UNIT – III HUMAN ANATOMY AND PHYSIOLOGY

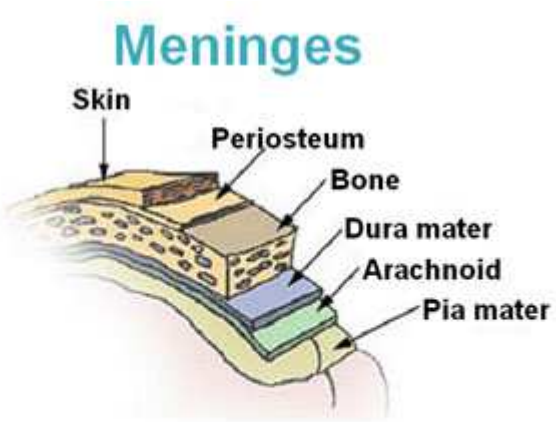
IIIB -NEURAL CONTROL AND COORDINATION

Very Short Answer Questions

1. Name the cranial meninges covering the brain of man?

A. Brain is covered by three connective tissue membranes called Meninges.

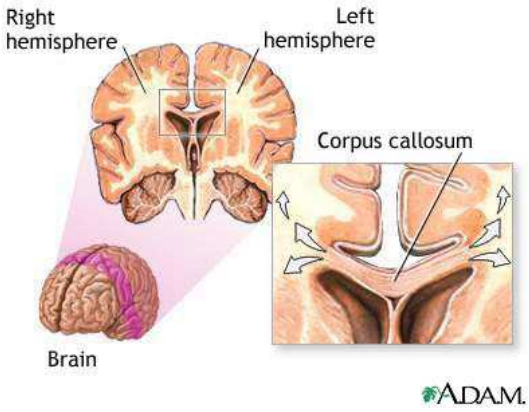
(1) Outer Duramater (2) Middle Arachnoid mater (3) Inner Piamater



Dura mater -- outer layer lining skull
Arachnoid (mater) -- contains blood vessels
Subarachnoid space -- filled with CSF
Pia mater -- covers brain

2. What is Corpus callosum?

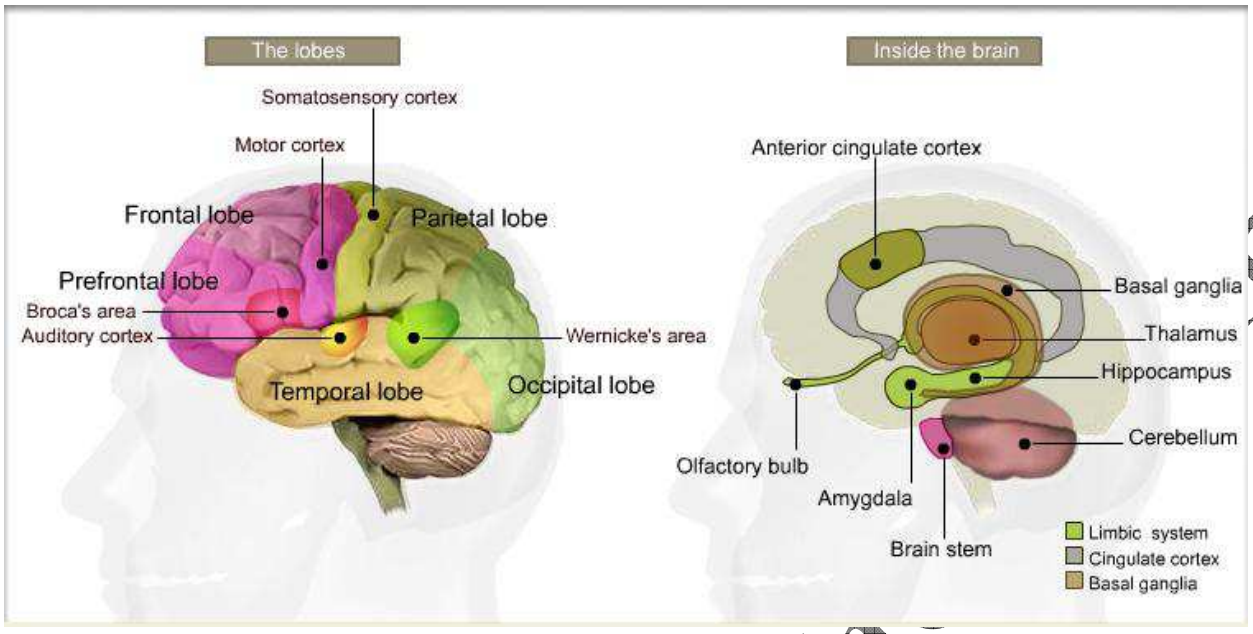
A. A transverse, wide and flat bundle of myelinated fibres which connect the two cerebral hemispheres internally beneath the cortex is known as corpus callosum or colossal commissure. It brings coordination between right and left halves of cerebral hemispheres.



3. What do you know about arbor vitae?

A. Arbor vitae is a branching tree like core of white matter of cerebellum in brain.

It is surrounded by a sheath of grey matter (cerebellar cortex).



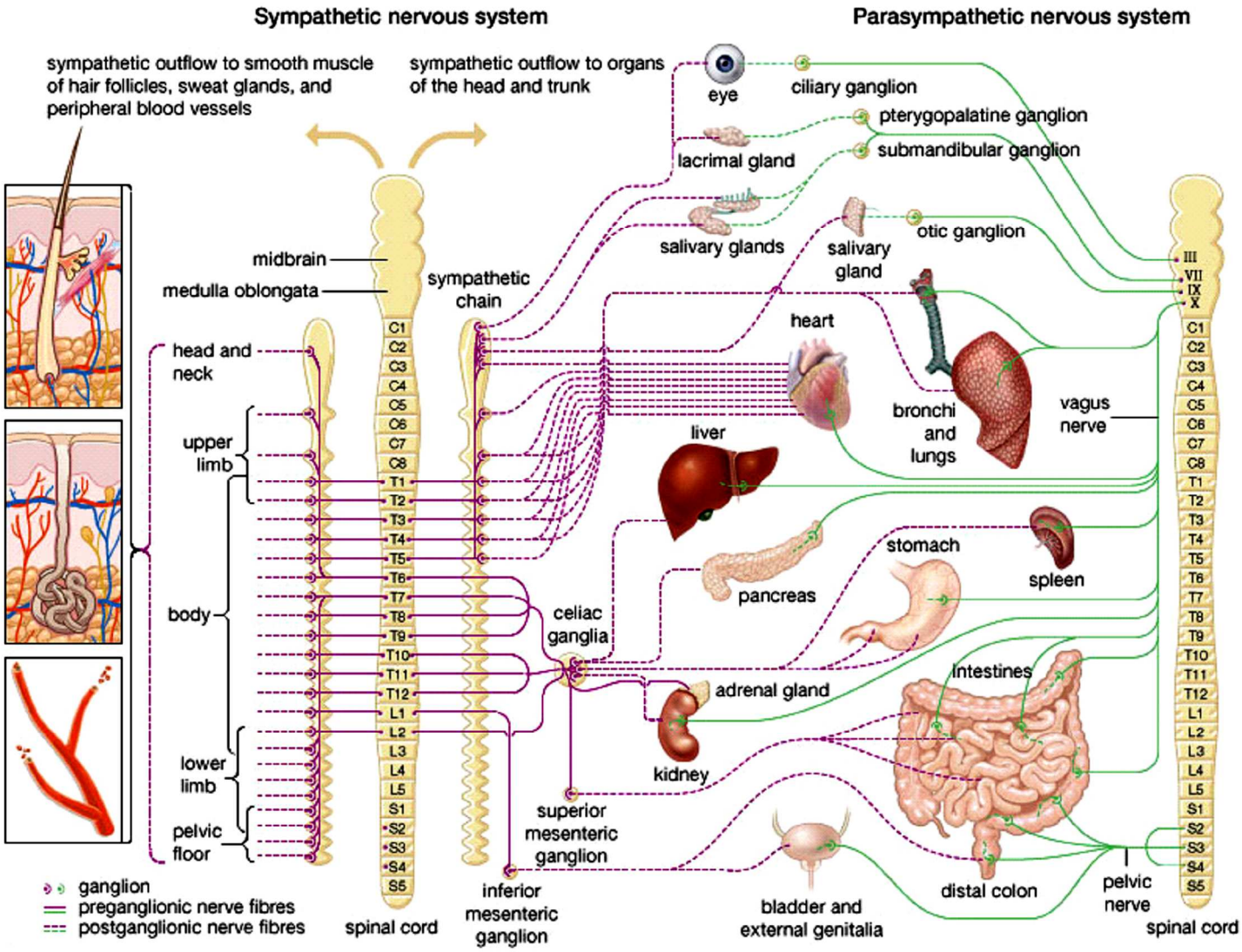
4. Why the sympathetic division is called thoracolumbar division?

A. The preganglionic sympathetic neurons have their cell bodies in the grey matter of thoracic and lumbar regions of the spinal cord.

So, sympathetic division is called thoracolumbar division.

5. Why the parasympathetic division is called craniosacral division?

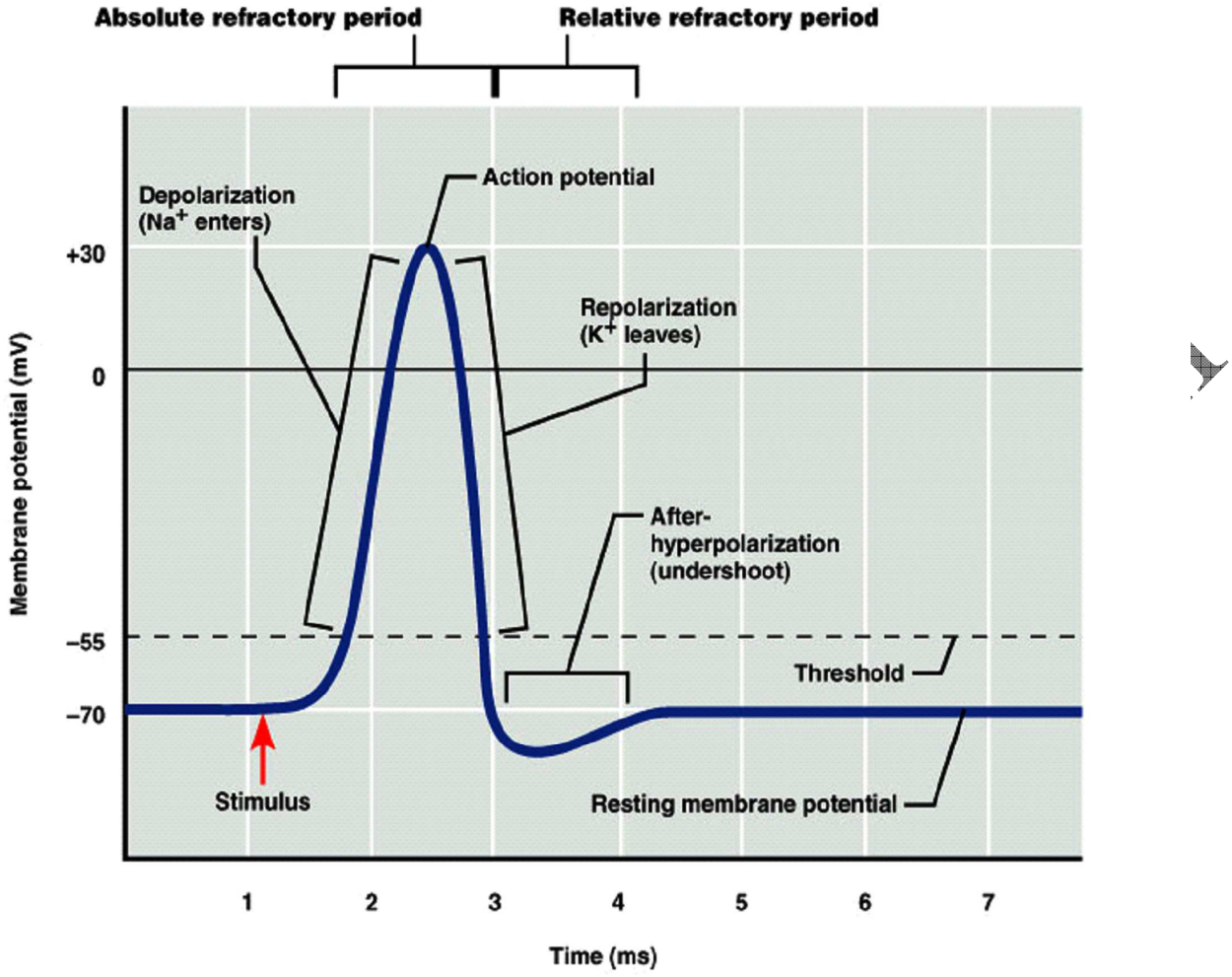
A. The cell bodies of the preganglionic neurons of the parasympathetic division are located in the III,VII, IX and X cranial nerves of brain and in the 2,3 and 4 sacral spinal nerves So the parasympathetic division is also known as the cranio acral division.



6. Distinguish between the absolute and relative refractory periods?

A. **Absolute Refractory Period:** During the absolute refractory period, even a very strong stimulus cannot initiate a second action potential. This period coincides with the period of depolarization and re-polarization.

Relative Refractory Period: It is the time during which a second action potential can be initiated by a larger than normal stimulus. It coincides with the period of hyper polarization.



7. What is all – or – none principle?

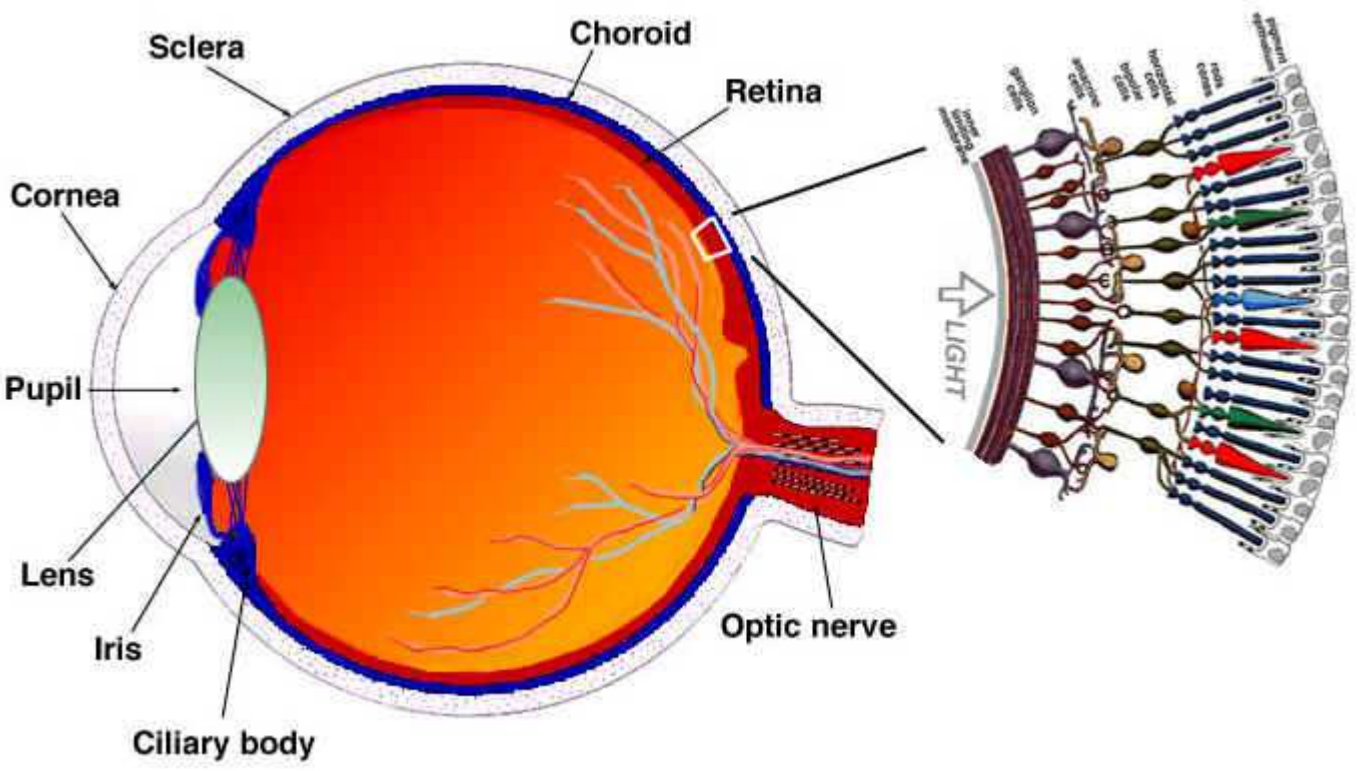
A. The action potential occurs in response to a threshold stimulus (or) supra threshold stimulus but does not occur at sub threshold stimuli.

It means the nerve impulse is either conducted totally (or) not conducted at all and this called all – or – None Principle.

8. How do rods and cones of human eye differ from each other chemically and functionally?

A. **Rods:** Rods contain a purplish red protein called rhodopsin or visual purple which contains a derivative of vitamin A. Rods are concerned with dim light (scotopic vision).

Cones: Cones contain a visual pigment called iodopsin, made of a protein called photopsin and they are important in daylight vision (photopic) and colour vision.



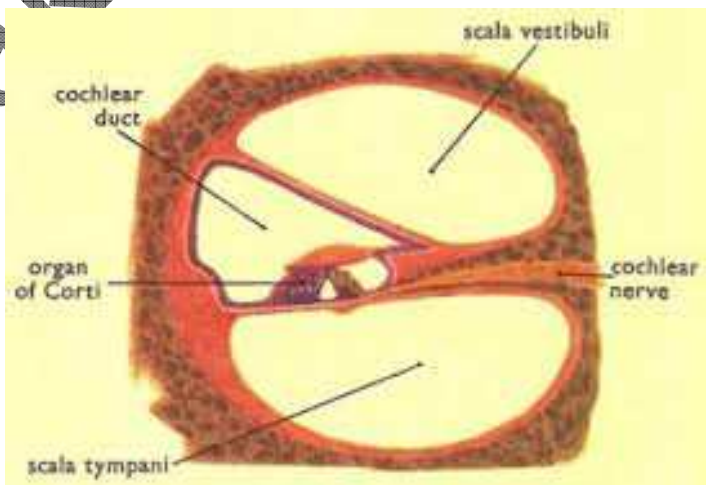
9. Distinguish between the blind spot and the yellow spot?

A. **Blind spot:** The site of the retina where the optic nerve exists, the eyeball and devoid of photo receptor cells like rods and cones is called blind spot. It is also known as optic disc.

Yellow spot: The centre of the posterior portion of the retina is called yellow spot or macula lutea. It contains a small depression in the centre known as fovea centralis.

10. What is organ of corti?

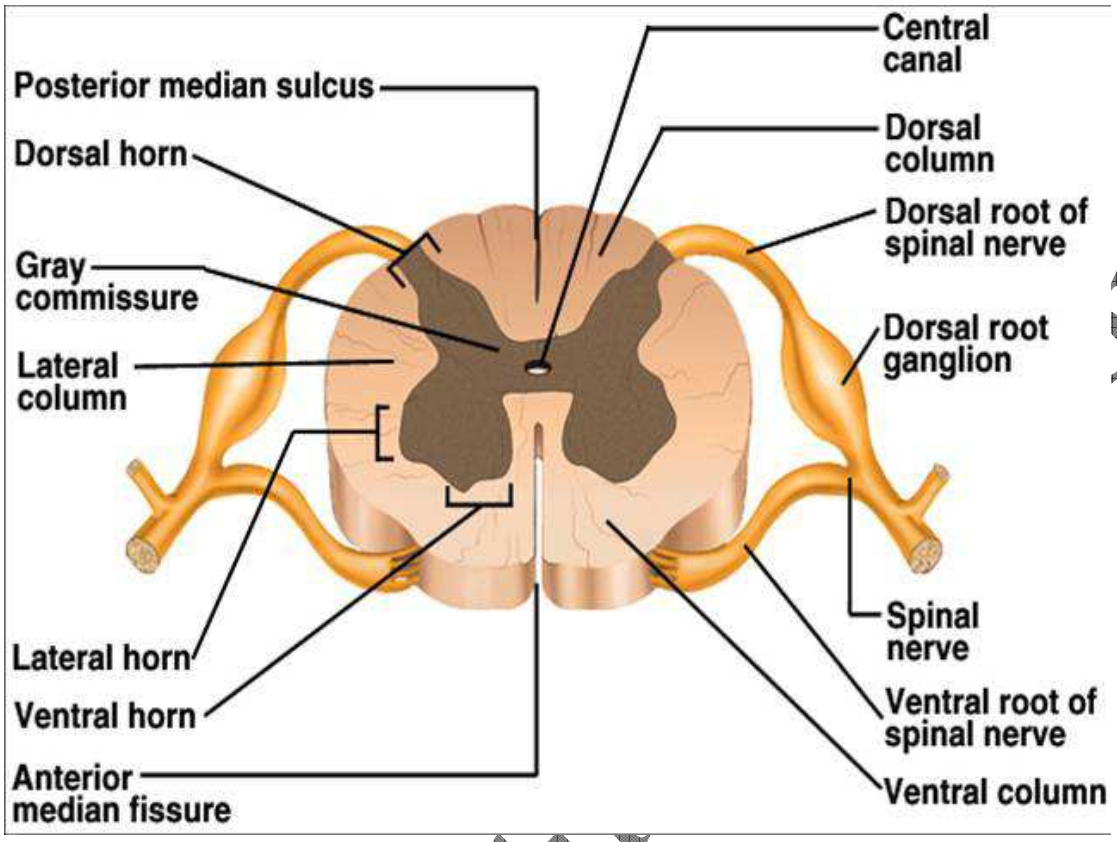
A. Organ of Corti is the sensory ridge present as cochlear epithelium on basilar membrane. The organ of corti contains hair cells that act as auditory receptors.



Short Answer Questions

1. Draw a labelled diagram of the T.S. of the spinal cord of man?

A.



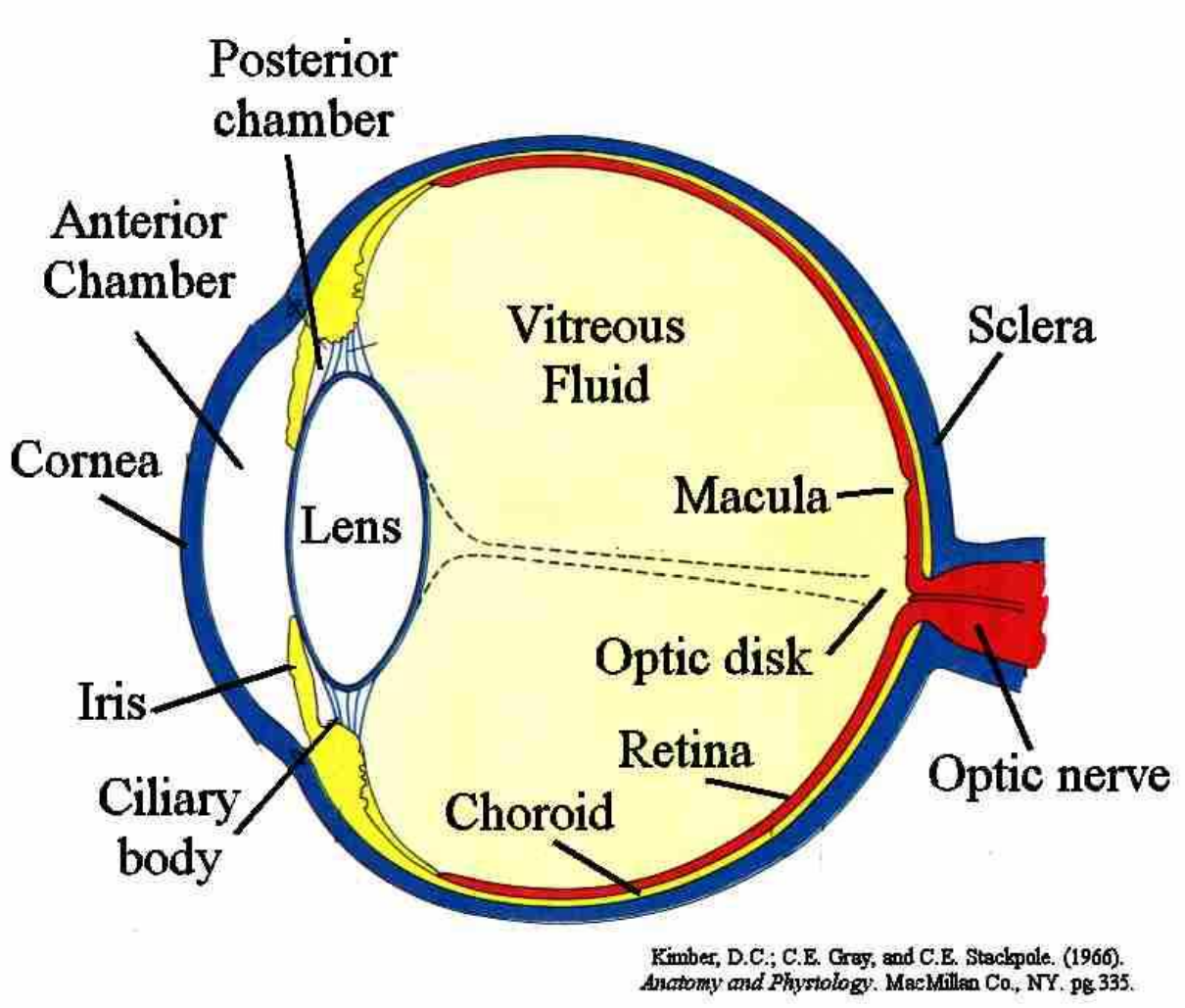
2. Distinguish between somatic and autonomic neural systems?

A.

Somatic Neural System	Myosin
1. The sensory neurons conduct sensory impulses from the different somatic receptors to the CNS	1. The autonomic neurons are associated with interoceptors present in the viscera.
2. All these sensations are consciously perceived	2. These sensory signals are generally not continuously perceived
3. Somatic motor neurons innervate the skeletal muscles and produce voluntary movements	3. Autonomic motor neurons regulate the involuntary activities of the cardiac muscle, smooth muscle and glands
4. Acetylcholine is the neurotransmitter	4. Acetylcholine (or) norepinephrine is neurotransmitter

3. Give an account of the retina of the human eye?

- Retina is the third and inner coat of the eye. It consists of a pigmented epithelium and a neural portion. The pigmented epithelium is a sheet of melanin with epithelial cells. The neural portion has three layers namely photoreceptor layer closer to choroid coat, bipolar cell layer and ganglion cell layer.
- Photoreceptor layer consists of photoreceptor cells like rods and cones. Rods contain a protein called rhodopsin. Rods are concerned with dim light. Cones contain a visual pigment called iodopsin and they are important in daylight vision and colour vision. There are three types of cones and are responses to red, green and blue colors.
- The centre of the posterior portion of the retina is called Yellow Spot or Macula Lutea.
  A depression present in the yellow spot is called 'Fovea centralis' with cones only.
  Fovea is responsible for sharp vision and useful while walking, reading, driving etc.,
- The site of retina which is devoid of rods and cones is known as blind spot (or) optic disc from which the optic nerve exists the eye ball.



Kimber, D.C.; C.E. Gray, and C.E. Stackpole. (1966). *Anatomy and Physiology*. MacMillan Co., NY. pg 335.

4. Give an account of synaptic transmission?

A. synapses are the junctions between neurons through impulse are transmitted from one neuron to another.

- Synapses are of two types. (1) Electrical synapses and (2) Chemical synapses

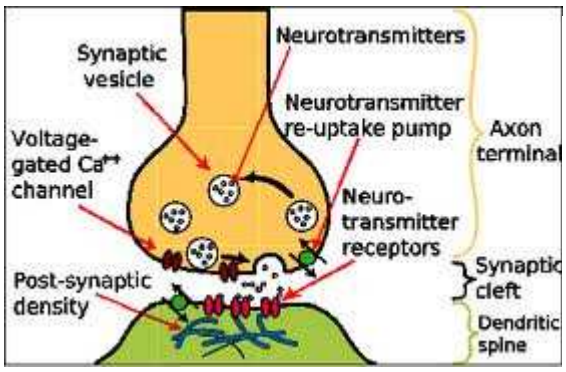
Electrical Synapses: These are electrically conductive links between two neurons. They are called as "Gap Junctions" also. Impulses transmission across electrical synapses is always faster than that across a chemical synapses.

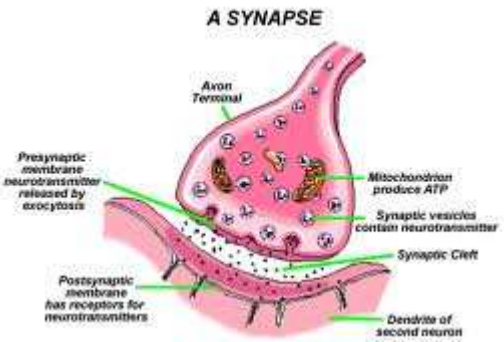
Chemical synapses: membranes of pre and post synaptic neurons are separated by a fluid-filled space known as synaptic cleft.

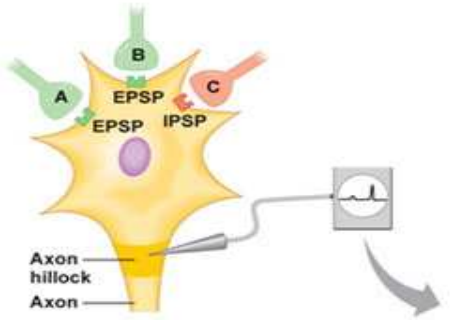
- Chemicals called neurotransmitters are involved in the transmission of impulses at chemical synapses.
- When an impulse arrives at the axon terminal, it depolarizes the membrane opening voltage gated calcium channels. Calcium ions stimulate the release of neurotransmitters into the cleft by exocytosis from synaptic vesicles. The released neurotransmitters bind to their specific receptors, present on the post synaptic membrane.
- Post synaptic membrane has ligand gated channels. They are ion channels which respond to chemical signals, rather than to changes in the membrane potential. The entry of ions can generate a new potential in the post synaptic neuron. The new potential developed may be either excitatory (or) inhibitory.
- Excitatory post synaptic potentials (EPSPs) cause depolarization, where as inhibitory post synaptic potentials (IPSPs) cause hyper polarization of post synaptic membrane.
- Post synaptic potentials are graded potentials and summation of these potentials occurs at axon hillocks.
- Summation is of two types like

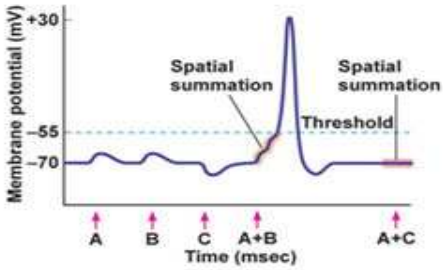
a)Spatial summation - - summation of inputs from many presynaptic membranes.

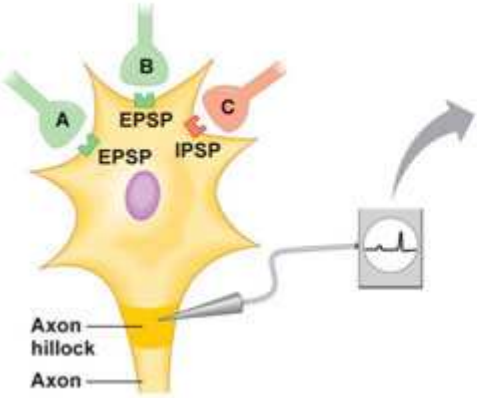
b) Temporal summation – summation of successive inputs from a single presynaptic membrane.

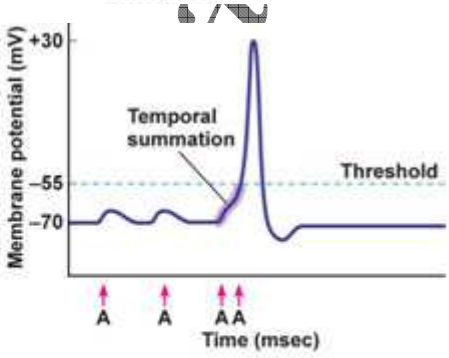












5. List out the differences between sympathetic and parasympathetic neural system in man?

A.

Sympathetic Neural System	Parasympathetic Neural System
1. SNS originates the thoracic and lumbar regions of the spinal cord 2. Its ganglia are linked up to form a chain 3. Preganglionic fibres are short and the postganglionic fibres are long	1. PNS originates in the cranial region of the brain and the sacral region of the spinal cord 2. Its ganglia remain isolated 3. Preganglionic fibres are long and the postganglionic fibres are short

4. Norepinephrine is produced at the terminal ends of the post – ganglionic fibres at the synapses on the effectors organ. Hence the system is called ‘adrenergic’ usually 5. Active during stressful conditions preparing the body to face them 6. The overall effect is excitatory and stimulating	4. Acetylcholine is produced at the terminal ends of the postganglionic fibres at the effector organ. Hence the system is called ‘cholinergic’ usually 5. Active during relaxing times, restoring normal activity after stress 6. The overall effect is inhibitory

Long Answer Questions

1. Give a brief account of the structure and functions of the brain of man?

A. Brain is the site of information, processing and control. It is protected in the cranial cavity and covered by three cranial meninges namely duramater (outer layer), arachnoid mater (thin middle layer) and piamater (inner layer).

The brain can be divided into three major parts called

1) Fore Brain

2) Mid Brain

3) Hind Brain

1. **Fore Brain:** The fore brain consists of (i) Olfactory bulb, (ii) Cerebrum and (iii) Diencephalon

   i) **Olfactory Bulb:** It receives impulses pertaining to smell, from the olfactory epithelium.

   ii) **Cerebrum:** Cerebrum forms the major part of the human brain. A deep cleft divides the cerebrum longitudinally into two halves, which are termed as the left and right cerebral hemispheres. The hemispheres are connected by a transverse, wide and flat bundle of myelinated fibres beneath the cortex, called corpus callosum. It brings the coordination between the left and right sides of the hemispheres. The surface of the cerebral cortex shows many folds and grooves. The folds are called gyri, the deepest and shallower grooves between folds are called fissures and sulci respectively.

   The cerebral cortex contain three functional areas called

   a) Sensory Areas: Receive and interpret the sensory impulses

   b) Motor Areas: Which control voluntary muscular movements.

   c) Association Areas: Which are neither clearly sensory nor motor in function, they deal integrative functions, such as memory and communications.

   The cerebral medulla consists of mostly myelinated axons. Each cerebral hemisphere of the cerebrum is divided into four lobes namely frontal, parietal, temporal and occipital lobes.

iii) Diencephalon: It contains three main parts namely, (a) Epithalamus, (b) Thalamus and (c) Hypothalamus.

a) **Epithalamus:** It is the roof of the diencephalon. It is the axon nervous part which is fused with the pia mater to form the anterior choroid plexus. The epithelium of the epithalamus forms a pineal stalk, which ends in a rounded structure called pineal body.

b) Thalamus: It lies superior to the mid brain. It is the major coordination centre for sensory and motor signaling.

c) Hypothalamus: It lies at the base of the thalamus. The hypothalamus forms a funnel – shaped downward extension called infundibulum, connecting the hypothalamus with the pituitary gland. It also contains a group of neurosecretory cells, which secrete hormones called hypothalamic hormones.

Hypothalamus controls and integrates the activities of the autonomous nervous system and it has osmoregulatory, thirst, feeding of the satiety centres.

Limbic System: The inner part of cerebral hemisphere and group of associated structures forms limbic system. Limbic system along with hypothalamus is involved in the regulation of sexual behaviour and expression of emotional reactions.

2) Mid Brain: Mid brain is located between the thalamus of the fore brain and pons varolii of hind brain. The ventral portion of mid brain consists of a pair of longitudinal bands of nervous tissues called cerebral peduncles. The dorsal portion of the mid brain consists of four lobes called corpora quadrigeminal. The two larger anterior lobes are called superior colliculus, which are concerned with visual function. The smaller posterior lobes are called inferior colliculus and are concerned with auditory functions.

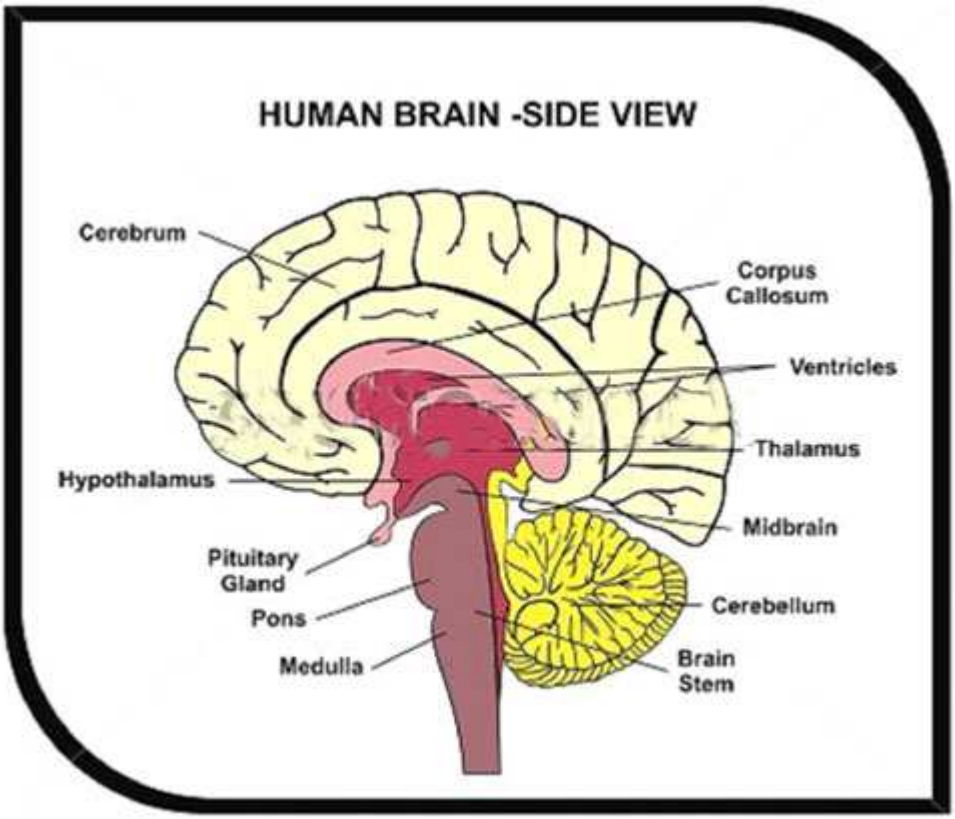
3) Hind Brain: The hind brain comprises of cerebellum, pons varolii and medulla oblongata.

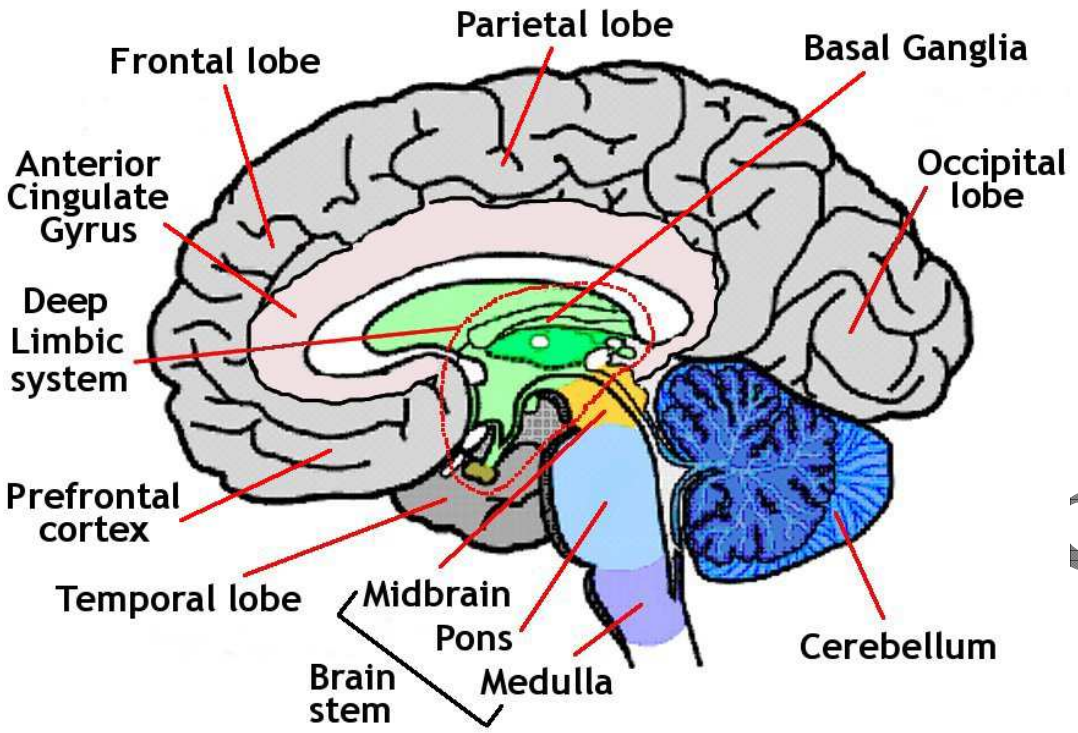
i) Cerebellum: It is the second largest part of the brain. It consists of two cerebellar hemispheres and a central vermis. Each cerebellar hemisphere consists of three lobes namely anterior, posterior and floccular lobes. It has a branching tree like core of white matter called arbor vitae.

ii) Pons Varolii: It consists of nerve fibres which form a bridge between the two cerebellar hemispheres. It is a relay station between the cerebellum, spinal cord

and the rest of the brain. Pons has the pneumotaxic centre as it regulates the amount of air a person can take in each time.

iii) **Medulla Oblongata:** It is the posterior part of brain. It extends from the Pons Varolii above and continuous with the spinal cord below. Medulla includes cardiovascular and respiratory centers, the centers for swallowing, vomiting, coughing, sneezing and hiccupping. The mid brain, pons and medulla oblongata are collectively referred to as brain stem.

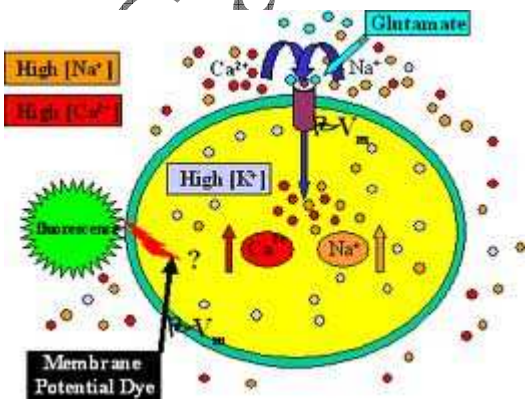


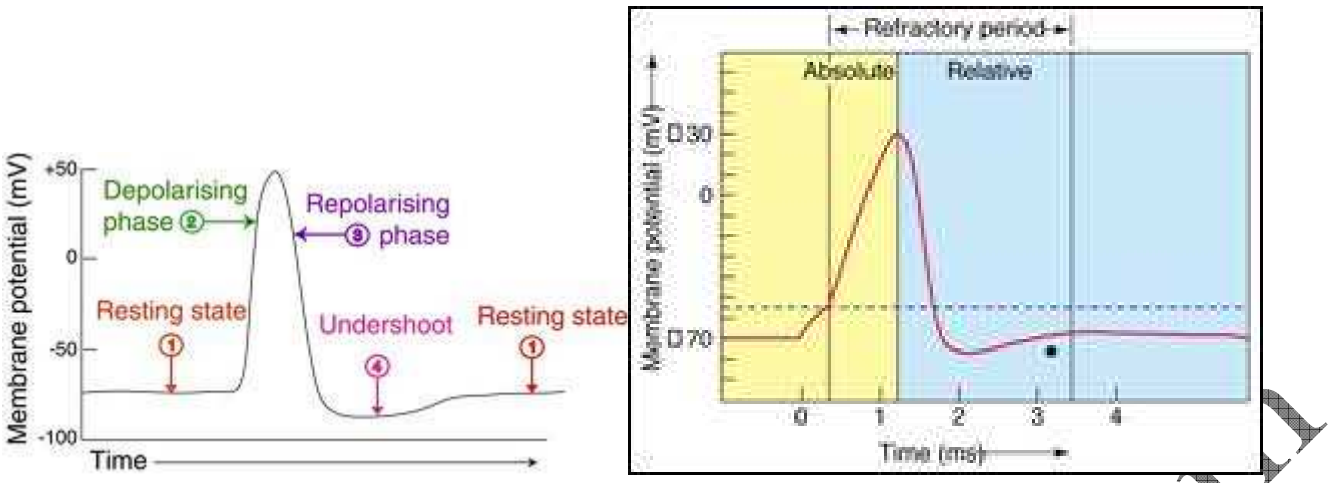


2. Explain the transmission of nerve impulse through a nerve fibre with the help of suitable diagrams.

A. Nerve impulse is the combination of mechanical, chemical (or) electrical disturbances occurs in neuron because of stimulus. The propagation of a impulse along nerve fibre is called transmission. In this process both physical and chemical changes are involved. The entire process is divided into stimulation, excitation, conduction and response.

Resting Membrane Potential: The resting membrane potential exists because of a small buildup of negative ions in the axoplasm along the inside of the membrane and an equal buildup of positive ions in the extra cellular fluid along the outer surface of the membrane. Such a separation of positive and negative electrical charges is a form of potential energy. In neurons the resting membrane potential ranges from – 40 to – 90mV. A typical value is – 70mV.





At resting phase, the axolemma is polarized. If the inner side becomes less negative, it is said to be depolarized. If the inner side becomes more negative, it is said to be hyperpolarized. During the resting phase the activation gates of sodium are closed, the inactivation gates of sodium are open and the activation and the activation gates of potassium are closed.

Sodium – Potassium Pump: Sodium and potassium ions diffuse inwards and outwards, respectively, down their concentration gradients through leakage channels. Such a movement of ions, if unchecked, would eventually disturb the resting membrane potential. These flows of ions are offset by sodium – potassium pumps (Na^+/K^+ ATPases) present in the axonal walls. These pumps expel three Na^+ ions for each two K^+ ions imported. As these pumps remove more positive charges from the axoplasm than they bring into it, they contribute to the negativity of the resting membrane potential i.e., - 70mv.

Depolarization (Rising phase): When a nerve fibre is stimulated, the plasma membrane becomes more permeable to Na^+ ions than to K^+ ions as the activation and inactivation voltage gates of sodium open and activation voltage gates of potassium close. As a result the rate of flow of Na^+ into the axoplasm exceeds the rate of flow of K^+ to the ECF. Hence, the axolemma is positively charged inside charged outside. This reversal of electrical charge is called “depolarization”.

Outer face of the point which is adjacent to the site of depolarization remains positively charged. The electrical potential difference between these two areas is called “action potential”. An action potential occurs in the membrane of the axon of a neuron when depolarization reaches a certain level called ‘threshold potential’ (- 55mV). The particular

stimulus which is able to bring the membrane potential to threshold is called 'threshold stimulus.'

Re-polarization (Falling Phase): As the wave of depolarization passes away from its site of origin to the adjacent point, the activation gates of sodium remain open, inactivation gates of sodium close and activation gates of potassium open at the site of origin of depolarization. As a result the influx of Na^+ ions into the axoplasm from the EVF is checked and 'efflux' of K^+ ions occurs, which leads to the returning of axolemma to the resting state (exit of potassium ions causes a reversal of membrane potential to negative inside). This is called 'Re-polarization'.

Hyper-polarization (Undershoot): The Re-polarization typically goes more negative than the resting potential to about – 90mV. This is called 'hyper-polarization'. This occurs because of the increased K^+ permeability that exists while voltage gates K^+ channels are open activation and inactivation gates of Na^+ channels remain closed. The membrane potential returns to its original resting state as the K^+ channels close completely. As the voltage falls below the – 70mV level of the resting state, it is called 'undershoot'.

The Refractory Periods: The period of time after an action potential begins during which the neuron cannot generate another action potential in response to a normal threshold stimulus is called the 'refractory period'. These are two kinds of refractory periods, namely absolute refractory period and relative refractory period. During the absolute refractory period, even a very strong stimulus cannot initiate a second action potential. The relative refractory period is the time during which a second action potential can be initiated by a larger than normal stimulus.

Conduction Speed: The conduction speed of a nerve impulse depends on the diameter of the axon the greater the axon's diameter, the faster is the conduction. In a myelinated axon, the voltage – gated Na^+ and K^+ channels are concentrated at the nodes of Ranvier. As a result, the impulse 'jumps' from one Ranvier's node to the next, rather than travelling the entire length of the nerve fibre. This mechanism of conduction is called Saltatory conduction. Saltatory conduction is faster (in myelinated fibres) than the continuous conduction (in non-myelinated fibres).