physiology team 429

Physiology of Consciousness

Done By :

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Levels 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 with 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

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

a person with a flat EEG can not be conscious !

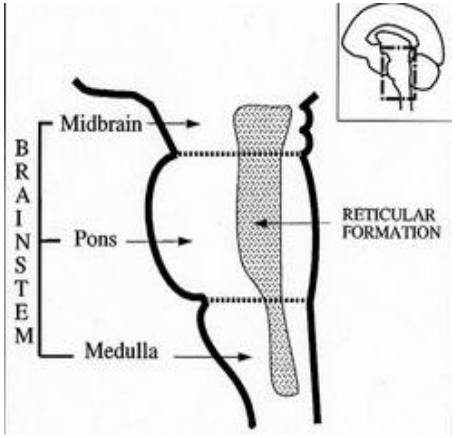
- Consciousness depends upon interactions between :

(1) Reticular Formation (RF) .

(2) Thalamus

(3) Cortical Association areas .

Reticular formation



Functions:

1. **Somatic motor control**

2. **Cardiovascular control**

has the cardiac and vasomotor centers of the medulla oblongata

3. **Pain modulation**

- The RF is a pathway by which pain signals from the lower body reach the cerebral cortex.
- It is 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

Def/ a process in which the brain learns to ignore repetitive, meaningless stimuli while remaining sensitive to others.

EX .. when a person can sleep through loud traffic in a large city, but is awakened promptly due to the sound of an alarm .

Reticular Activating System (RAS)

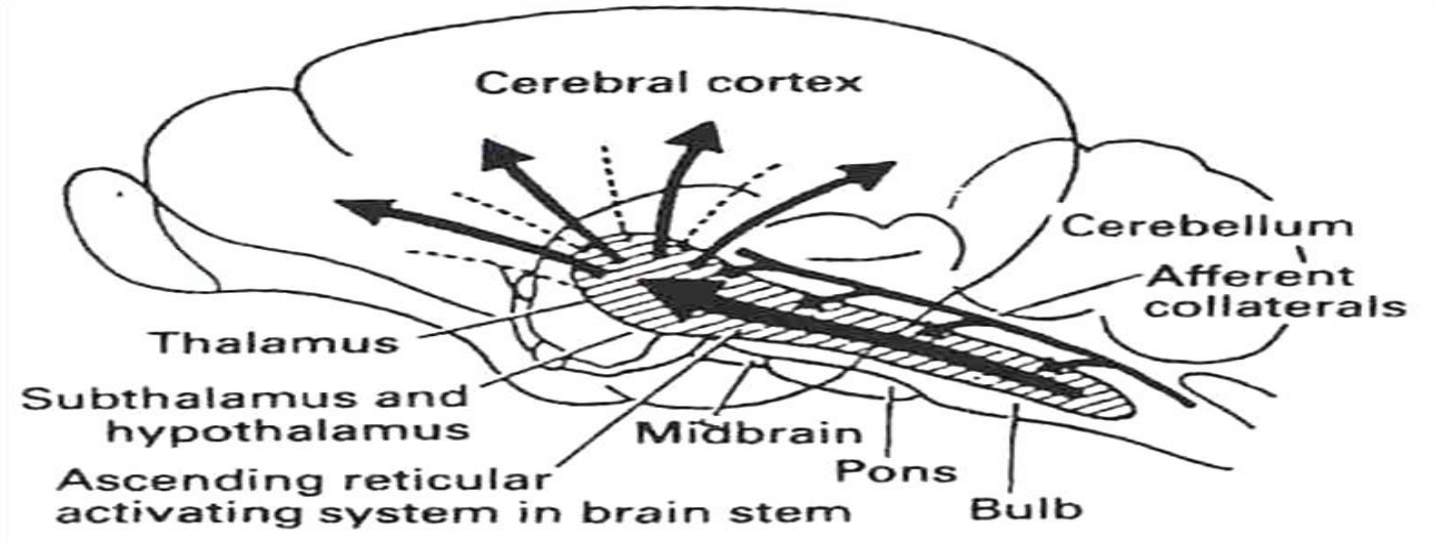
- The (RAS) is the system which keep our cortex awake and conscious
- Reticular Activating system = Bulboreticular Facilitatory area + thalamu
- Bulboreticular it's an area in the upper pons and midbrain and is essential for **wakefullness** of the Reticular Activating system .
- Bulboreticular Facilitatory area is called The Brainstem Ascending RAS
- Bulboreticular Facilitatory (excitatory) area sends excitatory signals into thalamus as a result the thalamus excites almost all area of the cortex

- The brainstem reticular formation runs all the way up to the mid-brain. As a result, the RAS is a very complex collection of neurons that serve as a point of convergence for signals from the external world and from interior environment.

- In other words, it is the part of your brain where the world outside of you, and your thoughts and feelings from "inside" of you, **Meet**.

- This RAS is very capable of generating dynamic effects on the activity of the cortex, including the frontal lobes, and the motor activity centers of the brain.

- Any interruption of the ascending pathway of the RAS (E.g by tumor) causes the subject to go into unremitting coma .



- In 1945 , the Italian neurophysiologist Moruzzi and his colleagues found that a lesion in the mid-pons makes the animal spends the rest of its life unconscious .

- They concluded that the areas in the upper pons and midbrain are essential for wakefulness , and called it the Bulboreticular Facilitory (Excitatory) Area of the reticular formation .

Anatomical componenets

- The RAS is composed of several neuronal circuits connecting the brainstem to the cortex .

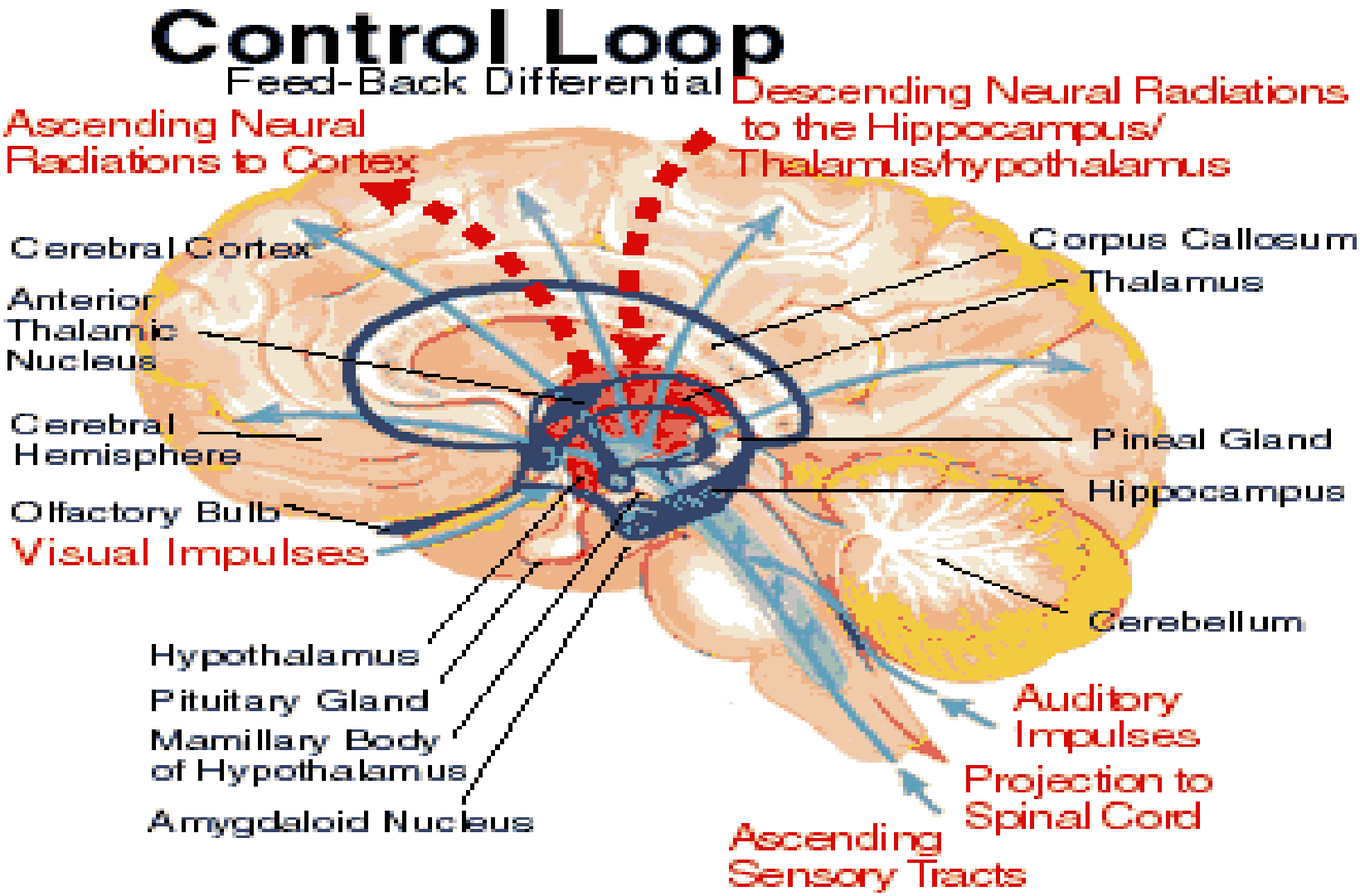
- These pathways **originate** in the upper brainstem reticular core and **project** through synaptic relays in the rostral intralaminar and thalamic nuclei to the cerebral cortex.

- As a result, individuals with bilateral lesions of thalamic intralaminar nuclei are lethargic or somnolent (drowsiness & sleepiness).

Several areas traditionally included in the RAS are:

- **Midbrain Reticular Formation**.
- **Mesencephalic Nucleus (mesencephalon**)
- Thalamic Intralaminar nucleus
- Dorsal Hypothalamus.
- Tegmentum.

Sensory inputs to RAS



Neurotransmitters

- The neuronal circuits of the RAS are modulated by complex interactions between a few main neurotransmitters.

- The awakening action of the RAS is mediated by fibers secreting Acetylcholine (Ach) and Norepinephe (NE)

- The RAS contains both cholinergic and adrenergic components, which exhibit synergic as well as competitive actions to **regulate** thalamocortical activity and the corresponding behavioral state.

Cholenergic

- Cholinergic component of the RAS are two ascending mesopontine tegmental pathways
- rostrally situated between the mesencephalon and the centrum ovale .

- <u>These pathways involve</u>
  - Cholinergic neurons of the posterior midbrain
  - The pedunculopontine nucleus (PPN)
  - The laterodorsal tegmental nucleus (LDT)

  which are active during waking and REM sleep.

- Cholinergic projections descend throughout the reticular formation and ascend to the
  - substantia nigra
  - basal forebrain
  - thalamus
  - cerebellum.

- Cholinergic activation in the RAS results in increased acetylcholine (ACH) release in these areas.

Adrenergic

- The adrenergic component of the reticular activating system is closely associated with the noradrenergic neurons of the **locus coeruleus**.

- In addition to noradrenergic projections that parallel the aforementioned cholinergic paths, there are ascending projections directly to the cerebral cortex and descending projections to the spinal cord.

- Unlike cholinergic neurons, the adrenergic neurons are active during waking and slow wave sleep but cease firing during REM sleep.

Functions of RAS

1- Regulating sleep-wake transitions

- The main function of the RAS is to modify and potentiate thalamic and cortical function such that (EEG) desynchronization ensues.

  There are distinct differences in the brain's electrical activity during periods of wakefulness and sleep: Low voltage fast burst brain waves (EEG desynchronization) are associated with wakefulness and REM sleep , large voltage slow waves are found during non-REM sleep.

- Stimulation of the RAS produces EEG desynchronization by **suppressing** slow cortical waves (0.3–1 Hz), delta waves (1–4 Hz), and spindle wave oscillations (11–14 Hz) and by **promoting** gamma band (20 – 40 Hz) oscillations.

- The physiological change from a state of deep sleep to wakefulness is reversible and mediated by the **RAS**.

- Inhibitory influence from the brain is active at sleep onset, likely coming from the **preoptic area** (POA) of the hypothalamus. During sleep, neurons in the RAS will have a much lower firing rate; conversely, they will have a higher activity level during the waking state.

- 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 RAS also helps mediate **transitions** from relaxed wakefulness to periods of high attention.
- There is increased regional blood flow (presumably indicating an increased measure of neuronal activity) 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 that are needed for the processing and learning of information, and the ability to pay attention to the correct task.

- If the RAS doesn't excite the neurons of the cortex as much as it ought to, then we see the results of an under-aroused cortex, such as difficulty learning, poor memory, little self-control, and so on. In fact, if RAS failed to activate the cortex at all one would see a lack of consciousness or even coma.

- If the RAS was **too excited**, and aroused the cortex or other systems of the brain too much what will happen ?

  we would see individuals with excessive startle responses (quick involuntary movement), hyper-vigilance (abnormally increased arousal, responsiveness to stimuli, and scanning of the environment for threats), touching everything, talking too much, restless, and hyperactive.

- So the Reticular Activating System must be **activated** to normal levels for the rest of the brain to function as it should.

Factors that influense the level of consciousness

1- Peripheral sensory input

- Level of activity of the bulboreticular facilitatory and consequentaly the level of alertness and arousal is largely **determined** by the number and type of sensory (afferent) signals that enter the CNS from the periphery.

- Pain signals in particular ,increase activity in the excitatory area and therefore strongly excite the brain to attention

2- Thalamocortical sector

- Not only do excitatory signals pass to the cerebral cortex from the RAS, but feed back signals also return from the cortex back to the thalamus

  (which is part of RAS)
- 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 and feedback Corticothalamic (CT) fibers .
- These neural circuits between the thalamus & cortex are essential for determining the level of consciousness .

Indications 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 and other general Qs like who is the president ?)

- Vital signs

  pulse , BP, respiration , pupils , reflexes (particularly brainstem reflexes)

- EEG

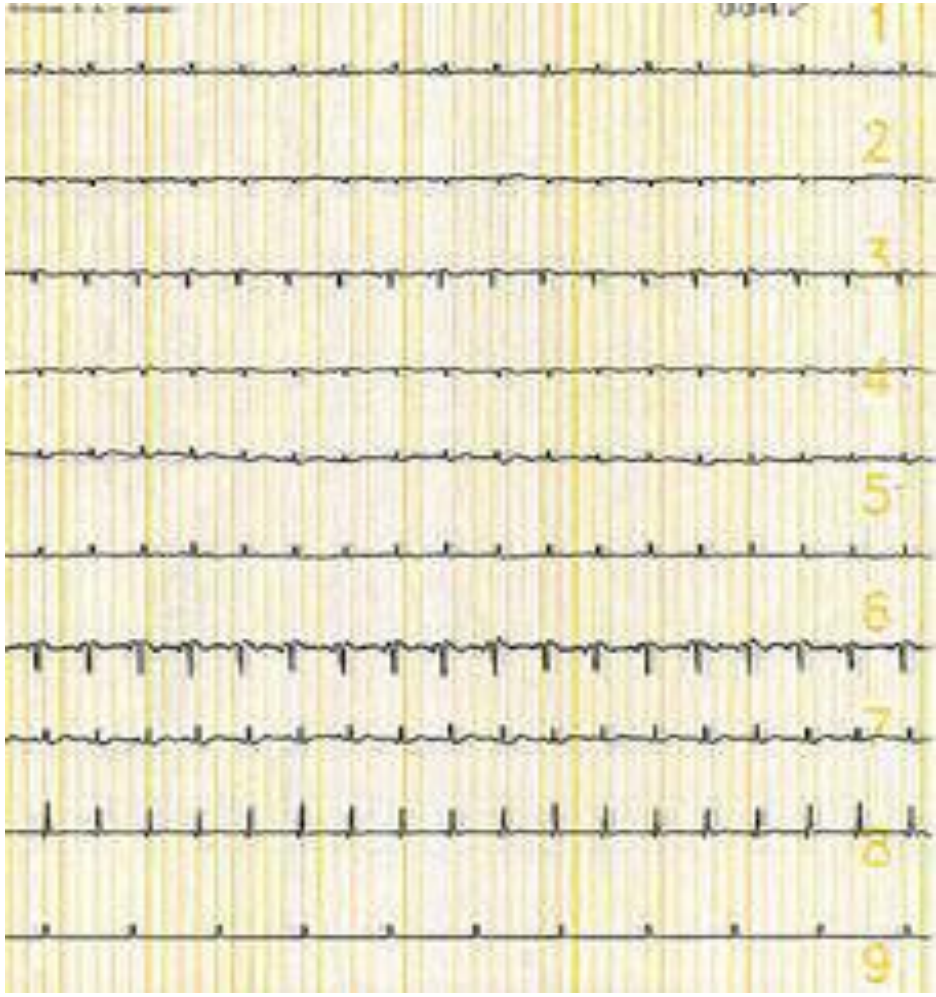
  Each of these states (wakefulness , sleep , coma and death) has specific EEG patterns .

- Evoked potentials

  (in cases of Brain Death).

Brain Death Confirmatory Testing with EEG

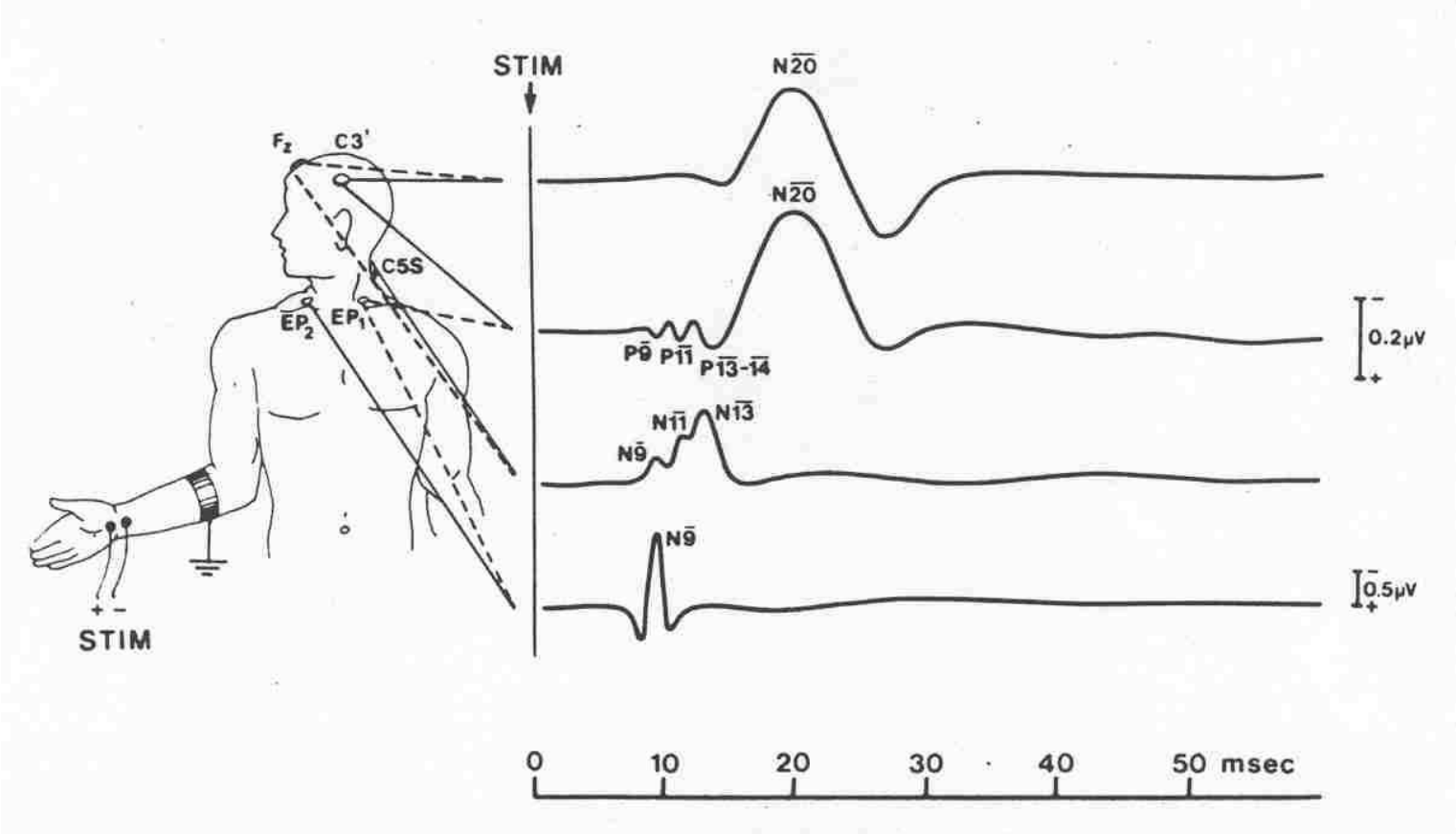
Normal EEG (at normal magnification)



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 .



EEG (Electroencephalogram)

routine EEG is recording of cortical activity from scalp surface

- **Alpha rhythm:**
- Observed in awake, relaxed adult humans with eyes closed
- Frequency =8-13 hz
- Most prominent in the parito-occipital region,though it is sometimes observed in other location.
- when attention is focused on something the alpha rhythem become relapced by irregular low-voltage activity this phenomenon is known as alpha block
- The replacement of alpha by irregular low-voltage activity is also called Desynchronaization &alerting response
- Is due to activity of RAS
- However ,the rapid EEG,activity seen in the alert state is also synchronized but at a higher rate ,therfore the term "desynchronization "is misleading

- **Beta waves(fast rhythm)**
- 14-30 hz ,lower ampletude than alpha
- In frontal region
- **Gamma waves (fast activity):**
- 30-80 hz
- Effect of "focused attention /alert wakefulness, even if eyes are closed .
- Often seen in a subject who is, on being aroused ,focuses his attention on something
- They are often replaced by irregular fast activity as the individual initiates motor activity in response to the stimulus

Revision for the EEG waves that's in the sleep lecture

- **Theta waves**
- Large amplitude .regular ,4-7Hz activity
- Occoure on children
- Recorded from the hippocampus in experimental animals.

- **Delta waves:**
- Large amplitude .<4Hz waves
- In deep sleep and coma
- In frontal regions

Revision for the EEG waves that's in the sleep lecture

The Normal EEG is Largely Age-Dependent

• For example : EEG of premature babies is different from that of full-term newborn (even different grades of prematurity have different special EEG features ,depending on the intrauterine age).
• During childhood the occipital rhythm changes from the delta range (0.5-2.0 Hz) in the newborn and gradually increases until it gets established at the alpha range .
• The age-dependent changes in childhood EEG are used as landmarks to indicate the degree of the child's cerebral growth & maturation.
• EEGs of early childhood , late childhood , adolescence , middle age and old age also have some differences .
• In cases of coma EEG may be dominated by delta waves
• In case brain death the EEG is flat, even at very high magnification
(where only machine timing artefacts may be seen).