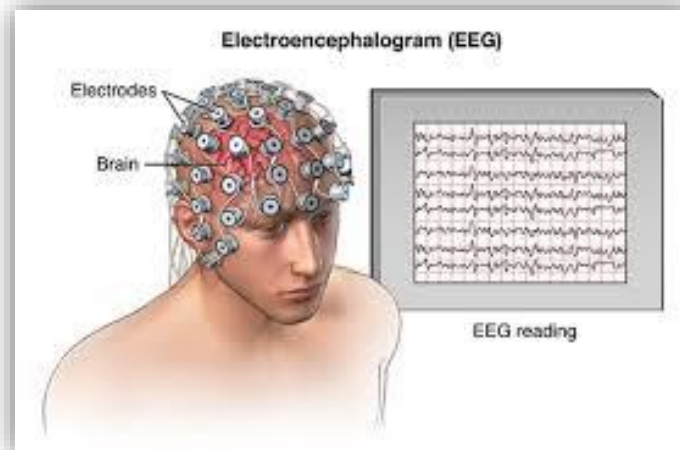




University of Diyala/ College of Medicine  
Department of Physiology  
Physiology Lab

# Electroencephalography EEG

Dr. Asmaa Abbas Ajwad



# Introduction

- **EEG** stands for **Electroencephalography**. It is the recording of electrical activity along the scalp produced by the firing of neurons within the brain. In clinical contexts, EEG refers to the recording of the brain's spontaneous electrical activity over a short period of time, usually 20–40 minutes , as recorded from multiple electrodes placed on the scalp.
- During an EEG test, small electrodes like cup or disc type are placed on the scalp.
- They pick up the brain's electrical signals and send them to a machine called electroencephalogram.
- It records the signals as wavy lines on to a computer screen or paper in order of microvolt.
- EEG waves : frequency range = 0.1 to 100Hz and amplitude = 2 to 200 micro volt.

# Clinical Use (Indications) of EEG

## **The Main Diagnostic Application is Epilepsy:**

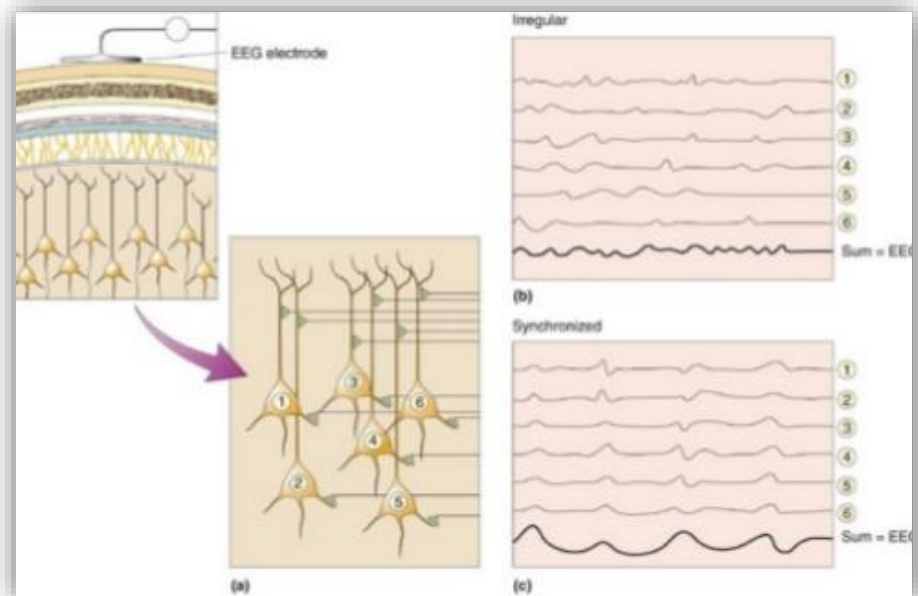
- To distinguish epileptic seizures from other types of spells, such as psychogenic , syncope (fainting), sub-cortical movement disorders, and migraine variants.
- To characterize seizures for the purposes of treatment.
- To localize region of brain from which a seizure originates for work of possible seizure surgery.
- To determine whether to wean anti-epileptic medications.

## **The secondary clinical use is :**

- In the diagnosis of coma, encephalopathies, & brain death.
- Monitor certain procedures e.g; the depth of anesthesia.
- Used in the intensive care units for brain function monitoring.

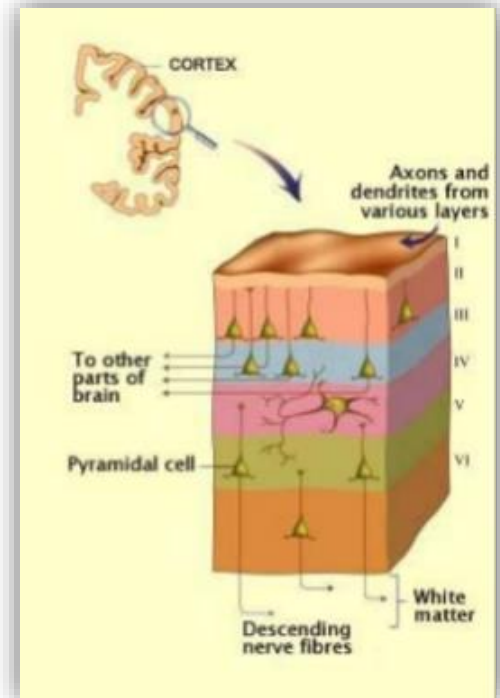
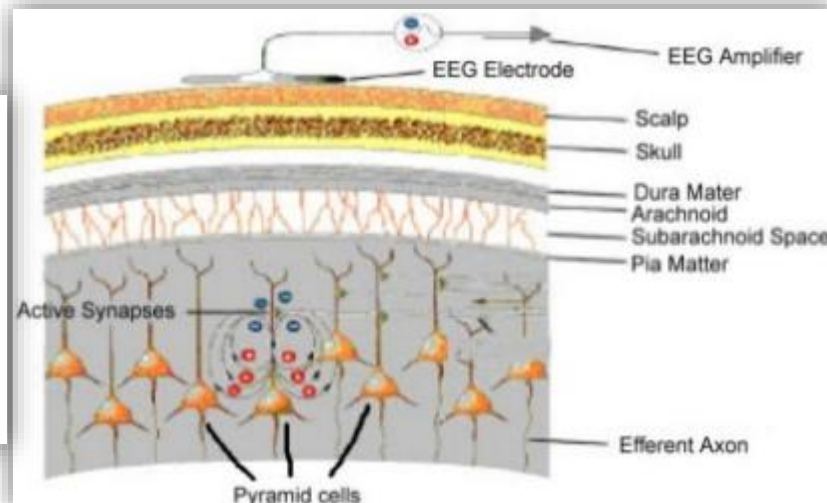
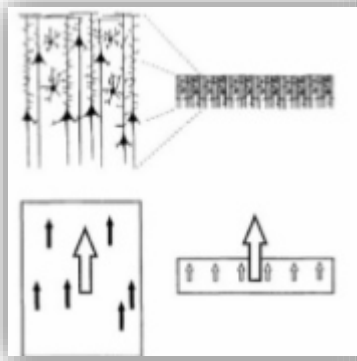
# Source of EEG Activity

Neurons create action potentials, which are discrete electrical signals that travel down axons and cause the release of chemical neurotransmitters at the synapse. This neurotransmitter then activates a receptor in the dendrite or body of the neuron that is on the other side of the synapse, the post-synaptic neuron. The neurotransmitter, when combined with the receptor, typically causes an electric current within the dendrite or body of the post-synaptic neuron. Thousands of post-synaptic currents from a single neuron's dendrites and body then sum up to cause the neuron to generate an action potential. This neuron then synapses on other neurons, and so on. EEG reflects correlated synaptic activity caused by post-synaptic potentials of cortical neurons. The timing of neurons activity is crucial. Synchronized neural activity produces larger signals.



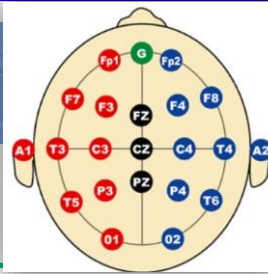
# Layers of the Cerebral Cortex

- ✓ The 2 mm thick cortex can be divided into six distinct layers.
- ✓ Each layer is distinguished both by the type of neurons that it contains and by the connections that it makes with other areas of the brain.
- ✓ *It is believed that the activation of the large pyramidal cells of layer V is what is reflected in most EEGs.*
- ✓ EEGs reflect synchronous firing of pyramidal cells. There are perhaps  $10^5$  neurons under a  $\text{mm}^2$  of cortical surface. EEG electrodes measure the space-averaged activity of  $>10^7$  neurons. A  $\mu\text{volt}$  signal will only be detected if pyramidal neurons are synchronously activated and many small dipoles are combined.



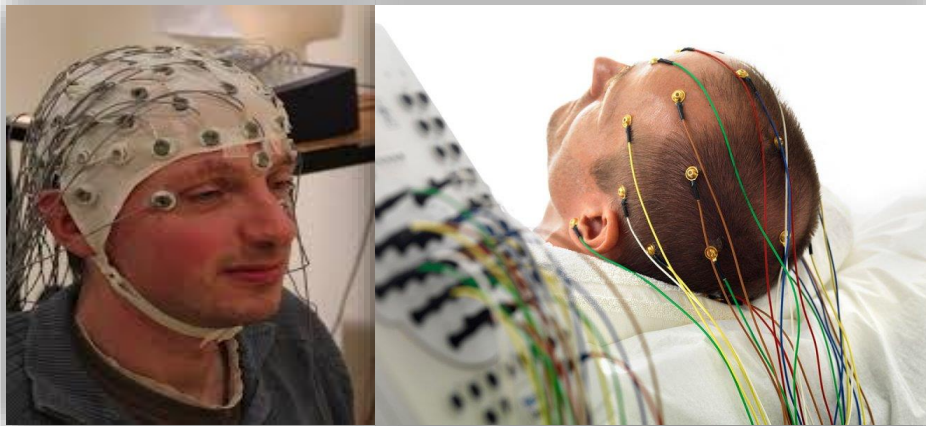


# Components of EEG



## 1. Electrodes

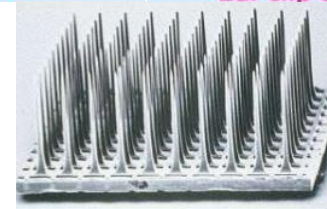
- Small metal discs usually made of stainless steel, tin, gold or silver covered with a silver chloride coating .They are placed on the scalp. Each electrode site is labeled with a letter and a number , the letter refer to the area of brain underlying the electrode. Even numbers denote the right side of the head and odd numbers denote the left side of the head .
- Types of electrode placement : (a) EEG electrodes placed separately on scalp, (2) EEG electrodes mounted as special band on head.



Disk electrodes



Ear clip electrode

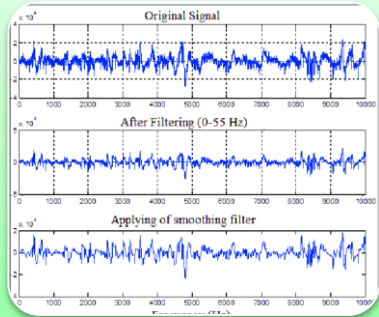


Intracortical electrodes

# Components of EEG



**2. Amplifier:** It is an electronic device that increases the power of a signal. It does this by taking energy from a power supply and controlling the output to match the input signal shape but with a larger amplitude. Human brain wave activity is too small to be readable unless the signal is amplified.



**3. Filters :** Use of the filters in recording and displaying EEG data is an indispensable tool in producing interpretable EEG tracings. Without filters, many segments of EEG would be essentially unreadable. Filters make the EEG signal clean so it would be easy to trace it



**4. Writing unit :** A pen-ink-paper system is used . The speed of the paper is 30 mm/s with additional speeds of 15 mm and 60 mm/s selectable during operation. The writing unit may be replaced by a digital screen in modern EEG devices.

# Components of EEG



EEG machine



Pt connected to EEG machine



# EEG Electrodes Placement (10-20) system

- The system is based on the relationship between the location of an electrode and the underlying area of cerebral cortex. The numbers '10' and '20' refer to the fact that the distances between adjacent electrodes are either 10% or 20% of the total front-back or right-left distance of the skull.

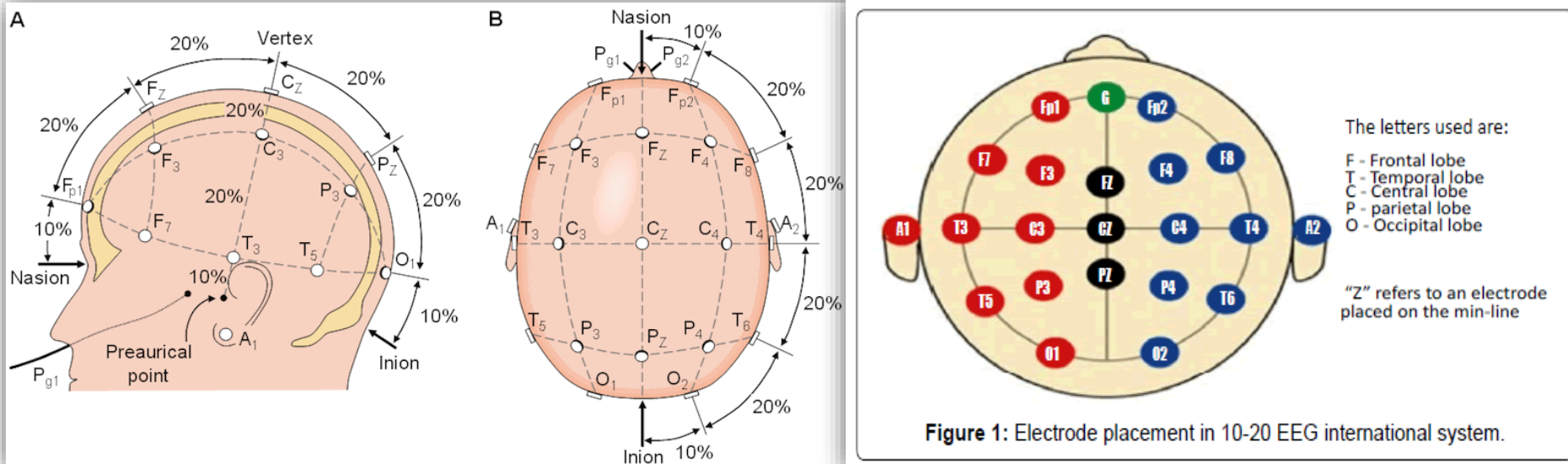
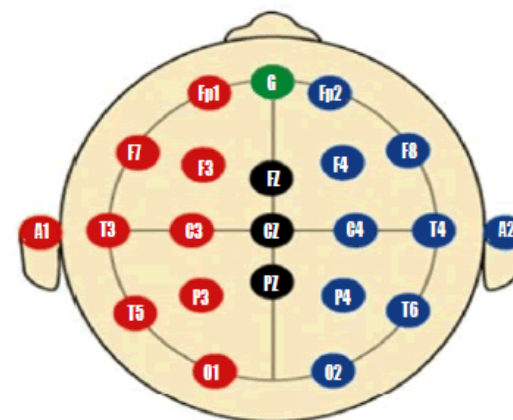
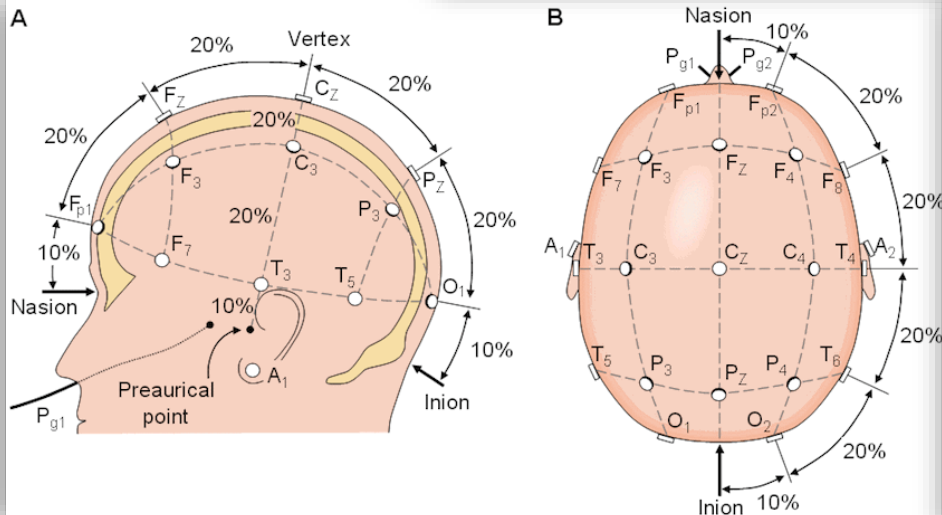
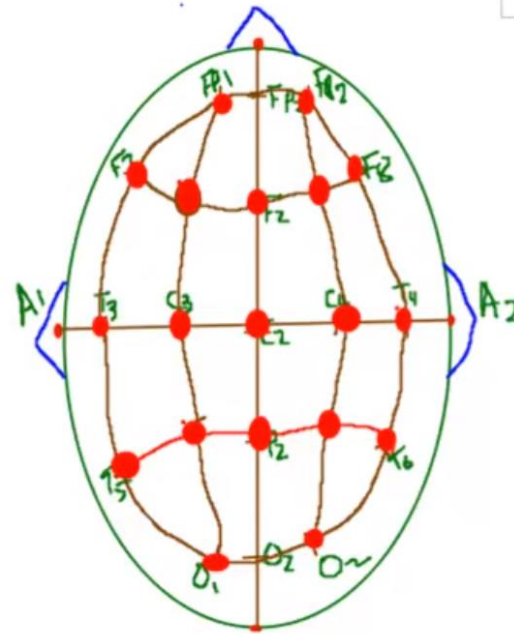


Figure 1: Electrode placement in 10-20 EEG international system.

# EEG Electrodes Placement (10-20) system

LEFT

RIGHT



The letters used are:


F - Frontal lobe  
T - Temporal lobe  
C - Central lobe  
P - parietal lobe  
O - Occipital lobe


"Z" refers to an electrode placed on the mid-line

Figure 1: Electrode placement in 10-20 EEG international system.


# Instructions For the Patients

- 
- Wash your hair and scrub the scalp thoroughly. Do not apply hair any oil, gels, or sprays.

- 
- Continue your normal medications and bring a list of medications you take with you.

- 
- Continue normal diet. Attempt to eat a meal within two hours of your scheduled test.

- 
- Do not drink caffeinated beverages on the day of your test. No alcoholic beverages within 48 hours prior to testing.

- 
- The night before the test, stay up until 1:00 a.m. and sleep until 5:00 a.m. (4 hours sleep). Stay awake until your test time. **NO NAPS Please.**

# Method

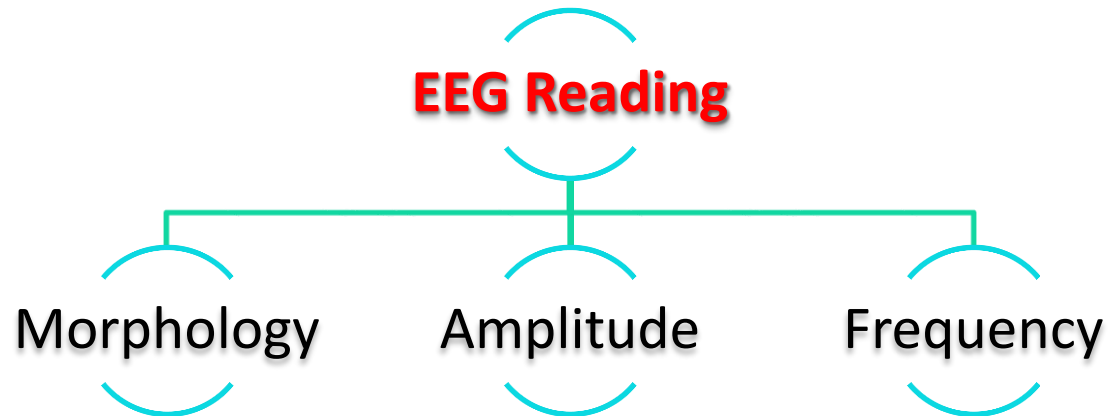
- ✓ Computerized methods now exist.
- ✓ A routine clinical EEG recording typically lasts 20–30 minutes (plus preparation time) & usually involves recording from scalp electrodes.
- ✓ In conventional scalp EEG, recording is obtained by placing electrodes on scalp with a conductive gel or paste.
- ✓ Electrodes are typically placed on scalp using **a standardized method called 10-20 system**, Which is named by their location: F, frontal; C, central; P, parietal; T, temporal; Fp, frontopolar; O, occipital. They are numbered with odd numbers over the left hemisphere, even numbers over the right, and z referring to the midline.
- ✓ Electrode contact must be firm in order to ensure low impedance.
- ✓ Connect patient to one **common ground** to avoid artifact & improve signals.

# Method

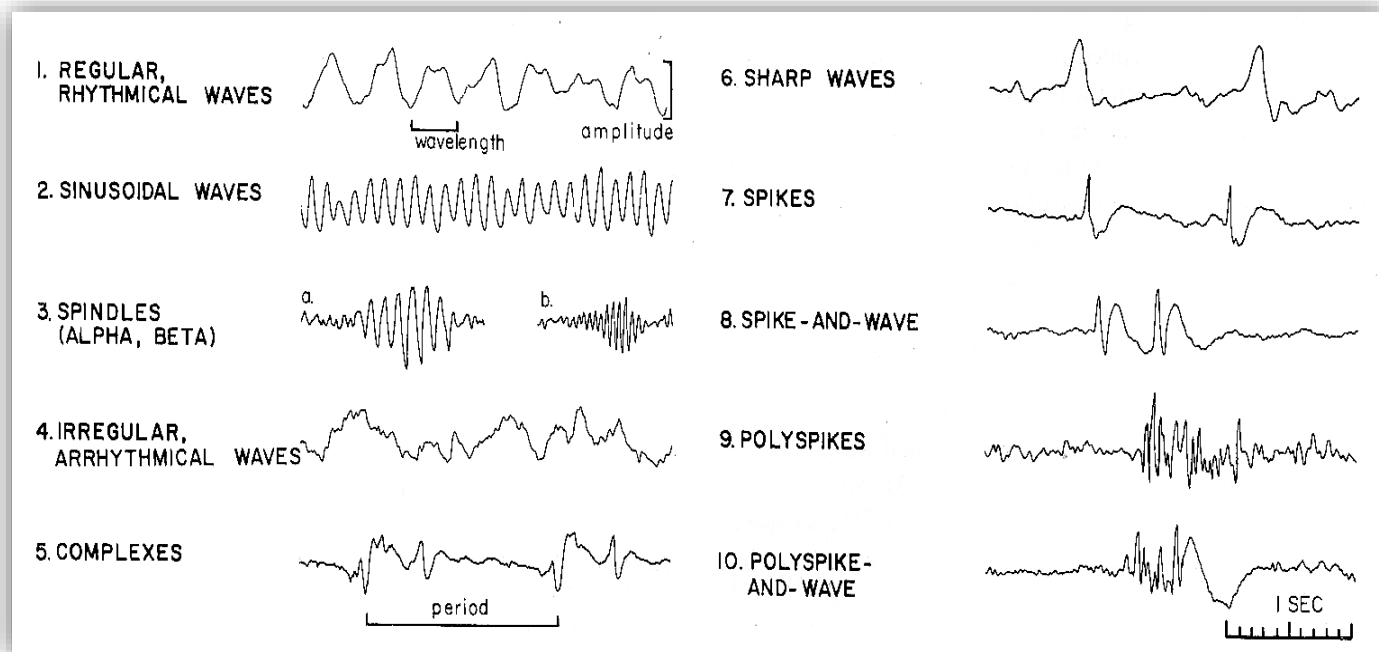
- ✓ During recording, a series of activation procedures are performed that may induce abnormal EEG. **These procedures include hyperventilation, photic stimulation, eye closure, mental activity, sleep & sleep deprivation.**
- ✓ Hyperventilation is a method of “activating” EEG.
  - *It should not be performed in a very elderly patient or those who are suspected of having any intracranial mass lesions or a recent transient ischemic event/stroke.*
  - *In adult, it is normal to hyperventilate the patient for 3 min. This act causes the subject to exhale excessive amounts of CO<sub>2</sub> & becomes hypocapnic → mild cerebral vessel vasoconstriction → mild cerebral hypoxia.*
  - *Hypoxia & hypocapnia potentially can produce changes in EEG signal.*
- ✓ In case of inpatient epilepsy, monitoring is done by video EEG.
- ✓ Normal EEG varies with age. Neonatal EEG is quite different from that of adult.
- ✓ EEG in childhood generally has slower frequency oscillations than adult EEG.



# EEG Reading



## 1. Morphology (wave shape)



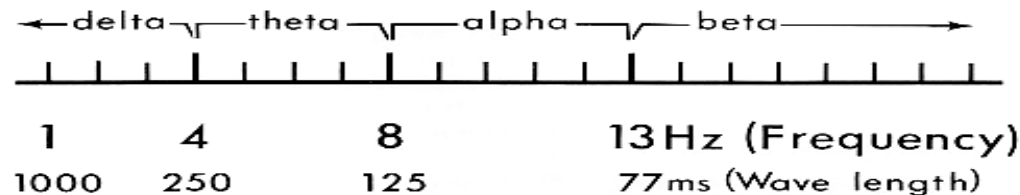
# EEG Reading

## 2. Amplitude

- ✓ Voltage in microvolts
- ✓ A peak-to-peak measurement
- ✓ Compared with the calibration signal
- ✓ Commonly 20 -100  $\mu\text{V}$  (in normal EEG)
- ✓ Amplitude changes may be pathological

## 3. Frequency

- ✓ The rhythmic EEG activity is classified as:
  - Delta : less than 4 Hz.
  - Theta : 4 to 8 Hz
  - Alpha : 8 to 13 Hz
  - Beta – more than 13 Hz



# Types of EEG Rhythms

## Alpha Rhythm

- Sinusoidal waves (8-13 Hz)
- Maximal over the posterior head region (occipitally)
- Occurs during wakefulness and relaxation. Easily produced when quietly sitting in relaxed position with eyes closed (few people have trouble producing alpha waves)
- Best seen with the patient's eyes closed.
- Blocked or attenuated with eye opening.

## Beta Rhythm

- Is not prominent
- Frequency: 14-30 Hz, Amplitude: 2-20  $\mu$ V
- Best seen frontally
- Not affected by eye opening

# Types of EEG Rhythms

## Theta Rhythm

- **Characteristics:** Frequency: 4-7Hz, low amplitude (frontally).
- Believed to be more common in children than adults.
- Theta waves are related to drowsiness.

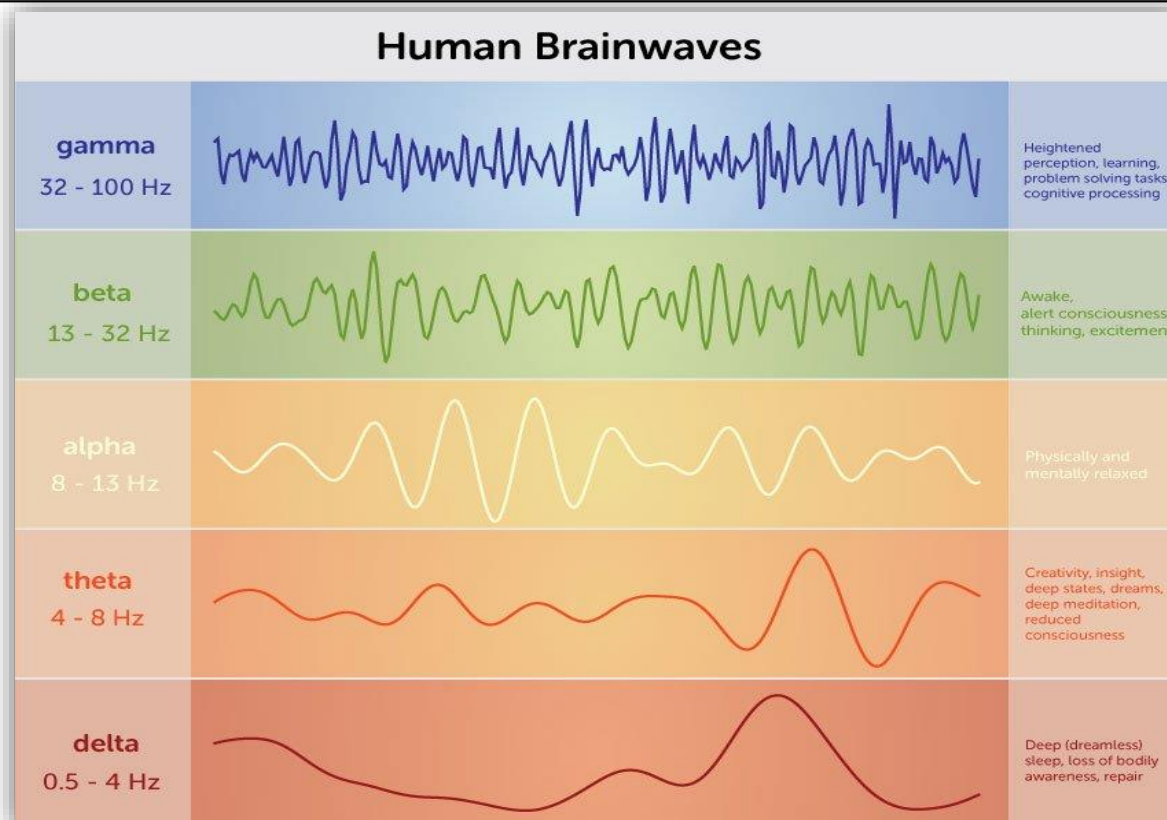
## Delta Rhythm

- **Characteristics:** frequency: .5-3.5 Hz, amplitude: 20-200 $\mu$ V
- Found during periods of deep sleep in most people
- Characterized by very irregular and slow wave patterns
- Also useful in detecting tumors and abnormal brain behaviors

# Types of EEG Rhythms

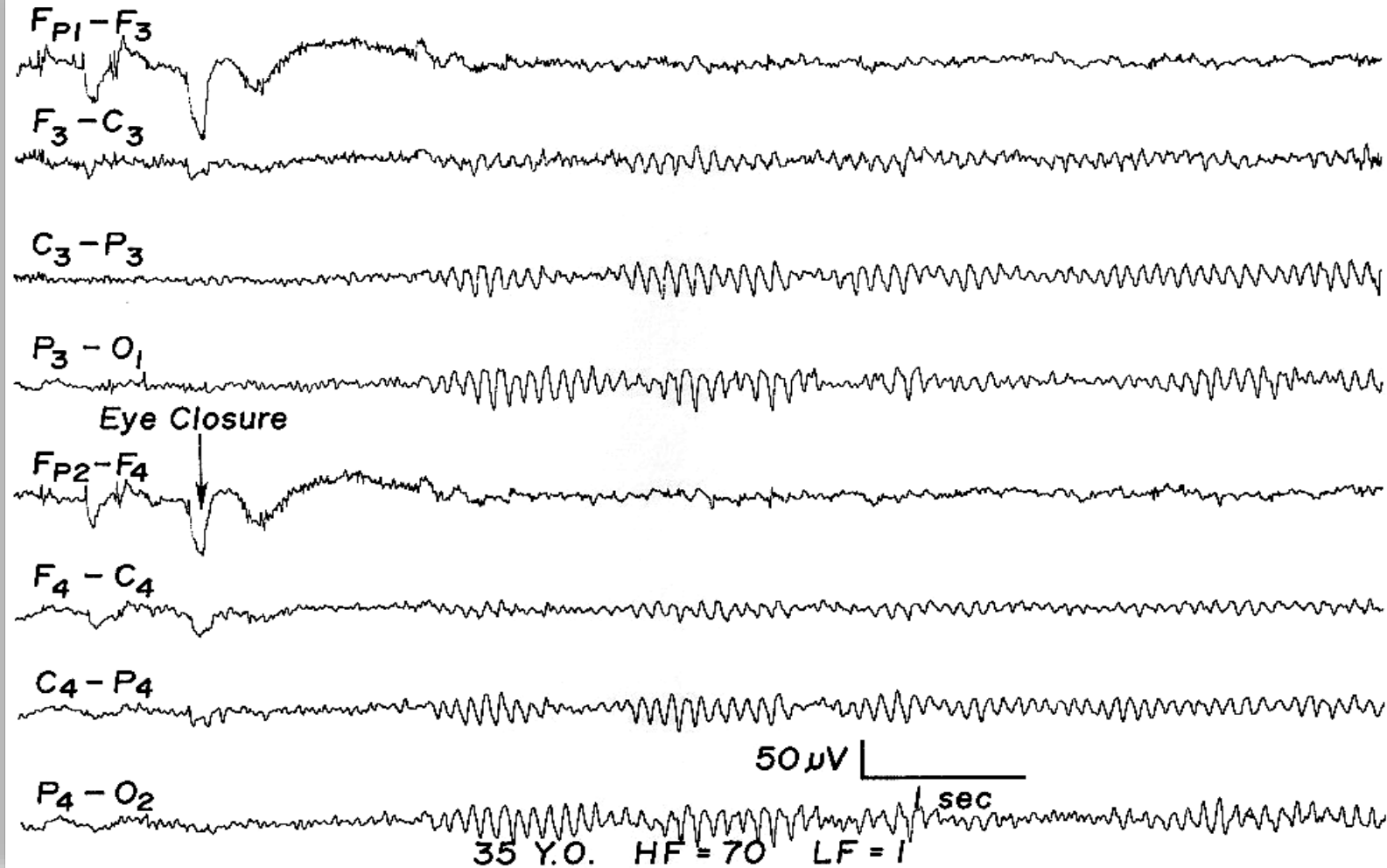
## Gamma Rhythm

- **Characteristics:** Frequency: 36-44Hz, Amplitude: 3-5 $\mu$ V.
- Occurs with sudden sensory stimuli.





# EEG Signal



# Artifacts

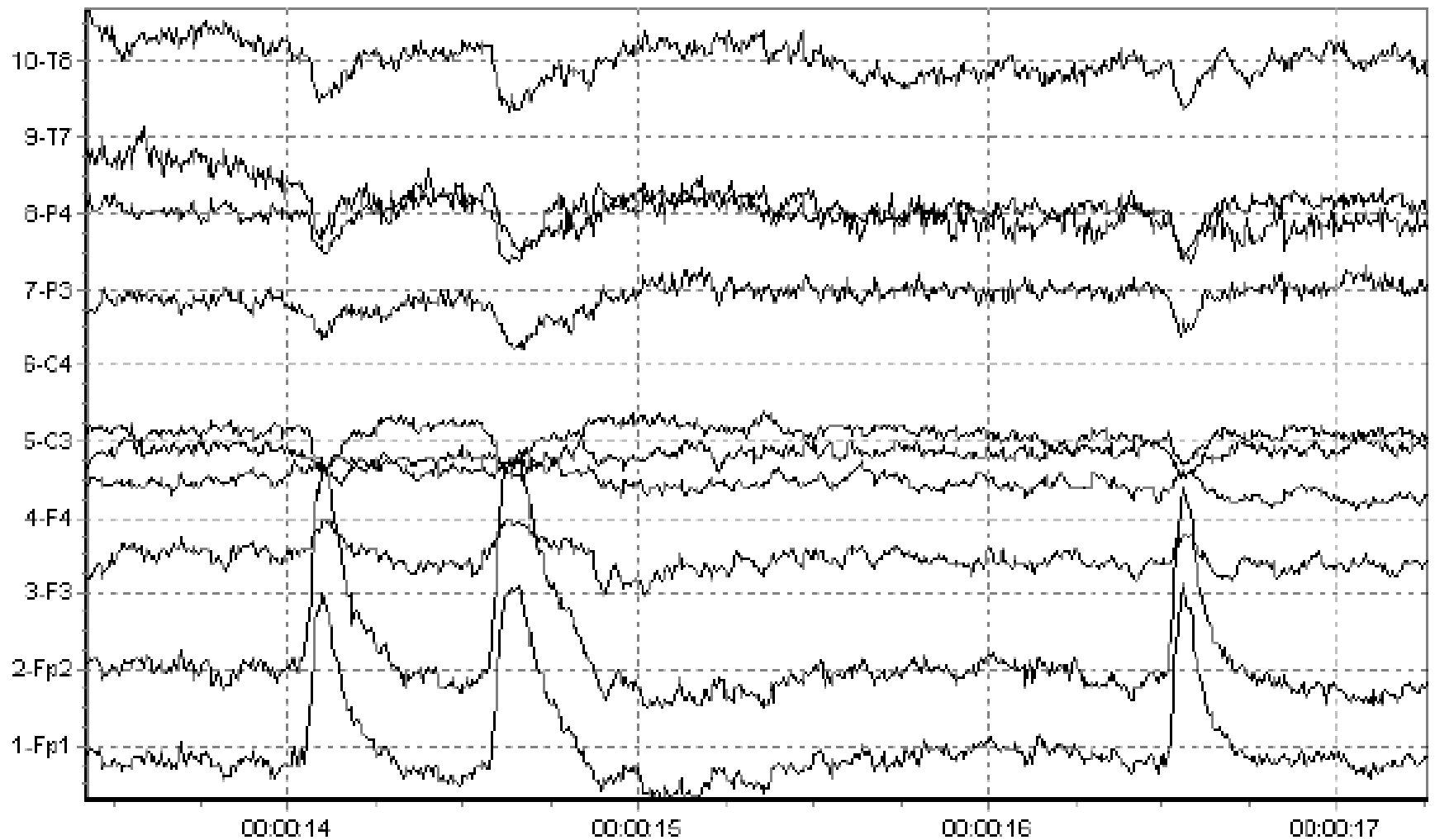
## Biological Artifacts

- Electrical signals detected along scalp by EEG, originate from non-cerebral origin.
- Eye-induced artifacts (eye blinks& eye movements).
- ECG (cardiac) artifact
- EMG (muscle activation)-induced artifacts
- Glossokinetic artifacts (tongue movement).

## Environmental Artifacts

- Originate from outside the body.

# Eye Blink Artifact



# Factor Influencing EEG

## Age

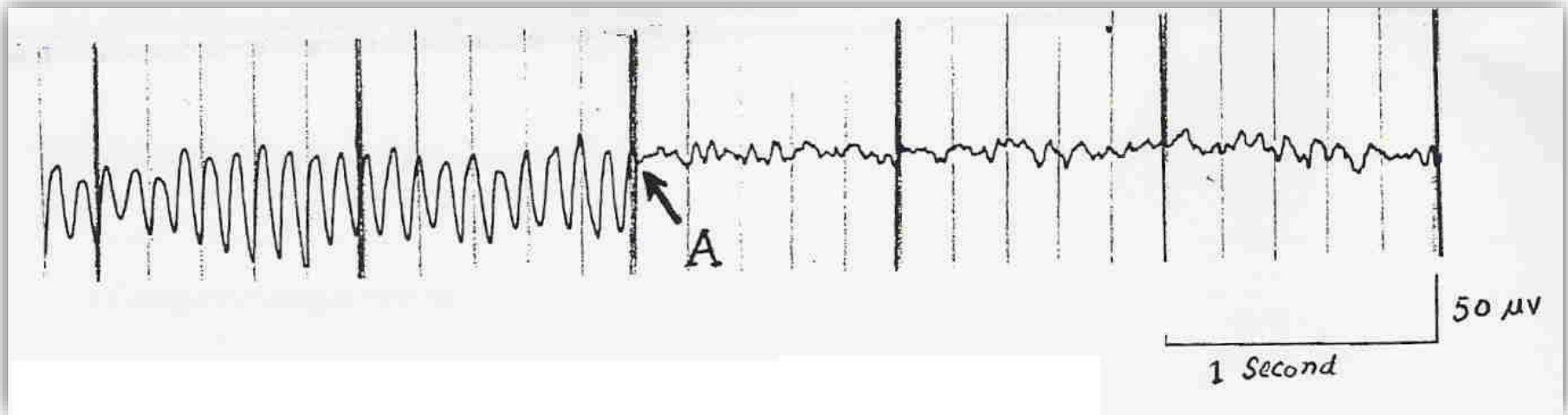
- Infancy – theta, delta wave
- Child – alpha formation.
- Adult – all four waves.

- Level of consciousness (sleep)

## Slow Wave (Delta)

- Hypoglycemia (deficiency of glucose in the bloodstream)
- Hypothermia
- Low glucocorticoids.

# Desynchronization or Alpha Block



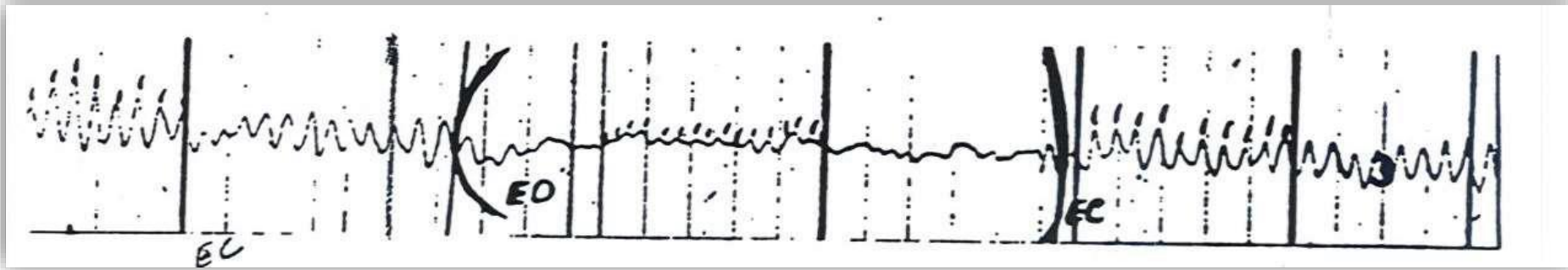
## Causes:

- Eyes opening (after closure)
- Thinking by the subject (**mathematical calculation**)
- Sound (clapping)

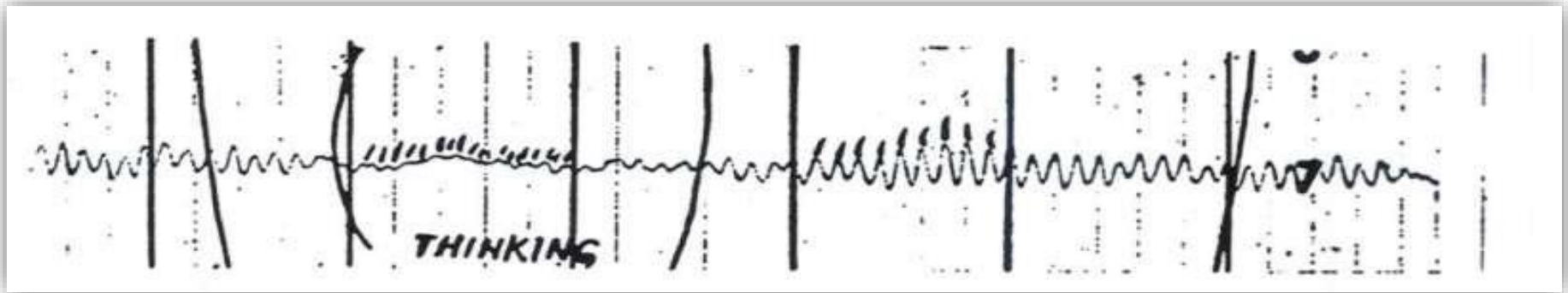


# Eye Opening and Thinking

- ✓ **Eye Opening:** Alpha rhythm changes to beta on eye opening (desynchronization /  $\alpha$ -block)

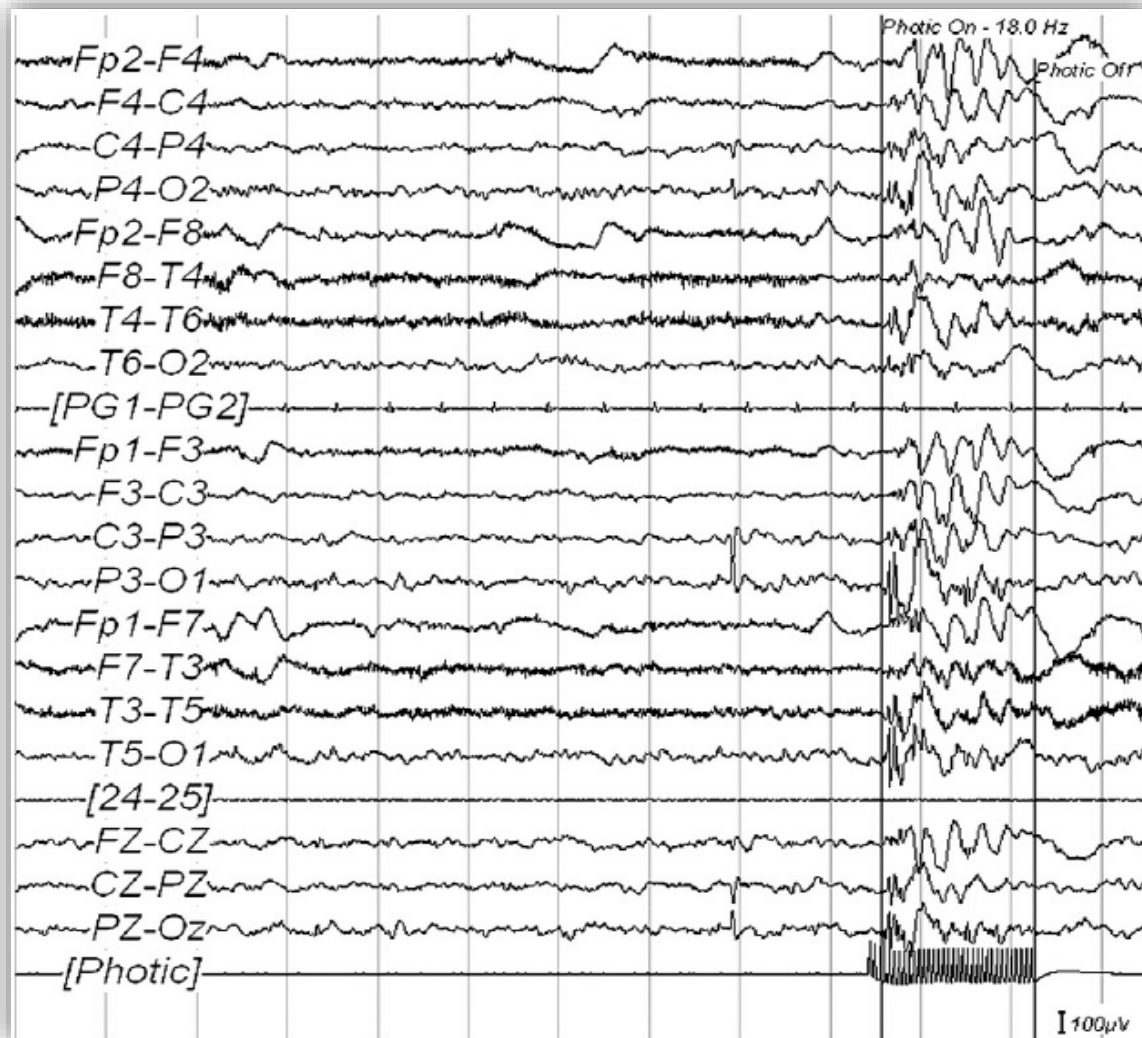


- ✓ **Thinking:** Beta waves are observed



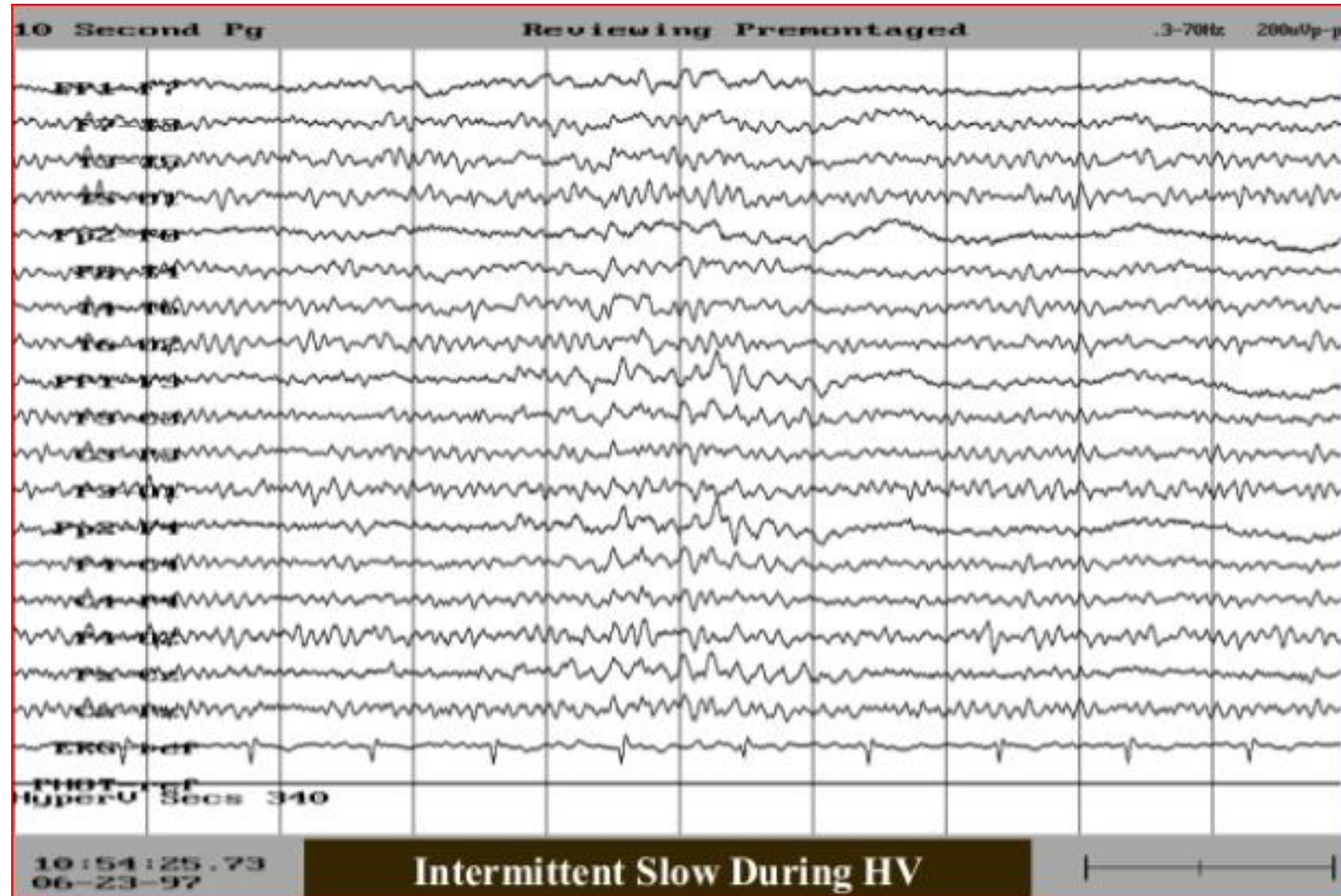
# Provocation Test

## ✓ Intermittent photic stimulation



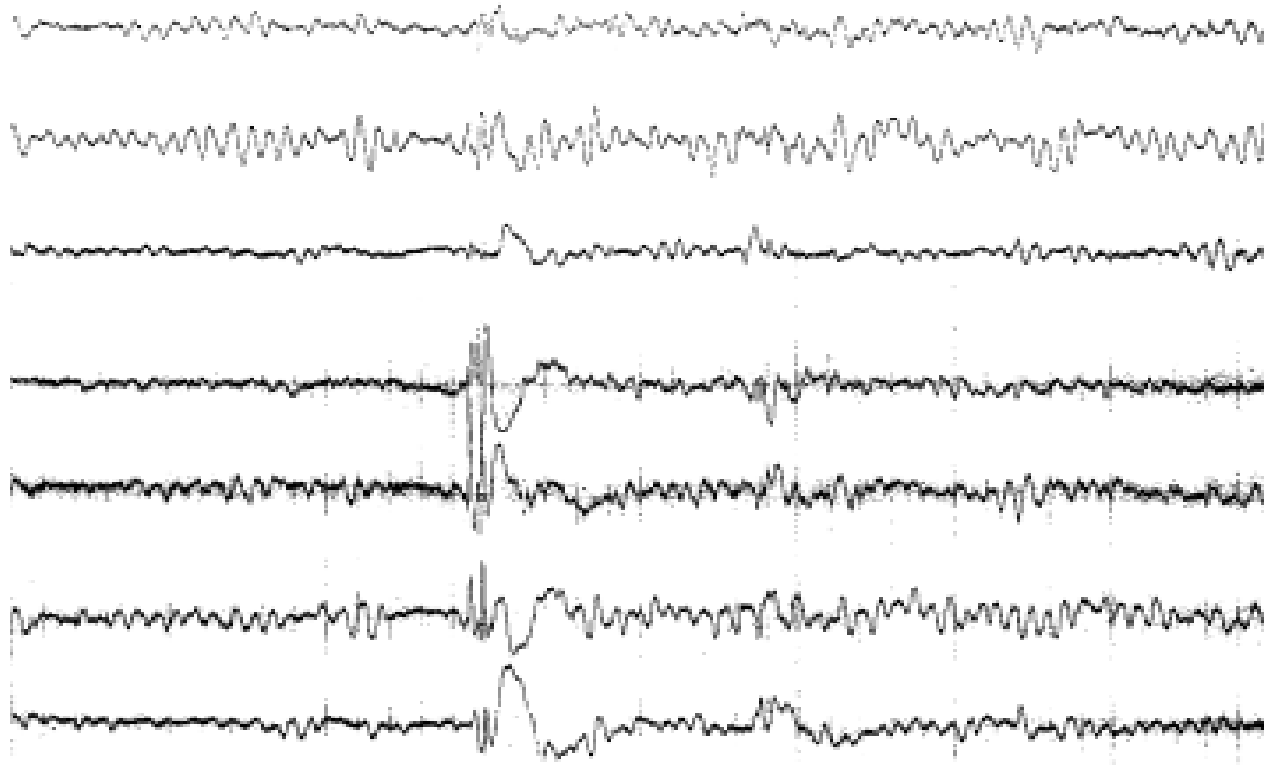
# Provocation Test

✓ Hyperventilation



# EEG during Epilepsy

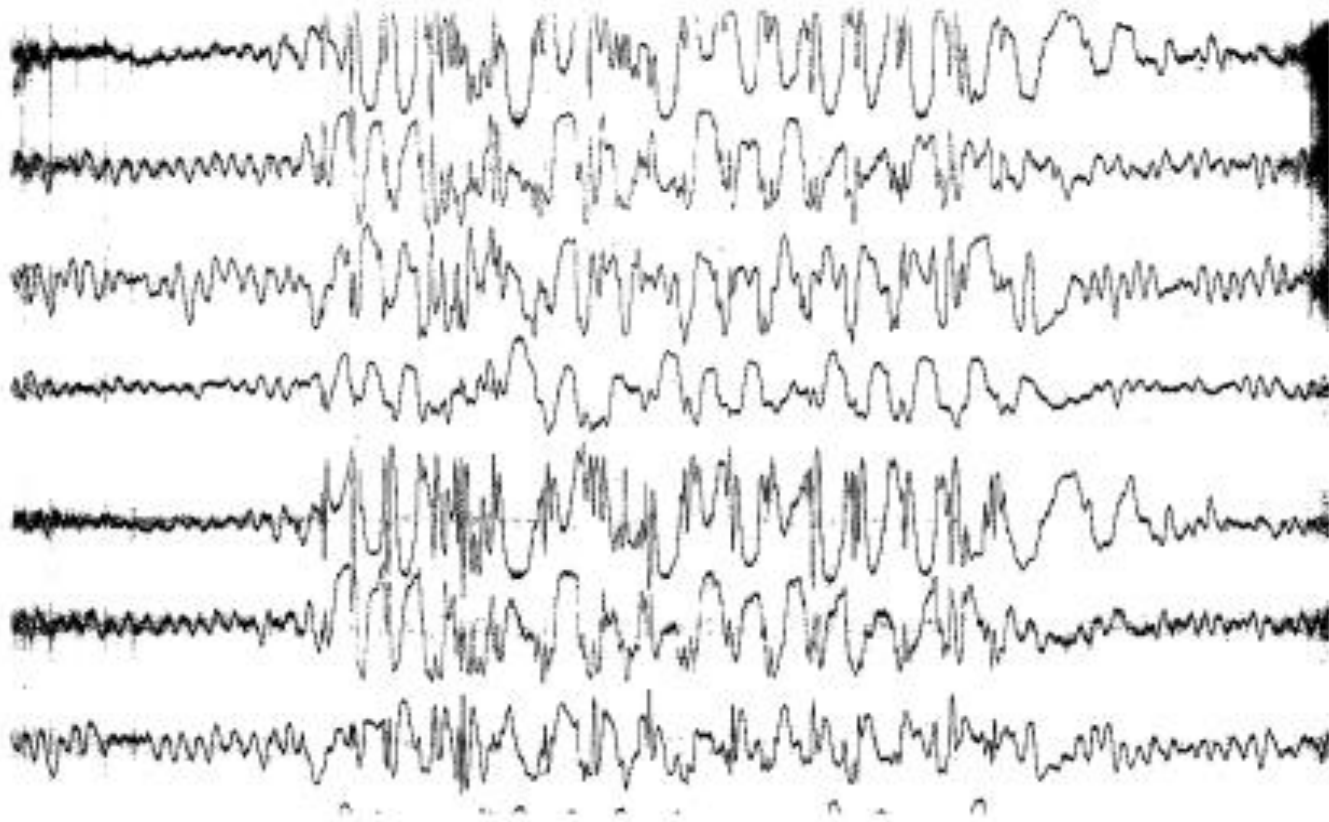
## Interictal patterns in epilepsy – local focus:





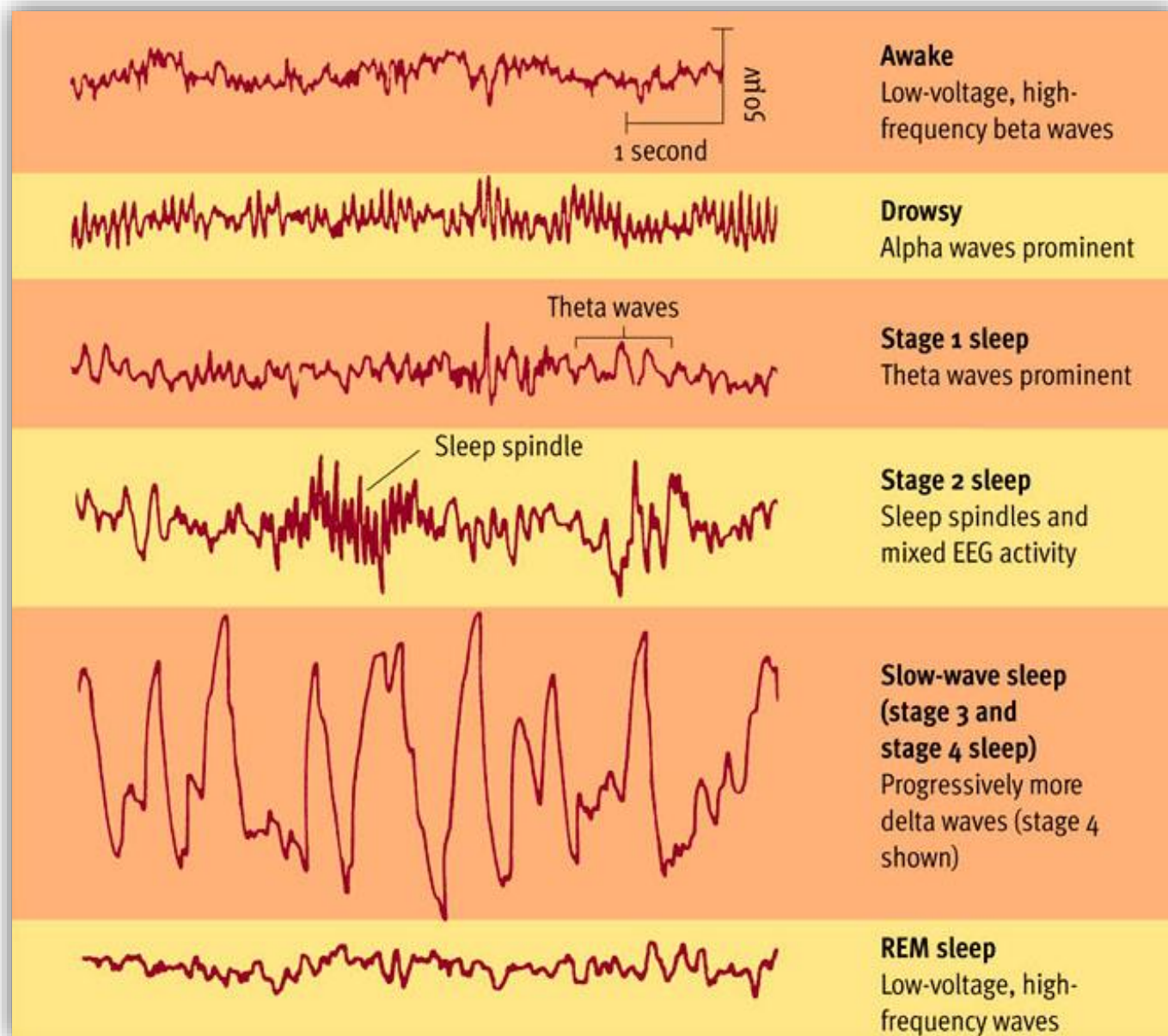
# EEG during Epilepsy

**Interictal patterns in epilepsy –**  
**generalized:**



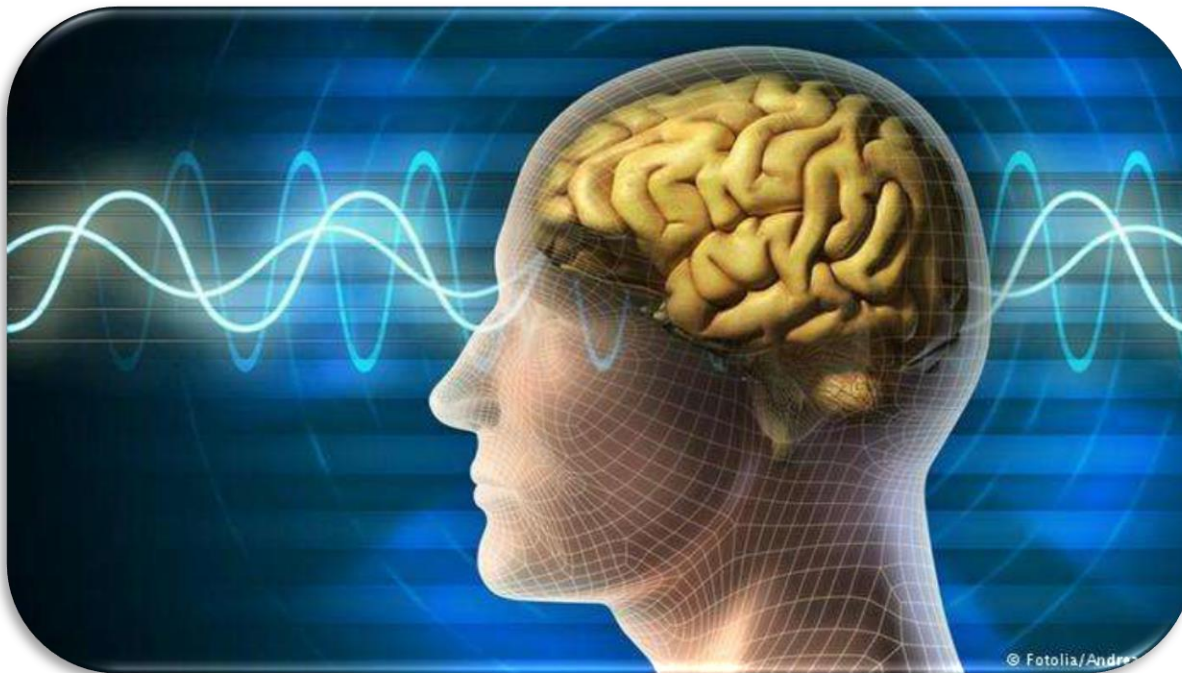


# EEG Brain Waves in the Sleep Cycle



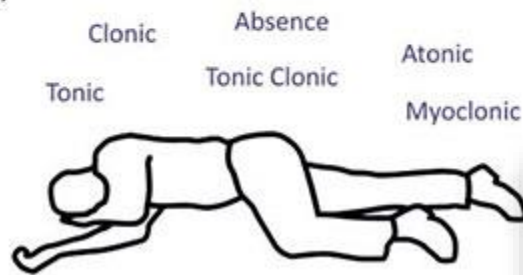
# References

- ✓ EEG lecture/Dr. Asmaa Khalaf /2017.
- ✓ EEG/ Prof. K. H. Noorul Ameens/ Dr.M.Arivumani.
- ✓ EEG/ Vajarala Ashikh.
- ✓ EEG/ AKASH KUMAR BHOI Assistant Professor SMIT
- ✓ EEG/ Ahmed Nazar mustafa university of duhok/college of medicine
- ✓ [WWW.eegwiki.com](http://WWW.eegwiki.com)
- ✓ EEG/ SATHISHKUMAR G



## there are over 40 different types of seizure

Epileptic seizures are caused by a disturbance in the electrical activity of the brain. There are many different types of epileptic seizure and not all seizures involve convulsions, unconsciousness and shaking.



## SEIZURES VERSUS EPILEPSY

Seizure is a single occurrence of jerky movements and other features of a fit

Epilepsy is defined as two or more than two unprovoked seizures occurring in an individual

Do not need any treatment with anti-epileptic drugs or surgery

Anti-epileptic drugs are used and non-responding patients might need surgery