

Physiology of Consciousness

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The Objectives of this Lecture

- At the end of these lectures the student should be able to :
- (1) Define consciousness
- (2) Explain what is meant by the “ Reticular Activating System ”(RAS)
- (3) Define the location and function of the Bulboreticular Facilitatory Area .
- (4) Describe how the interaction between the Bulboreticular Facilitatory Area , Thalamus and Cerebral Cortex subserves & sustains consciousness
- (5) Explain how we can differentiate between a conscious and unconscious person by means of behavior , physical signs , EEG and Evoked Potentials .

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 :

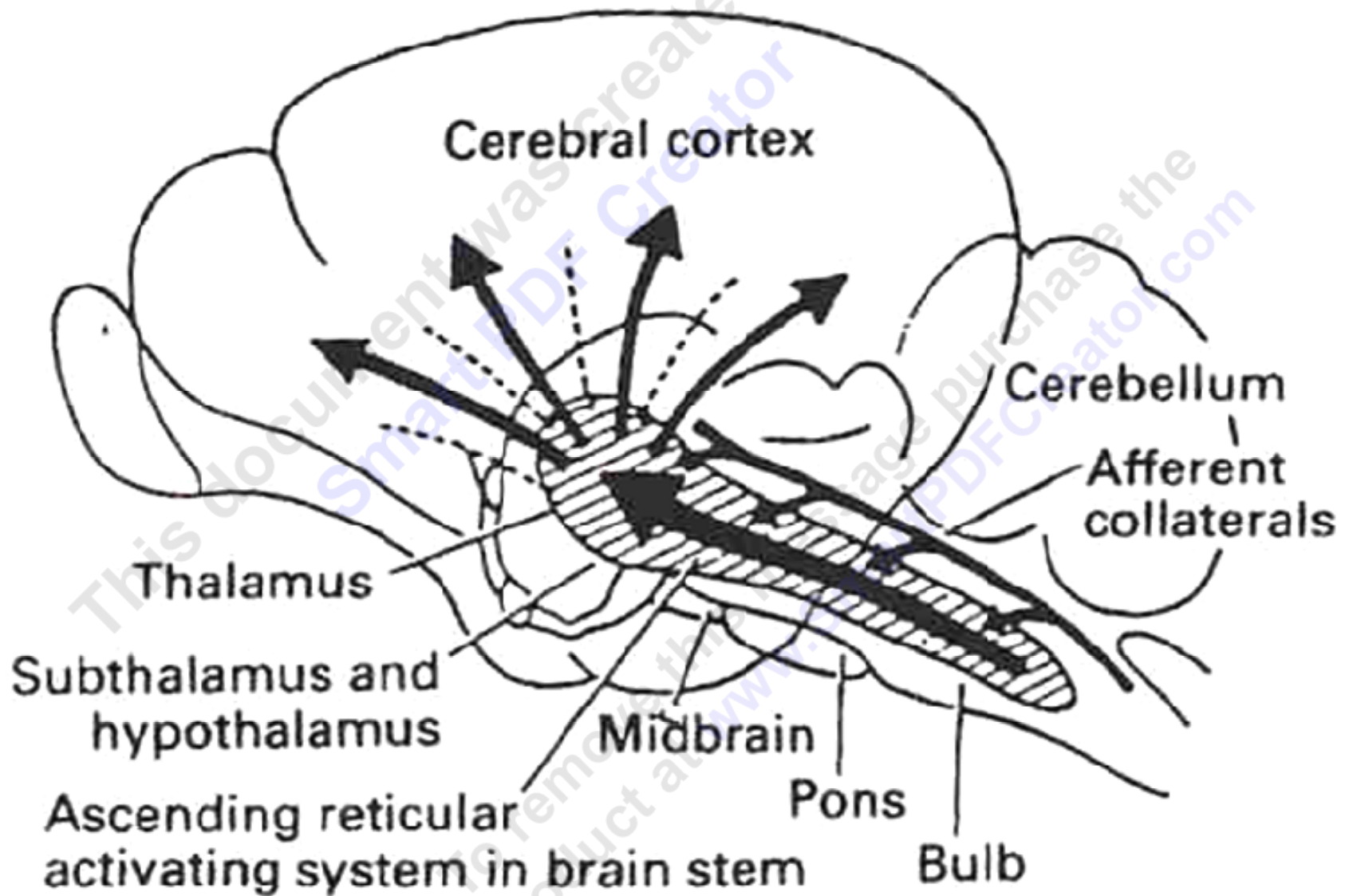
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Reticular Activating System
(*RAS*)

(Bulboreticular Facilitatory 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

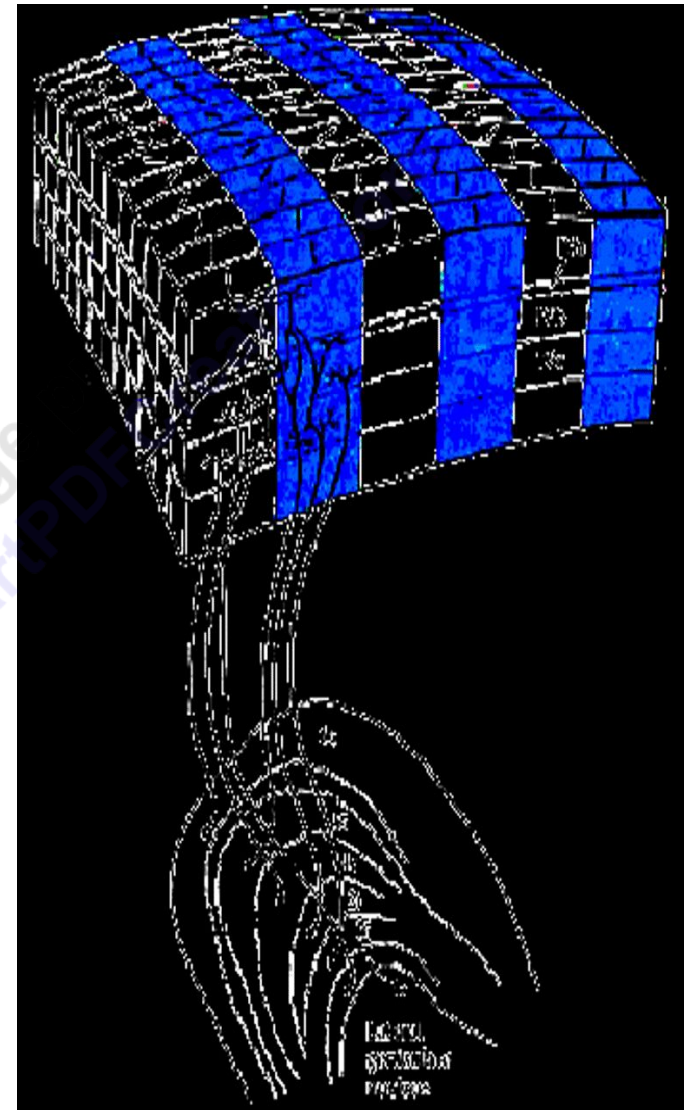
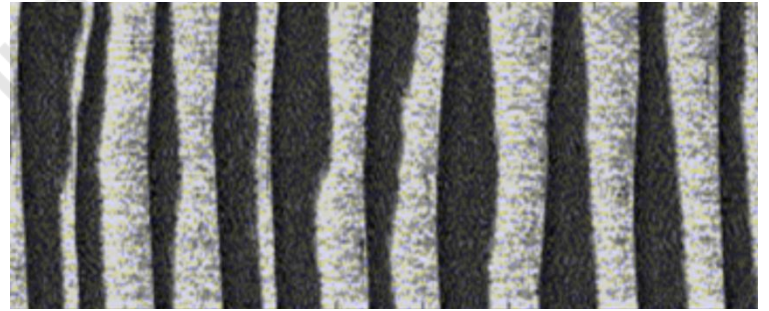


- **The awakening action of the RAS is mediated by fibers secreting Acetylcholine (Ach) and Norepinephe (NE)**
- **The RAS provides the main drive that maintains effective cortical excitability level , & interruption of this ascending pathway (e.g., by a tumor) causes the subject to go into unremitting 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 .



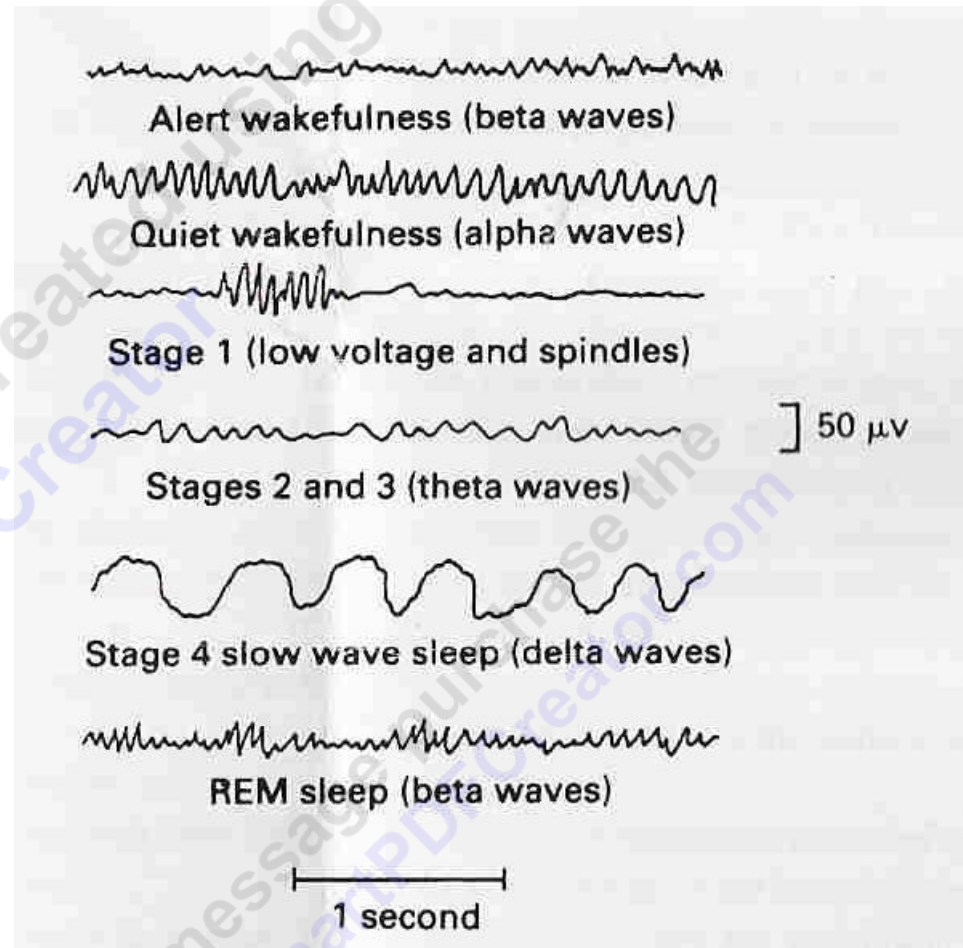
Indices (indicators) of Level of Consciousness

- 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).

EEG (Electroencephalogram)

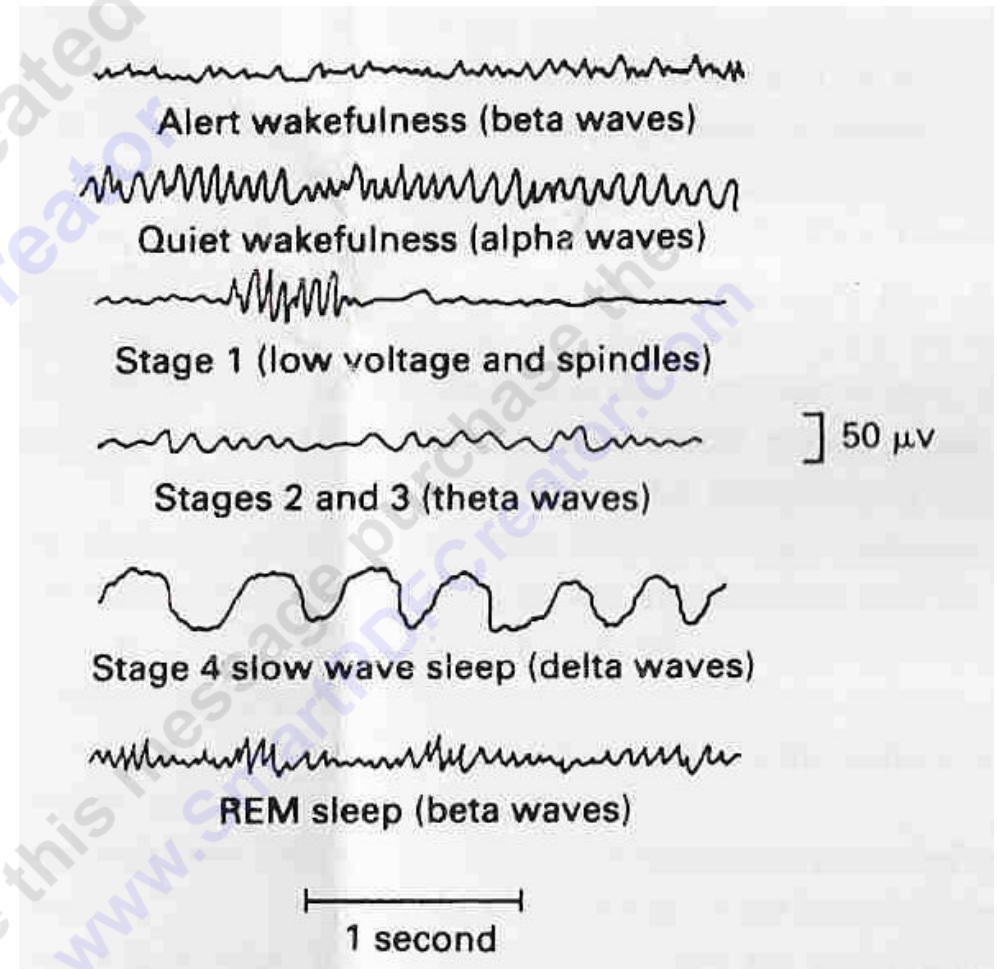
Routine EEG (Electroencephalogram) → is recording of cortical activity from scalp surface

- 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

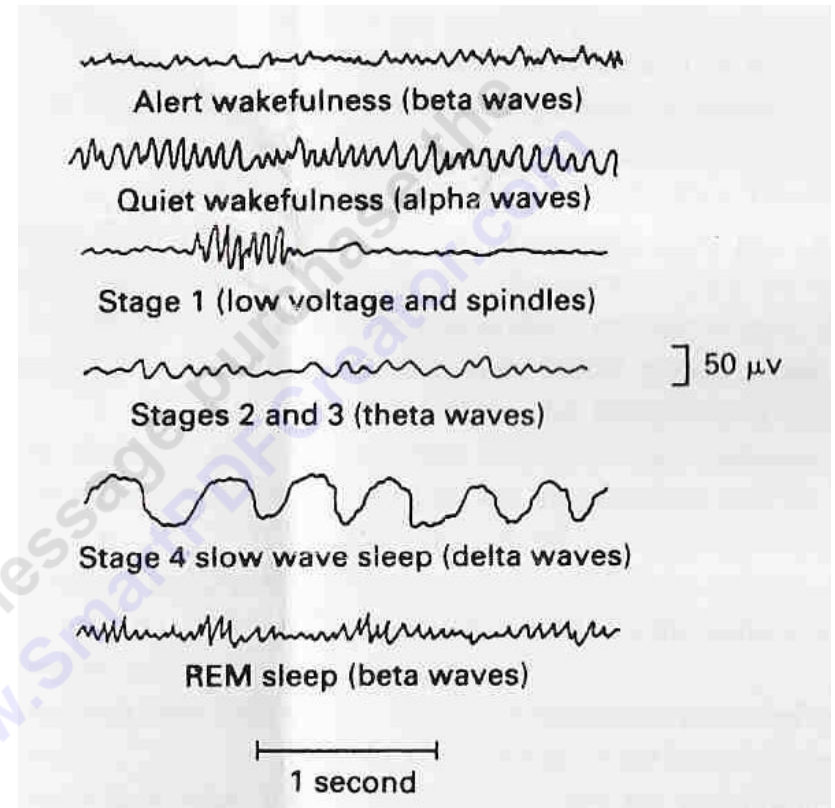


- **This replacement of alpha by irregular low-voltage activity is also called It is also called Desynchronization & Alerting Response**
- **It is due to activity of RAS**
- **However , the rapid EEG activity seen in the alert state is also synchronized , but at a higher rate . Thefore , the term “ desynchronization ” 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 .**
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- **Delta Waves :**
 - **Large amplitude , < 4 Hz waves**
 - **In deep sleep and coma .**
 - **In frontal regions .**



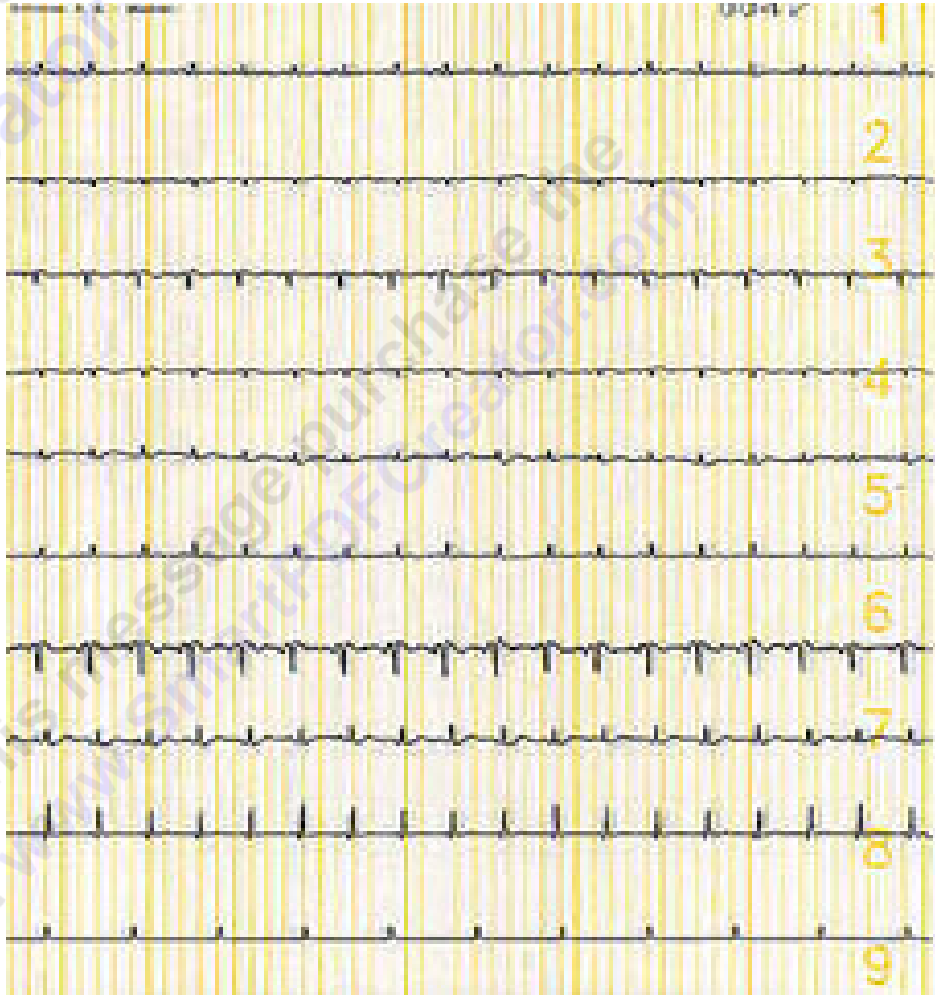
The Normal EEG is Largely Age-Dependent

- 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



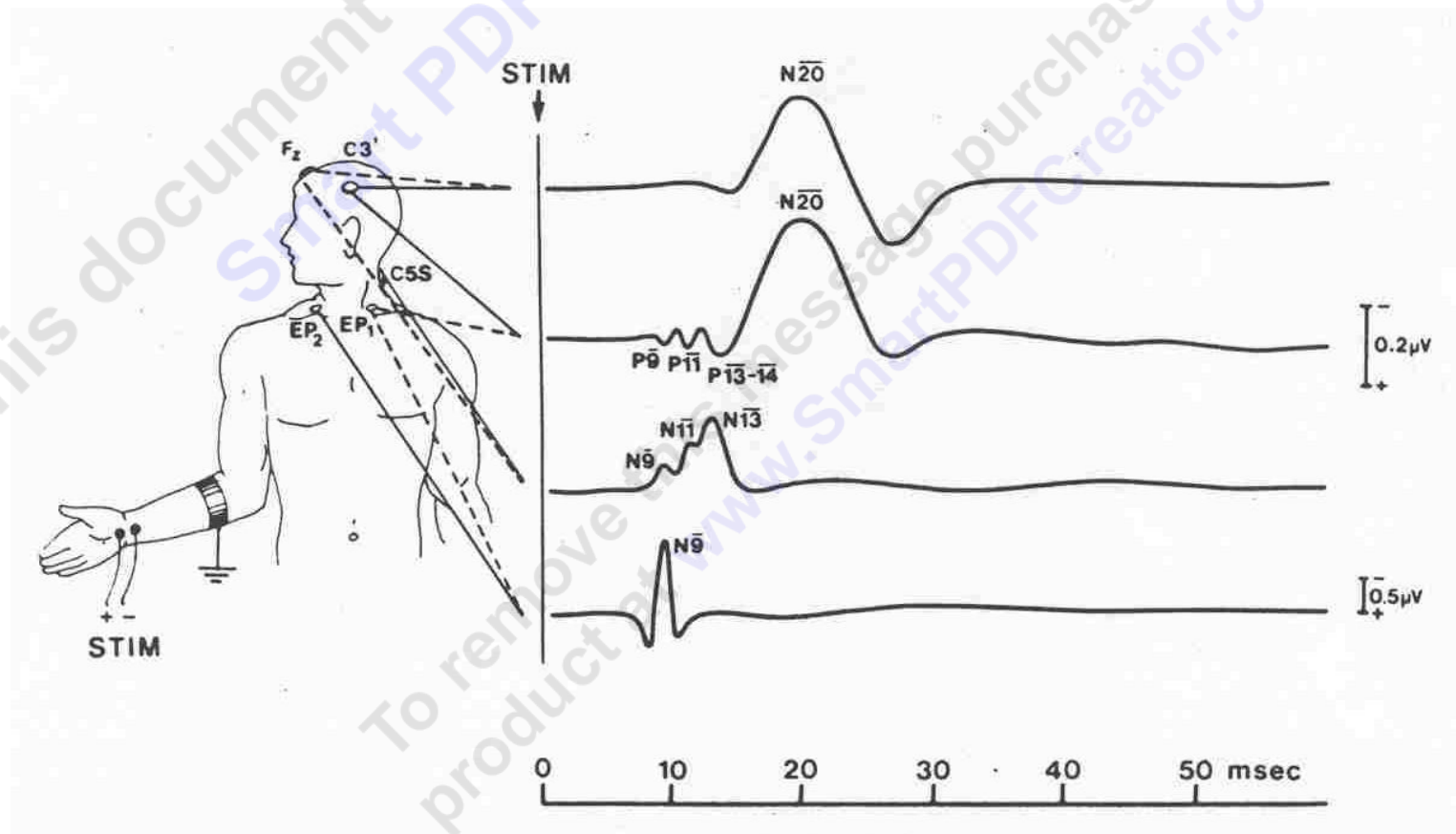
Normal EEG (at normal magnification)



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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