

NERVOUS SYSTEM

PART - I

Points to be covered in this topic

- **1. INTRODUCTION**
- **2. CLASSIFICATION OF NERVOUS SYSTEM**
- **3. NEURON**
- **4. NEUROGLIA**
- **5. CLASSIFICATION AND PROPERTIES OF NERVE FIBRE**
- **6. ELECTROPHYSIOLOGY**
- **7. ACTION POTENTIAL**
- **8. NERVE IMPULSE**
- **9. RECEPTORS**
- **10. SYNAPSE**
- **11. NEUROTRANSMITTERS**

NERVOUS SYSTEM

□ INTRODUCTION

- The **nervous system** is the major **controlling**, **regulatory**, and **communicating system** in the body.
- It is the center of all mental activity including **thought**, **learning**, and **memory**.
- The nervous system is responsible for **regulating** and **maintaining homeostasis**.

➤ THE NERVOUS SYSTEM IS CLASSIFIED IN TWO MAJOR CLASSES

I. CENTRAL NERVOUS SYSTEM

II. PERIPHERAL NERVOUS SYSTEM

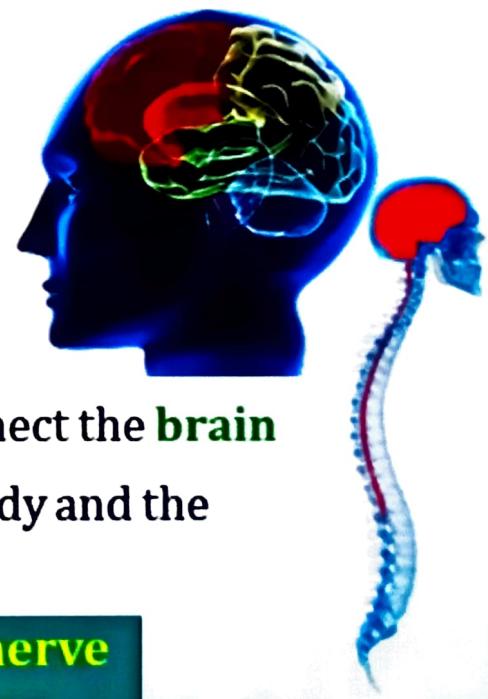
I. CENTRAL NERVOUS SYSTEM

- The central nervous system consist of **brain** present in the **cranial cavity** and the **spinal cord** present in the **vertebral column**.
- The spinal cord has **32 segments** and the brain consists of the **brain stem**, **diencephalon**, **cerebellum**, and **cerebrum**.

1. Brain

1. Forebrain
2. Midbrain
3. Hindbrain

2. Spinal cord



II. PERIPHERAL NERVOUS SYSTEM

- Peripheral nervous system is to connect the **brain** and **spinal cord** to the rest of the body and the external environment

1. Cranial nerves
2. Spinal nerve
3. Autonomic nervous system

NEURONS

- Reception or production, conduction and **transmission of messages** in the form of an electrical signal.

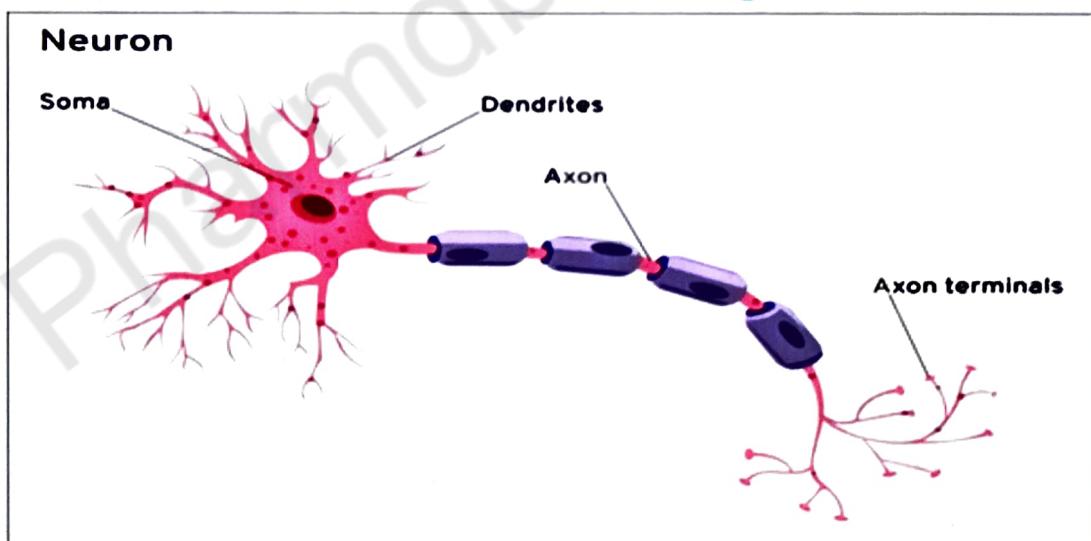
❖ STRUCTURE OF NEURONS

1. Cell body or soma

- The cell body is the **core section** of the neuron.
- The cell body contains genetic information, **maintains** the neuron's structure, and **provides energy** to drive activities.

2. Axon

- An axon is a **long, tail-like** structure.
- It joins the cell body at a specialized junction called the **axon hillock**.
- Many axons are insulated with a fatty substance called **myelin**.
- Myelin helps axons to conduct an **electrical signal**.

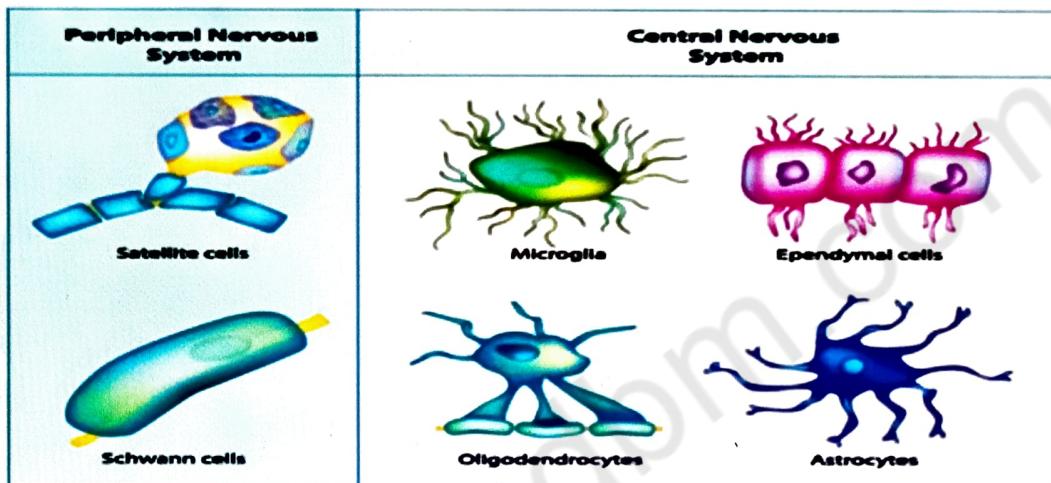


3. Dendrites

- Dendrites are **fibrous roots** that branch out from the cell body.
- Like antennae, **dendrites receive** and **process signals** from the axons of other neurons.
- Neurons can have more than **one set of dendrites**, known as **dendritic trees**.

NEUROGLIA

- Closely associated with neurons, more numerous but **smaller in size**.
- They are the **support of neurons** and have other important and unique functions
- The neuroglia comprises **6 cell types**, depending on location, structure and function:
 - ✓ **4 types in the CNS**
 - ✓ **2 types in the SNP**



Nerve fibers can be classified based on different criteria

1. **Histologically** - as myelinated or non-myelinated
2. **Functionally** - as afferent (sensory) or efferent (motor).
3. **Based on diameter and conduction velocity** which is known as Gasser and Erlanger's classification.
4. **Based on the type of neurotransmitter** released from their terminals as adrenergic, cholinergic, dopaminergic, etc.

Unmyelinated fiber A:



Partly myelinated fiber B:



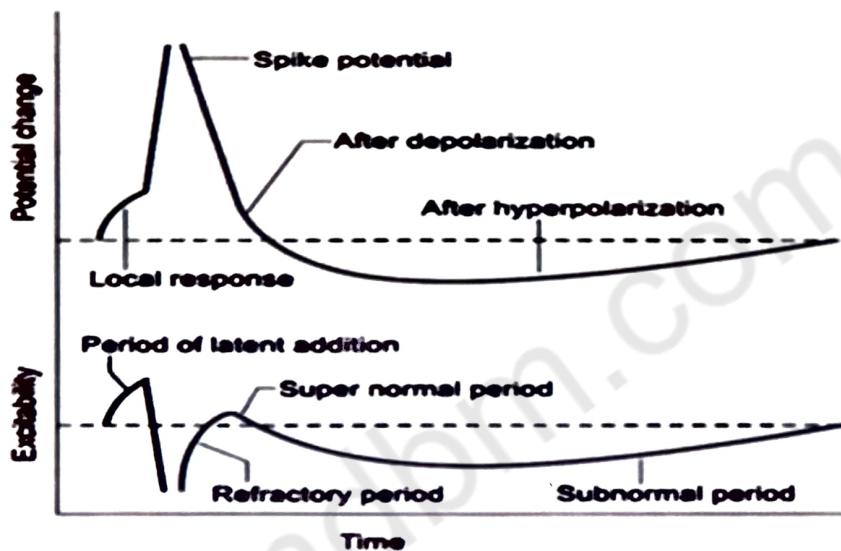
Individual axons

Fully myelinated fiber C:



► PROPERTIES OF NERVE FIBER

- ❖ **Excitability** - When a stimulus is applied, the nerve fiber demonstrates a change in its electrical activity from its **resting state**.
- ❖ **Conductivity** - It is the ability of the nerve fiber to **transmit impulses** all along the whole length of axon without any change in the amplitude of the **action potential**.
- ❖ **Refractory period** - It is the duration after an **effective stimulus**, when a second stimulus is applied, there will be no response for the **second stimulus**.



- ❖ **All or none law** - when the tissue is **stimulated** with threshold or more than threshold strength, the **amplitude** of response will remain the same but for a stimulus of less than threshold strength, there will not be any response.

□ ACTION POTENTIAL

- The resting membrane potential changes suddenly, quickly, transitorily, and propagative when an **action potential occurs**.
- An action potential can be generated only by neurons and muscle cells, a property known **excitability**.
- Nerve signals **originate** from action potentials.
- The neurons **generate** and **conduct** these signals along their processes in order to transmit these signals to the target tissues.
- A stimulus will either **activate** them in some way, inhibit them, or modulate them.

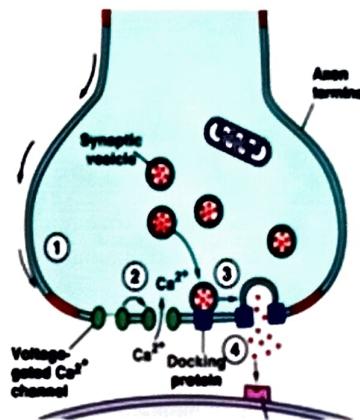
NERVE IMPULSE

An **electrical signal** that travels along a nerve fiber in response to a stimulus and serves to **transmit** a record of sensation from a receptor or an instruction to act to an **effector**

❖ STEPS OF NERVE IMPULSE

1. Polarized - Resting neuron

- **Inside membrane** is slightly **negative**.
- **Outside membrane** is slightly **positive**.
- Most membrane channels are **closed**, there is some normal **diffusion** of K or Na between cell and the environment through the sodium/potassium **pump** (active transport) stimulus occurs.

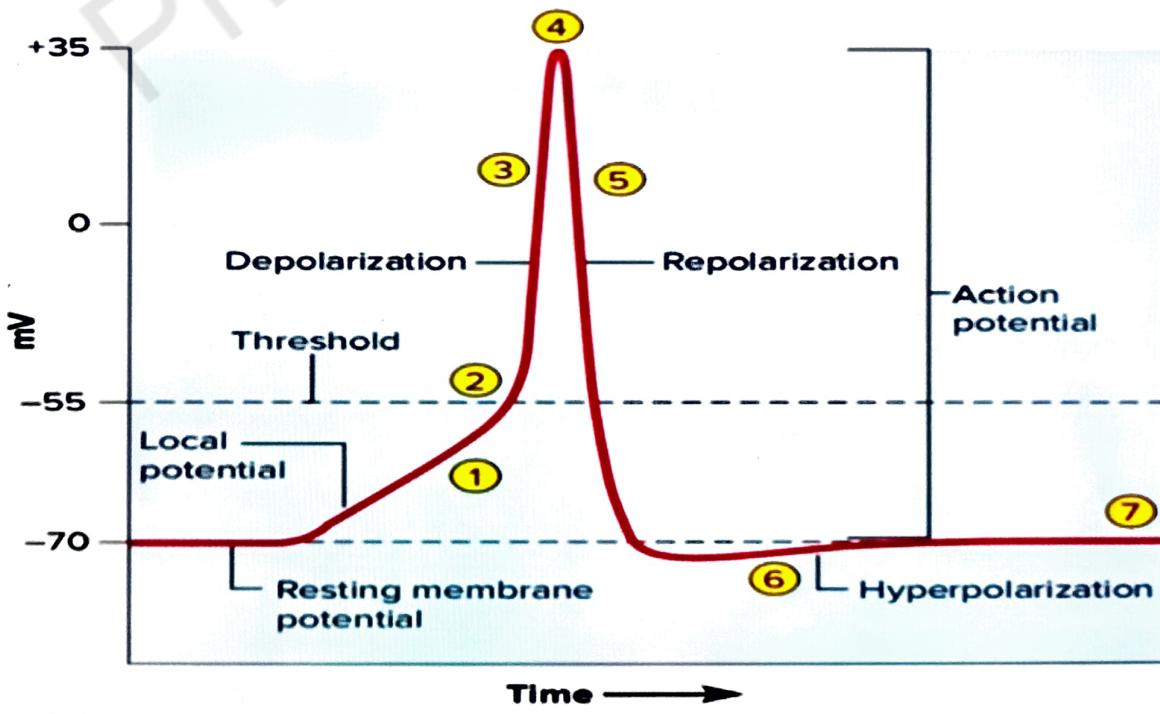


2. Depolarization - Active neuron

- Sodium (Na⁺) channels open allowing **Na⁺** to **diffuse** into the cell quickly

3. Repolarize - Normalizing

- K⁺ gates open in order to allow K⁺ to **diffuse** out of the cell



(a)

RECEPTORS

Biological transducers that **convert energy** from both external and internal environments **into electrical impulses**.

❖ TYPES OF RECEPTORS

1. CHEMORECEPTORS

- It is known as **chemosensor**, is a specialized sensory receptor cell which transduces a chemical substance to generate a **biological signal**.

2. THERMORECEPTORS

- A **thermoreceptor** is a **non-specialised** sense receptor, or more accurately the receptive portion of a **sensory neuron**.

3. MECHANORECEPTORS

- Mechanoreceptors are a type of **somatosensory receptors** which relay extracellular stimulus to intracellular **signal transduction** through mechanically gated ion channels.

4. PHOTORECEPTORS

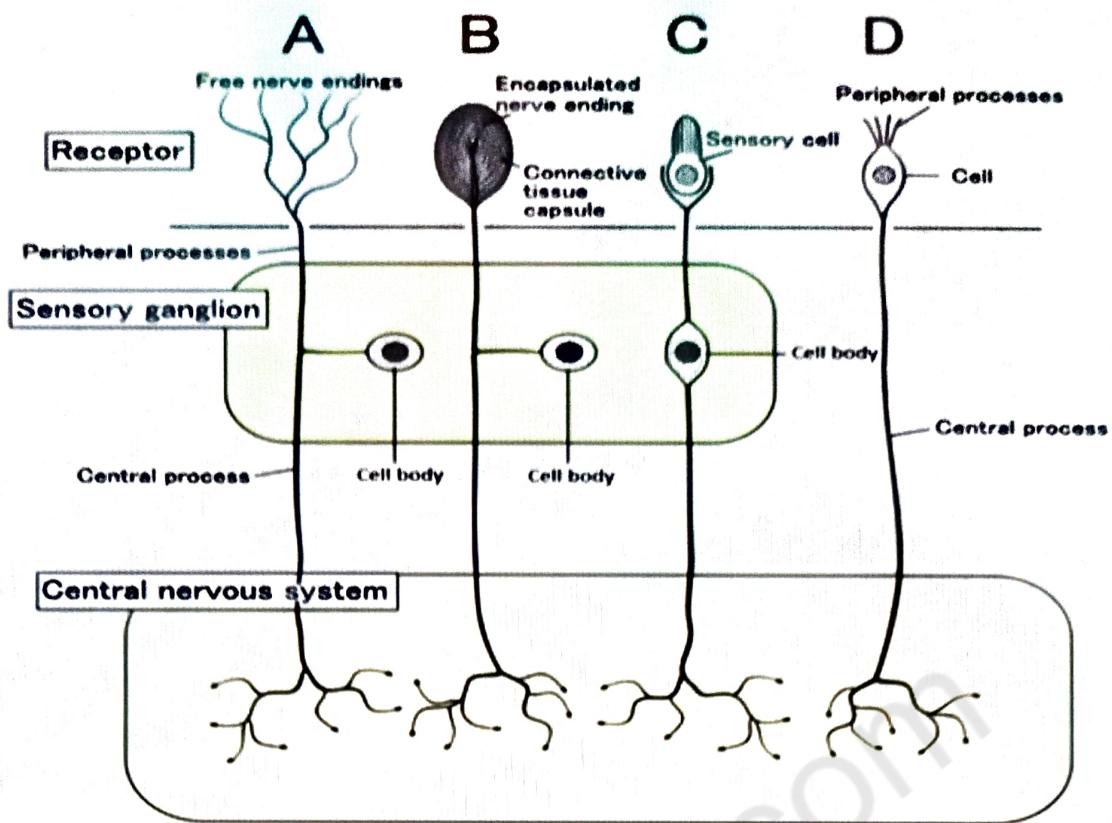
- Photoreceptors contain **proteins** that turn light energy into electrochemical signals, allowing cells in our nervous system to make sense of the **visual world**

5. SENSORY RECEPTORS

- Sensory receptors comprise specialised cells close to neurons or neuron endings, which are a part of the **afferent neurons** and send signals to the **central nervous system** and brain for processing and integration.

➤ Types of Sensory Receptors

- **Free nerve endings or dendrites**
- **Encapsulated nerve endings**
- **Specialised receptor cells**



□ SYNAPSE

- An synapse is a junction between **neuronal cells** that permits communication between them. A chemical messenger called a neurotransmitter transmits messages from the **presynaptic neuron** to the **postsynaptic neuron**.

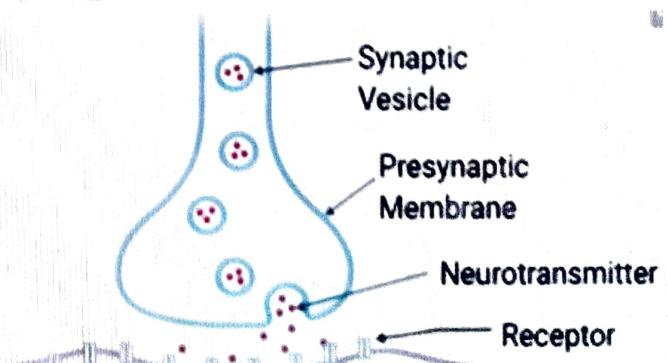
❖ TYPES OF SYNAPSE

1. CHEMICAL SYNAPSE

- A chemical synapse is formed when neurotransmitters, or chemical messengers are released by **presynaptic neurons** .

2. ELECTRICAL SYNAPSE

- As voltage changes occur between the **presynaptic cell** and **postsynaptic** cell .



NEUROTRANSMITTERS

- Our bodies are filled with **chemical messengers** known as neurotransmitters
- Functions the brain regulates with neurotransmitters are **Digestion, Sleep cycle, Appotite, Mood, Breathing, Heart rate**

❖ TYPES OF NEUROTRNSMITTERS

- ✓ **Excitatory neurotransmitter** - Target cells are **stimulated** to act by neurotransmitters
- ✓ **Inhibitory neurotransmitter reduces** the likelihood that the target cell will act
- ✓ Several neurons can be sent messages by **modulatory neurotransmitters** at the same time

1. Excitatory neurotransmitter

- Target cells are **stimulated to act** by neurotransmitters
 - Examples of Excitatory neurotransmitter
- ✓ **Glutamate** - Glutamate is typically synthesized within **neurons** from glutamine and is the most abundant neurotransmitter in the brain. It is an **excitatory neurotransmitter** and binds to four different receptors
 - **NMDA receptors**
 - **AMPA receptors**
 - **Kainate receptors**
- ✓ **Aspartate** - Aspartate stimulates NMDA receptor though not as strongly as the amino acid neurotransmitter glutamate does

2. Inhibitory neurotransmitter

- ✓ **GABA** - GABA is synthesized from **glutamate** and is an **inhibitory neurotransmitter** within the CNS. It binds to two different receptors:
 - **GABA A receptors**
 - **GABA B receptors**

✓ Glycine

- Glycine is an **amino acid** which is used at the majority of **inhibitory synapses** in the spinal cord and brainstem. It binds to **ionotropic** receptors which are permeable to chloride and bicarbonate ions.

✓ Dopamine

- Dopamine system plays a **central role** in several significant medical conditions, including **Parkinson's disease**, attention deficit hyperactivity disorder, **Tourette syndrome**, **schizophrenia**, bipolar disorder, and addiction.

3. Both inhibitory neurotransmitter and excitatory neurotransmitter

✓ Acetylcholine (ACh)

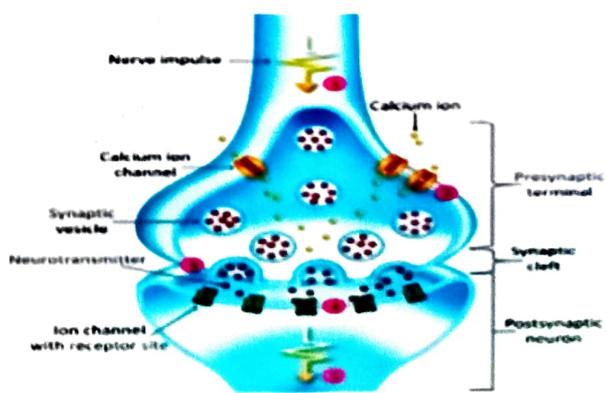
- ACh is used both in the **central** and **peripheral** nervous system, in particular at the NMJ. It is synthesised in neurons from **choline** and **acetyl-CoA**.
- ACh is an excitatory neurotransmitter and binds to two different receptor types
 - Nicotinic ACh receptors (nAChRs)**
 - Muscarinic ACh receptors (mAChRs)**

✓ Noradrenaline

- Noradrenaline widely is classified as a **sympathomimetic** receptor and function on both **CNS** and **ANS**.

✓ Serotonin

- It is a **monoamine neurotransmitter**. Its biological function is complex and multifaceted, modulating mood, cognition, reward, learning, memory, and numerous **physiological processes** such as **vomiting** and **vasoconstriction**.



CENTRAL NERVOUS SYSTEM

Points to be covered in this topic

→ 1. INTRODUCTION

→ 2. VARIOUS PARTS AND FUNCTION OF CNS

→ 3. REFLEX OF ACTIVITY

□ INTRODUCTION

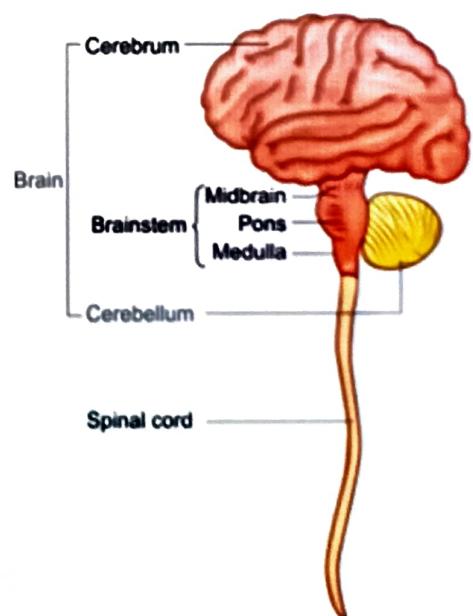
- The central nervous system consist of **brain** present in the **cranial cavity** and the **spinal cord** present in the **vertebral column**.
- The spinal cord has **32 segments** and the brain consists of the **brain stem, diencephalon, cerebellum, and cerebrum**.
- The nervous system is the **major controlling, regulatory, and communicating** system in the body.
- The nervous system is responsible for **regulating and maintaining homeostasis**.

□ VARIOUS PART OF CENTRAL NERVOUS SYSTEM

- The central nervous system consist of **brain** present in the **cranial cavity** and the **spinal cord** present in the **vertebral column**.

1. Brain

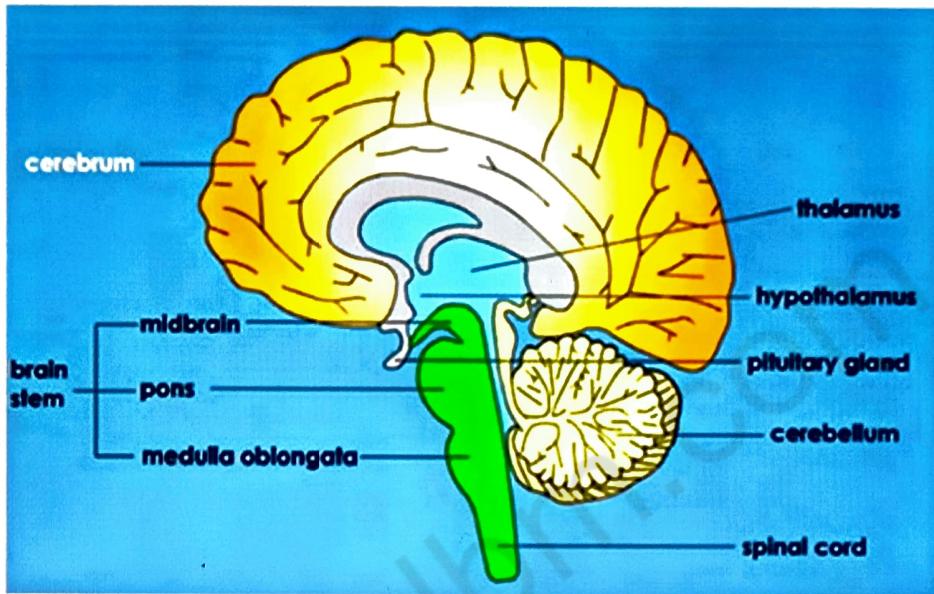
- i. Forebrain
- ii. Midbrain
- iii. Hindbrain



2. Spinal cord

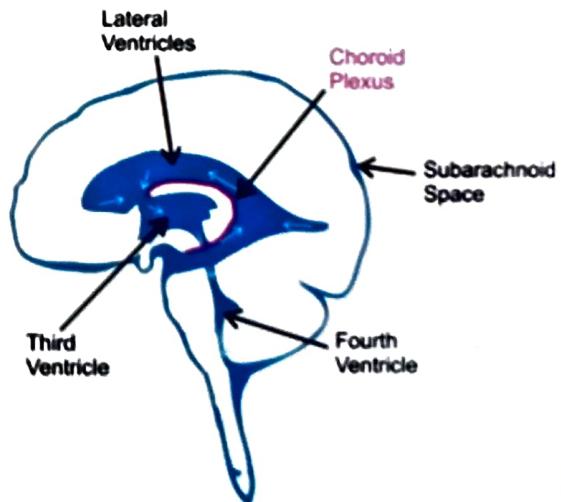
1. BRAIN

- It is one of the **largest organs** in the body, and coordinates most body activities
- It is the center for all thought, **memory, judgment**, and **emotion**.
- Each part of the brain is responsible for **controlling** different body functions, such as **temperature, regulation** and **breathing**.



➤ VENTRICLES OF BRAIN

- The ventricles of the brain are a **communicating network** of cavities filled with **cerebrospinal fluid** (CSF) and located within the brain parenchyma
- ❖ **Types of ventricles**
 - **Lateral ventricles** - Lateral ventricles are two **c-shaped** cavities one on each side of **cerebral hemisphere**
 - **Third ventricle** - The third ventricle is one of the **four ventricles** in the brain that communicate with one another
 - **Fourth ventricle** - The fourth ventricle is a cavity of **hindbrain** connected to the **third ventricle** by a narrow cerebral aqueduct.



➤ CEREBROSPINAL FLUID

- Cerebrospinal fluid (CSF) is a **clear, colorless** liquid found in your **brain** and **spinal cord**.
- It fills the **brain ventricles**, **cisterns**, and **sulci**. It also fills the central canal of the **spinal cord**.
- It is produced by specialized **ependymal cells** in the choroid plexuses.
- It is produced daily at a rate of about **25 ml per hour**
- The cerebrospinal fluid is primarily comprised of **water (99%)**. It also contains small quantities of **glucose, protein, sodium, potassium, calcium, magnesium, and chloride**.

✓ Function of CSF

- **Mechanical cushion** to brain
- **Source of nutrition** to brain
- **Excretion** of metabolic waste products
- Intra-cerebral **transport** medium
- **Control of chemical** environment
- **Auto regulation** of intracranial pressure

➤ PARTS OF BRAIN AND ITS FUNCTION

I. Cerebrum

a. Right cerebral hemisphere

b. Left cerebral hemisphere

II. Cerebellum

III. Brain stem

a. Medulla

b. Pons

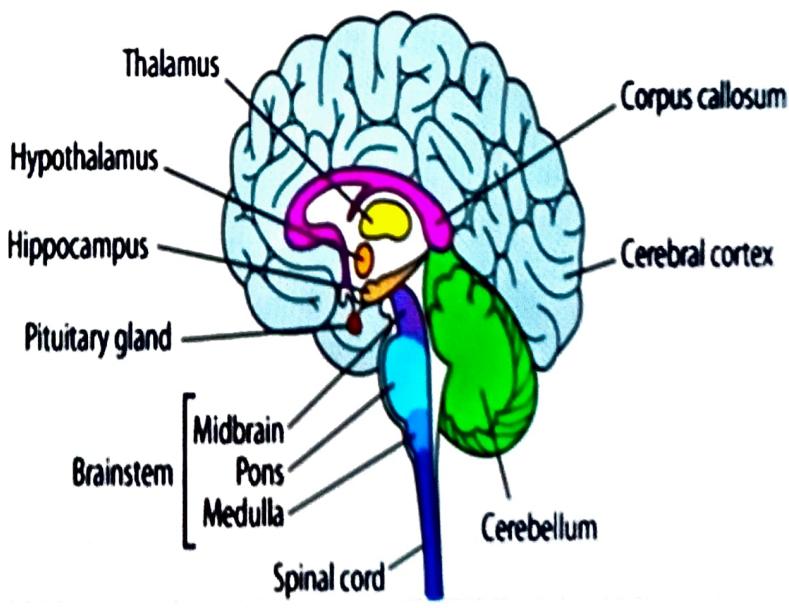
c. Mid brain

IV. Diencephalon

a. Thalamus

b. Hypothalamus

c. Epithalamus & Pineal gland



I. CEREBRUM

- It is the **largest section** of the brain.
- It is located in the **upper portion** of the brain and is the area that processes **thoughts, judgment, memory, problem solving, and language, imaginations.**
- The cerebrum is subdivided into the **left** and **right** Both **hemisphere** are connected by a bridge of **nerve fibers** that relay information between 2 hemisphere called **corpus callosum**.

➤ **Cerebral cortex**

- The superficial layer of the cerebrum is **gray mater** & this is 2-4 mm thick called **Cerebral cortex** contains **billions neurons**.
- During embryonic development when the brain size increases rapidly, the gray mater of the **cortex enlarges** much faster than deeper white mater so as result **cortical region roles** & **fold upon itself**.

❖LOBES OF CEREBRUM

✓ **Frontal lobe**

- Most **anterior portion** of the cerebrum (under forehead) **central sulcus** it separate the **frontal & parietal lobe**.
- **controls** motor function, **personality**, and **speech** Like Center of reasoning, **Planning**, some parts of speech, **movement**, **Emotions**, **problem solving**.
- Also called as **motor cortex**

✓ **Parietal lobe**

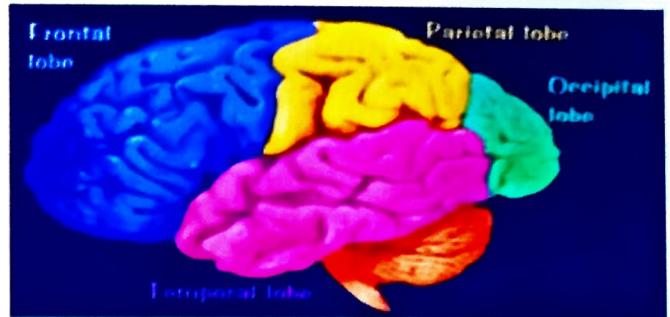
- The most **superior portion** of the cerebrum
- **Receives** and **interprets** nerve impulses from sensory receptors and interprets language.
- **Receives** sensory input from the skin.
- Also called as **sensory cortex**

✓ **Occipital lobe**

- The most **posterior portion** of the cerebrum.
- **Receives** input from the **eyes** & **controls vision**.
- Also called as **visual cortex**.

✓ **Temporal lobe**

- The **left** and **right** lateral portion of the **cerebrum**.
- **Controls hearing and smell**
- Also called **Auditory cortex**



❖ **FUNCTIONS OF CEREBRUM**

- Motor functions like control of **voluntary movements**.
- Sensory functions like **perception of pain, temperature, touch, hearing, taste, & smell**.
- Control of **intelligence, speech, memory & learning** etc.
- Occipital lobe primary **visual center** of brain.
- It also controls **subconscious contraction** of skeletal muscle.

2. CEREBELLUM

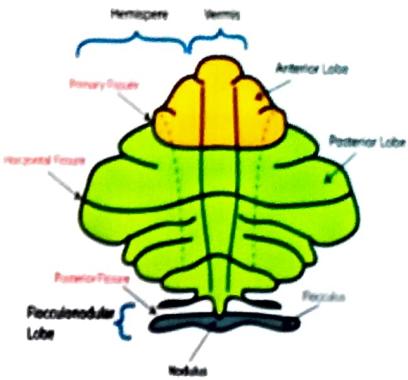
- **Second largest** portion of the brain
- Located beneath the **posterior part** of the **cerebrum**
- A deep groove known as **transverse fissure** separates cerebrum to cerebellum.
- Aids in **coordinating** voluntary body movements and **maintaining** balance and **equilibrium**.
- The external surface of cerebellum, called **cerebellar cortex**, look like **butterfly**, constricted area called **vermis**

➤ **Divisions & layers of cerebellum**

- **Anterior lobe** and **Posterior lobe** both regulate subconscious aspects of skeletal muscle movements.
- **Flocculonodular lobe** – on the **inferior surface** maintain **equilibrium** and **balance**.
- Superficial layer of cerebellum called **cerebellar cortex** consist of **gray mater, series of slender & parallel folds** called **folia**.
- Deep to gray mater white mater called **arbor vitae** resemble to branch of tree.

❖ Functions of cerebellum

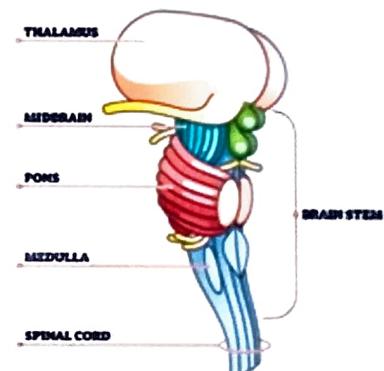
- Coordinate **contractions** of skeletal muscles
- May play a role in cognition/**learning** from **experiences** & **language processing**.
- One major function of the cerebellum is to **coordinate** the timing and force of these different muscle groups to **produce fluid limb or body movements**.
- **Sensory input** from the **skin, Viscera, special sense organ** and **pressure** is relayed to thalamus before redistribution to the cerebrum.



3 BRAIN STEM

- The brainstem is the **posterior stalk**-like part of the brain that connects the **cerebrum** with the **spinal cord**.
- In the human brain the brainstem is composed of the **midbrain**, the **pons**, and the **medulla oblongata**.

BRAIN STEM



❖ Mid brain

- The midbrain or **mesencephalon** extends from the pons to the diencephalon & about **2.5 cm long**.
- It acts as a pathway for impulses to be conducted between the **brain** and the **spinal cord**.
- associated with **vision, hearing, motor control, sleep/wake, arousal (alertness), and temperature regulation**.
- Anterior part of the midbrain called **cerebral peduncles** and Posterior part called "Tectum"

✓ Functions of mid brain

- The midbrain serves important functions in **motor movement**, particularly movements of the **eye**, and in auditory and **visual processing**.
- **Dopamine produced** in the substantia nigra and ventral tegmental area plays a role in **excitation, motivation**.
- The midbrain helps to relay information for **vision** and **hearing**.

❖ Pons

- Pons means bridge—**connects the cerebellum to the rest of the brain**.
- Like medulla it also **sensory tract** and **motor tract**.
- Contains **nuclei** that deals with **respiration, swallowing, bladder control, hearing, equilibrium, eye ball movements, facial expressions** etc.

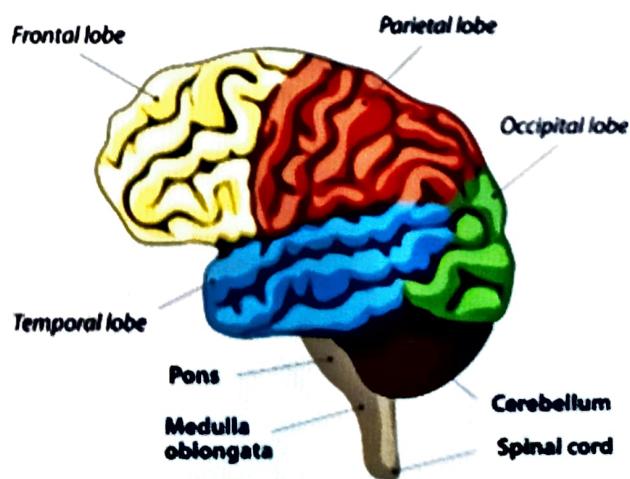
✓ Function of Pons

- **Relays sensory** information to cerebellum.
- Connects **forebrain to hindbrain**.
- **Regulates breathing**.
- Involved in **control of sleep cycle**.

❖ Medulla oblongata

- Lowermost part of the **brain stem** & continuation of the **superior portion of spinal cord**.
- Situated at the **base of the skull**/ starts from foramen magnum & extends to the inferior border of the pons, a distance of about **3 cm**.
- The **ascending & descending sensory** & motor white matter tracts (nerves) connecting brain to **spinal cord** pass through **medulla oblongata**.

HUMAN BRAIN



✓ Function of Medulla oblongata

1. It plays an essential role in **passing messages** between your **spinal cord** and **brain**.
2. The cardiovascular center: regulate the heart rate, force of heartbeat & diameter of blood vessels.
3. The **medullary rhythmicity center** - responsible for **maintaining basic rhythm of breathing**
4. The **vasomotor center** - **regulate blood pressure**.
5. **Others** - **vomiting, swallowing, cough, hiccupping & sneezing** etc.
6. **5 pairs** of cranial nerves originates from the nuclei located in medulla oblongata.

4. DIENCEPHELON

- Diencephalon is **posterior part** of the forebrain that connects the **midbrain** with the **cerebral hemisphere**.

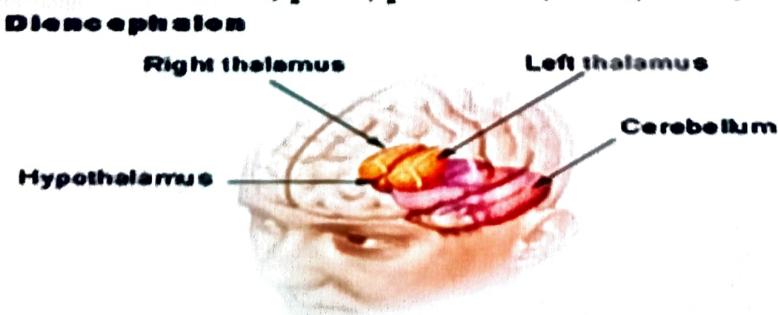
❖ Thalamus

- Thalamus means **inner room** in Greek, as it sits deep in the brain at the **top of the brainstem**.
- The thalamus is called the **gateway** to the **cerebral cortex**, as nearly all sensory inputs pass through it to the higher levels of the **brain**.
- Important relay station for all Incoming sensory nerves from periphery/**spinal Cord** with different impulses of **pain, temperature, Touch, pressure** are conveyed to thalamus first than Go to cerebrum.

(1) **Median geniculate nucleus**—related to **hearing**

(2) **lateral geniculate nucleus**—related to **vision**

(3) **Ventral posterior nucleus**—related to **taste & somatic sensations** like touch, pain, pressure, cold, heat, vibrations etc.



❖ Hypothalamus

- The hypothalamus sits under the thalamus at the **top of the brainstem**. Although the hypothalamus is **small**, it **controls** many critical bodily functions
- The hypothalamus is a **portion** of the brain that contains a number of **small nuclei** with a variety of functions.

✓ Functions of hypothalamus

- One of the most important functions of the hypothalamus is to link the nervous system to the **endocrine system** via the **pituitary gland**.
- **Controls** autonomic nervous system.
- **Regulates body temperature**.
- **Regulates** food intake and **Controls** endocrine system.
- Regulates **water balance** and **thirst** and **Controls sleep** wake cycles.
- **Controls** CVS regulation **Heart rate & BP** The hypothalamus is shaded blue. The **pituitary gland** extends from the hypothalamus.

❖ Epithalamus & Pineal gland

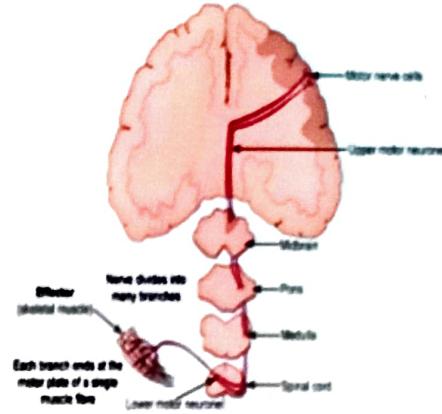
- Epithalamus is a **small region superior & posterior** to the thalamus.
- It consists of **pineal gland**
- Pineal gland is about the size of a **pea** & **protrudes** from posterior midline of the 3rd ventricle.
- It's a **endocrine gland** secrets hormone **Melatonin**.
- Darkness **stimulates** the pineal gland to **secrets melatonin** it promotes sleepiness.

✓ Functions of epithalamus & Pineal gland

- The function of the epithalamus is to connect the **limbic system** to other parts of the brain.
- The main function of the pineal gland is to receive and **convey information** about the current light-dark cycle from the environment and, **consequently produce and secrete melatonin** cyclically at night .

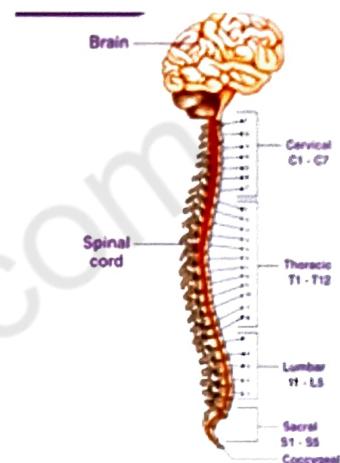
❖ **Effector**

- It is the part of the body that responds to the motor **nerve impulses** such as muscle or gland. Its action is called as **reflex**.
- If the effector is skeletal muscle, the reflex is called as **somatic reflex**.
- If the effector is **smooth muscle**, **cardiac muscle** or gland the reflex is called **autonomic reflex**.



2. SPINAL CORD

- The spinal cord is a **long bundle** of nerves and cells that extends from the lower portion of the brain to the lower back.
- It carries signals between the **brain** and the **rest of the body**.



❖ **External Anatomy of Spinal cord**

✓ **Cervical enlargement**

- **Superior enlargement** extends from the **4th cervical vertebrae** to the **1st thoracic vertebrae**; nerves to and from the upper limbs arises from the **cervical enlargement**.

✓ **Lumbar enlargement**

- **Inferior enlargement** extends from the **9th to the 12th thoracic vertebrae**; nerves to and from the lower limbs arise from **lumbarg enlargement**.

✓ **Posterior root or dorsal root**

- The dorsal or sensory root contains **sensory nerve** fibers which conducts the **nerve impulses** from periphery to the spinal cord.

✓ **Anterior root or ventral root**

- The ventral or motor root contains **motor neurons** conducting nerve impulses from the spinal cord to the periphery.

❖ Internal Anatomy of the Spinal Cord

✓ Anterior median fissure

- Deep groove on **anterior** (ventral) side

✓ Posterior median sulcus

- Shallower groove on **posterior** (dorsal) side.

✓ Anterior or ventral horns

- Somatic motor nuclei provide nerve (grey) **impulses** for contraction of skeletal muscles.

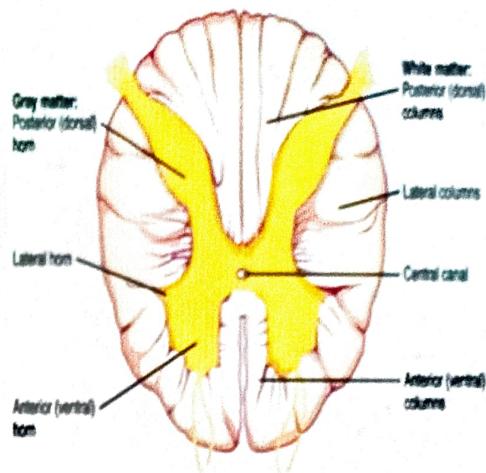
✓ Posterior or dorsal grey horns

- It contains **somatic** or **autonomic sensory nuclei**.

✓ Anterior (ventral) white columns

✓ Posterior (dorsal) white columns

✓ Lateral white columns



❖ Division of Spinal Nerves

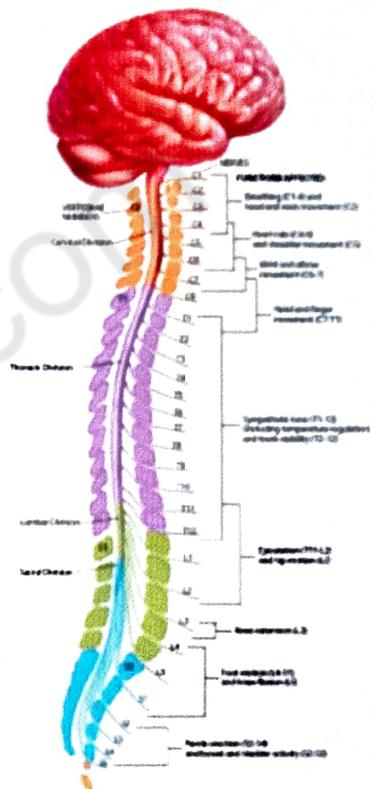
✓ Cervical nerves: 8 pairs

✓ Thoracic nerves: 12 pairs

✓ Lumbar nerves: 5 pairs

✓ Sacral nerves: 5 pairs

✓ Coccygeal nerves: 1 pair



❖ Functions of afferent and efferent nerve tracts

✓ Autonomic Sensory Neuron (afferent)

- These neurons are associated with **interoceptors** which are sensory receptors located in **blood vessels, visceral organs, muscles**.
- Sensory neurons are responsible for **receiving information** from sensory receptors to the central nervous system.

✓ Autonomic Motor Neuron (Efferent)

- These regulate visceral activities by either **increasing** or **decreasing** on going activities in their effector tissues
- The autonomic nervous system is divided into two divisions.
- **Sympathetic** (Thoraco lumbar outflow) division
- **Parasympathetic** (Carnio sacral outflow) division

- This system is further into two branches: the **sympathetic** system and the **parasympathetic** system. The sympathetic division of the autonomic nervous system regulates the **flight-or-fight** responses.
- The parasympathetic division of the autonomic nervous system helps **maintain normal body functions** and conserves **physical resources**.
- The two divisions have both **structural** and **functional** differences.
- They normally work in the **opposite manner**
- Each division has two **motor neurons**, **autonomic ganglia** and **effector organs**
- **Pre-ganglionic neurons**
- **Post-ganglionic neurons**
- The autonomic ganglion is the **collection of cell bodies** outside the **CNS**

□Reflex activity

- A reflex arc is a **flat, autonomic, unplanned sequence** of actions that occurs in response to a particular stimulus.
- When integration takes place in the spinal cord grey matter, the reflex is called as **spinal reflex**.
- If integration occurs in the brain stem it is called as **cranial reflex**.
- When there is contraction of skeletal muscles it is called as **somatic reflexes**.
- When there is **contraction of smooth muscles, cardiac muscles and glands** it called as **autonomic** reflex.
- The pathway followed by nerve impulses that produce a reflex is called as **reflex arc**.
- A reflex arc includes the following five functional components
 - **Sensory receptors**
 - **Sensory neuron**
 - **Integrating centre**
 - **Motor neuron**
 - **Effector**

