Continue insect nervous system

Conduction of impulses in the nervous system

- The sensory, motor and association give the anatomical basis for behaviors .
- The disturbance impulse which is propagated along them consists in : a change in electrical potential due to a momentary depolarization of the axon surface, passing like a wave throughout the neuron.
- e.g. Normal contraction in the body musculation are due to trains of motor impulses which rise and decline in frequency as contraction begins and ends.
- e.g., in locust: the giant axon has a resting " membrane " potential of about - 10 mv. On stimulation : the membrane is depolarized and on action " spike " potential appears with average 99mv.

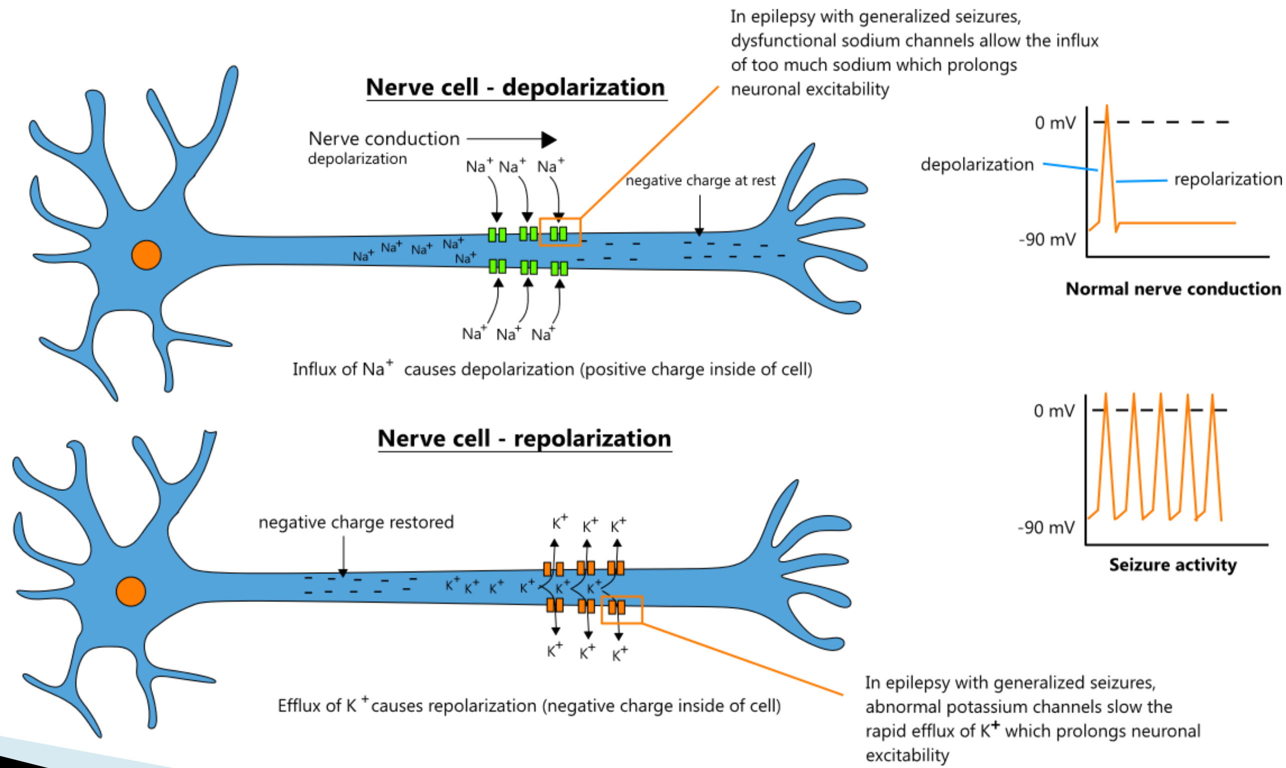
Basic Functions of neurons
Electrical properties of the neuron

- A difference in electrical potential is maintained across the plasma membrane of a neuron, the inside being negatively charged with respect to outside.
- In an unstimulated cell, the resting membrane potential is often about -70mV.
- The membrane potential arises from the differences of positively and negatively charged ions inside and outside the cell.
- Several factors produce this difference:

1- Donnan equilibrium is established by non-diffusible organic anions within the neuron.

- The resting cell membrane is more permeable to potassium than to sodium ions; and membrane pumps exchange sodium ions from the cell to potassium ions outside the cell in a ratio 3:2. As a result potassium ions are high inside the cell while sodium and chloride are high outside.

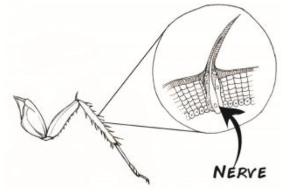
- Changing in the membrane potential enable neurons to communicate with each other.
- A decrease in the membrane negative charge, is called depolarization, an increase in negativity is called hyperpolarization.



Nerve Impulses & Stimulation

- Stimuli may be perceived in a number of ways depending on the nature of the stimulus and the characteristics of the sense organs.
- The energy received by the sensory cell as a result of stimulation, is transformed to electrical energy and this leads to the production of a nerve impulse, which travels along the nerve axon to the central nervous system.

  - Then the impulse crosses a synapse & directly via one or more interneuron‘s, continues along a motor neuron, crossing a synapse before producing some response in an effector organ, usually a muscle.
- The production and conduction of nerve impulse in insects appears to be similar to the process in other animals & is therefore based to a large extent on the general concepts of nervous conduction.



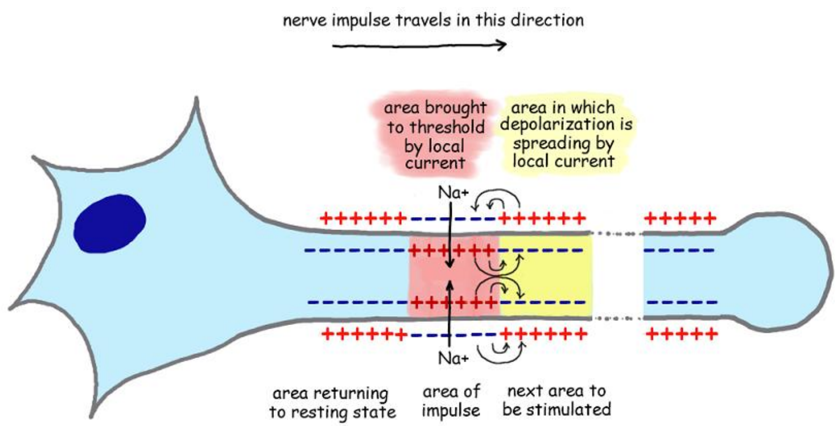
Signal Transmission

- Transmission of signals via the nervous system involves three different processes.

- First, the incoming signal, which may be mechanical , chemical or visual, is converted to electrical energy (transduction).

- Visual perception involves the breakdown of some light sensitive pigments.
- The change in membrane potential produced by the incoming signal is called receptor potential, it varies in size according to the strength of the stimulus .

- Second, the electrical signal is conducted along the axon as action potentials.
- Finally, the electrical signal is usually converted to a chemical signal for transmission to the following cell at the synapse that leads to the response of the effective organ in the end.

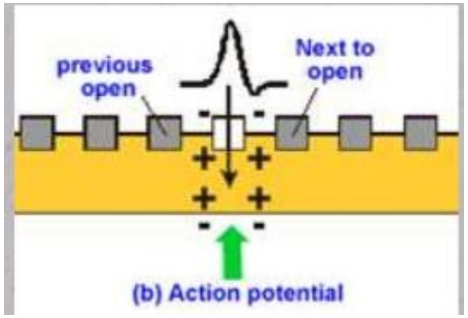


The nerve impulse

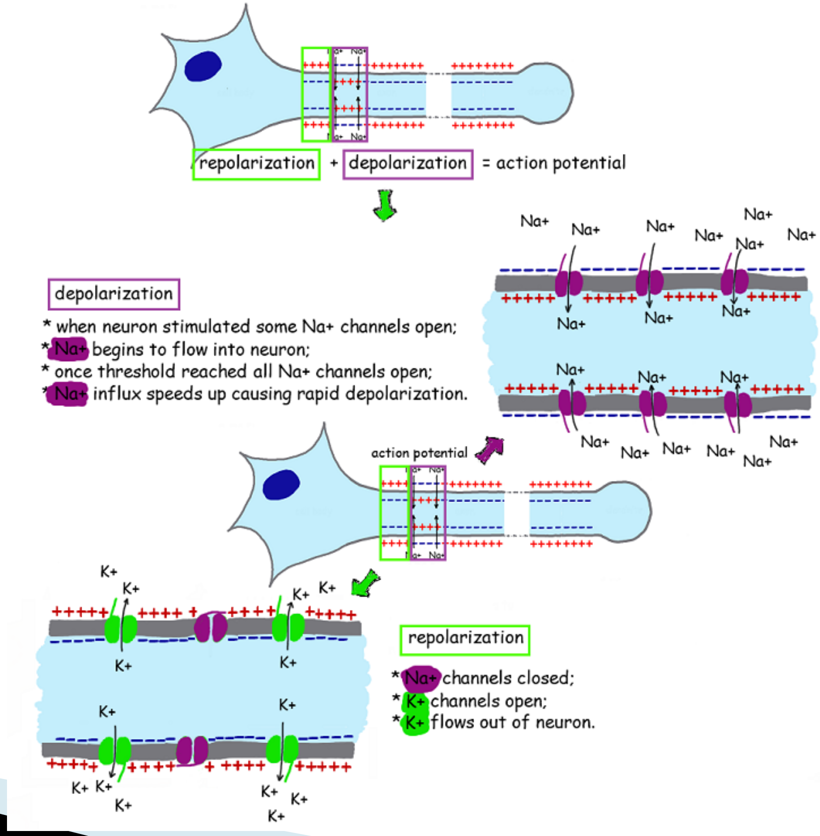
* stimulation of the nerve causes a change in the charges inside and outside of the membrane;
* the charges reverse because Na+ rushes into the neuron (called depolarization);
* the charge reversal in one region causes local current to move to the next region,
* charge reversal in areal of impulse causes local currents in next area to be stimulated,
* the nerve impulse spreads along the axon through the process of depolarization and repolarization;

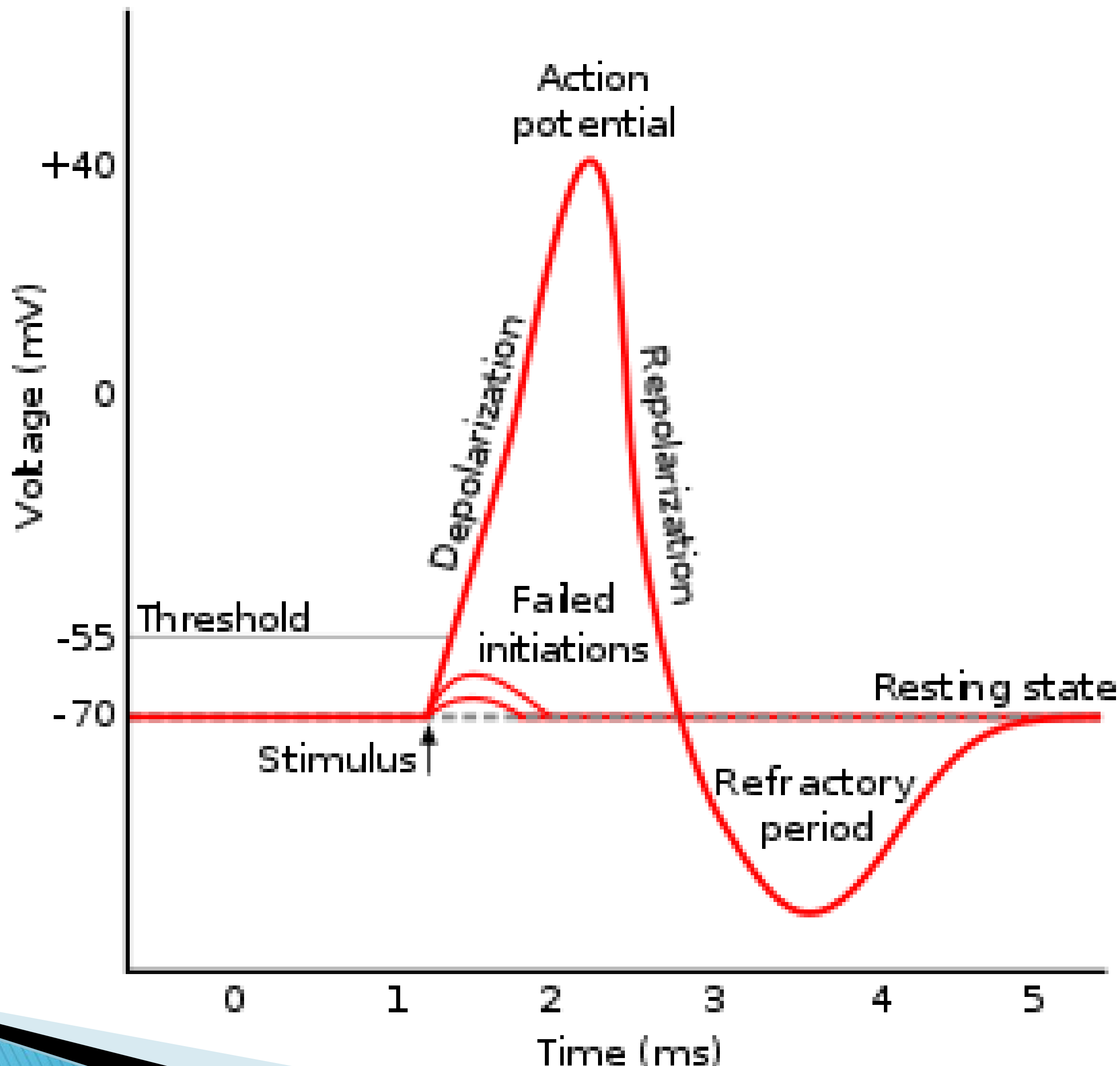
Action potential (Spike potential)

- The first phase of the action potential is a small increase in permeability of the cell membrane to sodium.
- As a result sodium ions flow into the axon down the concentration gradient and produce a mall depolarization of the membrane.
- This cause voltage-sensitive sodium channels to open, and results in a rapid positive swing in the charge on the inside of the membrane.
- This is the rising phase of the action potential .
- When sodium channels close, potassium channels open as they are activated more slowly than sodium channels.
- Potassium flows out of the fiber, which again becomes more negatively charged on the inside. This is the falling phase of the action potential.



- A current flows in a local circuit a way from the point of depolarization inside the axon, and towards it on the outside
- The " spike potential " travels along the nerve by the depolarization of each succeeding stretch .
- The velocity of conductance increases with the diameter of the fiber.




Action potential
+40
0
-55
-70
Voltage (mV)
Depolarization
Repolarization
Threshold
Failed initiations
Resting state
Stimulus
Refractory period
0
1
2
3
4
5
Time (ms)

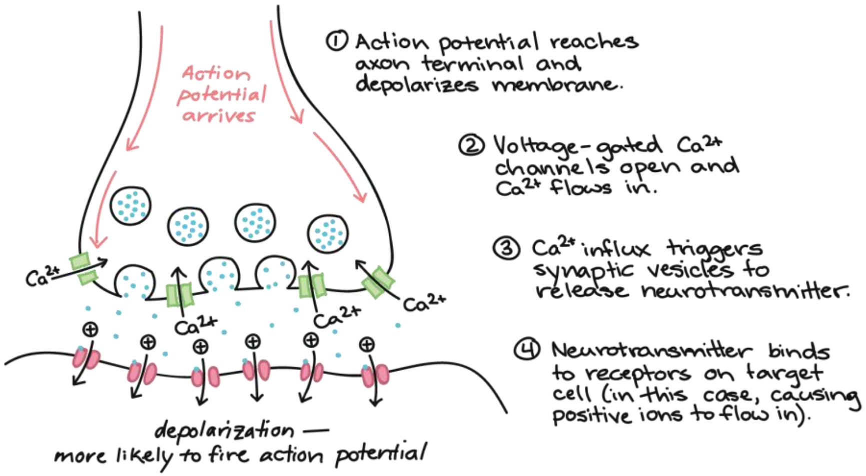
Effect of Hemolymph Composition on Conduction

- Since the passage of impulses in the nerve involves the movement of ions into & out from the axon, this movement is influenced by the concentration of ions in the medium bathing the axon " extracellular spaces".
- If the level of K in the extracellular fluid is raised there is less tendency for K to flow out of the axon & hence the membrane potential is reduced.
- Similarly a low level of Na in the external medium reduces the height of action potential.

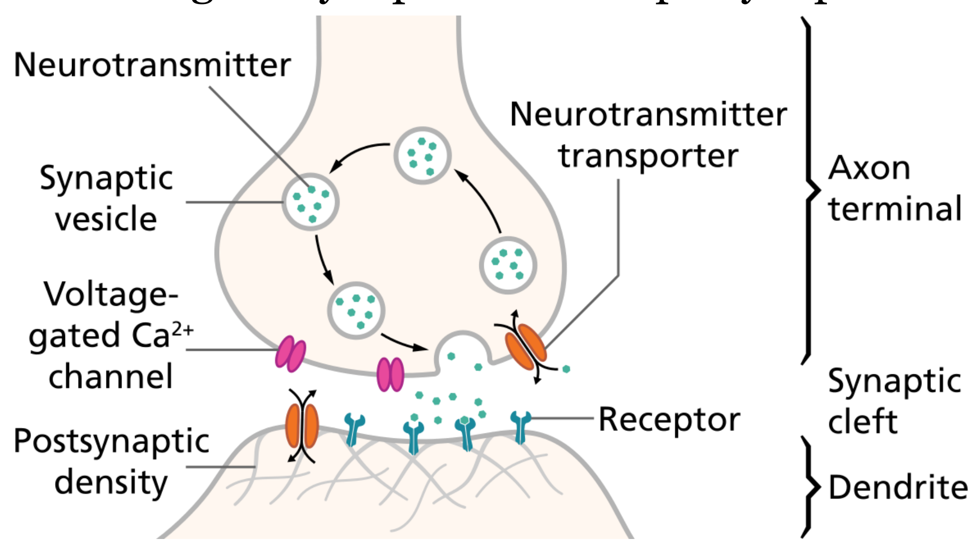
- In many insects the concentration of Na in the hemolymph is high , while that of K is low, but in some particularly in herbivorous the converse is true.
- It might be supposed that this would influence nervous conduction, but this is not so because the concentration of ions in the extracellular fluid within the nerve sheath are quite different from those in the hemolymph. Thus" the nervous tissue lies in its own micro- environment.
- Calcium is also essential for efficient nerve conduction, being bound to molecules on the nerve membrane.

Synaptic Conduction

- The neurons are not continuous with one another.
- The terminal arborizations of the axon of one neuron come into intimate association with the collateral or terminal arborizations of another neuron to form a synapse.
- The arrival of an action potential at presynaptic terminal of a chemical synapse results in the opening of voltage-sensitive calcium channels so that calcium ions move into the neurons.



- Calcium increase the probability that a synaptic vesicle, containing transmitter substance, will fuse with the neural membrane and release the transmitter into the synaptic cleft.
- The basic quantity of transmitter released by a vesicle is known as a quantum.
- The transmitters affects the permeability of postsynaptic membrane either directly, causing ligand-gated ion channels to open, or indirectly, binding to membrane receptors and activating second messenger system.
- As a result depolarization is produced in the next neuron.
- The magnitude of the postsynaptic potential is variable, and is proportional to the amount of transmitter substance crossing the synapse from the presynaptic terminal.



Chemical messengers of neurons

- A variety of chemical messengers are produced and released by insect neurons.
- These substances can grouped into four classes, based on their chemical structure:

- acetylcholine
- biogenic amines
- Amino acids
- Peptides

- These messengers have three types of functions:

1- Neurotransmitters: are only released into the synaptic cleft and have a transient effect on the electrical potential of the postsynaptic membrane.

2- Neuromodulators: are released in the vicinity of the synapse, modifying synaptic transmission. Their effects are relatively slow and long lasting.

3- Neurohormones: are released into the hemolymph from neurohemal release areas and function as hormones.

1- Neurotransmitters

- The central nervous system of insects is particularly rich in acetylcholine.
- Many other neurotransmitters are present in insects including Serotonin, histamine, dopamine and Glutamate.

2- Neuromodulators

- Neurotansmitters can be altered by chemicals known as neuromodulators.
- It could be produced presynaptically or postsynaptically.
- Biogenic amines and a number of neuropeptides are widely distributed in the central nervous system.
- The overall effects of neuromodulators may be more profound than changes at a single synapses might suggest.

3- Neurohormones

- They are produced by neurons in various ganglia of the C.N.S.
- Cells producing neurohormones are commonly known as neurosecretory cells.
- They may act as both hormonal and/or neural functions.

The S.N.S. is divided into

1 – The Oesophageal S. N. S.

- Innervates foregut, midgut and the heart.

2- The Ventral S.N.S.

- A pair of transverse nerves to spiracles.

3 – The Caudal S.N.S.

- Supplies the reproductive system and the posterior part of the gut.

- The Peripheral Nervous System (P.N.S):

- It includes all the nerves radiating from the ganglia of the central and sympathetic nervous systems.

- It consists of sensory neurons of two main types: Bipolar and multipolar neurons.