NERVOUS SYSTEM

In the animal kingdom, the higher the organism, the more important becomes the system of cells that function to co-ordinate its activities. Nervous system in man mainly includes brain and spinal cord. Nature has developed two distinct coordinating mechanisms-

- Chemical messenger- Hormones, secreted by endocrine glands which regulate the activity of cell in parts of body.
- Neurons- It is superior, selective and specialized system of nerve cells which receives and gives instruction by means of electrical impulse directed over specific pathway.

STRUCTURE OF NEURON-

A neuron may be defined as a nerve cell consisting of a cell body which is drawn into many processes. It is the structural and functional unit of nervous system. Neurons occur within the grey matter of the brain, spinal cord & in the ganglia of cranial & spinal nerves and autonomic nervous system.

Neuron consists of-

1. Cell body (or) Perikaryon
2. Processes of nerve cell- Axon & dendrites/dendrons

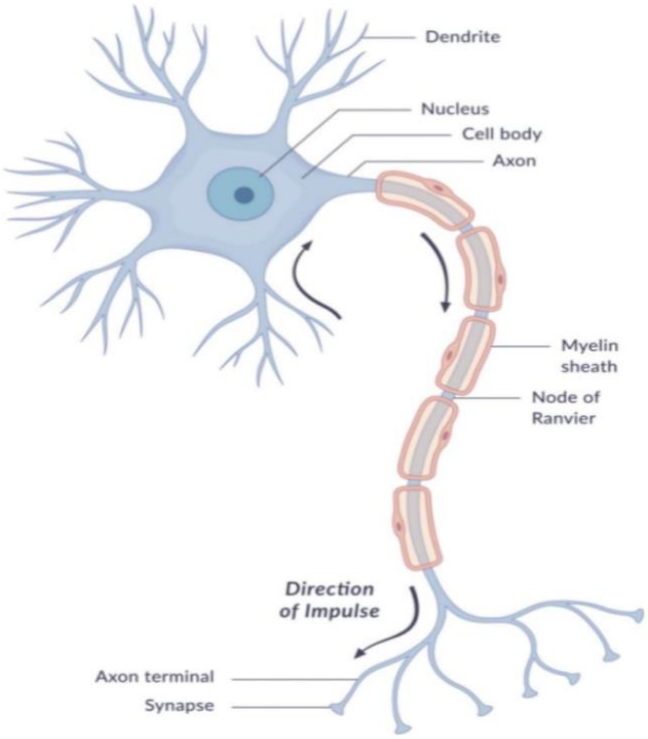
CELL BODY

1. The part of a complete neuron that looks like an ordinary cell is the cell body(cyton)
2. The cell membrane is the outermost layer covering the cell & cytoplasm.
3. Cytoplasm of the nerve cell is called as neuroplasm.
4. Neurofibrils are firm, protoplasmic threads embedded in the neuroplasm. Neurofibrils exist both in cell body & cell processes.
5. Nissl bodies are small masses of granular material which has affinity for basic dyes. They are present in cyton and dendron.
6. Centriole is usually large, spherical & central in position. It varies in size based on size of the cell and activity of the cell.

CELL PROCESSES

Cell cytoplasm is drawn into thread like processes which are of 2 types

1. Dendrites/Dendrons- Dendron means ‘tree’.
    - Dendrites are processes which conduct the impulse to the neuron.
    - They are afferent- carries impulse to cell body.
    - Dendrons are small and form branches/branching.
    - Dendron may be distinguished microscopically by the presence of nissl bodies and mitochondria



2. Axons- It is the tail like structure of neuron
    - Axons are efferent process of the neuron.
    - They carry impulse away from the cell.
    - Axon is large, single are terminally branched.
    - Axon maintains uniform size throughout the length
    - Myelin sheath is present on axon which acts as insulating layer & allows nerve impulses to transmit more rapidly along the axon
    - Myelin sheath is made up of fatty acids.
    - The gaps between myelin sheath are called node of ranvier
    - Node of Ranvier helps in speeding up the transmission of signals.

- Axon terminals are located at the end of neuron. They are responsible for transmitting signals to other neurons.
- Neurotransmitters are released from the terminal of axon.

RESTING MEMBRANE POTENTIAL

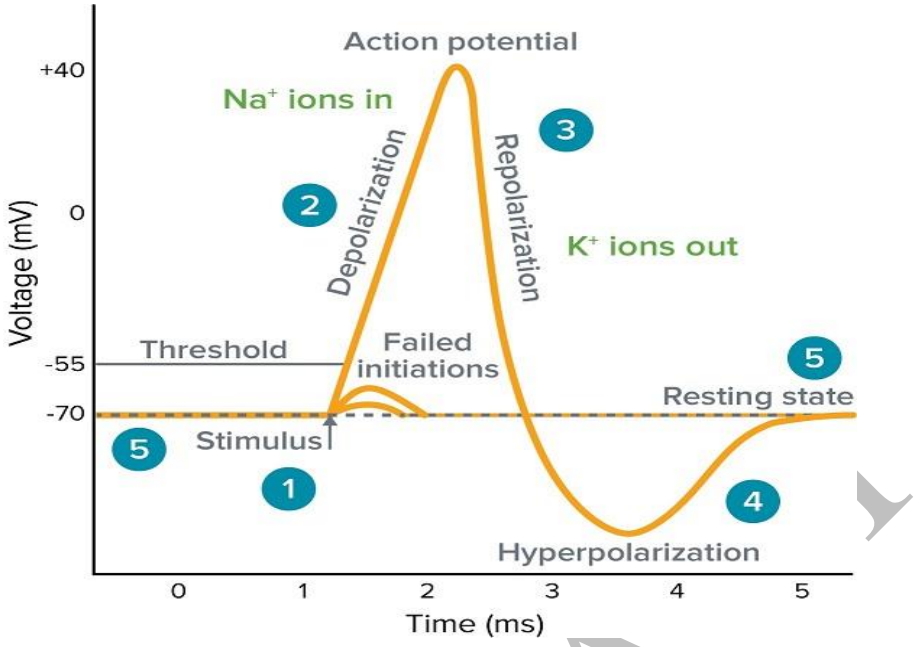
1. In a cell, the fluid outside the cell membrane is extra-cellular fluid and inside the membrane is called intra-cellular fluid.
2. In our body, neurons send electrochemical messages which produces electric signal or electrical impulse.
3. Chemicals in the body are electrically charged and when they have electric charge are called 'ions'.
4. In the extra cellular fluid contains sodium and chloride ions in large quantity when compared to potassium ions & intra-cellular fluid contains more amount of potassium ions when compared to sodium ions.
5. Sodium, potassium & calcium ions have positive charge while chloride and anions have negative charge.
6. Anions include proteins, amino acids & RNA.
7. The cell membrane is semi permeable and it allows few ions to pass through the cell membrane in a specific channel called 'ion channels'.
8. Transport of substances across the cell membrane is diffusion.
9. Diffusion generates membrane potential. The ions try to balance between inside & outside of the cell during diffusion.
10. When a cell does not send a signal, it is at 'resting state'. The inside of the cell is negative when compared to the outside of the cell.
11. This permits the entry of K+ ions and Cl- ions and stops the entry of Na+ ions.
12. The cell membrane is negative inside and positive outside the cell.
13. The difference in ion concentration results in resting membrane potential of the cell.
14. Value of RMP is between -60mV to -100mV.
15. The value remains constant until an external factor disturbs the cell membrane.
16. At resting state, the cell is polarized
17. Large negatively charged molecules do not pass through the cell membrane to set up the negative RMP.

There are three main rules for the movement of ions-

1. Ions move from higher concentration to lower concentration.
2. They are away from like charges and move towards opposite charges.
3. Movement depends on permeability of cell membrane.

ACTION POTENTIAL

1. Action potential or nerve impulse causes a movement of ions across the cell membrane of a neuron.
2. The cell membrane of neuron contains thousands of tiny molecules known as channels.
3. These channels allow either Na+ or K+ ions to pass through it.
4. Generally the channels on the neurons are closed & membrane is said to be in resting state.
5. At this state, the inside of cell is negative and outside of the cell is positive and it will be -70mv inside the cell.
6. The cell membrane of neuron is polarized because of this electrical difference across the membrane.
7. A nerve impulse starts when pressure or other sensory inputs disturbs a neuron's plasma membrane where the potential voltage reaches the threshold voltage of -55mV.
8. This causes hundreds of sodium channels in that region of the membrane to open and this in turn allow positively charged Na+ ions to flow inside the cell membrane.
9. Now inside of the cell membrane temporarily becomes more positive than the outside.
10. This causes the voltage to rise & is called depolarized state.
11. The membrane is now depolarized because the net charge inside the axon changes from negative to positive as the Na+ ions flow inside the cell.
12. As the impulse passes the potassium channels begin to open. Thus positively charged K+ ions flow outside the cell.
13. This causes inside of the cell to resume a net negative charge.



14. At this point the voltage would fall.
15. The m3embrane is said to be repolarized because again negatively charged inside and positively charged outside the cell.
16. Now this depolarization and repolarization of the neuron is called an action potential.
17. After the nerve impulse some voltage gated potassium channels remain open. It results in further movement of potassium out of the cell.
18. As the voltage falls below the reading of resting state, the membrane is said to be hyperpolarized.
19. Because it is even more negative than at the beginning.
20. At this stage, neuron is unable to conduct nerve impulse & is said to be in refractory period.
21. Refractory period is very short period during which the sodium-potassium pump continues to return sodium ions to outside and potassium ions to inside of the cell.
22. Thus returning neuron to resting potential.
23. Action potential is a wave of depolarization and repolarization.

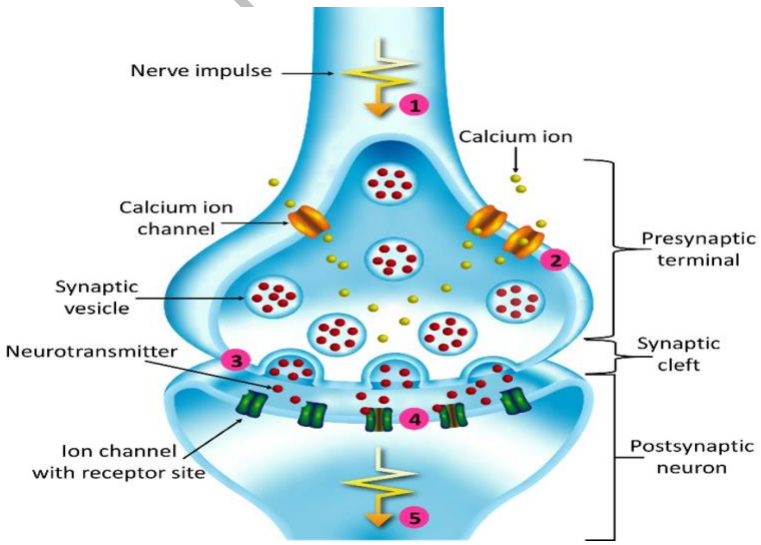
SYNAPSE-

Synapse is the site of transmission of electric nerve impulses between 2 nerve cells or between a neuron and a gland or neuron and muscle cell. Synapse is also called as neuronal junction or synaptic junction.

Synaptic transmission- The transfer of nerve impulse across synaptic junction is called synaptic transmission.

Conduction of Synapse-

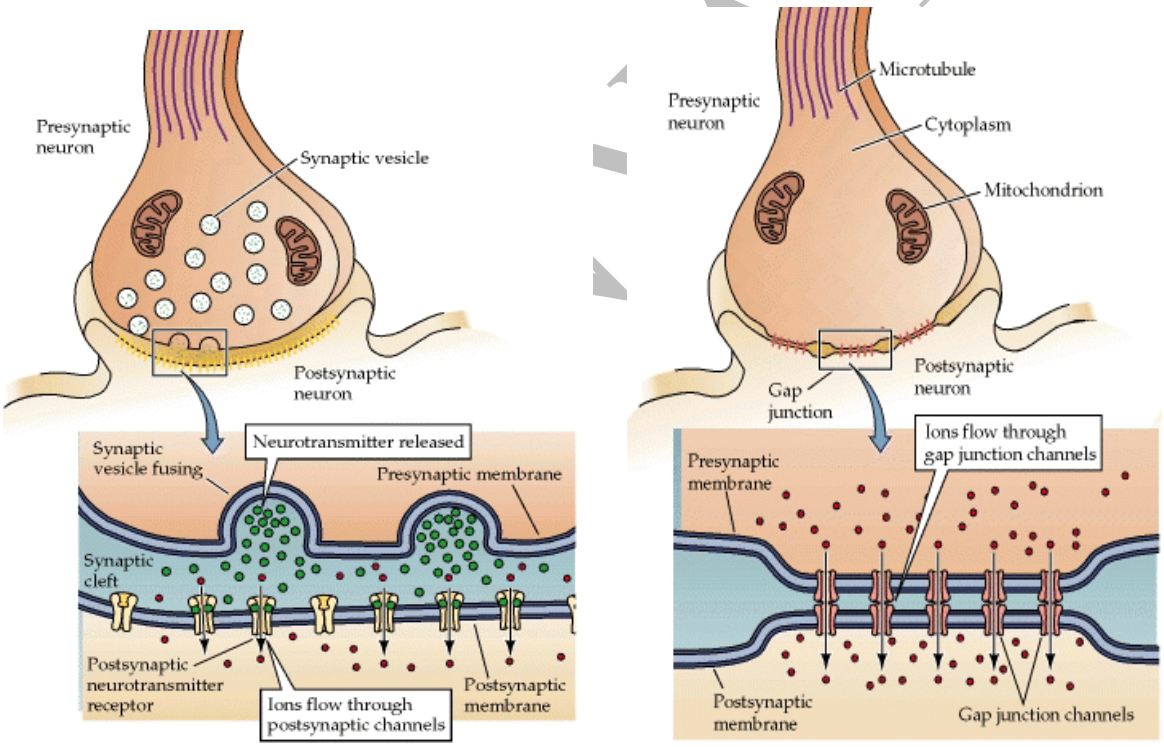
1. A single synapse consists of Pre-synaptic terminal, synaptic cleft and Post-synaptic terminal.
2. The cell which sends the nerve impulse is called Pre-synaptic cell & the cell which receives a nerve impulse is called Post-synaptic cell.
3. The action potential generated in a neuron will be transmitted to the adjacent neuron by means of synapse through knob-like structures present in axon terminal.
4. There will be microscopic space between the neurons called synaptic cleft which will be 0.02µ wide.
5. The arrival of nerve impulse at Pre-synaptic terminal causes the movement of synaptic vesicles.
6. They fuse with the membrane and release neurotransmitter.
7. This neurotransmitter transmits the nerve impulse to the Post-synaptic fibre by diffusing across synaptic cleft.



TYPES OF SYNAPSE:

Types of synapses based on function-

1. Chemical synapse- electrical activity in the pre-synaptic neuron is converted into chemical called neurotransmitters that binds to receptor located in the post-synaptic cell/neuron. Neurotransmitters may initiate an electric response or secondary messenger.
2. Electrical synapse- the pre-synaptic and post-synaptic cell membranes are connected by special channels called gap junctions that are capable of passing an electric current causing voltage changes in pre-synaptic cell to induce voltage changes in post-synaptic cell. Through electrical impulse there will be rapid transfer of signals from one cell to the next cell.



CHEMICAL SYNAPSE ELECTRICAL SYNAPSE

Based on the cellular structure involved in transmission of synapse, it is classified into 5 types-

1. Axosecretory synapse- axon terminal secretes impulse directly into bloodstream

2. Axoaxonic synapse- axon terminal passes the nerve impulse to another axon
3. Axodendritic synapse- axon terminal ends on a dendrite spine
4. Axoextracellular synapse- axon with no connection secretes the impulse into extra-cellular fluid
5. Axosomatic synapse - axon terminal secretes transmitters into body/soma of the cell
6. Axosynaptic synapse- axon terminal ends on another axon terminal.