UNIVERSITY OF JORDAN
FACULTY OF MEDICINE
DEPARTMENT OF PHYSIOLOGY & BIOCHEMISTRY
INTRODUCTION TO NEUROPHYSIOLOGY
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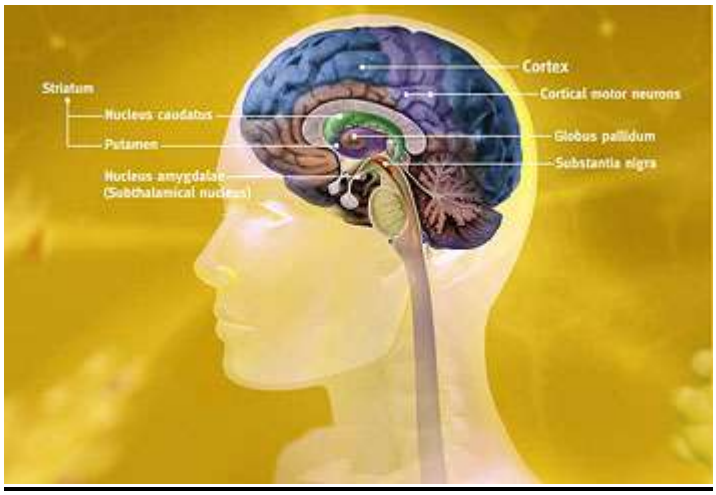
Textbook of Medical Physiology
by: Guyton & Hall, 12 th edition 2011

Eman Al-Khateeb, Professor of Neurophysiology

Introduction, CNS organization:
Major levels of CNS function:



1. Spinal Cord level:
Walking movements, spinal reflexes, and reflex control of local blood vessels, gastrointestinal movements and urinary excretion.

2. Sub-Cortical level:
Control subconscious activities. Arterial blood pressure, Respiration (Function of medulla and Pons), Equilibrium (Function of cerebellum, vestibular nuclei and reticular formation), Feeding reflexes (Function of Brainstem and Limbic System) & many emotional patterns.

3. Cortical level:
The cerebral cortex is large memory storehouse, it is also essential for most of our thought processes, intelligence and language. It converts lower brain functions that are imprecise to determinative and precise operations.

THE CENTRAL NERVOUS SYSTEM;

Contains more than 100 billion neurons, 200 – 200,000 input to each neuron, Single output (axon) that branches,

Human 70Kg (his brain weight = 1.4 Kg)……. 2 %. Although the human brain represents only 2 % of the body weight, it contributes up to 20 % of the body resting metabolism; it receives 15% of the cardiac output, 20 % of total body oxygen consumption, and 25 % of total body glucose utilization.

Excitable tissue:

Any tissue that its cells are capable of generating rapidly changing electrochemical impulses (AP) and transmit them along their membranes, e.g. Nerve and Muscle cells.

Resting Membrane Potential (RMP):

RMP is the electrical potential across the membrane when the cell at rest or inactivity.
It is equal to - 90 mv in large nerve fiber.

Ionic basis of RMP:

1. Passive outward diffusion of K^+:

At rest, the membrane is 100 times more permeable to K^+ than to inward diffusion of Na^+.
This k^+ outward diffusion will create a state of electropositivity outside the membrane & electronegativity on the inside & contributes to - 86 mv of the RMP in large nerve fiber.

2. Electrogenic pump (Na^+ - K^+ pump):

Which pumps 3 Na^+ ions out for every 2 K^+ pumped in. It utilizes ATP as a source of energy. For every cycle of the pump the inside losses one positive charge, a process that lead to an excess of positive charges outside. It creates only - 4 mv potential difference across the membrane. Therefore RMP = (- 86) + (- 4) = - 90 mv

Action Potential (AP), the nerve impulse:

AP is rapid transient change in the membrane potential that spreads rapidly along the nerve fiber membrane. In order to initiate an AP there must be an electrical, chemical or mechanical stimulus.

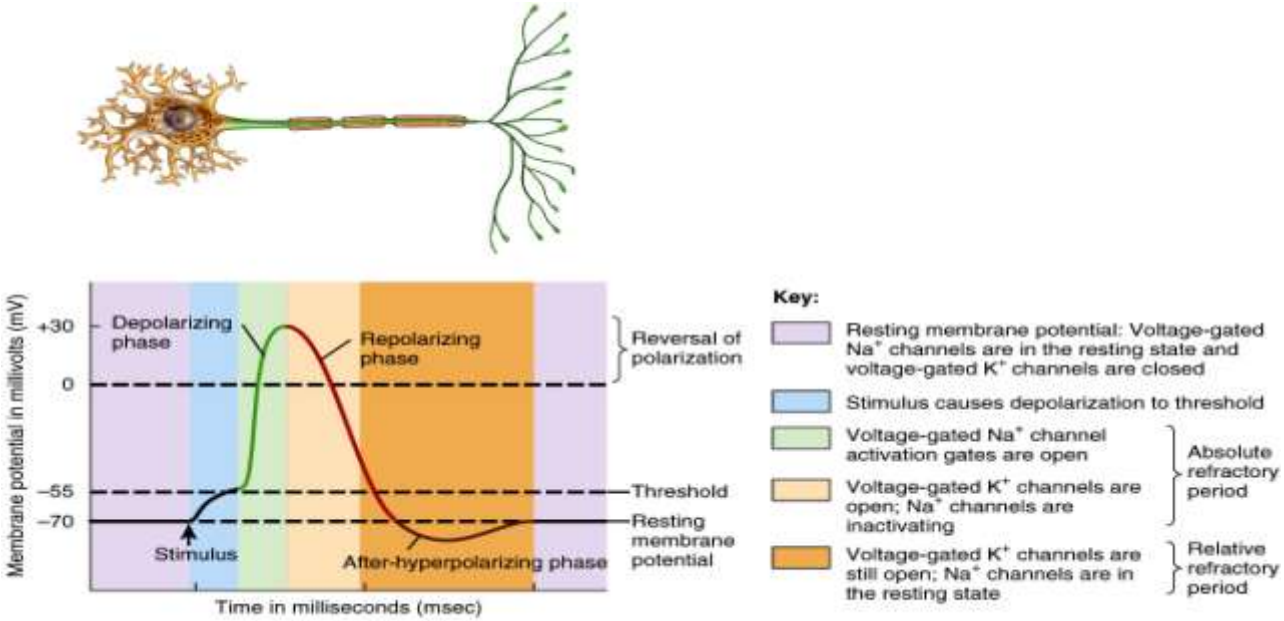


Figure 12.19 Tortora - PAP 12/e

Stages of AP:

1. RMP stage it is - 90 mv in large myelinated nerve fiber.
2. Depolarization stage: Na^+ influx leading to positive potential. This change in membrane potential is due to opening of voltage gated Na^+ channels for short period leading to Na^+ influx in a positive feedback vicious cycle, this means:
Change in membrane potential -------- opening of voltage gated Na^+ channels ----- Na^+ influx ----------Change in membrane potential ------and so on .
3. Repolarization stage: It is due to:
a. Closure of voltage gated Na^+ channels preventing Na^+ influx.
b. Opening of voltage gated K^+ channels which lead to K^+ efflux.
4. Positive after potential.

Re-establishing Na^+ & K^+ ionic gradients after AP's are completed:

The activity of Na^+ - K^+ pump is strongly stimulated when excess Na^+ accumulates inside the cell membrane, when Na^+ concentration intracellularly is doubled, the activity of the Na^+- K^+ pump increases 8 folds.

Properties of AP:

1. Regenerative: once initiated it continues without the need for external input of energy.
2. Threshold: it is the level of membrane potential required to cause an AP. It is between -50 to -70 mv.
3. All on None nature: The size of the AP is independent on stimulus energy and AP has fixed amplitude.
4. AP propagates via salutatory conduction in myelinated nerve fiber making the conduction 50 times faster than the unmyelinated nerve fibers, besides conserving energy through less use of Na-K ATPase.

5. AP has a refractory period (1/2500 sec) that determines the frequency of AP and the direction of propagation.

Tetrodotoxin:
Is a potent neurotoxin with no known antidote, which blocks AP in nerves by binding to the pores of the voltage – gated, fast sodium channels in nerve cell membrane. It can be used medically to treat arrhythmias. Novocaine which is used as a local anesthetic has a similar action of tetrodotoxin.

Electrtonic Potential (EP), Graded Potential:

1. It is local potential; arise mainly in dendrites and some.
2. It is graded, and its amplitude varies (1 – 50 mv) as it depends on the intensity of stimulus
3. It rises rapidly and decays exponentially and fades with distance and has longer duration than AP.
4. It has the capability to summate spatially and temporally.
5. Ligand-gated or mechanically gated channels are involved in EP.
6. Either hyperpolarizing or depolarizing potential.
7. Has no refractory period.

Examples of EP: End plate potential, EPSP, IPSP, Receptor Potential, Generator Potential.