

Normal EEG in adult

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Talk

- Definition of **normal/abnormal** EEG
- **Descriptors** of EEG activity
- Normal EEG of **wakeful** resting adults (20-60 years)
- Normal **sleep** EEG of adults (over 20 yr)
- Normal EEG of the elderly (over 60 yr)
- Activation procedures

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Definition of normal/abnormal EEG

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Definition

- EEG usually called "**normal**"
 - Not because it contains normal patterns
 - Because it lacks abnormal patterns
- EEG called "**abnormal**"
 - Contain abnormal components
 - Regardless of whether contain normal components

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Definition

- A wide "**variety**" of normal EEG patterns seen
 - between persons of the same age
 - greater among different age groups
 - more in waking than in sleep record
- Normal variants

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Definition

- There are only a few definitely abnormal EEG components in any age group
 - Spikes, sharp waves
 - **abnormal** slow waves
 - **abnormal** amplitude changes

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Definition

- Normal EEG **not guarantee** the absence of brain pathology
 - Not all brain pathology / dysfunction produce EEG abnormalities
- Abnormal EEG **not always** indicate cerebral abnormality
 - Few specific mild EEG abnormalities seen in some instances in normal persons

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Descriptors of EEG activity

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Descriptors of EEG activity

- | | |
|----------------|------------------|
| ■ Wave form | ■ Phase relation |
| ■ Repetition | ■ Timing |
| ■ Frequency | ■ Persistence |
| ■ Amplitude | ■ Reactivity |
| ■ Distribution | |

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Wave form

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Wave form

- **Wave** = any change in difference of electrical potential between two recording electrodes ☹️
- Sequence of waves = **activity** ☹️

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Wave form

- Monophasic wave
 - Single deflection: up or down ☹️
- Diphasic wave
 - 2 components on opposite sides ☹️
- Triphasic wave
 - 3 components alternating about baseline ☹️
- Polyphasic wave
 - 2 or more components of different direction

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Wave form

- Transient wave
 - Single wave or complex waves
 - Clearly standing out against background
 - Regarding "not definitely abnormal"
- Sharp transient
 - Sharply contoured waveform
 - Not abnormal epileptiform waveform ☹️

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Wave form

- Paroxysmal activity
 - One or more wave
 - Begin abruptly
 - Reach maximum amplitude abruptly
 - Disappear suddenly
 - Clearly standing out of background
 - Usually abnormal

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Repetition

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Repetition

- Regular or rhythmic repetitive waves
 - Similar intervals between individual waves
 - Often, similar shape ☹️
- Irregular or arrhythmic repetitive waves
 - Variable, irregular intervals between individual waves
 - Sequence of waves of different frequency
 - Often, irregular shape ☹️

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Regular or rhythmic repetitive waves

- Sinusoidal waves
 - Sine-wave shape ☹️
- Spindles
 - Gradually increase and then decrease in amplitude ☹️

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Frequency

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Frequency

- Number of times a repetitive wave recurring in one second ☹️
- Frequency of a single wave
 - Calculated from wave length ☹️
- Periodic wave or complex
 - "Period" being calculated from "time interval" between them ☹️

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Frequency bands

- Delta frequency band
 - Under 4 Hz ☹️
- Theta frequency band
 - From 4 to under 8 Hz ☹️
- Alpha frequency band
 - From 8 to 13 Hz ☹️
- Beta frequency band
 - Over 13 Hz ☹️

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Frequency

- Fast activity
 - Over 13 Hz
- Slow activity
 - Under 8 Hz
- Frequency not regarded as cerebral activity
 - Less than 0.5 Hz
 - More than 20 Hz

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Amplitude

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Amplitude

- Measured in microvolt (μV)
- Measuring total vertical distance of wave
- Range
 - Low, under 20 μV
 - Moderate or medium, 20-50 μV
 - High, over 50 μV ☹️

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Amplitude

- Asymmetry
 - Comparing between corresponding parts of two sides
 - Simultaneous time
 - Abnormal
 - If persist
 - For alpha rhythm; different more than two times

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Amplitude

- Affected by
 - Spacing
 - Impedance

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Distribution

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Distribution

- Occurrence of electrical activity recorded by electrodes positioned over different parts of head
- Practically used distribution
 - Widespread, diffuse or generalized ☹️
 - Lateralized ☹️
 - Focal or localized ☹️

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Timing

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Timing

- Timing of waves in different areas
 - Similar
 - Simultaneous: broadly precise coincidence
 - Synchronous: definitely precise coincidence
 - Bilaterally synchronous or bisynchronous
 - Different
 - Asynchronous
 - Independent

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Persistence

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Persistence

- To describe how often activity occurs
 - Occasionally
 - Sporadic: irregular and infrequent
 - Intermittently
 - Periodic
 - Throughout
 - Persistent
- May be calculated as "index"

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Reactivity

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Reactivity

- Changes produced by various maneuvers
 - Increased
 - Diminished
 - Blocked

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Reactivity

Maneuvers

- Opening or closing eyes
- Hyperventilation
- Photic stimulation
- Sensory stimulation
- Changes in level of alertness
- Movements, e.g. arm movement
- Others, e.g. simple calculation

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Normal EEG of wakeful resting adults (20-60 years)

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Normal EEG of wakeful resting adults (20-60 years)

Composed of various types of activity
alone or in combination

- | | |
|--------------------------|--|
| ■ Alpha rhythm | ■ Kappa rhythm |
| ■ Beta rhythms | ■ Intermittent posterior theta rhythms |
| ■ Mu rhythm | ■ Low voltage activity |
| ■ Lambda waves | |
| ■ Vertex sharp transient | |

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Alpha rhythm

defined by frequency, distribution and reactivity

- **Frequency** : alpha activity, 8-13 Hz
 - Fairly constant
 - Equal in both sides
- **Distribution** : posterior part
 - Greatest amplitude and most persistent in occipital and parietal areas
 - Seen in temporal and central in the young
- **Reactivity** : blocked by eye opening, sudden alerting, attention and mental concentration

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Alpha rhythm

- **Wave form** : regular, often sinusoidal
- **Phase relation** : may vary over different parts
- **Timing** : simultaneous on both sides
- **Persistence** :
 - Vary among normal subject
 - Prominent, waxes and wanes, rare occurrence, complete absence
 - Decrease with age

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Beta rhythms

- **Defined by only frequency**: over 13 Hz
- **Distribution**
 - Frontal beta rhythms
 - Widespread beta rhythm
 - Posterior beta rhythm or fast alpha variant
- **Reactivity**: disappear in drowsiness/sleep

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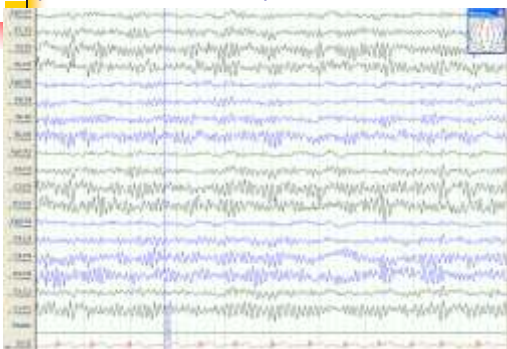
Beta rhythms

- **Amplitude** :
 - Usually lower than alpha activity
 - Symmetry, different less than 35% in amplitude
- **Persistence** : increase with age

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คลื่นไฟฟ้าสมองปกติขณะพักและหลับตา (alpha rhythm, posterior slow wave of youth, frontal beta activity)



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Normal sleep EEG of adults (over 20 yr)

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Normal sleep EEG of adults (over 20 yr)

Elements of sleep EEG

- Slow wave ☹️
- Sleep spindles ☹️
- Positive occipital sharp transients of sleep (POSTs) ☹️
- Vertex sharp wave ☹️
- K complexes ☹️

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Normal sleep EEG of adults (over 20 yr)

Eye movements during sleep

- Slow lateral eye movements ☹️
- Rapid eye movement ☹️

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Normal sleep EEG of adults (over 20 yr)

Sleep stages

- Drowsiness ☹️
- Stage I ☹️
- Stage II ☹️
- Stage III
- Stage IV ☹️
- Stage REM ☹️

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Normal EEG of the elderly (over 60 yr)

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Normal EEG of the elderly (over 60 yr)

Similar to that of younger adults except

- Alpha rhythm
 - May be slower, less persistent, less reactive
- Beta activity
 - Often more prominence
- Sporadic generalized slow wave
 - Slightly more common

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Normal EEG of the elderly (over 60 yr)

- Intermittent temporal slow waves
 - Appear in some apparently normal subjects
- Sleep
 - Less deep, more often interrupted by wakefulness

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Activation procedures

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Activation procedures

- To induce, enhance or better define abnormal EEG patterns
- However, they may induce normal patterns that are not seen in spontaneous EEG.

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Activation procedures

- Hyperventilation
- Photic stimulation
- Sleep recordings
- Other stimuli, e.g. patterned light, startling noise, musical sounds, reading, tactile stimuli, etc.

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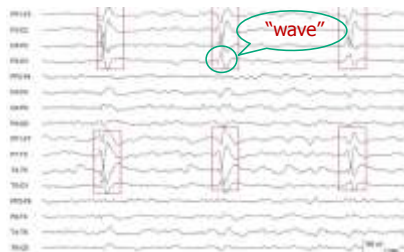
51

EXAMPLE OF EEG

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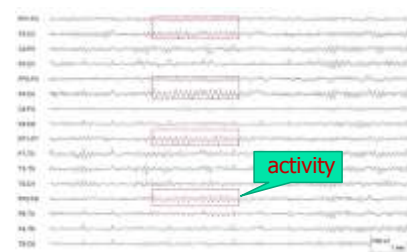
Wave = any change in difference of electrical potential between two recording electrodes 🤪



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Activity = Sequence of waves 🤪



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Monophasic wave (Single deflection: up or down)



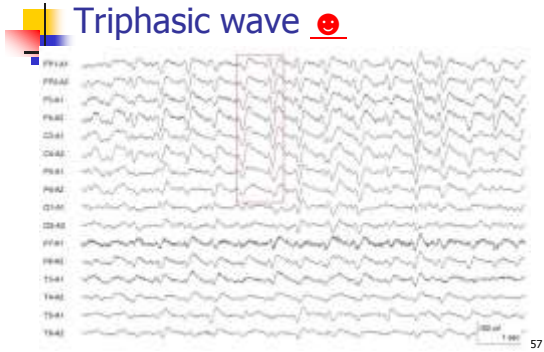
55

Diphasic wave ☹️



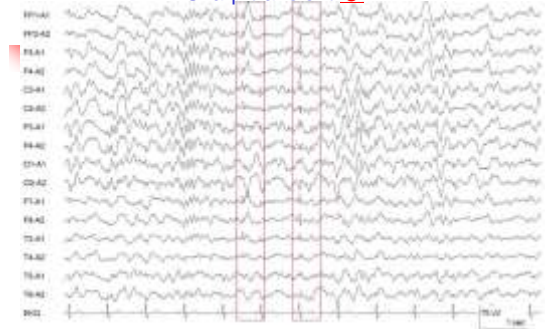
56

Triphasic wave ☹️



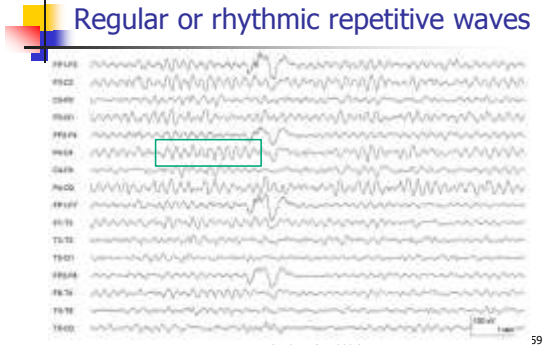
57

Sharp transient ☹️



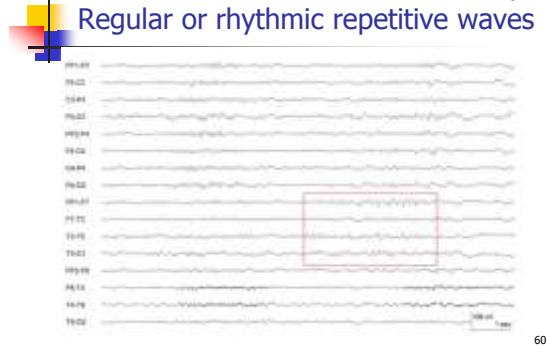
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Regular or rhythmic repetitive waves



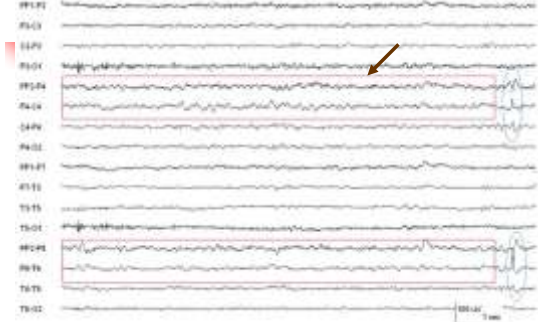
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Regular or rhythmic repetitive waves



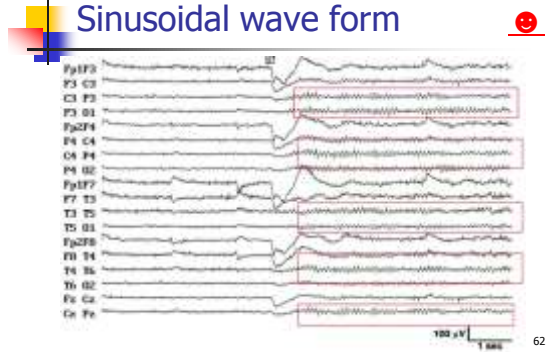
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Irregular or arrhythmic activity



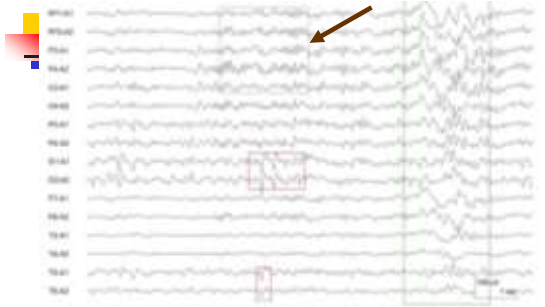
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Sinusoidal wave form



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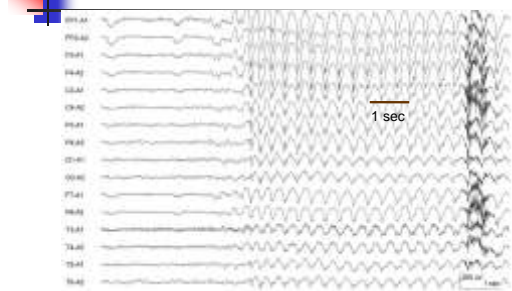
Spindles



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Frequency is number of times a repetitive wave recurring in one second.



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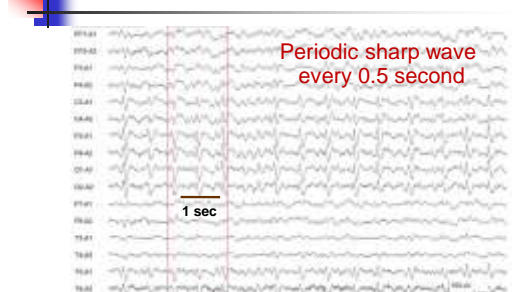
Frequency of a single wave is calculated from wave length.



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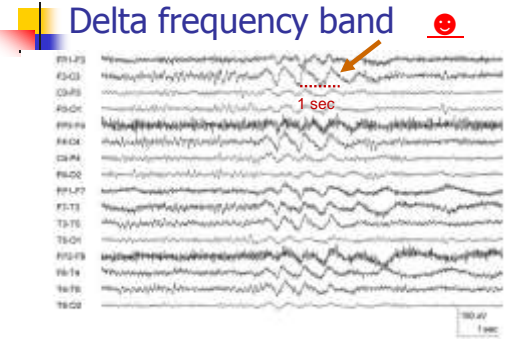
Periodic wave or complex "Period" being calculated from "time interval" between them



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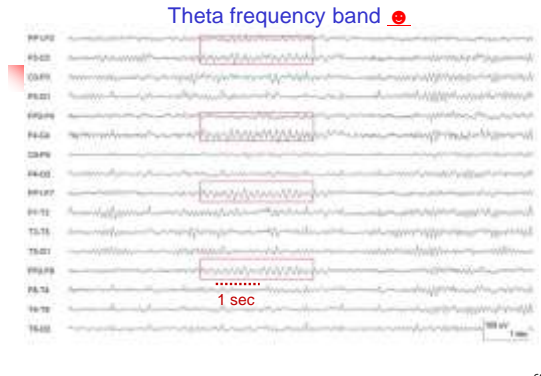
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Delta frequency band



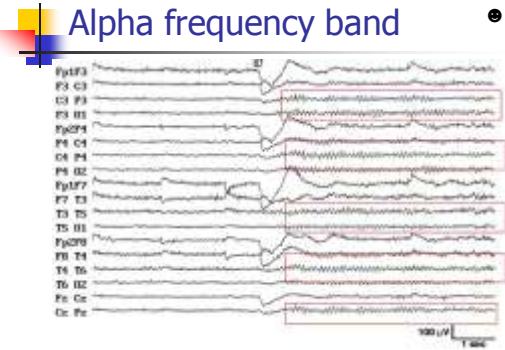
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Theta frequency band



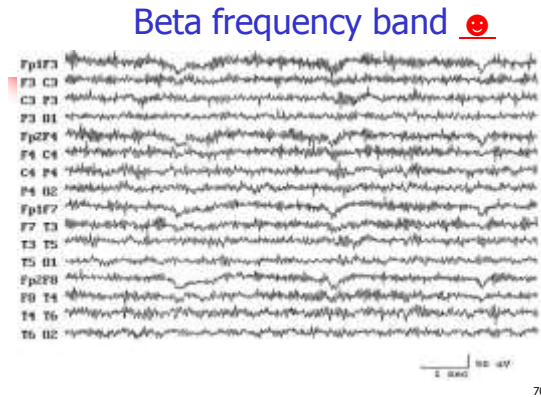
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Alpha frequency band



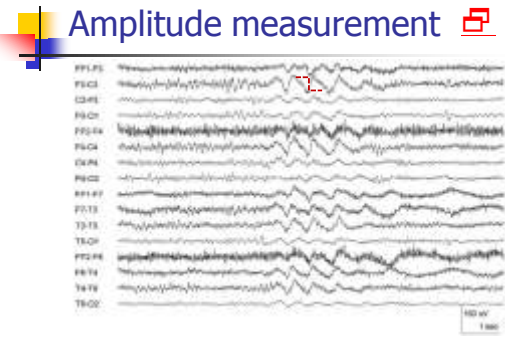
69

Beta frequency band



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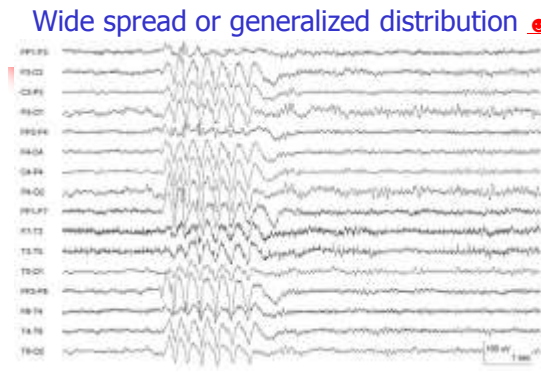
Amplitude measurement



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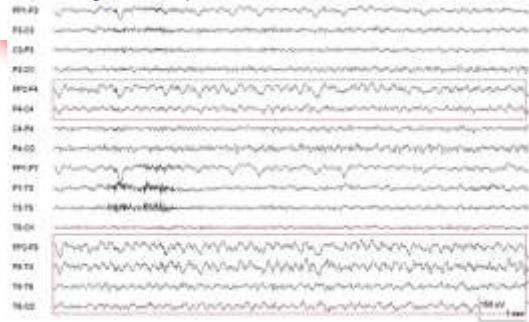
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Wide spread or generalized distribution



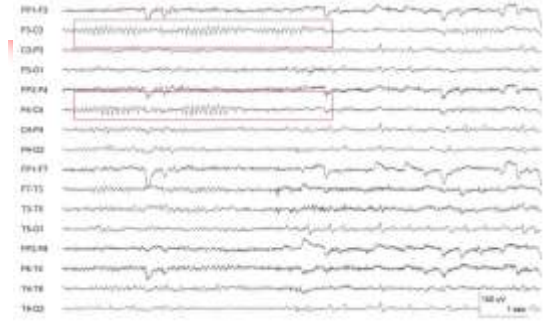
72

Right hemisphere, lateralized distribution 🟡



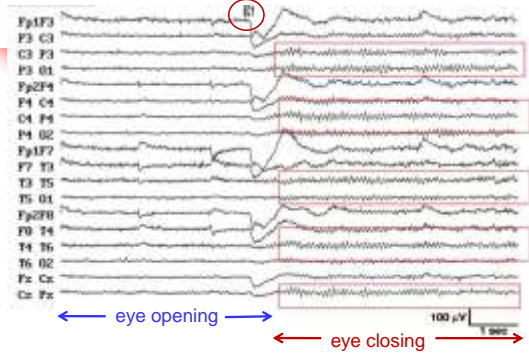
73

Localized distribution, central area 🟡



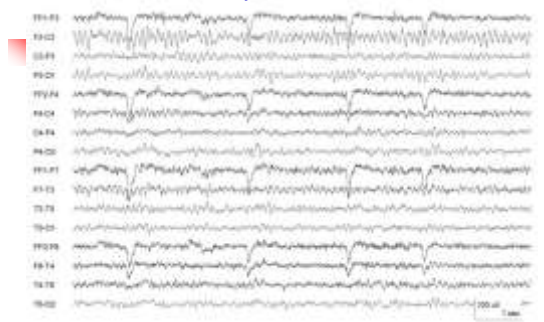
74

Alpha rhythm blocked by eye opening 🟡



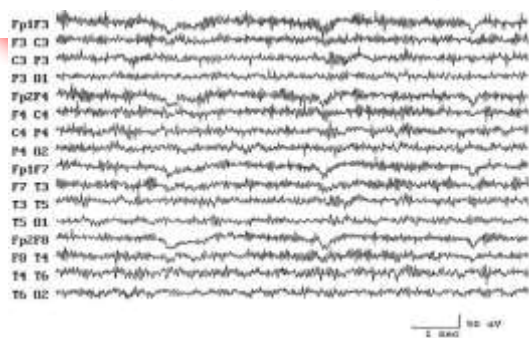
75

Beta activity in both frontal areas 🟡



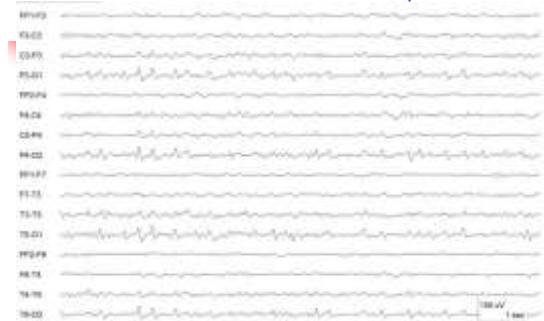
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Widespread beta activity 🟡



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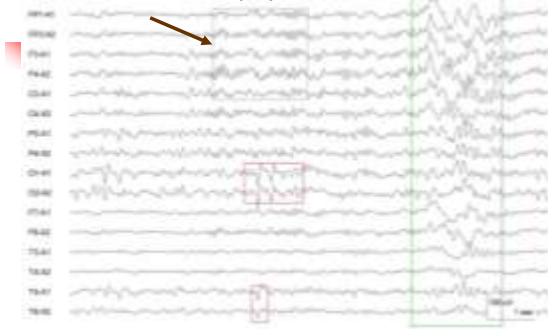
Slow waves in NREM sleep 🟡



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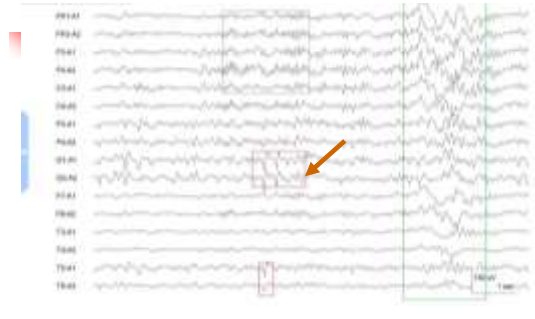
Sleep spindle 🚫



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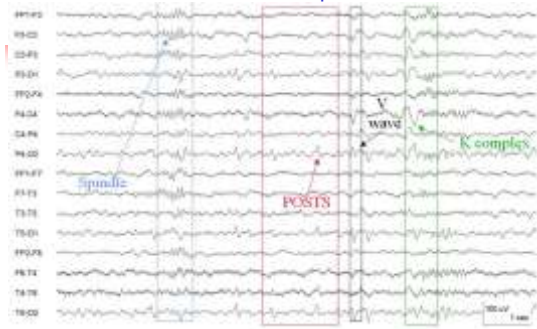
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POSTs 🚫



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Non-REM sleep 🚫



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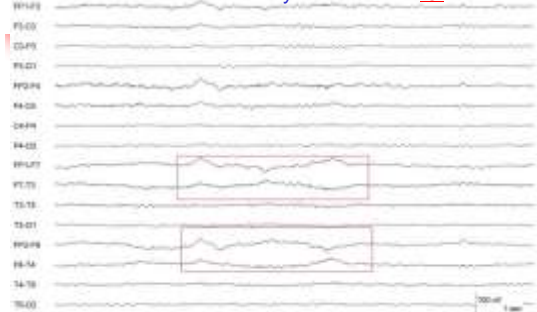
81

K complexes 🚫



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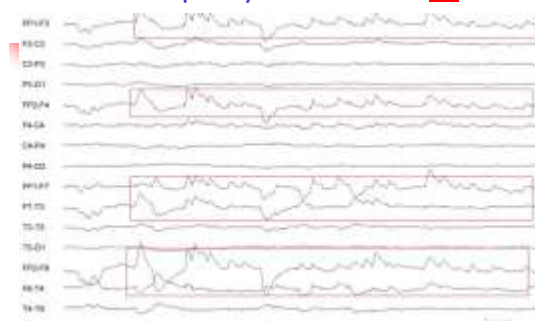
Slow lateral eye movement 🚫



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Rapid eye movement 🚫

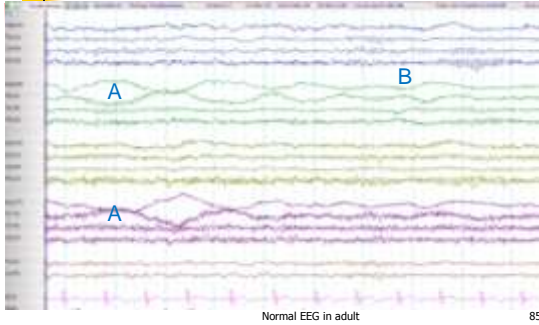


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EEG in drowsiness :

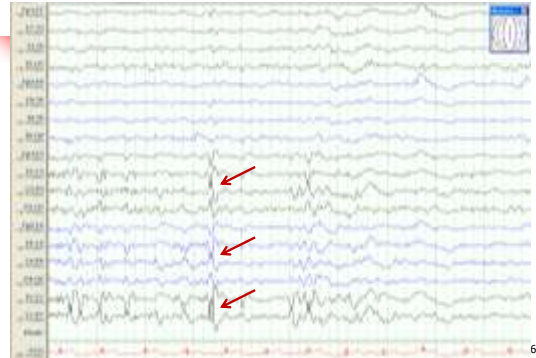
- A. Slow lateral eye movement and
- B. Waxing and waning of posterior alpha rhythm



Normal EEG in adult

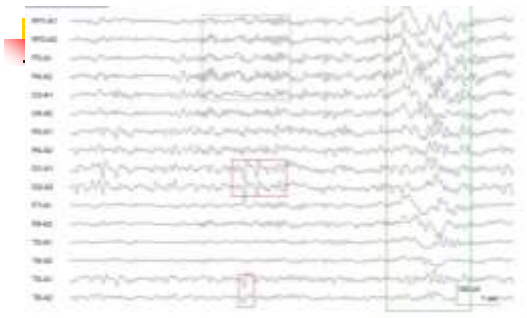
85

Sleep stage 1: sleep vertex sharp wave



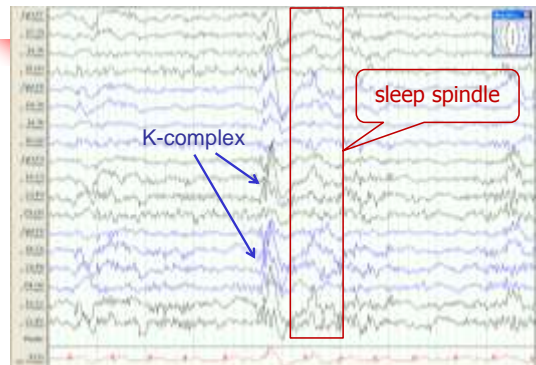
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Sleep stage II

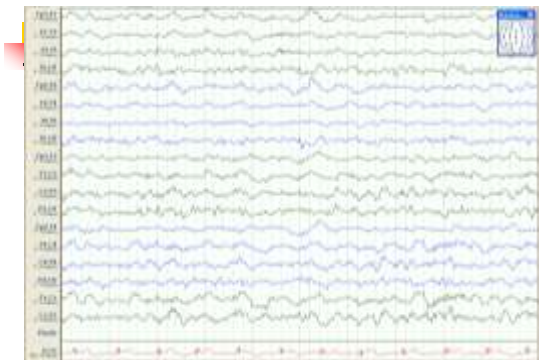


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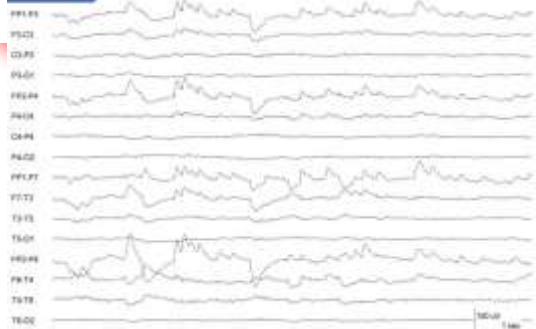
Sleep stage II : K-complex and sleep spindle



Sleep stage III-IV



REM sleep



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