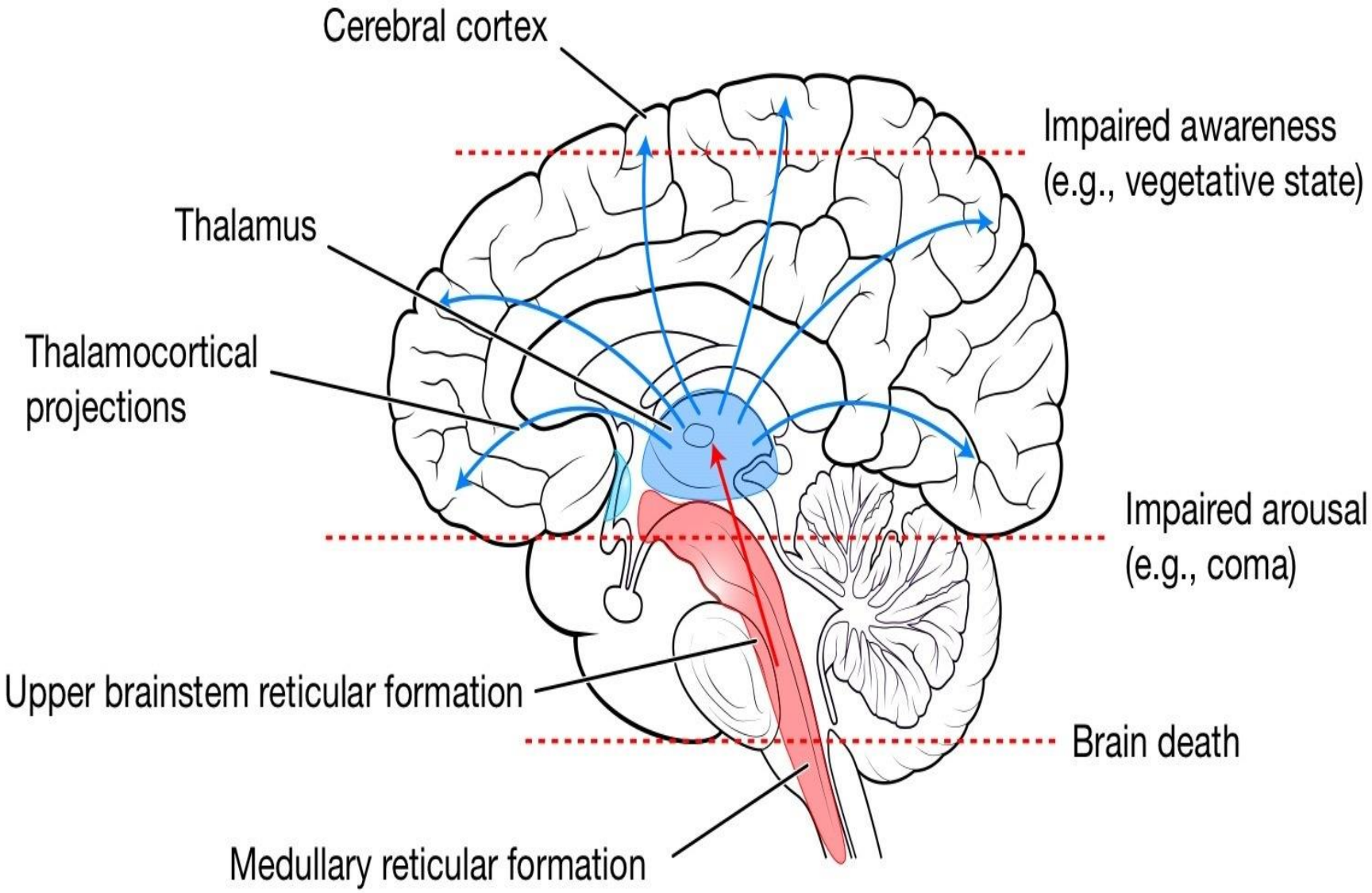


Brain Death (Flat EEG ,at very high magnification)

Brain Death Confirmatory Testing with Somatosensory 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 .




Cerebral cortex
Impaired awareness
(e.g., vegetative state)
Thalamus
Thalamocortical
projections
Impaired arousal
(e.g., coma)
Upper brainstem reticular formation
Brain death
Medullary reticular formation