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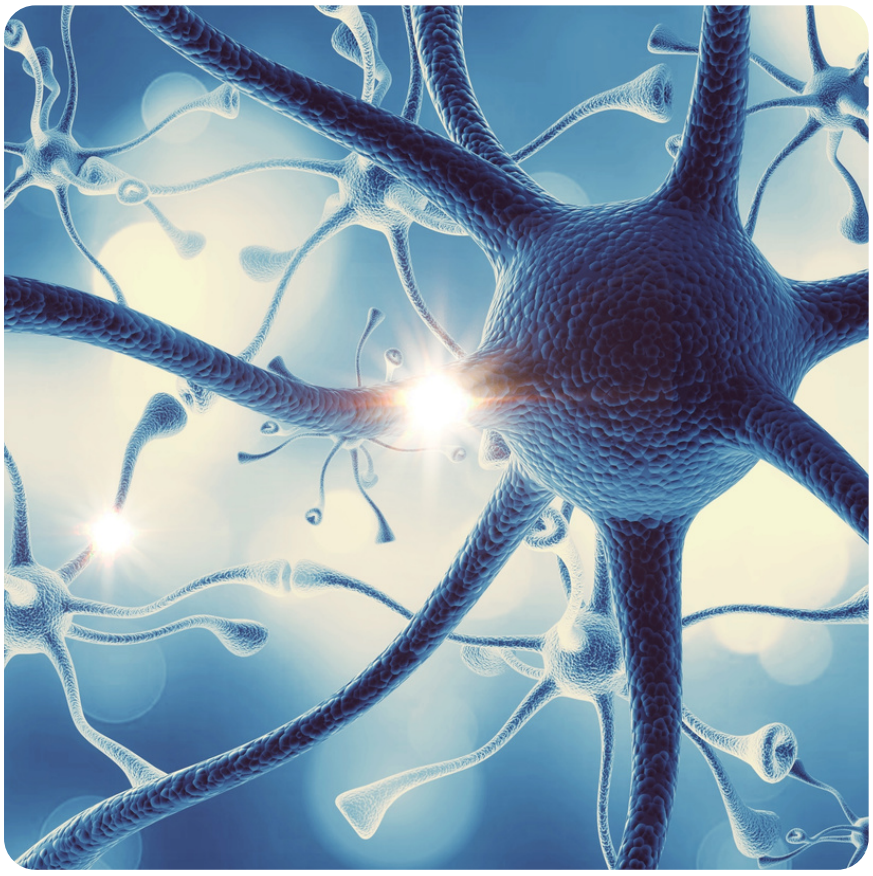

STUDY MATERIAL

Neural control and coordination (Nervous System)

ENGLISH MEDIUM

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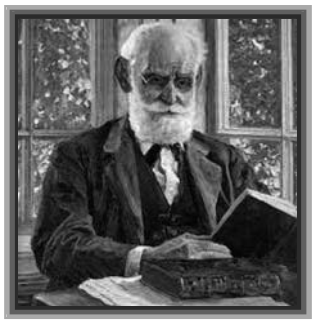
IVAN PAVLOV



Ivan Petrovich Pavlov was an eminent Russian physiologist and psychologist who devised the concept of the conditioned reflex. He conducted a legendary experiment in which he provided training to a hungry dog to drool at the sound of a bell, something which was related to the sight of food.

Pavlov also formulated a similar conceptual theory, highlighting the significance of conditioning and associating human behavior with the nervous system. He won the 1904 Nobel Prize for Physiology or Medicine. As a young child, he suffered a serious injury, due to which Pavlov spent much of his childhood with his parents in the family home and garden, acquiring various practical skills and a deep interest in natural history.

He studied medicine at university under a famed physiologist of the time, S. P. Botkin, who taught him a great deal about the nervous system. Ivan Pavlov conducted neurophysiological experiments with animals for years after receiving his doctorate at the Academy of Medical Surgery. The legendary experiment for which Pavlov is remembered was when he used the feeding of dogs to establish a number of his key ideas.

Moments before feeding, a bell was rung to measure the dog's saliva production when they heard the bell. Pavlov found out that once the dogs had been trained to associate the sound of the bell with food, they would produce saliva, whether or not food followed. The experiment proved that the dog's physical response, salivation, was directly related to the stimulus of the bell, hence the saliva production was a stimulus response. The continued increased salivation, even when the dogs had experienced hearing the bell without being later fed, was a conditioned reflex.

PIERRE PAUL BROCA

Born28 June 1824

Pierre Paul Broca was a French physician, surgeon, anatomist, andanthropologist. He was born in Sainte-Foy-la-Grande, Gironde. He is best known for his research on Broca's area, a region of the frontal lobe that has been named after him. Broca's Area is involved with language. His work revealed that the brains of patients suffering from aphasia contained lesions in a particular part of the cortex, in the left frontal region. This was the first anatomical proof of the localization of brain function.

SIR CHARLES SCOTT SHERRINGTON

Born27 November 1857

Nobel Prize in Physiology or Medicine (1932)

Sir Charles Scott Sherrington was an English neurophysiologist, histologist, bacteriologist, and a pathologist. He received the Nobel Prize in Physiology or Medicine with Edgar Adrian, 1st Baron Adrian, in 1932 for their work on the functions of neurons. Prior to the work of Sherrington and Adrian, it was widely accepted that reflexes occurred as isolated activity within a reflex arc. Sherrington received the prize for showing that reflexes. The Integrative Action of the Nervous System, he had effectively laid to rest the theory that the nervous system, including the brain, can be understood as a single interlinking network.

NEURAL CONTROL AND COORDINATION

01. INTRODUCTION

- **Introduction**
- **Neural System**
- **Human Neural System**
- **Nervous Tissue**
- **Generation & conduction of nerve impulse**
- **Synapse**
- **Central Neural System**
- **Peripheral Nervous System**
- **Reflex Actions**

In human body the **neural system** and the **endocrine system** jointly **coordinate** and **integrate** all the activities of the organs so that they function in a synchronised fashion. **Co-ordination** is the process through which two or more organs interact & complement the functions of one another. The neural system provides an organised network of **point-to-point** connections for a quick coordination. The endocrine system provides chemical integration through hormones.

- Nervous system and endocrine system are called **Integrative system** of the body.
- Nervous system carries informations in the form of impulses to the different parts of body. High speed services are offered by this system.

02. NEURAL SYSTEM

- The neural system of all animals is composed of highly specialised cells called **neurons** which can detect, receive and transmit different kinds of stimuli.
- The neural organisation is very simple in lower invertebrates. For example, in Hydra it is composed of a network of neurons.
- The neural system is better organised in insects, where a brain is present along with a number of ganglia and neural tissues.
- The vertebrates have a more developed neural system.

03. HUMAN NEURAL SYSTEM

The human neural system is divided into two parts :

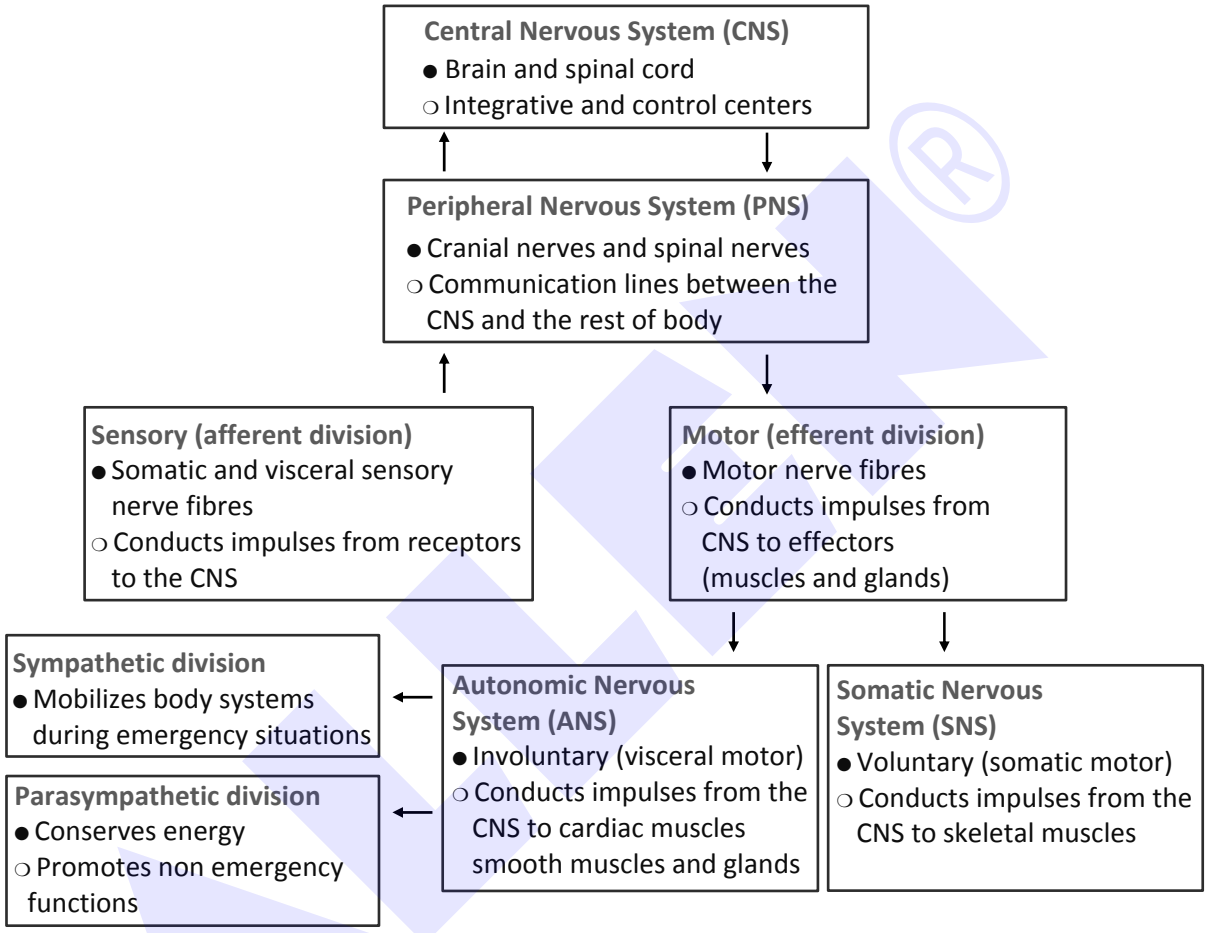
- **Central neural system (CNS)**
- **Peripheral neural system (PNS)**

The CNS includes the brain and the spinal cord and is the site of information processing and control. The PNS comprises of all the nerves of the body associated with the CNS (brain and spinal cord). The nerve fibres of the PNS are of two types :

- **Afferent fibres**
- **Efferent fibres**

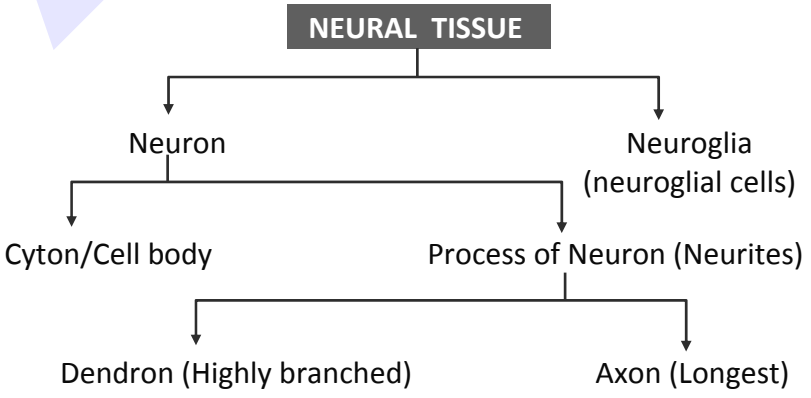
The afferent nerve fibres transmit impulses from tissues/organs to the CNS and the efferent fibres transmit regulatory impulses from the CNS to the concerned peripheral tissues/organs.

- The PNS is divided into two divisions :-
  - **Somatic neural system (SNS)**
  - **Autonomic neural system (ANS)**
- The somatic neural system relays impulses from the CNS to skeletal muscles while the autonomic neural system transmits impulses from the CNS to the involuntary organs and smooth muscles of the body.
- The autonomic neural system is further classified into **sympathetic** neural system and **parasympathetic** neural system.



04. NERVOUS TISSUE

Nervous tissue originates from **ectoderm** and is specialized for receiving stimuli (excitability), transmit message (conductivity)



(1) NEURON (NERVE CELL)

It is the **functional** and **structural** unit of nervous system. It generates and transmits nerve impulses. It is the longest cell of the body.

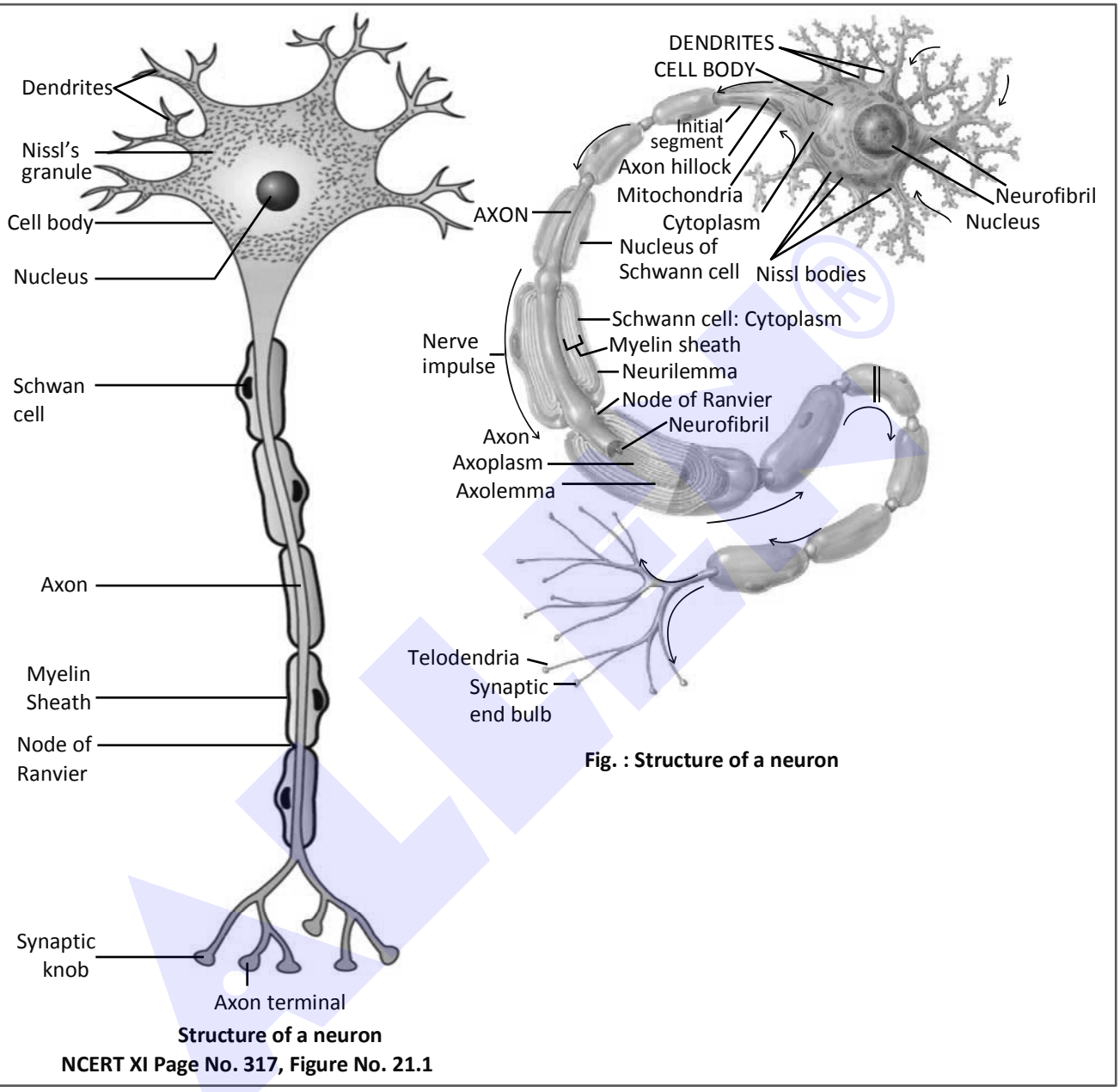


Fig. : Structure of a neuron

Structure of a neuron
NCERT XI Page No. 317, Figure No. 21.1

Structure of a neuron : A nerve cell is made up of cell body & cell process (Dendron + Axon = Neurites)

(A) Cell Body or Cyton or Soma or Perikaryon:

- It contains uninucleated cytoplasm.
- Except centriole, all cell organelles are found in cytoplasm.
- Centriole is absent in the nerve cell thus cell division is absent.
- Some other cell organelles like Nissl's granule and neurofibril are also found in nerve cell.

(i) Nissl's granules :

- Endoplasmic reticulum & ribosome form granules like structure called as **Nissl's granules** or **Tigroid body**.
- These are the centre of protein synthesis.
- Site – Cyton & dendron

(ii) Many small fibrils are found in the cytoplasm called **neurofibrils**, these help in internal conduction in the Neuron.

(B) Cell Processes :

(i) Dendron :

- It is small cell process. It's fine branches are called dendrites. Some receptor's are found on the dendrites, so dendron receive the stimuli & produce **centripetal** (towards the cell body) **conduction**.

(ii) Axon (Long process = Axon = Nerve fibre) :

- It is longest cell process of cyton, its diameter is uniform.
- Axon is covered by **Axolemma**. Part of cyton where axon arises called **Axon hillock**.
- Cytoplasm contained in axon is **axoplasm**.
- Nissl's granules are absent in the axoplasm.
- Axoplasm of axon contains only neurofibrils and mitochondria.
- The axon hillock is the neuron's trigger zone, because it is the site where action potential are triggered.
- The terminal end of axon is Telodendria and button shape structure are called as **Synaptic knob**, which possess synaptic vesicles containing chemicals called **neurotransmitters**. The axons transmit nerve impulses away from the cell body to a synapse or to a neuro-muscular junction.
- More mitochondria are found in the telodendria which synthesize neurotransmitters like Acetylcholine (Ach) with the help of **Acetyl-choline transferase enzyme**.
- Axon is the **functional part** of nerve cell, therefore term nerve fibre usually refer to Axon.

Differences between Axon & Dendron

Axon	Dendron
1. It is always single in a neuron.	1. One or more.
2. It has no Nissl's granules.	2. Nissl's granules present.
3. It is long.	3. Short.
4. Nerve impulse travels away from the cell body. (**centrifugal**)	4. Nerve impulse travels towards the cell body. (**centripetal**)

(2) MYELINOGENESIS

Myelin is a fatty material with a high electrical resistance and acts as an electrical insulator in the same way as the rubber and plastic covering of electrical wiring.

(A) Peripheral Nervous System (PNS) :

- Axon is covered by a layer of phospholipids/sphingomyelin which is called as **medulla or myelin sheath**.
- Medulla is covered by thin cell membrane, which is called as **neurilemma or sheath of schwann cells.**
- The neurilemma is composed of schwann cells.
- In the peripheral nerves, myelinogenesis begins with the deposition of myelin sheath in concentric layer around the axon by schwann cells.
- Myelin sheath is discontinuous around the Axon. Those interruptions where Axon is uncovered by myelin sheath are called **nodes of Ranvier**
- Schwann cell takes part in the deposition of myelin sheath (myelinogenesis).
- Myelin sheath acts as insulator and prevents leakage of ions.

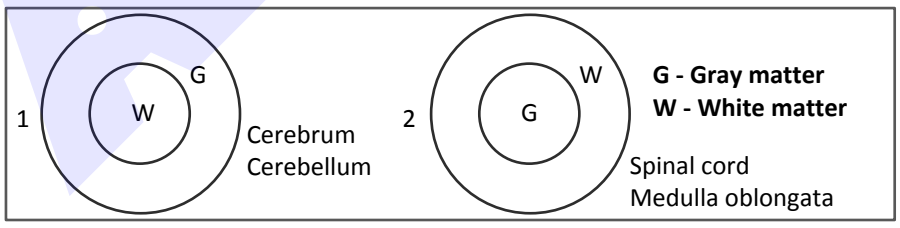
(B) Central Nervous System (CNS) :

- Neurilemma or schwann cells are not present in CNS, therefore myelinogenesis process occurs with the help of **oligodendrocytes (Neuroglia).**
- Neurons in which myelin sheath is present, are called **medullated or myelinated neurons**. In some nerve cells where myelin sheath is absent, called as **non medullated** or **non myelinated neurons**.

In PNS, there are two types of neuron, namely, myelinated and nonmyelinated. The Myelinated nerve bifres are envelopes with schwann cells, which form myelin sheath around Axon. Myelinated nerve fibres are found in spinal and cranial nerves. Unmyelinated nerve fibre is enclosed by a Schwann cell that does not form a myelin sheath around the axon, and is commonly found in autonomous and the somatic neural systems.

Gray matter :- It is composed of **nerve cells**. It consists of cytons & nonmedullated nerve fibres (Gray fibers).

White matter :- It contains myelinated **nerve fibres** (White fibres).



Important terms to remember

Collection of cytons
- **Nuclei -** term used for CNS (Brain and spinal cord)
- **Ganglia -** outside the CNS term used for PNS

Collection of nerve fibre
- **Tract** – CNS
- **Nerve** – PNS

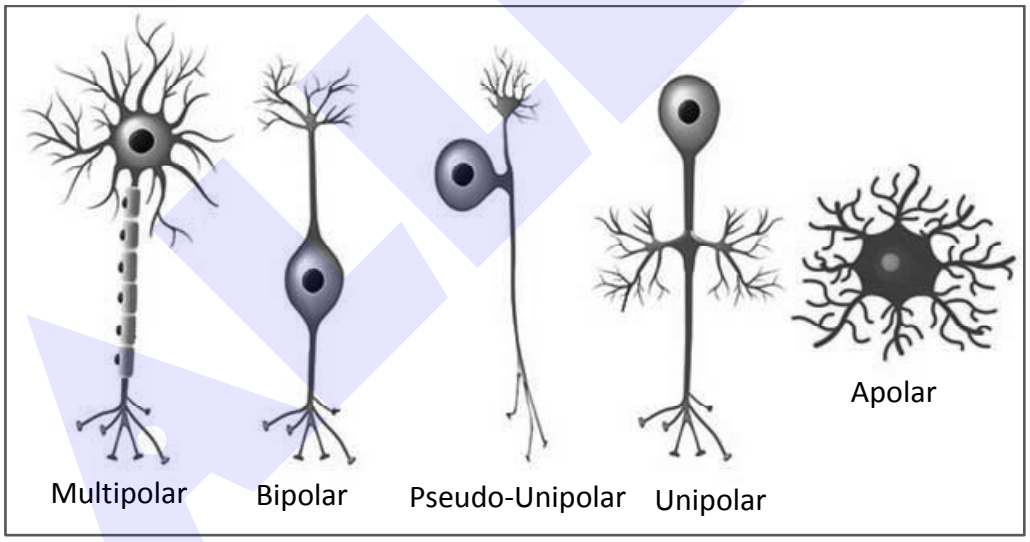
(3) TYPES OF NEURONS

(A) On the Basis of Structure :

Unipolar	Bipolar	Multipolar
Single process arises from cyton. (1 Axon) e.g. Nervous system of embryo	Two process arises from cyton (1 Axon & 1 dendron) e.g. Olfactory epithelium Retina :- (i) Rod and cones (modified bipolar neurons) (ii) Bipolar neuron layer of retina	Neuron which have one axon but many dendrons. e.g. Most neurons of vertebrates. (Cerebral cortex)

Apolar/Nonpolar Neuron :– No definite dendron/axon. Cell process are either absent or if present are not differentiated in axon and dendrons. Nerve impulse radiates in all directions. **e.g. *Hydra*, amacrine cell of retina.**

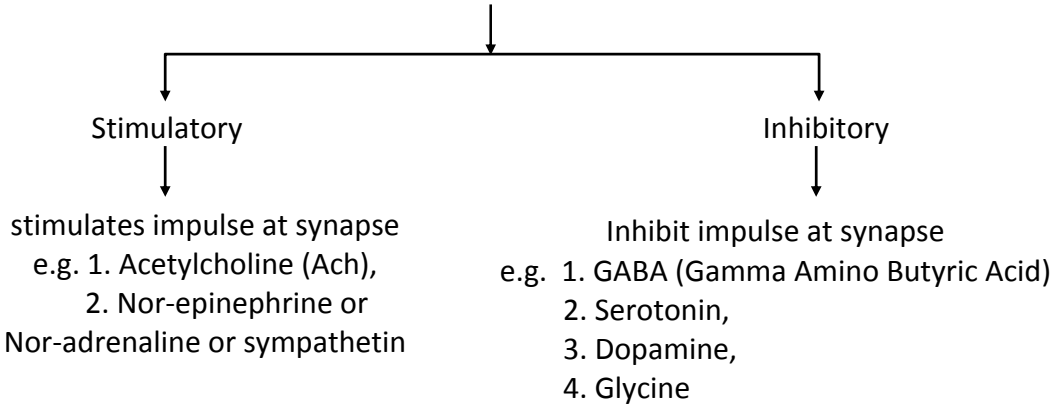
Pseudounipolar :– In this type, nerve cell has only axon but a small process develop from axon which act as dendron. eg. **Dorsal root ganglia of spinal cord.**



(B) On the Basis of Function

- Sensory or afferent: Sensory organ → CNS
- Inter neuron or Inter connecting neuron or internuncial neuron
- Motor or Efferent: CNS → Effector (organ)

(C) On the basis of Neurotransmitters or Neurohumors or Neurohormones



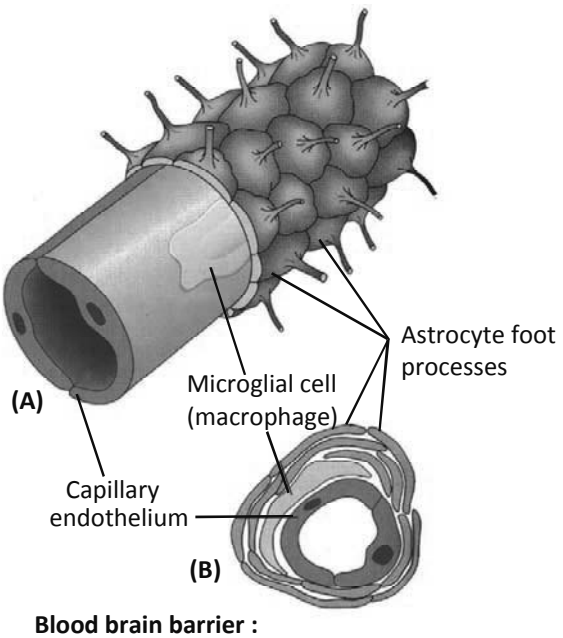
(4) NEUROGLIA/GLIAL CELLS

These are supporting cells which form a packing substance around the neurons. These are of three types :

	Astrocytes	Oligodendrocytes	Microgliocytes
(i)	**Morphology :-** Large cell Numerous process	Smaller few process	Smallest With branching
(ii) 1.	**Function :-** It forms **blood brain barrier**	1. Formation & preservation of **Myelin sheath in CNS**.	1. Scavenger cells of CNS and phagocytic in nature.

(5) BLOOD BRAIN BARRIER (BBB)

The Blood-Brain Barrier is formed by Astrocyte cells, which are coupled by tight junctions. The barrier prevents the entry of neurotoxins.



Blood brain barrier :
(A) Longitudinal section, (B) Transverse section

BEGINNER'S BOX — NEURAL TISSUE

1. Which statement is correct about nerve fibres ?

(1) All nerve fibres of CNS are enclosed by Schwann cells.

(2) Only myelinated nerve fibres of PNS are enclosed by Schwann cells.

(3) All nerve fibres of PNS are enclosed by Schwann cells.

(4) Only myelinated fibres of CNS are enclosed by Schwann cells.

2. Which neuroglial cell helps in formation of blood brain barrier ?

(1) Capillary endothelial cells (2) Astrocyte

(3) Both (1) and (2) (4) Oligodendrocyte

3. Which statement is true ?

(1) In PNS, only non-myelinated neuron are found.

(2) In CNS, myelinated and non-myelinated neurons are found.

(3) In PNS, myelinated and non-myelinated neurons are found.

(4) Both (2) and (3)

4. Which structure is not found in white matter ?

(1) Telodendria (2) Cell body

(3) Dendrons and non-myelinated axons (4) All of the above

5. Nissl's granules are made up of ?

(1) Endoplasmic Reticulum and Mitochondria (2) Ribosome and Mitochondria

(3) Ribosome and Endoplasmic Reticulum (4) Golgi body and Ribosome

6. Which of the following is true for Neurilemma ?

(1) Discontinuous at nodes of Ranvier

(2) Continuous at nodes of Ranvier and made by schwann cells

(3) Discontinuous at nodes of Ranvier and made by schwann cells

(4) Continuous at nodes of Ranvier and made by oligodendrocytes

7. Fibres which transmit impulses towards the cell body called as :-

(1) Axon terminal (2) Axon

(3) Dendrites (4) Axon hillock

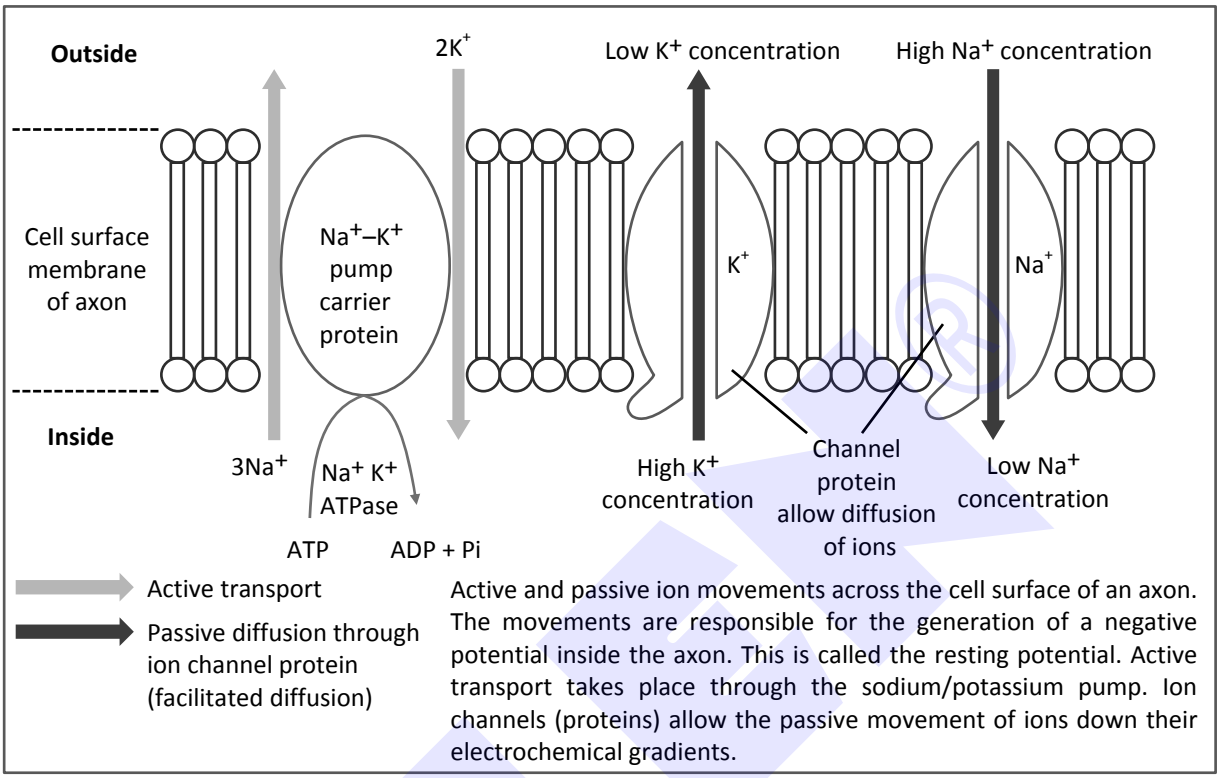
8. The axonal membrane is ____ to negatively charged proteins present in the axoplasm :-

(1) Selectively permeable (2) Permeable

(3) Semipermeable (4) Impermeable

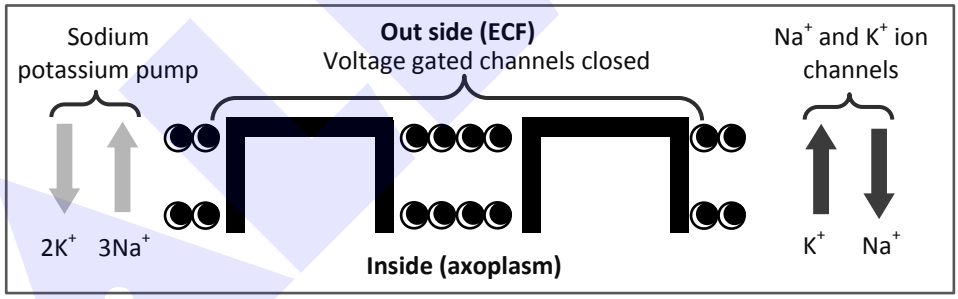
05. GENERATION AND CONDUCTION OF NERVE IMPULSE

Excitable cells - Neurons are excitable cells because their membranes are in a polarized state due to differential concentration gradient of ions across membrane. This axolemma is selectively permeable in nature.



Active and passive ion movements across the cell surface of an axon. The movements are responsible for the generation of a negative potential inside the axon. This is called the resting potential. Active transport takes place through the sodium/potassium pump. Ion channels (proteins) allow the passive movement of ions down their electrochemical gradients.

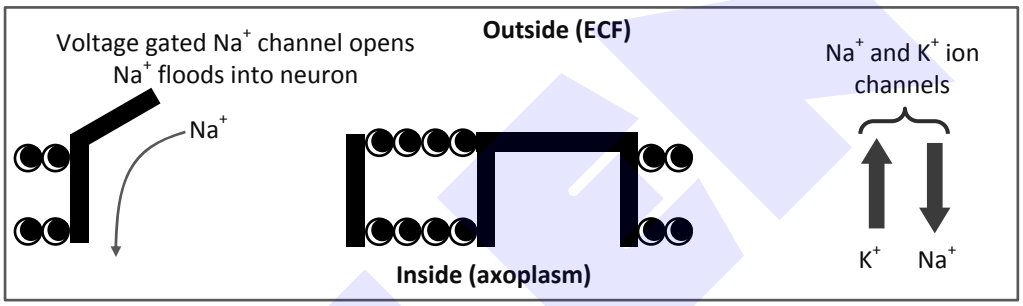
(1) RESTING PHASE



- The potential difference (a charge) which exists across the cell surface membrane of nerve cells, negative inside the cell with respect to the outside. The membrane is said to be **polarised**.
- The potential difference across the membrane at rest is called the **resting membrane potential** and this is about –70 mV (the negative sign indicates that inside the cell is negative with respect to the outside). (Range→ – 60 to – 85 mV)
- The resting potential is maintained by **active transport** and **passive diffusion** of ions.
- Resting membrane potential is maintained by the active transport of ions against their electrochemical gradient by **sodium potassium pump**. These are **carrier proteins** located in the cell surface membrane. They are driven by energy supplied by ATP and couple the removal of three sodium ions from the axon with the up take of two potassium ions.

- The active movement of these ions is opposed by the passive diffusion of the ions. The rate of diffusion is determined by the permeability of the axon membrane to the ion.
- Potassium ions have a membrane permeability greater than that of sodium ions.
- Therefore potassium ions loss from the axon is greater than sodium ion gain.
- This leads to a net loss of positive ions from the axon, and the production of negative charge within the axon (Further there are many organic anions within the axoplasm, which also contribute to axoplasm negativity).
- Due to active transport (mainly) and diffusion process, positive charge is more outside and negative charge is more inside.

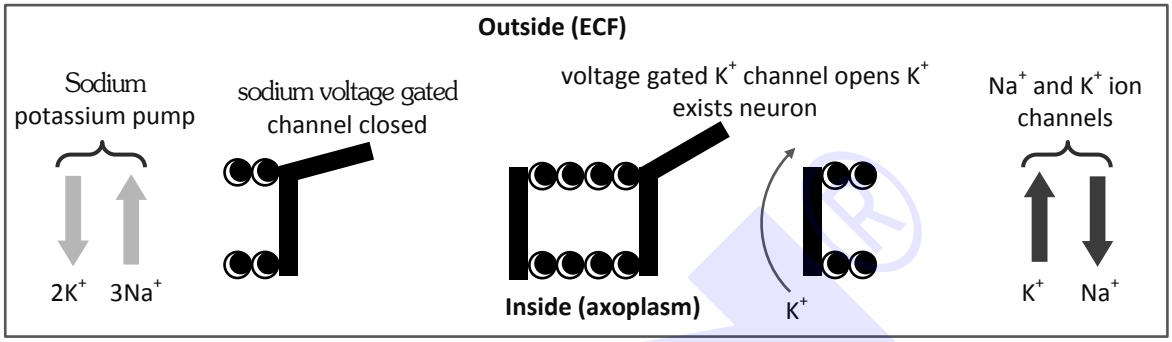
(2) EXCITING STAGE



- Once the event of depolarization occurs, a nerve impulse or spike is initiated. **Action potential** is another name of **nerve impulse.** This is generated by a change in the sodium ion channels. These channels, and some of the potassium ion channels, are known as **voltage gated channel,** meaning they can be opened or closed with change in voltage. In resting state these channels are closed due to binding of Ca^{++}.
- A potential is generated and it cause sudden opening of the sodium gates. Opening of gates increases the permeability of the axon membrane to sodium ions which enter by diffusion. This increases the number of positive ions inside the axon.
- A change of +10mV in potential difference from RMP through influx is sufficiently significant to trigger a rapid influx of Na^+ ions leading to generation of action potential. This change of +10 mV is called as **threshold stimulus.**
- At the point where membrane (Axolemma) is completely depolarised due to rapid influx of Na^+ ions, the negative potential is first cancelled out and becomes **"0"**.
- Due to further entry of Na^+, the membrane potential "over shoots" beyond the zero and becomes positive upto +30 to +45mV.

- This potential is called as **action potential**. In this state, the inner surface of axolemma becomes positively charged and outer surface becomes negatively charged. *The rise in the stimulus-induced permeability to Na^+ is extremely shortlived.It is quickly followed by a rise in permeability to K^+.*

(3) REPOLARISATION



- After a fraction of second, the sodium gates get closed. Depolarisation of the axon membrane causes potasium gates to open.
- *Within a fraction of a second, K^+ diffuses outside the membrane and restores the resting potential of the membrane at the site of excitation and the fibre becomes once more responsive to further stimulation.*
- Since potassium is positively charged, its exit makes the inside of cell less positive, or more negative and the process of repolarization or return to the original resting potential begins.
- The repolarization period returns the cell to its resting potential (–70 mV). The neuron is now prepared to receive another stimulus and conduct it in the same manner.
- The time taken for restoration of resting potential is called **refractory period**, because during this periods the membrane is incapable of receiving another impulse.
- Nerve impulse travels as action potential which passes along the axon as a wave of depolarization.
- The whole process of depolarisation and repolarisation is very fast. It takes only about 1 to 5 milli second (ms).

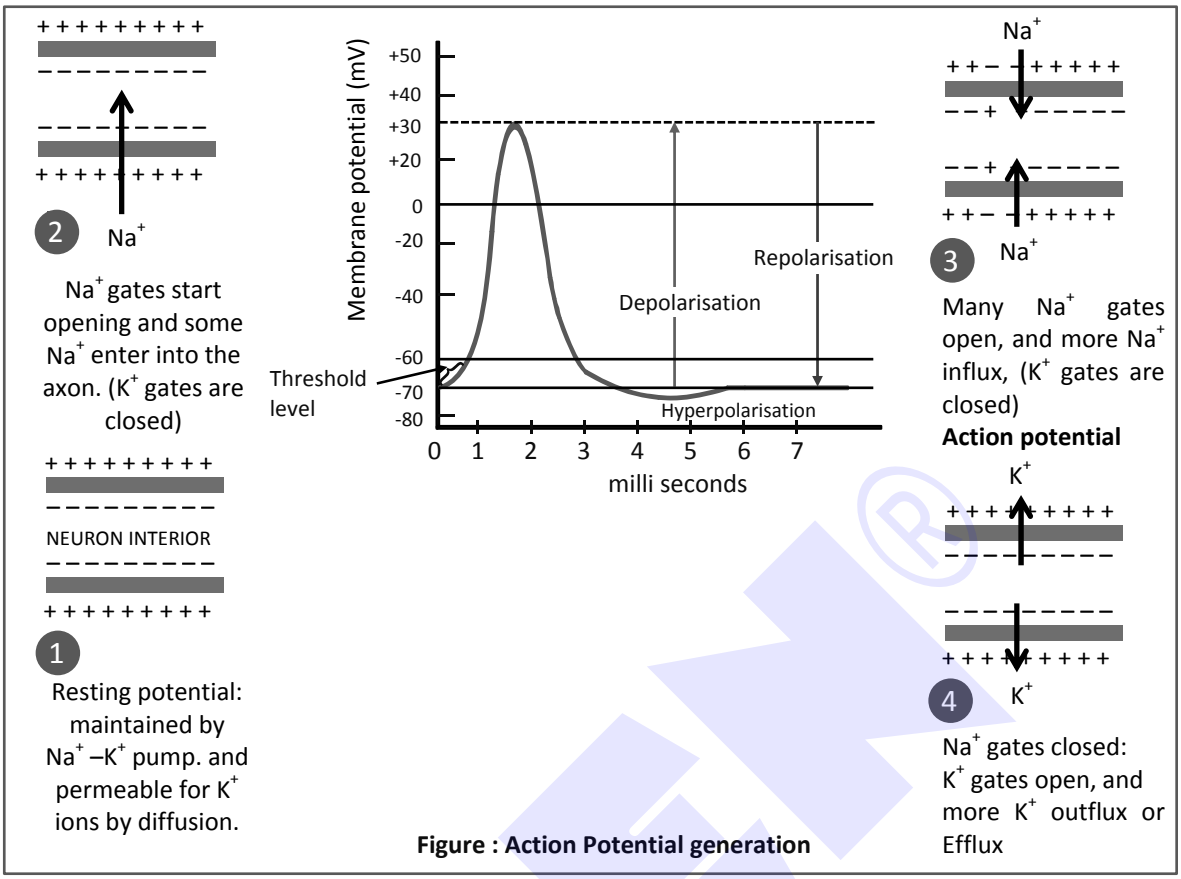
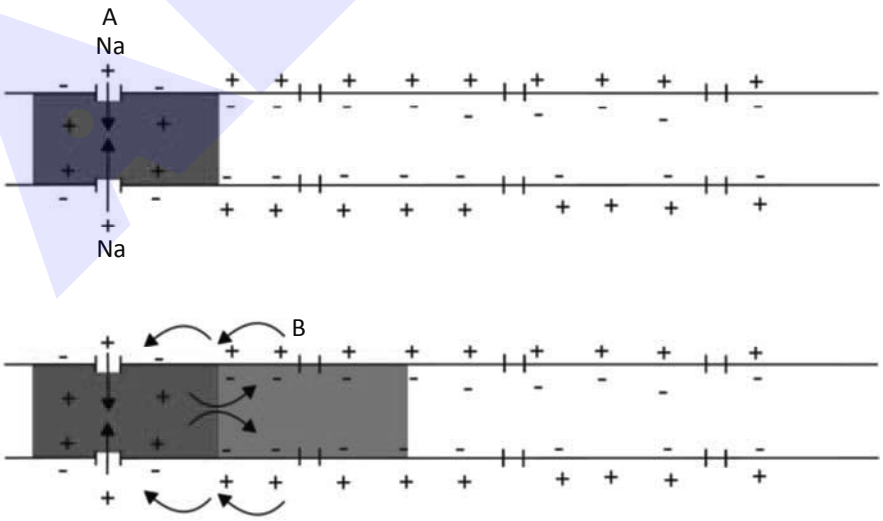


Figure : Action Potential generation

Process	Na^+-K^+ pump	Passive diffusion	Na^+ VGC	K^+ VGC	Potential with value	Inside Charge after the event
Polarisation	✓	✓	×	×	RMP (–60 to –85mV)	Negative
Depolarisation	×	✓	✓	×	+30 to +45 mV	Positive
Repolarisation	✓	✓	×	✓	–70 mV	Negative
Hyperpolarisation	✓	✓	×	✓	–85 mV	Negative

- Open/Operating → ✓ , Closed → ×



Diagrammatic representation of impulse conduction through an axon (at points A and B)

NCERT Page No. 318, Figure No. 21.2

(4) SALTATORY CONDUCTION OF NERVE IMPULSE

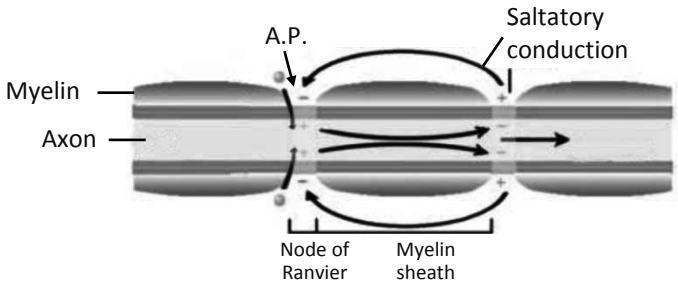


Fig. : Diagram showing 'Saltatory conduction' in myelinated Neuron

- This type of conduction occurs in **myelinated fibre**.
- This means, in effect that the action potential jumps from node to node and passes along the myelinated axon faster as compared to the series of small local circuits in a non-myelinated axon. This type of conduction is called **saltatory conduction**. Leakage of ions takes place only in nodes of Ranvier and less energy is required for saltatory conduction.

06. SYNAPSE

- It is the junctional region between two neurons where information is transferred from one neuron to another.
- Telodendria of one neuron form synapse with dendron of next neuron.
- It transmit stimulus in the form of electrochemical wave.

Synapse = Presynaptic knob + synaptic cleft + postsynaptic membrane

- Telodendria membrane is called **pre synaptic membrane** & membrane of dendron of other neuron called as **postsynaptic membrane.** Space between pre and post synaptic membranes is called **synaptic cleft.** It may or may not be seperate.
- A nerve impulse is transmitted from the neuron to another through junction called synapse.
- There are two types of synapses, namely, **electrical synapses** and **chemical synapses**.
- At electrical synapses, the membranes of pre- and post-synaptic neurons are in very close proximity.

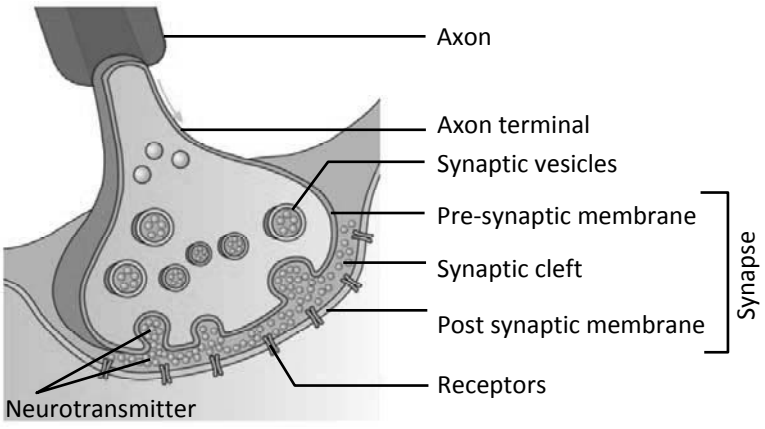


Diagram showing axon terminal and synapse
NCERT XI Page No. 319, Figure No. 21.3

- Electrical current can flow directly from one neuron into the other across these synapses.
- **Transmission of an impulse across electrical synapses is very similar to impulse conduction along a single axon**.
- Impulse transmission across an electrical synapse is always faster than that across a chemical synapse. Electrical synapses are rare in our system.

  On the other hand, chemical synapses are characterised by a synaptic cleft. At these synapse, impulse transmission occurs with the help of a chemical, called neurotransmitter.
- **Mechanism :-** When the AP develops in presynaptic membrane, it becomes permeable for Ca^{++}. Ca^{++} enter presynaptic membrane & neurotransmitter vesicles burst due to the stimulation by Ca^{++} and they release neurotransmitters in synaptic cleft.

  Neurotransmitter reaches the postsynaptic membrane via synaptic cleft & binds to specific receptors. This binding opens up ion channels, allowing the entry of ions which can generate a new potential on post synaptic membrane. The potential may be **excitatory (EPSP)** or **inhibitory (IPSP).** In **Excitatory postsynaptic potential (EPSP)** Ach is main neuro transmitter, which develop due to opening of Na^{+} gatted channels.
- On the rest of the Ach, **cholinestrase** enzyme functions, which is found in synaptic cleft. This enzyme decomposes the Ach into choline & Acetate.
- If neuro inhibitory transmitter (GABA) binds with post synaptic membrane to open the Cl^{-} gatted channels and hyperpolarization of neuron occurs. Now the potential is called **inhibitory postsynaptic potential (IPSP)** & further nerve conduction is blocked.

TYPE OF SYNAPSE

	Electrical	**Chemical**
(i) Conduction	Fast	Slow
(ii) Synaptic cleft	0.2 nm	> 20 nm
(iii) Neurotransmitter in synaptic cleft	Absent	Present
(iv) Occurence in body	Rare in our body	Most common
(v) Synaptic delay	Absent	Present
(vi) Blocking	Cannot be controlled	Controlled by neurotransmitter

Golden Key Points

- Conduction of nerve impulse is unidirectional.
- It follow **all or none law.** Magnitude of response will always be same irrespective of strength of stimulus above threshold stimulus.
- Velocity of nerve impulse $\propto$ Diameter of neuron.
- This velocity is affected by physical & chemical factor, such as pressure, cold, heat, chloroform and ether etc.
- Depolarization : Na^+ influx.
- Repolarization : K^+ efflux.
- If myelin sheath is continuous there will be no nerve impulse conduction in nerve fibres.
- If question is informing for only about channel opening and closing then consider only VGC.
- Simple diffusion channels are always open (In every state).

BEGINNER'S BOX — NERVE IMPULSE CONDUCTION

1. Which statement is false regarding nerve impulse ?

(1) After applying a stimulus on polarised membrane, that site become freely permeable to Na^+ and leads to rapid efflux of Na^+.

(2) The rise in the stimulus induced permeability to Na^+ is extremely short lived.

(3) After depolarization K^+ diffuses outside the membrane and restores the resting potential.

(4) Ionic gradients across the resting membrane are maintained by the $Na^+ – K^+$ ATPase pump.

2. Resting membrane potential is achievied by :-

(1) Passive diffusion by ion channels/Leaky channels

(2) $Na^+ – K^+$ ATPase pump.

(3) Negatively charged proteins in axoplasm.

(4) All of the above

3. Which statement is correct regarding nerve impulse conduction ?

(1) The membrane potential change from positive to negative and then back again.

(2) Sodium ions flow out through ion channels and potassium ions flow in.

(3) Potassium channels close as the membrane potential becomes positive.

(4) The membrane potential becomes less negative due to opening of Na^+ VGC.

4. A nerve impulse is transmitted from one neuron to another neuron through junction called as:-

(1) Neuro muscular junction (2) Synapse

(3) 1 & 2 both (4) Node of Ranvier

5. The axoplasm inside the axon contains high concentration of ..... and ..... :-

(1) K^+ and Na^+

(2) K^+ and Negatively charged proteins

(3) Na^+ and Cl^-

(4) Both (1) and (3)

6. The ion channels are ..... to different ions :-

(1) Completely permeable (2) Impermeable

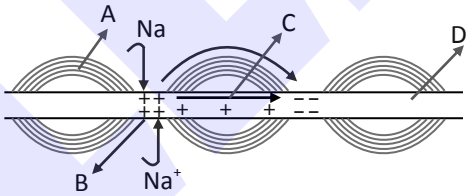
(3) Selectively permeable (4) Both (1) and (3)

7. The electrical potential difference accross the plasma membrane at the site of depolarisation is called :-

(1) Graded potential (2) Resting potential

(3) Action potential (4) None of the above

8. Given below is the diagram representing conduction of nerve impulse in myelinated neuron label the parts, with correct option:-



(1) A – Axolemma, B – Site of polarisation
C – Wave, D – Axolemma

(2) A – Myelin sheath, B – Site of Depolarisation
C – Action potential jumps from node to node
D – Axoplasm

(3) A – Axoplasm, B – Repolarisation,
C – Ionic movement, D – Axon

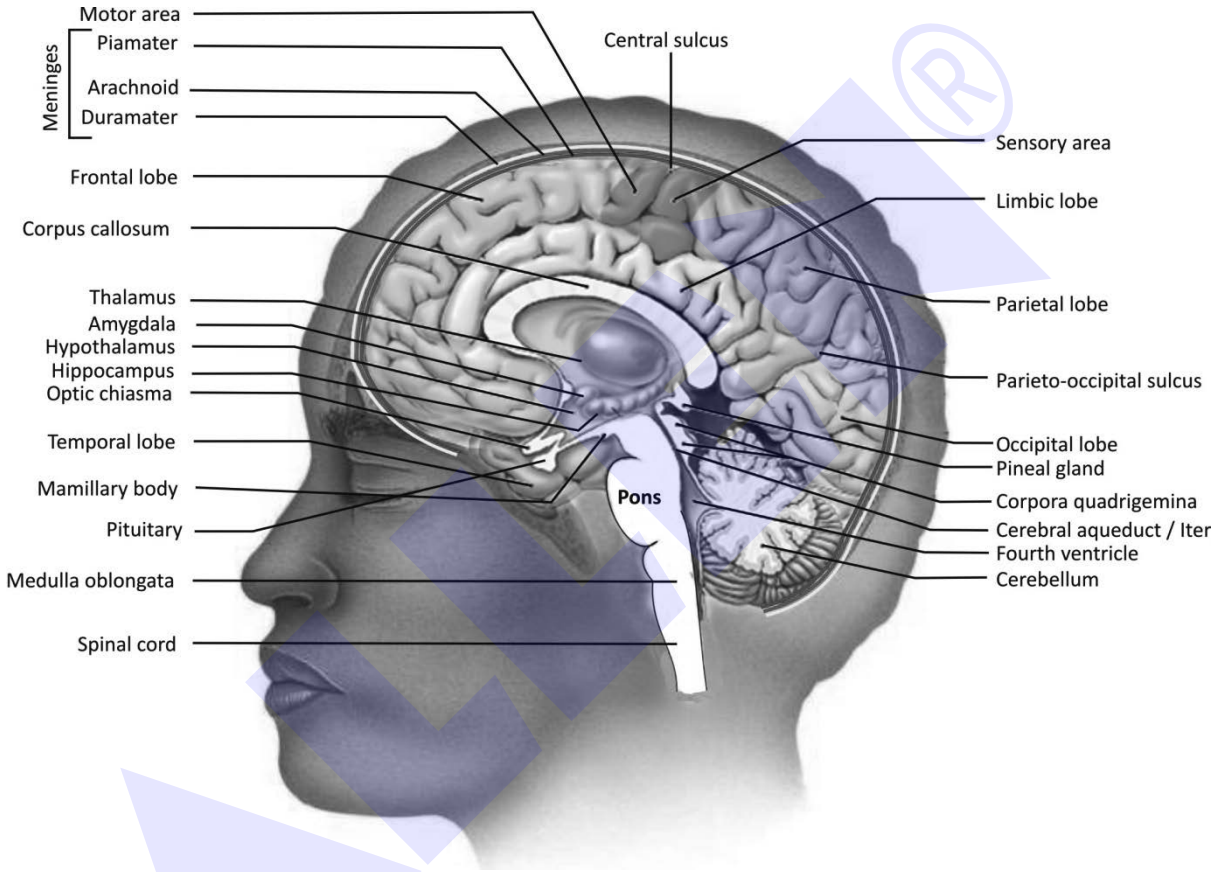
(4) A – Myelin sheath, B – Hyperpolarisation,
C – Action potential, D – Axoplasm

07. CENTRAL NEURAL SYSTEM

- It includes the brain and the spinal-cord.
- These are formed from the neural-tube which develops from the **ectoderm** after the gastrula stage of embryo.

Development of CNS :

Anterior part of neural tube develops into **brain** while caudal part of neural tube develops into **spinal cord**.



DIVISIONS OF HUMAN BRAIN

	Division	Sub-divisions & Parts
(1)	Fore brain	1. Olfactory lobe 2. Cerebrum 3. Diencephalon
(2)	Mid brain	1. Optic lobes and Crura cerebri
(3)	Hind Brain	1. Pons 2. Cerebellum 3. Medulla oblongata (M.O.)

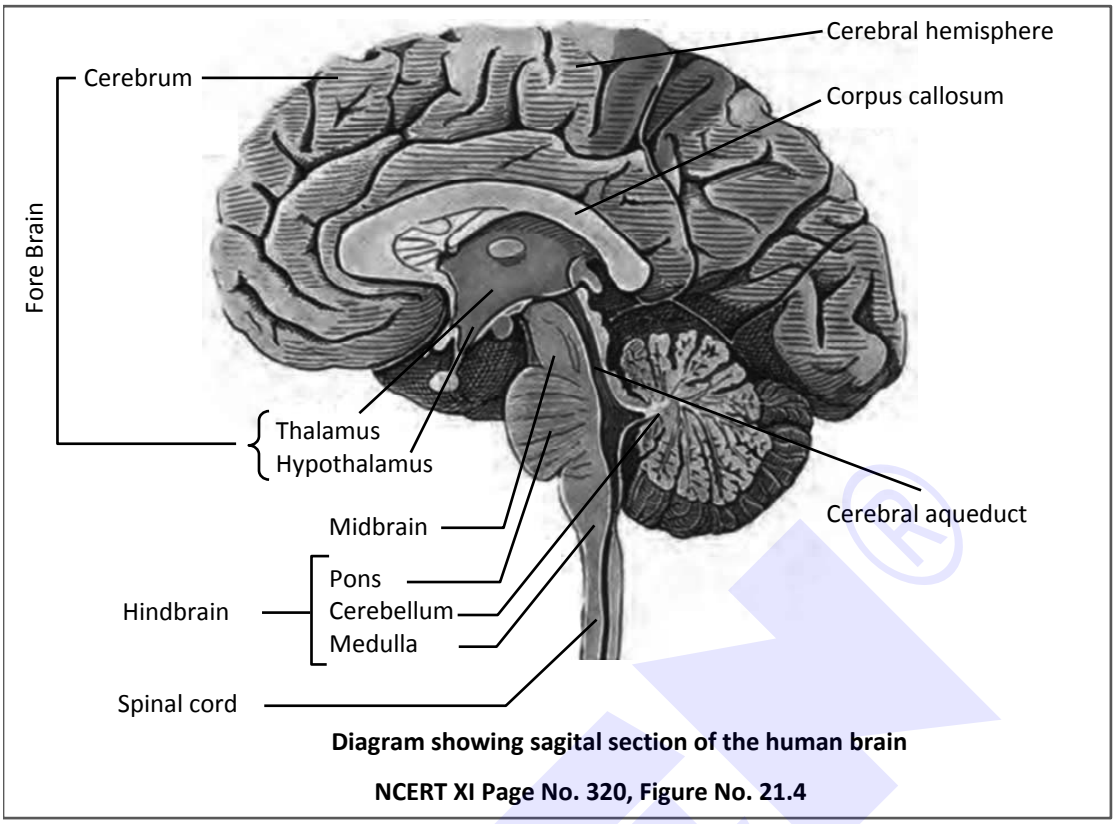


Diagram showing sagital section of the human brain

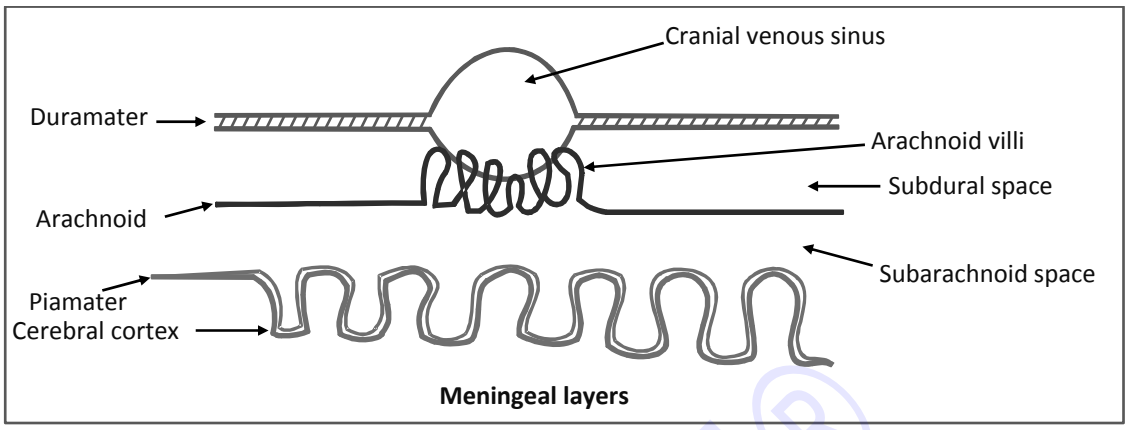
NCERT XI Page No. 320, Figure No. 21.4

(1) HUMAN BRAIN

- The brain is the central information processing organ of our body and acts as the **'Command and control system'.**
- It controls the voluntary movements, balance of the body, functioning of vital involuntary organs (e.g. lungs, heart, kidney etc.), thermoregulation, hunger and thirst, circadian (24 hours) rhythms of our body, activities of several endocrine glands and human behaviour.
- It is also site for processing of vision, hearing, speech, memory, intelligence, emotions and thoughts.
- It is situated in cranial box which is made up of 1 frontal bone, 2 parietal bone, 2 temporal bone, 1 sphenoid, 1 ethmoid and 1 occipital bone. The weight of brain of an adult male is 1400 gm and of female is 1250 gm.

(A) Brain Meninges :

Brain is covered by three membranes of connective tissue termed as **meninges** or **menix**.



Meningeal layers

(i) Duramater :

- This is the first and the outermost membrane which is thick, strong and elastic layer.
- At several places it forms cranial venous sinuses containing blood.

(ii) Arachnoid :

- It is middle and delicate layer and found only in mammals. **(Mammalian character)**
- At several places it forms villi like foldings to absorb CSF called **arachnoid villi.**

(iii) Piamater :

- Inner most, thin and transparent membrane, which is firmly attached to the brain.

(B) Cerebrospinal-Fluid (CSF) :

- This fluid is clear and alkaline in nature just like lymph.
- C.S.F. is formed in ***choroid plexus*** found in the ventricles of the brain.

Functions of C.S.F. :

- Protection of Brain :- It acts as shock absorbing medium and works as cushion.
- It provides buoyancy to the brain, so net weight of the brain is reduced from about 1.4 kg to about 0.18 kg.

(C) Fore Brain :

- The fore brain consists of **Cerebrum, Diencephalon** (containing epithalamus, thalamus, hypothalamus) and **olfactory lobe.**

(i) Cerebrum :

- Cerebrum forms the major part of the brain which is most developed in human.
- Cerebrum consists of two cerebral hemispheres, on the dorsal surface a longitudinal groove is present between two cerebral hemispheres called as **median fissure.** Both the cerebral hemispheres partially connected with each other by curved white thick nerve fibre called **corpus callosum** (Largest **commisure** of brain) **(Mammalian character)**.

- Each cerebral hemisphere is divided into 4 lobes-Anterior, Middle, Posterior and Lateral.

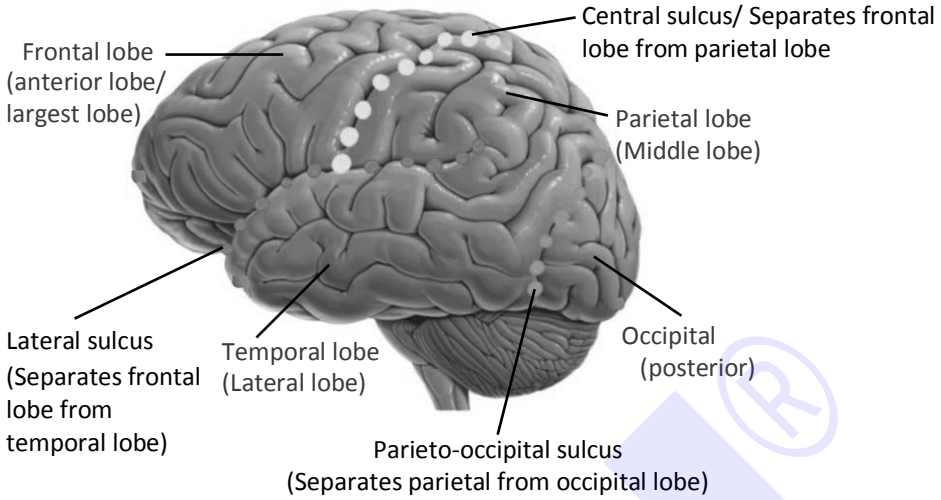


Fig. Dorso-lateral surface of cerebral hemisphere

- The outer part of cerebral hemisphere is called **Cerebral cortex** and thrown into prominent folds. These folds are found as **ridges** and **grooves** on dorsal surface of cerebral hemisphere. Ridges are known as **Gyri** while grooves are called **sulci**. Gyri and sulci increase the surface area of cerebrum.
- The cerebral cortex referred to as the gray matter due to its greyish appearance. The neuron cell bodies are concentrated here giving the colour. This thick layer of gray matter on dorsal surface is also known as **Neopallium**.
- The cerebral cortex contains three types of functional areas :-
  (a) **Sensory area** – Analysis of sensory impulses eg. *Somesthetic area* for general sensation (Touch, Pain, Temperature etc.)
  (b) **Motor area** – Generation of motor impulses eg. *Broca's area* for fine movement of tongue and speech. *Motor area* for voluntary movement of limb muscles.
  (c) **Association area** – These are large regions that are neither clearly sensory nor motor in function. They are responsible for certain complex functions like :-
  - **Intersensory associations :** As you are aware that all sensory inputs like touch, sound, light, smell are sent to brain. These different sensation require association and inter connection with each other for their proper interpretation.
  - **Memory :** Memory of past events is recorded by the association areas also with the different lobes of the cerebrum. Memory is basically of two types : Short term memory and long term memory.
  - **Communication :** The ability of communication also controlled by the assoication areas of cerebral cortex.

Function of cerebrum : It is the most important part of brain because it controls and regulates different part of brain. This is the centre of conscious senses, will power, voluntary movements, knowledge, etc.

- Different sense organs send impulse here and in this part of brain, analysis and coordination of impulse is done then messages are transferred to organs.

(ii) Diencephalon :

- It is small chamber like posterior part of fore brain which is covered by cerebrum. It consists of 3 parts :

(a) **Epithalamus** (b) **Thalamus** (c) **Hypothalamus**

(a) **Epithalamus :** It form the roof of diencephalon. Pineal body (Epiphysis cerebri) is found on epithalamus & control sexual maturity.

(b) **Thalamus :** It forms upper lateral wall of Diencephalon. It form 80% of diencephalon. It acts as a **relay centre.** It receives all sensory inputs from all part of body & these impulses are send to the cerebral cortex. Cerebrum wraps around the thalamus. It is a major coordinating centre for sensory & motor signalling.

(c) **Hypothalamus :** It forms the lower or ventral part of diencephalon. It lies at the base part thalamus.

- The hypothalamus contains a number of centre which control body temperature, urge for eating and drinking (Hunger and thirst).
- It also contains several group of neurosecretory cells, which secrete hormone called hypothalamic hormone.
- A cross like structure is found on anterior surface of hypothalamus called as **optic chiasma,** through Infundibulum **pituitary body** is attached to **middle part** of hypothalamus. **Corpus mammillare** or **corpus albicans** or **mammillary body** is found on the posterior part of hypothalamus. **(Mammalian character)**

Hypothalamus controls :-

(1) Thermoregulation

(2) Behaviour and emotion

(3) Endocrine control

(4) Biological clock system

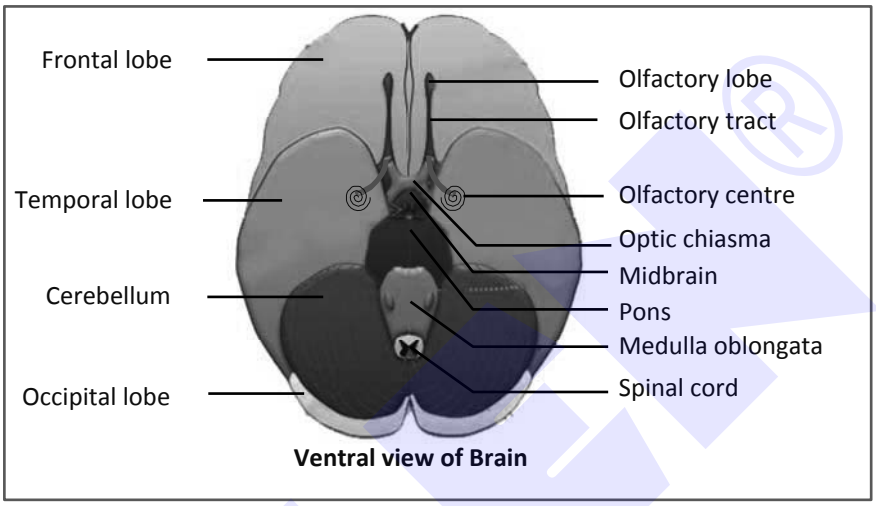
(5) ANS control

(6) Osmoregulation

Limbic system :

The inner part of cerebral hemispheres and a group of associated deep structures like **amygdala**, **hippocampus** olfactory lobe etc. form a complex structure called **Limbic system.** Along with the hypothalmus, it is involved in the regulation of sexual behaviour, expression of emotional reactions (e.g. excitement, pleasure, rage, fear) and motivation, olfaction and autonomic responses.

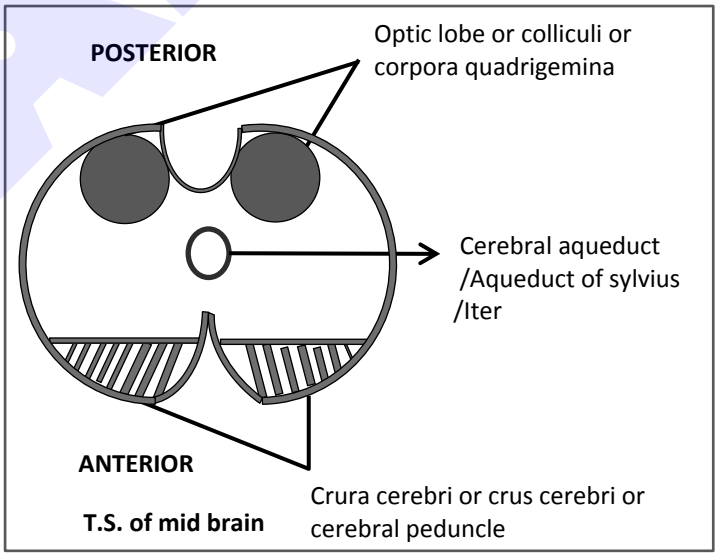
(iii) Olfactory Lobe or Bulb (Extension of limbic system) :



Ventral view of Brain

- One pair olfactory lobe/bulb are embedded in ventral surface of frontal lobe of cerebral hemisphere. It is a small spherical & solid structure in human brain.
  It is connected to **olfactory centre** (temporal lobe) through **olfactory tract** and are extentions of the brain's limbic system.
  Functions : It is supposed to be centre of smell intensity. Some animal like sharks and dogs have well developed olfactory lobes.

(D) Mid Brain :



T.S. of mid brain

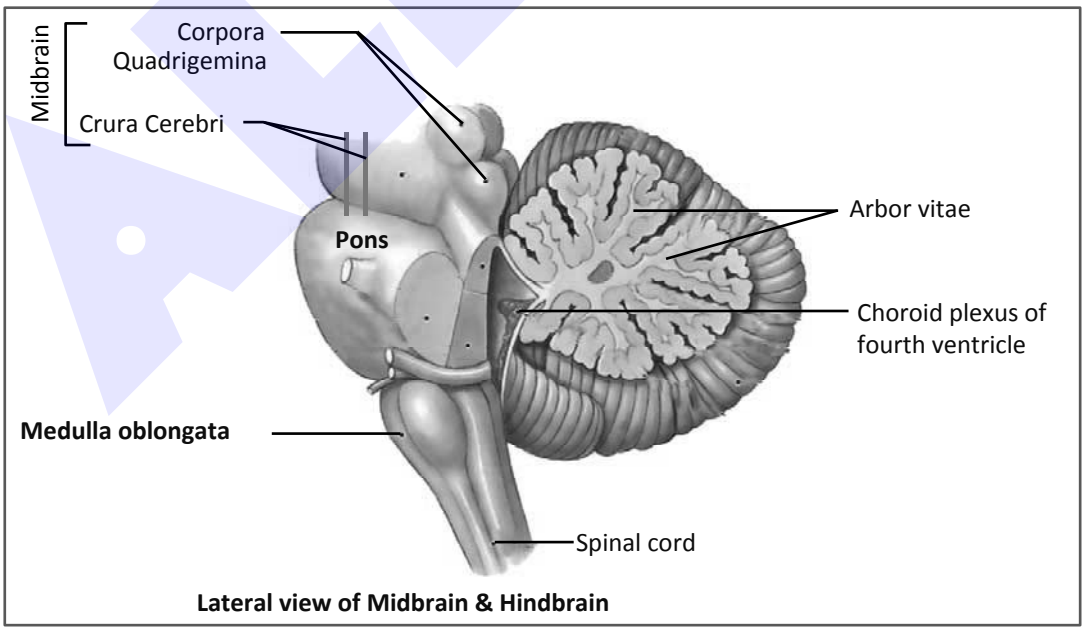
- It is a small part of brain. The midbrain is located between **diencephalon** of the fore brain and **pons** of the hind brain. A canal called **Cerebral aqueduct** passes through the midbrain.
- Anterior part of midbrain contains two longitudinal myelinated nerve fibre called **cerebral** or **crura cerebri.**
- On posterior part of mid brain four spherical projections are found called **colliculus** or **optic lobe.** Four colliculus are collectively called as **corpora quadrigemina.** (2 upper & 2 lower) **(Mammalian character)**
- Mid brain and hind brain (except cerebellum) form the brain stem.

Function :

- The mid brain receives and integrates **visual, tactile** and **auditory inputs.**
- **Crura cerebrai** controls the **muscle of limb** while **superior and inferior colliculus** are related with **pupillary (light) reflex and acoustic (Sound) reflex action respectively.**

(E) Hind Brain :

- The hind brain comprises **pons, cerebellum** and **medulla** (also called the medulla oblongata).



Lateral view of Midbrain & Hindbrain

(i) Pons :

- It is a small spherical projection. Which is situated below the midbrain and upper side of medulla oblongata. Pons consists of fibre tracts that interconnect different regions of the brain. e.g. Transverse and longitudinal nerve fibre. **Transverse nerve fibre** connect with cerebellum while **longitudinal nerve fibre** connect cerebrum to medulla oblongata.

  Function :- It regulates the breathing reaction through **pneumotaxic centre.**

(ii) Cerebellum :

- It is made up of 3 lobe (2 lateral lobe and 1 vermis). Both lateral lobes become enlarged and spherical in shape, so lateral lobe of cerebellum are also called as **cerebellar hemisphere.** Cerebellum has very convoluted surface in order to provide the additional space for many more neurons.
- Outer part of cerebellum is made up of gray matter while inner part is of white matter. White matter projects outside & forms a branched tree like structure known as **Arbor Vitae**.

  Functions : The cerebellum integrates information received from the semicircular canals of the ear and the auditory system and also by this portion of hind brain impulses are received from different voluntary muscles and joints.
- Due to this region, coordination of voluntary muscle through involuntary regulation is more developed in human compared to other animals i.e. Body balance.
- The person who take alcohol in excess their cerebellum gets affected as a result that person can not maintain his balance and walking is disturbed.
- Thus it is related with **fine and skill full voluntary movements.**

(iii) Medulla Oblongata :

- Posterior part of hind brain is tubular and cylindrical in shape. Medulla of brain is connected to spinal cord.
- Mid brain, pons and medulla are situated in one axis and it is called as ***Brain stem***.

  Functions : It is the most important part of brain which controls all the involuntary activities of the body e.g. **cardiovascular reflex, respiration, metabolism, gastric secretion** etc. As well as this act as conduction path for all impulses between spinal cord and remaining portions of brain.
- It is also concerned with cranial reflex action like sneezing reflex, salivation reflex, coughing reflex, swallowing reflex, vomiting reflex, yawning reflex.

BEGINNER'S BOX — HUMAN BRAIN

1. Which lobe of cerebral hemisphere perform voluntary motor function of body ?
(1) Parietal lobe (2) Frontal lobe (3) Occipital lobe (4) Temporal lobe

2. Which part of brain contains such area which are neither clearly sensory nor motor in function ?
(1) Cerebeller cortex (2) Cerebral cortex
(3) Grey matter of cerebrum (4) Both (2) and (3)

3. Arbor vitae are found in which part of brain ?
(1) Fore brain (2) Mid brain (3) Hind brain (4) All of the above

4. Which part of nervous system is the central information processing part act as command & control system?
(1) S.N.S. (2) P.N.S. (3) A.N.S. (4) C.N.S.

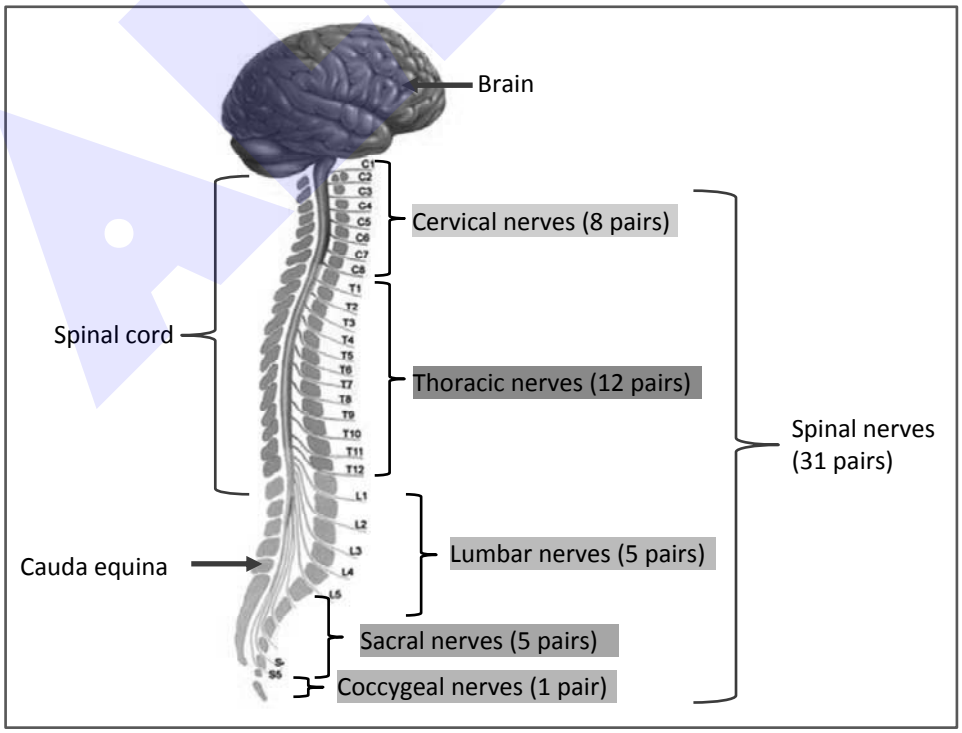
5. Grey matter includes :-
(1) Concentrated cell body (2) Unmyelinated axon
(3) Myelinated axon (4) (1) & (2) both

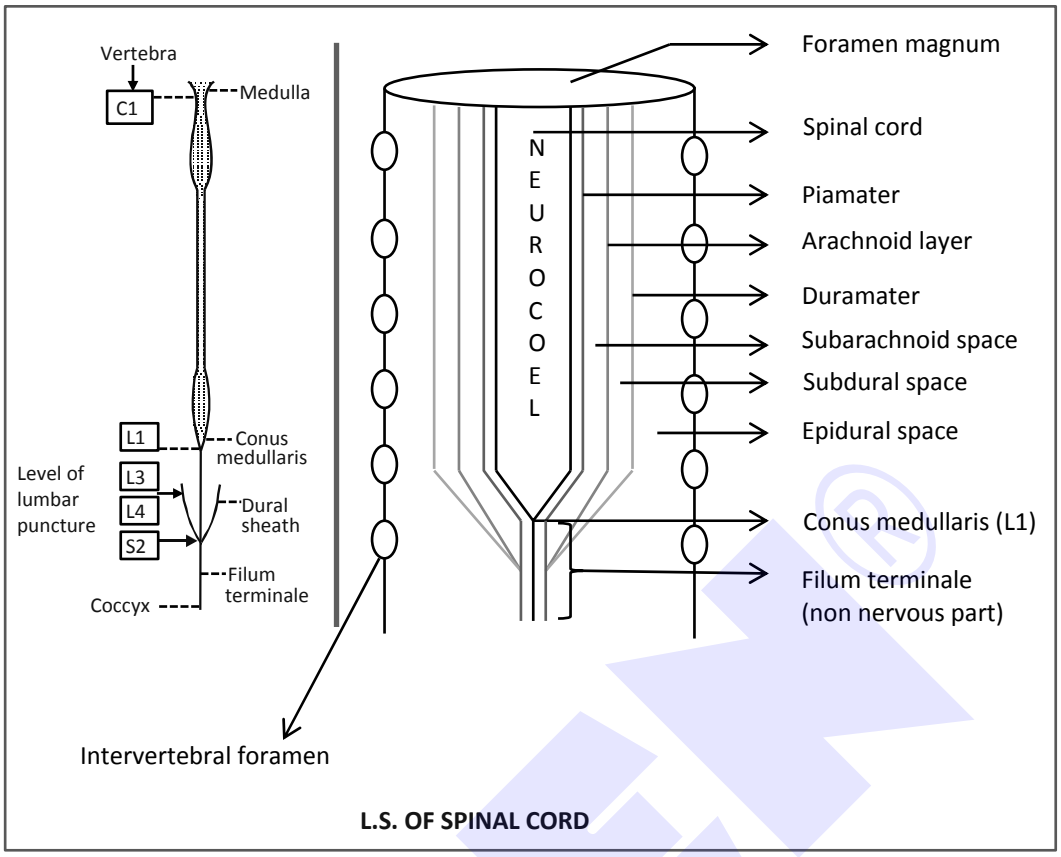
6. The layer of cells which covers the cerebral hemisphere is called :-
(1) Piamater (2) Duramater (3) Cerebral cortex (4) Both (1) & (2)

7. Excitment, Pleasure, Rage fear & Motivation are combined function of :-
(1) Amygdala (2) Hippocampus (3) Limbic lobe (4) All of these

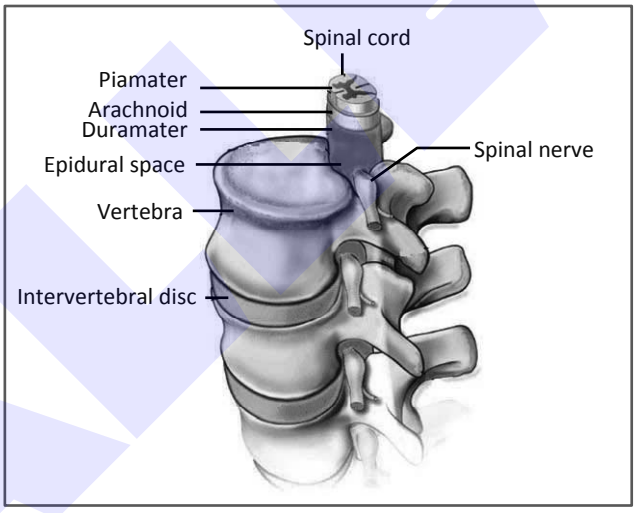
8. Which of the following contains a number of centres which control body temperature urge for eating and drinking?
(1) Thalamus (2) Medulla oblongata (3) Hypothalamus (4) Cerebrum

(2) SPINAL CORD





L.S. OF SPINAL CORD



- Medulla oblongata comes out from **foramen magnum** & continues in neural canal of vertebral column, the continued part of MO is known as Spinal cord. It extends from base of skull to (L_1) lumbar vertebra.
- Its upper part is wide while lower most part is known as **conus-medullaris**.

  Conus medullaris present **upto L_1 vertebra**. Terminal part of conus medullaris extend in the form of thread like structure called **filum terminale.**

- Filum terminale is **non-nervous part**. Metacoel also continues in spinal cord where it is known as **neurocoel or central canal**.
- The group of spinal nerve at the terminal end (L_1) of spinal cord form tail like structure called **cauda equina (horse tail).**
- Spinal cord is also covered by Duramater, Arachnoid & piamater. A narrow space is found between vertebra & duramater known as **Epidural space.**

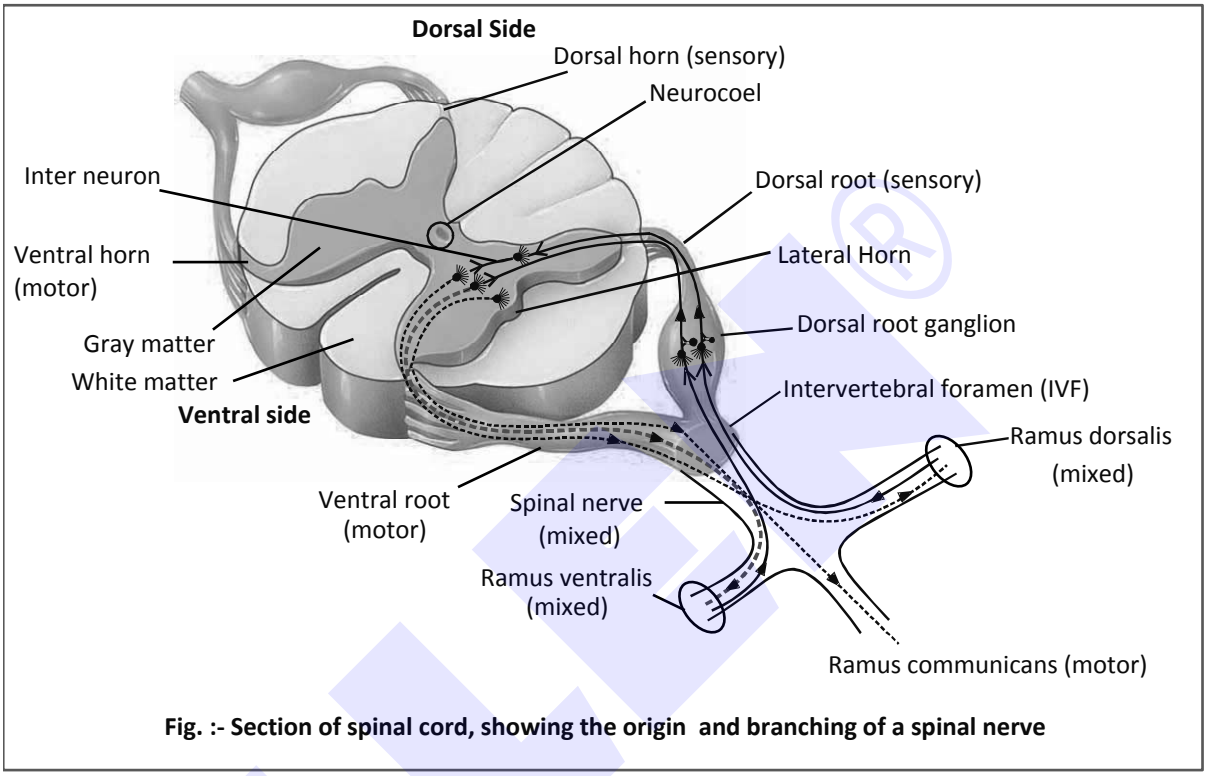


Fig. :- Section of spinal cord, showing the origin and branching of a spinal nerve

- The outer-part of spinal cord is of white matter while inner-part contain gray matter.
- On the dorso-lateral & ventro-lateral surface of spinal cord, the gray matter (butter fly shaped) projects outside & forms the one pair dorsal & ventral horn.
- Due to formation of dorsal & ventral horn white matter is divided in 4 segments & segment.
- Dorsal & ventral horn continue in a tube like (bundle of never fibres) structure known as **Dorsal root and Ventral root**. In root of dorsal horn, ganglia is present called **Dorsal root ganglia**.
- **Sensory neurons** are found in the dorsal root ganglia which is **pseudounipolar** in nature. Its axon extend & gets embedded into gray matter of spinal cord & make synapse with ventral root neuron.
- **Multipolar motor neurons** are found in the **ventral root.** Its cyton and dendron are embedded into gray matter of spinal cord where they make synapse with axon of sensory neuron.
- Both sensory & motor nerve fibers combindly come out from intervertebral foramen & form spinal nerve.

- In some part of spinal cord on both side lateral horns are also found. Motor neurons are found in these horn. There nerve fibre follow the ventral root & comes out through intervertebral foramen. These fibre called **Ramus communicans**.
- Ramus communicans forms **ANS.**
- Spinal nerve & its branches are mixed type (except ramus communicans).

Functions of spinal cord :-

(i) It acts as a bridge between brain & organs of the body.

(ii) It also provides relay path for the impulses coming from brain

(iii) Spinal cord regulates and conducts most of the reflex action.

★ Golden Key Points ★

PERIPHERAL NERVOUS SYSTEM

(1) SOMATIC NERVOUS SYSTEM

- All the nerves arising from brain and spinal cord are included in peripheral nervous system. Nerves arising from brain are called **cranial nerves**, and nerves coming out of spinal cord are called **spinal nerves**.
- **12-pairs** of cranial nerves are found in reptiles, birds and mammals but amphibians and fishes have only **10-pairs** of cranial nerves.

(A) Cranial Nerves :

No.	Name	Nature	Function
I.	Olfactory	Sensory	Smell
II.	Optic	Sensory	Sight
III.	Occulomotor	Motor	Movement of eyeball
IV.	Trochlear	Motor	Movement of eyeball
V.	Trigeminal (Dentist nerve)	Mixed	Teeth and Jaw muscles (mastication)
VI.	Abducens	Motor	Movement of eyeball
VII.	Facial	Mixed	Taste (anterior 2/3 part of Tongue) Facial expression
VIII.	Auditory	Sensory	Hearing and equilibrium
IX.	Glossopharyngeal	Mixed	Taste (Posterior 1/3 part of tongue) & saliva secretion
X.	Vagus (Pneumogastric)	Mixed	Visceral sensations and movements
XI.	Accessory spinal	Motor	Movement of pharynx, larynx
XII.	Hypoglossal	Motor	Movement of tongue

(B) Spinal Nerves :

- In Human only **31 pairs** of spinal nerves are found.
- Each spinal nerve is mixed type and arises from the roots of the horns of gray matter of the spinal cord. In dorsal root only afferent or sensory fibres and in ventral root efferent or motor fibres are found.
- Both the roots after moving for distance in the spinal canal of vertebrates combine with each other and come out from the Inter vertebral foramen in the form of spinal nerves.
- As soon as the spinal nerves come out of the inter vertebral foramen they divide into 3 branches :-

(i) **Ramus- dorsalis**
(ii) **Ramus ventralis**] S.N.S. (Somatic nervous system)

(iii) **Ramus communicans → A.N.S.** [Sympathetic nervous system / Parasympathetic nervous system

(2) AUTONOMIC OR VISCERAL NERVOUS SYSTEM

- The autonomic nervous system. *Viseral nervous system is a part of peripheral nervous system that comprises the whole complex of nerves, fibres, ganglia and plexuses by which impulses travel from the central nervous system to the viscera and from the viscera to central nervous system.* It controls activities inside the body that are normally involuntary, such as heart beat, peristalsis, sweating etc.
- It consists of motor neuron passing to the smooth muscle of internal organs. Smooth muscles are involuntary muscles. Most of the activities of the autonomic nervous system is controlled within the spinal cord or brain by reflexes known as **visceral reflexes** and does not involve the conscious control of higher centres of the brain.
- Overall control of the autonomic nervous system is maintained by centres in the **medulla** (a part of the hind brain) and **hypothalamus**.
- The autonomic nervous system is composed of two type of neurons.
  (a) **Preganglionic neuron** (myelinated)
  (b) **Postganglionic neuron** (non myelinated)

Sites of ANS –

Involuntary muscles, Exocrine glands, Blood vessels, Skin (Pilomotor muscles, Blood vessels, Sweat glands)

Divisions of ANS : There are the two division of the autonomic nervous system :-

ANS

(A) Sympathetic
Sympathetic system is related with such visceral reactions. which increase the protection of body in adverse atmospheric conditions along with calorie consumption (Causes loss of energy).

(B) Parasympathetic
Parasympathetic system is related with those reactions in which energy is conserved.

In this way, autonomic nervous system controls the activities of visceral organs double sided i.e. antagonistic to each other.

Autonomic Nervous Control of Visceral Organs

S. No.	Name of Visceral Organs	Affect of sympathetic nervous system	Affect of parasympathetic nervous system
1.	Secretion	Acetyl choline + sympathetin	Only acetylcholine
2.	Iris of eye	Dilates pupils	Constricts pupils
3.	Heart	Increases the rate of cardiac contraction	Inhibits the rate of cardiac contraction
4.	Secretion of adrenal gland	Stimulates adrenal secretion	Inhibits adrenal secretion
5.	Salivary secretion	Inhibits the secretion of saliva	Stimulates the secretion of saliva
6.	Lungs, trachea and bronchi	Dilates trachea bronchi & lungs for easy breathing	Constricts these organs during normal breathing
7.	Alimentary canal	Inhibits peristalsis of alimentary canal	Stimulates the peristalsis of alimentary canal
8.	Digestive glands	Inhibits the secretion of these glands	Stimulates the secretion of the glands
9.	Sweat glands	Stimulates secretion of sweat	Inhibits secretion of sweat
10.	Arrector pilli muscles	Stimulates contraction of these muscles of skin, causing goose flesh	Relaxes Arrector pilli muscles
11.	Urinary bladder	Relaxes the muscles of urinary bladder **(Inhibits Micturition)**	Contracts the muscles for ejaculation of urine (Micturition)
12.	Anal sphincter	Closes anus by contracting anal sphincters **(Inhibits defaecation)**	Relaxes anal sphincter and opens the anus (Defaecation)
13.	External genitalia of male (penis)	Ejaculation	Erection

- Longest cranial nerve is **Vagus nerve.**
- Largest cranial nerve is **Trigeminal nerve.**
- Smallest cranial nerve is **Abducens nerve.**
- Thinnest Cranial nerve **Trochlear nerve.**
- I, II and VIII cranial nerves are pure sensory nerves.
- III, IV, VI, XI and XII are pure motor cranial nerves.
- V, VII, IX, X are mixed cranial nerves.

BEGINNER'S BOX — SPINAL CORD & PNS

1. Which spinal nerve is not part of cauda equina ?
(1) Sacral spinal nerves. (2) Lumbar spinal nerves.
(3) Thoracic spinal nerves. (4) Coccygeal spinal nerve

2. Which structure is pure sensory ?
(1) Ramus dorsalis (2) Dorsal root (3) Spinal nerve (4) Ventral root

3. The lower most part of the spinal cord upto which, the nervous part extend :-
(1) Epidural space (2) Conus medullaris (3) Cauda equina (4) Central canal

4. Sensory neurous found in the dorsal root Ganglia are :-
(1) Motor (2) Apolar (3) Pseudounipolar (4) Multipolar

5. The group of cranial nerves which are associated with the movement of eye ball are :-
(1) I, II, VIII (2) III, IV, VI (3) VII, IX, XII (4) III, IV, VII

6. Somatic nervous system is formed by :-
(1) Ramus dorsalis (2) Ramus communicans
(3) Ramus ventralis (4) Both (1) & (3)

7. Which of the following is **not** a function of parasympathetic nervous system ?
(1) Inhibition of peristalsis of alimentary canal (2) Relaxation of arrector pilli muscles
(3) Erection of penis (4) Contraction of urinary bladder

8. Which of the following nerves is purely sensory ?
(1) Occulomotor (2) Trochlear (3) Facial (4) Optic

08. REFLEX ACTIONS

- **"Marshal Hall"** first observed the reflex actions.
- *The entire process of response to a peripheral nervous stimulation, that occurs involuntarily i.e. without conscious effort or thought and requires the involvement of a part of the central nervous system is called a* ***reflex action****.*
- **Reflex actions** are spontaneous, automatic, involuntary, mechanical responses produced by stimulating specific receptors.
- Reflex actions are **involuntary actions.** Reflex actions are completed very quickly as compared to normal actions. They prevent body from any adverse effect.
- It is form of animal behaviour in which the stimulation of a sensory organ (receptor) result in the activity of some organ without the intervention of will.

REFLEX ARC

- The reflex pathway comprises at least one afferent neuron (receptor) and one efferent (effector or excitor) neuron appropriately arranged in a series.
- The afferent neuron receives signal from a sensory organ and transmits the impulse via a dorsal nerve root into the CNS (at the level of spinal cord).
- The efferent neuron then carries signals from CNS to the effector.

- The path of completion of reflex action is called **reflex arc**.
- Sensory fibres carry sensory impulses in the gray matter. These sensory impulses are converted now into motor impulses and reach up to muscles. These muscles show reflex actions for motor impulses obtained from motor neurons.

Types of Reflex action :-

(i) On the basis of site :-

(A) Cranial reflex :	(B) Spinal reflex :
(i) These actions are completed by brain.	(i) These actions are completed by spinal cord.
(ii) No urgency is required for these actions.	(ii) Urgency is required for these actions.
(iii) These are slow actions e.g. watering of mouth to see good food.	(iii) These are very fast actions e.g. Displacement of the leg at the time of pinching by any needle.

(ii) On the basis of previous experiences :-

(A) Conditioned reflex :	(B) Unconditioned reflex :
Previous experience is required to complete these actions e.g. swimming, cycling, dancing, singing etc. These actions were studied first by **Evan Pavlov** on dog. Initially these actions are voluntary at the time of learning and after perfection , these become involuntary.	These actions do not require previous experience e.g. sneezing, coughing, yawning, sexual behaviour for opposite sex partner, migration in birds etc.

(iii) On the basis of synapse :

(A) Monosynaptic reflex :	(B) Polysynaptic reflex :
There is a direct synapse (relation) found between sensory and motor neurons, thus nerve impulse travels through only one synapse. eg. – **Stretch reflex/ Knee-Jerk reflex** Receptor → Sensory neuron → Motor neuron → effector muscle	There are one or more small neurons found in between the sensory and motor neurons. These small neurons are called connector neuron or inter neurons or internuncial neurons. e.g. **withdrawal reflex**.

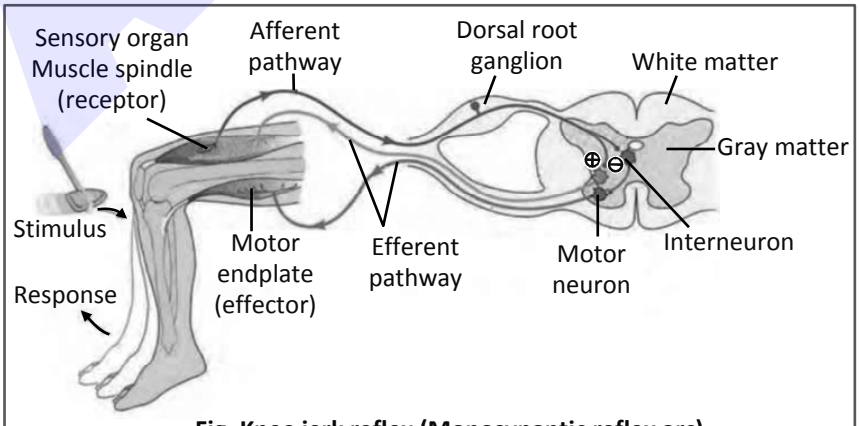


Fig. Knee jerk reflex (Monosynaptic reflex arc)
NCERT XI Page No. 322, Figure No. 21.5

BEGINNER'S BOX — REFLEX ACTION

1. The form of animal behavior in which stimulation of sensory organ result in the activity of some organ without the intervention of will is known is :-
(1) Slow action (2) Reflex action
(3) Voluntary response (4) Planned response

2. The (A) neuron receives signals from sensory organ and transmit the impulse via (B) nerve root into the CNS.
(1) A – Afferent, B – Dorsal (2) A – Afferent, B – Ventral
(3) A – Efferent, B – Dorsal (4) A – Efferent, B – Ventral

3. All of the following are examples of conditioned reflex except :-
(1) Swimming (2) Dancing (3) Playing piano (4) Sneezing

4. The (A) neuron carries the signal from CNS to the effector via (B) root.
(1) A – Efferent, B – Dorsal (2) A – Afferent, B – Dorsal
(3) A – Efferent, B – Ventral (4) A – Afferent, B – Dorsal

5. The direction of stimulus response is opposite in which of the following reflex action ?
(1) Biceps tendon reflex (2) Knee jerk reflex
(3) Tricep tendon reflex (4) Withdrawal reflex

6. At least how many afferent and efferent neuron and involved in any reflex action ?
(1) One afferent, one efferent neuron
(2) One afferent, two efferent, one interneuron
(3) One afferent, one efferent, two interneuron
(4) Two efferent, one efferent, one interneuron

EXTRA POINTS

1. In human brain more than 100 billion neurons are present.

2. Each neuron cell connect with 25,000 other cell.

3. **Glycine** is neuro inhibitory hormone present in spinal cord.

4. **Glutamic acid** is mainly used by our brain cells as excitatory neurotransmitter.

5. The velocity of nerve- impulse is 5 to 50 times more faster in Myelinated nerve - fibres than in Non- myelinated nerve -fibres.

6. Cerebrum is the centre of following:-
(1) Intelligence **(2)** Emotion **(3)** Will- power **(4)** Memory
(5) Consciousness **(6)** Experience **(7)** Knowledge
(8) Voluntary control **(9)** Laughing and weeping **(10)** Defaecation and micturition.

7. Increase in the amount of cerebro- spinal fluid is a diseased condition termed as the **hydrocephalus**

8. Acetylcholine is synthesized by the Mitochondria.

9. **Reticular activating System :–**

It is special sensory fibre which is situated in Brain stem & further go into Thalamus. It is related with **consiousness**, **alertness** & **awakening**. Therefore it is also called **gate keeper of consiousness**.

10. **Parkinson's disease :-** It occurs due to hyposecretion of dopamine which creates rigidity is muscle leads to muscle tremors. It begin from progressive degeneration of neuron of basal nuclei ultimately creates mask like face.

11. **Hutington's chorea (Autosomal dominant disorder) :-** It develops a deficiency of neurotransmitter GABA which causes rapid, involuntary & progressive dementia followed by death. It's a impairment of cerebellum.

12. **Alzheimer's disease :-** In this disease, the cerebral cortex is atrophied and ultimately the ventricle enlarges. Symptoms consist loss of memory particularly recent memory due to hyposecretion of acetylcholine.

13. **Cavities of brain (Ventricles)**

- Paracoel or Lateral ventricle or I & II ventricle (largest) – Found in Cerebral hemisphere
- III Ventricle or Diocoel – Found in Diencephalon

Note: I & II open in III Ventricle via Foramen of Monro

- IV Ventricle – Cavity of hind brain.

Note: Cavity of Medulla Oblongata – Metacoel

Cavity of Spinal cord – Neurocoel/Central Canal

BEGINNER'S BOX ANSWERS KEY

NEURAL TISSUE

Que.	1	2	3	4	5	6	7	8
Ans.	**3**	**2**	**4**	**4**	**3**	**2**	**3**	**4**

NERVE IMPULSE CONDUCTION

Que.	1	2	3	4	5	6	7	8
Ans.	**1**	**4**	**4**	**2**	**2**	**3**	**3**	**2**

HUMAN BRAIN

Que.	1	2	3	4	5	6	7	8
Ans.	**2**	**4**	**3**	**4**	**4**	**3**	**3**	**3**

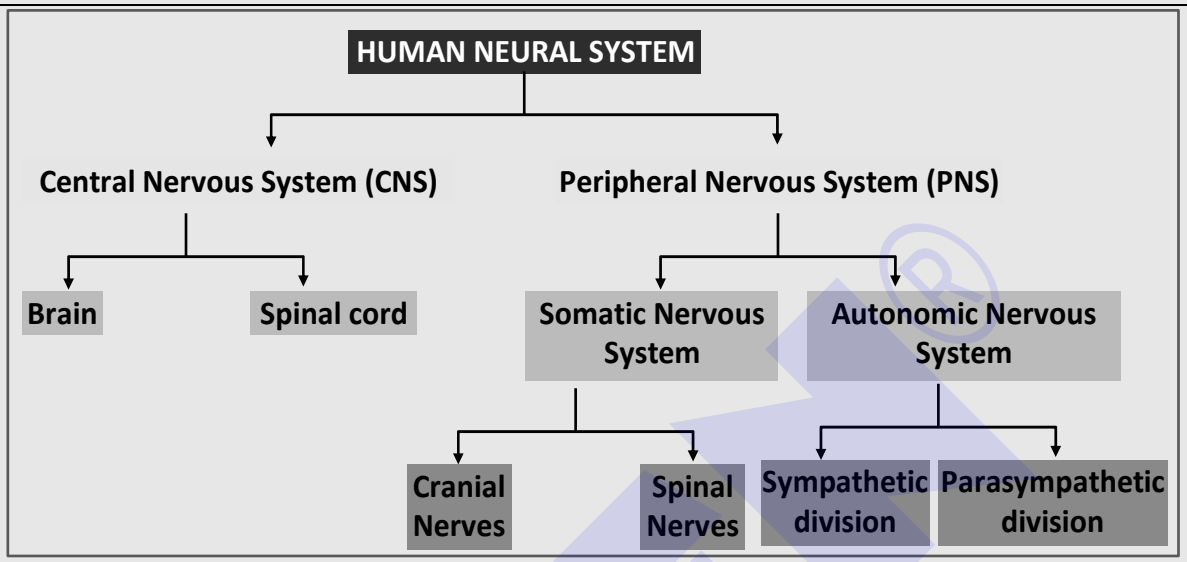
SPINAL CORD & PNS

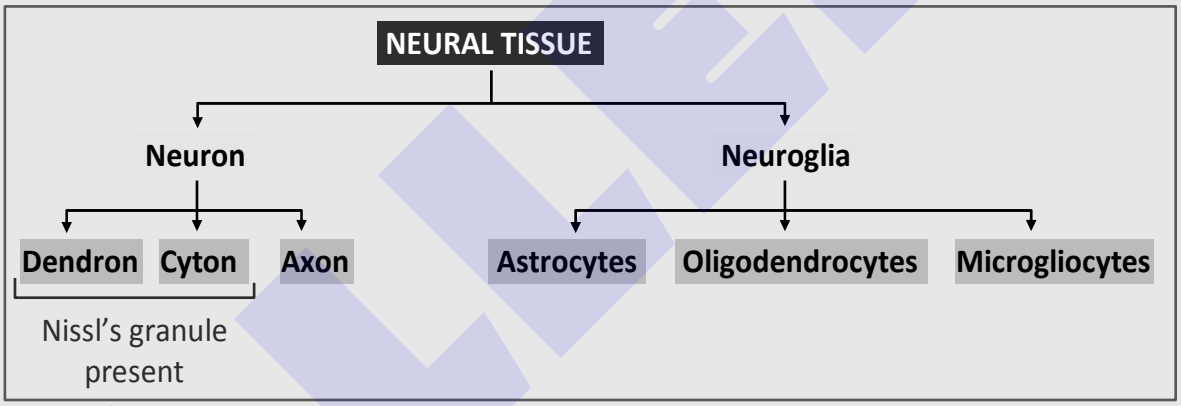
Que.	1	2	3	4	5	6	7	8
Ans.	**3**	**2**	**2**	**3**	**2**	**4**	**1**	**4**

REFLEX ACTION

Que.	1	2	3	4	5	6
Ans.	**2**	**1**	**4**	**3**	**4**	**1**

ESSENCE





GENERATION OF NERVE IMPULSE

Process	Na^+-K^+ pump	Passive diffusion	Na^+ VGC	K^+ VGC	Potential with value	Inside Charge after the event
Polarisation	✓	✓	×	×	RMP (–60 to –85mV)	Negative
Depolarisation	×	✓	✓	×	+30 to +45 mV	Positive
Repolarisation	✓	✓	×	✓	–70 mV	Negative
Hyperpolarisation	✓	✓	×	✓	–85 mV	Negative

TYPE OF SYNAPSE

	Electrical	Chemical
(i) Conduction	Fast	Slow
(ii) Synaptic cleft	0.2 nm	> 20 nm
(iii) Neurotransmitter in synaptic cleft	Absent	Present
(iv) Occurence in body	Rare in our body	Most common
(v) Synaptic delay	Absent	Present
(vi) Blocking	Cannot be controlled	Controlled by neurotransmitter

SPECIAL NOTE : MAJOR FUNCTIONS OF THE BRAIN

PART OF BRAIN	FUNCTION
Frontal lobe of cerebrum (Fore-brain)	Voluntary movements
Cerebellum (Hind brain)	Balance of the Body
Hypothalamus and Medulla oblongata	Functioning of the vital involuntary organs
Hypothalamus	Thermoregulation
Hypothalamus	Hunger and thirst
Pineal gland and Hypothalamus	Circadian (24 hour) rhythms of our body
Hypothalamus	Activities of endocrine glands
Cerebrum	Higher functions
Cerebrum **(Hippocampus)**	Memory
Cerebrum :- Parietal lobe Occipital lobe Temporal lobe	Processing and analysis of various sensation
Hypothalamus and limbic System **(amygdala)**	Emotion and Human behaviour

- Medulla oblongata comes out from **foramen magnum** & continues in neural canal of vertebral column, the continued part of MO is known as Spinal cord. It extends from base of skull to (L_1) lumbar vertebra.
- All the nerves arising from brain and spinal cord are included in peripheral nervous system. Nerves arising from brain are called **cranial nerves**, and nerves coming out of spinal cord are called **spinal nerves**.
- **12-pairs** of cranial nerves are found in reptiles, birds and mammals but amphibians and fishes have only **10-pairs** of cranial nerves.
- In Human only **31 pairs** of spinal nerves are found.
- Overall control of the autonomic nervous system is maintained by centres in the **medulla** (a part of the hind brain) and **hypothalamus**.