Pathophysiology of Epilepsy

Definition of seizure and Epilepsy

* Seizures are symptoms of a disturbance in brain function , which can be due to epilepsy or other causes
* A seizure is a sudden surge in electrical activity in the brain that causes an alteration in sensation, behavior, or consciousness

* Abnormal , excessive electrical discharge of a group of neurons within the brain.
* When a person has recurrent (2 or more) , unprovoked seizures → " epileptic ".
* Hence seizures can be a symptom of epilepsy .

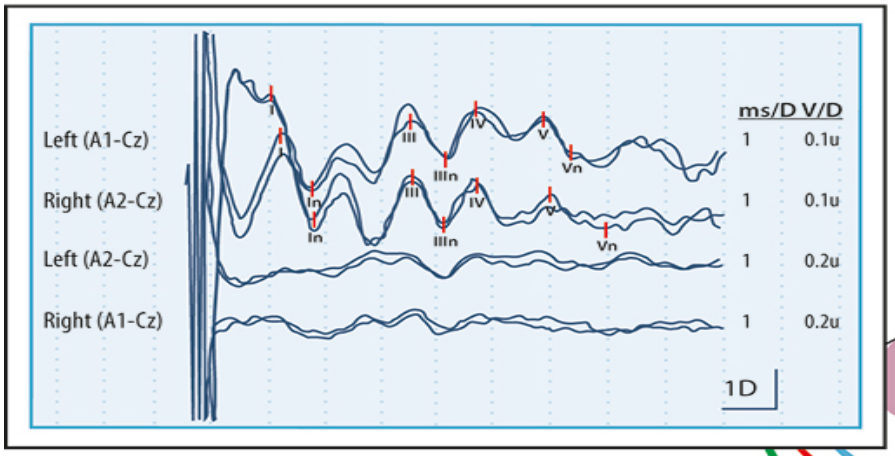
Functional Neurophysiological Investigation

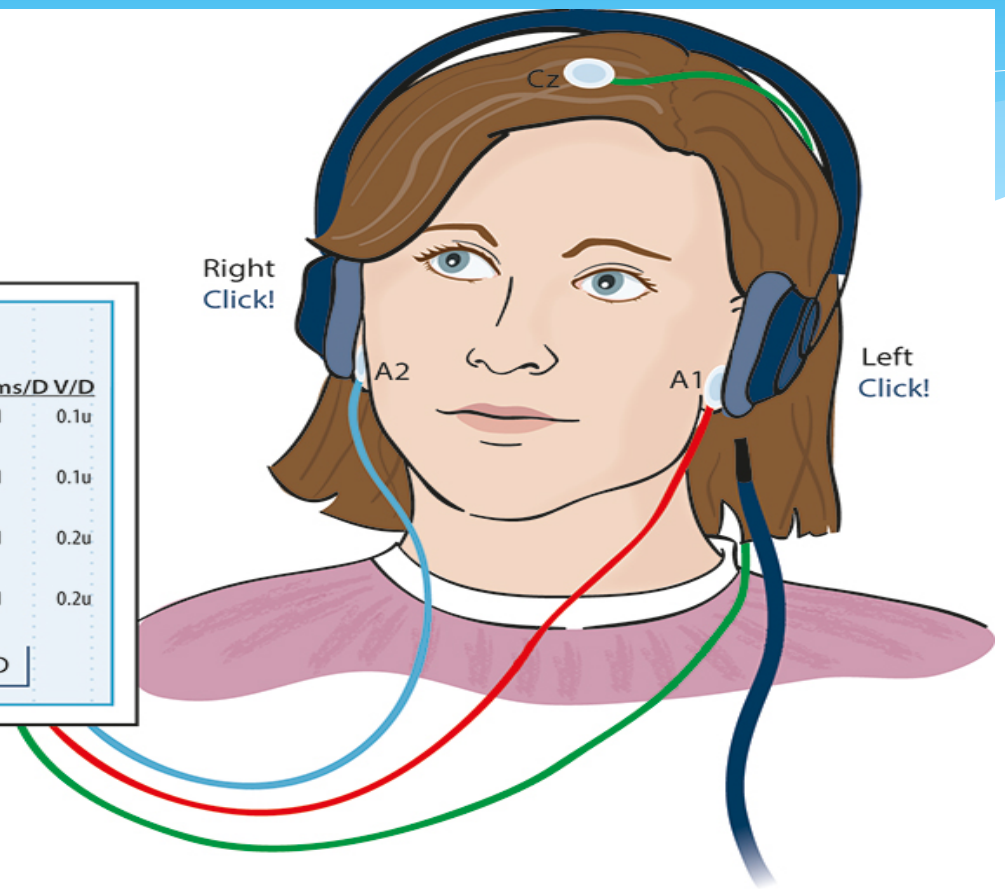
* Electromyography (EMG) and nerve conduction studies
* Electroencephalography (EEG)
* Evoked potentials (EP)
* Polysomnography (sleep study to diagnose disorders associated with abnormal sleep)
* Intraoperative monitoring, Intraoperative neurophysiologic monitoring
* Functional MRI

Evoked potential (EP)

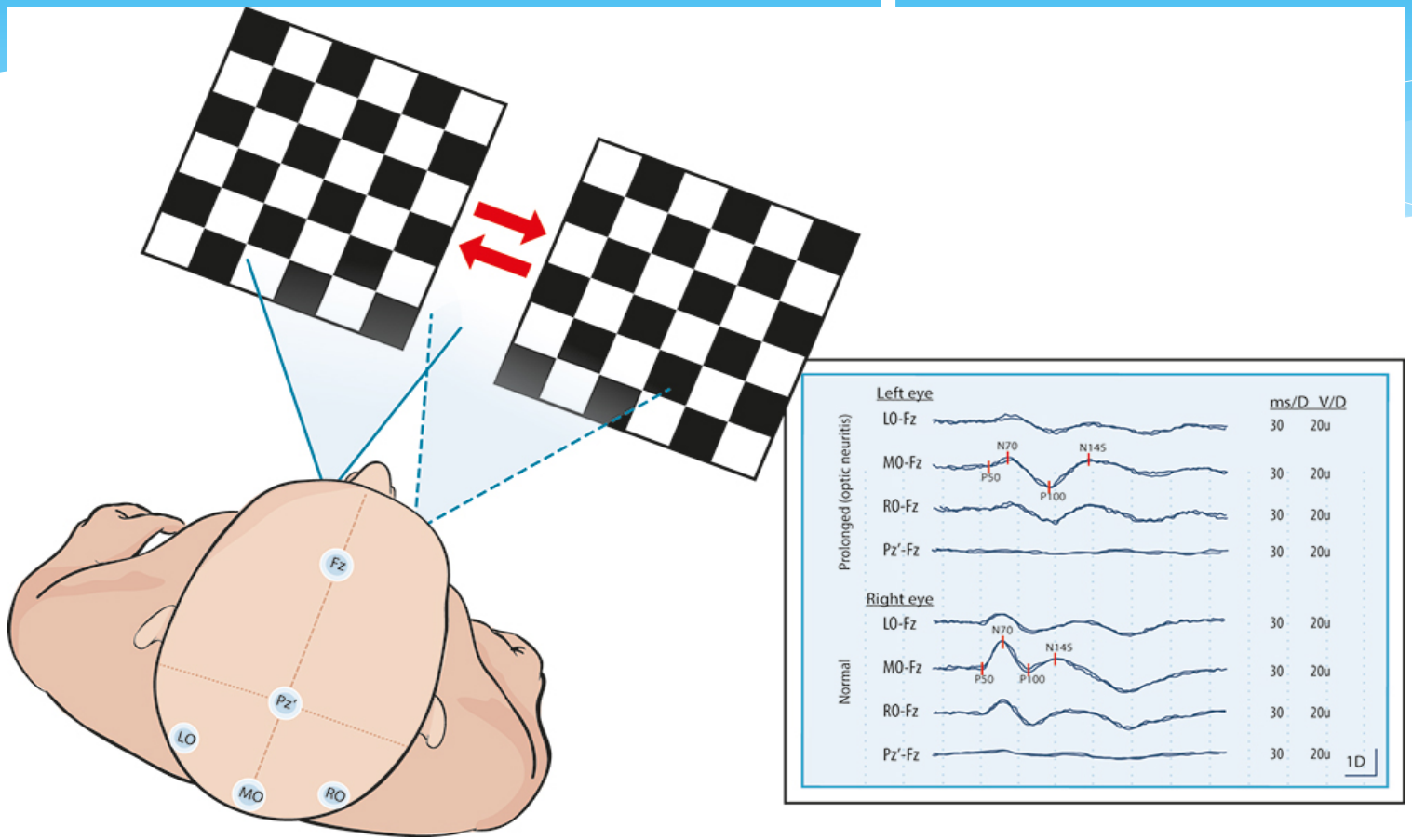
* Measure the electrical activity of the brain in response to stimulation of specific sensory nerve pathways
* Detect the slowing of electrical conduction caused by damage
* Auditory EP
* Visual EP

Auditory evoked potential





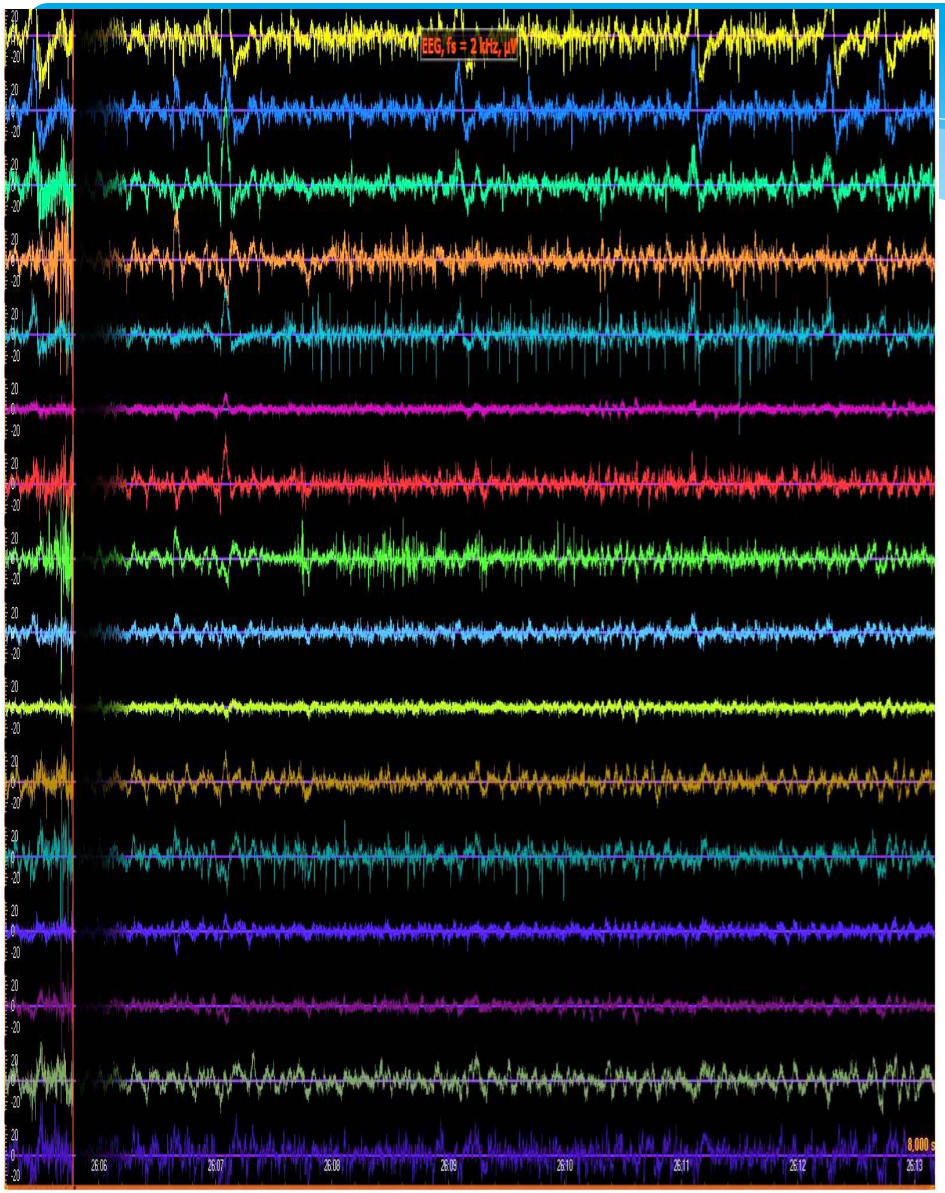
Visual evoked potential

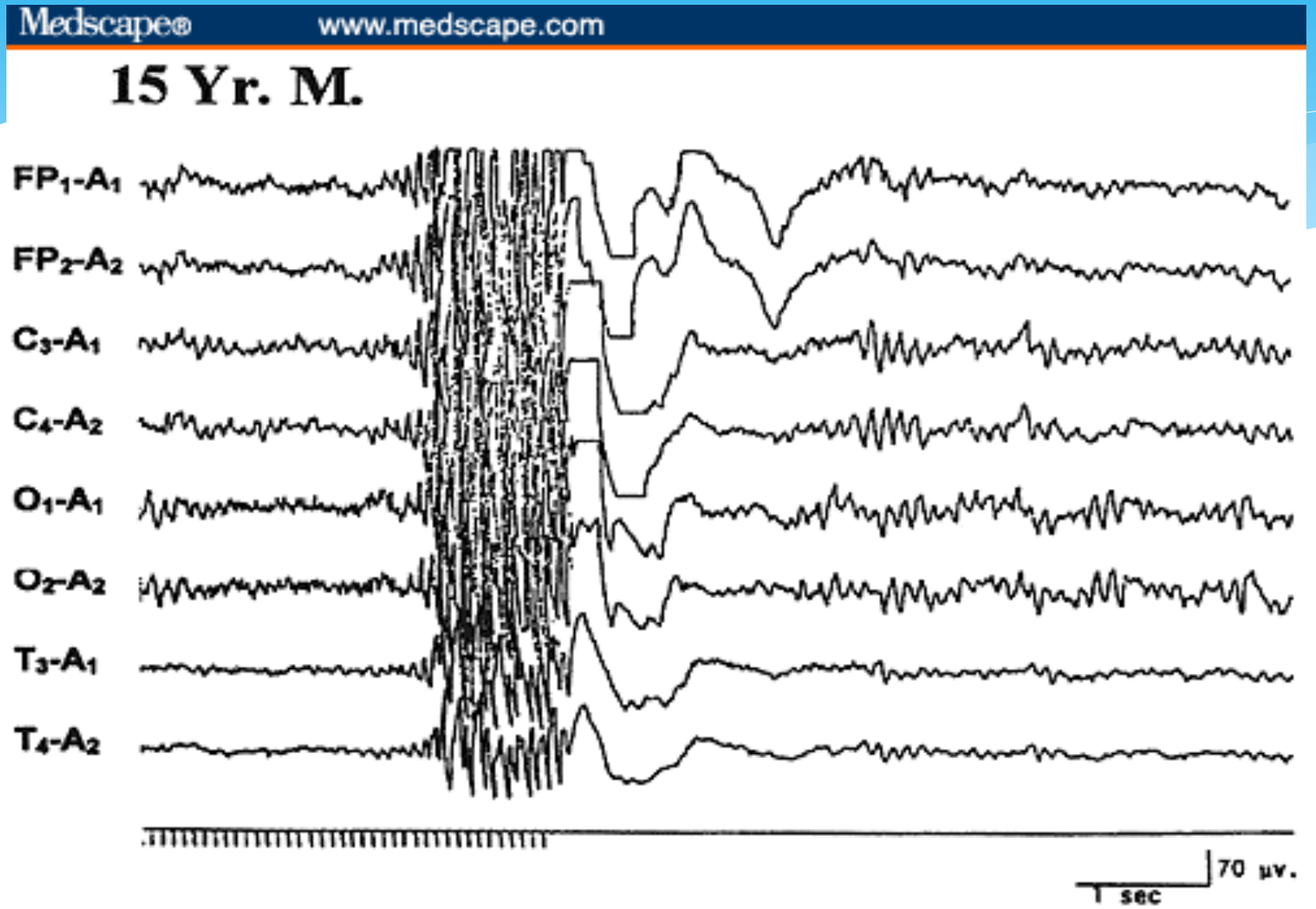


Electroencephalogram (EEG)

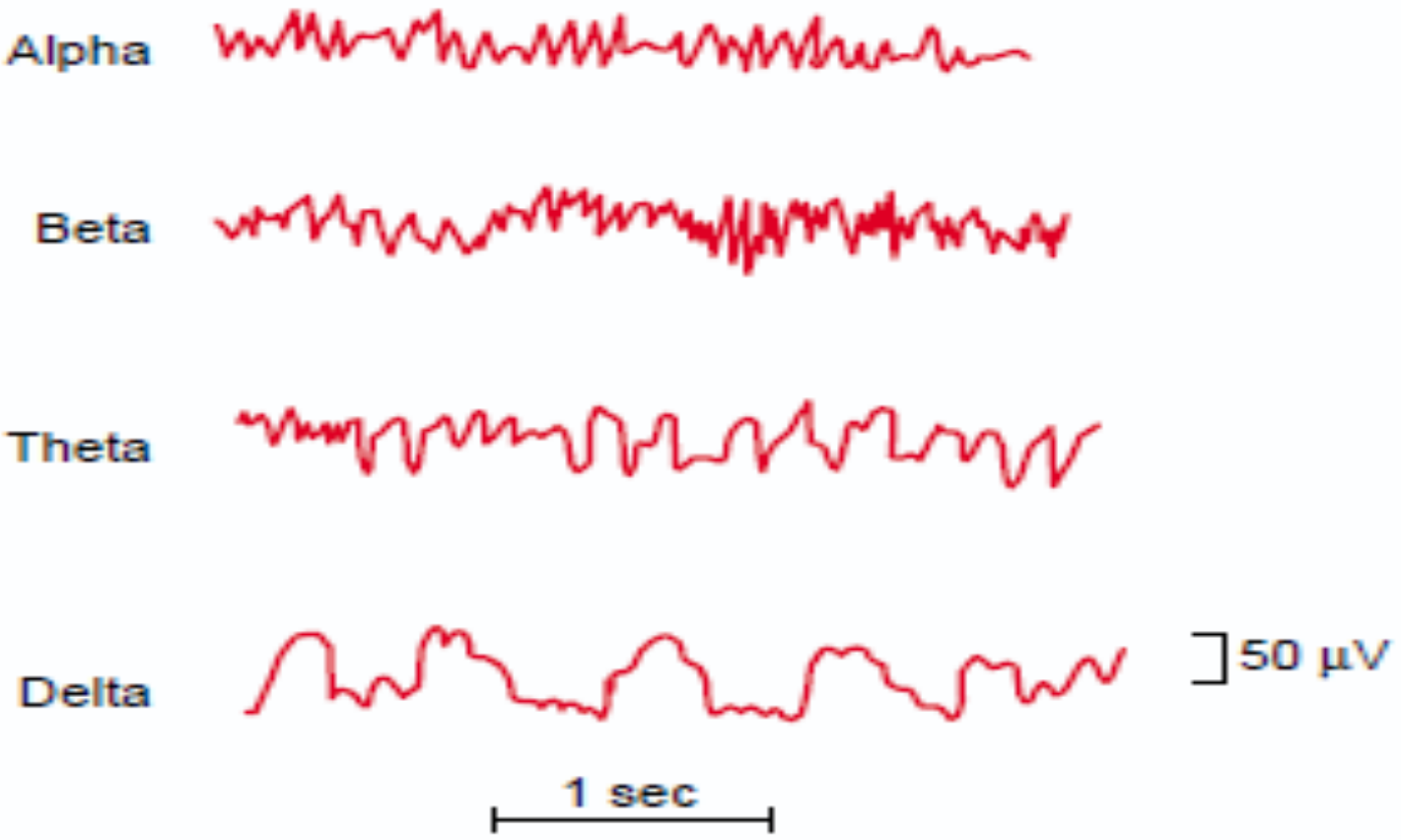
* Measuring electrical activity of the brain (without stimulation)
* EEG ›››› diagnosis, classifying seizures ›››› therapeutic decisions
* **spikes** or **sharp waves (**Epileptiform EEG patterns)

- Focal epileptiform discharges indicate focal epilepsy
- Generalized epileptiform activity indicates a generalized form of epilepsy.


EEG, fs = 2 kHz, µV

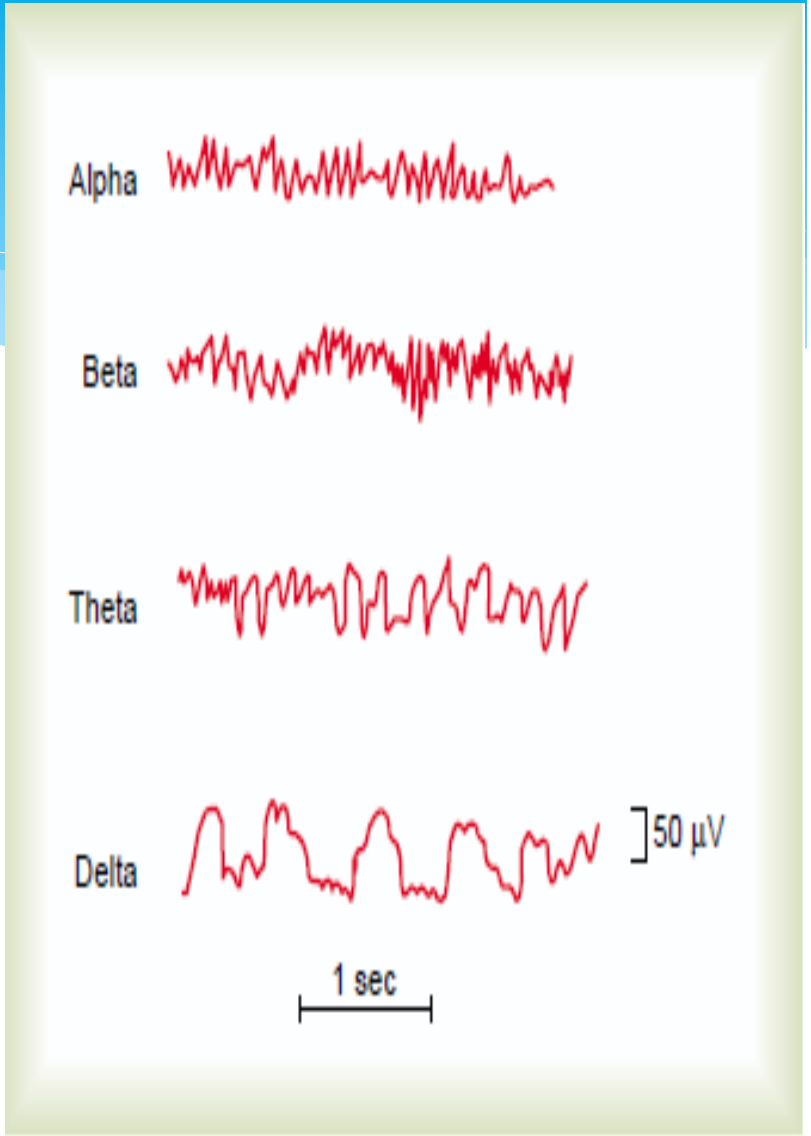

Medscape®
www.medscape.com
15 Yr. M.
FP1-A1
FP2-A2
C3-A1
C4-A2
O1-A1
O2-A2
T3-A1
T4-A2
70 µv.
1 sec
Source: Semin Neurol © 2003 Thieme Medical Publishers

Electroencephalogram



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

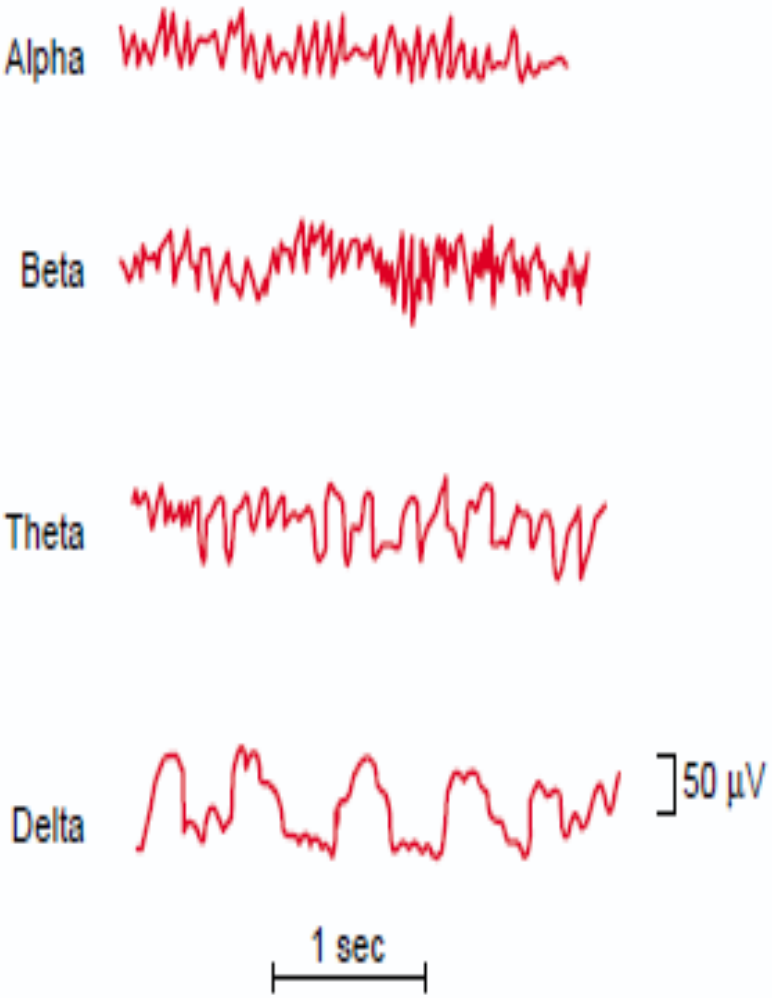
* Beta waves:
* Frontal lobes
* Produced by visual stimuli and mental activity, awake
* 13 to 25 cycles per second .



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

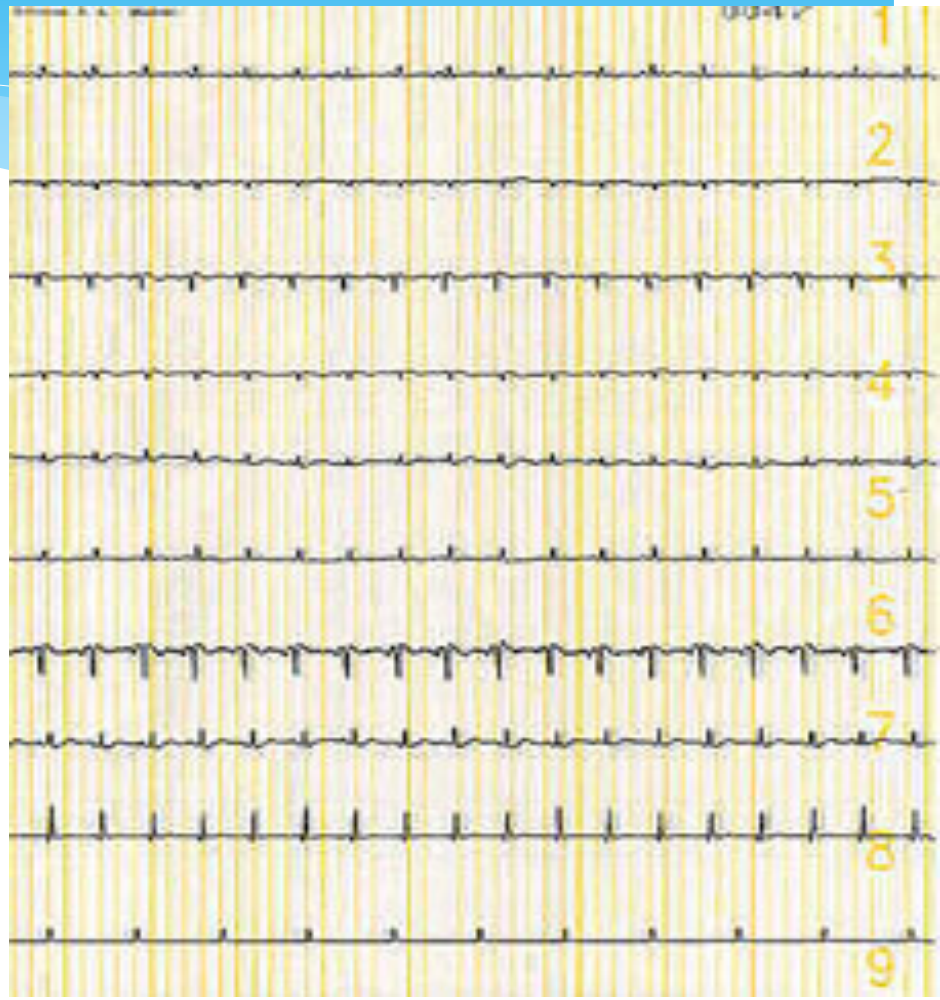
* Delta:
* From the cerebral cortex
* 1 to 5 cycles/second
* Normal in:
* Adult during sleep
* Awake infant

* In an awake adult indicates brain damage



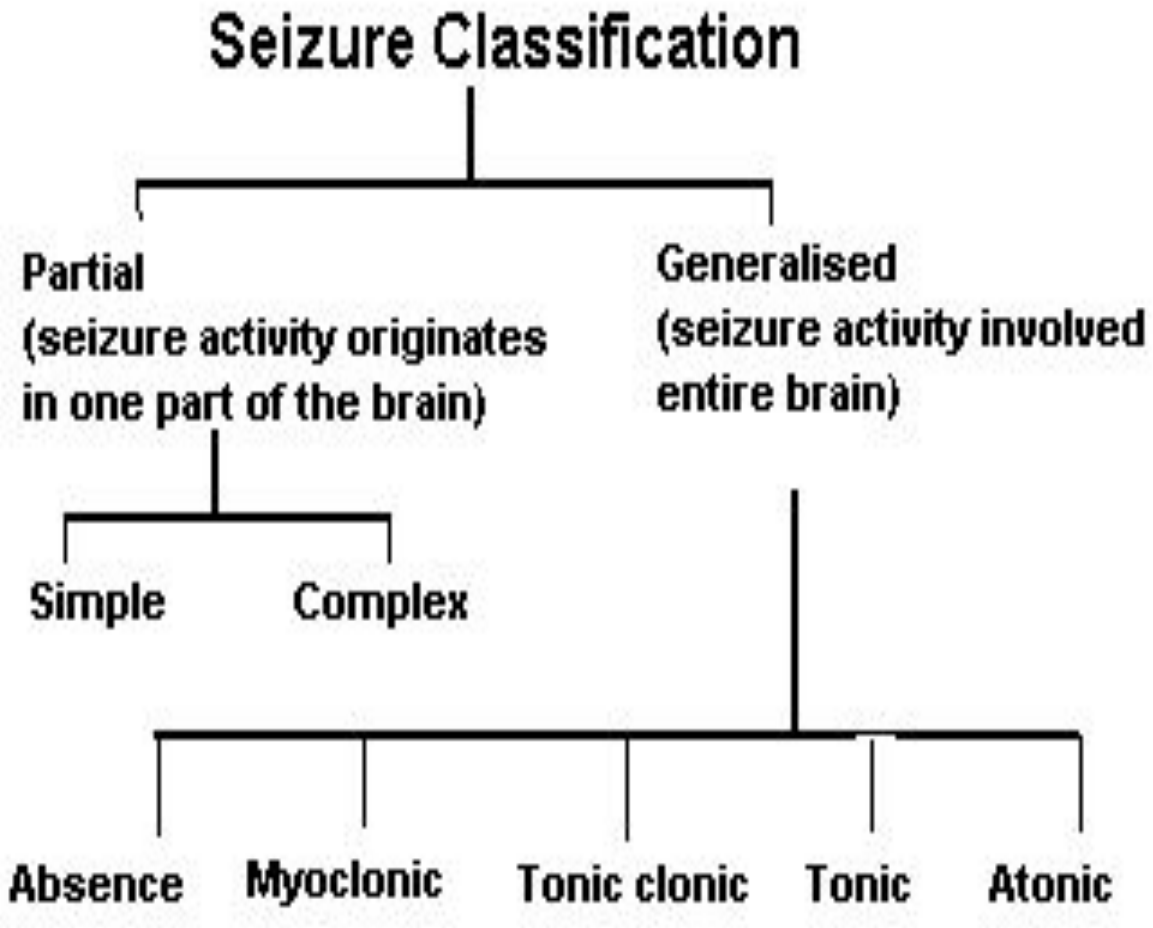
Brain Death Confirmatory Testing with EEG

Normal EEG (at normal magnification)

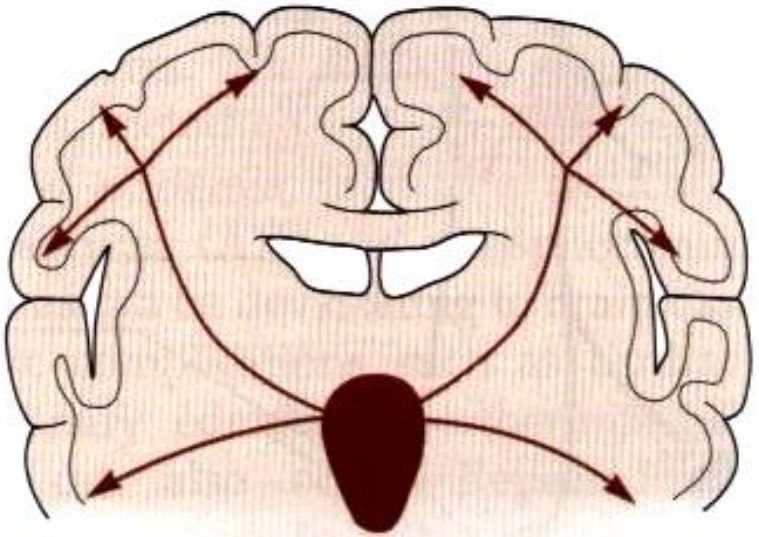


Brain Death (Flat EEG ,at very high magnification)

* Type of Seizures
* Partial
* or
* Generalized

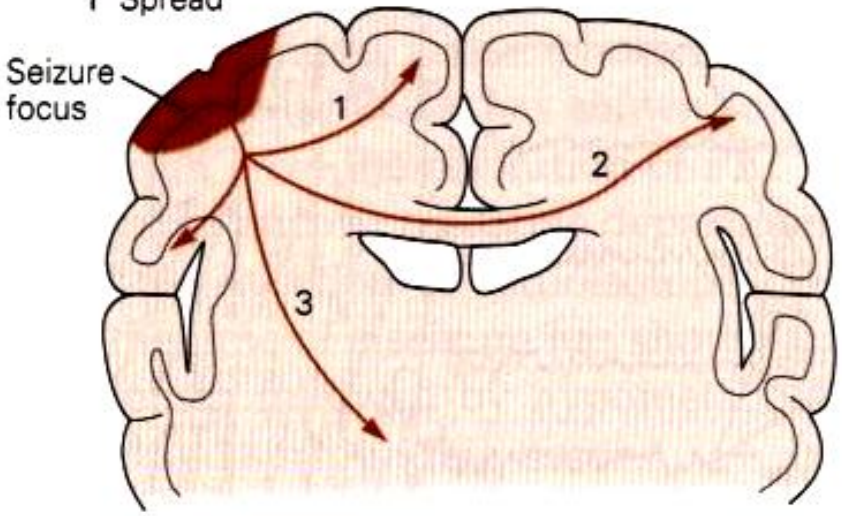


Primary generalized seizure

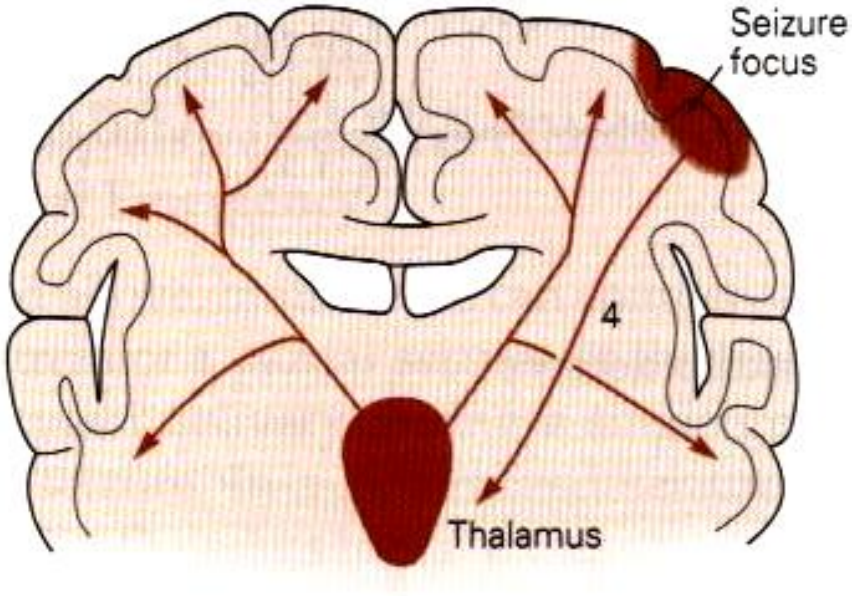


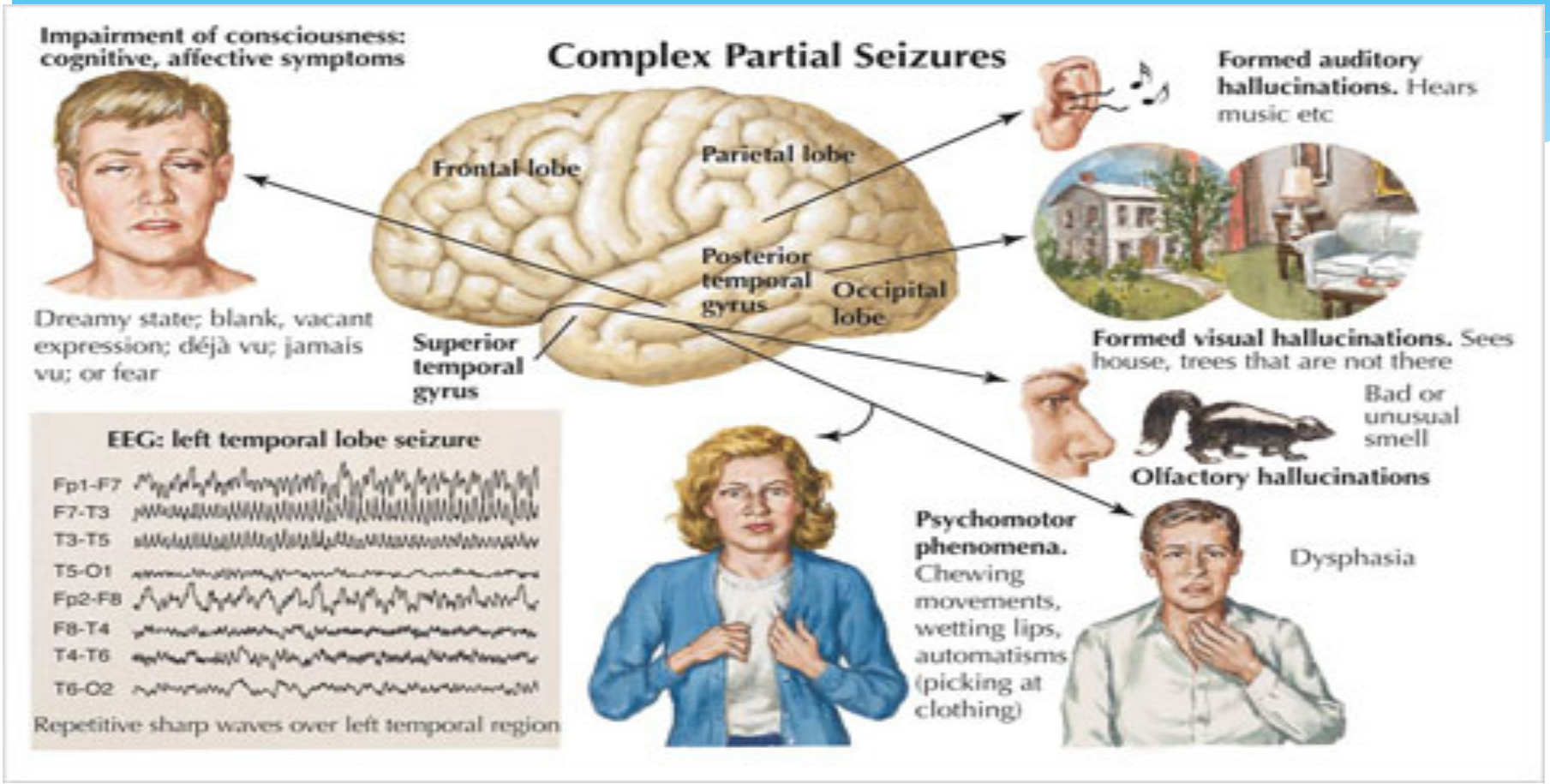
A Partial seizure

1 Spread



2 Secondary generalization




Complex Partial Seizures
Impairment of consciousness: cognitive, affective symptoms
Dreamy state; blank, vacant expression; déjà vu; jamais vu; or fear
Frontal lobe
Parietal lobe
Posterior temporal gyrus
Occipital lobe
Superior temporal gyrus
Formed auditory hallucinations. Hears music etc
Formed visual hallucinations. Sees house, trees that are not there
Bad or unusual smell
Olfactory hallucinations
Psychomotor phenomena. Chewing movements, wetting lips, automatisms (picking at clothing)
Dysphasia
EEG: left temporal lobe seizure
Fp1-F7
F7-T3
T3-T5
T5-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Repetitive sharp waves over left temporal region

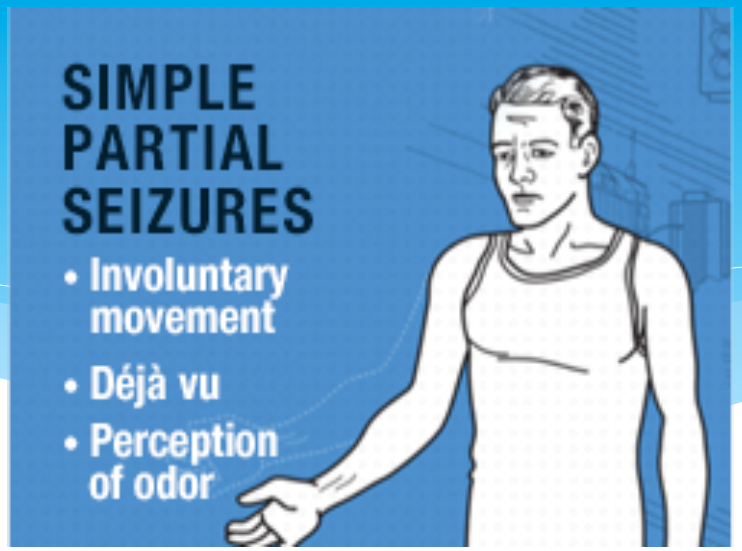
Seizure Classification & Clinical Manifestations

1. Focal / Partial seizures → their onset (start) is limited to part of the cerebral hemisphere

2. Generalized seizures → those that involve the cerebral cortex diffusely (whole of it) from the beginning (*generalized* seizures)

Partial Seizures

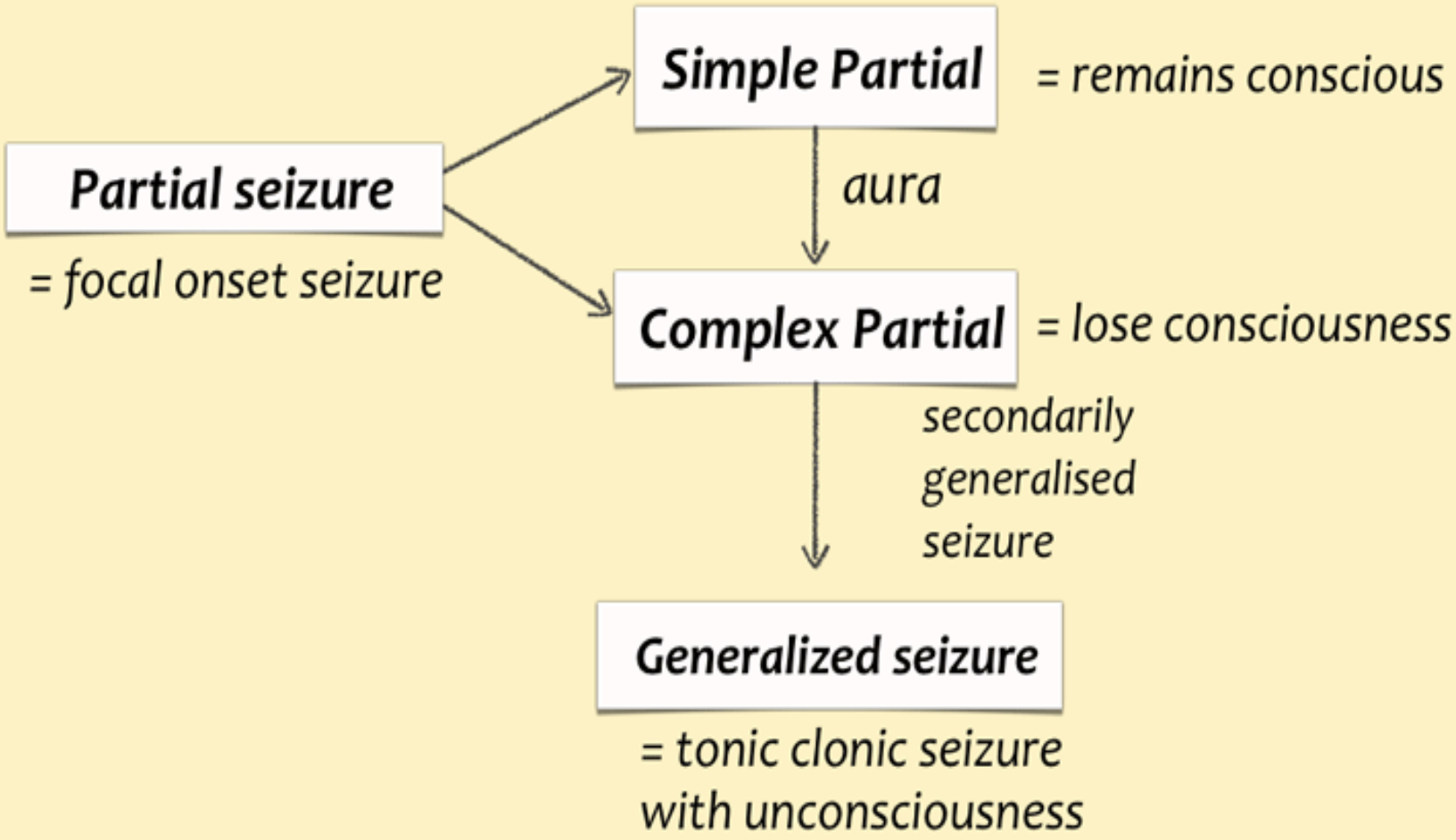
* **a. Simple partial seizures**
  Motor, somatosensory, and psychomotor symptoms
  without impairment of consciousness



* **b. Complex partial seizures**

Impairment of consciousness with or without simple partial symptoms

Epilepsy and Seizures



Generalized seizures

Manifest a loss of consciousness:

Generalized seizures include:

1-**Myoclonic** (are brief shock-like jerks of a muscle or group of muscles)

2- **Clonic** (rapidly alternating contraction and relaxation of a muscle -- in other words, repeated jerking)

3- **Tonic** (the tone is greatly increased and the body, arms, or legs make sudden stiffening movements)

4- **Tonic-clonic seizures** (Grand Mal epileptic seizure)

Generalized

5- Atonic (Lose of muscles strength)

6- Absence seizures (Or non-convulsive)
(Petit mal epileptic seizures)

a. Loss of contact with environment for 5 to 30 seconds.
b. Appears to be day dreaming or may roll eyes, nod head, move hands, or smack lips.
c. Resumes activity and is not aware of seizure.

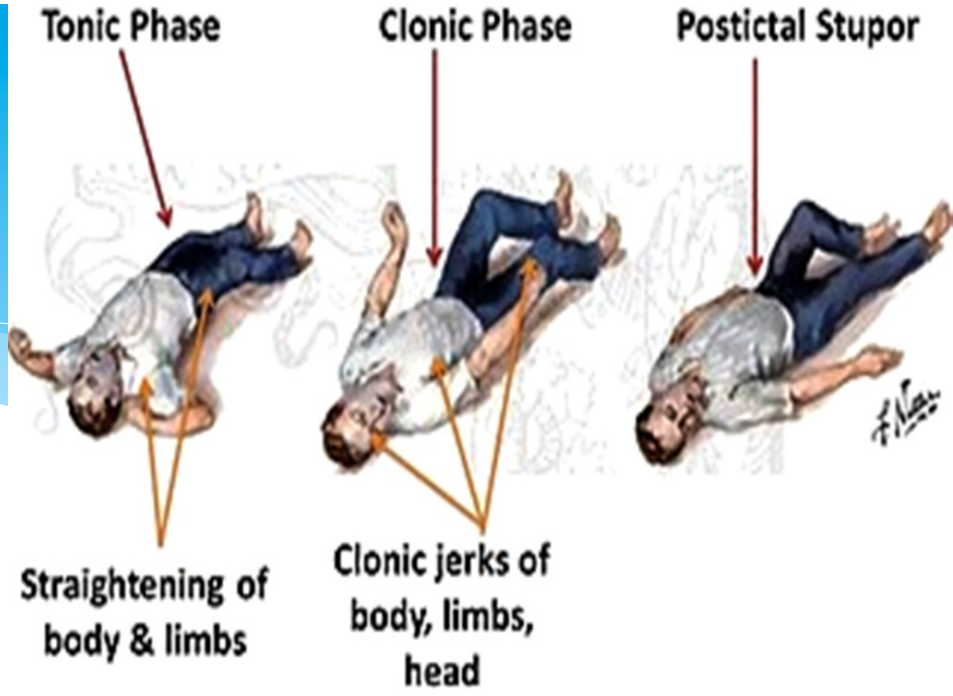
* The onset of a seizures:

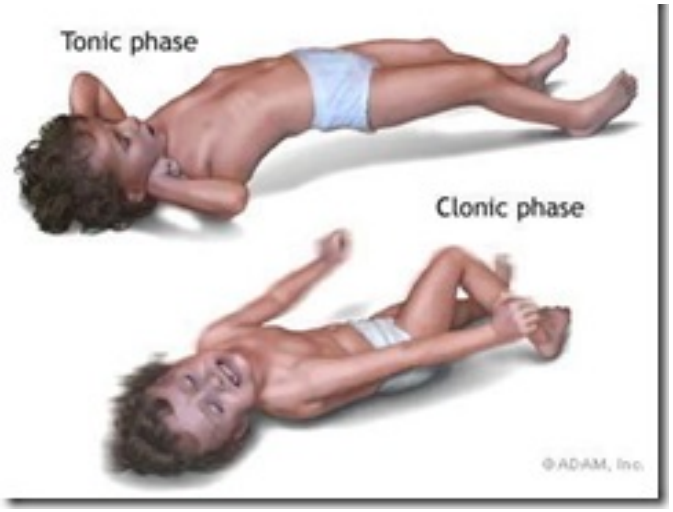
Small group of abnormal neurons undergo

- Prolonged depolarizations
- Rapid firing of repeated action potentials

* Spread to adjacent neurons or neurons with which they are connected into the process.

* A clinical seizure occurs when the electrical discharges of a large number of cells become abnormally linked together, creating a storm of electrical activity in the brain.
* Seizures may then spread to involve adjacent areas of the brain or through established anatomic pathways to other distant areas.





* The clinical manifestations of a seizure reflect the area of the brain from which the seizure begins (i.e., seizure focus) and the spread of the electrical discharge.

* Clinical manifestations accompanying a seizure are numerous and varied, including →
*
* (1) indescribable bodily sensations,
* (2) "pins and needles" sensations,
* (3) smells or sounds,
* (4) fear or depression,
* (5) hallucinations,
* (6) momentary jerks or head nods,
* (7) staring with loss of awareness, and
* (8) Convulsions → i.e., involuntary muscle contractions) lasting seconds to minutes

Pathophysiology of Epilepsy (at molecular level)

- Cortical cell membrane level:

➢ Instability of the nerve cell membrane → Polarization abnormalities (excessive polarization ,hypopolarization , or lapses in repolarization), allowing the cell to be more susceptible to activation → Hypersensitive neurons with lowered thresholds for firing and firing excessively , related to →

- (1) Excess of Excaitatory neurotransmitters (acetylecholine- or Glutamate –related activity)

- (2) Decreased inhibitory (GABA –related activity)

➢ → leading

-Instability of cell-membrane

- Lowered threshold for excitation

→ excessive polarization, hypopolarization allowing the cell to be more susceptible to activation spontaneously or by any ionic imbalances in the immediate chemical environment of neurons → Seizures

* Some types of seizures susceptibility are linked to genes
* (run in families)
* Genetic abnormalities >>>> increasing a person's susceptibility to seizures_that are triggered by an environmental factor
* Several types of epilepsy have now been linked to defective genes for ion channels, the "gates" that control the flow of ions in to and out of cells and that regulate neuron signaling.