Human Anatomy & Physiology-2

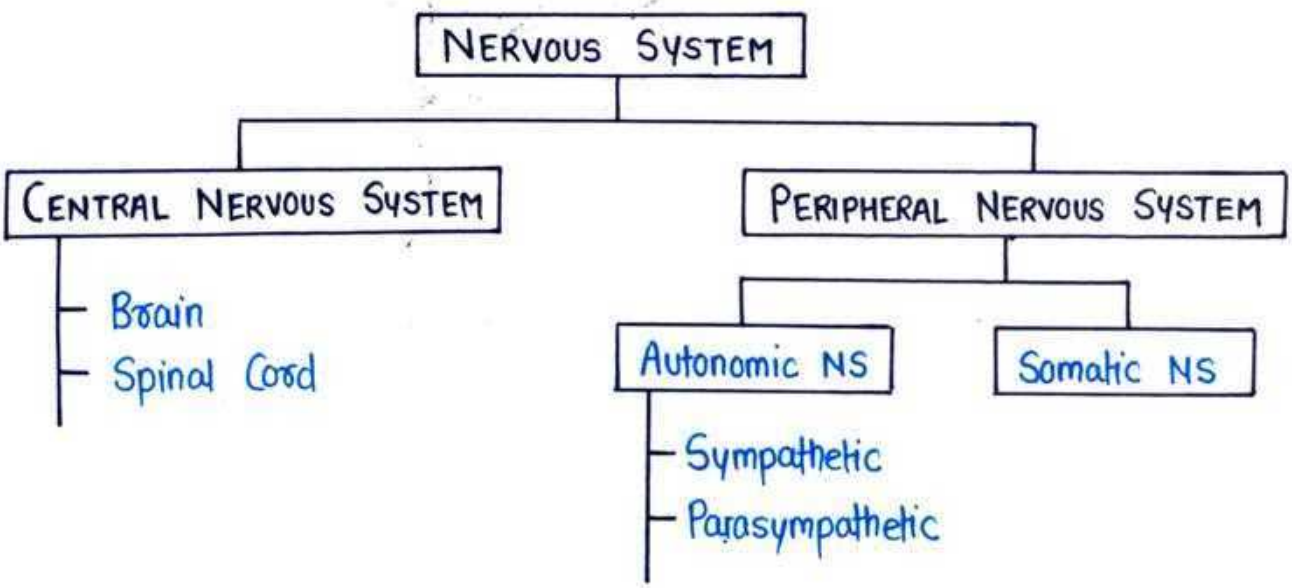
UNIT-1 Notes

Rx Pharma Education

NERVOUS SYSTEM

- The nervous system is the most complex system of human body containing millions of nerve cells network.
- It is the major controlling and coordinating system of human body.
- It is the body's command centre.
- The nervous system is the major controlling, regulatory and communicating system in the body.
- It is the centre of all the mental activities including thought, learning, memory.
- It is also responsible for maintaining homeostasis.

Organisation / Classification of Nervous System



Cells of Nervous System

There are basically two types of cells in nervous system.

① Neurons (Nerve Cells)
② Neuroglia (Glial Cells)

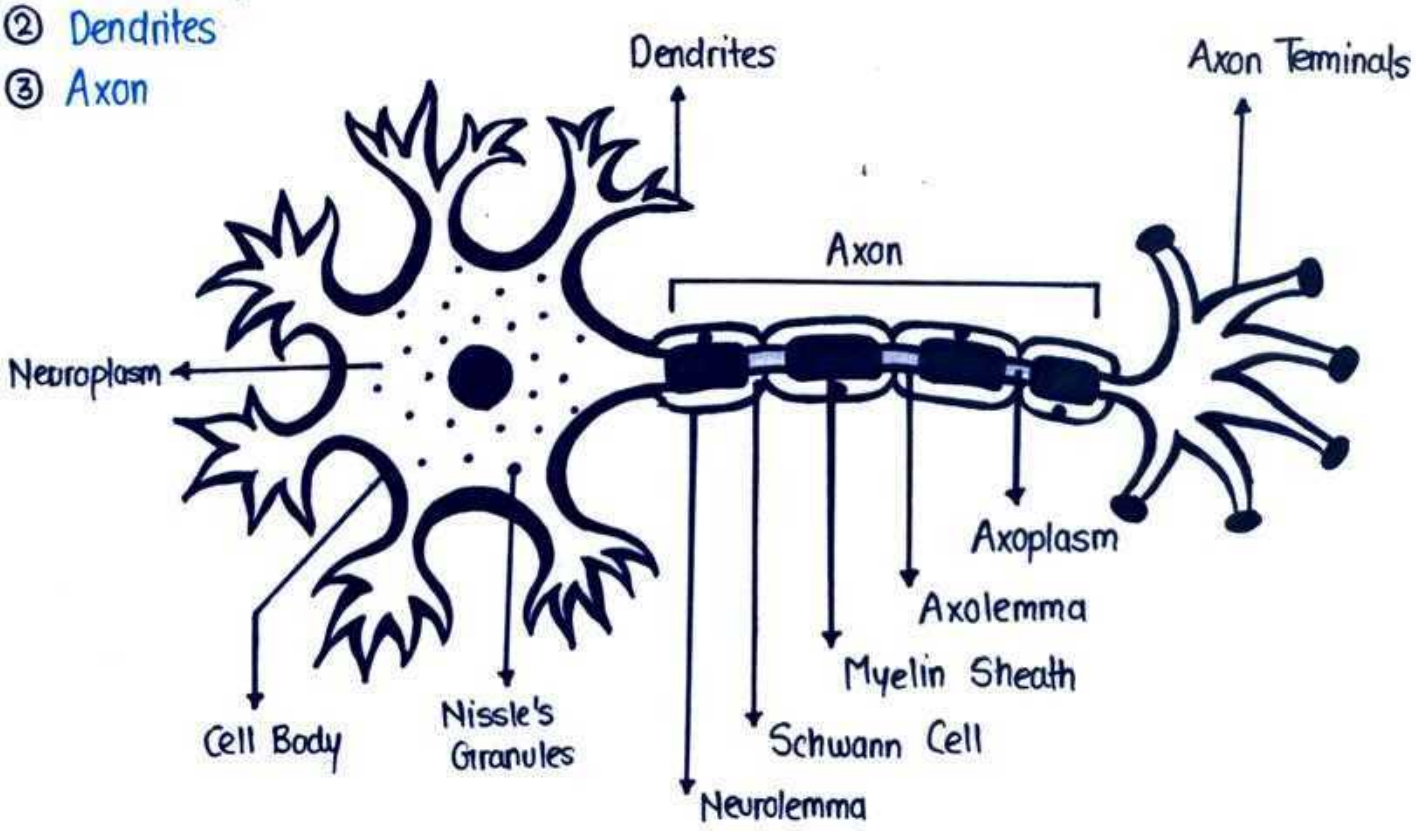
NEURONS

- Neurons are the basic structural and functional unit of nervous system.
- They generates , carry and transmit nerve impulses.
- It is also known as Nerve Cells.

Structure of Neurons

A Neuron is basically composed of three parts :

① Cell Body
② Dendrites
③ Axon



CELL BODY

- It is also known as Soma.
- The cell body is the central region containing nucleus is the site of all major metabollic activity of cell.
- It is approx 4-100 micrometer in diameter.
- The cytoplasm of neuron is known as Neuroplasm.
- The ribosomes of neurons is called as Nissle's Granules.
- Dendrites and Axons are nothing but the extensions of cell body.

AXON

- Axon is a thin, long and cylindrical process/extension that arise from the cell body of Neuron.
- Axons are the most important part of neuron that carry and transmit nerve impulses from one neuron to other.
- Generally most of the axons are covered by a fatty substance called Myelin Sheath which is further wrapped by Schwann Cells.
- The area of axon where myelin sheath is absent is known as Node of Ranvier.
- The site from which axon is extended from cell body is known as Axon Hillock.
  The end part of axon is known as Axon Terminal.

DENDRITES

- Dendrites are also the extensions of cell body that receives stimulus or nerve impulses from other neurons and sends them to the cell body.

Classification Of Neurons / Nerve Fibres

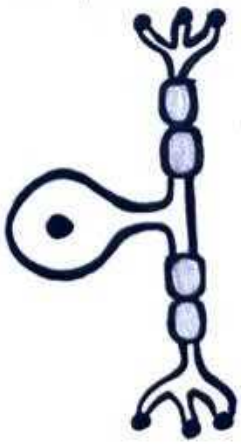
Neurons can be classified on the basis of 3 categories :

- On the basis of polarity / extension
- On the basis of function
- On the basis of Myelin Sheath

On the basis of Polarity

On the basis of Polarity, neurons are of 4 types :

① Unipolar Neurons
② Bipolar Neurons
③ Pseudounipolar Neurons
④ Multipolar Neurons

Unipolar	Bipolar	Pseudounipolar	Multipolar
These are the neurons in which cell body has single process. 	These are those neurons in which cell body has two process 	These neurons has single process but further this process divided into two other process. 	These are the neurons in which cell body has multiple process. 

On the basis of function

On the basis of function Neuron can be divided into three types :

① Sensory (Afferent) Neurons
② Motor (Efferent) Neurons
③ Interneurons

Sensory Neurons

- They are also known as Afferent Neurons.
- They carry nerve impulses from tissues and organs to the central nervous system.

Motor Neurons

- They are also known as Efferent Neurons.
- They carry nerve impulses from central nervous system to the effector organs.

Interneurons

- They are also known as Association neurons.
- They are found exclusively on Central Nervous System.
- The connects sensory and motor neurons.

On the basis of Myelin Sheath

On the basis of presence & absence of myelin sheath, neurons can be further divided into two types :

① Myelinated Neurons
② Non- myelinated Neurons

Myelinated Neurons

- These neurons are covered by a thick layer of myelin sheath.
- Impulse conduction in myelinated neurons is very fast compared to Non- myelinated neurons.

Non- Myelinated Neurons

- These neurons do not contain myelin sheath.
- Impulse conduction in non- myelinated neurons is slow compared to myelinated neurons.

Special Properties of Neurons

- It contains branches or process called Dendrites.
- It don't have centrosomes, hence it cannot be further sub divide.

Properties Of Neurons / Nerve Fibres

Neurons / Nerve fibres possess / contains some special properties as follows :

- Conductivity
- Excitability
- Refractory Period
- Unfatigability
- All or none law
- Accomodation

Excitability

It is the ability of neurons / nerve fibres to respond to various stimuli and convert them into nerve impulse.

Conductivity

It is the ability of nerve fibre to conduct nerve impulses (electrical impulses) along its length from one part to another.

Refractive Period

When the nerve fibre is once excited, it will not respond to any other stimulus for a selective time period & this time period is known as Refractive period.

Unfatigability

It is the ability of neove fibres to net get fatigued even if they receives continuous stimuli.

All or None Law

It is one of the most important property of neove fibres, neove fibres gets excited only at a particular threshold strength. Either they will give maximum response or they give no response.

Accomodation

If the continuous stimuli is applied to the neove fibres then it will decrease the excitability of neove fibres.

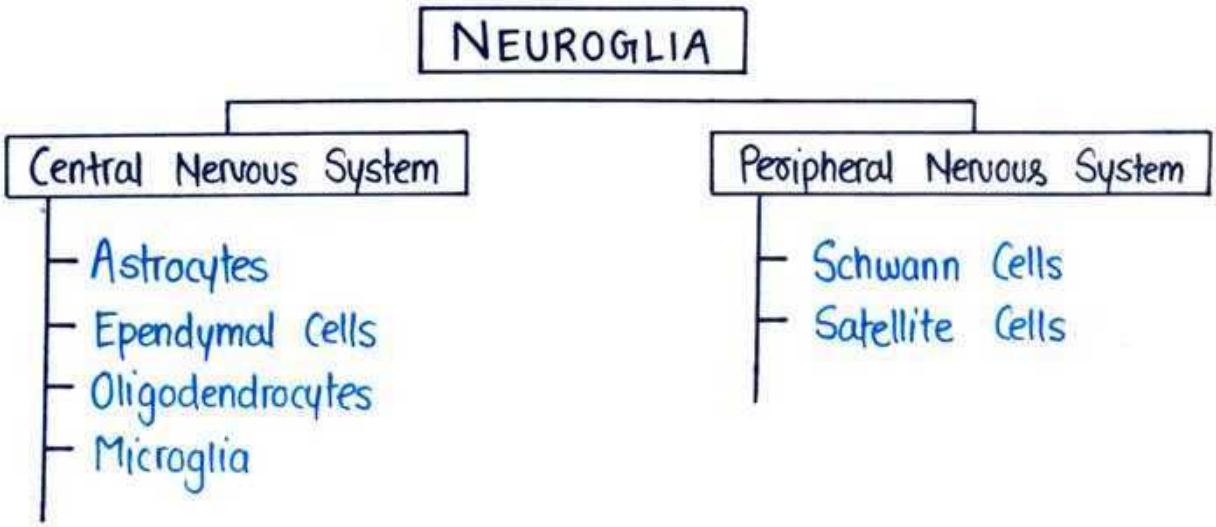
NEUROGLIA

- They are also known as Non-neuronal or Glial Cells.
- These are the supporting cells of neurons but do not generate or conduct nerve impulses.
- Unlike neurons, these cells have cell division property.

Functions of Neuroglia

- They provide nutrition to neuron.
- They protect neurons from pathogens.
- They provide structural and functional support to neurons.
- They form Myelin sheath
- They also maintains Homeostasis.

Types of Neuroglia



ASTROCYTES

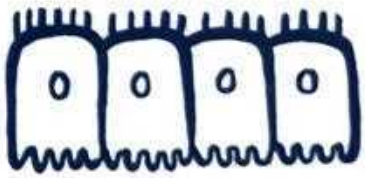
- These are the most abundant neuroglial cells.
- They are found in large number near blood vessels.
- They are of star shaped.
- They form and maintains Blood Brain Barrier.

OLIGODENDROCYTES

- They are smaller compare to Astrocytes
- They form myelin sheath in the neurons of central nervous system.
- They are the supporting network of neurons.

EPENDYMAL CELLS

- They form epithelial lining of brain & spinal cord & they are columnar epithelium.
- They secretes and absorbs CSF (Cerebrospinal fluid)



MICROGLIA

- They are the smallest neuroglial cells.
- They are derived from monocytes.
- They are phagocytic in nature & help in neuroglial repair.

SCHWANN CELLS

- They are the major glial cells in PNS.
- They form myelin sheath in the neurons of Peripheral Nervous System.
- They are also known as Neurilemma Cells.

SATELLITE CELLS

- They form extracellular space of nervous system.
- They provide physical support to neurons.

ELECTROPHYSIOLOGY

- Neuron is a special type of cell found in our nervous system which is able to generate, carry and transmit nerve impulse.
- Electrophysiology is nothing but the study of electrical properties of neurons.
- In Electrophysiology we basically study about :
  - How Nerve Impulse generated.
  - How stimulus changed membrane ion concentration.
  - How stimulus converted into nerve impulse.

ACTION POTENTIAL

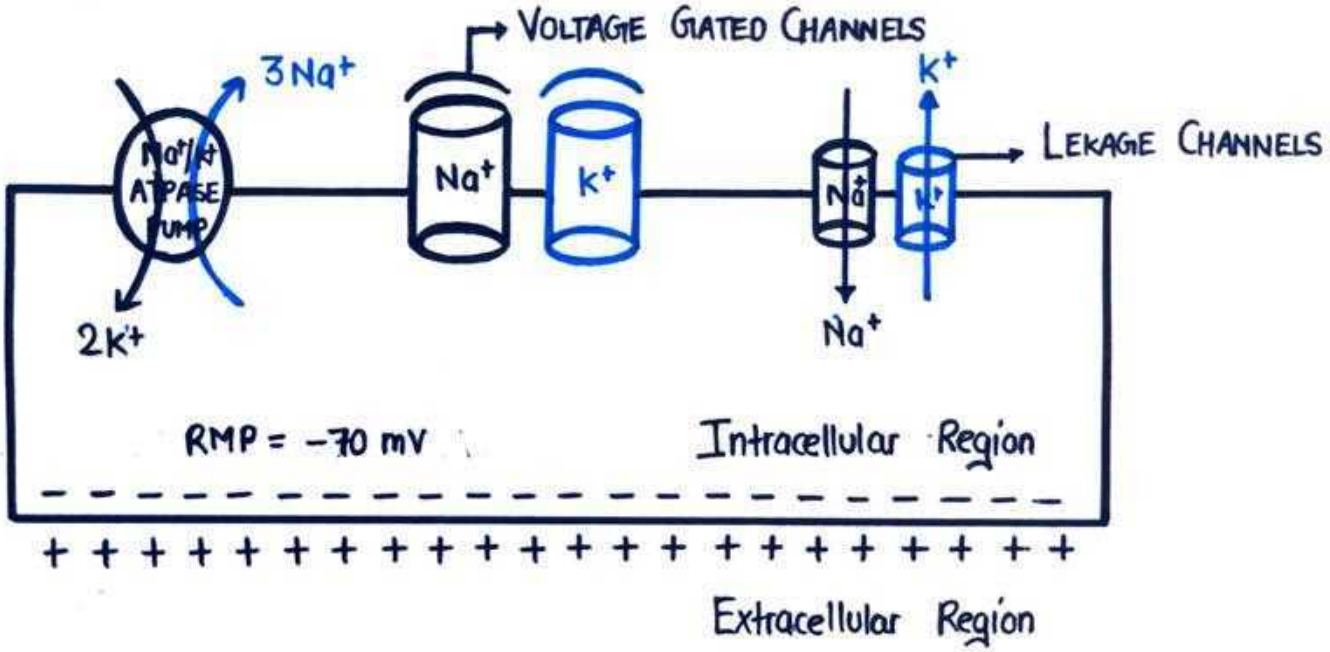
An action potential is the potential difference generated across the membrane of neuron due to disbalance of positive and negative charge which ultimately give rise to generation of Nerve Impulse.

Events During Generation of Action Potential

- Polarization
- Depolarization
- Repolarization
- Hyperpolarization

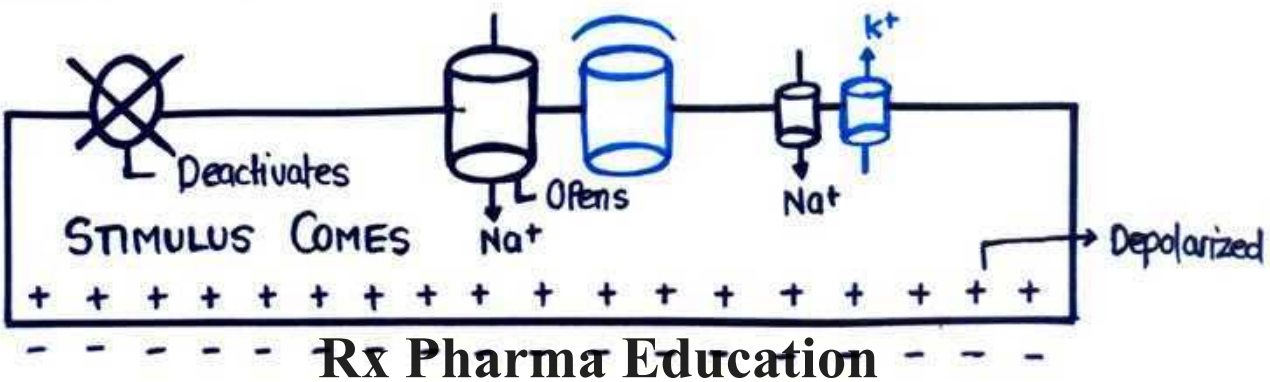
POLARISATION

- It is also known as Resting Stage.
- At this stage no stimulus comes hence no any action potential generated.
- At resting stage : Inside Membrane : Negative Charge & High K^+ ions
  Outside Membrane : Positive Charge & High Na^+ ions
- Resting membrane Potential = -70 mV



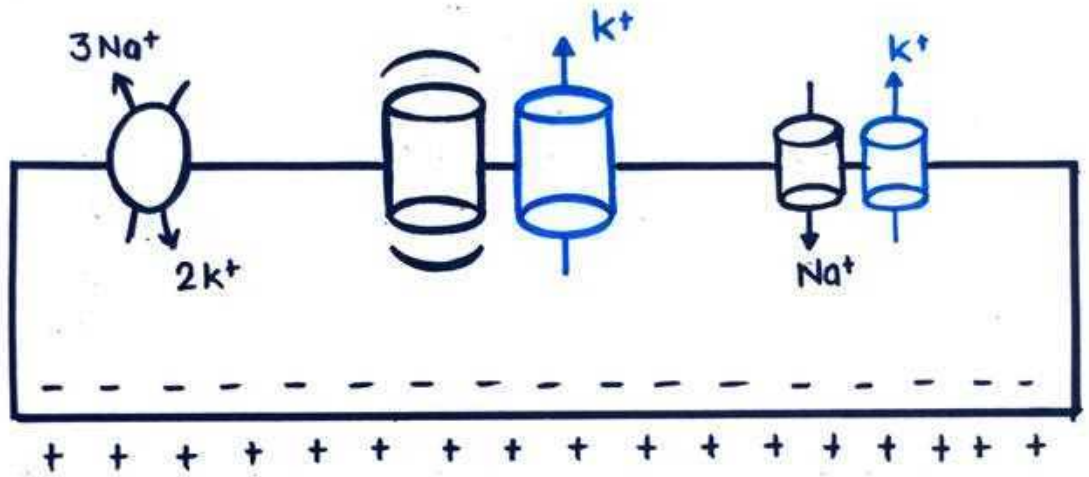
DEPOLARIZATION

- When stimulus comes it deactivates sodium potassium pump.
- Now Na^+ ions continuously increasing inside cell membrane via leakage channels & ultimately inside of membrane becomes positively charged & this stage is called depolarization (Voltage gate Na^+ also opens)
- Membrane Potential rises to +30 mV



REPOLARIZATION

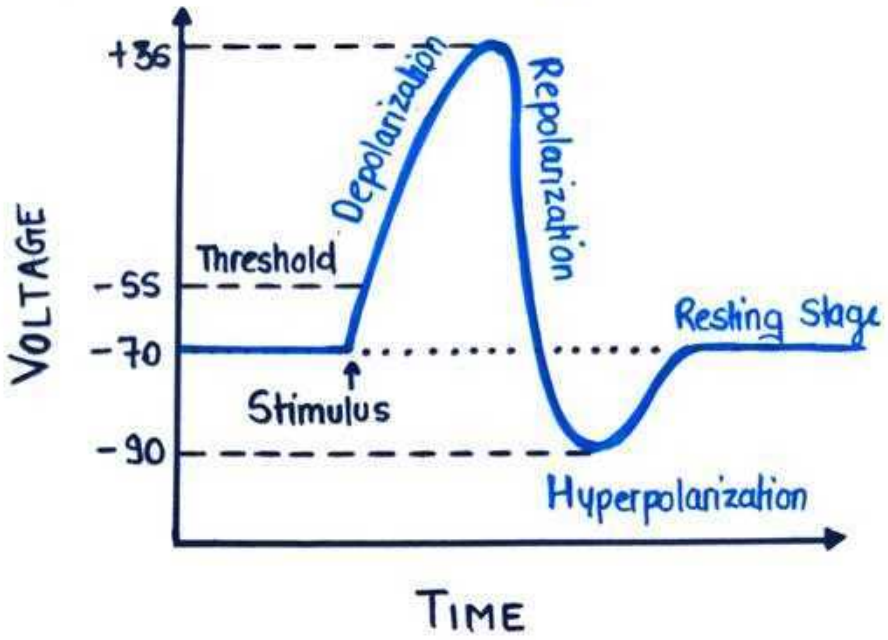
- Now when wave of depolarization passed from one part of membrane to another, voltage gated Na^+ channel again gets closed and now voltage gated K^+ channels opens.
- Now K^+ ions continuously passing out from the cell & ultimately the inside of membrane again becomes negatively charged & this stage is called Repolarization, ATPase pump again activates.



HYPERPOLARIZATION

- Although membrane again becomes repolarized but still K^+ channels (voltage gated) still remains opened.
- Now due to this K^+ ions continues passing outside of membrane and membrane potential becomes -90 mV which cause hyperpolarization.
- When potential reaches -90 mV K^+ channels also gets closes and finally membrane reaches to resting stage.

Graphical Representation of Events during Action Potential



NERVE IMPULSE

A Nerve Impulse is a message in the form of electrical signals generated inside the neuron as a result of Action Potential developed due to arrival of stimulus.

SYNAPSE

- A synapse is a junction between two neurons where transmission of nerve impulses takes place.
- Synapse allow communication between two neurons & other cells through the use of neurotransmitters.
- Generally this junction is formed between axon terminal of one neuron and the dendrite of another neuron.
- Neurotransmitters transmits signals from Presynaptic neuron to Postsynaptic neuron.

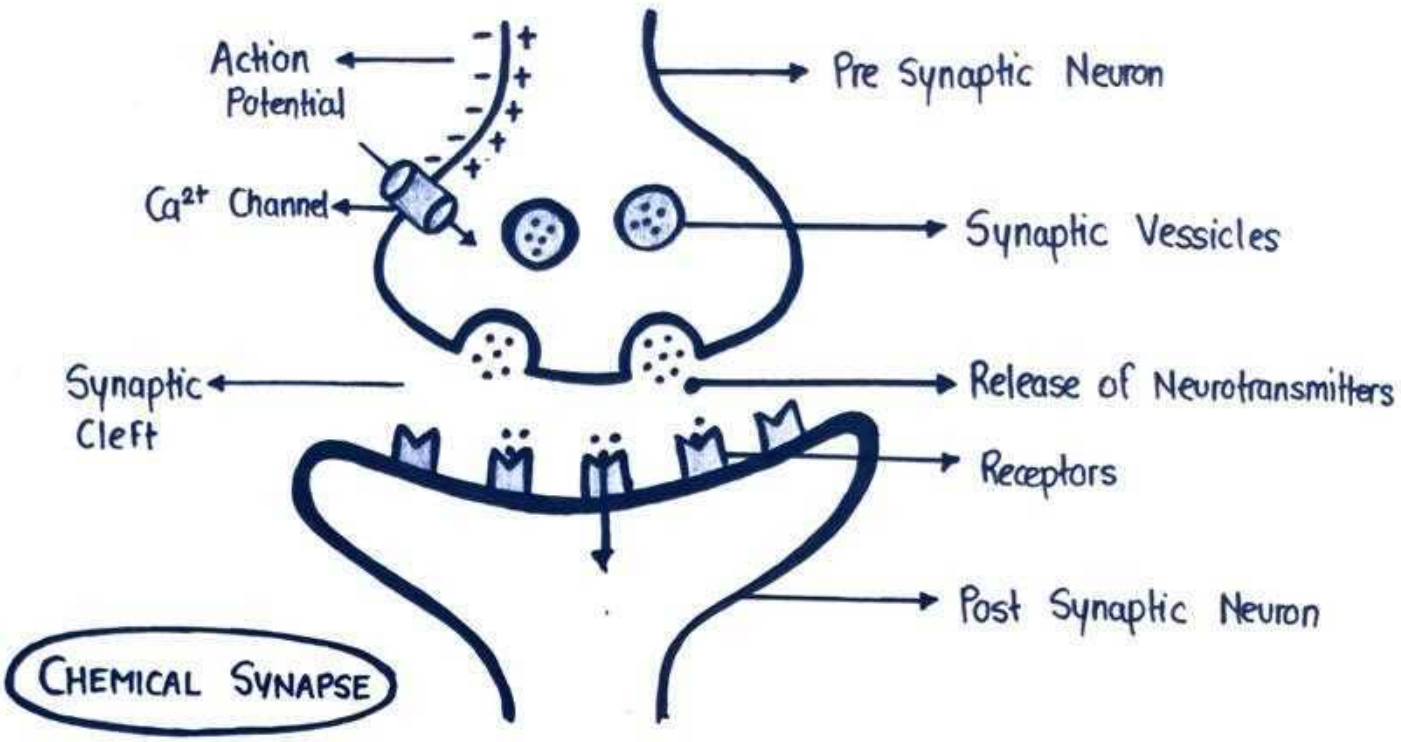
Classification of Synapse

There are basically two types of Synapse :

① Chemical Synapse
② Electrical Synapse

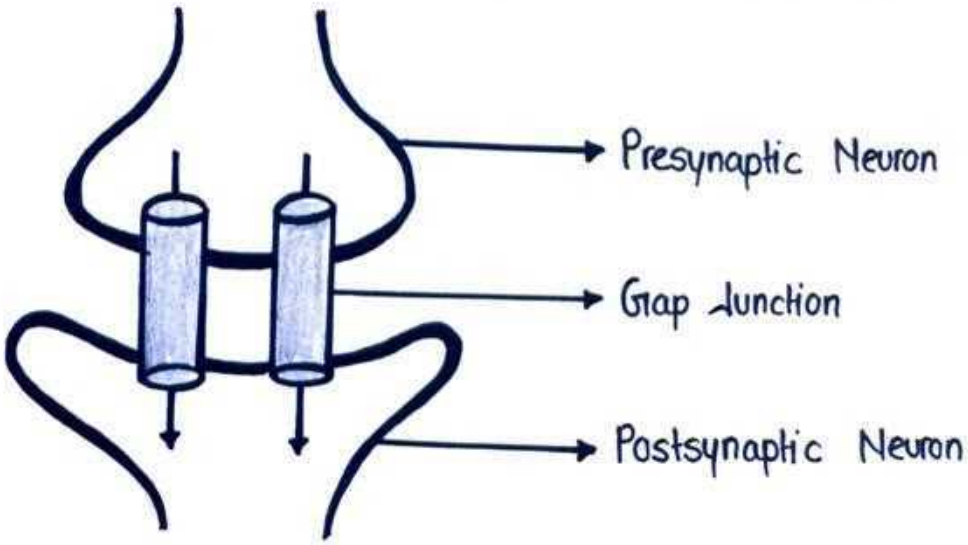
CHEMICAL SYNAPSE

- A chemical synapse is a junction between two neurons through which signals are transmitted by the release of chemical neurotransmitters.
- In the chemical synapse there is no continuity between two neurons because of presence of a space, called Synaptic Cleft.
- Neurotransmitters release from vessicles due to generation of Action Potential.
- Almost every synapse in human body is a type of chemical synapse.



ELECTRICAL SYNAPSE

- Electrical Synapse is a type of synapse in which there is a direct connection between presynaptic and postsynaptic neuron through Gap Junction.
- In electrical synapse transmission occurs very rapidly.
- They are very fewer in number compare to chemical synapse.



NEUROTRANSMITTERS

- Neurotransmitters are the chemical messengers that transmit signals from one neuron to another across a synapse.
- Neurotransmitters are generally packed in synaptic vessicles.
- They are very important for rapid transfer of nerve impulse between two neurons.

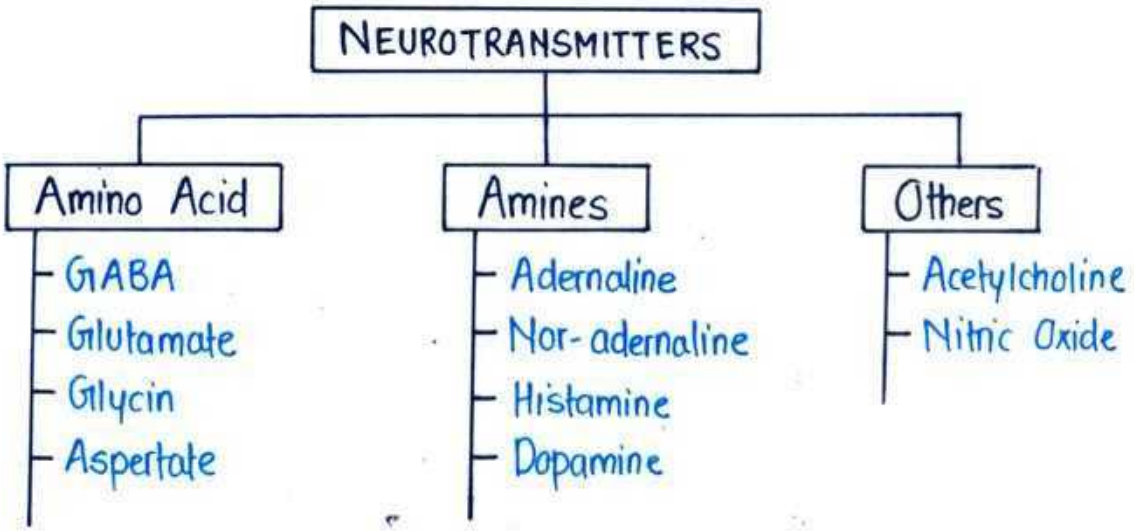
Types of Neurotransmitters

Neurotransmitters can be classified on the basis of two categories:

- On the basis of chemical nature
- On the basis of function

On the basis of chemical nature

On the basis of chemical properties neurotransmitters can be classified as follows:



On the basis of Function

On the basis of function, it can be again classified into taree types :

① Excitatory Neurotransmitters
② Inhibitory Neurotransmitters
③ Both

Excitatory Neurotransmitters

- These neurotransmitters act by stimulating the target neurons.
- They increases the influx of sodium ions inside the cell & cause depolarization.
- Examples : Acetylcholine, Adernaline, Serotonin etc.

Inhibitory Neurotransmitters

- These neurotransmitters act by inhibiting the target neurons.
- They increases the outflux of potassium ions outside the cell & cause repolarization.
- Examples : GABA, Glycine, Serotonine etc.

Both (Excitatory & Inhibitory)

- Neurotransmitters which contains both excitatory & inhibitory properties are classified in this group.
- Examples : Acetylcholine, Dopamine etc.

CENTRAL NERVOUS SYSTEM

- The central nervous system is mainly consist of Brain and Spinal Cord.
- Both Brain and Spinal Cord is protected by cranial cavity and vertebral column respectively.
- The central nervous system is the major controlling, regulatory and communicating system in our body.
- It is responsible for everything we do, feel & think.

Parts of CNS

① Brain
② Spinal Cord

MENINGES

- Although Brain and Spinal Cord is protected by cranial bones and vertebral column but since they are very sensitive & important organ of our body, hence they are further protected by three layer of covering called Meninges.
- Meninges provide both protection & nourishment to brain & spinal cord.

Layers of Meninges

① Dura Matter (Outermost Layer)
② Arachnoid Matter (Middle Layer)
③ Pia Matter (Innermost Layer)

Dura Matter

- It is the toughest and outermost layer.
- It is further divided into two sub layers :
  - Endosteal layer : Outer layer towards skull.
  - Meningeal layer : Inner layer towards Arachnoid matter.

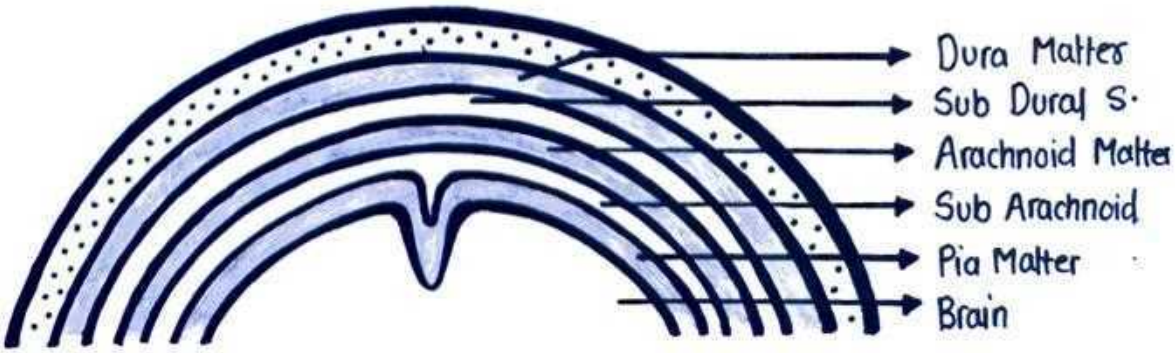
Arachnoid Matter

- It is the middle fibrous layer.
- It is separated from dura matter by Subdural Space.
- It is separated from Pia matter by Subarachnoid space.
- Arachnoid matter and Pia matter are collectively known as Leptomeninges.

Pia Matter

- It is the innermost layer of meninges.
- It is highly vascular connective tissue layer.
- It carries the blood vessels into brain.
- It plays major role in the formation of Choroid Plexus.

Sub Dural Space : Space between Dura Matter & Arachnoid Matter.
Sub Arachnoid Space : Space between Arachnoid Matter & Pia Matter.



GREY MATTER & WHITE MATTER

The organs of Central Nervous System i.e., Brain & Spinal Cord are composed of two kind of tissues

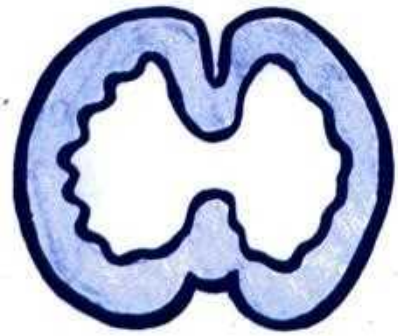
- Grey Matter
- White Matter

Grey Matter

- It is the major component of central nervous system mainly consist of Neuronal Cell body & dendrites.
- In brain it is present on the outer side while in spinal cord it is present in the inner side.

White Matter

- The white matter is the network of fibres mainly consist of mylinated axons / nerve fibres.
- In brain it is present in the inner side while in spinal cord it is present on the outer side.



BRAIN

SPINAL CORD

THE BRAIN

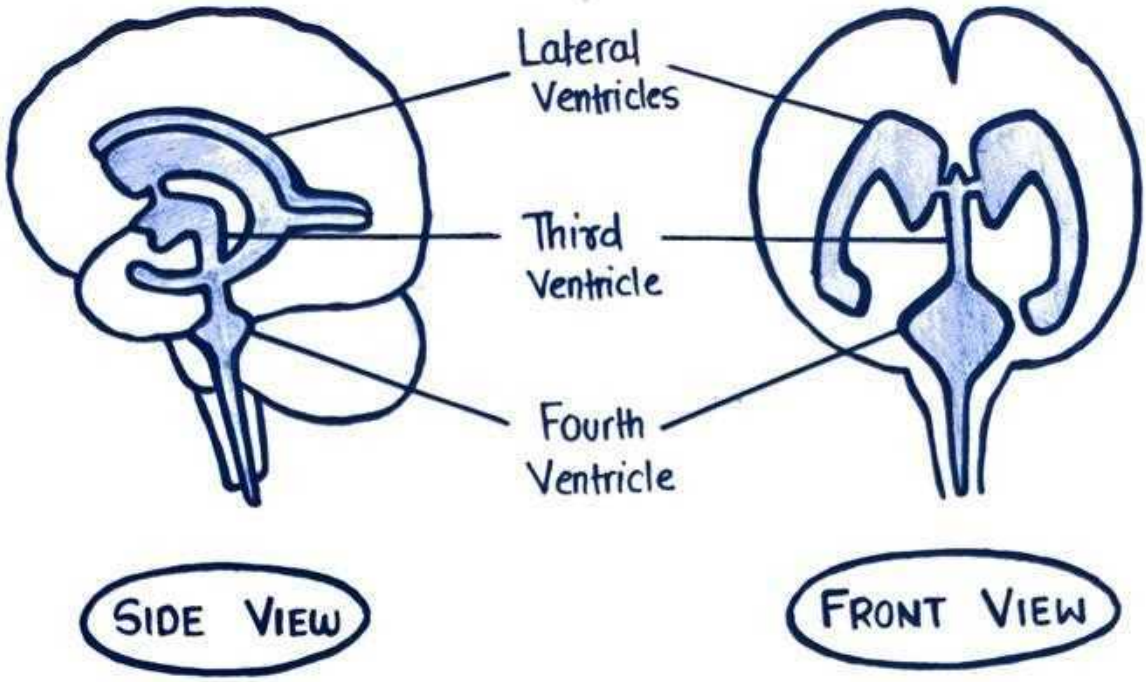
- Brain is one of the largest organ in the body which coordinates most of the body activities.
- It is the control centre of the body.
- The adult human brain weighs on average about 1·4 - 1·5 kg.
- In males the average weight is about 1370 g while in females it is about 1200 grams.
- It is made up of about 100 billion neurons.
- It is one of the most complex living structure in this universe.

VENTRICLES OF BRAIN

- The ventricles are cavities (hollow spaces) filled with Cerebrospinal Fluid
- There are four ventricles in our brain that are interconnected to each other.
- Each ventricles is lined by ependymal cells which forms Choroid Plexus that produces Cerebrospinal Fluid.

Four Ventricles of Brain

① Right Lateral Ventricles
② Left Lateral Ventricles
③ Third Ventricle
④ Fourth Ventricle



Lateral Ventricles (Right & Left)

- There are 2 lateral ventricles in our body located in each hemisphere of brain.
- They are roughly C shaped
- They are lined by ependymal cells and filled with CSF.
- Both ventricles are separated with each other by Septum Lucidum.

Third Ventricle

- It is located below lateral ventricles.
- It is narrow funnel shaped cavity of brain filled with CSF
- It is connected with 4th ventricle by cerebral aqueduct.

Fourth Ventricle

- It is diamond shaped cavity located below third ventricle.
- It is connected with 3rd ventricle by cerebral aqueduct.

CEREBROSPINAL FLUID (CSF)

- CSF is a clear, colourless & transparent fluid found in the ventricles, sub arachnoid space and central canal of spinal cord.
- It is mainly formed by choroid plexus of lateral ventricles.

Choroid Plexus : Choroid Plexus is a network of blood vessels lined by ependymal cells that produces CSF.

- The volume of CSF is approx 100- 150 ml.
- It is secret at a rate of 0.5 ml/min or 500-700 ml/day.
- Its pH is slightly alkaline 7.3.

Composition of CSF

It is composed of :

- 99% Water
- 1% Solid Substances

INORGANIC	ORGANIC
Sodium, Potassium Calcium, Magnesium Bicarbonates, Chlorides etc.	Proteins Sugar Uric acid Creatinine etc.

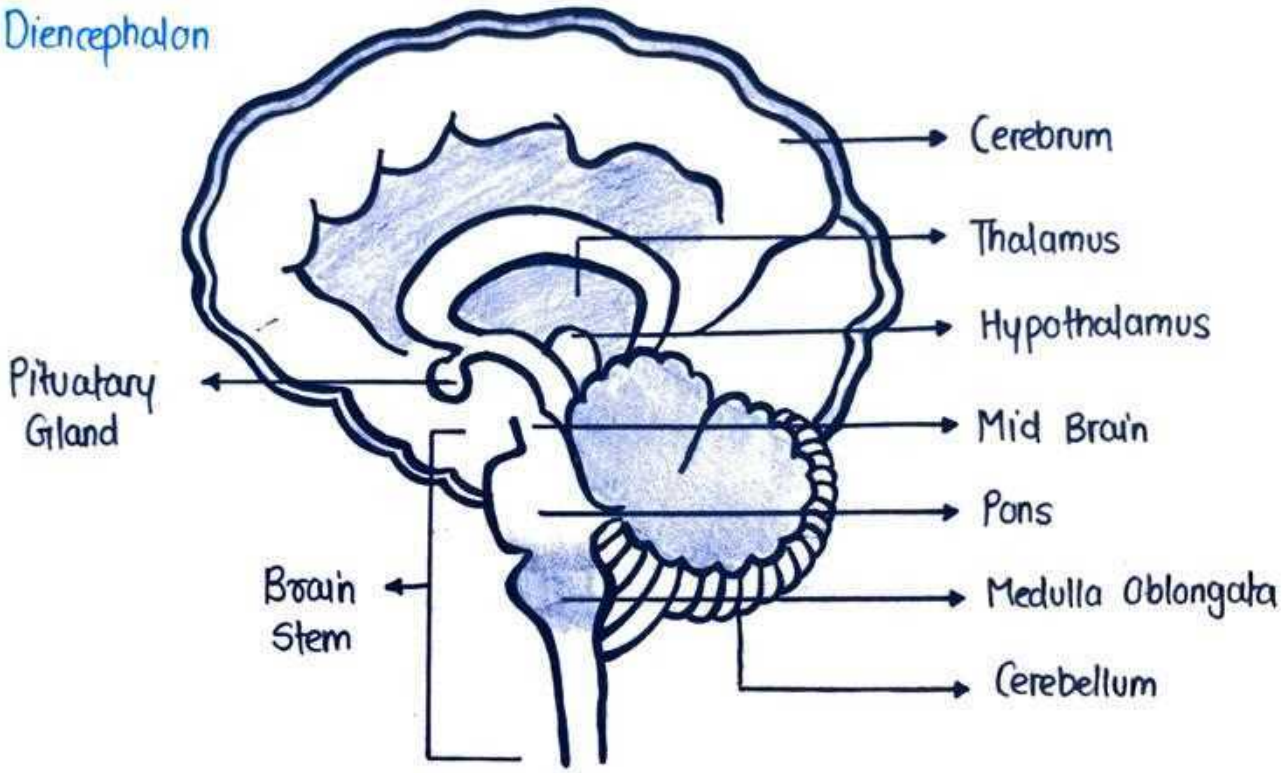
Function of CSF

- It support, protects & act as shock absorbent for CNS.
- It provide nutrients to brain & spinal cord.

PARTS OF BRAIN

The Brain can be divided into 4 major parts :

- Cerebrum
- Cerebellum
- Brain Stem
- Diencephalon



CEREBRUM

- It is the largest portion of brain.
- It is divided into two cerebral hemisphere i.e., Right Hemisphere & Left Hemisphere.
- It is located in the upper portion of brain responsible for learning & senses.
- The superficial layer of cerebrum is known as Cerebral Cortex.
- Both hemispheres connected by Corpus Callosum.
- Right Hemisphere : Control left side of body.
- Left Hemisphere : Control right side of body.

LOBES OF CEREBRUM

The cerebrum of brain is divided into 4 major lobes :

① Frontal Lobe
② Parietal Lobe
③ Temporal Lobe
④ Occipital Lobe

Frontal Lobe

- It is also known as Motor Cortex.
- It controls motor functions like personality, movement, planning decision making, creativity, concentration, thoughts etc.

Parietal Lobe

- It is also known as Sensory Cortex.
- It is responsible for controlling logical reasoning, direction, distance recognition, storage of language.

Temporal Lobe

- It is also known as Auditory Cortex
- It controls hearing, smell, dreams etc.

Occipital Lobe

- It is also known as Visual Cortex.
- It receives input from eyes & controls vision.

CEREBELLUM

- It is the second largest portion of brain.
- It is located below the posterior part of cerebrum.
- It is also known as 'Little brain'
- Structurally it resembles cerebrum, Like cerebrum it is also divided into two cerebellar Hemisphere.
- The cerebellum controls muscle contraction, movement, balance of body & posture etc.
- It also plays major role in cognition (learning).

BRAIN STEM

- The brain stem is a stem like part of brain that is connected with the spinal cord.
- It is mainly composed of mid brain, pons and medulla oblongata.

Mid Brain :
- It is one of the smallest portion of brain.
- It mainly controls the function of sensory organs eye, ears.

Pons :
- Pons means bridge : It connects cerebellum with brain.
- It controls sleep cycle and also manage breathing rate.
- The signals reach the brain from body through the pons.
- It maintains balance between body & mind.

Medulla Oblongata :
- It is lowermost part of brain.
- It is directly connected with spinal cord.
- It mainly controls involuntary actions of body like respiration, Blood Circulation, Heart rate Yawning, Blinking, Vomiting etc.

DIENCEPHELON

- It is the posterior part of brain that connects midbrain with the H Cerebrum.
- It mainly composed of Thalamus, Hypothalamus & Epithalamus.

Thalamus

- Thalamus is the gateway of brain as nearly all sensory inputs pass through it.
- It receives information from all the sensory nerves and sends to the different regions of brain.

Hypothalamus

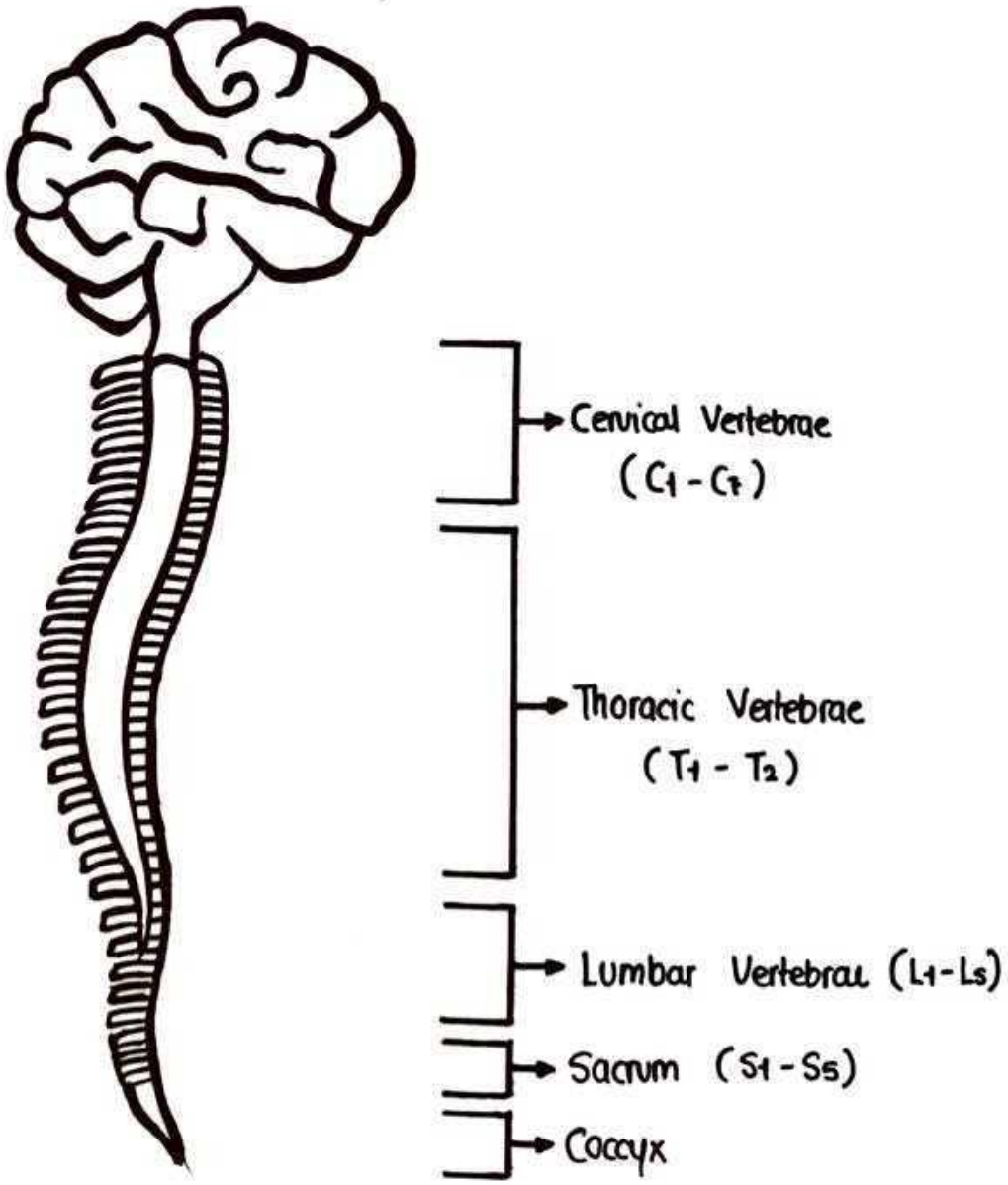
- Hypothalamus is small but one of the most important portion of brain.
- It mainly controls body temperature.
- It is responsible for nearly all type of feelings & emotions like Anger, Fear, Love, Hate, Happiness Hobby, Hunger, Thrust etc.

Epithalamus

- Epithalamus is a small region superior & posterior to thalamus.
- It consist of pineal gland which is a endocrine gland that secretes Melatonin.

SPINAL CORD

- Spinal Cord is a thin tube like structure starts from medulla oblongata of brain & extends to 1st & 2nd Lumbar vertebra.
- It is a part of Central Nervous System.
- In Men the length of spinal cord is about 45 cm while in women it is about 43 cm.
- It's weight is about 35 gm.
- It controls and regulates most of reflex action.



COVERING OF SPINAL CORD

Spinal Cord is a very sensitive organ of central nervous system, hence it is protected and covered by three layer of tissue called Meninges and bones of Vertebral column.

Meninges

Like brain spinal cord is also protected and nourished by three layers of membranes called Meninges.

① Dura Matter
② Arachnoid Matter
③ Pia Matter

Vertebral Column

- It is also known as spinal column or backbone.
- The bones of vertebral column are called 'Vertebrae'.
- They provide protection to spinal cord.
- They are divided into 5 different parts.

① Cervical Vertebrae : 7 (C_1 to C_7)
② Thoracic Vertebrae : 12 (T_1 to T_{12})
③ Lumbar Vertebrae : 5 (L_1 to L_5)
④ Sacrum : 5 (Fused)
⑤ Coccyx : 4 (Fused)

SPINAL CORD SEGMENTS

Spinal cord is divided into 31 segments from which 31 pairs of spinal nerves arises.

① Cervical Segment / Cervical Nerves : 8
② Thoracic Segment / Thoracic Nerves : 12
③ Lumbar Segment / Lumbar Nerves : 5
④ Sacral Segment / Sacral Nerves : 5
⑤ Coccygeal Segment / Coccrygeal Nerves : 1

SPINAL CORD ENLARGEMENTS

There are two major enlargements in the spinal cord :

① Cervical Enlargement
② Lumbar Enlargement

Cervical Enlargement

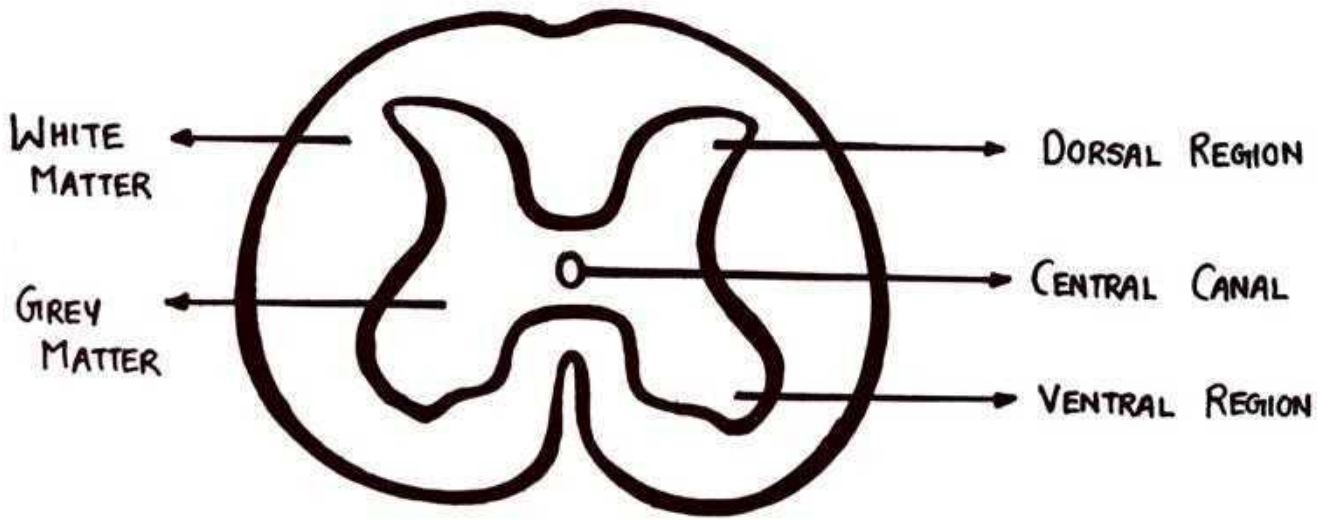
It is the superior enlargement extends from 4th cervical vertebrae to the 1st thoracic vertebrae [$C_4 - T_1$].

Lumbar Enlargement

It is the inferior enlargement extends from 9th to 12th thoracic vertebrae. [$T_9 - T_{12}$].

Internal Anatomy Of Spinal Cord

- Spinal cord is composed of an inner core of grey matter surrounded by an outer covering of white matter.
- Grey matter consist of neuronal cell body
- White matter consist of axon part.
- Exactly in the centre of grey matter there is a canal called Central Canal.
- The posterior part of grey matter is known as Dorsal region in which there are two dorsal horns.
- The anterior part of grey matter is known as Ventral region in which there are two ventral horns.
- The Grey matter in spinal cord resembles the shape of a butterfly.



REFLEX ACTIVITY

- Reflex activity can be simply defined as an involuntary and immediate response of voluntary muscles to a specific stimulus.
- The pathway followed by nerve impulses that produces the reflex activity is known as **Reflex Arc**.
- If the reflex action is produced by brain then it is known as **Cranial Reflex**
- If the reflex action is produced by spinal cord then it is known as **Spinal Reflex**
- A Reflex Arc contain 5 major components :

① Receptor
② Sensory Neurons
③ Control Centre
④ Motor Neurons
⑤ Effector