

NERVOUS SYSTEM

PART - I

Points to be covered in this topic

→ **1. INTRODUCTION**

→ **2. CLASSIFICATION OF NERVOUS SYSTEM**

→ **3. NEURON**

→ **4. NEUROLOGIA**

→ **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 CLASS

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

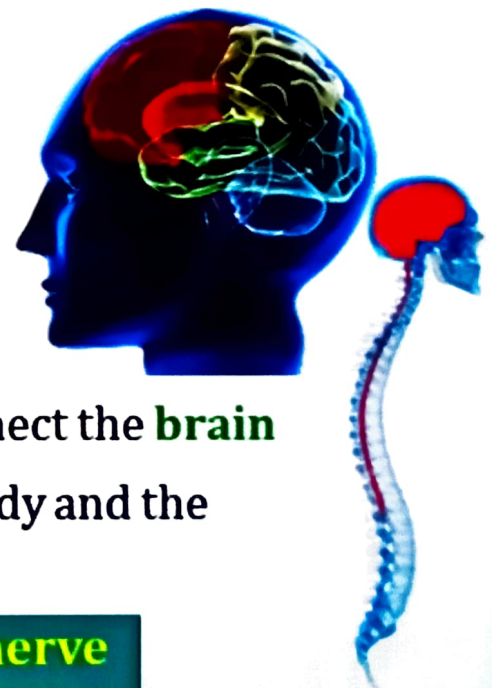
1. Forebrain
2. Midbrain
3. Hindbrain

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.

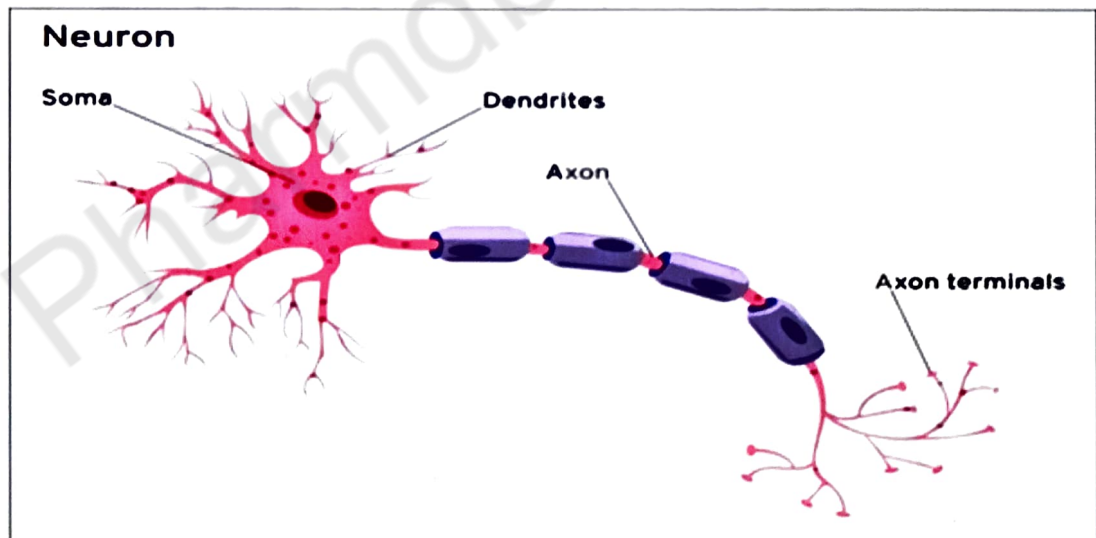
❖ STRUCTURE OF NEURONS

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**.

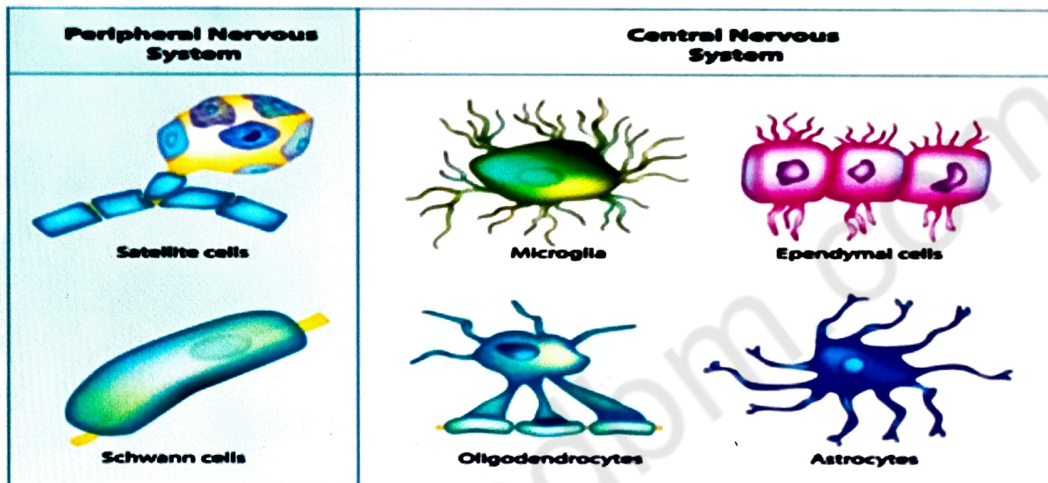


3. Dendrites

- 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

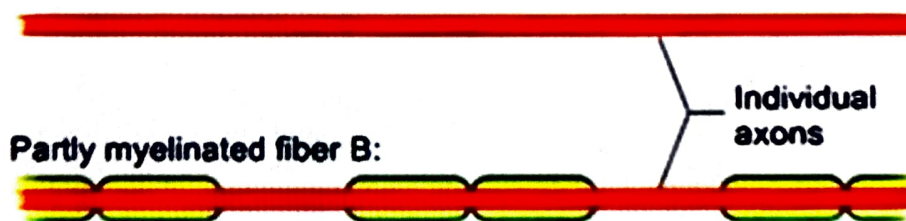
- Closely associated with neurons, more numerous but **smaller in size**.
- They are the **support of neurons** and have other important and unique functions
- The neuroglia comprises **6 cell types**, depending on location, structure and function:
 - ✓ 4 types in the CNS
 - ✓ 2 types in the SNP



□ 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:

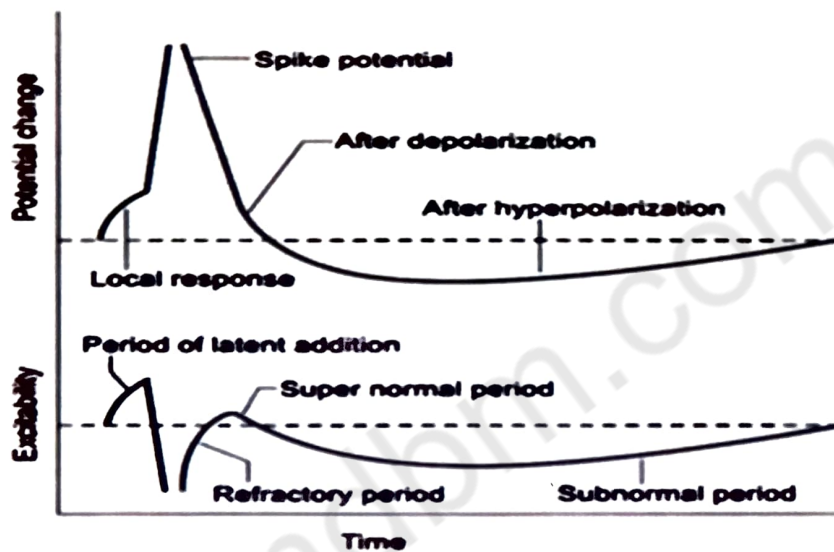


Fully myelinated fiber C:



➤ **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.

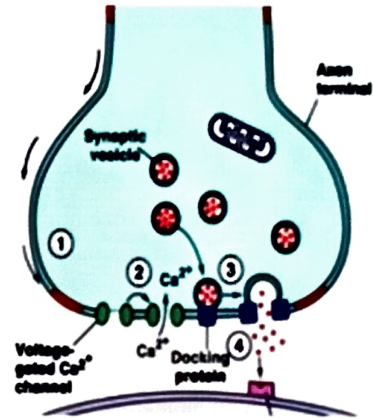
NERVE IMPULSE

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
- **Outside membrane** is slightly.
- 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.

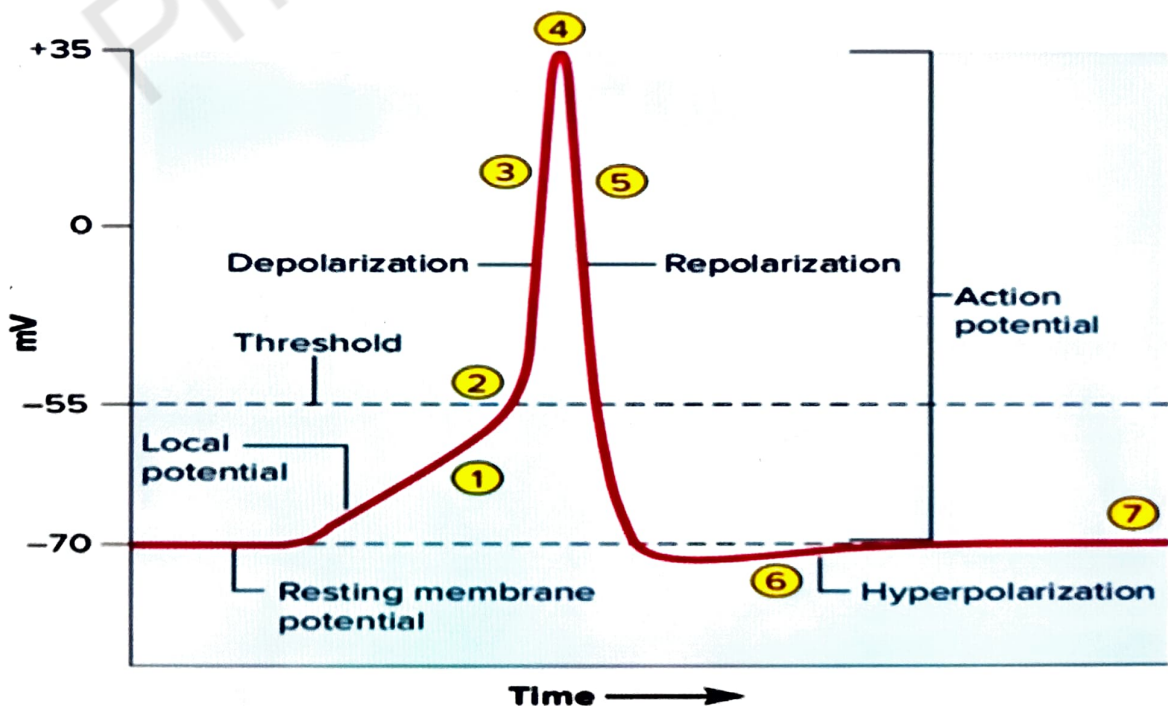


2. Depolarization - Active neuron

- 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

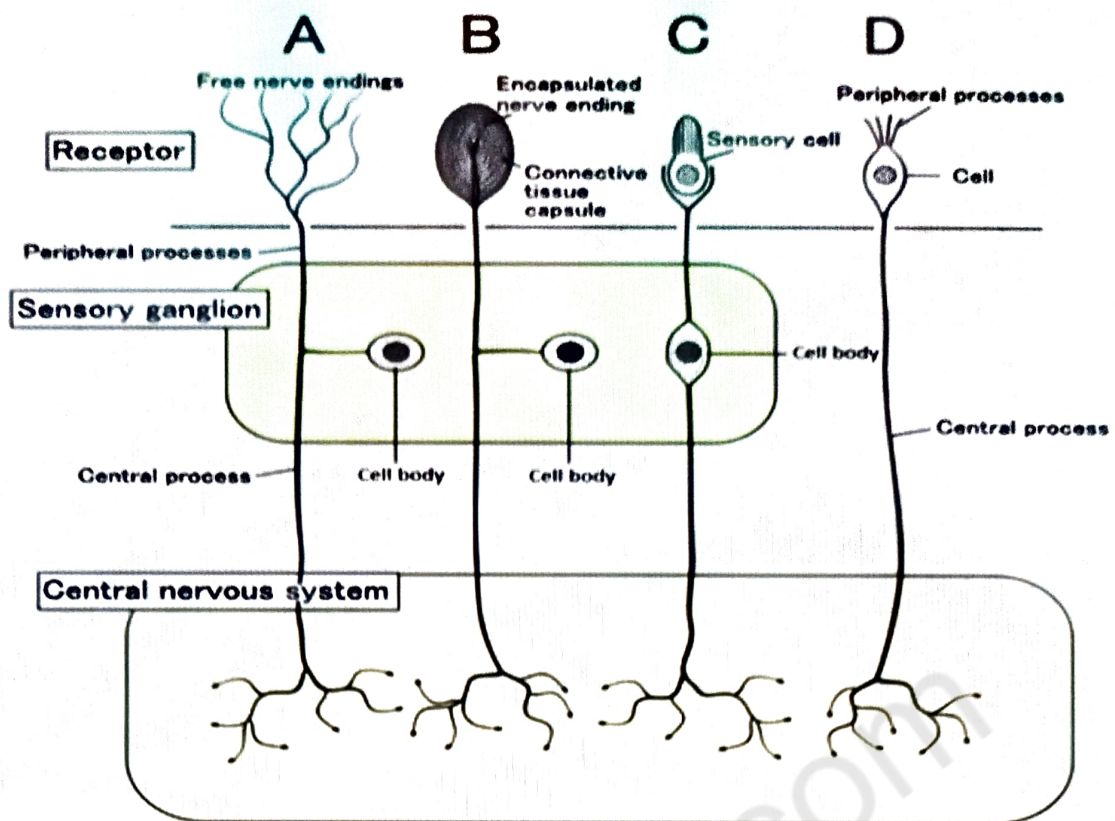
- Photoreceptors contain **proteins** that turn light energy into electrochemical signals, allowing cells in our nervous system to make sense of the **visual world**

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**.

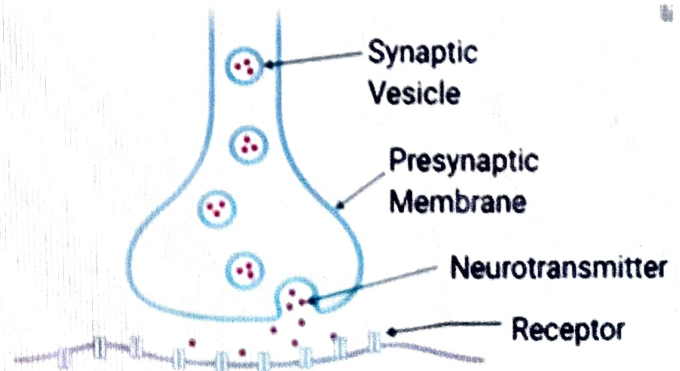
❖ TYPES OF SYNAPSE

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)

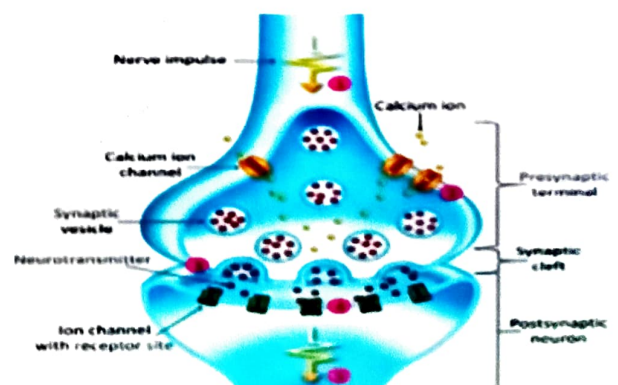
- ACh is used both in the **central** and **peripheral** nervous system, in particular at the NMJ. It is synthesised in neurons from **choline** and **acetyl-CoA**.
- ACh is an excitatory neurotransmitter and binds to two different receptor types
 - ✓ **Nicotinic** ACh receptors (nAChRs)
 - ✓ **Muscarinic**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

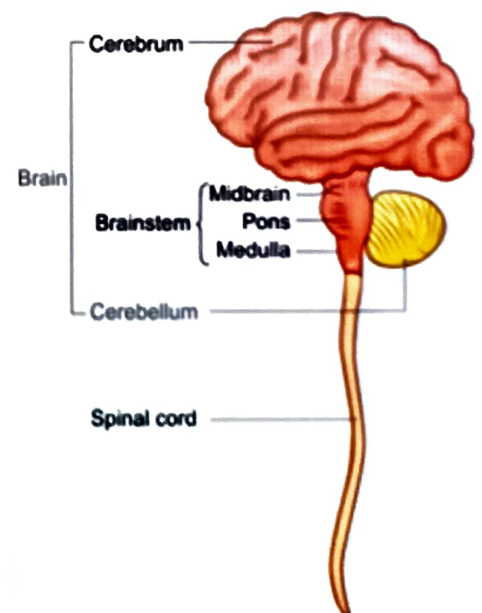
□ VARIOUS PART OF CENTRAL NERVOUS SYSTEM

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

1. Brain

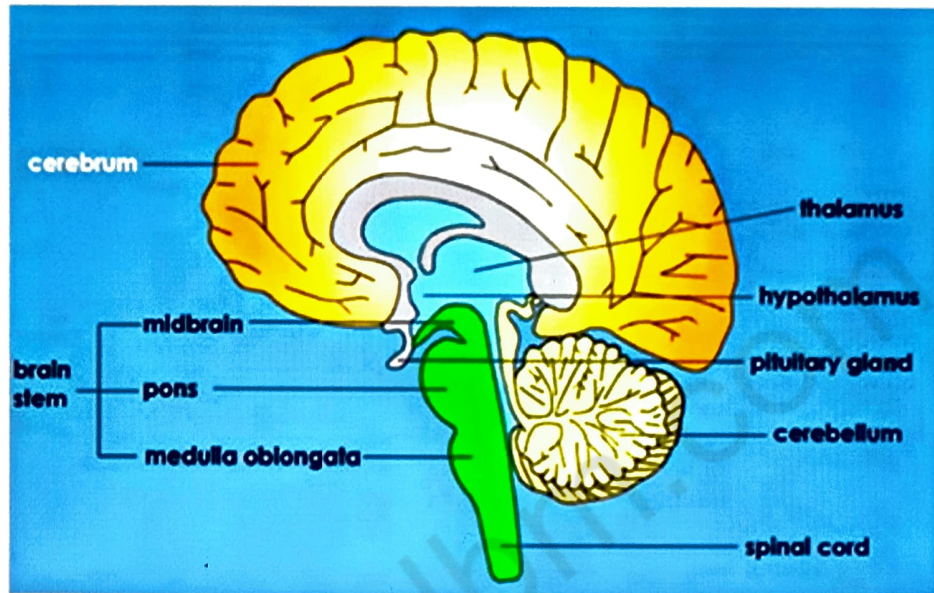
- Forebrain
- Midbrain
- Hindbrain

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**.

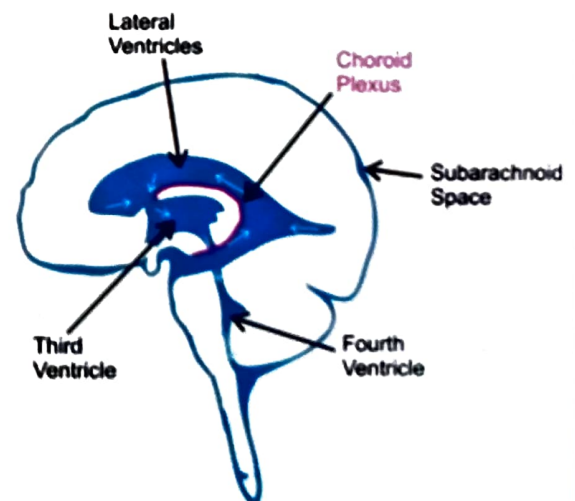


➤ VENTRICLES OF BRAIN

- 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

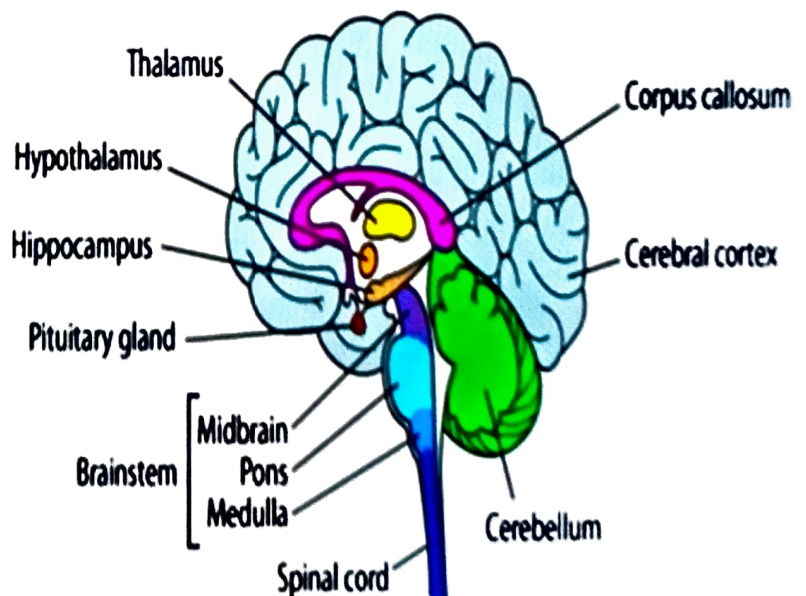
II. Cerebellum

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** & **perital 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**

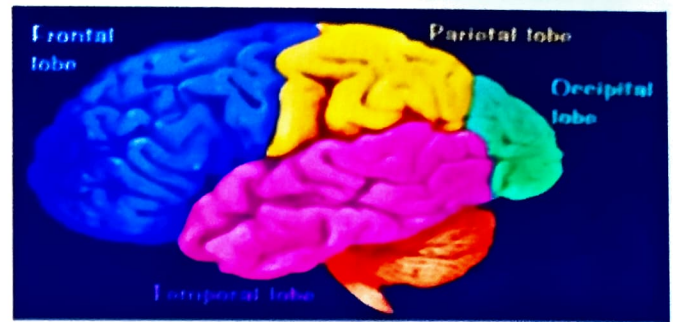
- The most **superior portion** of the cerebrum
- **Receives** and **interprets** nerve impulses from sensory receptors and interprets language.
- **Receives** sensory input from the skin.
- Also called as **sensory cortex**

✓ **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

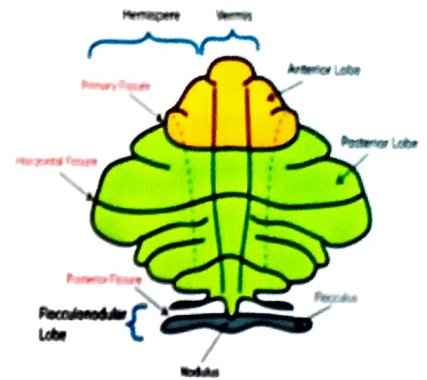
- **Second largest** portion of the brain
- Located beneath the **posterior part** of the **cerebrum**
- A deep groove known as **transverse fissure** separates cerebrum to cerebellum.
- Aids in **coordinating** voluntary body movements and **maintaining** balance and **equilibrium**.
- The external 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

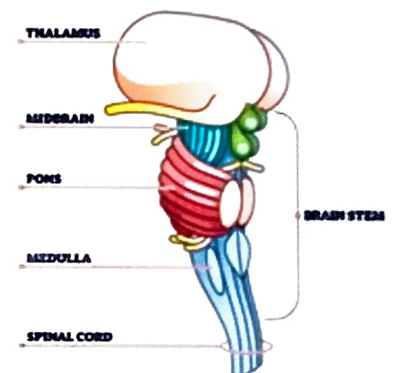
- Coordinate **contractions** of skeletal muscles
- May play a role in cognition/**learning** from **experiences** & **language processing**.
- One major function of the cerebellum is to **coordinate** the timing and force of these different muscle groups to **produce fluid** limb or **body movements**.
- **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.

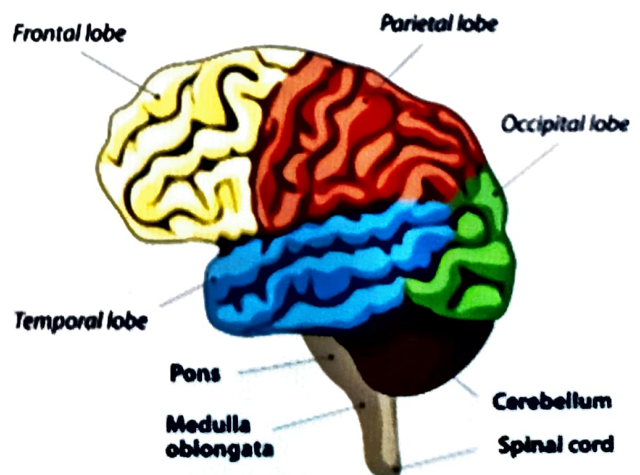
✓ Function of Pons

- **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**.

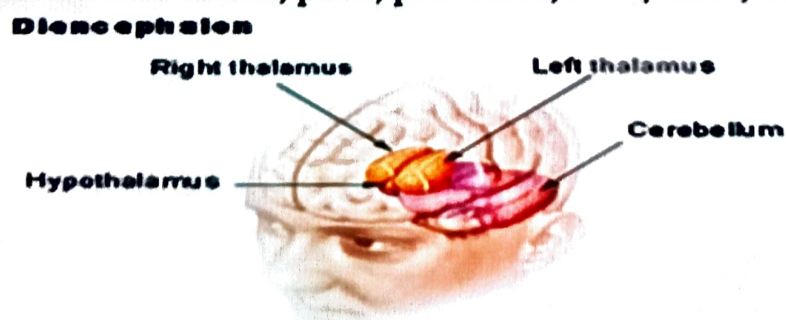
❖ **Thalamus**

- 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

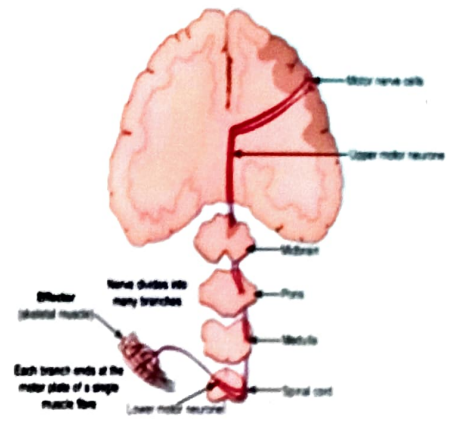
- Epithalamus is a **small region superior** & **posterior** to the thalamus.
- It consist of **pineal gland**
- Pineal gland is about the size of the **pea** & **protrudes** from posterior midline of the 3rd ventricle.
- It's a **endocrine gland** secrets hormone **Melatonin**.
- Darkness **stimulates**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

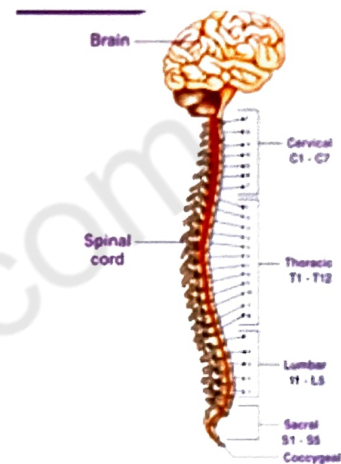
❖ Effector

- 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 1 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

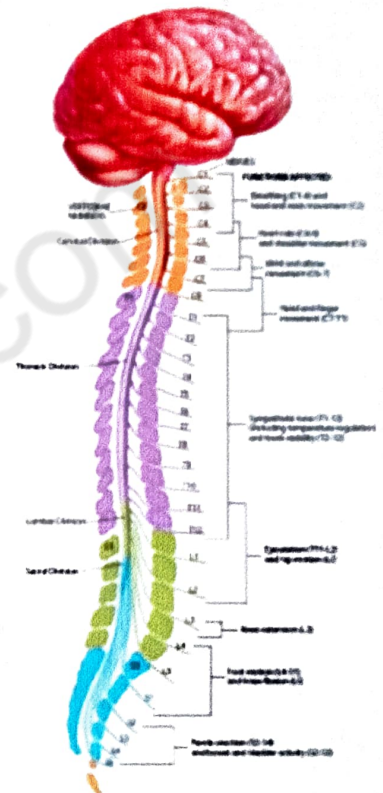
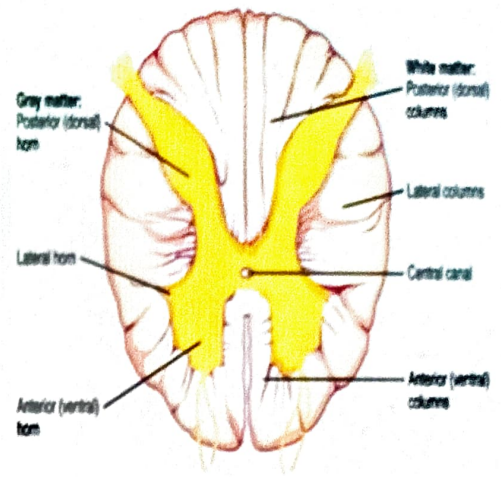
- ✓ Cervical nerves: 8 pairs

- ✓ 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** (Cervico 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 are 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 are includes the following five functional components

- **Sensory receptors**
- **Sensory neuron**
- **Integrating centre**
- **Motor neuron**
- **Effector**

