

# Physiology of Consciousness

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# Brain Activity States

- Q : What are " states " ( in terms of function ) in which brain activity can be ?
- (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

# What is Consciousness ?

- Therefore , 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 .

## References :

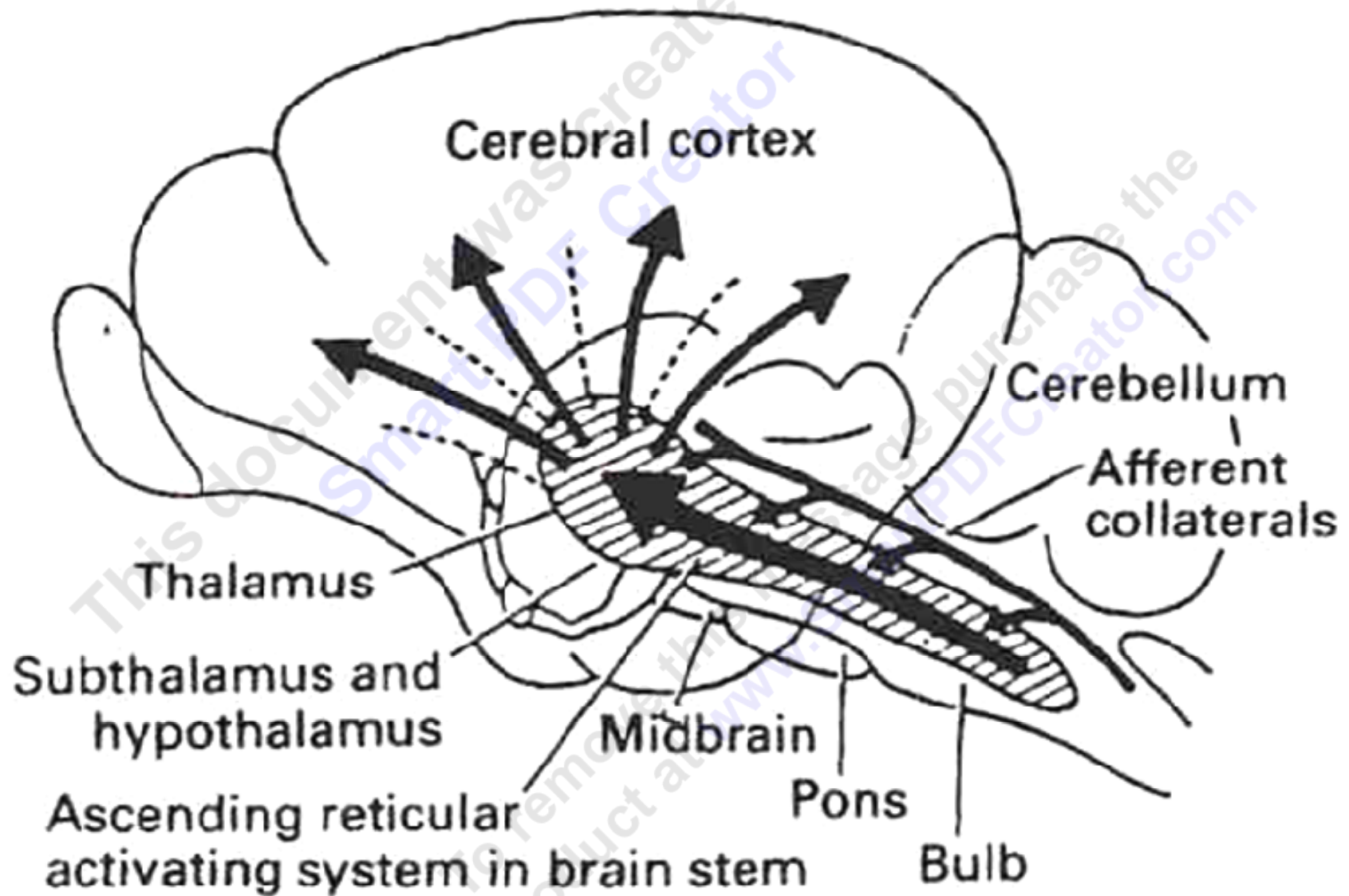
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- (4) Gloor P. Consciousness as a neurological concept . Epilepsia 1998 ; 27: S 14-26
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# *Reticular Activating System* (*RAS*)

(Bulboreticular Facilitory Area + Thalamus)

- 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 .
- ( This Bulboreticular Facilitory Area is also called by some scientists The Brainstem Ascending Reticular Activating System ).
- The Bulboreticular Facilitory ( Excitatory ) Area sends excitatory signals into Thalamus . As a result , the thalamus excites almost all areas of the cortex .
- The Bulboreticular Facilitory ( Excitatory ) Area + Thalamus together constitute the Reticular Activating System ( RAS) .
- The RAS is the system which keeps our cortex awake and conscious .

# RAS



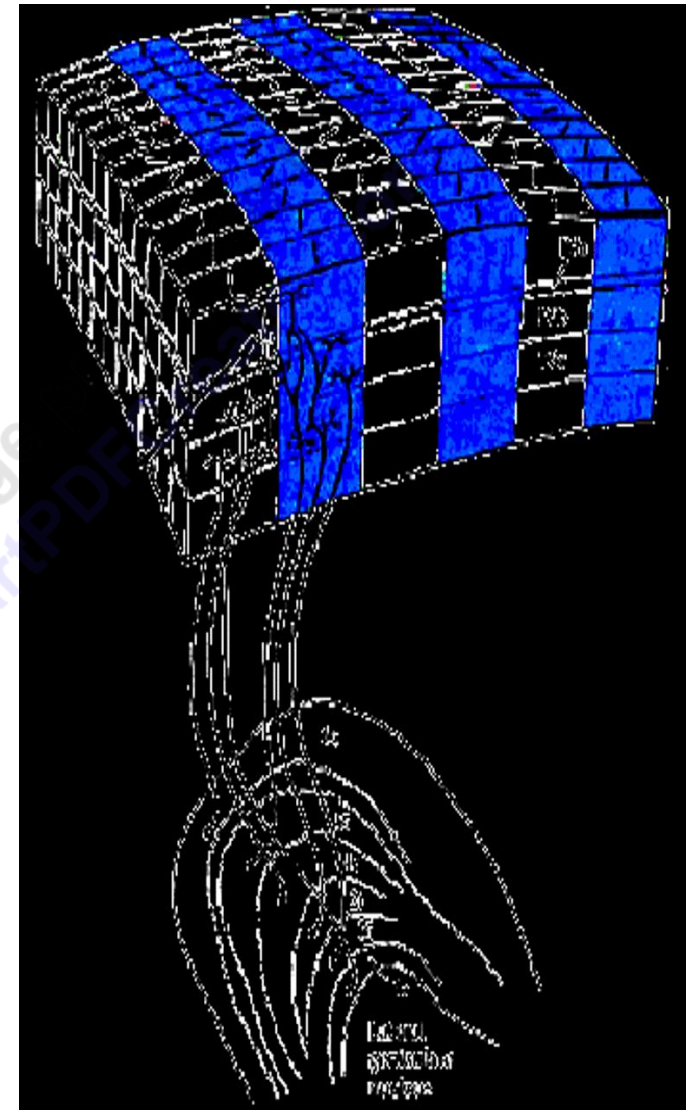
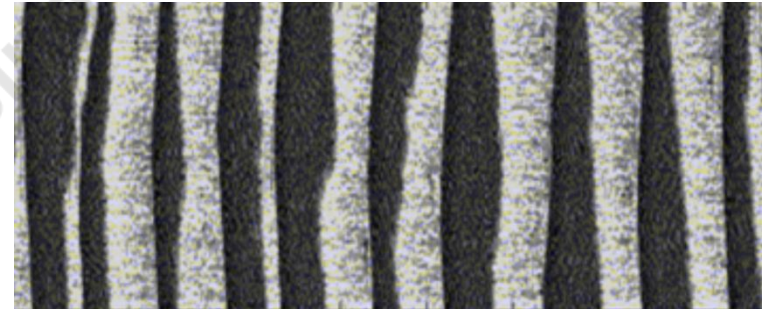
- The awakening action of the RAS is mediated by fibers secreting Acetylcholine ( Ach) and Norepinephrine (NE)
- The RAS provides the main drive that maintains effective cortical excitability level , & interruption of this ascending pathway ( e.g., by a tumor ) causes the subject to go into unremitting coma lasting for the remainder of life.
- The level of consciousness is largely influenced by :
  - (1) peripheral sensory inputs , and by
  - (2) Thalamocortical sectors .

- **Peripheral Sensory Inputs Increase the Level of Excitation of the Bulboreticular Facilitatory Area :**

- The level of activity of the Bulboreticular Facilitatory area and , consequently , 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 this excitatory area and therefore strongly excite the brain to attention .
  - **Role of Thalamo-Cortical Sectors :**
- Not only do excitatory signals pass to the cerebral cortex from the RAS , but feedback signals also return from the cortex back to the Thalamus ( which is part of the 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 Cortico-thalamic (CT) fibers.
- ✓ These neural circuits between the thalamus & cortex are essential for determining the level of consciousness .



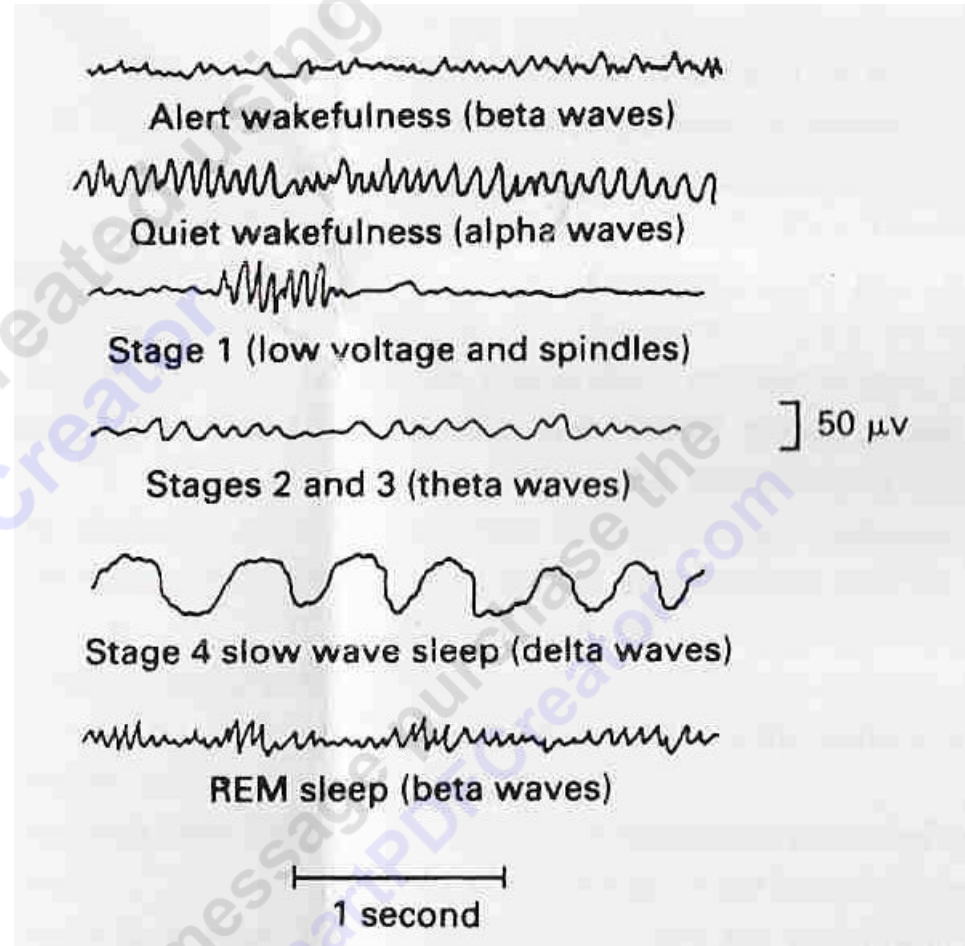
## Indices ( indicators) of Level of Consciousness

- 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 ? )
- Physical 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 ).

# The EEG ( Electroencephalogram ) Normal ( Waking State ) Patterns

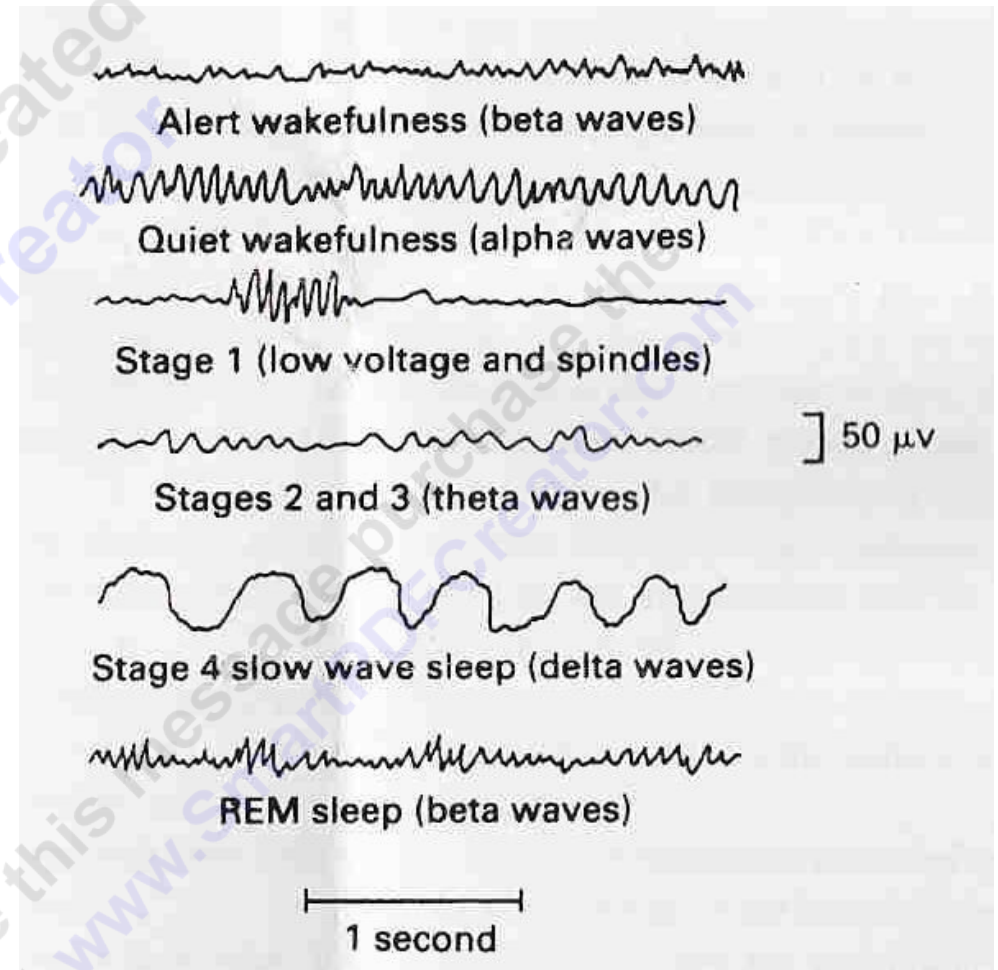
Routine EEG ( Electroencephalogram ) → is recording  
of cortical activity from scalp surface

- Alpha Rhythm :
- Observed in awake , relaxed adult humans with eyes closed
- Frequency = 8-13 Hz
- Most prominent in the Parieto-Occipital region , though it is sometimes observed in other locations When attention is focused on something the alpha rhythm becomes replaced by irregular low-voltage activity This phenomenon is known as Alpha Block



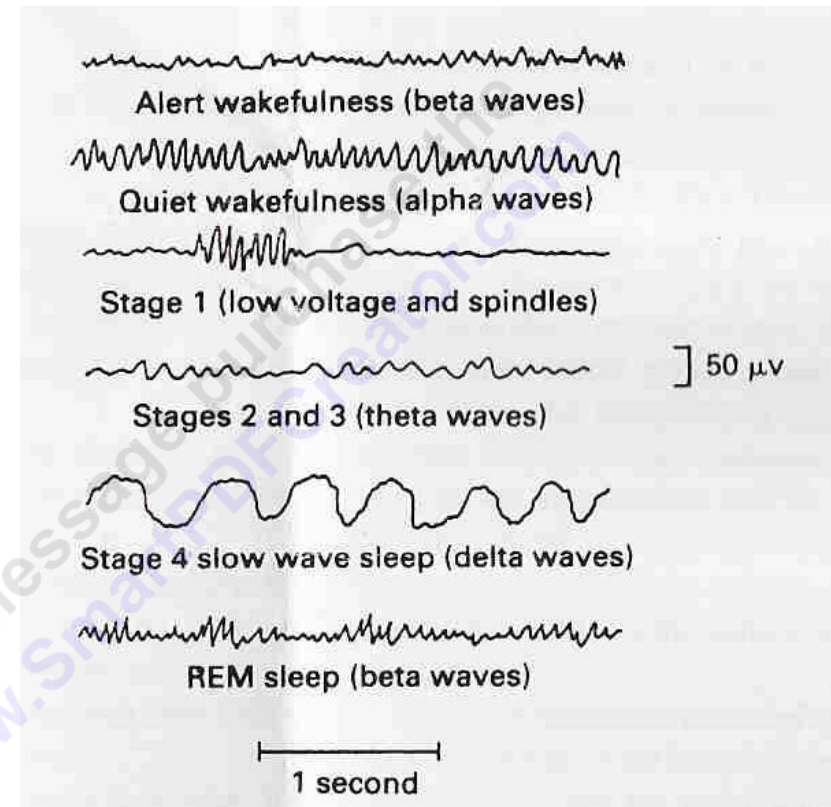
- This replacement of alpha by irregular low-voltage activity is also called It is also called Desynchronization & Alerting Response
- It is due to activity of RAS
- However , the rapid EEG activity seen in the alert state is also synchronized , but at a higher rate . Therefore , the term “ desynchronization ” is misleading .

- **Beta Waves ( a fast rhythm ) :**
- **14-30 Hz , lower amplitude than alpha .**
- **In frontal regions .**
- **Gamma Waves ( a fast activity ) :**
- **30 -80 Hz .**
- **Effect of “Focused Attention”&/or “alert Wakefulness , even if eyes are closed” : Often seen in a subject who is , on being aroused , focuses his attention on something ( a particular object/person/ animal ,etc)..**
- **They are often replaced by irregular fast activity as the individual initiates motor activity in response to the stimulus .**





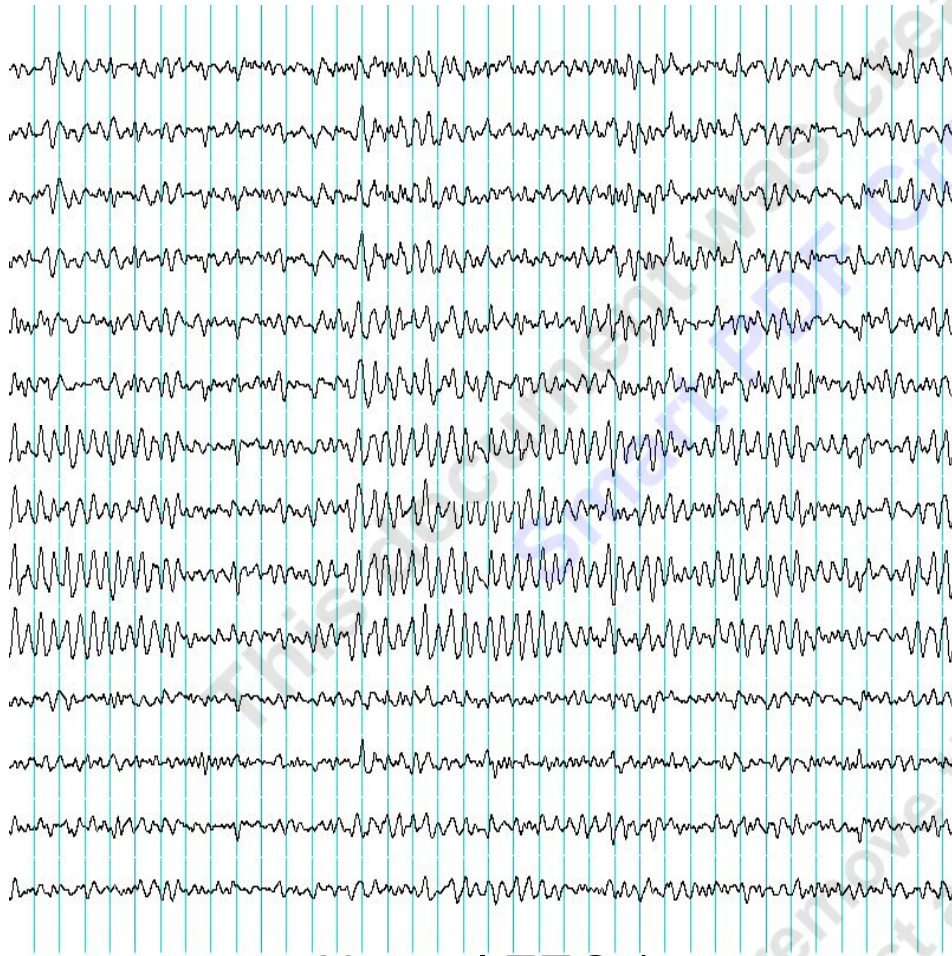
- **Theta Waves :**
- Large amplitude , regular , 4-7 Hz activity
- Occurs in children .
- Recorded from the Hippocampus in experimental animals .
- **Delta Waves :**
- Large amplitude , < 4 Hz waves
- In deep sleep and coma .
- In frontal regions .



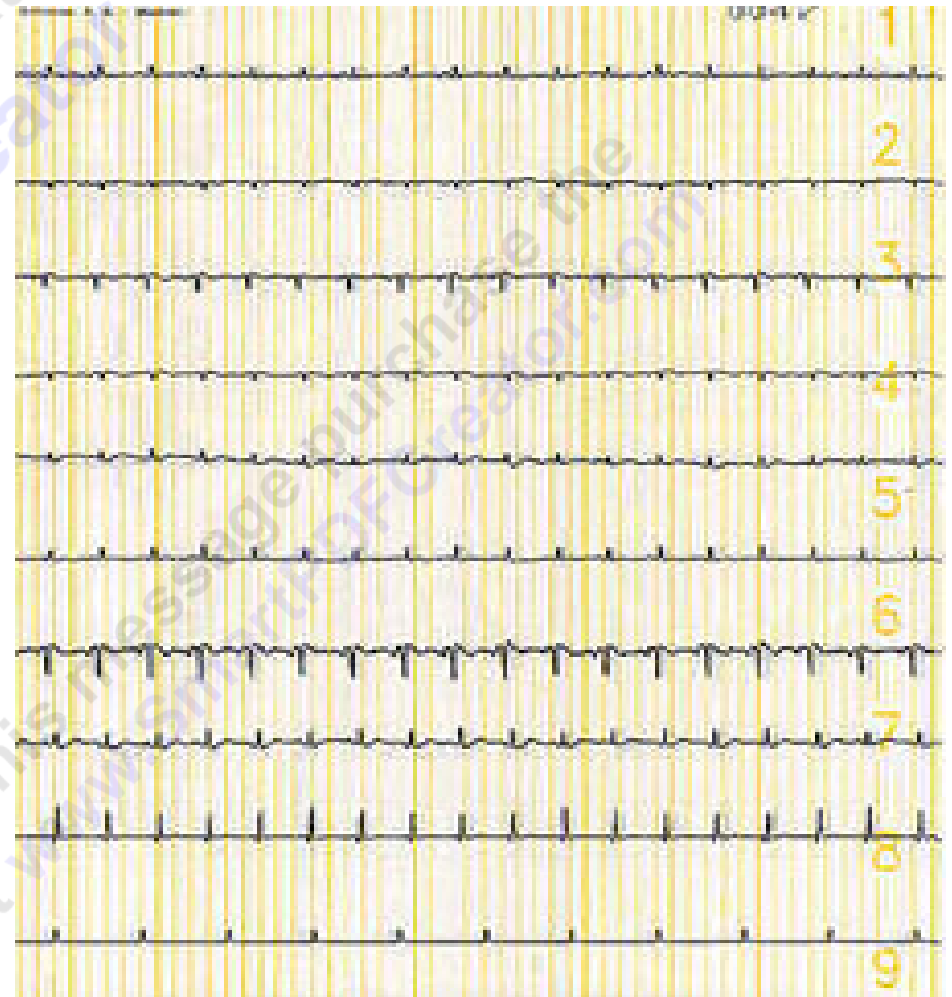
## The Normal EEG is Largely Age-Dependent

- The EEG shows special features in different age groups of normal subjects .
- 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 ).

# Brain Death Confirmatory Testing with EEG



Normal EEG ( at  
normal  
magnification )

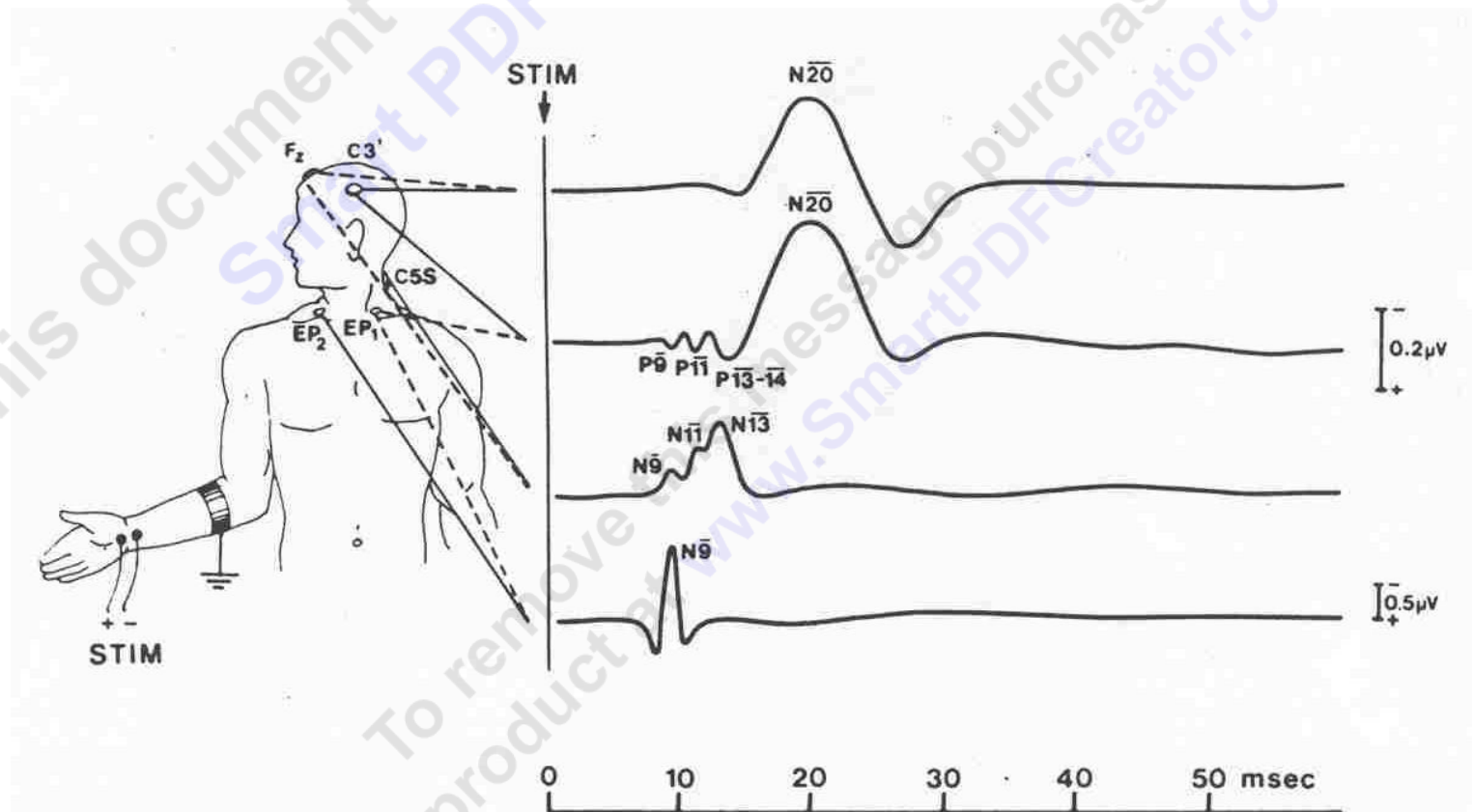


Brain Death ( Flat EEG ,at very high  
magnification )



# 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.



- Thanks

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