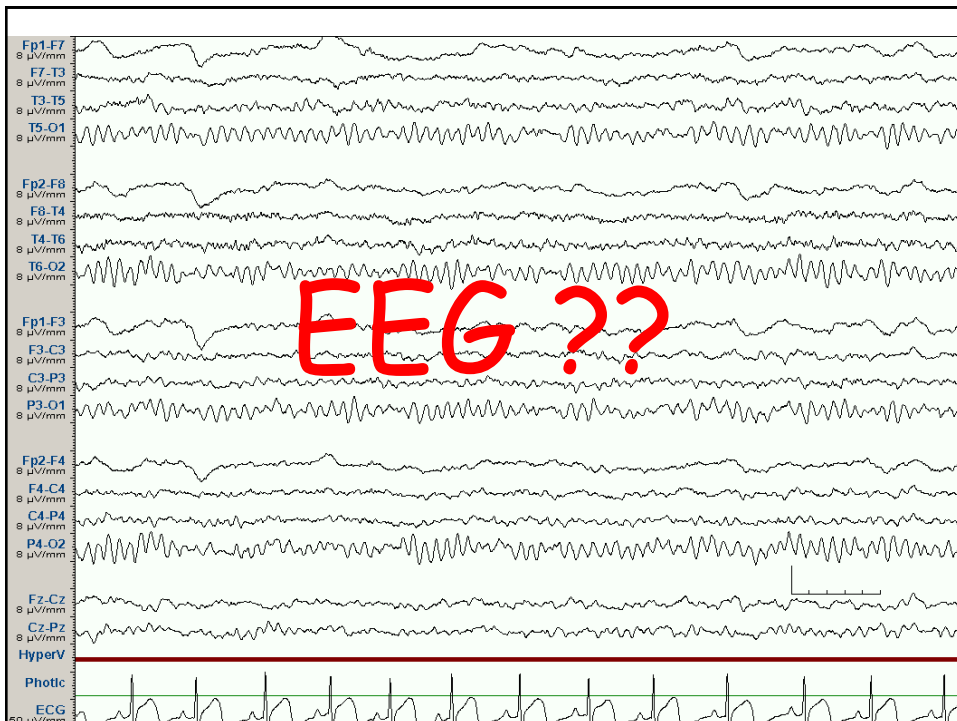


Normal EEG in children

EEG workshop
20/7/53

Sorawit Viravan



What is EEG?

- Electroencephalogram
- Detect brain wave by scalp electrodes
- Summation of postsynaptic potentials (EPSP & IPSP) → brain waves

EEG

- Electrode placement
- Montage
- EEG activity

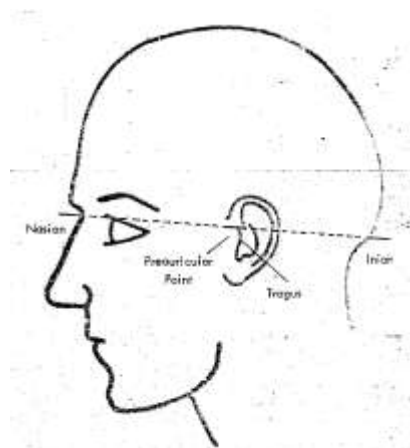
Electrode placement

- **International 10-20 system**
 - Minimum 21 electrodes
 - **Odd-numbered electrodes** are placed on **the left side** of the head, and **even-numbered electrodes** are placed on **the right side** of the head
 - Specific letters designate the anatomical area; for example “F” means frontal

International 10 -20 system –

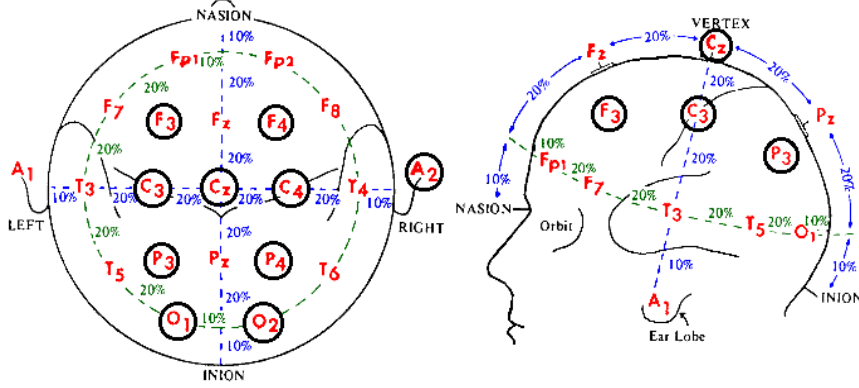
4 landmarks are used

nasion (point between forehead and nose) &
inion (bump – lowest point of skull at back of head)
& 2 pre auricular points

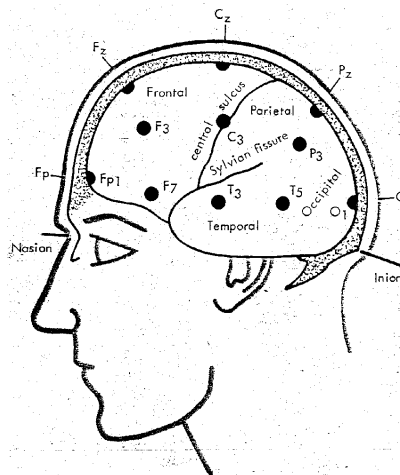


LEFT LATERAL VIEW OF SKULL LANDMARKS.

International 10-20 system



Anatomical regions represented by EEG letters





Common Montage types

The difference in voltage between two electrodes

- **Bipolar:**

Each channel represents difference between 2 adjacent electrodes

- AP bipolar
- Coronal / transverse bipolar

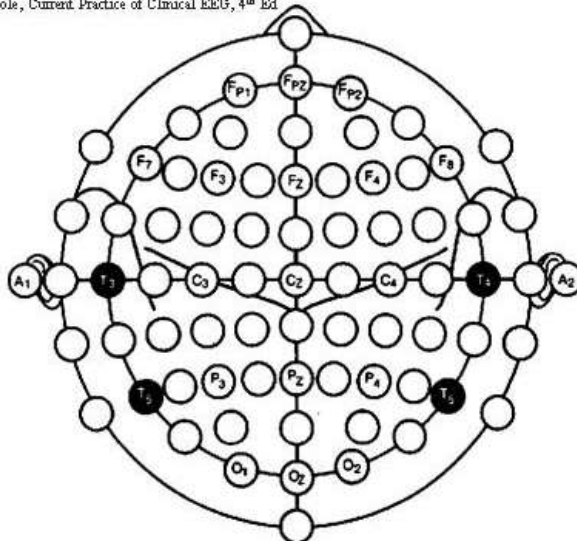
- **Referential:**

Each channel represents the difference between a certain electrode and the designated reference position

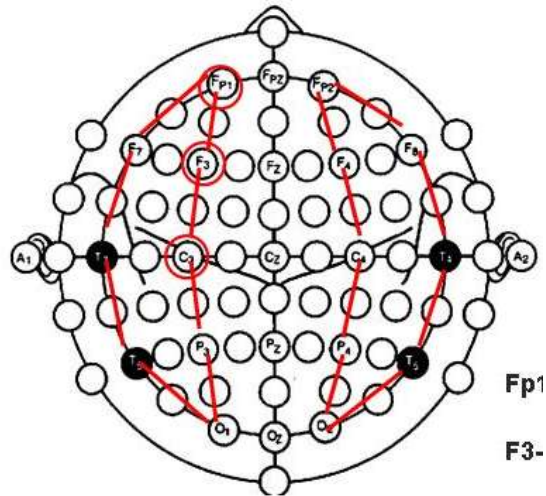
- ipsilateral ear
- average
- midline, etc.

Electrode placement: 10-20 system

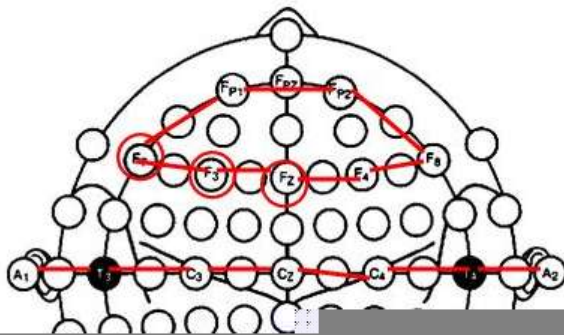
From Pedley and Ebersole, Current Practice of Clinical EEG, 4th Ed



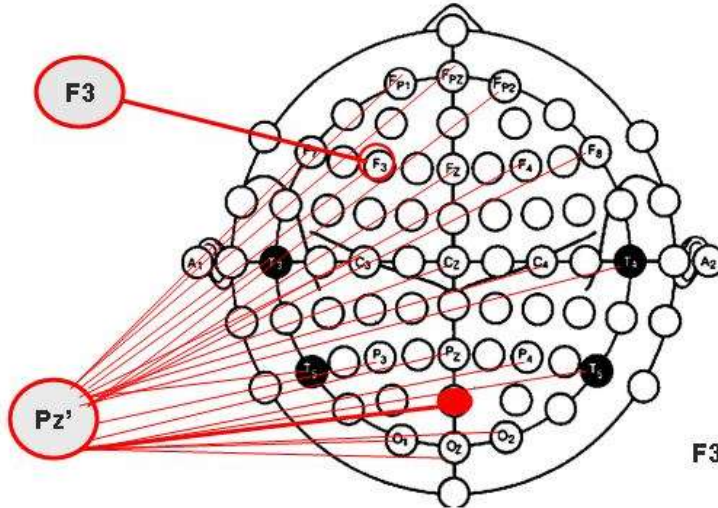
AP bipolar montage (double banana): for localization



Coronal / transverse bipolar montage: for localization



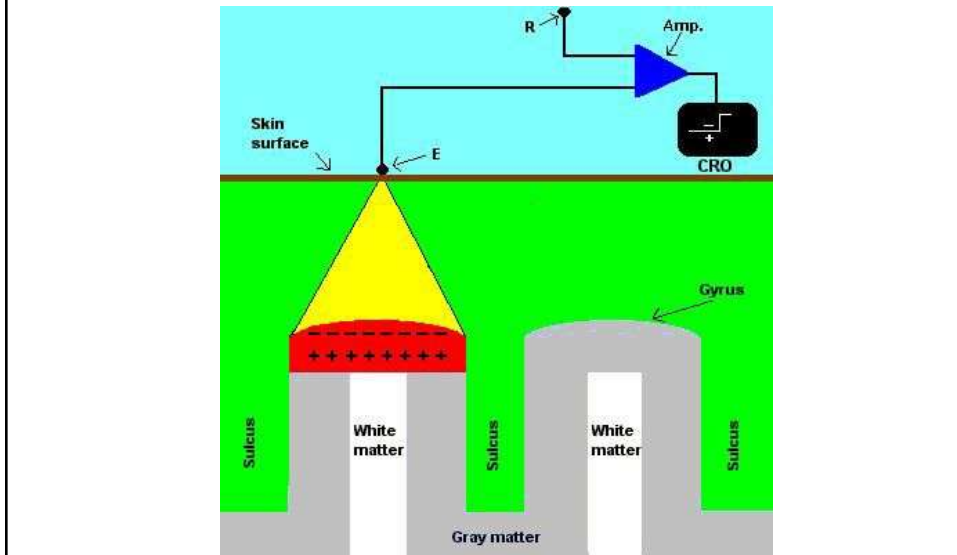
Referential montage: for amplitude measurement



Brain wave

- EPSP causes depolarization in pyramidal cell of the cerebral cortex gyrus
- Any change in difference of electrical potential between two recording electrodes
- Sequence of waves → activity

Electrode (E) located directly over the active dipole layer
→ negativity



EEG activity

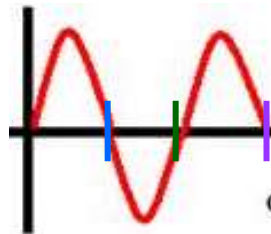
- Waveform
- Frequency
- Amplitude
- Polarity
- Timing

Wave form

- Spike
 - Sharply contoured, duration 20-70 msec
- Sharp wave
 - Sharply contoured, duration 70-200 msec
- Sharp transient
 - Sharply contoured waveform
- Other morphology
 - spindles, arciform, saw-tooth

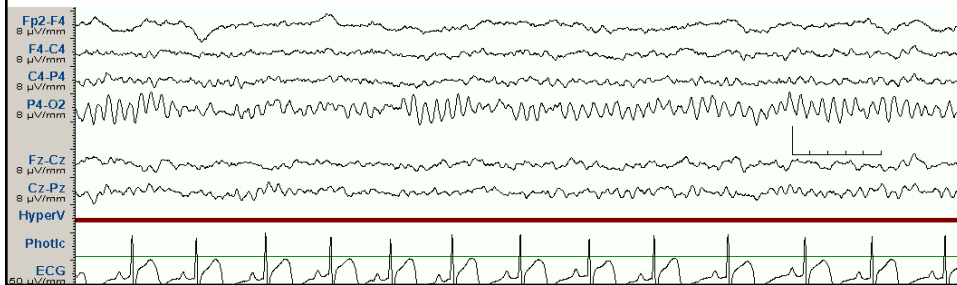
Wave form

- Monophasic wave
 - Single deflection: up or down
- Diphasic wave
 - 2 components on opposite sides
- Polyphasic wave
 - 2 or more components of different direction



Frequency

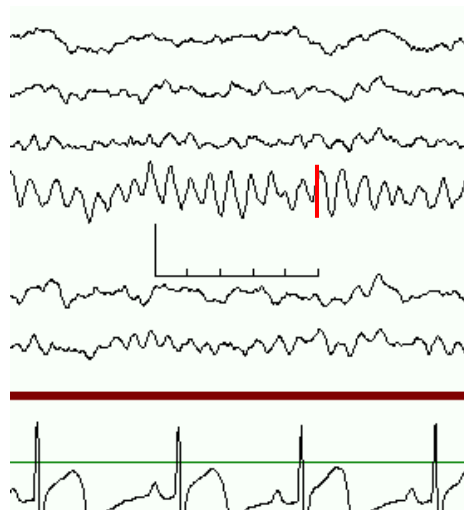
- Delta wave < 4 Hz
- Theta wave 4-7 Hz
- Alpha wave 8-13 Hz
- Beta wave > 13 Hz



Amplitude

Total vertical distance of wave

- Low < 20 μV
- Medium 20-50 μV
- High > 50 μV



Affected by barriers

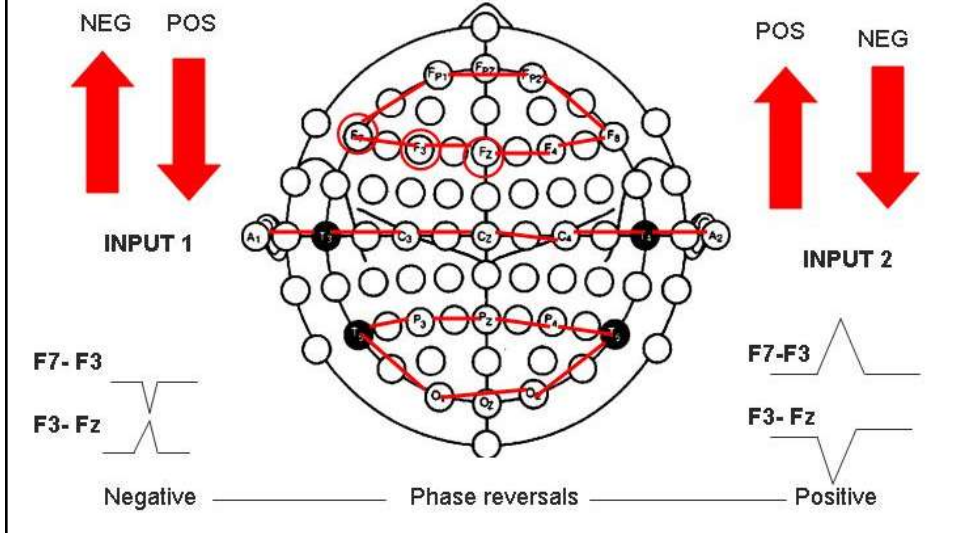
Distribution

- Generalized / diffuse
- Lateralized
- Focal / localized

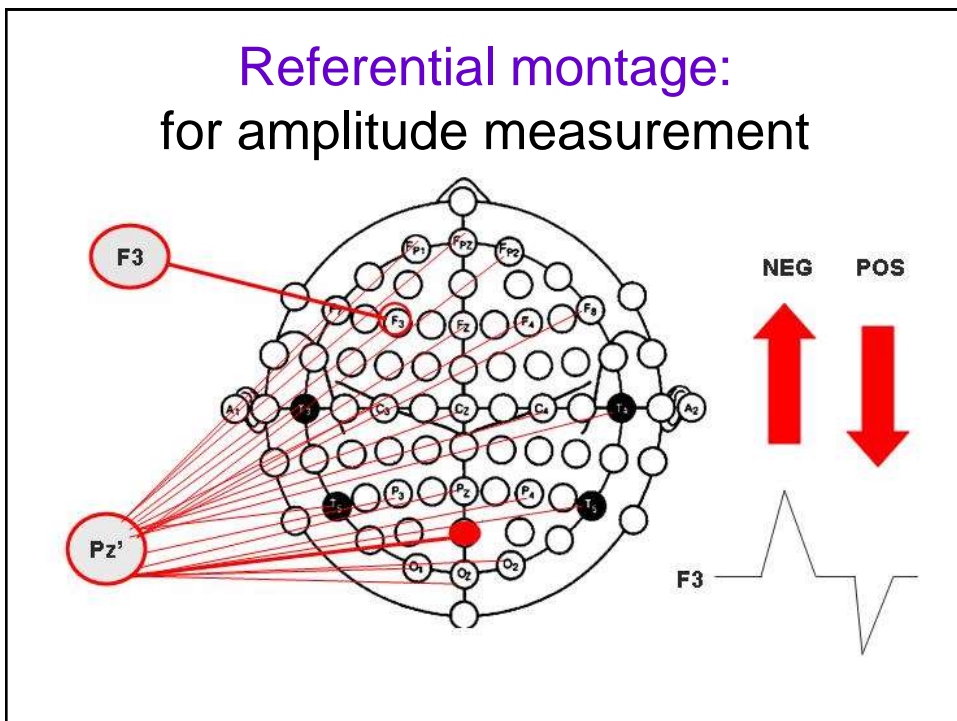
Timing

- Synchronous
- Bilaterally synchronous
- Asynchronous
- Independent

Coronal bipolar montage: for localization

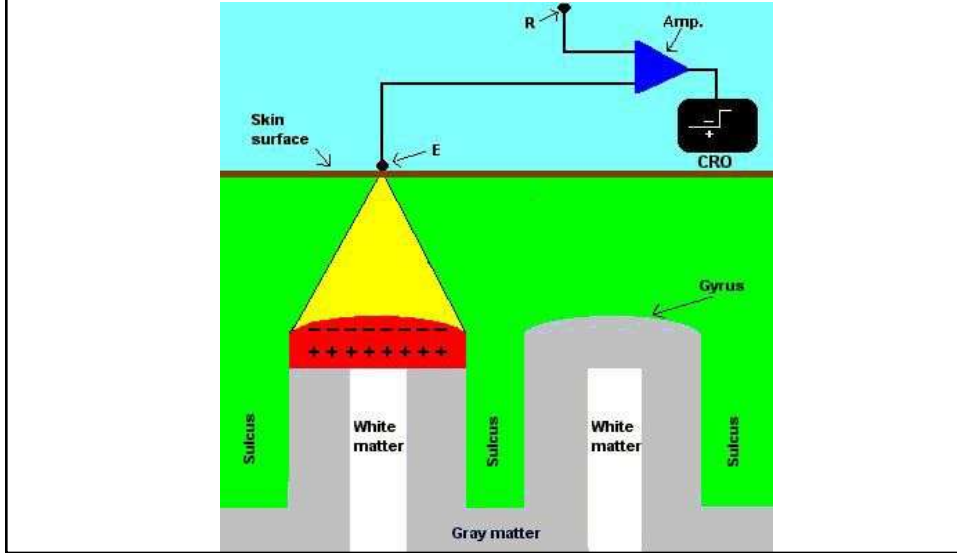


Referential montage: for amplitude measurement



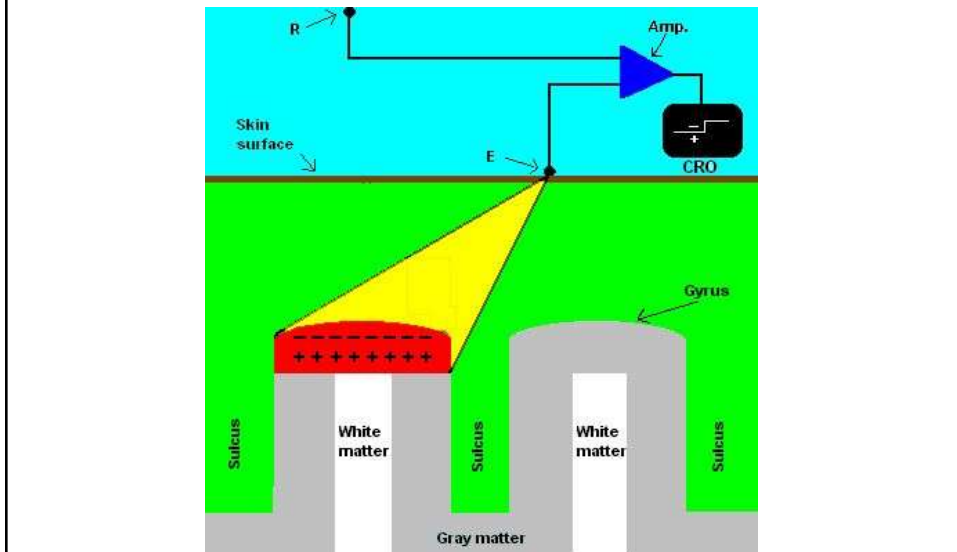
EPSP causes depolarization in pyramidal cell of the cerebral cortex gyrus

Electrode (E) located directly over the active dipole layer → negativity



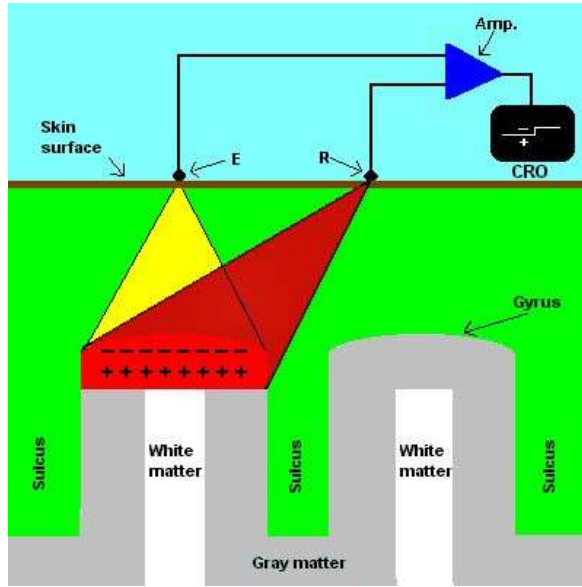
E further away from dipole layer, it sees the dipole layer at an angle

So the deflection of tracing is smaller, it is still negative

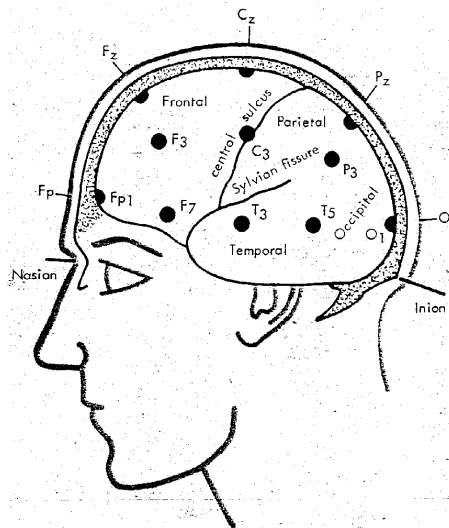
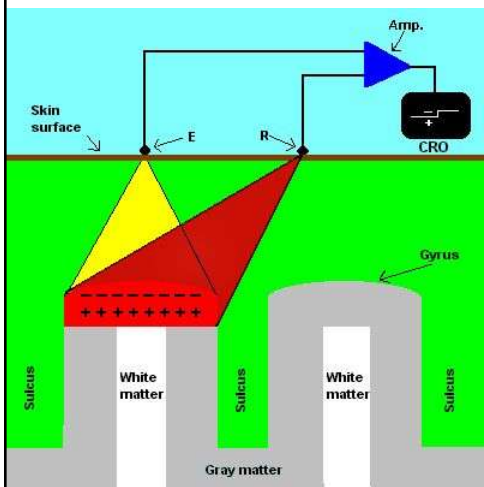


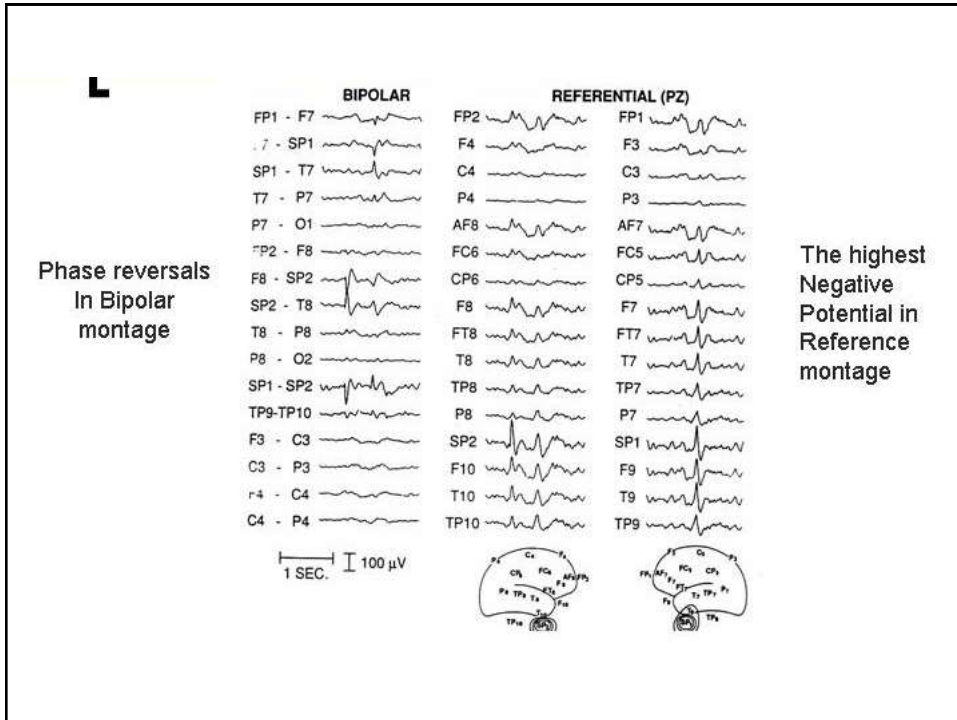
Example of bipolar montage: both electrodes are influenced by the event

Net result = E more negative than R



Electrical field





EEG in children

- Newborn EEG (0-28 days in full term baby)
- EEG of children age 1 month - adolescent

EEG in newborn

- Post conceptional age
- Duration at least 60 minutes
- Awake / Active sleep / Quiet sleep

- Continuity / Synchrony
- Symmetry / Reactivity
- Normal specific EEG pattern

Pediatric EEG

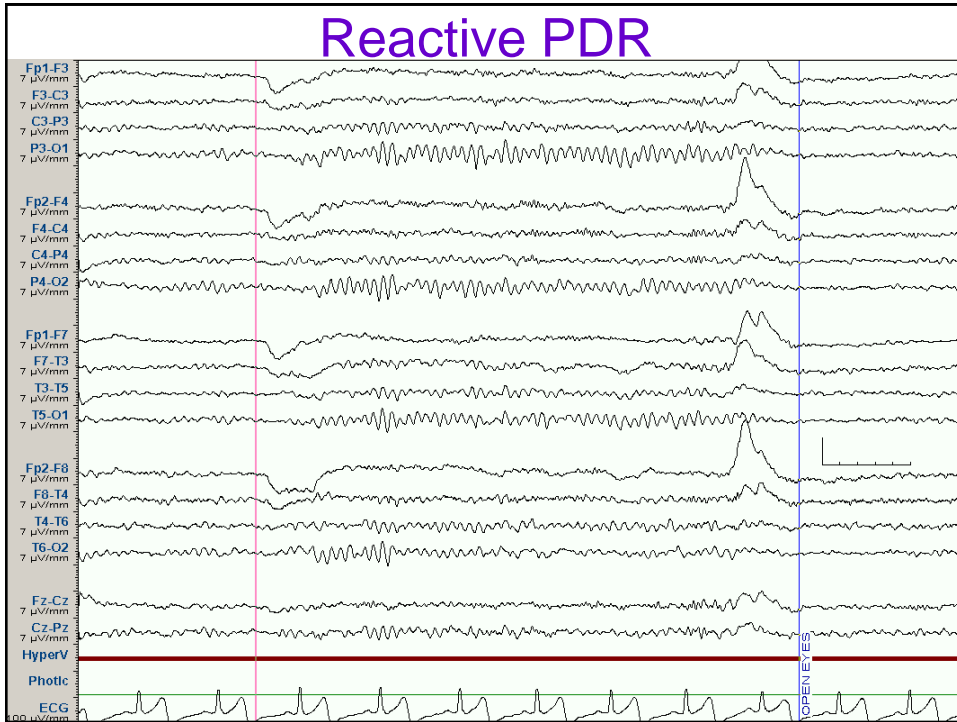
Awake

- Posterior dominant rhythm (PDR)
- Posterior slow wave of youth (PSWY)
- Mu rhythm
- Beta activity
- Lambda wave

- Eye movement
- Artifact

PDR

- Alert, eye-closed, in rest state
- First seen at 3 months of age
- Maximum posterior head region
- Reactivity
 - Attenuation with eye opening, \pm anxiety



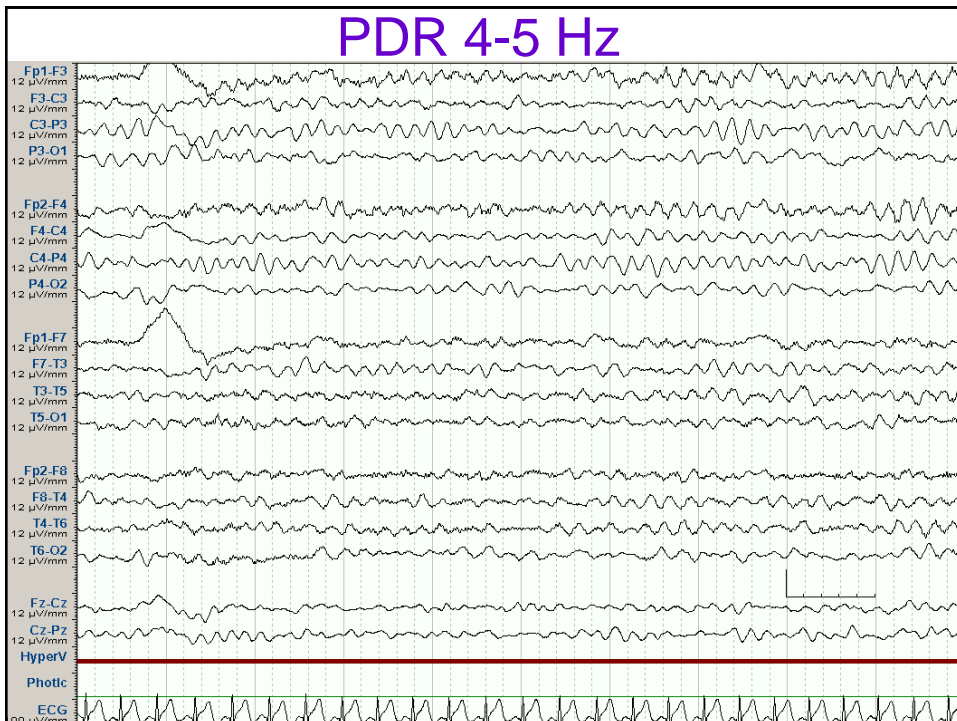
PDR

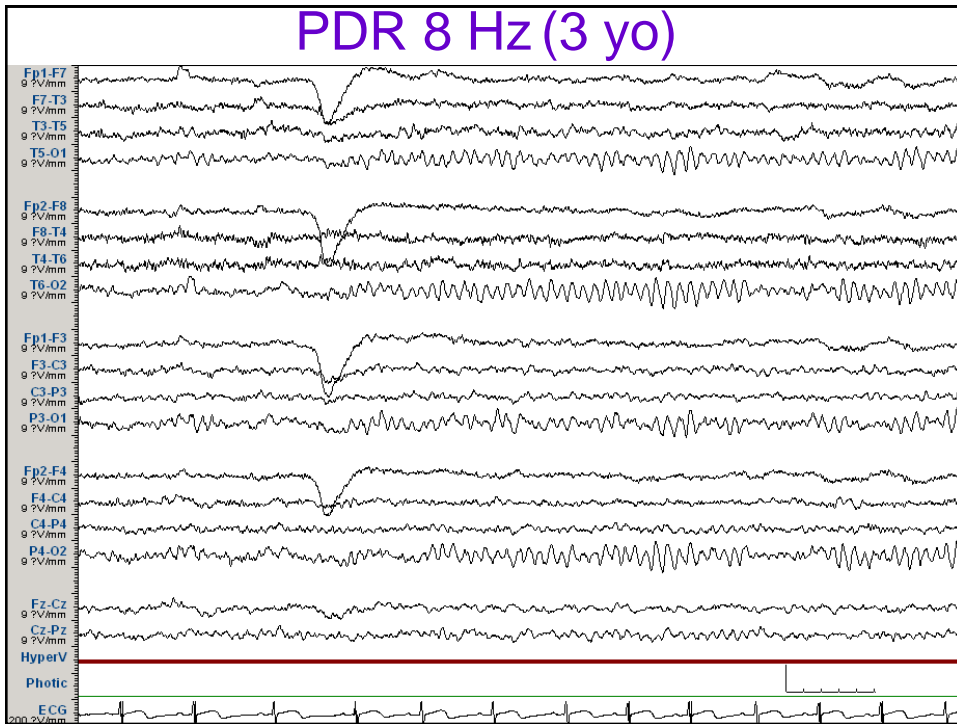
- Higher amplitude over right hemisphere
($< 50\%$ difference)
due to asymmetric skull thickness
- Amplitude $\sim 50-100$ μV
- Decreasing amplitude with increasing age
due to increased bone density of the skull

PDR

Frequency in Children

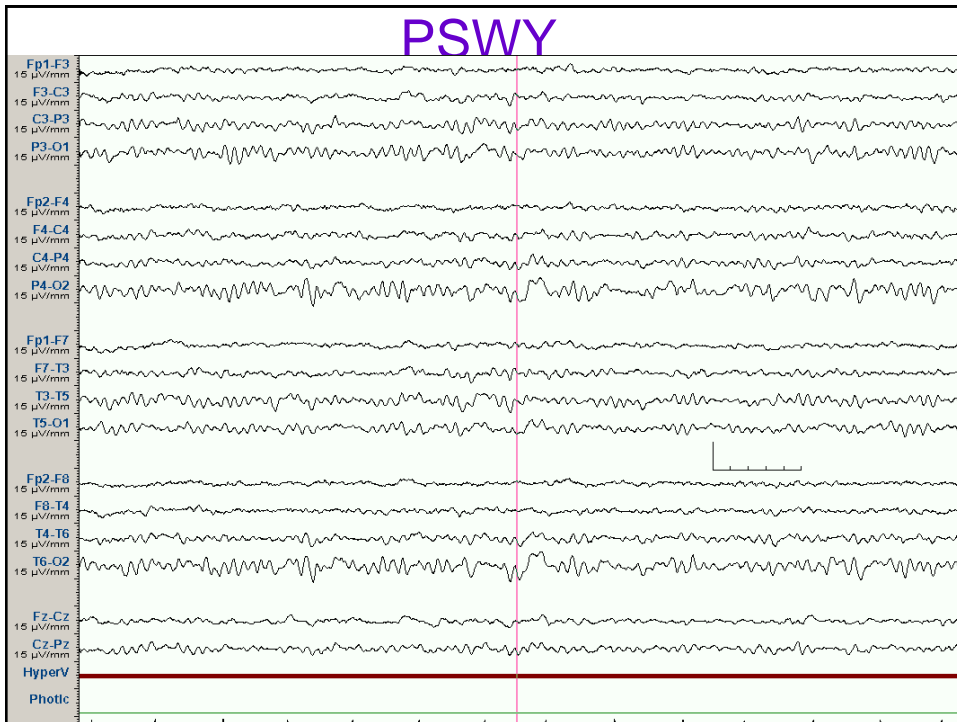
3-4 months:	4 Hz
12 months:	5-6 Hz
2 years:	7 Hz
3 years:	8 Hz
9 years:	9 Hz
15 years:	10 Hz





PSWY

- Slow activity intermixed with PDR
- Moderate voltage (<120% of normal alpha rhythm voltage)
- May be asymmetry
- Best seen in 8-14 years
- Block with eye opening
- Disappear with the alpha rhythm during drowsiness and light sleep

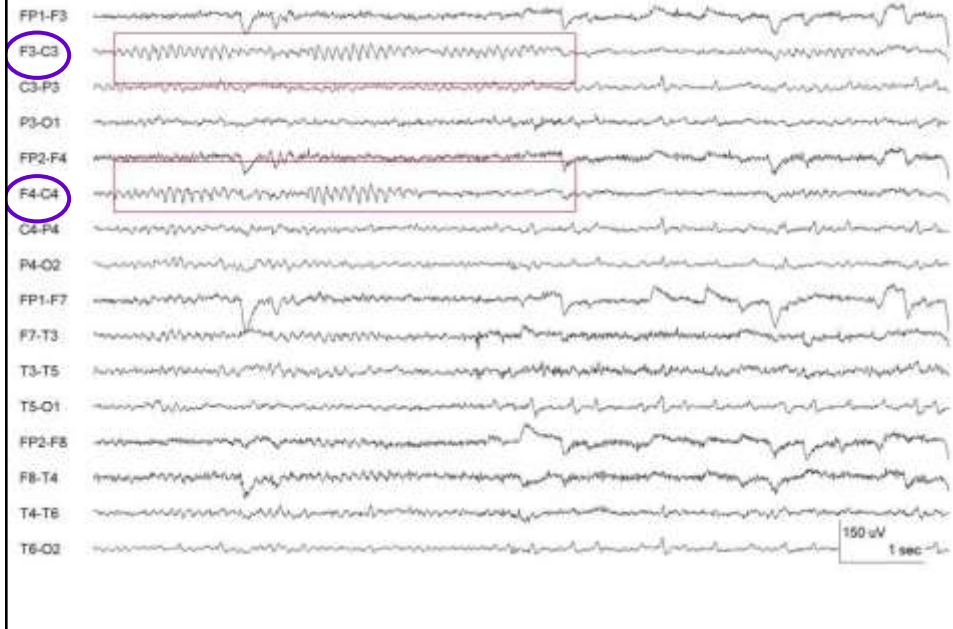


Mu

- **central arch-like rhythm** of alpha frequency (usually 8-10 Hz)
- May be related to the functions of the sensorimotor cortex at rest
- Best seen between 8-16 years
- Asymmetrical

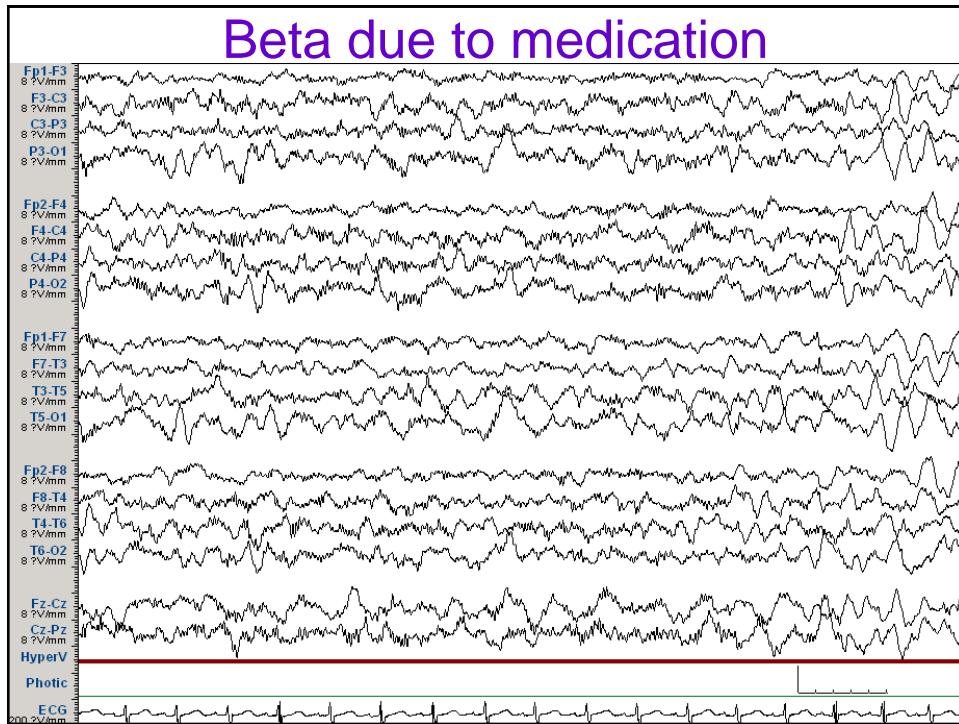
- **Blocked unilaterally with movement of the contralateral extremity**
- Not blocked by eye opening

Mu rhythm



Beta

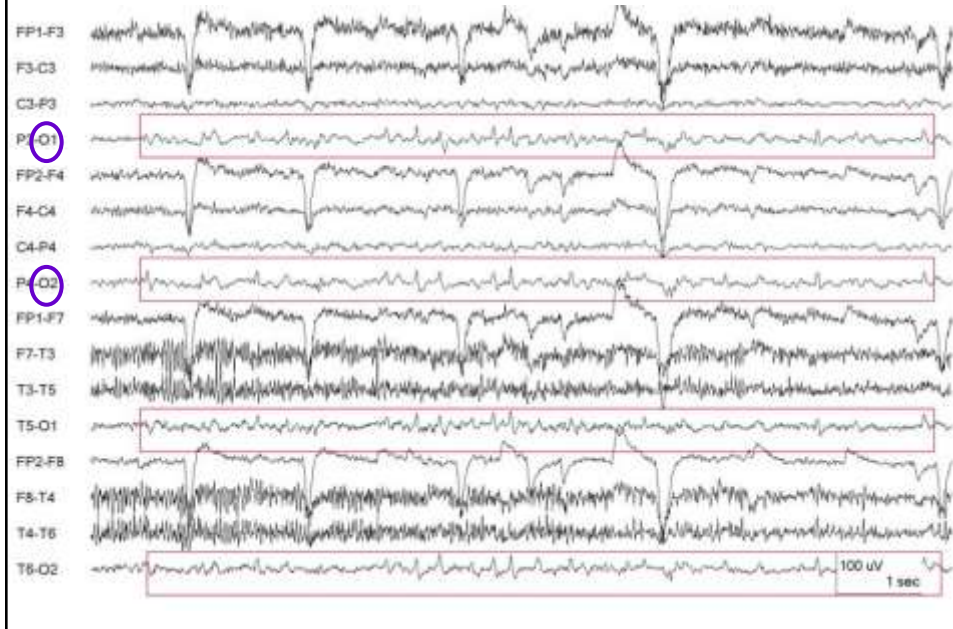
- Frequencies more than 13 Hz
- Amplitude < 20 uV, usually < 10 uV
- Three band
 - 18-25 Hz band (common)
 - 14-16 Hz band (less common)
 - 35-40 Hz band (rare)
- Increased by
 - Drugs eg. barbiturate, benzodiazepine, chloral hydrate (18-25 Hz > 14-16 Hz)



Lambda wave

- Surface positive, check mark-like wave
- Occipital region
- During eye opening
- Visually scanning at complex picture (ceiling, TV etc.) with saccadic eye movement
- Best seen in 2-15 years
- May be asymmetrical

Lambda



Eye movement (EM)

Vertical EM (Fp1, Fp2)

- Eye opening
- Eye closure
- Eye blinking

Horizontal EM (F7, F8)

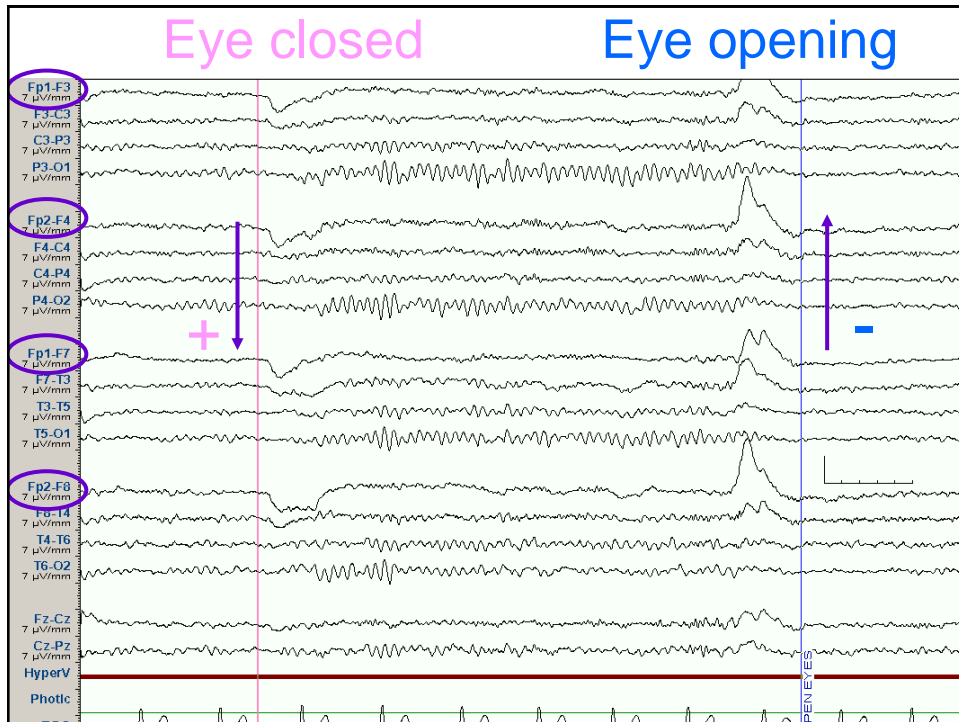
- To the left
- To the right

Eye movement (EM)

- Cornea → positivity
- Retina → negativity
- Nearest electrode of the direction of EM will pick up positivity, the opposite electrode will pick up negativity

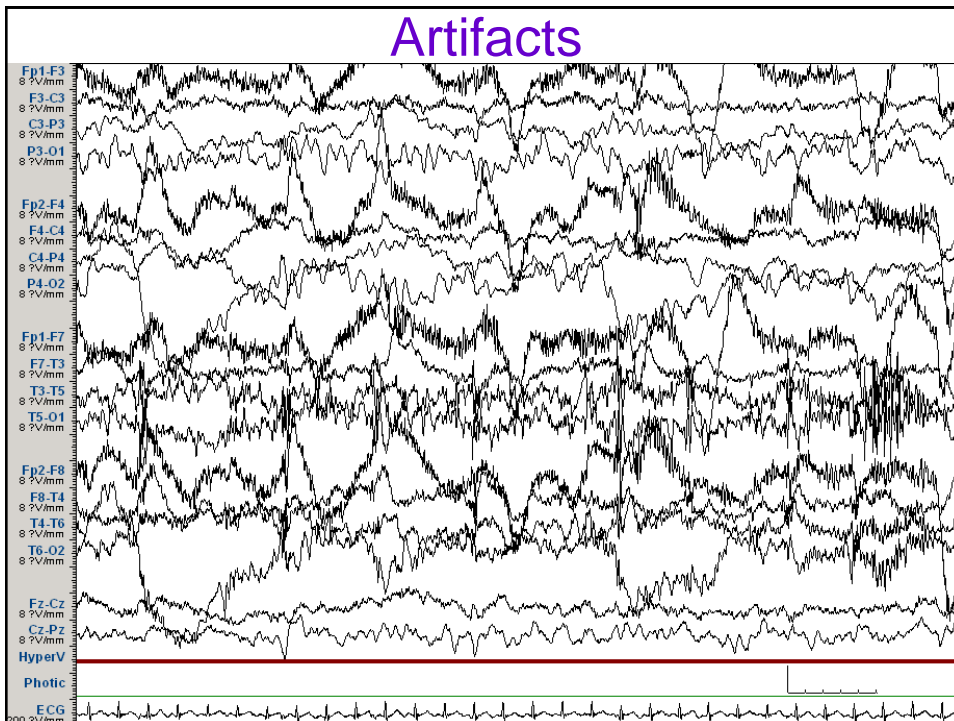
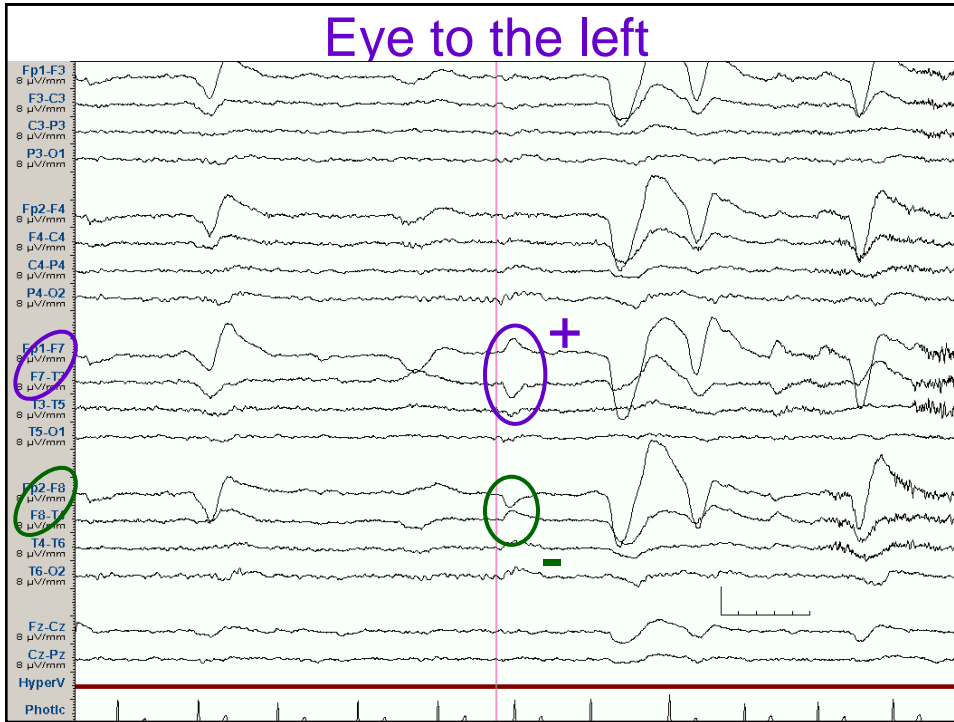
Vertical EM

- Eye closure (relatively eyes go up)
 - Fp1 and Fp2 pick up positivity
 - downward deflection at Fp1-F7, Fp2-F8
- Eye opening (relatively eyes go down)
 - Fp1 and Fp2 pick up negativity
 - upward deflection at Fp1-F7, Fp2-F8



Horizontal EM

- Eye turn to the left
 - F7 pick up positivity, F8 pick up negativity
 - positive phase reversal at F7 (Hole)
 - negative phase reversal at F8
- Eye turn to the right
 - F8 pick up positivity, F7 pick up negativity
 - positive phase reversal at F8 (Hole)
 - negative phase reversal at F7



Sleep

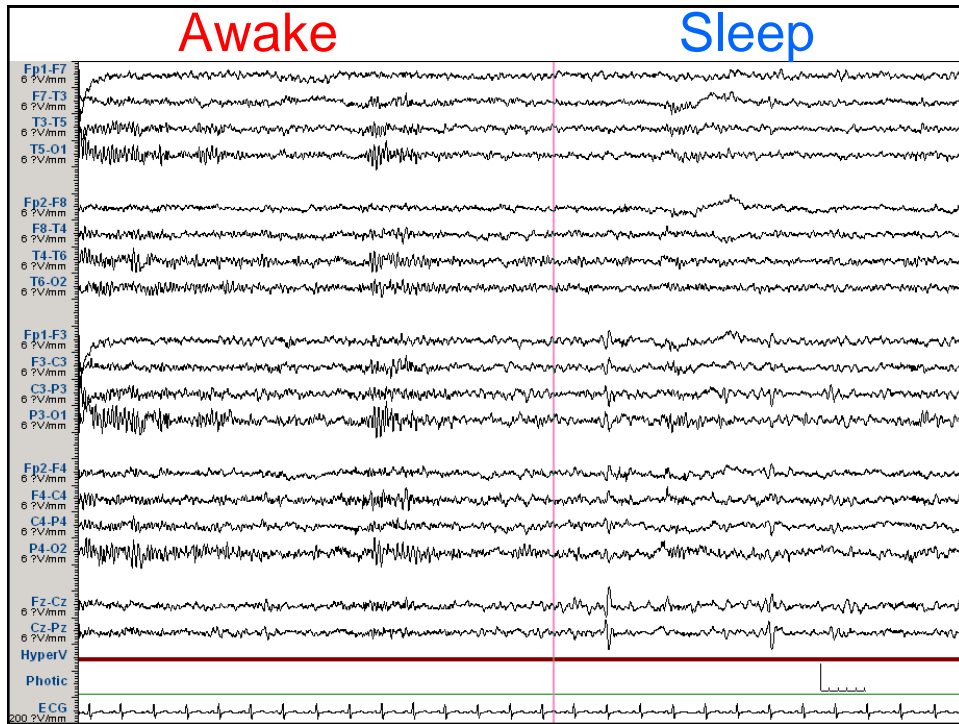
Non-REM sleep

- Stage 1 (drowsiness)
- Stage 2
- Stage 3 & 4

REM sleep

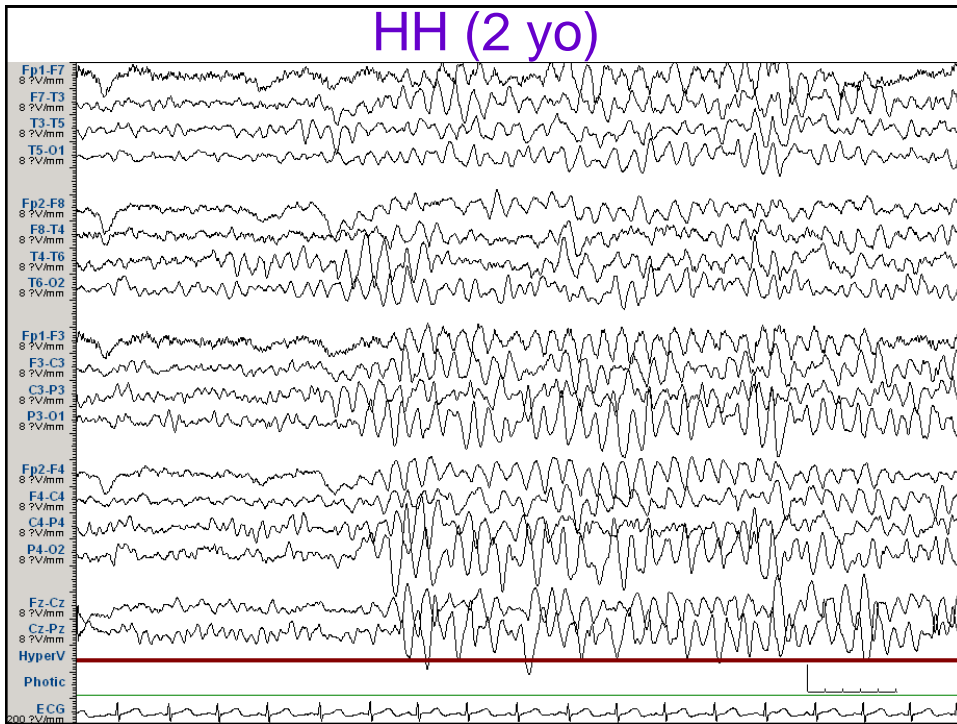
Stage 1

- Alpha drop out
- Hypnagogic hypersynchrony
- POSTs
- Beta activity
- Vertex wave



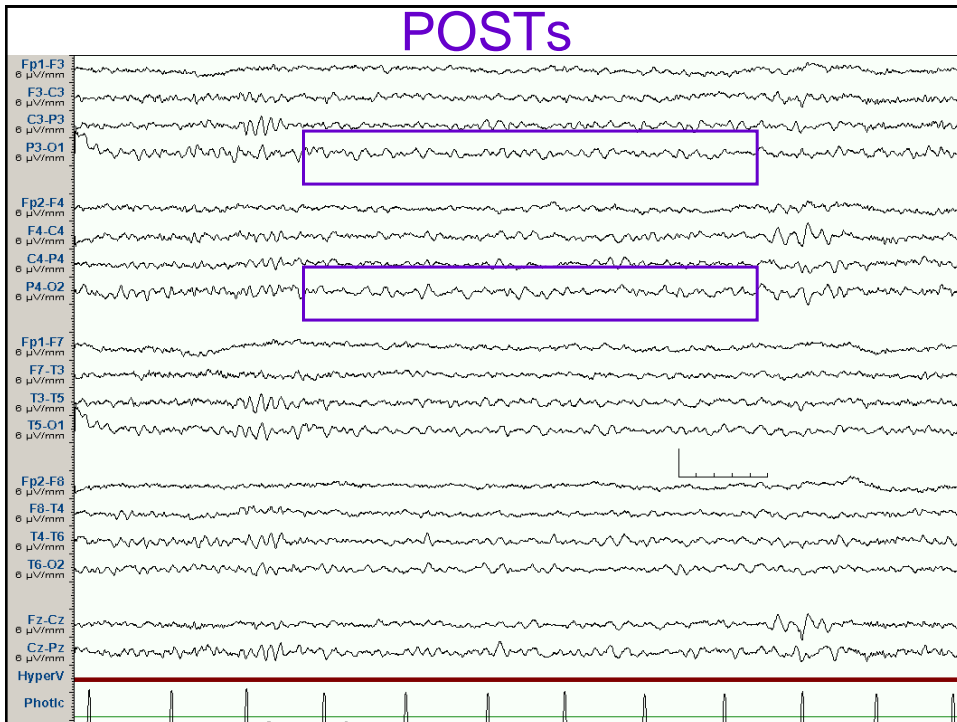
Hypnagogic hypersynchrony

- Burst of generalized high voltage 3-5 Hz
- Maximum fronto-central
- Awake → sleep
- Begin 6 months
- Best seen 1-5 years
- Rare after 11-12 years
- Hypnapompic: sleep → awake



POSTs

- Positive occipital sharp transients of sleep
- 4-5 Hz, checkmark-like, isolated or in trains
- Esp. daytime nap, arousal \rightarrow return to sleep
- Commonly asymmetry
- Age 4-50 years
- Best seen 15-35 years

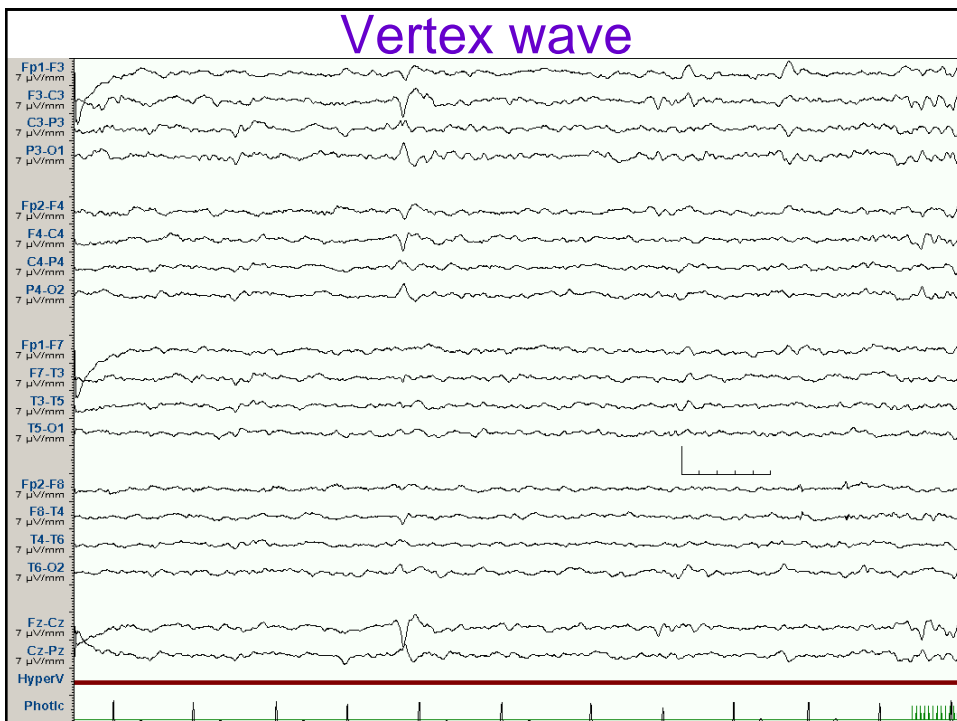


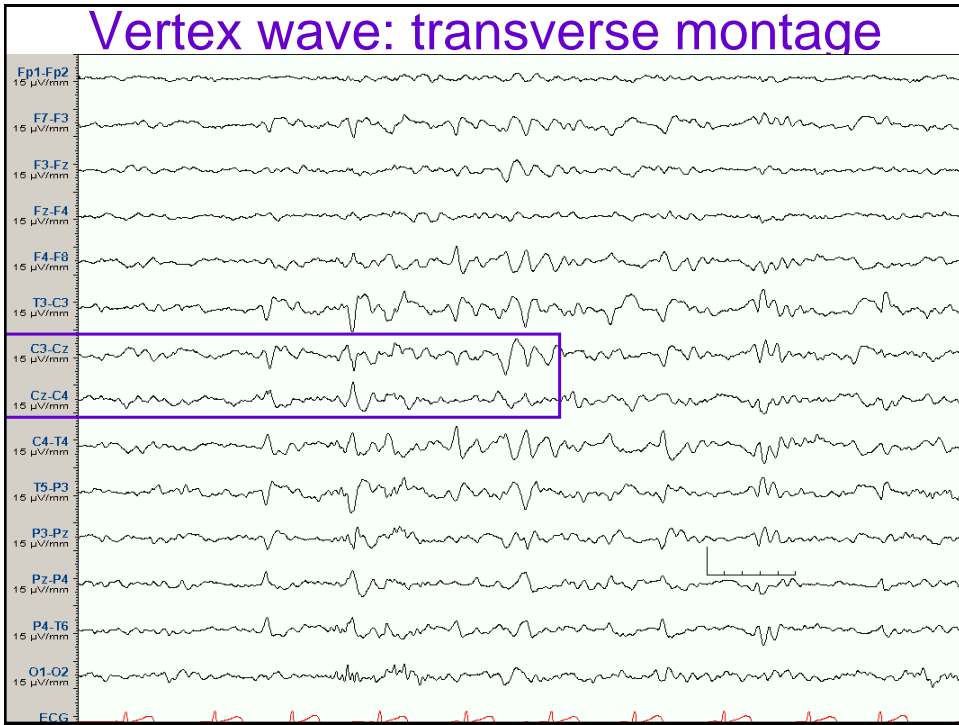
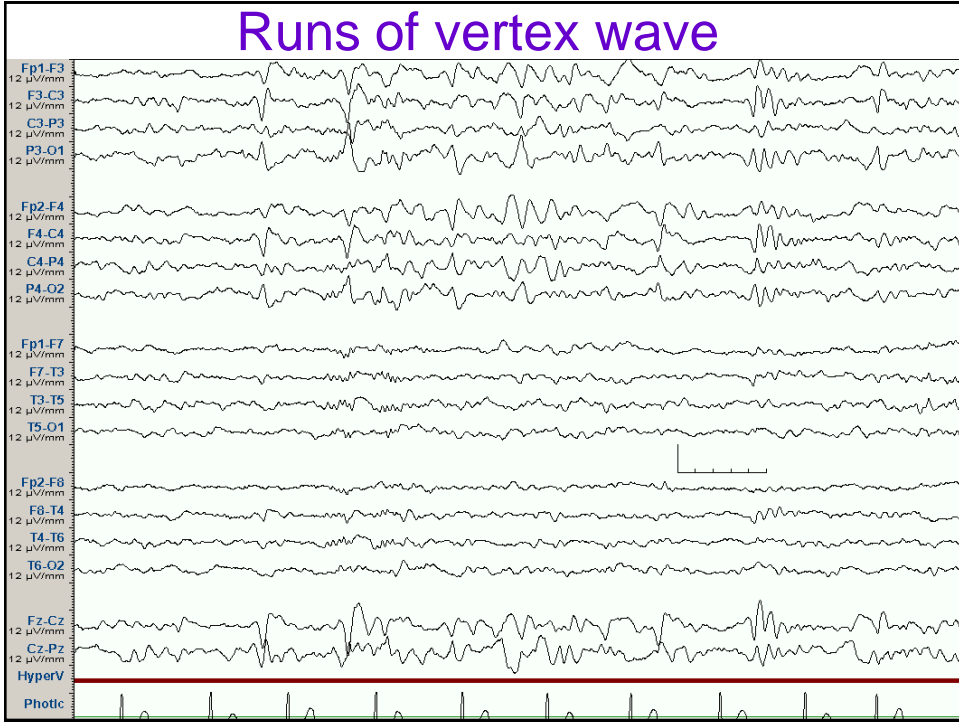
Beta activity

- 18-25 Hz, low voltage
- Maximum central region
- Begin 5-6 months
- Best seen 12-18 months
- Rare after 3 years

Vertex wave

- Sharp transient maximum Cz (vertex)
- Begin 8 weeks post term
- Age 1-4 years; spiky and high amplitude
- Runs of vertex





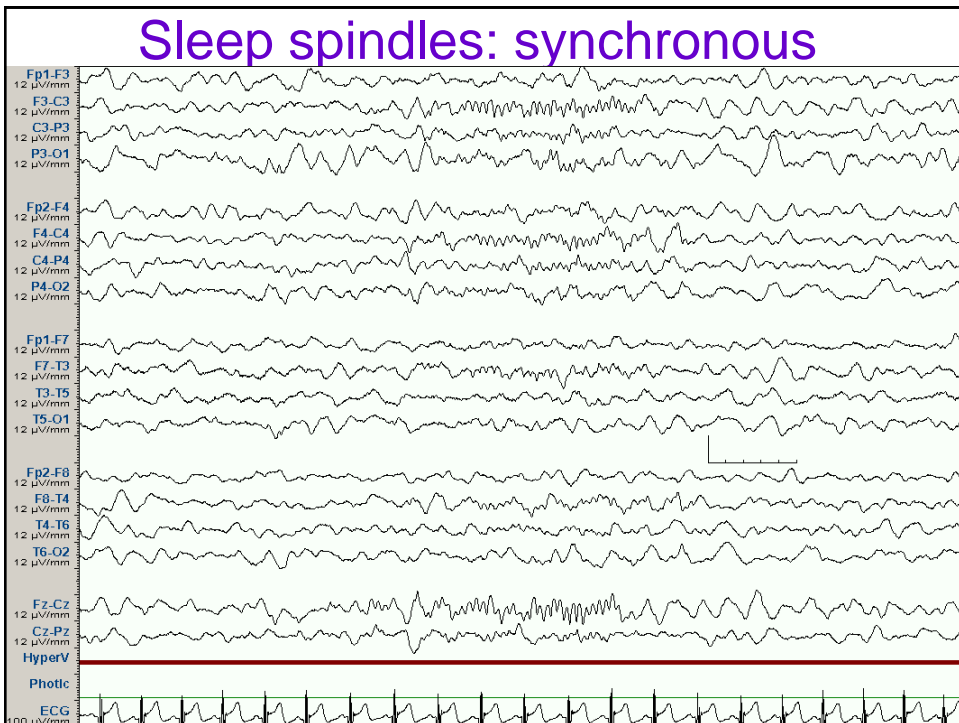
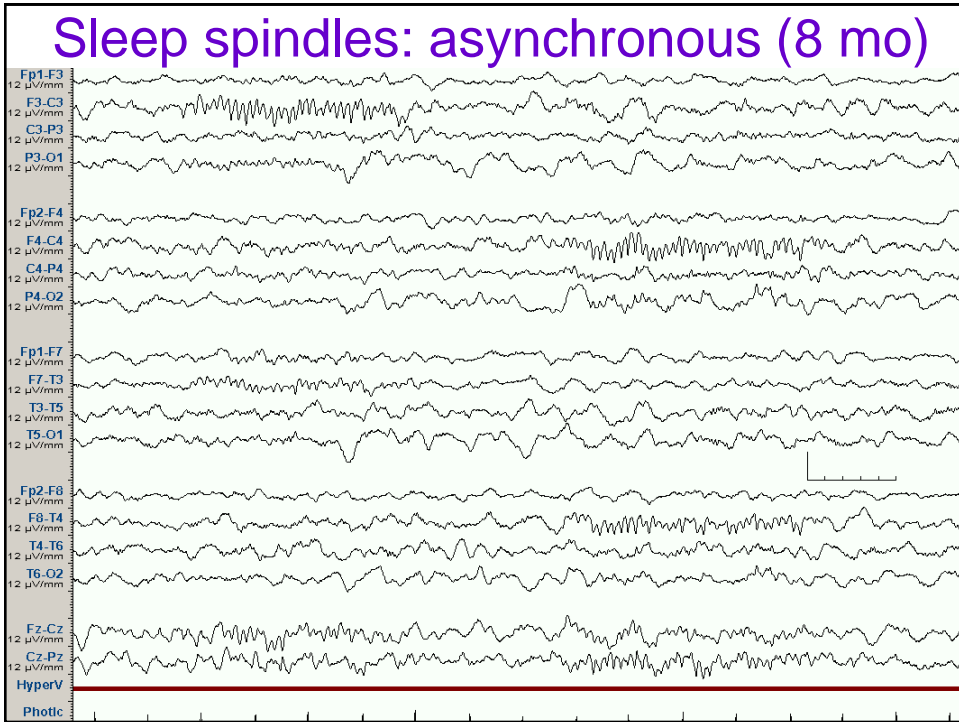
Stage 2

- Sleep spindles
- K-complex
- Delta wave
- (Vertex, POSTs)

Sleep spindles

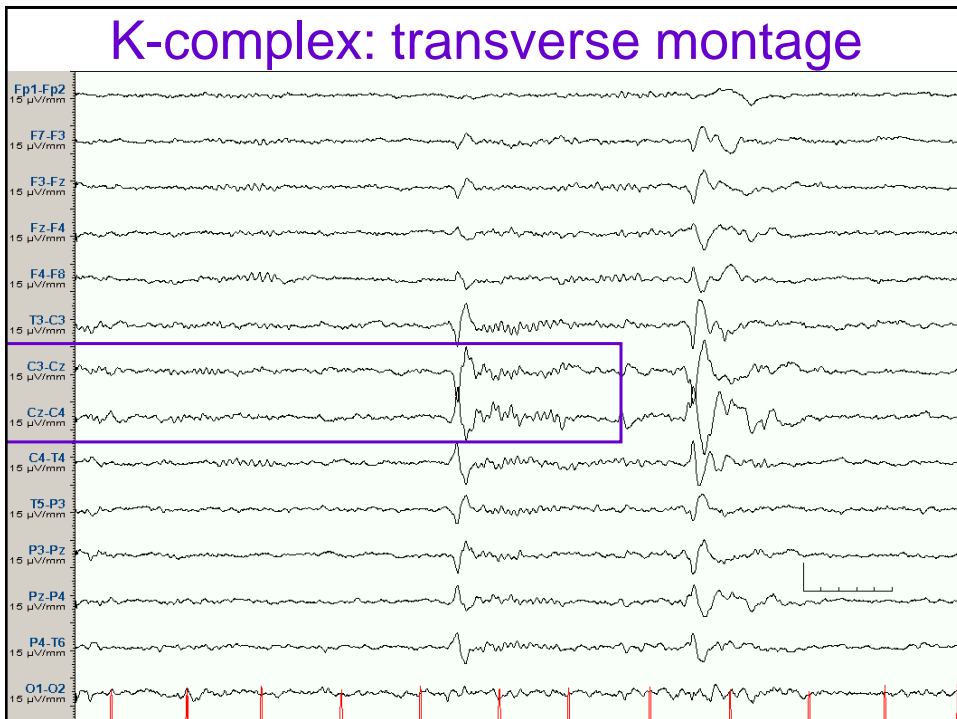
- 11-14 Hz
- Maximum central, frontal (Cz, C3C4, F3F4)
- 2-5 seconds duration, may be spiky
- Lack of fusiform shape as in adult

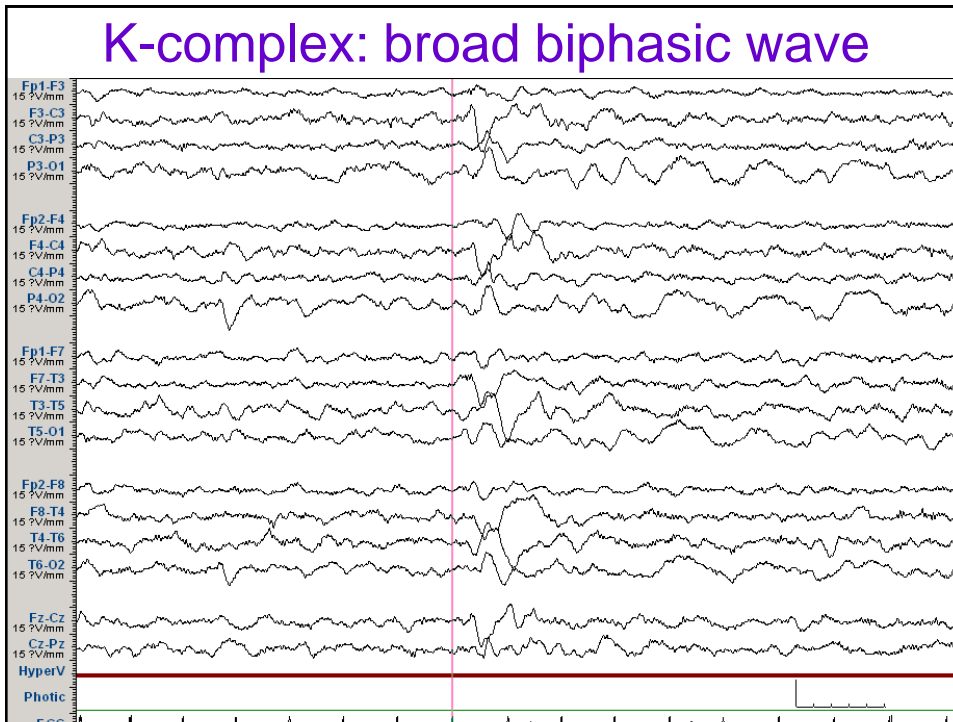
- Begin 6-8 weeks post term; asynchronous but symmetrical
- Age 2 years; synchronous



K-complex

1. Vertex + spindles
2. Biphasic high amplitude slow wave
> 0.5 seconds duration
 - Maximum Cz (vertex)
 - Begin 5 months



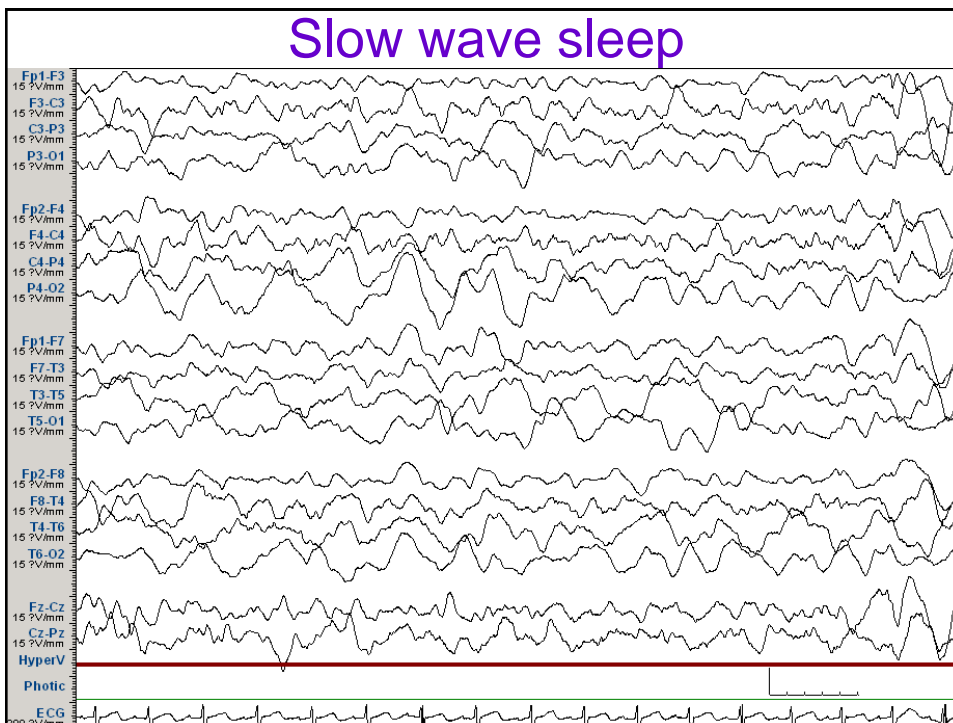


Stage 3 & 4

- Delta activity
- (Sleep spindles)

Delta activity

- 20-50% → stage III
- > 50% → stage IV



REM

- Sleep onset in newborn until 2.5 months, then NREM onset
- Rapid eye movement
- Relatively absent EMG
- Intermixed delta/theta, saw tooth appearance
- Rarely seen in routine pediatric EEG

Arousal

- Brief arousal period from sleep
- Abrupt change of the background
- Biphasic slow wave: begin 3 mo
- 4-5 Hz: begin 7 mo
- 8-10 Hz: adolescent
- Usually 4-5 seconds or longer

Activation

- Eye opening & eye closure
- Photic stimulation
- Hyperventilation

Photic stimulation

Done in dimly lit room, 30 cm away from eyes

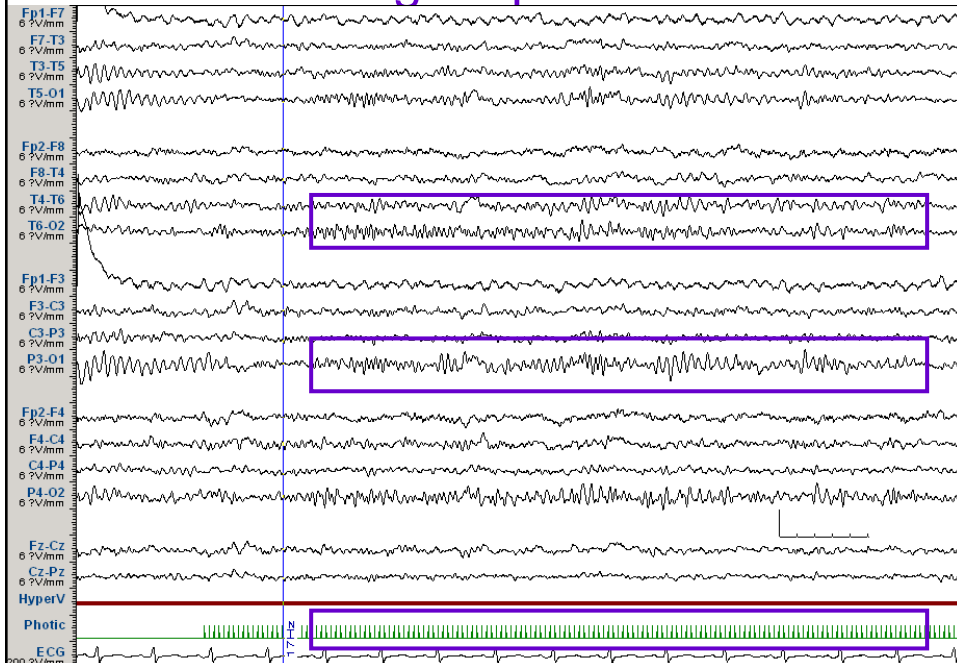
Frequency 1-30 Hz

- Visual evoked response
- Photo myogenic response
- Photic driving response

Photic driving response

- Usually > 3 Hz
- Posterior head region
- Related to stimulus frequency
- Asymmetry is not associated with structural brain disease in the absence of other abnormalities

Photic driving response at 17 Hz



Hyperventilation test

- Duration 3 minutes; adequate
- Normal response: build up of diffuse, synchronous high voltage delta activity
- More prominent posteriorly in age < 8 yrs
- Change usually resolve within 60 seconds

HV response (11 yo)



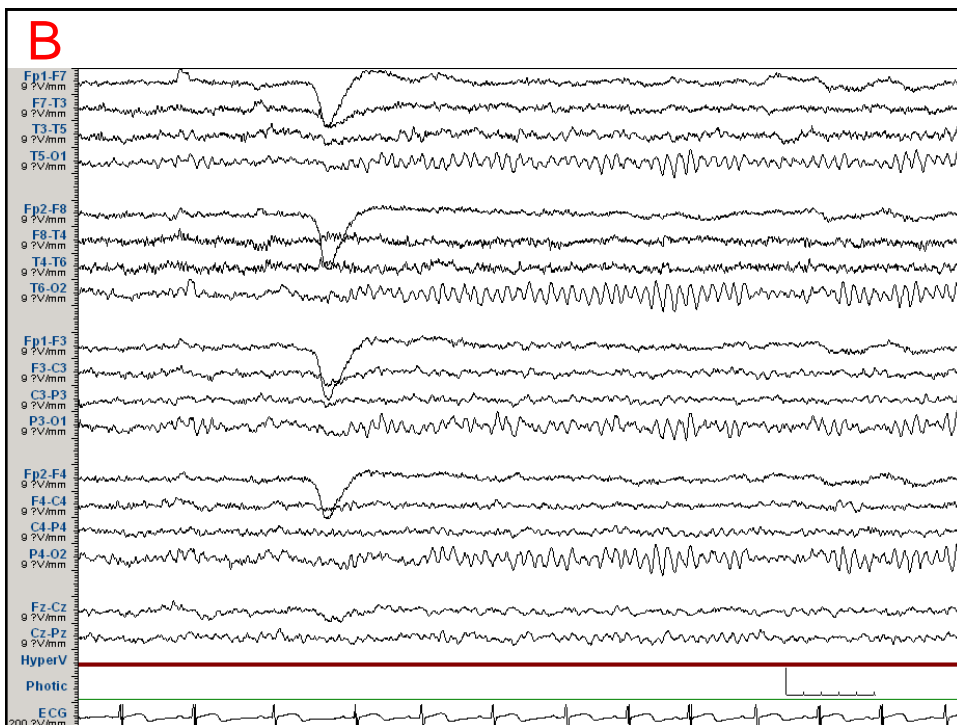
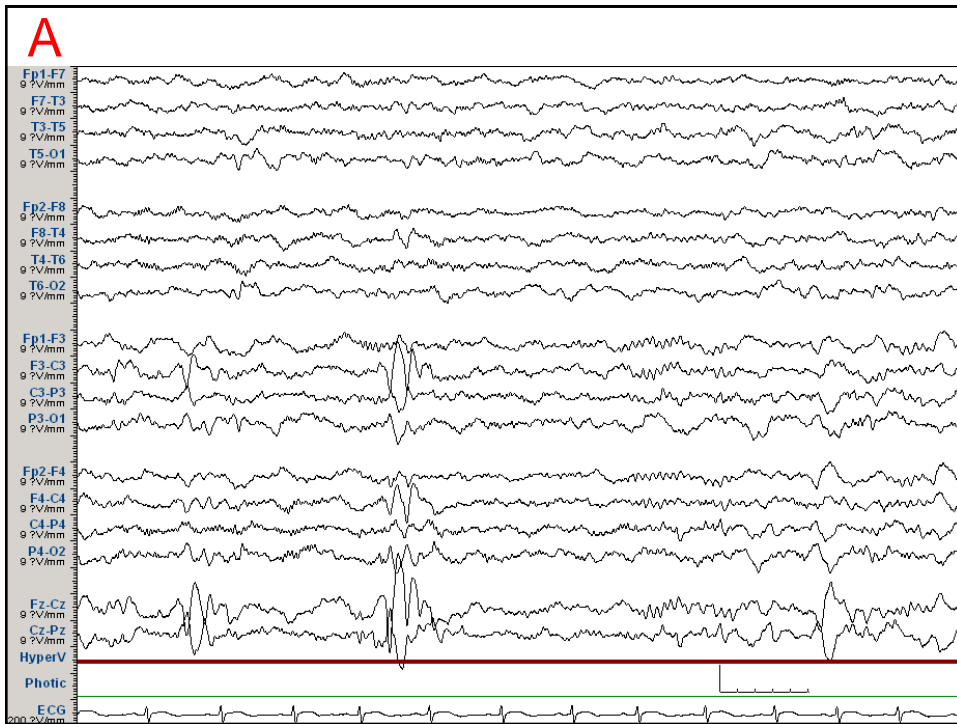
Reading EEG

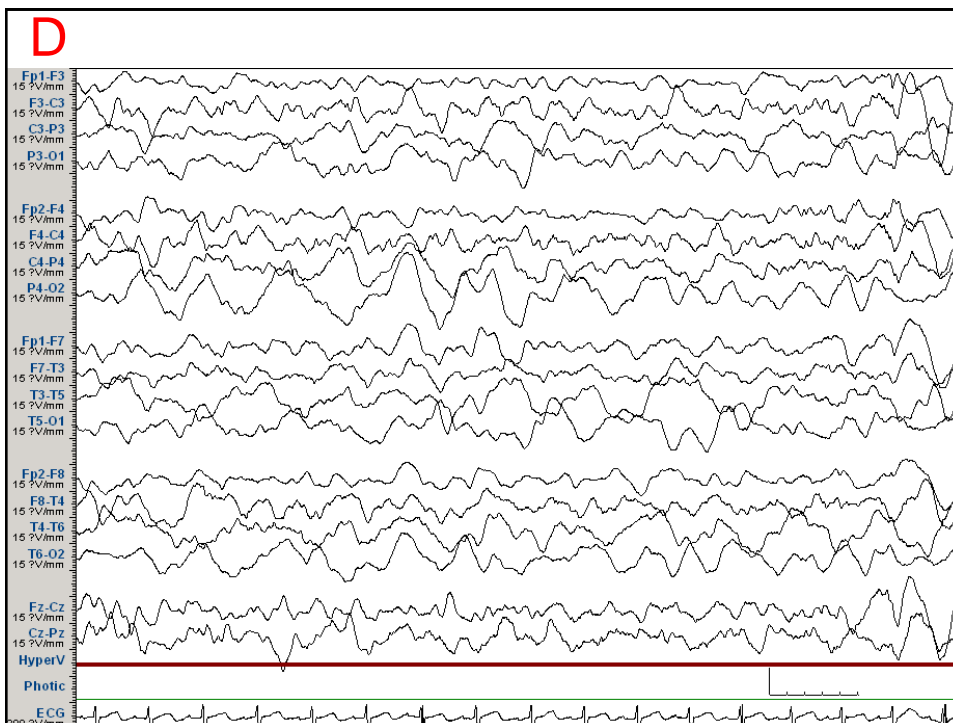
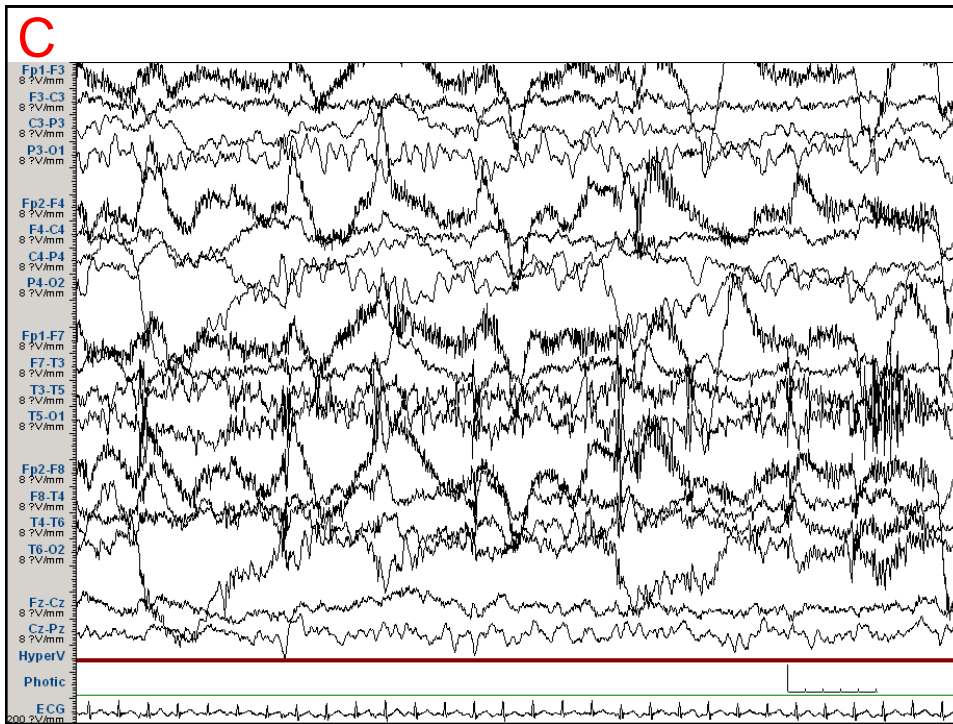
- **Age** of the patient
- Type of EEG **montage**
- **State** of the patient
- What is **normal EEG**?
- Which is not EEG (**not from the brain**)?
- Know **polarity** (upward deflection is negative on referential montage)

EEG example

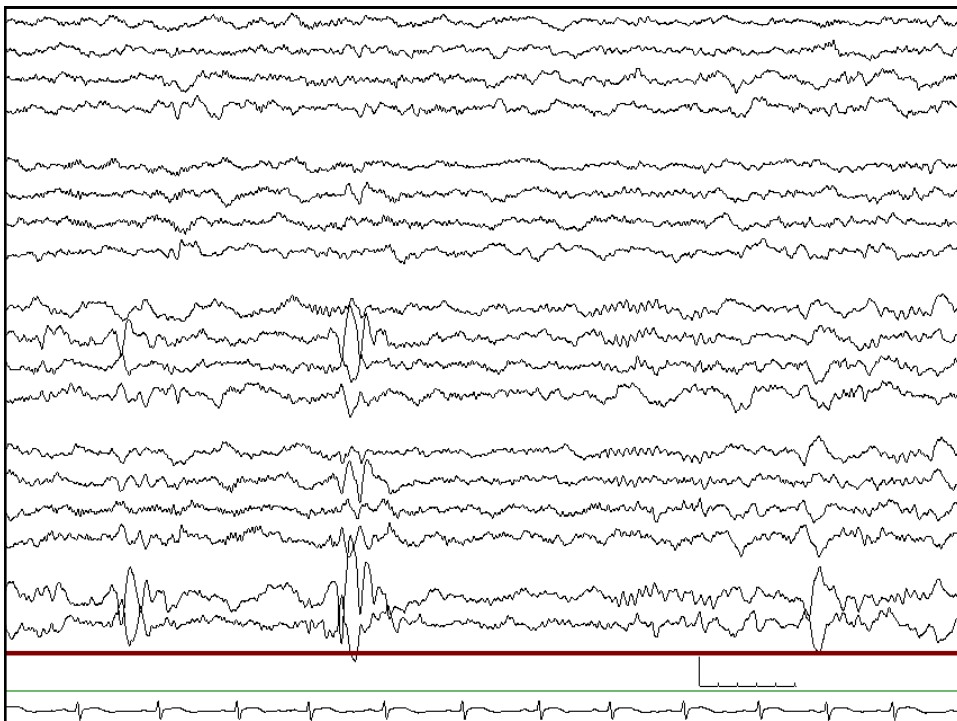
QUIZ ?

1. ข้อใดเป็น **EEG** ของผู้เข้าร่วมประชุมในขณะนี้



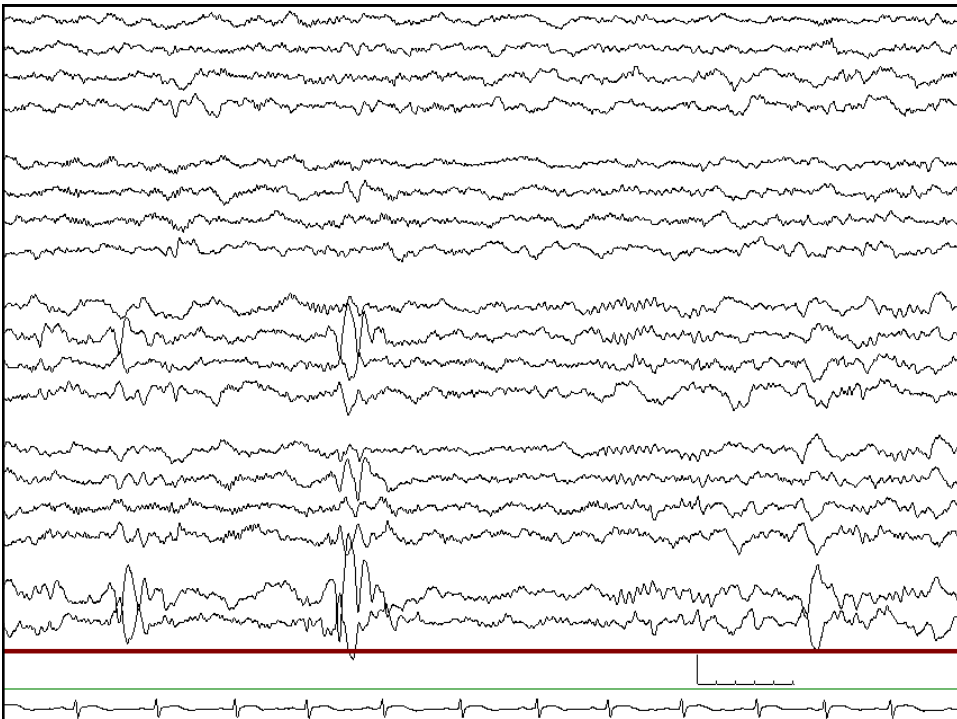


2. จงตอบคำถาม 2 ข้อจาก EEG ต่อไปนี้



2.1) Montage?

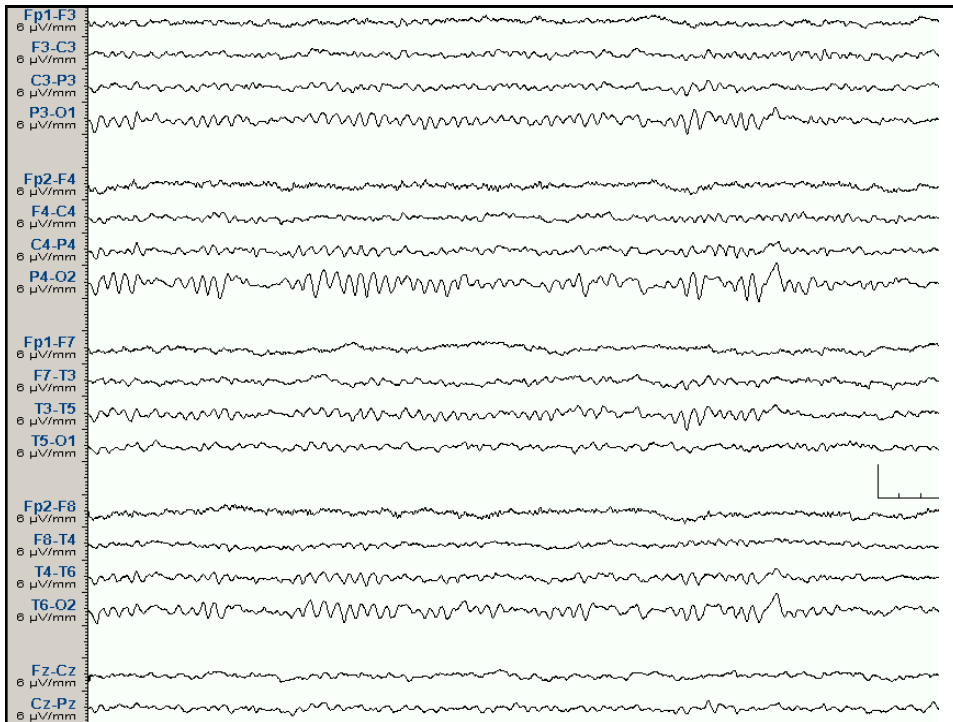
- A. Referential montage
- B. AP bipolar montage
- C. Coronal bipolar montage
- D. Dejavu montage



2.2) patient's state?

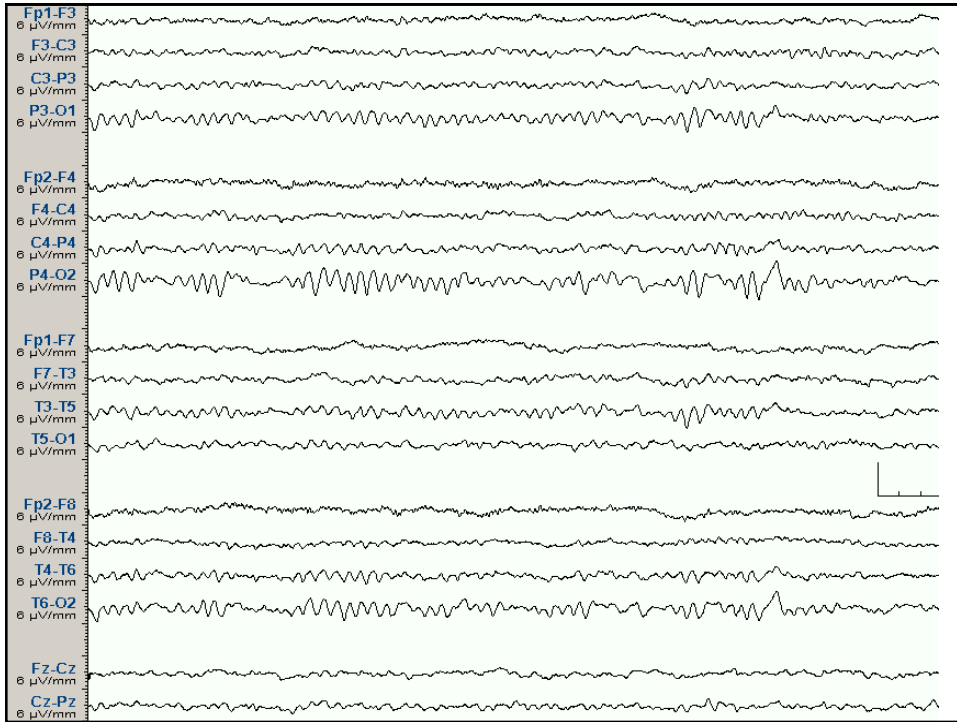
- A. Awake
- B. Drowsy
- C. Sleep stage 2
- D. Sleep stage 3-4
- E. Sleep stage 5

3. จงตอบคำถาม 2 ข้อจาก EEG ต่อไปนี้



3.1) patient's state?

- A. Awake
- B. Drowsy
- C. Sleep stage 2
- D. Sleep stage 3-4
- E. Sleep stage 5



3.2) patient's age?

- A. 2 months
- B. 1 year
- C. 4 years
- D. 9 years
- E. 30 years

Thank you for your attention

