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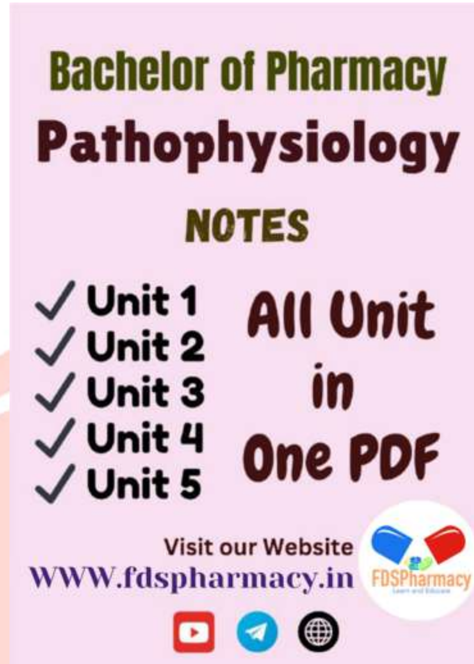
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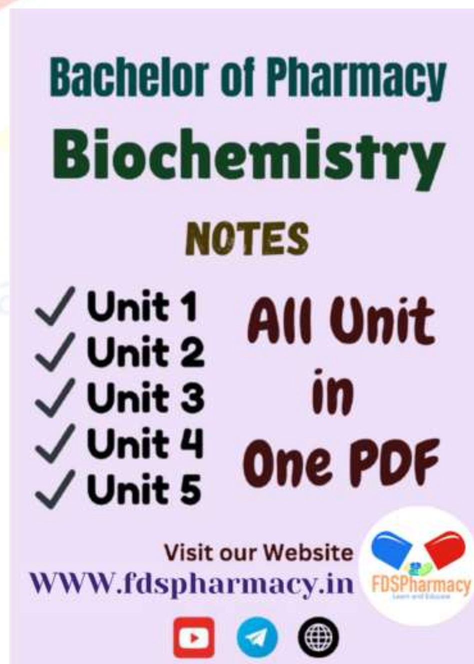
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HUMAN ANATOMY AND PHYSIOLOGY – II

UNIT 1

TOPIC :

- **Nervous system**

  Organization of nervous system, neuron, neuroglia, classification and properties of nerve fibre, electrophysiology, action potential, nerve impulse, receptors, synapse, neurotransmitters.

  Central nervous system: Meninges, ventricles of brain and cerebrospinal fluid. structure and functions of brain (cerebrum, brain stem, cerebellum), spinal cord (gross structure, functions of afferent and efferent nerve tracts, reflex activity)

NERVOUS SYSTEM

→ The nervous system is a complex network of neurons and supporting cells that coordinate all the functions of the body by transmitting signals between different parts of the body. It controls voluntary and involuntary actions and plays a major role in maintaining homeostasis.

Organization of Nervous System

The nervous system is organized into:

A. Central Nervous System (CNS):

- **Definition:** The CNS includes the brain and spinal cord. It is the control center for processing and interpreting sensory information and issuing commands.
- **Function:** Integration of data and control of bodily functions such as thought, movement, and emotion.

B. Peripheral Nervous System (PNS):

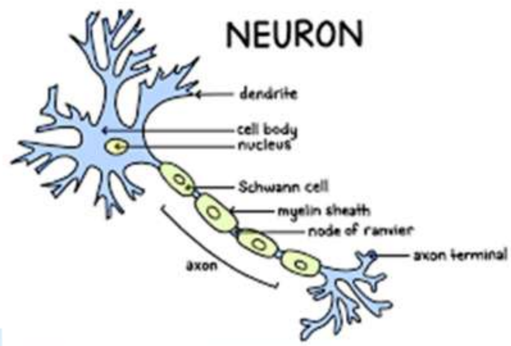
- **Definition:** The PNS consists of all nerves outside the brain and spinal cord. It connects the CNS to limbs and organs.
- **Function:** Relays messages between the CNS and the rest of the body.
- Subdivisions:
    - **Somatic Nervous System (SNS):** Controls voluntary muscle movements.
    - **Autonomic Nervous System (ANS):** Controls involuntary activities like heart rate, digestion, etc. It is further divided into:
        - **Sympathetic Nervous System (fight or flight)**
        - **Parasympathetic Nervous System (rest and digest)**

Neuron

→ A neuron is the structural and functional unit of the nervous system. It is a specialized cell that is capable of receiving, processing, and transmitting electrical and chemical signals throughout the body.

→ Each neuron is adapted to carry nerve impulses over long distances and consists of three major parts:

1. Cell body,
2. Dendrites,
3. Axon



Structure of a Neuron

1. Cell Body (Soma / Cyton)

- It is the main part of the neuron that contains the nucleus and other cell organelles (like mitochondria, Golgi apparatus, ribosomes).
- Contains Nissl bodies (or Nissl granules): dense accumulations of rough endoplasmic reticulum (RER) and ribosomes that are involved in protein synthesis.
- Responsible for metabolic activities and maintenance of the neuron.

2. Dendrites

- Short, branched extensions from the cell body.
- They receive signals (stimuli) from other neurons or sensory receptors and transmit them toward the cell body.
- Covered with receptor proteins that detect neurotransmitters from other neurons.

3. Axon

- A long, cylindrical projection that carries nerve impulses away from the cell body to other neurons, muscles, or glands.
- It begins from a cone-shaped region called the axon hillock.

- The axon terminals (end branches) form synapses with the target cells and release neurotransmitters.

Types of Neurons

1. **Sensory Neurons (Afferent):** Carry signals from receptors to CNS.
2. **Motor Neurons (Efferent):** Carry signals from CNS to muscles/glands.
3. **Interneurons:** Located in CNS, they connect neurons and process signals.

NEUROGLIA (GLIAL CELLS)

→ Neuroglia, also called glial cells, are the non-neuronal cells of the nervous system that provide support, protection, and nutrition to neurons. Unlike neurons, they do not transmit electrical impulses, but are essential for maintaining the internal environment of the nervous system.

Functions of Neuroglia

1. **Provide structural support** to neurons.
2. **Insulate axons** by forming myelin sheaths.
3. **Maintain homeostasis** in the nervous tissue.
4. **Remove debris and waste** products via phagocytosis.
5. **Form the blood-brain barrier (BBB)**.
6. **Assist in the repair and regeneration** of nervous tissue.
7. **Regulate the chemical environment** necessary for impulse transmission.

Types of Neuroglia

→ Neuroglia are classified into two main types depending on their location:

A. Neuroglia in the Central Nervous System (CNS)

1. Astrocytes
    - **Star-shaped** cells, most abundant glial cells in CNS.
    - **Functions:**
        - Maintain **blood-brain barrier**.
        - Regulate nutrient and ion balance.
        - Provide **structural support** to neurons.
        - Assist in tissue **repair and scar formation** after injury.
2. Oligodendrocytes
    - Small cells with few processes.

- **Function:** Form **myelin sheath** around axons in the **CNS**, which increases the speed of nerve impulse conduction.

3. Microglia
   - Small, mobile, **phagocytic cells** (act like macrophages).
   - **Function:** Act as the **immune defense** of the CNS by removing dead cells and pathogens.
4. Ependymal Cells
   - Line the **ventricles of the brain** and **central canal of the spinal cord**.
   - **Function:** Produce and help circulate **cerebrospinal fluid (CSF)**.
   - May have **cilia** to move CSF.

B. Neuroglia in the Peripheral Nervous System (PNS)

1. Schwann Cells (Neurolemmocytes)

   - Surround and myelinate axons in the PNS.
   - Each Schwann cell forms myelin for a single axon.
   - Help in regeneration of damaged PNS axons.

2. Satellite Cells

   - Surround neuron cell bodies in PNS ganglia.
   - Function: Regulate the exchange of materials between neurons and interstitial fluid; provide nutritional and structural support.

NERVE FIBRES

→ Nerve fibres are the long, slender extensions of neurons (mainly axons) that carry nerve impulses to and from the brain and spinal cord to different parts of the body. They can be myelinated or unmyelinated, depending on the presence of a myelin sheath.

Structure of a Nerve Fibre:

1. **Axon:** Central part that conducts nerve impulses.
2. **Myelin Sheath (in myelinated fibres):** Insulating layer made of lipid-rich substance (formed by Schwann cells in PNS and oligodendrocytes in CNS).
3. **Nodes of Ranvier:** Gaps in the myelin sheath; allow **saltatory conduction**.
4. **Neurilemma:** Outer membrane of Schwann cells (PNS).
5. **Endoneurium:** Connective tissue around individual nerve fibres.

Types of Nerve Fibres (Classification)

Based on Sensory Function (Lloyd and Hunt classification – for muscle afferents):

Type	Diameter	Myelination	Function
Type I (Ia, Ib)	Largest	Yes	Muscle spindle (stretch reflex), Golgi tendon organ
Type II	Large	Yes	Touch, pressure
Type III	Medium	Yes	Pain, temperature
Type IV	Small	No	Pain, temperature

Properties of Nerve Fibres

1. **Excitability:** Ability to respond to a stimulus.
2. **Conductivity:** Transmit electrical impulses along the length of the fibre.
3. **Refractory Period:**
   - **Absolute refractory period** – No second impulse is possible.
   - **Relative refractory period** – Second impulse possible with stronger stimulus.
4. **All-or-None Law:** If a stimulus reaches threshold, the fibre fires completely.
5. **Accommodation:** Nerve adapts to a slowly increasing stimulus and may not respond.
6. **Summation:** Addition of sub-threshold stimuli over time (temporal) or space (spatial) to generate action potential.
7. **Saltatory Conduction:** In **myelinated** fibres, impulse jumps from one Node of Ranvier to another — **faster and energy-efficient**.
8. **Continuous Conduction:** In **unmyelinated** fibres — **slower** and less efficient.

ELECTROPHYSIOLOGY

- Electrophysiology is the branch of physiology that deals with the electrical properties of biological cells and tissues, especially the generation and propagation of electrical signals (nerve impulses) in neurons and muscle cells.

It focuses on:

- Resting membrane potential (RMP)
- Action potential
- Ionic basis of electrical activity
- Electrical conduction in neurons

Action Potential

→ An action potential is a rapid and transient change in the membrane potential of a neuron or muscle cell, during which the inside of the cell becomes temporarily more positive than the outside. This occurs due to the movement of ions (mainly Na^+ and K^+) across the cell membrane through voltage-gated ion channels.

Resting Membrane Potential

- Before an action potential, a neuron is at resting membrane potential (about −70 mV).
- Inside of the cell is negatively charged compared to the outside.
- Maintained by:
  - Sodium-potassium pump (Na^+/K^+ ATPase) – pumps 3 Na^+ out and 2 K^+ in.
  - Selective permeability of the membrane to K^+.

Phases of Action Potential

1. **Depolarization:**
   - A stimulus causes the membrane to reach threshold potential (about −55 mV).
   - Voltage-gated Na^+ channels open.
   - Rapid influx of Na^+ → inside becomes positive.
   - Membrane potential rises up to +30 to +40 mV.
2. **Repolarization:**
   - Na^+ channels close.
   - Voltage-gated K^+ channels open.
   - K^+ efflux (moves out of the cell) restores negative potential inside.
3. **Hyperpolarization (Afterpotential):**
   - K^+ channels stay open too long.
   - Membrane becomes more negative than resting potential (e.g., –75 mV).

   - Eventually returns to resting level.
4. **Restoration:**
   - Na^+/K^+ pump restores original ion distribution.

Propagation of Action Potential

- In unmyelinated neurons: Continuous conduction (slower).
- In myelinated neurons: Saltatory conduction (faster) – AP jumps from one node of Ranvier to another.

Importance of Action Potential

- Transmits nerve impulses in neurons.
- Initiates muscle contraction in skeletal and cardiac muscles.
- Enables communication between neurons via synapses.
- Basis for reflex actions, sensory perception, and motor control.

NERVE IMPULSE

- A nerve impulse is a wave of electrical activity that travels along the length of a neuron. It is essentially the transmission of an action potential from one end of the neuron to the other, allowing for the communication of information within the nervous system.

Mechanism of Nerve Impulse Conduction

1. **Resting State:**
   - Neuron is polarized (inside negative, outside positive).
   - Resting membrane potential: −70 mV.
   - Maintained by the sodium-potassium pump and selective permeability to ions.
2. **Depolarization:**
   - Stimulus causes the opening of voltage-gated Na^+ channels.
   - Na^+ rushes into the neuron → inside becomes positive.
3. **Repolarization:**
   - Na^+ channels close, K^+ channels open.
   - K^+ flows out, restoring negative internal charge.
4. **Hyperpolarization:**
   - Too much K^+ exits → more negative than resting state.
   - Gradually returns to resting potential.
5. **Propagation:**
   - This wave of depolarization and repolarization travels along the axon.
   - The next segment of membrane depolarizes as the impulse moves forward.

Conduction Types

1. **Unmyelinated Fibers**:
   - **Continuous conduction**
   - Every part of axon undergoes depolarization → slower
2. **Myelinated Fibers**:
   - **Saltatory conduction**
   - Impulse jumps between Nodes of Ranvier → faster and energy efficient

Significance of Nerve Impulse

- Allows for rapid communication between different parts of the body.
- Essential for reflexes, movement, sensation, thought, and emotion.
- Basis of neural circuits and brain function.

RECEPTORS

→ Receptors are specialized sensory structures or proteins present in sensory organs or on the cell membranes, which detect stimuli (changes in the environment) and convert them into electrical signals (nerve impulses) that are transmitted to the central nervous system (CNS) for interpretation.

Types of Receptors Based on Location

1. **Exteroceptors**
   - Located on **the body surface**
   - **Detect external stimuli** (light, sound, touch, etc.)
2. **Interoceptors (Visceroceptors)**
   - Found in **internal organs**
   - Detect **internal body changes** (e.g., blood pressure, pH)
3. **Proprioceptors**
   - Located in **muscles, tendons, joints, inner ear**
   - Detect **body position, movement, and muscle tension**

Structure of Receptors

- Can be free nerve endings (e.g., pain receptors) or encapsulated nerve endings (e.g., touch receptors).
- Some are specialized cells (e.g., rods and cones in the eye).

Function of Receptors

✓ Detect changes in the external or internal environment.
✓ Convert stimulus into electrical signals (transduction).
✓ Send signals to sensory neurons, then to CNS.
✓ Help in maintaining homeostasis, protection, and survival.

SYNAPSE

→ A synapse is a specialized junction between two neurons or between a neuron and an effector cell (e.g., muscle or gland), where nerve impulses are transmitted from one cell to another.

→ It is the key site for communication in the nervous system, allowing electrical or chemical signals to pass between cells.

Structure of a Synapse

➢ A typical chemical synapse includes:

1. **Presynaptic Neuron**
    - The sending neuron
    - Contains synaptic vesicles filled with neurotransmitters
    - Has a presynaptic terminal (axon terminal)

2. **Synaptic Cleft**
    - The gap between the two neurons (about 20–40 nm wide)
    - Neurotransmitters are released into this gap

3. **Postsynaptic Neuron**
    - The receiving neuron or effector cell
    - Contains receptors that bind neurotransmitters

Steps in Synaptic Transmission

1. **Action Potential Arrival**
   - Impulse arrives at presynaptic terminal.
2. **Calcium Influx**
   - Voltage-gated Ca^{2+} channels open, and Ca^{2+} enters the presynaptic neuron.
3. **Neurotransmitter Release**
   - Increased Ca^{2+} causes synaptic vesicles to fuse with membrane.
   - Neurotransmitters are released into the synaptic cleft via exocytosis.
4. **Neurotransmitter Binding**
   - Neurotransmitters bind to receptors on the postsynaptic membrane.
5. **Generation of Postsynaptic Potential**
   - Depolarization or hyperpolarization occurs in the postsynaptic cell depending on the neurotransmitter type.
6. **Neurotransmitter Removal**
   - Quickly removed by:
     - **Enzymatic degradation** (e.g., acetylcholinesterase)
     - **Reuptake** into the presynaptic neuron
     - **Diffusion** away from the synapse

Importance of Synapse

- ✓ Enables one-way transmission of nerve impulses.
- ✓ Amplifies or inhibits signals.
- ✓ Allows integration and processing of information.
- ✓ Essential for reflexes, learning, memory, and coordination.

NEUROTRANSMITTERS

- Neurotransmitters are chemical messengers that transmit signals from one neuron to another across a synapse. They are released from the presynaptic terminal of a neuron and bind to specific receptors on the postsynaptic neuron, muscle, or gland cell to elicit a physiological response.

Characteristics of Neurotransmitters

1. **Synthesized** and stored in neurons.
2. **Released** in response to an **action potential**.
3. Act on specific **receptors** on the postsynaptic membrane.
4. Produce a **specific response** (excitatory or inhibitory).
5. Have a **mechanism of removal** (degradation, reuptake, or diffusion).

Classification of Neurotransmitters

Based on Function

Type	Action
Excitatory	Stimulate the postsynaptic neuron (e.g., Glutamate, Acetylcholine)
Inhibitory	Inhibit the postsynaptic neuron (e.g., GABA, Glycine)
Modulatory	Modulate overall activity (e.g., Dopamine, Serotonin, Norepinephrine)

CENTRAL NERVOUS SYSTEM

→ Central Nervous System (CNS) consists of the brain (in the cranial cavity) and the spinal cord (in the vertebral column).

→ It is safely contained within the skull and vertebral canal of the spine.

→ The neural tube inside the embryo develops into a nervous system.

→ The neural tube has three expansions at its head end, which arise because of unequal growth rates.

→ These expansions take the form of forebrain, midbrain, and hindbrain:

1. Fore brain: i) Cerebral hemispheres ii) Basal ganglia iii) Thalamus iv) Hypothalamus
2. Midbrain: i) Tectum ii) Cerebral peduncles iii) Tegmentum
3. Hindbrain : i) Cerebellum ii) Pons iii) Medulla

MENINGES

- The meninges are three protective connective tissue membranes that surround the brain and spinal cord, forming a supportive and cushioning system for the central nervous system (CNS). They help protect the CNS from mechanical injury and also play a role in circulating cerebrospinal fluid (CSF).

Layers of Meninges (from outermost to innermost)

1. Dura Mater

- **Outermost**, **toughest**, and **thickest** meningeal layer.
- Composed of **dense fibrous connective tissue**.
- In the brain, it has **two layers**:
  - **Periosteal layer** (attached to skull)
  - **Meningeal layer** (lies closer to the brain)

- Forms **dural folds** (e.g., falx cerebri, tentorium cerebelli) and **dural venous sinuses** (collect venous blood).

2. Arachnoid Mater

- **Middle**, thin, and **web-like** membrane.
- Lies **beneath the dura mater**.
- **Subarachnoid space** (between arachnoid and pia) contains:
  - **Cerebrospinal fluid (CSF)**
  - **Blood vessels**
- Has **arachnoid villi/granulations** that absorb CSF into venous blood.

3. Pia Mater

- **Innermost**, **delicate** layer that **closely adheres** to the brain and spinal cord surfaces.
- Highly **vascular** – carries **capillaries** that nourish brain tissue.
- Follows the contours of the brain including sulci and gyri.

Functions of the Meninges

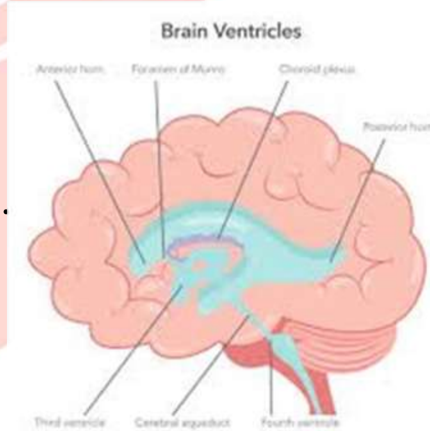
✓ Protect the CNS from mechanical shocks and trauma.
✓ Support and anchor the brain and spinal cord in place.
✓ Enclose cerebrospinal fluid (CSF), providing buoyancy and cushioning.
✓ Facilitate circulation of CSF through the subarachnoid space.
✓ Contain blood vessels that nourish the brain and spinal cord.

VENTRICLES OF THE BRAIN

→ The ventricles of the brain are a system of four interconnected, fluid-filled cavities within the brain. They are filled with cerebrospinal fluid (CSF) and are lined by ependymal cells (a type of neuroglia). These ventricles are important for the production, circulation, and drainage of CSF, which cushions and protects the brain and spinal cord.

The Four Brain Ventricles

1. Lateral Ventricles (First and Second)



- **Paired (one in each cerebral hemisphere)**.
- Located within the **cerebrum**.
- Consist of four parts:
    - **Anterior (frontal) horn**
    - **Body**
    - **Posterior (occipital) horn**
    - **Inferior (temporal) horn**
- Connected to the **third ventricle** via the **interventricular foramen (foramen of Monro)**.
- Produce and contain CSF.

2. Third Ventricle

- A **narrow, slit-like cavity** located in the **midline of the diencephalon**, between the **two halves of the thalamus**.
- Communicates with:
    - **Lateral ventricles** via the **foramina of Monro**
    - **Fourth ventricle** via the **cerebral aqueduct (aqueduct of Sylvius)**

3. Fourth Ventricle

- Located **between the brainstem (pons and medulla) and the cerebellum**.
- CSF exits the fourth ventricle to enter:
  - **Central canal** of the spinal cord
  - **Subarachnoid space** through:
    - **Median aperture (foramen of Magendie)**
    - **Two lateral apertures (foramina of Luschka)**

Functions of Brain Ventricles

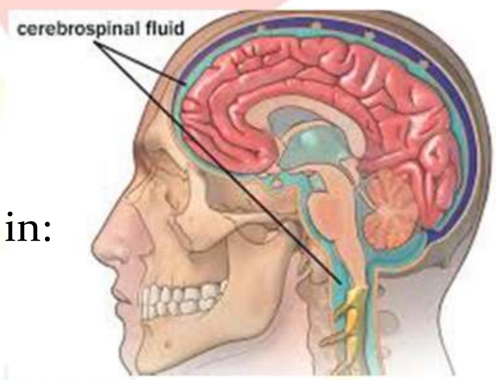
- ✓ Produce and circulate cerebrospinal fluid (CSF)
- ✓ Protect brain by cushioning from trauma
- ✓ Help maintain intracranial pressure
- ✓ Provide nutrients and remove wastes
- ✓ Maintain homeostasis in the brain environment

CEREBROSPINAL FLUID (CSF)

→ Cerebrospinal fluid (CSF) is a clear, colorless, and watery fluid that surrounds the brain and spinal cord. It is produced by specialized structures called the choroid plexus found in the brain ventricles. CSF serves multiple protective and physiological roles within the central nervous system (CNS).

Location of CSF

- **Brain Ventricles**: Lateral, third, and fourth ventricles
- **Subarachnoid Space**: Between the **arachnoid mater and pia mater** around the brain and spinal cord
- **Central Canal of Spinal Cord**



Production of CSF

- Produced mainly by the **choroid plexus** in:
  - Lateral ventricles
  - Third ventricle
  - Fourth ventricle
- Approximately **500 mL of CSF** is produced per day.
- At any given time, around **120–150 mL** of CSF is circulating in the system.

Circulation of CSF

1. Formed in the lateral ventricles
2. Passes through the interventricular foramina (of Monro) to the third ventricle
3. Flows through the cerebral aqueduct (of Sylvius) to the fourth ventricle
4. From the fourth ventricle, it enters the subarachnoid space via:
   - Median aperture (foramen of Magendie)
   - Lateral apertures (foramina of Luschka)
5. Circulates around the brain and spinal cord

6. Absorbed into venous blood through arachnoid villi and dural venous sinuses (especially the superior sagittal sinus)

Functions of CSF

- ✓ Protection: Acts as a cushion or shock absorber, protecting the brain and spinal cord from trauma.
- ✓ Buoyancy: Reduces the effective weight of the brain, preventing pressure on the base of the skull.
- ✓ Homeostasis: Maintains a stable chemical environment for CNS function.
- ✓ Circulation: Helps in the exchange of nutrients and waste between blood and nervous tissue.
- ✓ Cleansing: Removes metabolic waste products, drugs, and other substances from the CNS.

Brain and its Parts

→ Brain is a very complex organ, forming the centre of the nervous system.

→ It is enclosed in a bony structure termed as cranium.

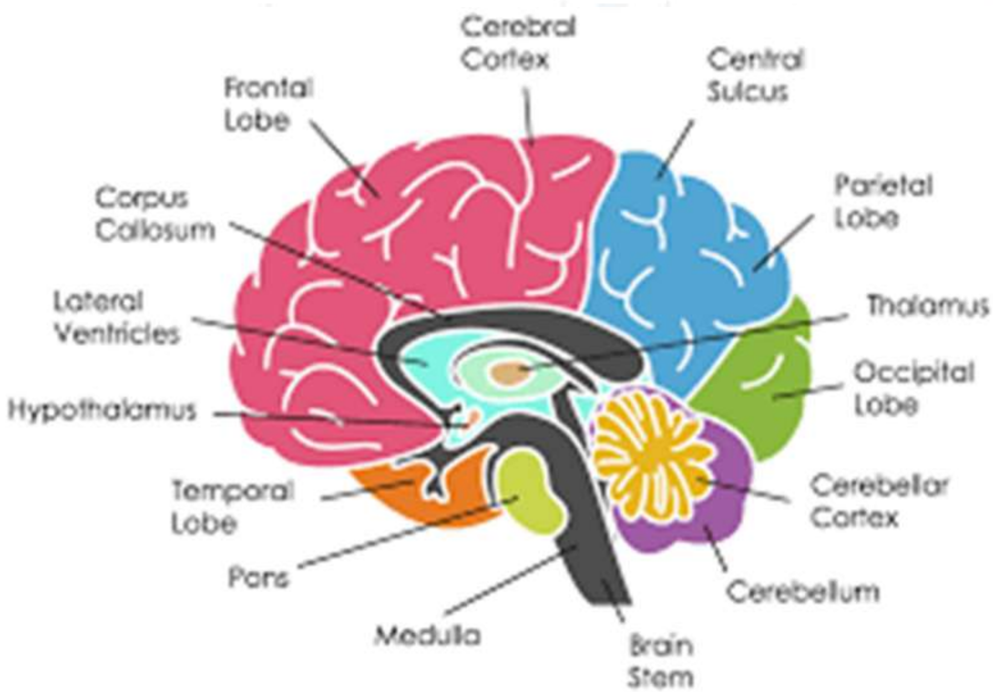
→ The general structure of _human brain resembles that of other mammals, except in size.

→ The human brain is three times larger in size than the brain of a typical mammal with a comparable body size.

→ Cerebral cortex (the major portion of the brain) consists of neural tissue arranged in a convoluted layer, which covers the surface of the forebrain. The frontal lobes of the brain are specifically, expanded and are responsible for carrying out functions like self-control, planning, reasoning, and abstract thought.

→ The average weight of brain in an adult man is about 1600gm (3.5 pounds), while in adult female it is 1450gm.

→ However, in terms of size, the brain of a male and female are equal.



Parts of Brain

Brain is enclosed in the cranial cavity It makes up around 1/50th the weight of the body.

The adult brain is composed of the following 4 maior parts

1) Cerebrum

2) Brain stem

i) Medulla oblongata ii) Pons iii) Midbrain

3) Cerebellum

4) Diencephalon

1) Cerebrum

- The brain stem joins the spinal cord and is made up of medulla oblongata, pons, and midbrain.
- Cerebellum is located posterior to the brain stem; diencephalon comprising of thalamus, hypothalamus, and epithalamus; and is located superior to the brain stem; and cerebrum (the largest part of the brain) lies on the diencephalon and brain stem.

Lobes of Cerebrum

Each of the two cerebral hemispheres is divided into lobes which are named after the cranial bones comprising them:

1) Frontal lobe,
2) Parietal lobe,
3) Temporal lobe, and
4) Occipital lobe

Deep sulcus (fissures) mark the boundaries of the cerebral lobes and are divided into central, lateral, and parieto occipital sulci.

Functions of Cerebrum

Each hemisphere of the cerebrum performs the following functions:

a. It is responsible for controlling all the voluntaryactivities.
b. It receives and processes information pertaining to sensory stimuli.

c. It is associated with higher brain functions like will, memory, intelligence, reasoning, and learning.
d. Three different types of activities related to cerebral cortex are:
   i. Mental activities related to memory, intelligence, thinking, and reasoning, sense of responsibility, moral sense, and learning.
   ii. Sensory perception related to perception of sensory stimuli including pain, temperature, touch, sight, hearing, taste, and smell.
   iii. Initiation and control over contraction of voluntary muscles.

Medulla Oblongata

- Medulla oblongata (2.5cm long) is the lower half of the brain stem, which continues with the spinal cord.
- The upper part of the brain stem is continuous with the pons.
- Medulla oblongata is situated within the cranium, just above the foramen magnum.
- Central fissures mark the anterior and posterior surfaces of the medulla oblongata.
- The outer part is made up of white matter and the inner part is made up of grey matter.
- The white matter passes between the brain and the spinal cord.

Medulla oblongata performs the following function

1) The rate and force of cardiac contraction is controlled by the cardiovascular centre with in medulla.
2) The rate and depth of respiration is controlled by the respiratory centre. Contraction of the diaphragm and intercostal muscles is stimulated by nerve impulses traversing from the respiratory centre to the phrenic and intercostal nerves. As a result, inspiration is initiated.

Pons

- Pons is a part of brain stem located above the medulla and below the midbrain.
- The cerebellum lies posterior to the pons.
- It primarily comprises of nerve fibres forming a bridge between the two cerebral hemispheres.
- It also consists of fibres traversing between the higher levels of brain and spinal cord.
- Groups of cells form relay stations within the pons, some of which are even associated with cranial nerves.

Pons performs the following functions:

1) Accessory breathing centres are present within the pons:

i) Inspiratory centre is provided by the apneustic centre, and

ii) Inspiratory centre is inhibited by the pneumotaxic centre.

2) Pons forms a centre for motor relay:

I) Synapsis of descending motor nerves frequently occurs within the pons, and

ii) Any injury to the pons results in insufficiency in activities controlled by the motor areas (e.g., paralysis

Midbrain

- The midbrain (or mesencephalon) comprises of tracts and nuclei.
- It divided into the tectum (dorsal part) and the peduncle (ventral part). It gives way to the cerebral aqueduct.

Function of Midbrain

- Significant functions like eye movement and other functions of the Visual and auditory systems are controlled by the midbrain.
- Body movements are controlled by the red nucleus and the substantia nigra (parts of the midbrain).

- Since neurons producing dopamine are located in the substantia nigra, degeneration of these neurons results in Parkinson's disease

Cerebellum

- Cerebellum appears as a distinct structure, forming the lower part of the brain beneath the cerebral hemispheres.
- The cerebellum is separated from the cerebrum by the transverse fissure, a deep groove located along the tentorium cerebelli.

Functions

a. Body posture and equilibrium is maintained by the cerebellum. The muscles, joints, eyes, and the ears bring in the sensory input for these functions.
b. In order to maintain the balance and equilibrium of the body, the cerebellum acts to influence impulses leading to the skeletal muscle contraction. It is responsible for controlling and coordinating the movements of several groups of muscles, resulting in smooth, even, and clear-cut action.
c. The coordination of voluntary muscular movement is carried out by the cerebellum. Activities of the cerebellum cannot be controlled voluntarily.

Spinal Cord

- Spinal cord is the elongated part of the CNS extending from the lower end.
- It is cylindrical in shape and includes the upper two-thirds of the vertebral canal.
- It ranges from the level of the upper border of the atlas to either the upper border or the lower border of vertebra.
- Spinal cord forms the pathway for sensory input to the brain and motor output from the brain.
- A total of 31 pairs of spinal nerves arise from the spinal cord.

- Spinal cord and spinal nerves help in the maintenance of homeostasis by providing quick, reflexive responses to many stimuli.
- The spinal cord and spinal nerves contain neural circuits responsible for rapid reactions towards environmental stimuli.
- For example, holding hot object will immediately relax the grasping muscles and the object falls prior to getting consciously aware of the extreme heat.

Functions

- The spinal cord has the following functions:
- 1) Sensory and motor tracts are contained within the white matter of the spinal cord.
- 2) The sensory tracts conduct nerve impulses towards the brain and the motor tracts conduct motor nerve impulses from the brain to the effector organs.
- 3) The grey matter of the spinal cord forms the spot for integration (summing) of Excitatory and Inhibitory Postsynaptic Potentials (EPSPS and IPSPS respectively).
- 4) CNS is connected to the sensory receptors, muscles, and glands all over the body via the spinal nerves and their branches.
- 5) All reflex activities are mediated through spinal cord.

GROSS STRUCTURE OF THE SPINAL CORD

Location and Extent

- **Begins**: At the **foramen magnum** (base of skull), continuous with the **medulla oblongata**.
- **Ends**: Around the **L1–L2 vertebral level** in adults.

- Below L2, it tapers into a structure called the **conus medullaris**, followed by the **cauda equina** (nerve roots) and the **filum terminale** (fibrous extension).

Length: ~45 cm in males, ~43 cm in females

Diameter: ~1 cm, with two enlargements:

- **Cervical Enlargement** (C4–T1): Supplies **upper limbs**
- **Lumbar Enlargement** (T11–L1): Supplies **lower limbs**

External Features

- **Cylindrical and segmented**
- 31 segments with **31 pairs of spinal nerves**:
  - 8 cervical
  - 12 thoracic
  - 5 lumbar
  - 5 sacral
  - 1 coccygeal

Internal Features

Gray Matter (Inner Butterfly-Shaped):

- **Dorsal (posterior) horns**: Contain **sensory neurons**
- **Ventral (anterior) horns**: Contain **motor neurons**
- **Lateral horns**: Present in thoracic/lumbar regions (autonomic neurons)
- Contains **interneurons** and **neuron cell bodies**

White Matter (Outer Region):

- Organized into **funiculi (columns)**:
  - **Dorsal column** – sensory (ascending)
  - **Lateral column** – sensory and motor

- ◦ **Ventral column** – motor (descending)
- Composed of **myelinated nerve fibers** forming tracts

FUNCTIONS OF AFFERENT AND EFFERENT NERVE TRACTS

A. Afferent (Sensory) Tracts – Ascending Pathways:

→ **Carry sensory information from body to brain**
→ **Located mainly in dorsal and lateral columns**

Tract	Function
Dorsal Column Tract (Fasciculus gracilis and cuneatus)	Fine touch, proprioception, vibration
Spinothalamic Tract	Pain, temperature, crude touch
Spinocerebellar Tract	Unconscious proprioception to cerebellum

B. Efferent (Motor) Tracts – Descending Pathways:

→ **Carry motor commands** from brain to muscles/glands
→ Located mainly in **lateral and ventral columns**

Examples

Tract	Function
Corticospinal Tract (Pyramidal)	Voluntary motor control (fine movements)
Reticulospinal Tract	Autonomic and reflex activity
Vestibulospinal Tract	Balance and posture control
Tectospinal Tract	Head and eye movements in response to stimuli

REFLEX ACTIVITY OF SPINAL CORD

- A reflex is a quick, automatic, and involuntary response to a specific stimulus, processed by the spinal cord or brainstem.

Components of a Reflex Arc

1. **Receptor** – Detects stimulus (e.g., skin receptor)
2. **Sensory neuron** – Transmits impulse to CNS
3. **Integration center** – In spinal cord (interneuron)
4. **Motor neuron** – Carries response signal
5. **Effector** – Muscle or gland that performs action

Types of Reflexes

Type	Description	Example
Monosynaptic	One synapse between sensory and motor neuron	Knee-jerk (patellar) reflex
Polysynaptic	Involves interneurons; more complex	Withdrawal reflex
Somatic Reflexes	Involve skeletal muscles	Flexor reflex
Autonomic Reflexes	Involve glands or smooth muscles	Pupillary reflex, salivation

Functions of Spinal Reflexes

- ✓ Protective (withdrawal from pain)
- ✓ Postural (maintain balance)
- ✓ Diagnostic (reflex tests used in neurology)
- ✓ Automatic control of body systems (e.g., urination, defecation)