ELECTROENCEPHALOGRAPHY (EEG)
EEG

- The electroencephalogram (EEG) is a recording of the electrical activity of the brain from the scalp.

- The first recordings were made by Hans Berger in 1929
Origin of EEG waves
Electroencephalogram

- EEG is the record of electrical activity of brain (superficial layer i.e. the dendrites of pyramidal cells) by placing the electrodes on the scalp.
Intracranial EEG (ECoG)
Intracranial EEG (ECoG)
Objectives of EEG practical

- Familiarize with the principles of techniques involved
- Count frequencies and measure the amplitudes of the record obtained.
- Categories the records into appropriate rhythms – α, β, θ, and δ.

Cont...
Objectives of EEG practical

- Identify and describe changes produced by provocation tests.
  e.g. eye opening & closing, intermittent photic stimulation (IPS) clapping sound, induce thinking & hyperventilation.

- Appreciate clinical uses of EEG
EEG Waves

- Alpha wave -- 8 – 13 Hz.
- Beta wave -- >13 Hz. (14 – 30 Hz.)
- Theta wave -- 4 – 7.5 Hz.
- Delta waves – 1 – 3.5 Hz.
Different types of brain waves in normal EEG
Alpha wave

- rhythmic, 8-13 Hz
- mostly on occipital lobe
- 20-200 μV
- normal,
- relaxed awake rhythm with eyes closed
Beta wave

- irregular, 14-30 Hz
- mostly on temporal and frontal lobe
- mental activity
- excitement
Theta wave

- Rhythmic, 4-7 Hz
- Drowsy, sleep
Delta wave

- slow, < 3.5 Hz
- in adults
- normal sleep rhythm
BETA: Alert/Working

ALPHA: Relaxed/Reflecting

THETA: Drowsy/Ideating

DELTA: Sleep/Dreaming

DELTA: Deep, Dreamless Sleep
Different types of brain waves in normal EEG

<table>
<thead>
<tr>
<th>Rhythm</th>
<th>Frequency (Hz)</th>
<th>Amplitude (μV)</th>
<th>Recording &amp; Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha(α)</td>
<td>8 – 13</td>
<td>50 – 100</td>
<td>Adults, rest, eyes closed. Occipital region</td>
</tr>
<tr>
<td>Beta(β)</td>
<td>14 - 30</td>
<td>20</td>
<td>Adult, mental activity Frontal region</td>
</tr>
<tr>
<td>Theta(θ)</td>
<td>5 – 7</td>
<td>Above 50</td>
<td>Children, drowsy adult, emotional distress Occipital</td>
</tr>
<tr>
<td>Delta(δ)</td>
<td>2 – 4</td>
<td>Above 50</td>
<td>Children in sleep</td>
</tr>
</tbody>
</table>
Requirements

- EEG machine (8/16 channels).
- Silver cup electrodes/metallic bridge electrodes.
- Electrode jelly.
- Rubber cap.
- Quiet dark comfortable room.
- Skin pencil & measuring tape.
Computerized EEG Machine
EEG Electrodes

Sliver Electrodes  Electrodes Cap
Procedure of EEG recording

- A standard EEG makes use of 21 electrodes linked in various ways (Montage).
- Apply electrode according to 10/20% system.
- Check the impedance of the electrodes.
10/20 % system of EEG electrode placement
EEG Electrodes

- Each electrode site is labeled with a letter and a number.
- The letter refers to the area of brain underlying the electrode
  e.g. F - Frontal lobe and T - Temporal lobe.
- Even numbers denote the right side of the head and
- Odd numbers the left side of the head.
Two types of recording

- Bipolar – both the electrodes are at active site
  - Bipolar montage are parasagittal montage.
- Unipolar – one electrode is active and the other is indifferent kept at ear lobe.
  - Always watch for any abnormal muscle activity.
  - Ask the subject to open eyes for 10 sec. then ask them to close the eyes.
Montage

- Different sets of electrode arrangement on the scalp by 10 – 20 system is known as montage.
- 21 electrodes are attached to give 8 or 16 channels recording.
Analysis

- Electrical activity from the brain consist of primarily of rhythms.
- They are named according to their frequencies (Hz) and amplitude in micro volt (μv).
- Different rhythms at different ages and different conditions (level of consciousness)
- Usually one dominant frequency (background rhythm)
Factor influencing EEG

- **Age**
  - Infant – theta, delta wave
  - Child – alpha formation.
  - Adult – all four waves.

- **Level of consciousness (sleep)**

- **Hypocapnia (hyperventilation)** slow & high amplitude waves.

- **Hypoglycemia**

- **Hypothermia**

- **Low glucocorticoids**

  \[
  \text{Slow waves}
  \]
NORMAL EEG CHANGES
Desynchronization or Alpha block

- Cause:
  - Eyes opening (after closure)
  - Thinking by the subject (mathematical calculation)
  - Sound (clapping)
Eye opening

- Alpha rhythm changes to beta on eye opening (desynchronization / $\alpha$- block)
Thinking

- Beta waves are observed
Provocation test

- Intermittent photic stimulation
  - Increase rate & decrease amplitude

- Hyperventilation
  - Decrease rate & increase in amplitude
Use of EEG

- **Epilepsy**
  - Generalized (grandmal) seizures.
  - Absence (petitmal) seizures.
- **Localize brain tumors.**
- **Sleep disorders (Polysomnography)**
  - Narcolepsy
  - Sleep apnea syndrome
  - Insomnia and parasomnia
- **Helpful in knowing the cortical activity, toxicity, hypoxia and encephalopathy &**
- **Determination of brain death.**
  - Flat EEG (absence of electrical activity) on two records run 24 hrs apart.
Sleep studies

- The EEG is frequently used in the investigation of sleep disorders especially sleep apnoea.
- Polysomnography: EEG activity together with
  - heart rate,
  - airflow,
  - respiration,
  - oxygen saturation and
  - limb movement
Sleep patterns of EEG

- There are two different kinds of sleep:
  - Rapid eye movement sleep (REM-Sleep)
  - Non-REM sleep (NREM sleep)/ slow wave sleep

- NREM sleep is again divided into 4 stages (I to IV). The EEG pattern in sleep is given in the following table:
<table>
<thead>
<tr>
<th>Stages of sleep</th>
<th>EEG pattern</th>
<th>Somatic or Behavioral changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alert</td>
<td>Alpha activity on eye closed</td>
<td>Respond to verbal commands</td>
</tr>
<tr>
<td></td>
<td>Desynchronization on eye opening</td>
<td></td>
</tr>
<tr>
<td>I (Drowsiness)</td>
<td>Alpha dropout &amp; appearance of vertex waves &amp; theta.</td>
<td>Reduced HR &amp; RR</td>
</tr>
<tr>
<td>II (Light sleep)</td>
<td>Sleep spindles, vertex sharp waves &amp; K-complexes</td>
<td>Reduced HR &amp; RR</td>
</tr>
<tr>
<td>III (Deep Sleep)</td>
<td>Much slow background K-complexes</td>
<td>Reduced HR &amp; RR</td>
</tr>
<tr>
<td>IV (very deep sleep)</td>
<td>Synchronous delta waves, some K-complexes</td>
<td>Reduced HR &amp; RR</td>
</tr>
<tr>
<td>----------------------------</td>
<td>-------------------------------------------</td>
<td>-----------------</td>
</tr>
</tbody>
</table>
| REM sleep (paradoxical sleep) | Desynchronization with faster frequencies | HR, BP & RR irregular  
Marked hypotonia  
Rapid eye movement  
50 – 60 /min.  
Dreaming threshold of arousal |