NOTES BASED ON PIOTR NOTES :- [CH-3] 20th Oct

3.1 MODELING :-

[deals with normal functio of Living organisms]

- The amount of experimental data concerning physiology and anatomy of the nervous system grows rapidly.

[deals with bodily structure esp as revealed by dissection & seperation of parts]

↓

Based on these data, theories are developed.

↓

Predictions from these theories are made.

↓

In order to test the theory, experiments are designed specifically and performed.

↓

NB:- It has been recognized that —
building computational models of neural structures may significantly improve efficiency of the iterative process.

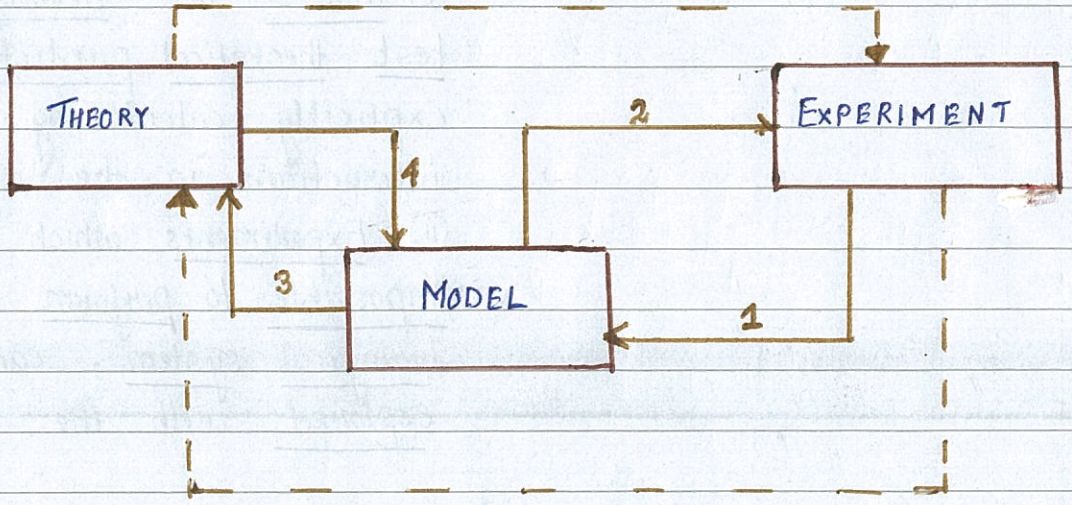

Diagram :- • It is a schematic diagram representing interactions between modeling, theoretical and experimental studies in order to reveal brain functions.

Explanation of Diagram :-

a) The dotted arrows represent 'traditional' interaction between theory and experiment.

b) Number Labelled Solid Lines represent :-

1 → Experiments allow for anatomically and physiologically realistic simulations.

2 → Models :- (i) may generate experimentally testable predictions
(ii) may provide interpretations for experimental data.

3 → Models may generate new ideas and thereby contribute to advancement of the theory.

4 → In complex systems,
(i) models are developed to test theoretical predictions by explicitly calculating all the interactions in the system.
(ii) Experiments which are impossible to perform in the biological system, can be explored with the model.

3.2 MODELING APPROACH :-

1. In general,

in order to model electrical activities of the brain :- (any of the impulse-conducting cells that constitute brain, nerves, spinal column)

↳ the level of neuronal organization at which we want to set a model have to be chosen.

↓

however, in practice different factors may contribute to this matter.

2. There should be a balance between computational efficiency and the level of detail necessary to investigate and bring information regarding a particular phenomenon.

3. To determine parameter values & validate modeling results → the level must be related to the nature of available real observations.

eg:- micro or macro electrode recordings.

↓

NB:- Generally,

4 orders of models of the electrical activity of brain systems → from micro to macroscopic levels may be distinguished.

↓

DIFFERENT APPROACHES :-

I. In case of some models (eg :- hippocampal networks)
- each cell is realistically represented by multiple compartments for the soma, dendrites and axon
- Each synaptic connection is simulated explicitly.

↓

thereby allowing to explain the importance of different physiological details for the overall behavior of the n/w.

⇓

However, this kind of realistic modeling involves large computing power.

→ This is one of the reasons why the simplified versions (in which only one compartment is taken into account) have been developed.

⇓

II. However,

1- compartment models loose the possibility to incorporate
- the morphology of the cells
- the spatial distribution of ionic conductances.

↓

But, these models reveal the contribution of various ionic conductances to the behavior of either
- a single cell
OR
- Set of cells forming a network with diff connectivity patterns.

← This is distributed model

NB :- However,

To simulate the behavior of a large population of neurons with highly detailed models can be a problem and complicated.

⇓

III. Modeling of large populations of interacting neurons at the macroscopic level may be followed by — Lumped Circuit Models

↓

In a lumped model,

it is not required to simulate single cells in a distributed network → spatial average over populations consisting of a given type of neurons is considered.

↳ in this manner, simplified network of interconnected populations is constructed, capturing essential properties of the real system.

⇓

IV. In addition to lumped models, there are mathematical models used to simulate dynamics of EEG in global terms.

Models Represented In This Document :-

1) Firstly, belonged to a class of lumped models.
   → justifying the fact that focal ERD (+surround ERS) is a phenomenon that reflects dynamic properties of neuronal populations at macroscopic level.
   ↓
   This approach was not enough for simulating mechanisms responsible for generation of SW seizures because the latter depend critically on both the neuronal & n/w properties of thalamocortical system.

2) Second model → is an extended version & included a key neuronal properties of thalamic cells, thereby setting the model at the intermediate hierarchical scale between the single cell and population level.
   → The advantages are :-

(i) Establish relation bet^n model parameters and both cellular & synaptic NIW properties of the modeled system.

(ii) Enables investigation of the system's dynamics [hardly accessible in distributed NIH mod

(iii) Computationally efficient.

(iv) Models local neurophysiological signals at macroscopic scale
   → ∴ Allows to compare model's O/P with electric brain signals such as EEG or local field potential.

(v) Under some circumstances, allowing application of System analysis methods to quantify the system's behavior.