Neural Control and Coordination

DISCLAIMER

The content provided herein are created and owned by various authors and licensed to Sorting Hat Technologies Private Limited ("Company"). The Company disclaims all rights and liabilities in relation to the content. The author of the content shall be solely responsible towards, without limitation, any claims, liabilities, damages or suits which may arise with respect to the same.

Neural Control and Coordination

INTRODUCTION

- In human beings, the **neural system** and the **endocrine system** jointly coordinate, and integrate all the activities performed by different organs so that they function in a synchronised manner.
- The neural system brings about this coordination and integration through an organised network of point-to-point connections between the **neurons**, whereas the endocrine system uses chemical messengers called **hormones** for coordinating the functions of different organs.
- Kingdom Animalia has experienced a progressive development of the neural system.
- In general, the neural system of all animals comprises of nerve cells called neurons which are highly specialized to detect, receive, and transmit various external or internal stimuli.

Definitions

Coordination: Coordination is the process by which different organs of an organism's body interact and complement each other's functions.

Integration: The process involving cooperation between two or more organs in such a way that they form a harmonious functioning unit.

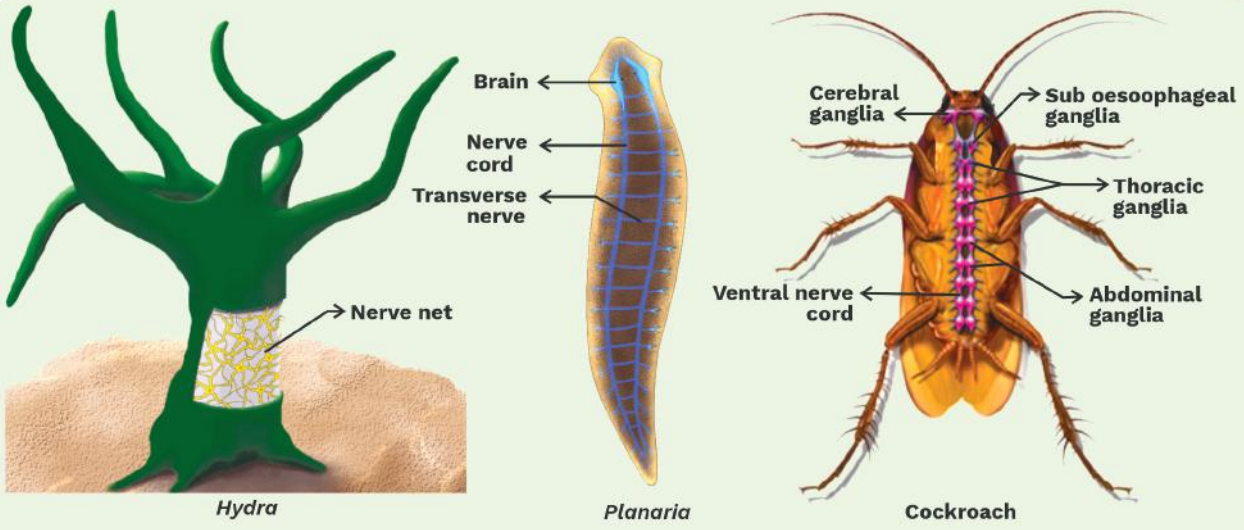


FIGURE: EVOLUTION OF NEURAL SYSTEM IN INVERTEBRATES

- A primitive neural system developed first time in **coelenterates**, e.g., ***Hydra*** has a network of nerve cells and their processes.
- In **Platyhelminthes**, the diffused neural system of coelenterates and ctenophores evolved into a **ladder-like** neural system, consisting of a central

Gray Matter Alert!!!

A sense organ for balance called statocyst developed first time in coelenterates, e.g., medusa of *Obelia*.

neural system having a **brain** (neural ganglia) and **two main longitudinal nerve cords** connected by transverse nerves and a peripheral neural system having a network of **peripheral nerves** extending throughout the body.

- This shows that **cephalization** occurred first time in platyhelminthes.
- **Insects** have a better organised neural system, where a brain or nerve ring and a solid, double, mid-ventral nerve cord are present along with **ganglia** and neural tissues.
- A more developed neural system is present in the **vertebrates**.

Definition

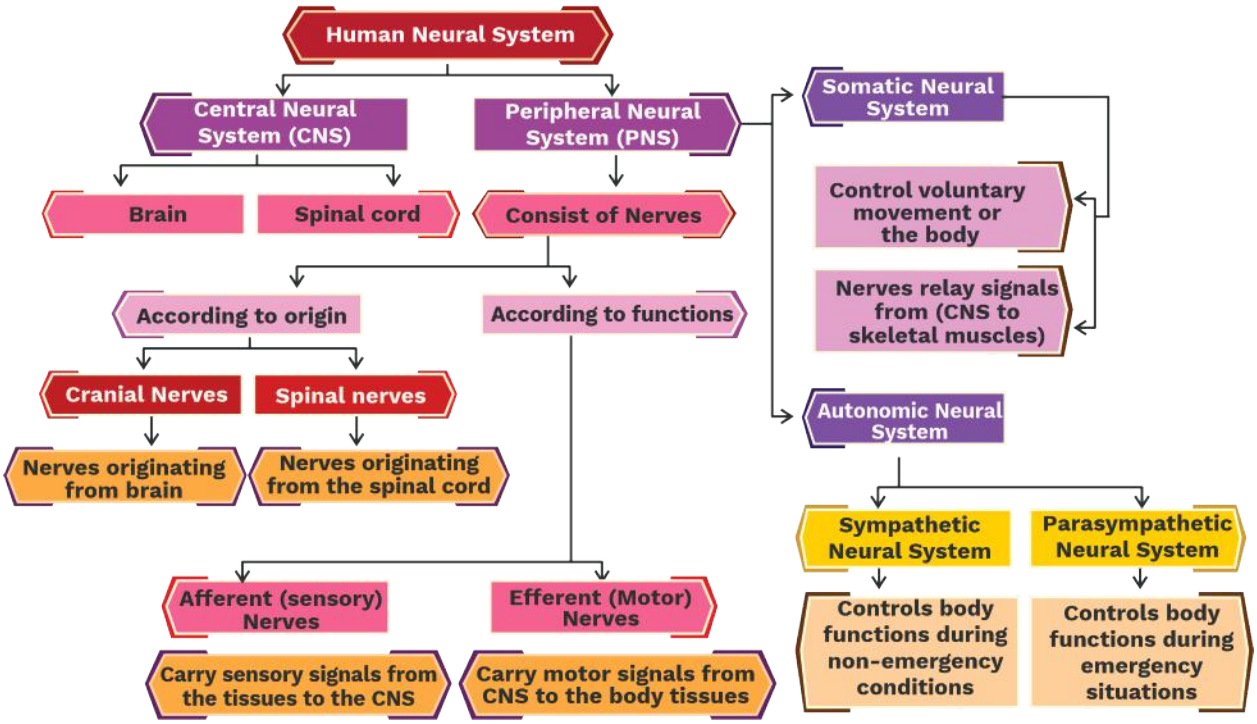
Ganglia: Aggregations of neuronal cell bodies present in the peripheral neural system.

Gray Matter Alert!!!

Cephalization is the formation of a brain and head by the concentration of nerve ganglia, sense organs and mouth at the anterior end of the body, slowly over many generations during the coarse of evolution.

HUMAN NEURAL SYSTEM

- The human neural system consists of two parts, central neural system (CNS) and peripheral neural system (PNS).
- The **Central Neural System (CNS)** runs longitudinally along the mid-dorsal axis of the body.



- It consists of the **brain** (enclosed within the skull) and the **spinal cord** (protected by the vertebral column).
- **Peripheral Neural System (PNS)** consists of all the nerves that arise from the central neural system and spread laterally in the body.
- According to the origin, there are two types of nerves, **cranial nerves** (originating from the brain) and **spinal nerves** (originating from the spinal cord).
- According to the functions performed, the nerve fibres of the PNS are of two types, namely, afferent nerve fibres and efferent nerve fibres.
- The **afferent** (sensory) nerves fibres carry sensory signals from the tissues to the CNS and thus form the afferent or sensory pathways.
- The **efferent** (motor) nerve fibres carry regulatory or motor signals from the CNS to the body tissues or organs, thus, forming the efferent or motor pathways.
- The peripheral neural system is divided into two divisions based on the different tissues to which it transmits impulses, namely, **somatic neural system** and **autonomic neural system**.
- The somatic neural system consists of nerves which relay impulses from the CNS to skeletal muscles, thereby, controlling the voluntary movements of the body.
- The autonomic neural system consists of nerves which relay impulses from the CNS to the visceral organs and smooth muscles, thereby, controlling and coordinating their involuntary functions.
- The autonomic neural system is further divided into **sympathetic neural system** and **parasympathetic neural system**.
- The functions of sympathetic and parasympathetic neural systems are **antagonistic** to each other.

Gray Matter Alert!!!

Visceral Neural System: It is a part of the PNS which consists of the whole complex of nerve fibres, ganglia and plexus which help in the transmission of impulses between the CNS and the viscera (soft, internal organs of the body).

Previous Year's Question

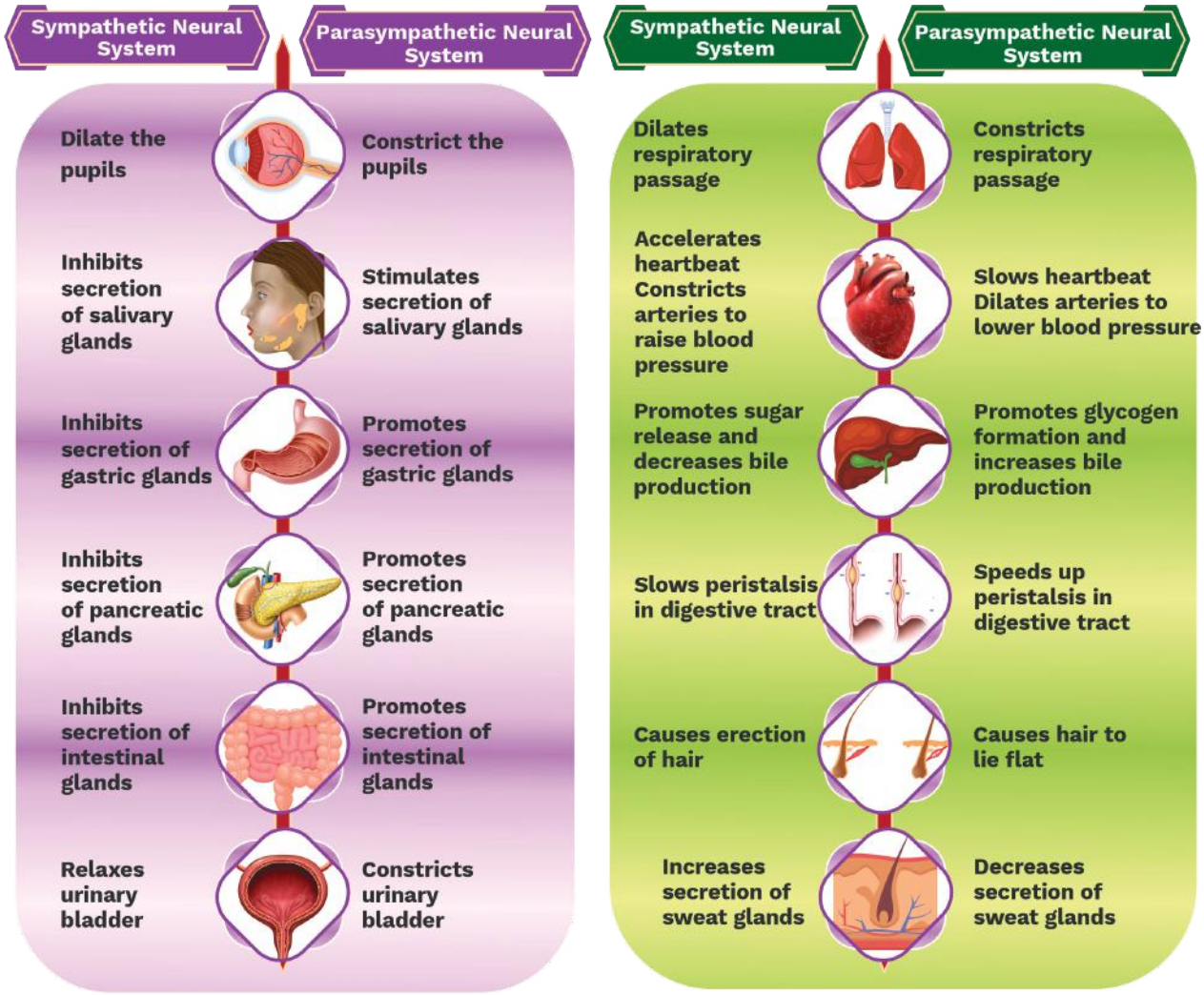
A person entering an empty room suddenly finds a snake right in front on opening the door. Which one of the following is likely to happen in his neuro-hormonal control system?

(1) Neurotransmitters diffuse rapidly across the cleft and transmit a nerve impulse

(2) Hypothalamus activates the parasympathetic division of brain

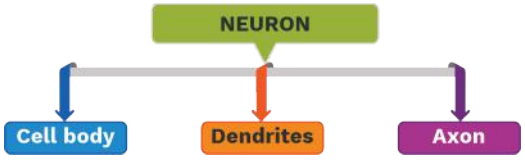
(3) Sympathetic nervous system is activated releasing epinephrine and norepinephrine from adrenal cortex

(4) Sympathetic nervous system is activated releasing epinephrin and norepinephrine from adrenal medulla



NEURON AS STRUCTURAL AND FUNCTIONAL UNIT OF NEURAL SYSTEM

- A **nerve cell** or **neuron** is the structural and functional unit of the human neural system.
- It originates from the embryonic **ectoderm**. New neurons do not develop after birth.
- Neurons are **elongated** cells which are specialized to receive stimuli and transmit information.
- Human neural system consists of about **100 billion** neurons. On an average, the human **brain** alone has approximately **86 billion** neurons.
- Neurons are also considered as the longest cells in the human body.



- Nerve cells do not undergo cell division, i.e., once formed, they **do not divide** to increase their number as they do not contain centrioles.
- A neuron is composed of three major parts, namely, **cell body**, **dendrites**, and **axon**. Dendrites and axon are together called **processes** of neurons.

Structure of a Neuron

- **Cell Body**
  - Cell body is also called **cyton**.
  - It occurs in a variety of shapes. It may be spherical, oval, pyramidal, or irregular.
  - Cell body consists of typical cell organelles of a eukaryotic cell. Nucleus with a prominent nucleolus, mitochondria, golgi complex, ribosomes, rough endoplasmic reticulum, lysosomes float in the cytoplasm of the cyton.

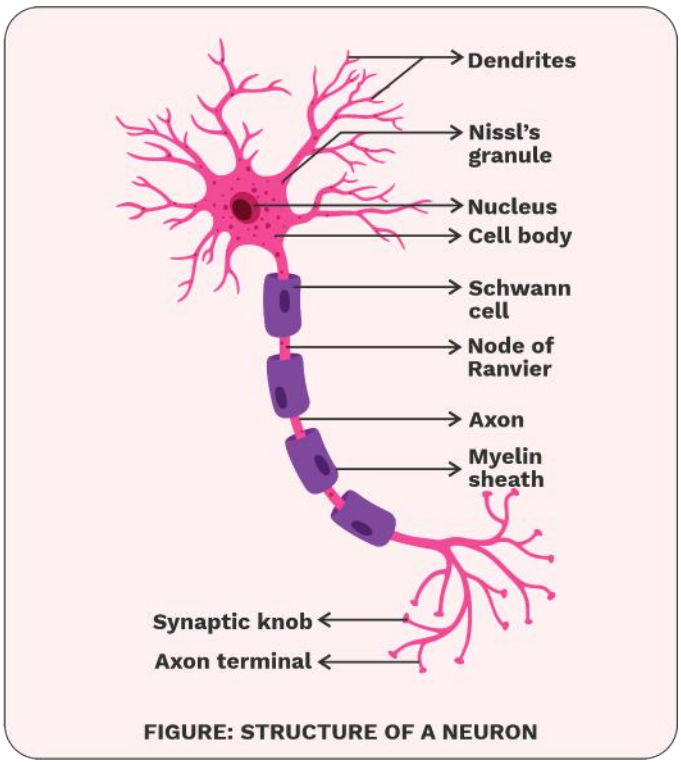


FIGURE: STRUCTURE OF A NEURON

Previous Year's Question

Which cell stops dividing after birth?

(1) Neuron (2) Glial
(3) Epithelium (4) Liver

Rack your Brain

Brain damage cannot be healed. Why?

Definition

Nucleolus: Nucleolus is a non-membrane bound, granular structure within the nucleus of a eukaryotic cell which is considered as the site of ribosome biosynthesis.

Previous Year's Question

Which of the damaged cells cannot be repaired?

(1) Liver cells
(2) Brain cells
(3) Bone cells
(4) Epidermal cells

- The cytoplasm is granular having pigment granules and fat globules.
- Neurofibrils, neurotubules and **Nissl's granules** (granular bodies formed by irregular clusters of rough endoplasmic reticulum which are known to synthesize proteins) are also present in the cyton.

- **Dendrites**
  - Dendrites are short fibres which projects out of the cell body and branch repeatedly.
  - Dendrites also contain Nissl's granules.
  - They receive stimuli and conduct the **impulses towards** the cell body.
- **Axon**
  - Axon is the longest cell process arising from the axon hillock region of the cyton.
  - The cell membrane of an axon is called **axolemma**.
  - Its cytoplasm (**axoplasm**) does not contain Nissl's granule, golgi complex, ribosomes, pigment granules or fat granules.
  - However, neurofibrils and neurotubules are present in its cytoplasm.
  - Axon is **branched distally**.
  - Axon terminals expand to form bulb-like structures called the **synaptic knob** and which possess secretory synaptic vessels containing neurotransmitters.
  - The axons transmit nerve impulses away from the cell body, i.e., in the direction of axon terminals so that the impulses reach a neural junction or a neuro-muscular junction.

Types of Neurons

- Based on the number of cell processes (axon and dendrites), the neurons are divided into three types, i.e., unipolar, bipolar, and multipolar.
- Based on functions performed, neurons are of three types, namely, sensory neurons, motor neurons and interneurons.

Definition

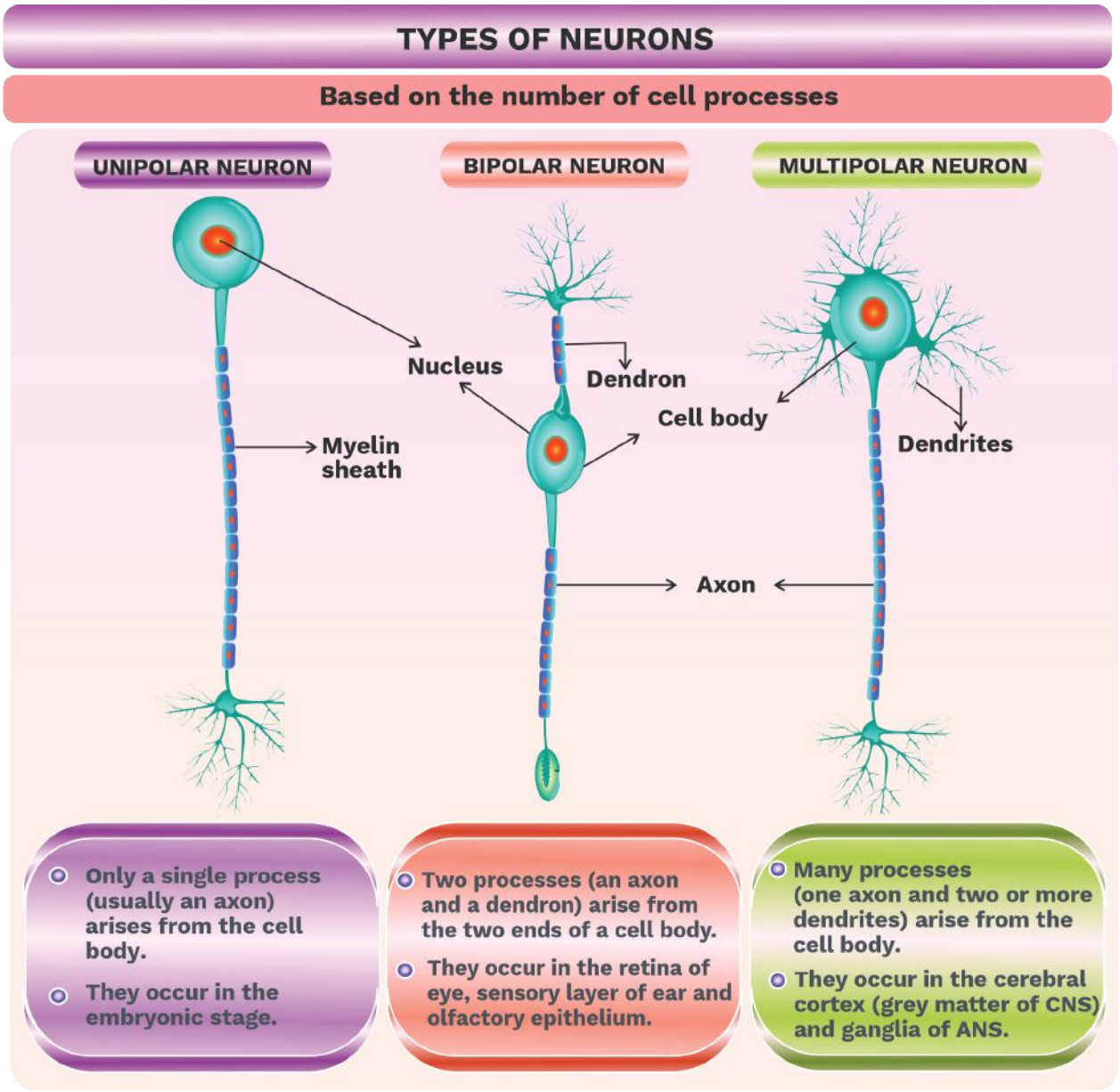
Nissl's granules: Nissl's granules are granular bodies formed by irregular clusters of rough endoplasmic reticulum which are known to synthesize proteins.

Previous Year's Question

Nissl's granules are absent in:
(1) Axon
(2) Cyton
(3) Dendron
(4) Both (a) and (b)

Rack your Brain

Why are dendrites considered as the afferent processes of a cell body?

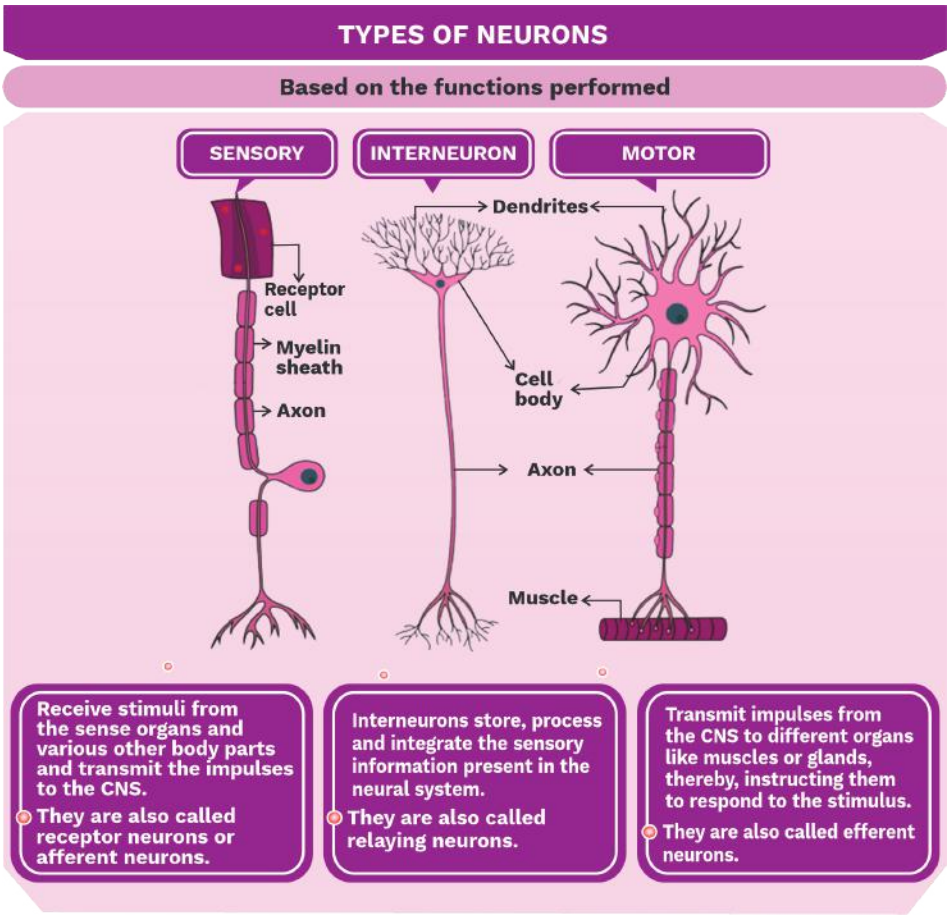


Nerve Fibres

- When the **axon** of a neuron is **covered** by layer/layers of **sheath**, it is called a nerve fibre.
- There are two types of nerves fibres based on the formation of myelin sheath around their axon, namely, myelinated, and non-myelinated nerve fibres.

Rack your Brain

Which type of neuron is mostly present in our body?



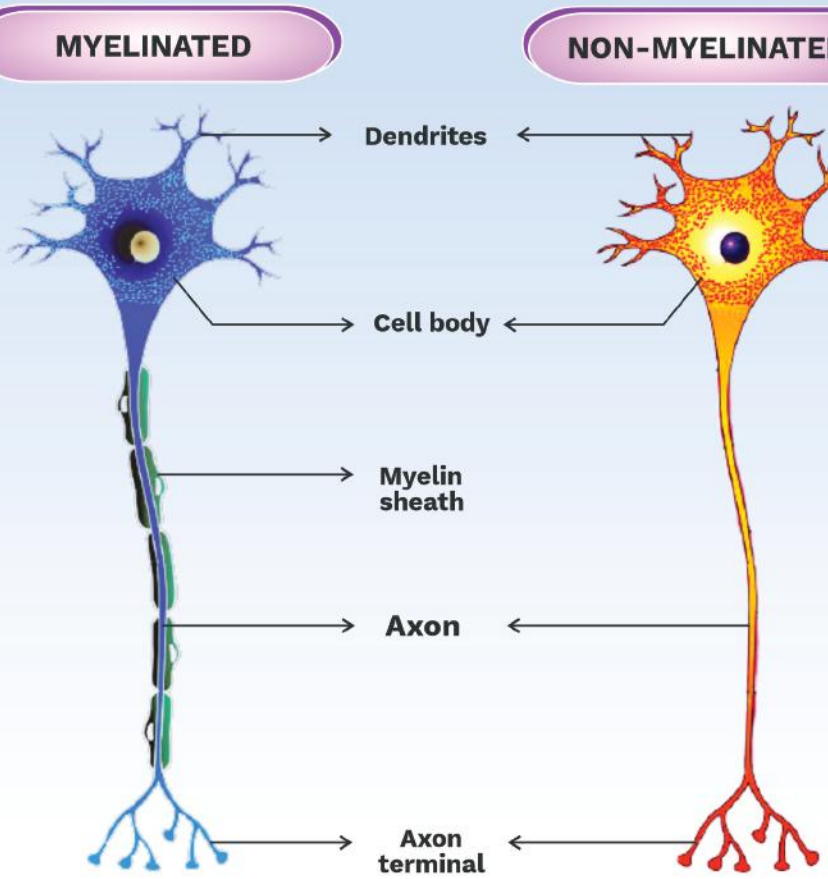
Myelinated or Medullary of Nerve Fibres

- The neurons of our neural system are supported by specialised cells called **neurological cells** or glial cells, e.g., oligodendrocytes and Schwann cells.
- In the **CNS**, **oligodendrocytes** support neurons by concentrically wrapping around the axons to form a continuous sheath called **myelin**.
- This myelin sheath which is formed by many layers of the plasma membrane of oligodendrocytes is composed of lipids, proteins, and water. It acts as an insulator and prevents any leakage of ions.
- In the **PNS** (cranial and spinal nerves), **Schwann cells** support the neurons by spirally wrapping themselves around the axons.

Previous Year's Question

Myelin sheath is produced by:
(1) Astrocytes and Schwann cells
(2) Oligodendrocytes and osteoclasts
(3) Osteoclasts and astrocytes
(4) Schwann cells and oligodendrocytes

TYPES OF NEURONS



Medullated (Myelinated) Nerve Fibres

1. Medullary sheath is present.
2. They appear white in fresh state.
3. Nodes of Ranvier are present at intervals.
4. They are generally present in the white matter of brain and spinal cord and in cranial and spinal nerves.
5. They carry impulses faster than non-medullated nerve fibres.

Non-medullated (Non-myelinated) Nerve Fibres

1. Medullary sheath is absent.
2. They appear grey in fresh state.
3. Nodes of Ranvier are absent.
4. They are present in autonomic nerves.
5. They carry impulses slower than medullated nerve fibres.

- Layers of plasma membrane of Schwann cells makes the myelin sheath (medullary sheath) around a nerve fibre.
- Myelin sheath is absent at certain points called nodes of Ranvier and is present in segments along the length of the axon. Each segment of the myelin sheath is made of one Schwann cells.
- An outer layer of Schwann cell cytoplasm (having a nucleus) is present in the myelinated nerve fibres of the peripheral neural system, which is called **neurilemma**. It helps in the regeneration of injured nerve fibres.
- **Non-myelinated or Non-medullary Nerve Fibres**
- Non-myelinated nerve fibres are also supported and enclosed by the Schwann cells. But these cells do not concentrically wrap around the axon and thus, do not form a myelin sheath.
- They are enclosed by the neurilemma only.
- Such nerve fibres are found in the autonomous and the somatic neural systems.

GENERATION AND CONDUCTION OF NERVE IMPULSE

- The cell membrane of a neuron consists of various **ion channels** which are specific for different ions present in the extracellular fluid (interstitial fluid) and in the axoplasm. For example, transmembrane ions channels, specific for sodium ions, potassium ions, chloride ions, etc., are present in the axolemma for the transport of these ions to and fro the axoplasm and the interstitial fluid.
- These selectively permeable ion channels are formed by **transmembrane proteins** and are generally gated, and open only when they receive a stimulus such as a particular voltage, chemicals, mechanical pressure, etc.
- When a neuron is **at rest**, i.e., when it does not receive any stimulus and is **not conducting** any

Gray Matter Alert!!!

Schwann cells are absent in the central neural system. Therefore, neurilemma is not found on the nerve fibres of the brain and spinal cord. Due to this reason, such nerve fibres do not regenerate after injury.

Definitions

Nerves: Bundles of nerve fibres present in the peripheral neural system.
Tracts: Bundles of nerve fibres present in the central neural system.

Previous Year's Question

Which of the following statement is correct for node of Ranvier of nerve?
(1) Neurilemma is discontinuous
(2) Myelin sheath is discontinuous
(3) Both neurilemma and myelin sheath are discontinuous
(4) Covered by myelin sheath

impulse, its axonal membrane is comparatively more **permeable** to potassium ions (**K^+**) and nearly **impermeable** to sodium ions (**Na^+**).

- The K^+ ions readily enter the axoplasm from the interstitial fluid. But sodium ion channels do not permit the entry of sodium ions into the axoplasm.
- Many **negatively charged proteins** are present in the axoplasm which are not allowed to move out in the extracellular fluid as the neural membrane is impermeable to them.
- Inside the **axoplasm**, this selective movement of ions results in a **high** concentration of **K^+ ions** and negatively charged proteins and a **low** concentration as **Na^+ ions**.
- In comparison to this, the fluid outside the axon has a high concentration of Na^+ ions and a low concentration of K^+ ions.
- A **concentration gradient** or **electrochemical gradient** is formed across the axolemma due to the unequal concentrations of ions.
- These ionic gradients across the resting membrane are maintained by the **active transport** (using ATP) of ions by the sodium-potassium pumps (Na^+/K^+ pumps).
- These transmembrane **sodium-potassium pumps** use the energy from ATP to expel (efflux) **three Na^+ ions** outwards and allow the entry (influx) of **two K^+ ions** in the axoplasm. Hence, there is a net export of only one positive charge per pump cycle.
- As a result, the outer surface of the axonal membrane possesses a positive charge while its inner surface becomes negatively charged. Therefore, the electric potential on the two sides of the axonal membrane differs.
- This transmembrane electrical potential difference on the two surfaces of nerve cell membrane makes it **polarised**.
- The electrical potential difference across the resting plasma membrane is called the **resting potential**.

Rack your Brain

How are sodium-potassium pumps electrogenic in function?

Gray Matter Alert!!!

Sodium-potassium pump (Na^+/K^+ pump), also called as sodium-potassium triphosphatase (Na^+/K^+-ATPase) is an enzyme (Transmembrane protein).

Previous Year's Question

During the propagation of a nerve impulse, the action potential results from the movement of

(1) K^+ ions from intracellular to extracellular fluid
(2) Na^+ ions from extracellular fluid to intracellular fluid
(3) K^+ ions from extracellular fluid to intracellular fluid
(4) Na^+ ions from intracellular to extracellular fluid

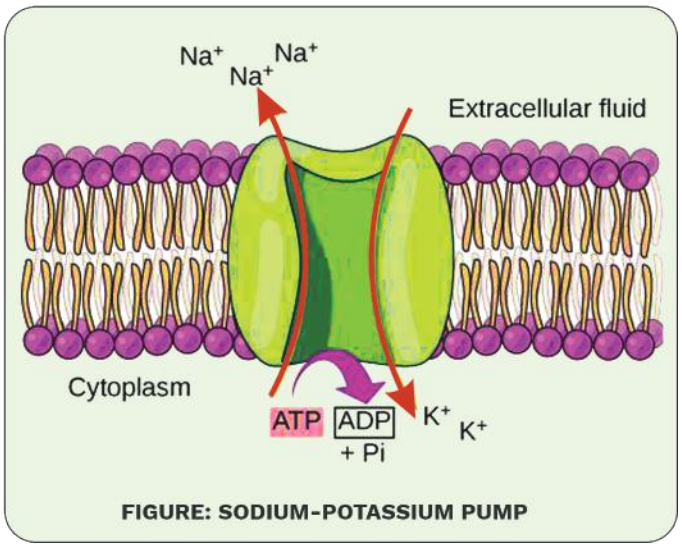


FIGURE: SODIUM-POTASSIUM PUMP

Generation of a Nerve Impulse

- Since, the membranes of neurons are polarized, they are **excitable cells**.
- When a **stimulus** reaches at a site (suppose site A) on the polarized membrane of a neuron, it causes closure of the sodium-potassium pumps and simultaneous opening of sodium ion channels.
- Na^+ ions rapidly enter the neuron and change the local potential difference by **reversing** the **polarity** at that site, i.e., the outer surface of the membrane becomes negatively charged and the inner side becomes positively charged.
- This phenomenon of reversal of the polarity of the membrane at the site A is called **depolarization** and the membrane becomes depolarized.
- The electrical potential difference across the plasma membrane at the site where stimulus is received (site A) is called the **action potential**, which is also termed as a **nerve impulse**.

Conduction of a Nerve Impulse

- At the depolarized area (site A), the potential difference across the membrane is small while its nearby region (site B), has a large difference

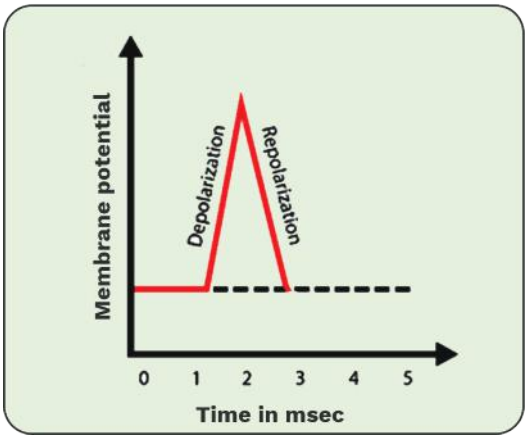
Definition

Excitability: The ability of a neuron to perceive a stimulus and become active due to change in the electric potential difference across its membrane.

Previous Year's Question

Depolarization of axolemma during nerve conduction takes place because of:

(1) equal amount of Na^+ and K^+ move out across axolemma
(2) Na^+ move inside and K^+ move more outside
(3) more Na^+ outside
(4) none of these



in the membrane potential. This is because the axon membrane at site B has a positive charge on the outer surface and a negative charge on the inner surface.

- This produces a **small current** in this area.
- The **current flows** on the inner surface from site A to site B and on the outer surface from site B to site A to complete the circuit of current flow.
- This local current acts as a **stimulus** and causes the Na^+ ion channels of site B to open and depolarize the area.
- Hence, the polarity at site B is reversed and an action potential is generated at site B. Thus, the nerve impulse generated at site A moves to site B. This process will continue till the nerve impulse reaches the end of the neuron.
- The rise in the stimulus-induced permeability to Na^+ ions is extremely short lived as the **Na^+ ion channels open** only for about **0.5 msec**.
- As the Na^+ ion channels close, there is a quick rise in the permeability to K^+ ions due to opening of K^+ ion channels.
- Within a fraction of a second, K^+ ions are pumped outside the membrane and interior of the neuron becomes negative again which makes the potential fall back to restore the resting potential of the membrane at the site of excitation.

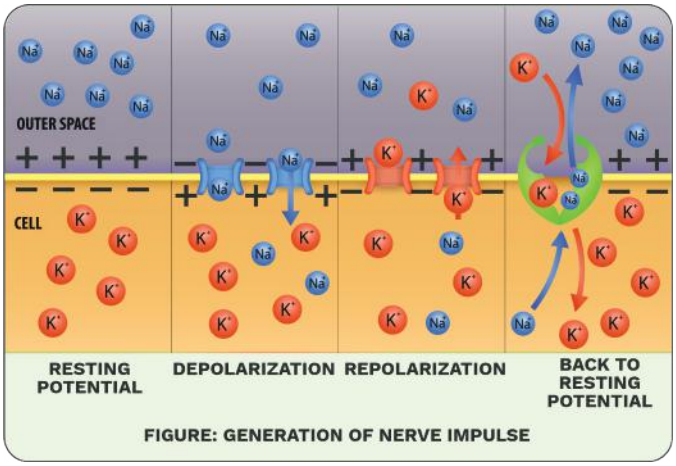


FIGURE: GENERATION OF NERVE IMPULSE

Previous Year's Question

The potential difference between outside and inside of a nerve before excitation is known as:

(1) Resting potential
(2) Action potential
(3) Spike potential
(4) Reaction potential

Gray Matter Alert!!!

The resting membrane potential of a neuron averages -70mV (-60mV to -85mV) in the inner side of membrane with respect to the outer side. Action potential ranges between +30mV to +45mV.

Previous Year's Question

When a neuron is in resting state, i.e., not conducting any impules, the axonal membrane is

(1) Comparatively more permeable to K^+ ions and nearly impermeable to Na^+ ions
(2) Comparatively more permeable to Na^+ ions and nearly impermeable to K^+ ions
(3) Equally permeable to both Na^+ and K^+ ions
(4) Impermeable to both Na^+ and K^+ ions

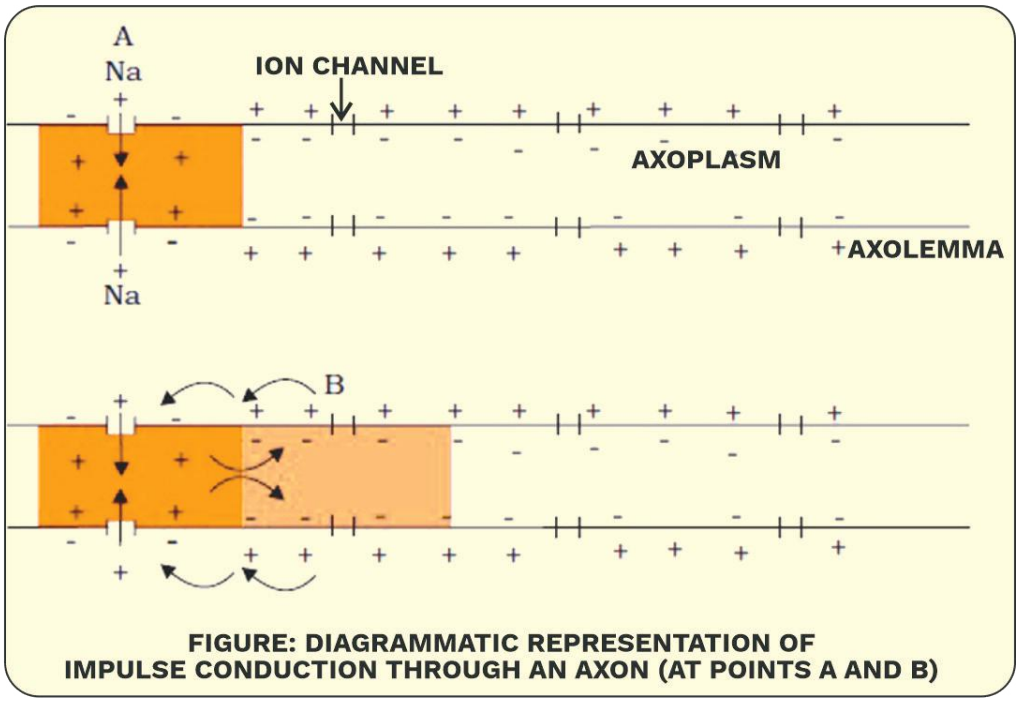


FIGURE: DIAGRAMMATIC REPRESENTATION OF IMPULSE CONDUCTION THROUGH AN AXON (AT POINTS A AND B)

- This phenomenon of change of membrane potential from excited state to resting state is called **repolarization**. It makes the neuron once more responsive to further stimulation.

Saltatory conduction

- It is the mode of conduction of nerve impulse in myelinated neurons which involves **jumping** of **action potential** from one **node of Ranvier** to another.
- The **myelin sheath** prevents the flow of ions between axoplasm and the extracellular fluid as the **lipids** present in it acts as **insulators** of the impulse. Thus, the action potential cannot travel as a continuous wave in myelinated neurons.
- The various gated ion channels and transport pumps involved in nerve impulse conduction occur at the region of nodes of Ranvier.
- Therefore, in a myelinated neuron, as the stimulus reaches a node of Ranvier, Na^+ ion

Rack your Brain

Depolarisation occurs in which region of a myelinated neuron?

Gray Matter Alert!!!

A nerve impulse travels with greater speed along a myelinated neuron because of saltatory conduction.

channels open, creating an action potential, i.e., a nerve impulse which **jumps** as an electric current to the next node of Ranvier.

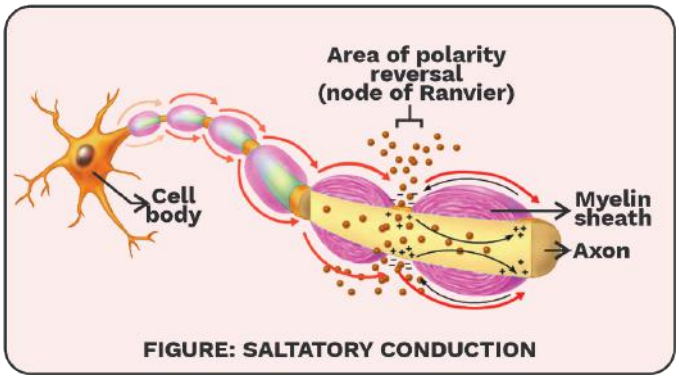


FIGURE: SALTATORY CONDUCTION

TRANSMISSION OF IMPULSES

- The junction between the end of one neuron and the dendrite of another neuron for the transmission of a nerve impulse is called **synapse**.
- The membrane of a pre-synaptic neuron and a post-synaptic neuron, which may or may not be separated by a gap called synaptic cleft, collectively forms a synapse.
- Conduction of nerve impulse across the synapse can be electrical or chemical. Accordingly, there are two types of synapses, namely, electrical synapses and chemical synapses.
- At **electrical synapses**, the membranes of pre-synaptic neurons and post-synaptic neurons lie very close as the **synaptic cleft** is only **0.2 nm** in width.
- As a result, the action potential developed over the **pre-synaptic membrane** can directly jump over the post-synaptic membrane as an electric current across these synapses.
- Transmission of nerve impulse across electrical synapses is very much like the nerve impulse conduction along a single axon.
- There is a **faster transmission** of nerve impulses across an electrical synapse as compared to a chemical synapse. Electrical synapses are not common in human neural system.

Previous Year's Question

Synapses store:
(1) Stimulating chemicals
(2) Inhibitory chemicals
(3) Conducting chemicals
(4) All of these

Definition

Neurotransmitters:
Neurotransmitters are chemical substances released from the synaptic vesicles of the presynaptic knob of a neuron by the arrival of a nerve impulse, which interact with specific receptors of the postsynaptic neuron and help in the transmission of the nerve impulse.

Previous Year's Question

Receptor sites for neurotrans-mitters are present on:
(1) Pre-synaptic membrane
(2) Tips of axons
(3) Post-synaptic membrane
(4) Membranes of synaptic vesicles

- At a **chemical synapse**, a fluid-fluid space called synaptic cleft, separates the membranes of the pre-synaptic neurons and post-synaptic neurons.
- Since, the action potential on the pre-synaptic membrane cannot directly jump over the synaptic cleft to reach the post-synaptic membrane, the transmission of action potential is brought about by chemicals called **neurotransmitters**.
- The distal branches of an axon, terminates into bulb-like structures called **pre-synaptic knobs**.
- A pre-synaptic knob consists of many **synaptic vesicles** filled with neurotransmitters.
- As an action potential (nerve impulse) reaches at the pre-synaptic membrane of the axon terminal, its voltage gated **Ca^{2+} ion channels** open.

Rack your Brain

Name the ions which influence the release of chemical messengers from the synaptic vesicles during transmission of impulses.

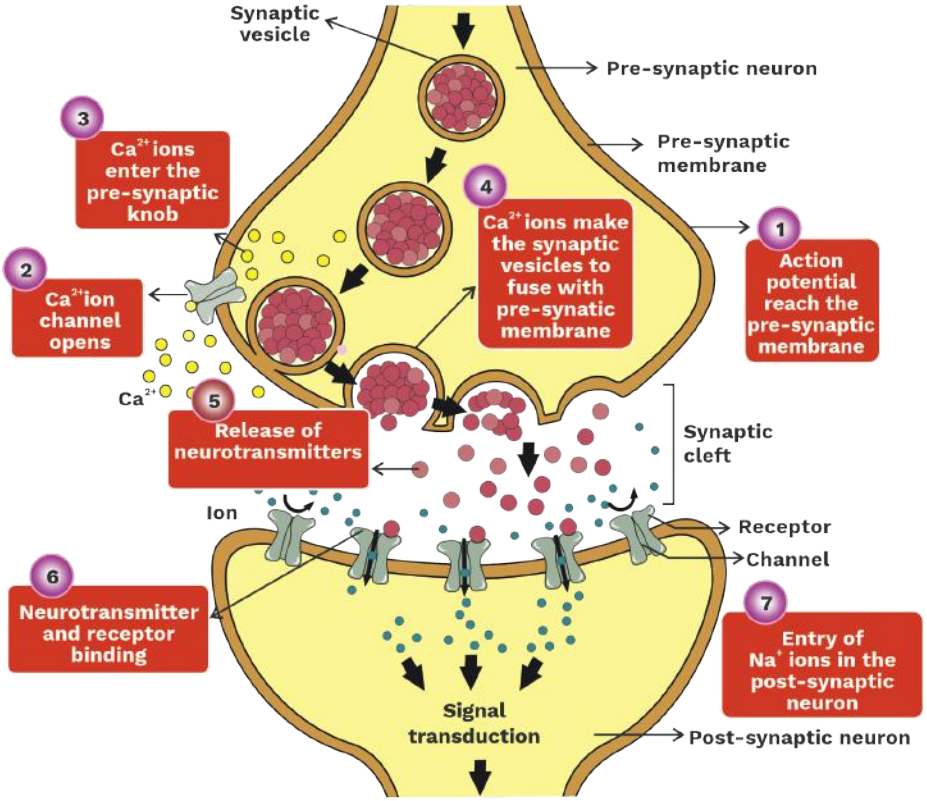


FIGURE: DIAGRAM SHOWING AXON TERMINAL AND SYNAPSE

- The concentration of Ca^{2+} ions in the fluid of the synaptic cleft is **10,000 times more** than the Ca^{+} ions present in the cytoplasm of the pre-synaptic knob. Due to this concentration gradient, the Ca^{2+} ions rush into the presynaptic knob as soon as the Ca^{2+} ion channels open.
- Ca^{2+} ions cause the movement of synaptic vesicles towards the pre-synaptic membrane.
- The synaptic vesicles fuses with the pre-synaptic membrane and release their neurotransmitters in the synaptic cleft through **exocytosis**.
- The released neurotransmitters bind to their specific **receptors** present on the post-synaptic membrane.
- This binding opens the Na^{+} ion channels of the post-synaptic membrane allowing the entry of Na^{+} ions which **generates** a **new action potential** of either excitatory or inhibitory nature in the post-synaptic neuron.
- Once a new nerve impulse is generated, the neurotransmitter molecules detach from their receptors. Some of the neurotransmitters are reabsorbed in the synaptic knob while others are broken down by hydrolytic enzymes.

Definition

Exocytosis: The process by which materials are moved from within the cell into the interstitial fluid.

CENTRAL NEURAL SYSTEM

- The central neural system consists of human brain and spinal cord.

Brain

- The brain is the central information processing organ of the human body.
- It functions as '**the command-and-control system**' as it controls all the voluntary movements, functioning of vital involuntary organs like lungs, heart, kidney, etc., balance of the body, hunger, thirst, thermoregulation, activities as well as secretions of endocrine glands, circadian (24-hour) rhythms of the body and human behaviour.

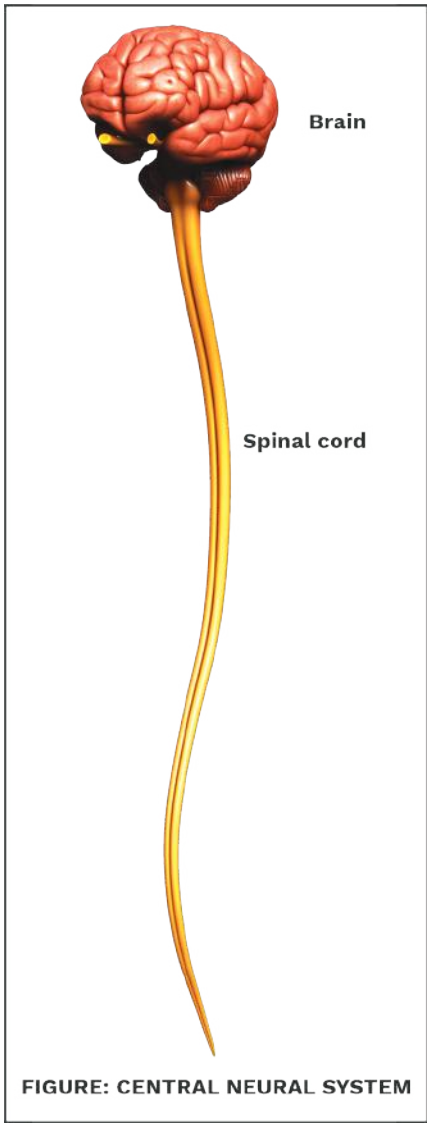


FIGURE: CENTRAL NEURAL SYSTEM

- It has processing centres for vision, hearing, speech, intelligence, memory, emotions and thoughts.
- Because of its prime importance in the body, the human brain is well **protected** by the **skull**.
- Inside the skull, the brain is further covered by protective membranes called **cranial meninges**. From outside (cranial side) to inside (towards brain), they are **dura mater**, **arachnoid mater**, and **pia mater**.
- Dura mater is non-vascular and do not allow movement of brain in the cranium. Subdural space occurs between dura mater and arachnoid mater whereas subarachnoid space occurs between arachnoid mater and pia mater. Subarachnoid space contains a fluid called the cerebrospinal fluid. **Cerebrospinal fluid** protects the brain from shocks by acting as a cushion. It provides a medium for exchange of food materials, gases, wastes, etc. Pia mater is thin and highly vascularized.
- Histologically, i.e., based on the neural tissue, the brain is divided into two regions, namely, grey matter and white matter.

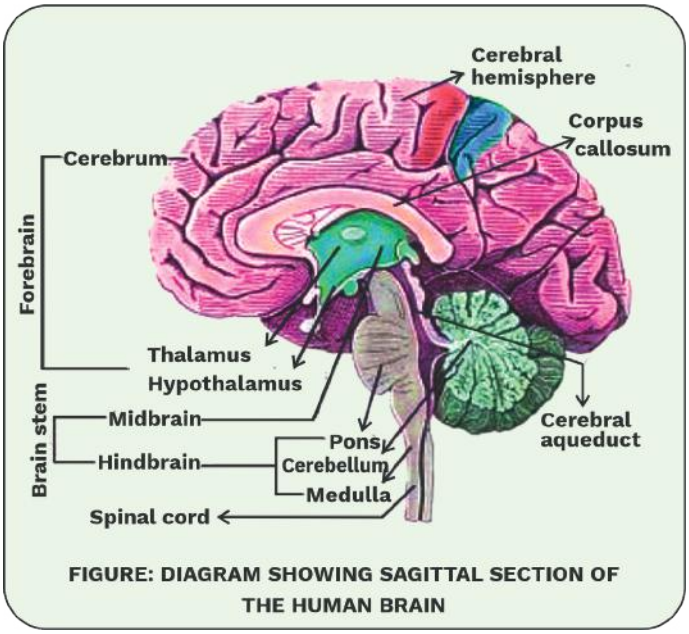


FIGURE: DIAGRAM SHOWING SAGITTAL SECTION OF THE HUMAN BRAIN

Rack your Brain

How is the human brain protected by its anatomy?

Previous Year's Question

The correct sequence of meninges from outer to the inner side is

(1) Arachnoid-pia mater-dura mater
(2) Arachnoid-dura mater-pia mater
(3) Pia mater-arachnoid-dura mater
(4) Dura mater-arachnoid-pia mater

Definition

Cerebrospinal Fluid: The cerebrospinal fluid is a colourless body fluid produced by choroid plexuses of the ventricles of the brain and occupies the subarachnoid space and ventricular system of brain and spinal cord.

- **Grey matter** consists of neuronal cell bodies and dendrites and non-myelinated nerve fibres (axons covered with sheath) whereas **white matter** contains myelinated axons. Grey matter occurs externally in the cerebral cortex while white matter occurs internally in the brain.
- The brain can be divided into three major parts, namely, **forebrain** (prosencephalon), **midbrain** (mesencephalon) and **hindbrain** (rhombencephalon).

Forebrain

- The forebrain consists of olfactory lobes, cerebrum, and diencephalon.

Olfactory lobes

- Olfactory lobes are located inferiorly to the cerebrum. They are **paired** structures with an olfactory bulb and an olfactory tract in each lobe.
- They help to send the various **smell stimuli** to the temporal lobes of cerebrum.

Cerebrum

- Cerebrum forms a major part of the human brain.
- It is divided longitudinally by a deep cleft (fissure) into the right and left cerebral hemispheres.
- The two cerebral hemispheres are connected to each other by a long tract of myelinated nerve fibres called **corpus callosum**.
- The layer of cells which covers the cerebral hemisphere is called **cerebral cortex**.
- The cerebral cortex is thrown into prominent folds. The upwards folds called **gyri** alternate with the downward groves or **sulci**.
- The cerebral cortex makes up the grey matter of the cerebrum as it consists of the cell bodies of myelinated neurons.
- Cerebral cortex has three types of specific areas, namely motor areas, sensory areas, and association areas.

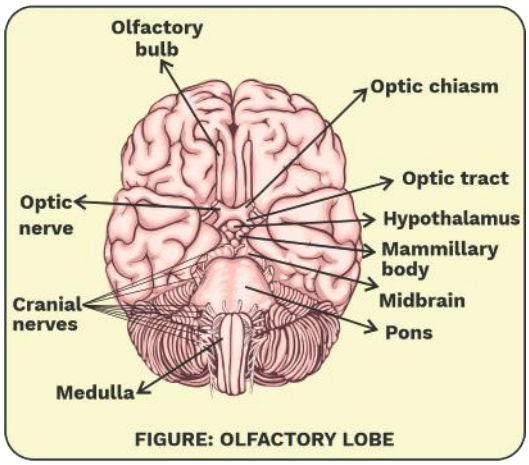


FIGURE: OLFACTORY LOBE

Rack your Brain

Which function will be lost due to damage of olfactory lobes?

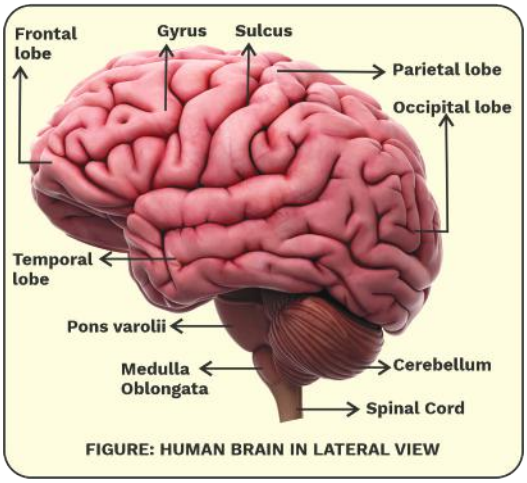


FIGURE: HUMAN BRAIN IN LATERAL VIEW

- **Motor areas** controls specific muscle movements, **sensory areas** deal with the stimuli received from the sense organs and visceral organs and **association areas** are responsible for complex functions like intersensory association, memory, and communication.
- The cerebral hemisphere is divided into four lobes by deep fissures, namely, frontal lobe, parietal lobe, temporal lobe, and occipital lobe.
- The **frontal lobe** controls the voluntary movements through its motor area. It has centres for intelligence, memory, will power, abstract reasoning, expression of emotions, creative ideas, judgement, speech, decision making, etc.
- **Parietal lobe** receives sensory stimuli of touch, pain, taste, temperature, and pressure. It also has sensory speech area and association area for integrating and processing various sensations, position in space, information from environment, etc.
- **Temporal lobe** helps in perception of smell, hearing, language comprehension, etc.
- **Occipital lobe** helps to decode and interpret visual information.
- The inner part of cerebral hemisphere consists of tracts with axon covered with myelin sheath, which gives an opaque white appearance to it, and hence, is called the white matter.

Diencephalon

- Diencephalon has three parts, namely, epithalamus, thalamus and hypothalamus.
- **Epithalamus** is a non-nervous roof of diencephalon which is folded anteriorly to from **anterior chord plexus** which fuses with the pia mater. Anterior choroid plexus forms the **cerebrospinal fluid**. The posterior part of epithalamus has **pineal gland** which secrete melatonin and serotonin hormones.

Previous Year's Question

The nerve centres which control the body temperature and the urge for eating are contained in:
(1) hypothalamus
(2) pons
(3) cerebellum
(4) thalamus

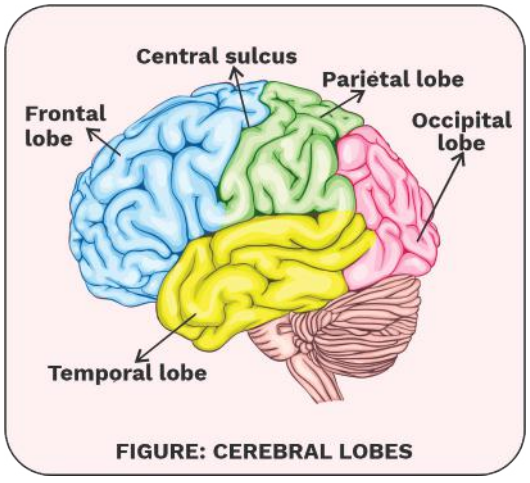


FIGURE: CEREBRAL LOBES

Definition

Pineal gland: Pineal gland or pineal body is an endocrine gland present at the posterior region of the epithalamus of the human brain and produces hormones like melatonin and serotonin to modulate sleep patterns. It is also called the 'seat of soul'.

- The cerebrum wraps around a structure called **thalamus**, which is a major coordinating centre for sensory and motor signalling.
- **Hypothalamus** lies at the base of the thalamus. It is highly vascularized. It contains several centres which regulate the body temperature, urge for eating and drinking, sweating, fatigue, sleep, satiety, emotional reactions, etc.
- It helps to control water balance in the body, influences heartbeat and breathing. Thus, hypothalamus maintains the body's homeostasis.
- It also contains several groups of neurosecretory cells, which secrete hormones called **hypothalamic hormones**.
- The inner parts of cerebral hemispheres (hypothalamus) and a group of associated deep structures like hippocampus, amygdala, etc., form a complex structure called the limbic lobe or **limbic system.**

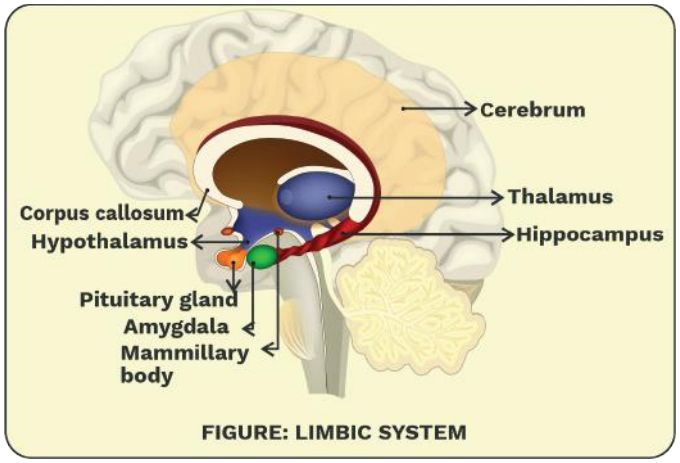


FIGURE: LIMBIC SYSTEM

- Hypothalamus has centres for rage, fear, reward, fight, and sexual drive.
- **Hippocampus** deals with a mixture of signals of smell and memories. It can perceive hallucinations. It transforms short term memory into long term memory. It also controls behaviour patterns.

Previous Year's Question

Injury localized to the hypothalamus would most likely disrupt:
(1) Regulation of body temperature
(2) Short-term memory
(3) Co-ordination during locomotion
(4) Executive functions, such as decision making

Gray Matter Alert!!!

- Hypothalamus is called the '**thermostat of the body**'.
- Limbic system is called the '**emotional brain**' as it controls emotional behaviors.

Previous Year's Question

The human brain comprises three parts, one of which is:
(1) spinal cord
(2) corpus callosum
(3) cerebellum
(4) Hypothalamus

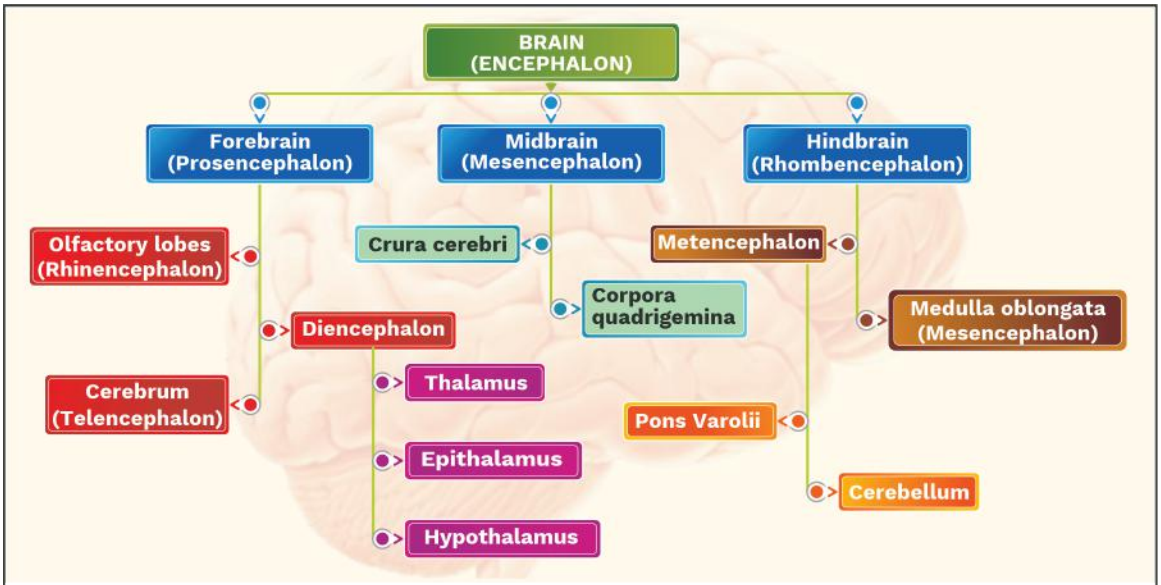


FIGURE: DIFFERENT PARTS OF HUMAN BRAIN

- **Amygdala** is associated with moods, anger, rage, aggression, fear, swallowing, eating, olfaction, and regulation of sexual behaviour.

Midbrain

- The midbrain is located between the thalamus/ hypothalamus of the forebrain and pons varolii of the hindbrain.
- Dorsally, the midbrain consists of four lobes called **corpora quadrigemina**.
- One pair of lobes controls **visual reflexes**, receiving visual impulses and muscles of the head for coordinated movement of head and eyes to focus on an object.
- The other pair of lobes control **auditory reflexes**, receiving auditory impulses and muscles of the head to coordinate the movement of head and ear for detecting the source of sound.
- A canal called the **cerebral aqueduct** passes through the midbrain.
- **Crura cerebri** are two tracts of nerve fibres on the inferior side of midbrain. They relay both sensory

Previous Year's Question

During the course of evolution which part of the brain has shown maximum increase in size
(1) Mid brain
(2) Fore brain
(3) Hind brain
(4) All of the above

Rack your Brain

If a person loses his memory in an accident, then which part of his brain has got injured?

and motor impulses between the forebrain and midbrain.

Hindbrain

- The hindbrain comprises of pons varolii, cerebellum and medulla oblongata.
- **Cerebellum** lies behind the cerebrum and above the medulla oblongata and is the second largest part of the brain (after the cerebrum).
- Cerebellum has very convoluted surface which provides additional space for many more neurons. It controls rapid muscle activities like running, typing, talking, etc.
- Cerebellum integrates information from auditory system and visual system. It helps in balance of the body and maintenance of muscle tone.
- Alcohol affects the functioning of the cerebellum.
- **Pons Varolii** is in front of the cerebellum, above the medulla oblongata. Pons consists of fibre tracts that interconnect different regions of the brain. It relays impulses between medulla oblongata and cerebral hemispheres as well as between cerebrum and cerebellum. **Pneumotaxic centre** is present in pons varolii which limits inspiration.
- **Medulla oblongata** extends from the pons varolii and connects with the spinal cord.
- A non-nervous part of the medulla oblongata fuses with the pia mater to form a highly folded structure called the posterior choroid plexus which forms the cerebrospinal fluid.
- Medulla oblongata controls various **involuntary functions** of the body, like swallowing, vomiting, peristalsis, gastric secretion, salivation, coughing, and sneezing. In has centres which control respiration and cardiovascular reflexes.
- Midbrain and hindbrain form the **brain stem**. Brain stem forms the connection between the brain and spinal cord. Three major regions make up the brain stem, i.e., **midbrain, pons varolii** and **medulla oblongata**.

Previous Year's Question

Which of the following regions of brain is incorrectly paired with its function?

(1) Corpus callosum- communication between the left and right cerebral cortices
(2) Cerebrum-calculation and contemplation
(3) Medulla oblongata-homeostatic control
(4) Cerebellum-language comprehension

Rack your Brain

Drunk people tend to stumble, fumble, and slur their words. Why?

Previous Year's Question

Body posture, equilibrium and rapid muscular activities are controlled by

(1) Cerebellum
(2) Thalamus
(3) Hippocampus
(4) Temporal lobe of cerebrum

- **Twelve pairs** of nerves called **cranial nerves** arise from the brain and form a part of the peripheral neural system. These nerves contain sensory fibres (e.g., olfactory, optic, and auditory cranial nerves), motor fibres (e.g., oculomotor, pathetic, abducens, accessory, and hypoglossal cranial nerves) and both sensory and motor fibres (e.g., trigeminal, facial, and glossopharyngeal).

Human Spinal Cord

- The human spinal cord is in the vertebral column and extends from the base of medulla oblongata to the second lumbar vertebra.
- It is also protected by the same three meanings found in the brain.
- It has a wider ventral fissure and a narrow dorsal sulcus.
- In spinal cord, the grey matter is internally placed while the white matter is external.
- The spinal cord conducts sensory and motor impulses to and fro the brain and provides nerve connections to many body parts.
- 31 pairs of spinal nerves arise from different segments of spinal cord. All these spinal nerves are a part of the peripheral neural system and are mixed in nature, i.e., both sensory and motor. They are composed of myelinated nerve fibres.

REFLEX ACTION AND REFLEX ARC

- The process which involves generation of a response to a peripheral nervous stimulation, that occurs **involuntarily**, i.e., without conscious effort or will and requires the involvement of a part of the central nervous system is called a **reflex action**.
- For example, a sudden withdrawal of a body part which comes in contact with objects that are extremely hot, cold, pointed or animals that are scary or poisonous.
- The reflex pathway comprises of five components,

Rack your Brain

How many cranial nerves are found in amniotes?

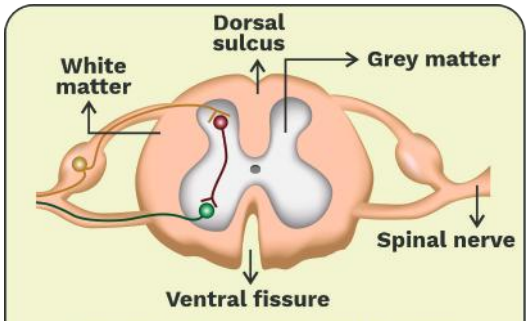


FIGURE: T.S. HUMAN SPINAL CORD

Previous Year's Question

Reflex action immediately involves?
(1) Spinal cord
(2) Cerebellum
(3) Medulla oblongata
(4) Optical lobe

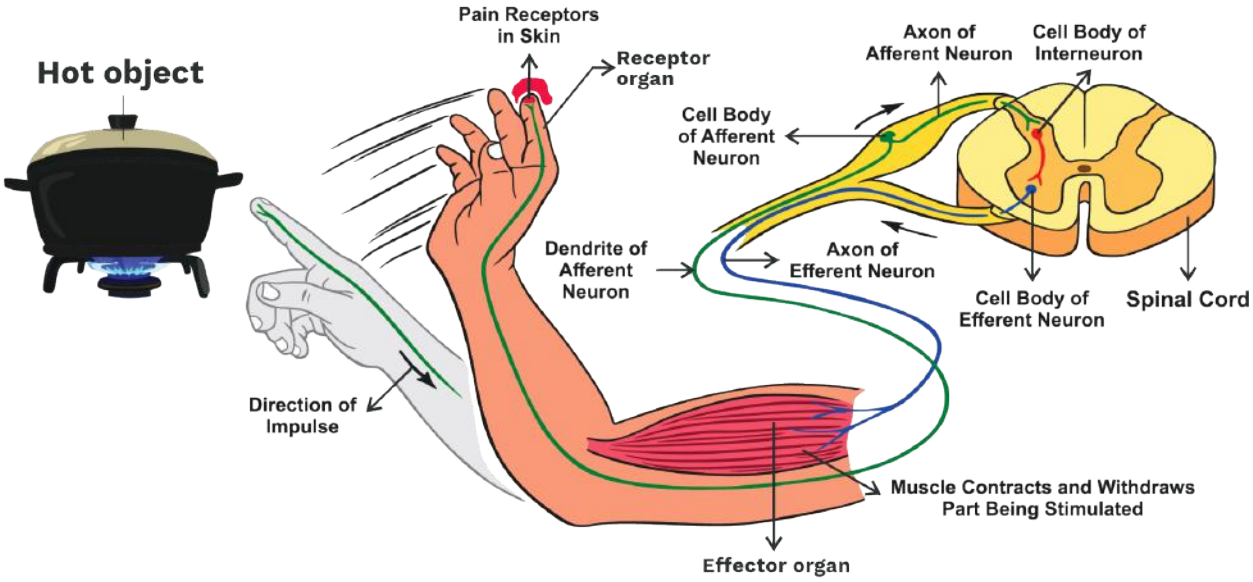


FIGURE: DIAGRAMMATIC REPRESENTATION OF REFLEX ARC

i.e., the **receptor** (sensory organ), **afferent neuron** (sensory nerve fibre), a part of the **central neural system**, **efferent neuron** (motor nerve fibre), and the **effector** (motor organ) appropriately arranged in a series.

- The afferent neuron receives signal from a sensory organ and transmits the impulse via a dorsal nerve root into the CNS (at the level of **spinal cord**). The efferent neuron then carries signals from CNS to the effector.
- The stimulus and response thus form a **reflex arc**.

SENSE ORGANS

- The five sense organs in the human body are **eyes** (organs of sight), **ears** (organs of hearing), **nose** (organ of smell), **tongue** (organ of taste), and **skin** (organ of touch).
- The nose consists of mucus-coated receptors called **olfactory receptors**, which are specialised for receiving olfactory stimuli from the environment.

Previous Year's Question

Which of the following is responsible for the control of reflex action?

(1) Sensory nerves
(2) Motor nerves
(3) Sympathetic nervous system
(4) Central nervous system

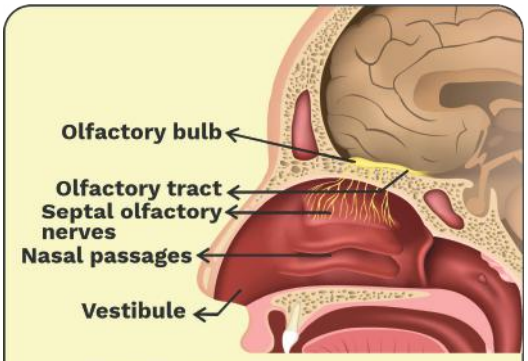


FIGURE: OLFACTORY BULB AND OLFACTORY TRACT

- These are made up of **olfactory epithelium** which is located at the roof of the nasal cavity and consists of three kinds of cells, i.e., **the olfactory receptor cells**, **supporting cells**, and **basal cells**.
- The neurons of the olfactory epithelium extend from the outside environment directly into a pair of broad bean-sized organs, called **olfactory bulb**, which are extensions of the brain's limbic system.
- Both nose and tongue detect **dissolved chemicals** in the surrounding environment.
- The chemical senses of gustation (taste) and olfactory (smell) are functionally similar and interrelated.
- The **tongue** has many raised projections on its upper surface. These projections or **papillae** consist of many **taste buds** having **gustatory receptors** that help to detect different tastes.
- Human tongue has four basic areas for taste, namely, sweet, salty, sour, and bitter.
- With each taste of food or sip of drink, the nerve fibres from the gustatory receptors transmit the nerve impulses to the brain and the nature of the food's flavour is perceived.

The Human Eye

- In humans, the sockets of the skull called **orbits** bear a pair of eyes.
- Eyes are the **organs of sight** as they perceive images of objects as light rays enter in them.
- The adult human eyeball is nearly a spherical, hollow structure.
- The **wall** of the eyeball is composed of **three layers**. The **outer fibrous layer** has a dense connective tissue called sclera with an anterior portion called cornea. The **middle vascular layer** with bluish colour has the choroid, ciliary body, and iris. The **inner neural layer** consists of the retina.
- **Sclera** is the white region of the eyeball and is made of collagen fibres whereas **cornea** is transparent and devoid of blood vessels.

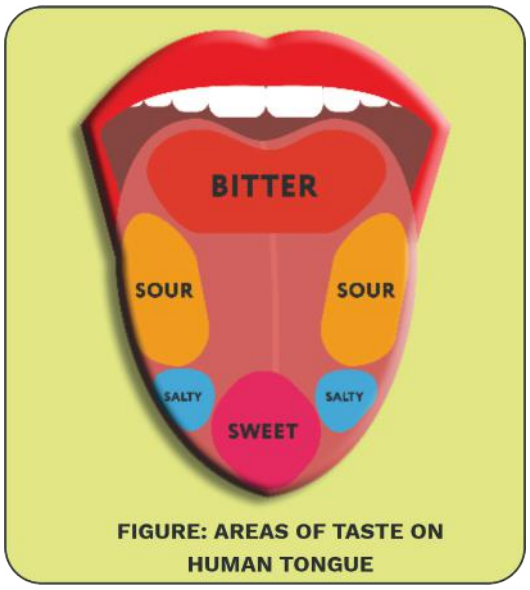
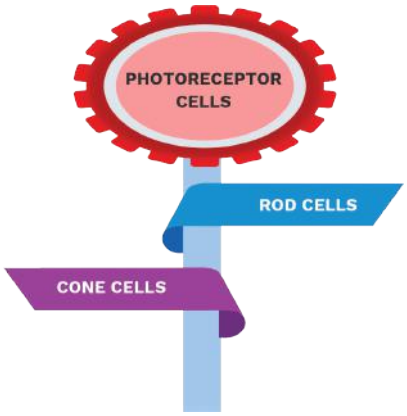


FIGURE: AREAS OF TASTE ON HUMAN TONGUE

Gray Matter Alert!!!

Vallate, fungiform and foliate papillae on human tongue are associated with taste buds, whereas filiform papillae contain tactile (touch) receptors and no taste buds.



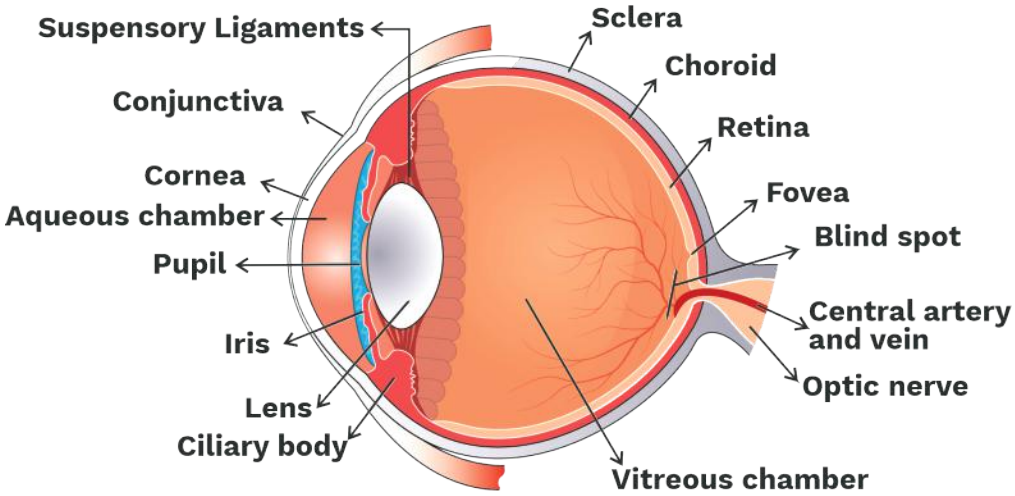


FIGURE: PARTS OF HUMAN EYE

- The **choroid** has numerous blood vessels and pigment cells which absorbs light. It is thin over the posterior two-thirds of the eyeball, but it becomes thick in the anterior part to form the **ciliary body**. The ciliary body is composed of ciliary muscles and ciliary processes. Ciliary processes continuously secrete a fluid called the **aqueous humor**.
- The ciliary body continues forward to form a pigmented and opaque structure called the **iris** which is the visible coloured portion of the eye.
- The eyeball contains a transparent crystalline **lens** which is held in place by **suspensory ligaments** attached to the ciliary body.
- Iris is placed in front of the lens and has an aperture surrounded in the centre called the **pupil**. The diameter of the pupil is regulated by the smooth muscle fibres of iris to control the amount of light entering the eye. Contraction of the **radial muscles** of the iris in **dim light** causes the dilation of the pupils whereas contraction of the **circular muscles** of the iris in **bright light** causes the pupils to constrict.

Previous Year's Question

Photosensitive compound in human eye is made up of:
(1) Guanosine and Retinal
(2) Opsin and Retinal
(3) Opsin and Retinol
(4) Transducin and Retinene

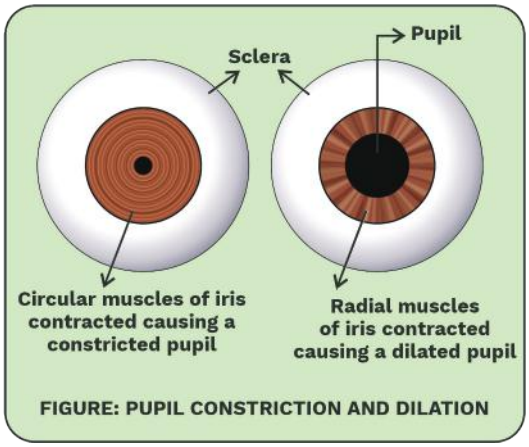


FIGURE: PUPIL CONSTRICTION AND DILATION

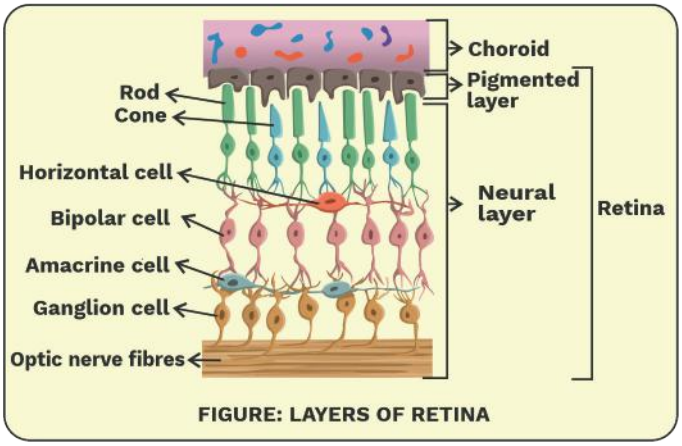


FIGURE: LAYERS OF RETINA

- The inner neural and sensory layer, the **retina,** has three layers of neural cells, namely, **ganglion cells** (inner layer), **bipolar cells** (middle layer), and **photoreceptor cells** (outer layer).
- Rods and cones are the two types of photoreceptor cells present in the retina and consist of the light-sensitive proteins called the photopigments.
- The **rods** impart **twilight** (scotopic) vision to the eyes. They contain a purplish-red photosensitive protein called the **rhodopsin** or visual purple. Rhodopsin is made of a protein called **opsin** and retinene or **retinal** which is an aldehyde of **vitamin A**.
- **Cones** provide the **daylight** (photopic) vision and colour vision to the eyes. In the human eye, there are three types of cones which possess their own characteristic photopigments that respond to **red**, **green**, and **blue** lights. The sensations of different colours are produced by various combinations of these cones and their photopigments. On equal stimulation of all the cone cells, a sensation of **white light** is produced.
- The area of retina where the optic nerve leaves the eye and the retinal blood vessels enter the eye is called **blind spot**. It does not have any rods and cones.
- The area of the retina just opposite to the centre of the cornea, at the posterior pole of the eye,

Rack your Brain

The transplant of cornea in human beings is almost always successful. Why?

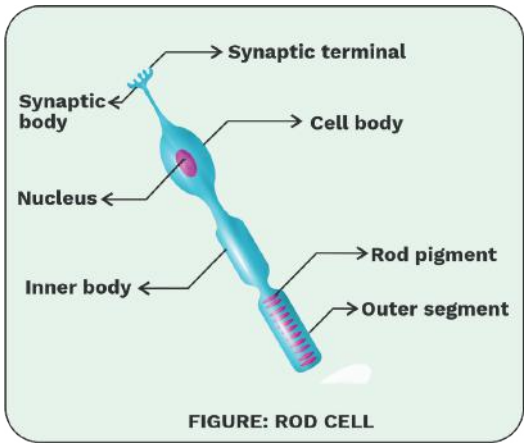


FIGURE: ROD CELL

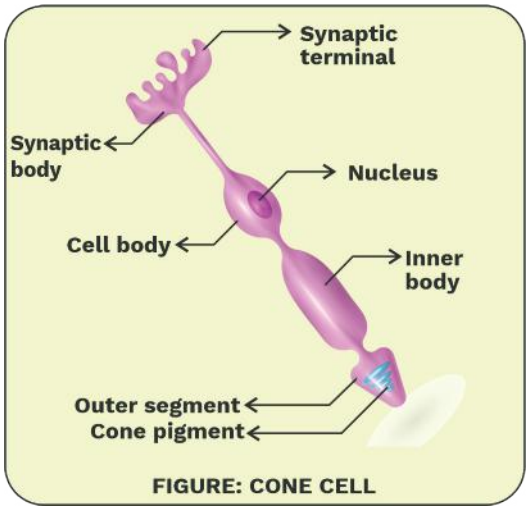


FIGURE: CONE CELL

lateral to the blind spot is a **yellowish spot** called **macula lutea** which has a central pit called the **fovea** (fovea centralis).

- The fovea consists of **only cone** cells as rods and blood vessels are absent in this region. It is the point where the visual acuity (resolution) is the greatest, i.e., it is the place of most **distinct vision**.
- **Aqueous chamber** is the space between the cornea and the lens and is filled with a fluid called **aqueous humor**. It provides nutrition to the lens and the cornea and maintains the shape of the front of the eye.
- **Vitreous chamber** is the space between the lens and the retina and is filled with a transparent gel called **vitreous humor**. If injured, the eye cannot replace vitreous humor.

The aqueous humor and the vitreous humor maintains the intraocular pressure and the shape of the eyeball.

Mechanism of Vision

- The light rays of visible spectrum pass through the **cornea** and the **lens**. From the lens, the light rays are focussed on the **retina**.
- On the retina, light induces **dissociation** of the **retinal** from opsin which results in structural changes in opsin proteins, thereby, changing the membrane permeability of the photoreceptor cells due to which **potential differences** are generated in their membranes.
- This produces a signal that generates action potential in the ganglion cells through the bipolar cells.
- These action potentials (impulses) are transmitted by the **optic nerves** to the **visual cortex** area of the brain, where the neural impulses are analysed, and the image is formed.
- On the basis of earlier memory and experiences, recognition of the formed image takes place.

Previous Year's Question

The posterior part of the retina, which is just opposite to the lens is:
(1) Cornea
(2) Yellow spot
(3) Area centralis
(4) Both (b) and (c)

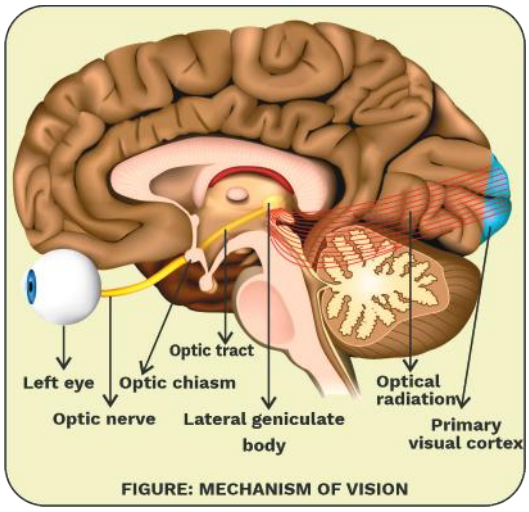


FIGURE: MECHANISM OF VISION

Previous Year's Question

Sensitive pigment layer of eye is:
(1) cornea
(2) retina
(3) sclera
(4) iris

The Human Ear

- Hearing and maintaining body balance are the two sensory functions performed by the human ears.
- Anatomically, the ear consists of three major sections called the outer ear, the middle ear, and the inner ear.
- **Outer Ear**
  - The **outer ear** or the external ear consists of the pinna and external auditory meatus (canal).
  - The **pinna** is an outward projecting elastic cartilage and collects the vibrations in the air which produce sound.
  - The **external auditory meatus** is a tubular canal which is supported by cartilage externally and by bone internally. The skin of the canal is lined by very **fine hair**.

Rack your Brain

Which part of the human ear does not play any role in hearing?

Previous Year's Question

The kind of tissue that forms the supportive structure in our pinna is also found in

(1) Vertebrae
(2) Nails
(3) Ear ossicles
(4) Tip of the nose

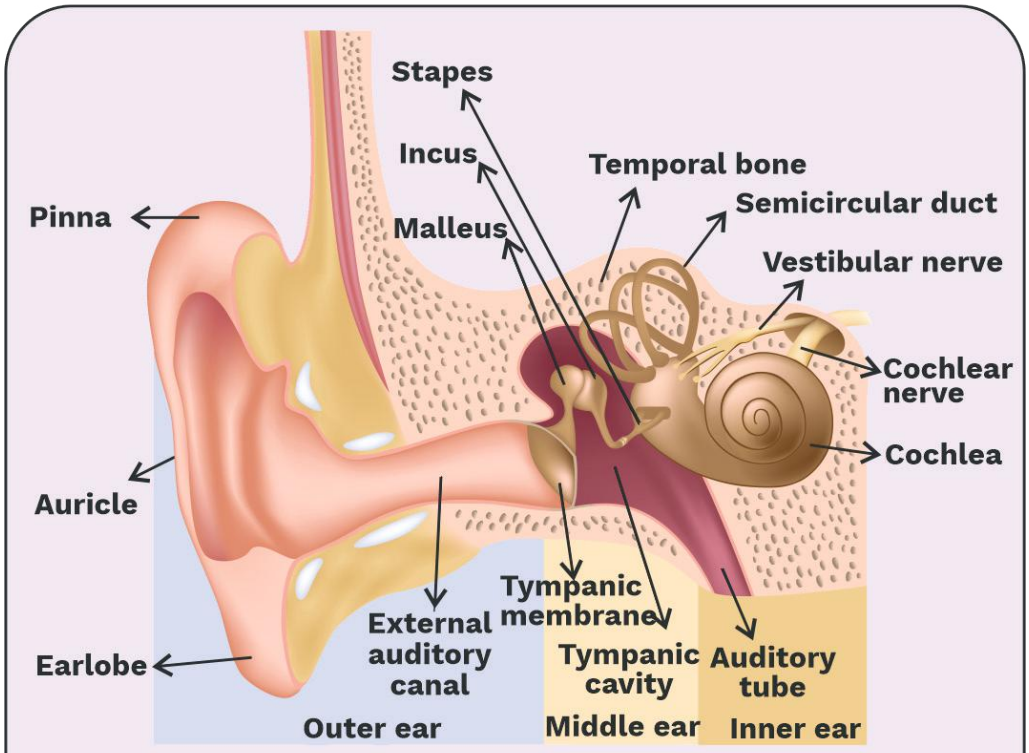


FIGURE: DIAGRAMMATIC VIEW OF EAR

- Some sweat glands in the skin of external auditory meatus modify to become **wax-secreting glands**. They secrete a waxy substance called **cerumen** (ear wax). Hair and cerumen prevent the entry of foreign bodies in the ears.
- The external auditory meatus leads inwards and extends up to the **tympanic membrane** (the ear drum).
- The tympanic membrane or tympanum is thin, almost oval, and semi-transparent. It is composed of connective tissues covered with skin outside and with mucus membrane inside. It separates the tympanic cavity of the middle ear from the external auditory meatus.

- **Middle Ear**
  - The **middle ear** consists of the air-filled tympanic cavity having **three ear ossicles** (bones) called malleus, incus and stapes which are attached to one another in a chain-like fashion.
  - The **malleus** (hammer shaped) is attached to the internal surface of the tympanic membrane on one side and to the **incus** (anvil shaped) on the other side. The incus in turn is connected with the stapes. The **stapes** (stirrup shaped) is attached to the membrane of the oval window (fenestra ovalis) of the cochlea.
  - The ear ossicles increase the efficiency of transmission of sound waves to the inner ear.
  - **Eustachian tube** connects the middle ear cavity with the nasopharynx to equalise the pressures on either side of the ear drum.
- **Inner Ear**
  - The **inner ear** called labyrinth consists of two parts, the bony and the membranous labyrinths. On each side of the head, there is a bony cavity called **bony labyrinth** which is filled by a fluid called the **perilymph**. The bony labyrinth is a series of channels.

Previous Year's Question

Ear drum is known as:
(1) Tympanic membrane
(2) Tensor tympani
(3) Scala tympani
(4) Scala vestibuli

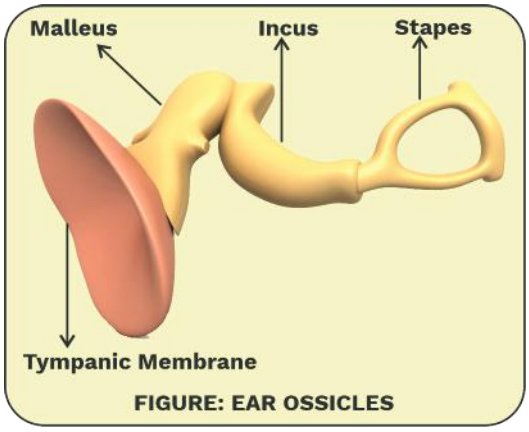


FIGURE: EAR OSSICLES

Previous Year's Question

Scala vestibuli is connected with:
(1) Fenestra rotunda
(2) Fenestra ovalis
(3) Scala tympani
(4) Scala media

- The **membranous labyrinth** floats in the perilymph of the bony labyrinth. The membranous labyrinth is filled with a fluid called **endolymph**.
- Membranous labyrinth has two parts, namely, the vestibular apparatus and the cochlea.
- The **vestibular apparatus** consists of **three semi-circular canals** and an **otolith organ** having two parts, i.e., the saccule and the utricle.
- Each semi-circular canal lies in a different plane at right angles to each other. The membranous canals are suspended in the perilymph of the bony canals.
- The semi-circular ducts bear swollen bases called ampullae. Each **ampulla** has a sensory patch of cells called **crista ampullaris** which consists of **sensory hair cells** and supporting cells.
- The **saccule** and **utricle** contain a sensory projecting ridge called **macula**. The macula also consists of sensory and supporting cells. The hair of the sensory cells of the macula are embedded in a gelatinous membrane called the otolith membrane. This membrane has very small proteinaceous and calcareous particles called **otoliths**.
- The crista and macula are the specific receptors of the vestibular apparatus and are concerned with the balance of the body and maintenance of body posture.
- A sensory **vestibular nerve** arises from the cochlear part of the membranous labyrinth and is concerned with the equilibrium of the body.
- The coiled portion of the membranous labyrinth is called **cochlea**.

- **Cochlea**
  - Cochlea is the main hearing organ. Internally, cochlear membranes, i.e., the Reissner's membrane and basilar membrane divide

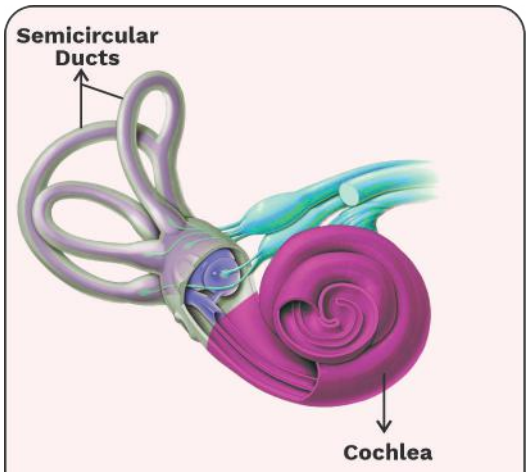


FIGURE: MEMBRANOUS LABYRINTH

Definition

Otolith: An otolith is a structure made of calcium carbonate in the saccule or utricle of the inner ear which help in maintaining the sense of balance.

Previous Year's Question

Cochlea of mammalian internal ear is concerned with:
(1) Smell
(2) Hearing
(3) Taste
(4) Equilibrium

the cochlea into three fluid filled chambers called the upper scala vestibuli, middle scala media (cochlea duct) and the lower scala tympani.

- **Scala vestibuli** and **scala tympani** are filled with perilymph whereas **scala media** is filled with endolymph.
- At the base of the cochlea, the scala vestibuli ends at the oval window (**fenestra ovalis**), while the scala tympani terminates at the round window (**fenestra rotunda**) which opens to the middle ear.
- The upper membrane of the scala media is the **Reissner's membrane** and its lower membrane is the **basilar membrane**.

Previous Year's Question

The perception of sound by a mammal involves the stimulation of the mechano receptors located in the internal ear:
(1) On the organ of Corti
(2) On the Reissner's membrane
(3) In the sacculus
(4) In the semicircular canal

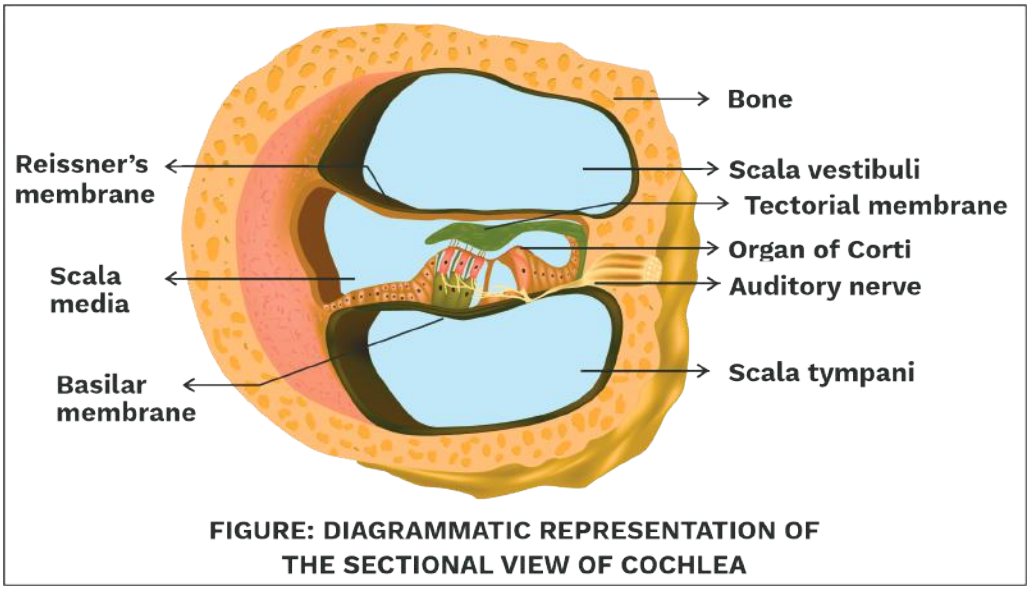


FIGURE: DIAGRAMMATIC REPRESENTATION OF THE SECTIONAL VIEW OF COCHLEA

- The **organ of Corti** is a structure located on the basilar membrane which contains hair cells, pillar cells, tunnel of Corti, cells of Deiters, and supporting cells.
- **Hair cells** act as auditory receptors. The hair cells are present in rows on the internal side of the organ of Corti. The basal ends of the hair cells are in close contact with the

Gray Matter Alert!!!

Vestibular nerve and cochlear nerve joins to form the auditory nerve.

afferent nerve fibres which unite to form the **cochlear nerve**.

- A large number of sensory processes called stereo cilia are projected from the apical part of each hair cells into the scala media.
- Above the rows of the hair cells is a thin elastic membrane called **tectorial membrane**. The tectorial membrane determines the patterns of vibration of sound waves.

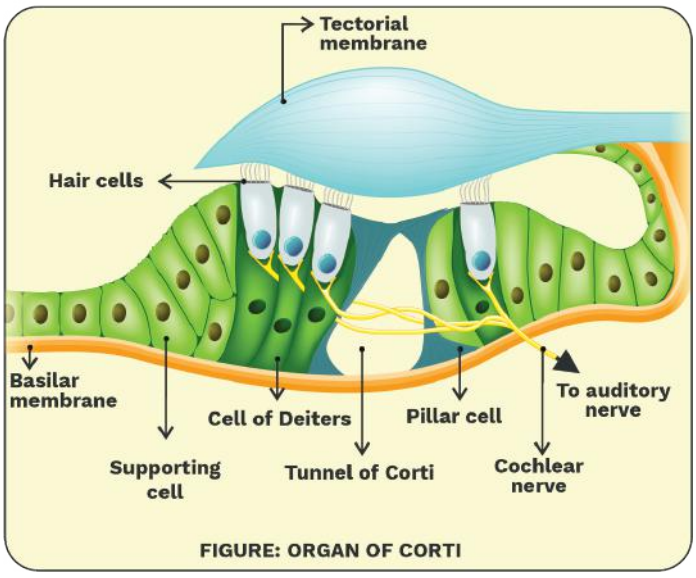


FIGURE: ORGAN OF CORTI

Mechanism of Hearing

- The sound waves are received by the **external ears**. They pass through the **external auditory meatus** and reach the tympanum or the ear drum.
- The **ear drum** vibrates in response to the sound waves and these vibrations are transmitted through the **ear ossicles** (malleus, incus, and stapes) to the oval window (**fenestra ovalis**).
- From the oval window, the sound vibrations are passed on to the fluid of the cochlea, i.e., **perilymph**, where they generate waves.
- The waves from the perilymph first reaches the **scala vestibuli** and then to the **endolymph** of the **scala media** through the Reissner's membrane.

Previous Year's Question

High frequency sound waves vibrate the basilar membrane
(1) Near the oval window
(2) Near the helicotrema
(3) In the middle of cochlea
(4) From oval window to helicotrema

Rack your Brain

Name the membranous structure in the mammalian ear which separates the scala vestibuli and scala media.

Gray Matter Alert!!!

The vibrations of the tympanic membrane are amplified approximately 20 times in the oval window.

- The waves from the endolymph reach the **tectorial membrane** and the **basilar membrane**. The movements of the basilar membrane bend the **hair cells**, pressing them against the tectorial membrane.
- As a result, **nerve impulses** are generated by the hair cells in the associated afferent neurons.
- These impulses are transmitted by the afferent fibres via **auditory nerves** to the temporal lobe of each cerebral hemisphere of the **brain**.
- Analyses of these nerve impulses in the brain causes the recognition of sound.

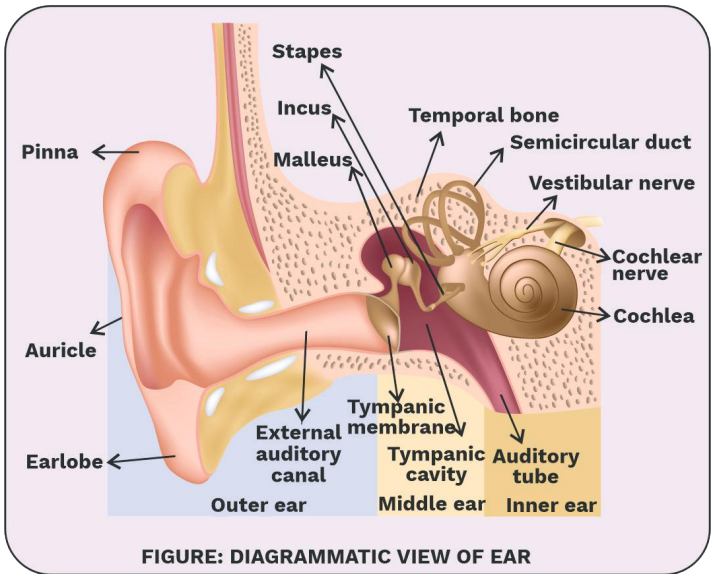


FIGURE: DIAGRAMMATIC VIEW OF EAR

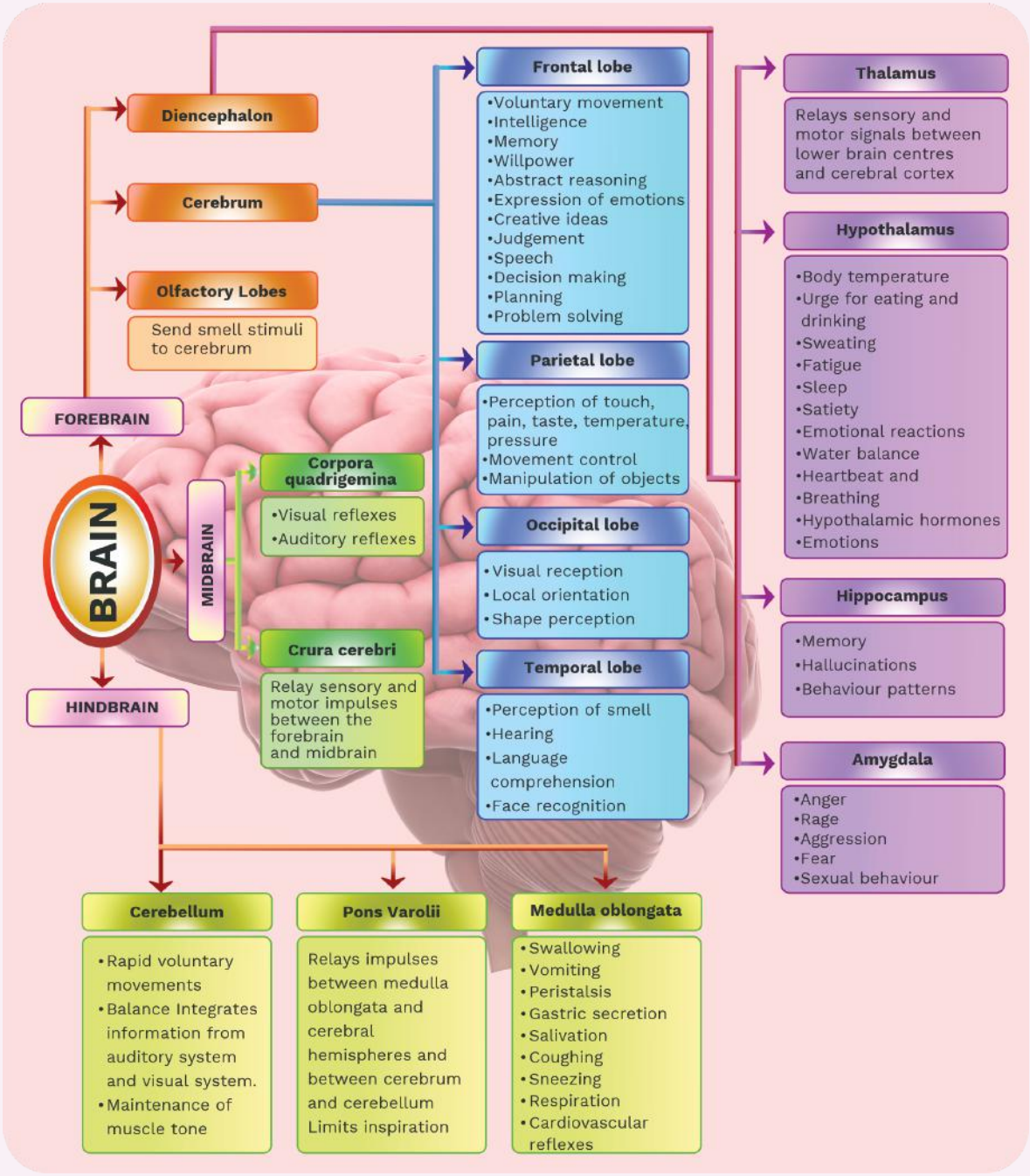
Previous Year's Question

Which of the following nerve supplies organ of Corti?
(1) Auditory
(2) Olfactory
(3) Trochlear
(4) Vagus

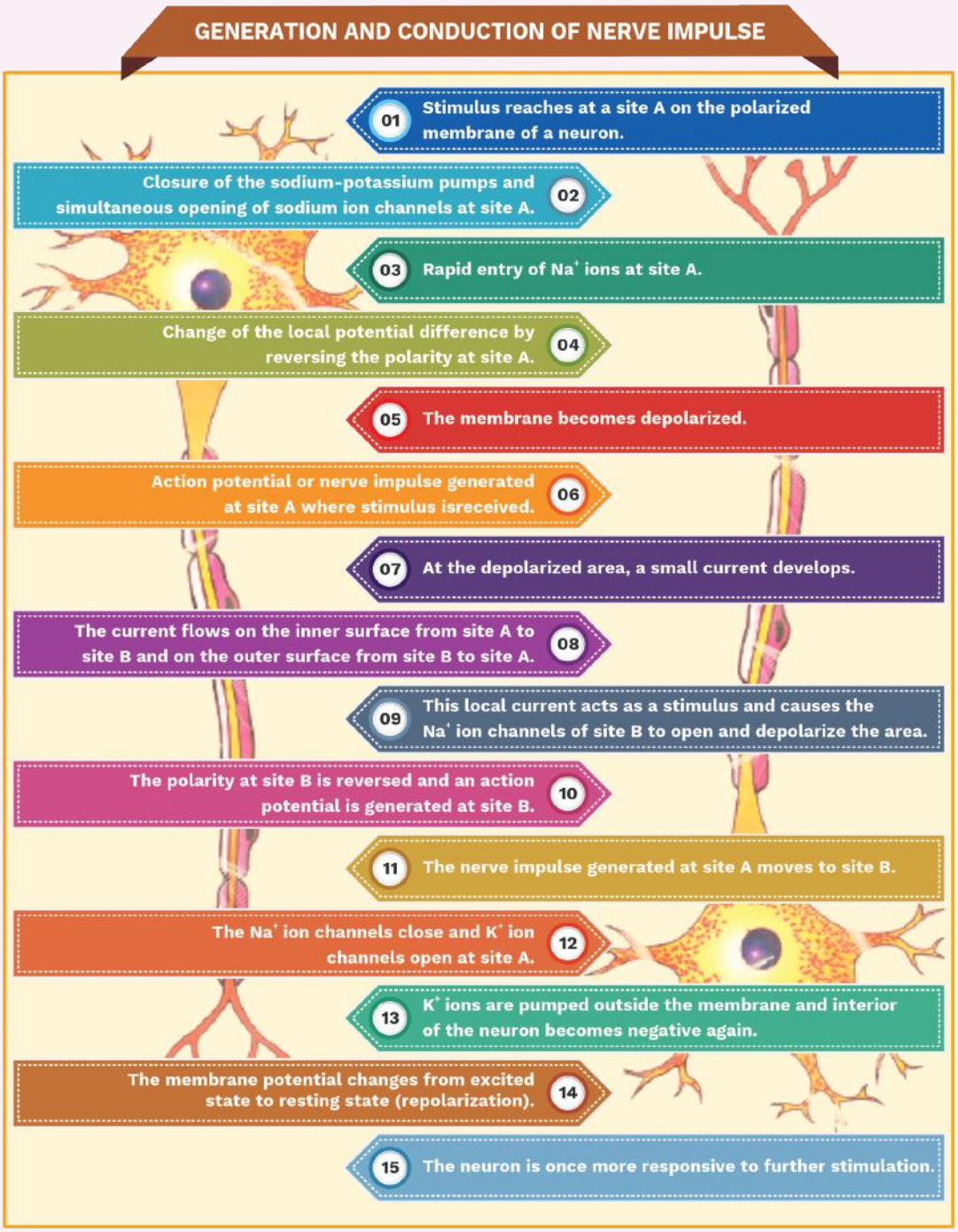
Gray Matter Alert!!!

Human beings can hear sounds in a frequency range from 20Hz to 20kHz.

Summary


BRAIN
FOREBRAIN
Diencephalon
Cerebrum
Olfactory Lobes
Send smell stimuli to cerebrum
MIDBRAIN
Corpora quadrigemina
•Visual reflexes
•Auditory reflexes
Crura cerebri
Relay sensory and motor impulses between the forebrain and midbrain
HINDBRAIN
Frontal lobe
•Voluntary movement
•Intelligence
•Memory
•Willpower
•Abstract reasoning
•Expression of emotions
•Creative ideas
•Judgement
•Speech
•Decision making
•Planning
•Problem solving
Parietal lobe
•Perception of touch, pain, taste, temperature, pressure
•Movement control
•Manipulation of objects
Occipital lobe
•Visual reception
•Local orientation
•Shape perception
Temporal lobe
•Perception of smell
•Hearing
•Language comprehension
•Face recognition
Thalamus
Relays sensory and motor signals between lower brain centres and cerebral cortex
Hypothalamus
•Body temperature
•Urge for eating and drinking
•Sweating
•Fatigue
•Sleep
•Satiety
•Emotional reactions
•Water balance
•Heartbeat and
•Breathing
•Hypothalamic hormones
•Emotions
Hippocampus
•Memory
•Hallucinations
•Behaviour patterns
Amygdala
•Anger
•Rage
•Aggression
•Fear
•Sexual behaviour
Cerebellum
•Rapid voluntary movements
•Balance Integrates information from auditory system and visual system.
•Maintenance of muscle tone
Pons Varolii
Relays impulses between medulla oblongata and cerebral hemispheres and between cerebrum and cerebellum
Limits inspiration
Medulla oblongata
•Swallowing
•Vomiting
•Peristalsis
•Gastric secretion
•Salivation
•Coughing
•Sneezing
•Respiration
•Cardiovascular reflexes

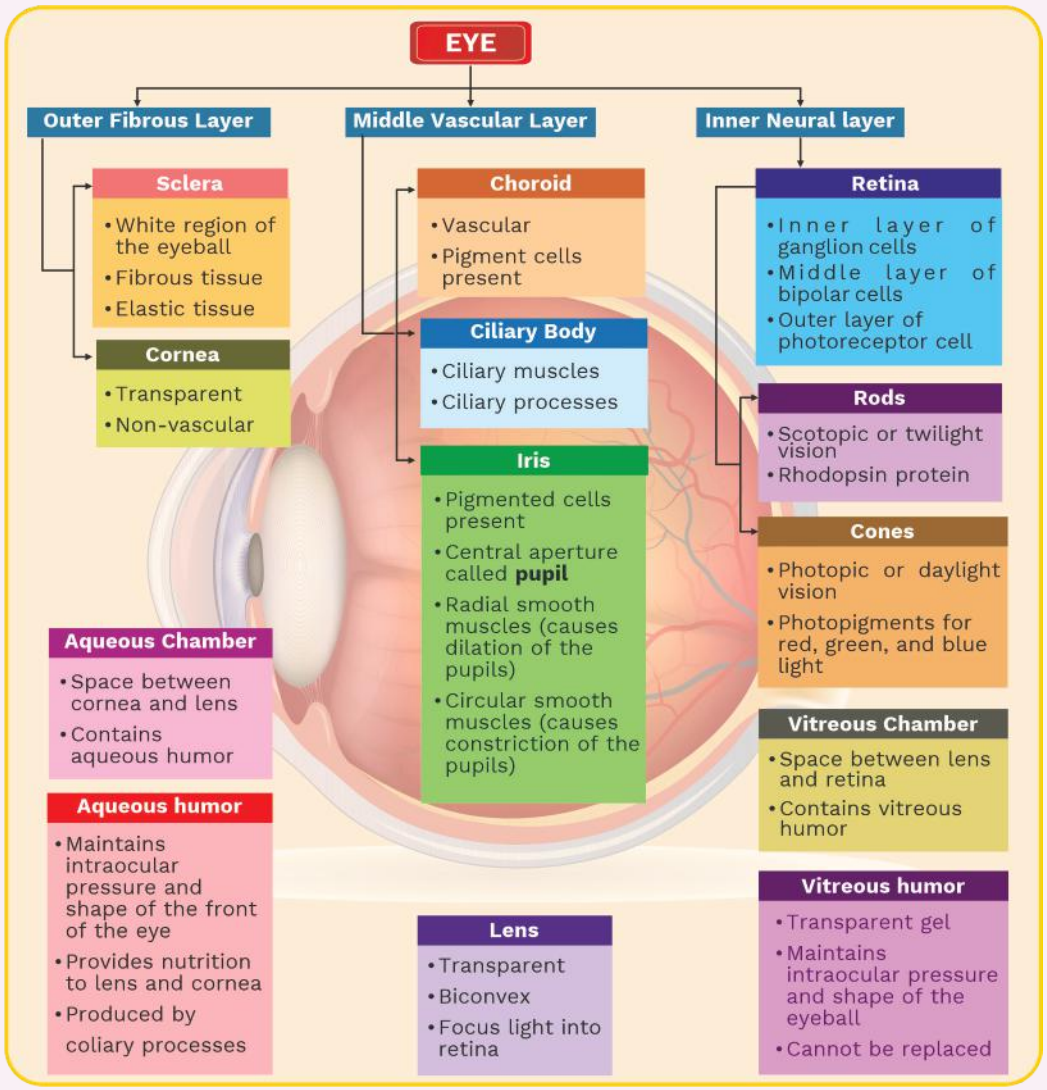
Summary


GENERATION AND CONDUCTION OF NERVE IMPULSE
01 Stimulus reaches at a site A on the polarized membrane of a neuron.
Closure of the sodium-potassium pumps and simultaneous opening of sodium ion channels at site A. 02
03 Rapid entry of Na+ ions at site A.
Change of the local potential difference by reversing the polarity at site A. 04
05 The membrane becomes depolarized.
Action potential or nerve impulse generated at site A where stimulus isreceived. 06
07 At the depolarized area, a small current develops.
The current flows on the inner surface from site A to site B and on the outer surface from site B to site A. 08
09 This local current acts as a stimulus and causes the Na+ ion channels of site B to open and depolarize the area.
The polarity at site B is reversed and an action potential is generated at site B. 10
11 The nerve impulse generated at site A moves to site B.
The Na+ ion channels close and K+ ion channels open at site A. 12
13 K+ ions are pumped outside the membrane and interior of the neuron becomes negative again.
The membrane potential changes from excited state to resting state (repolarization). 14
15 The neuron is once more responsive to further stimulation.

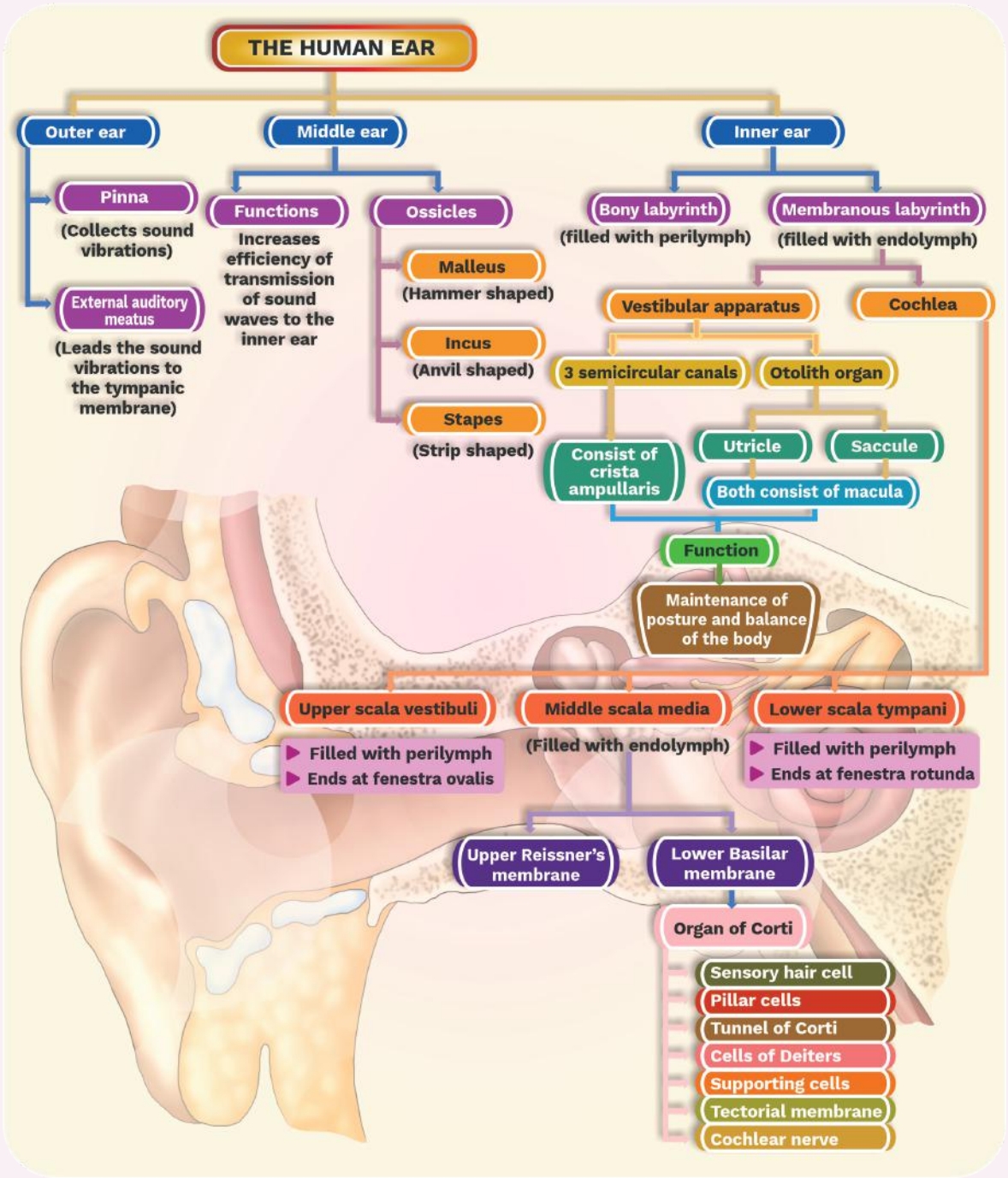
Summary


TRANSMISSION OF IMPULSES BETWEEN TWO NEURONS
01
An action potential (nerve impulse) reaches at the pre-synaptic membrane of the axon terminal of the pre-synaptic neuron.
Voltage gated Ca^{2+} ion channels on the pre-synaptic membrane open.
02
03
The Ca^{2+} ions from the synaptic cleft rush into the presynaptic knob.
Ca^{2+} ions cause the movement of synaptic vesicles towards the pre-synaptic membrane.
04
05
The synaptic vesicles fuses with the pre-synaptic membrane.
Neurotransmitters released in the synaptic cleft.
06
07
Neurotransmitters bind to their specific receptors present on the post-synaptic membrane.
Na^{+} ion channels of the post-synaptic membrane open.
08
09
Na^{+} ions enter the axoplasm of the post synaptic neuron.
A new action potential is generated in the post-synaptic neuron.
10

Summary


EYE
Outer Fibrous Layer
Middle Vascular Layer
Inner Neural layer
Sclera
•White region of the eyeball
•Fibrous tissue
•Elastic tissue
Cornea
•Transparent
•Non-vascular
Choroid
•Vascular
•Pigment cells present
Ciliary Body
•Ciliary muscles
•Ciliary processes
Iris
•Pigmented cells present
•Central aperture called pupil
•Radial smooth muscles (causes dilation of the pupils)
•Circular smooth muscles (causes constriction of the pupils)
Retina
•Inner layer of ganglion cells
•Middle layer of bipolar cells
•Outer layer of photoreceptor cell
Rods
•Scotopic or twilight vision
•Rhodopsin protein
Cones
•Photopic or daylight vision
•Photopigments for red, green, and blue light
Aqueous Chamber
•Space between cornea and lens
•Contains aqueous humor
Aqueous humor
•Maintains intraocular pressure and shape of the front of the eye
•Provides nutrition to lens and cornea
•Produced by coliary processes
Lens
•Transparent
•Biconvex
•Focus light into retina
Vitreous Chamber
•Space between lens and retina
•Contains vitreous humor
Vitreous humor
•Transparent gel
•Maintains intraocular pressure and shape of the eyeball
•Cannot be replaced

Summary


THE HUMAN EAR
Outer ear
Middle ear
Inner ear
Pinna
(Collects sound vibrations)
External auditory meatus
(Leads the sound vibrations to the tympanic membrane)
Functions
Increases efficiency of transmission of sound waves to the inner ear
Ossicles
Malleus
(Hammer shaped)
Incus
(Anvil shaped)
Stapes
(Strip shaped)
Bony labyrinth
(filled with perilymph)
Membranous labyrinth
(filled with endolymph)
Vestibular apparatus
Cochlea
3 semicircular canals
Otolith organ
Consist of crista ampullaris
Utricle
Saccule
Both consist of macula
Function
Maintenance of posture and balance of the body
Upper scala vestibuli
Filled with perilymph
Ends at fenestra ovalis
Middle scala media
(Filled with endolymph)
Lower scala tympani
Filled with perilymph
Ends at fenestra rotunda
Upper Reissner's membrane
Lower Basilar membrane
Organ of Corti
Sensory hair cell
Pillar cells
Tunnel of Corti
Cells of Deiters
Supporting cells
Tectorial membrane
Cochlear nerve

Solved Examples

Q1. **Which of the following animals have a primitive neural system?**
(1) Cockroach
(2) *Hydra*
(3) Shark
(4) Gorilla

A1. (2)
In *Hydra*, all neurons are similar and joined with one another to form a primitive neural system.

Q2. **Choose the incorrect statement from the following options.**
(1) Presence of Nissl's granules in a characteristic feature of neurons of cerebral cortex only.
(2) Fully formed neurons never undergo cell division.
(3) Axon hillock is the part of neuron from where the axon arises.
(4) Schwann cells form myelin sheath around the axon.

A2. (1)
Presence of Nissl's granules is a characteristic feature of all neurons.

Q3. **Cerebrospinal fluid is present in**
(1) Subdural space
(2) Sub-arachnoid space
(3) Epidural space
(4) Below the pia mater

A3. (2)
Cerebrospinal fluid present in the sub-arachnoid space.

Q4. **The left and the right cerebral hemispheres are connected by:**
(1) Fornix
(2) Corpus striatum
(3) Corpus callosum
(4) Olfactory tract

A4. (3)
The left cerebral hemisphere is connected with the right cerebral hemisphere by a large bundle of myelinated fibres called the corpus callosum.

Q5. **Which of the following is called the 'Thermostat' of the body?**
(1) Pituitary gland
(2) Thyroid gland
(3) Adrenal gland
(4) Hypothalamus

A5. (4)
Hypothalamus is also called the 'Thermostat' of the human body.

Q6. **Only cone cells are present in the:**
(1) Retina
(2) Fovea
(3) Blind spot
(4) Vitreous chamber

A6. (2)
Fovea is a thinned-out portion of the retina where only cone cells are present.

Q7. **Select the correct function of sympathetic neural system with respect to the organs it innervates. Sympathetic neural system:**
(1) Slows the heartbeat
(2) Promotes pancreatic secretion
(3) Relaxes the urinary bladder
(4) Constricts the pupils

A7. (3)
Sympathetic Neural System:
- Accelerates the heartbeat.
- Inhibits pancreatic secretion.
- Relaxes the urinary bladder.
- Dilates the pupils.

Q8. **Depolarization of axonal plasma membrane occurs when:**

(1) The outer surface of the membrane becomes negatively charged and the inner side becomes positively charged.

(2) The outer surface of the membrane becomes positively charged and the inner side becomes negatively charged.

(3) The outer surface of the membrane becomes positively charged and the inner side becomes positively charged.

(4) The outer surface of the membrane becomes negatively charged and the inner side becomes negatively charged.

A8. (1)

Depolarization of axonal plasma membrane occurs when the outer surface of the membrane becomes negatively charged and the inner side becomes positively charged.

Q9. **Which of the following is not a part of the brain stem?**

(1) Mid brain

(2) Medulla oblongata

(3) Cerebellum

(4) Pons varolii

A9. (3)

Mid brain, pons varolii, and medulla oblongata make up the brain stem.

Q10. **The middle ear is connected with the inner ear through:**

(1) Fenestra ovalis

(2) Cochlea

(3) Fenestra ovalis and fenestra rotunda

(4) Tympanum

A10. (3)

The middle ear is connected with the inner ear through two small openings called the fenestra ovalis (oval window) and the fenestra rotunda (round window).