NOTES BASED ON PIOTR NOTES :- [CH-1]

18th Oct

1.1 REASON FOR STUDYING NERVOUS SYSTEM :-

a) • By increasing knowledge of the nervous system, neuroscience aims to improve diagnosis and therapy of many nervous diseases such as epilepsy, Parkinson disease or mental disorders such as depression or schizophrenia.

b) • By understanding the neurobiological basis of human behavior → may provide an insight into nature of human behavior like hatred, love, criminal nature, talent etc.

c) • By understanding the brain → there is a hope to develop new technologies that give rise to brain-like logical operations eg:- Artificial neural networks.

1.2 BRAIN AT DIFFERENT SCALES :-

'Human brain' can be defined in a simplified manner as — a collection of 10^{11} nerve cells ie., neurons which are strongly interconnected and surrounded by 10 to 50 times more numerous glial cells (without considering the critical issue of the organization of nerve cells into functional circuits that process information and bring about behavior) ⇒ {this is the neurobiological way}

NB:- 'glial cells' surround neurons & hold them in place → provide support & protection for neurons in Central & peripheral nervous system; supply nutrients & oxygen to neurons; insulate one neuron from another.

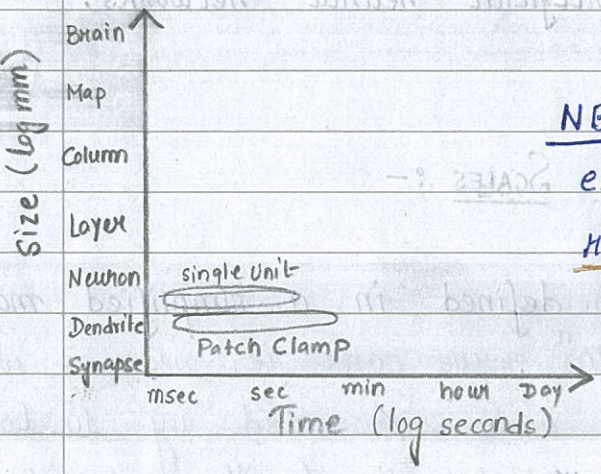
The underlying concept of neurobiological way of thinking about the brain is → 'Functional Units' ⇒ "cells"

→ Brain is analyzed at [all] two scales :-

Type 1 :- Levels of neural organization, Hierarchical Scale :-

- Behavior
- Systems
- Local circuits
- Neuron
- Micro circuits
- Synapse
- Membranes, molecules, ions
- Genes

Type 2 :- Spatial and temporal scales at which brain is investigated using several experimental techniques:



NB :- 'Scale' is especially relevant in electrophysiology, where experimental results depend critically on size and location of the electrodes and on the period over which signals are averaged.

NB :- • Electrophysiology deals with electrical phenomena associated with nervous & other bodily activity.

• Spatial & Temporal :-

1.3 EEG and brain oscillations :-

We know,

an electric potential difference exist within a system whenever positive and negative charges are seperated.

↓

This is also the case in every neuron where charge is seperated by providing different ion concentrations of two electrolyte solutions across a permeability selective barrier such as cell membrane.

→ This potential difference is called membrance potential (MP)

↓

Membrane potential is the difference in electric potential between the interior and the exterior of a biological cell. (With respect to the exterior of the cell, typical values of membrane potential range from −40 mV to -80 mV

NB:- • When the cell is at rest, it is called resting membrane potential (RMP).

• By convention —

a) The potential outside the cell is defined as zero.

b) The resting membrane potential in most neurons ranges from abt −60 mV to −70 mV.

• INPUTS :-

a) The I/Ps that a neuron receives from other neurons may CHANGE its membrane potential.

→ These synaptic I/Ps are of two types —

→ Those which produce excitatory postsynaptic potentials (EPSPs) and depolarize the membrane of the O/P neuron.

↓

(Depolarization is a sudden change within a cell, during which the cell undergoes a dramatic electrical change. In the process of depolarization, the negative internal charge of the cell becomes positive for a very brief time.

↳ This shift from a negative to positive internal cellular environment allows for the transmission of electrical impulses both within a cell & in certain instances between cells.)

→ Those which produce inhibitory postsynaptic potentials (IPSPs) acting on membrane in opposite manner.

- **Action Potential :-** The change in electrical potential associated with the passage of an impulse along the membrane of a nerve cell or muscle cell.

(dealing with electrical properties of biological cells)

- **Field Potential :-** Field Potential is an electrophysiological signal generated by the summed electric current flowing from multiple nearby neurons within a small volume of nervous tissue.

NB :- • Transmembrane ionic currents generate secondary ionic currents along the cell membranes in the intra- and extracellular space

⇓

However, the portion of these currents that flows through extracellular space is responsible for generation of field potentials (FP) which can be measured at a distance, form source.

- At locations (not too close to the neuron)
  → current distribution due to single synaptic action appears to be dipolar and potential behaves as if it was produced by current flow bet^n 2 poles.

EEG and MEG :-

↓ The synaptic activity of many parallel and synchronously active neurons produces the extracellular current flow that gives rise * to the electric potential recorded from the scalp and termed the electroencephalogram (EEG).

→ * similarly to the magnetic field, recording of which is called the magnetoencephalogram (MEG).

NB:- • One Imp feature of the EEG signals is that they exhibit oscillations of various frequencies.

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The frequency bands within which EEG rhythms can occur —

a) **Delta** → Below 3.5 Hz

b) **Theta** → 4 – 7.5 Hz

c) **Alpha** → 8 – 13 Hz

d) **Beta** → Above 13 Hz (or more recently) 14 – 30 Hz

e) **Gamma** → Above 30 Hz

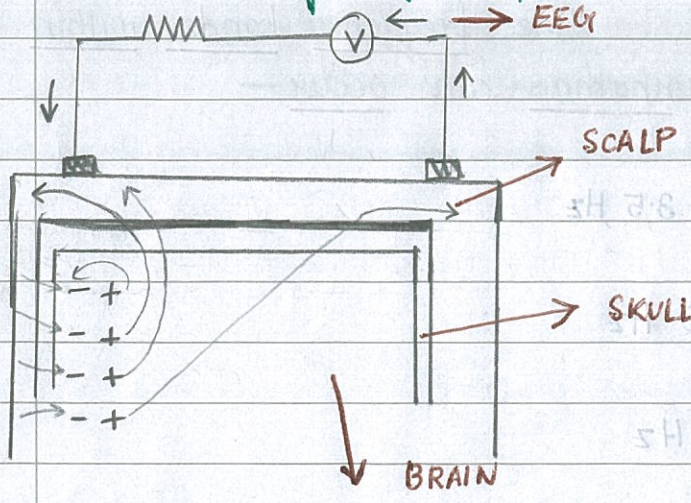
NB :- Apart from these above mentioned rhythms that can be recorded in healthy adult subjects → there are also many abnormal EEG patterns often associated with brain disfunction.

Electroencephalography is a valuable clinical tool eg in diagnosis of epileptic seizure disorders.

↳ Eg of pathological rhythm → 3 Hz spike & (SW) wave pattern that supports diagnosis of absence type of epilepsy.

Brain Oscillations :- refers to the rhythmic and repetitive electrical activity generated spontaneously and in response to stimuli by neural tissue in the central nervous system.

FIG-5 :- Origin of scalp potentials :-



- Current in the EEG measuring ckt depends on -
  - → Nature & location of Curr Sources
  - → Electrical Properties of the brain.
  - → Skull
  - → Scalp
  - → location of both electrodes

1.4 Aim And Scope :-

- **Aims :-** a) Attempt to provide a clear understanding of brain oscillations that emerge in the n/ws of neurons that build up thalamocortical neural n/w.

b) Studying of 2 Phenomena :-

(i) Experimental observations corresponding to mental and motor actions which cause variations in EEG rhythms over various locations on scalp. [Interesting fact is EEG rhythmicity changes in alpha band is NOT ONLY observed at brain locations related to an event but were also present in neighboring areas that did not correspond to the action performed.]

(ii) Abnormal brain functioning → dealing with spontaneous generation of absence epileptic seizures that consist of sudden lapse of consciousness with impairment of mental functions.
⇓ this may pass unnoticed by the subject but represented clearly in EEG as 3 Hz Spike & (SW) wave pattern

The neurophysiological detailed basis of both adjacent phenomena is not well established
↓
∴ Physiologically & anatomically based computational models are constructed in order to develop experimentally observed behavior.

- **Models :-** 1) First model represented is "classic" lumped alpha rhythm model developed by Lopes da Silva to explain origin of rhythmic activity in neuronal populations.

2) Secondly, implementation of extended version consisting of a chain of such modules mutually inhibitory connected by experimentally identified connections.
→ it allowed to stimulate spatial inhomogeneity of power in alpha band activity in neighbouring thalamic modules.

3) Thirdly, extension of alpha rhythm model to account for abnormal oscillations at freq 3 Hz associated with absence epileptic seizures.

- **Observations :-**
  - It is shown that how complex interactions in thalamocortical network may be responsible for SW oscillation.
- **Suggestion :-**
  - A clear understanding in the dynamics of pathological rhythm may have therapeutic implications.
- **Conclusion :-** Models presented here can be used to explain the mechanisms by which attentional processes & spontaneous absence seizures may be organized.