

Welcome to



BYJU'S Classes

Neural Control and Coordination



Topics Covered

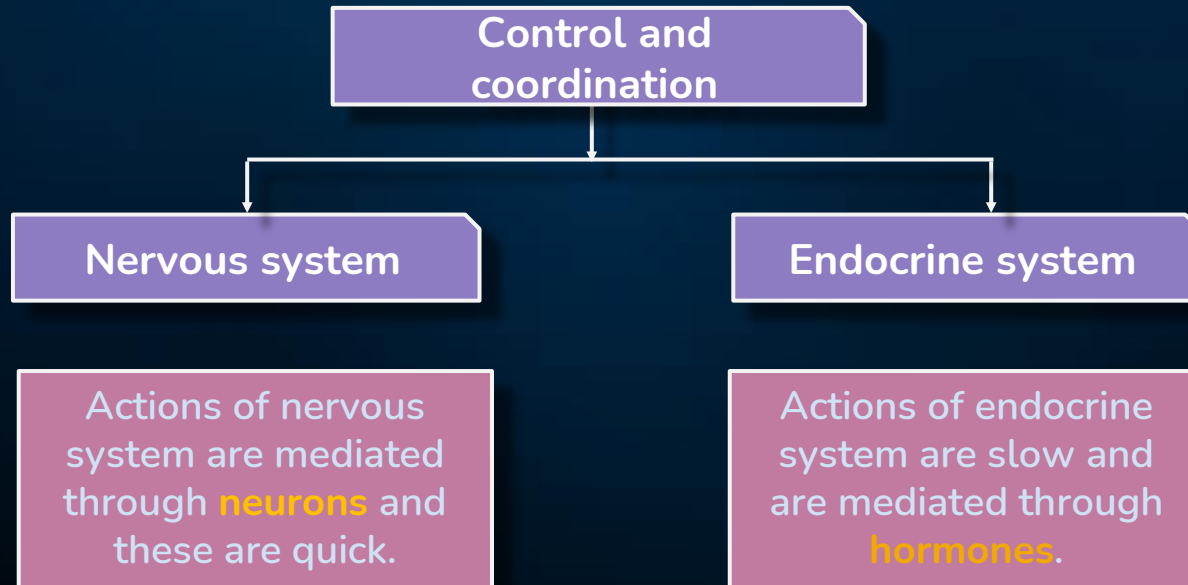


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8. Forebrain
9. Midbrain
10. Hindbrain
11. Sensory Reception and Processing
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Neural System

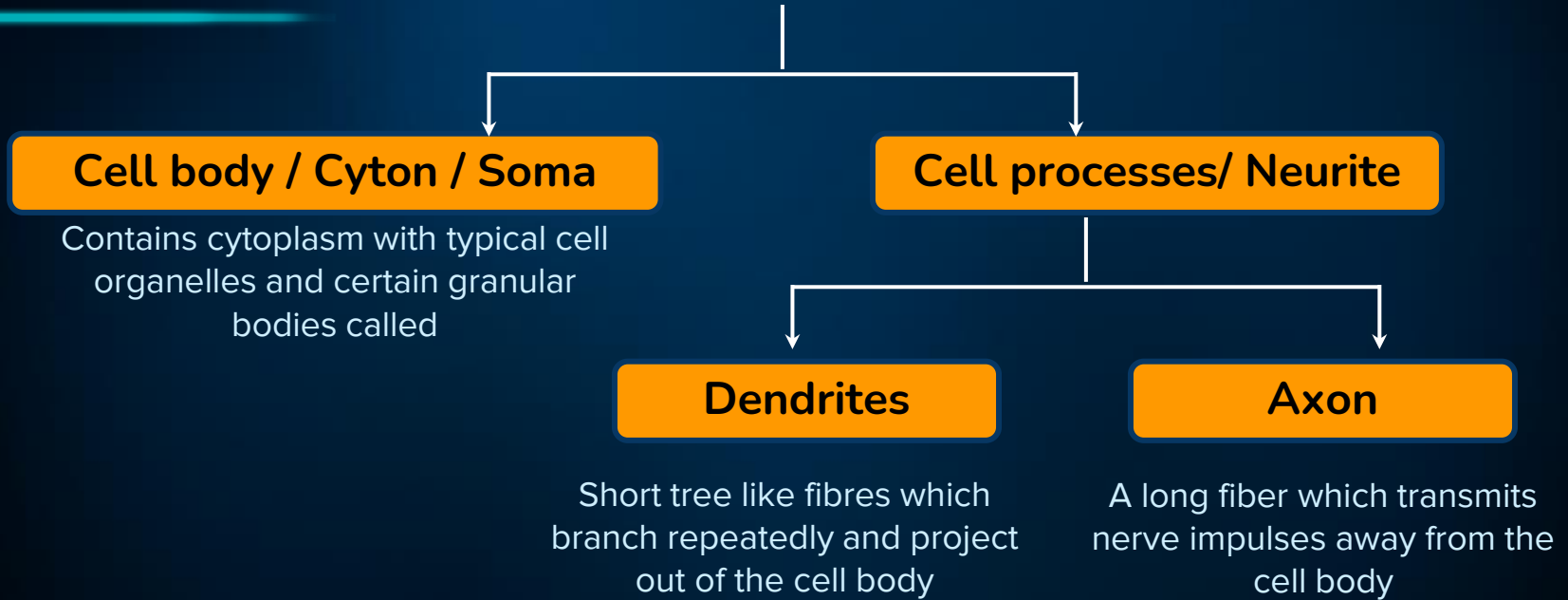
Neural system provides an **organised network of point-to-point connection** for quick coordination.

Endocrine system provides **chemical integration through hormones**.





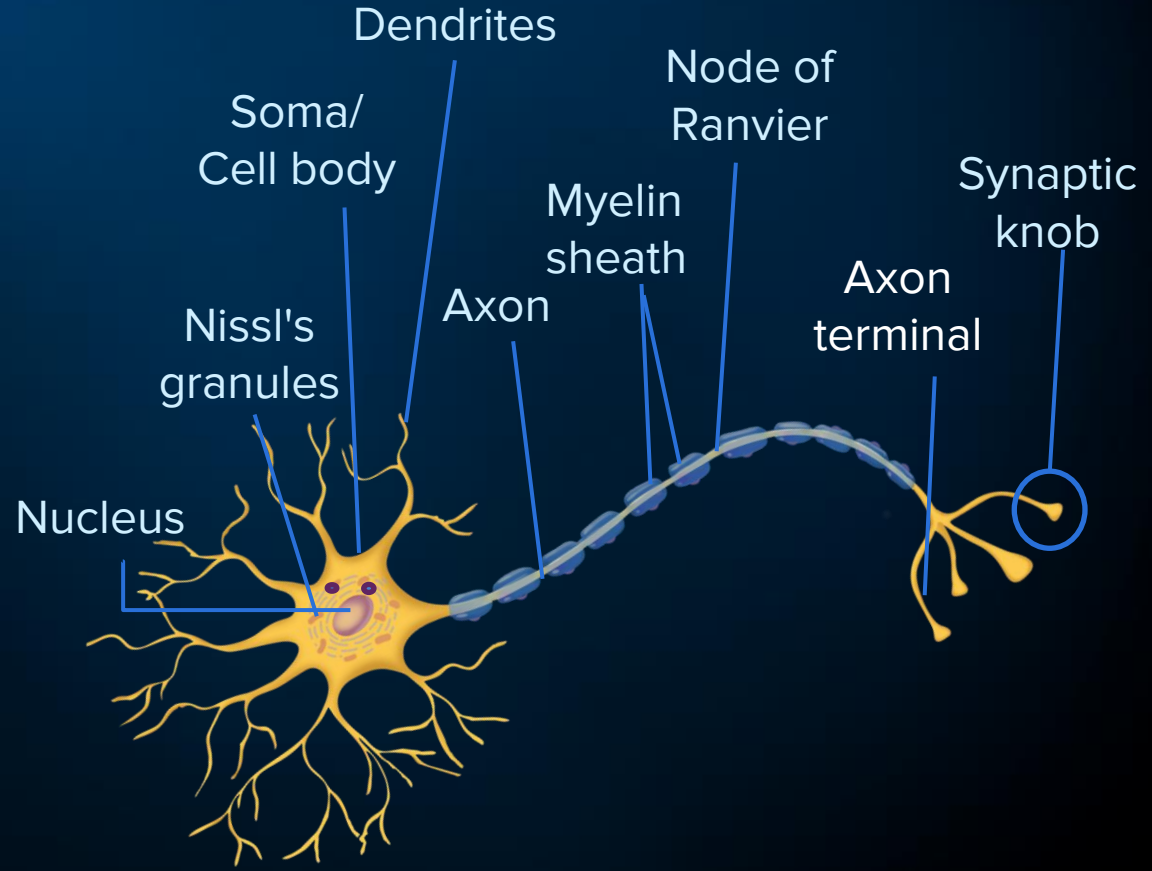
Neurons



- Neurons are the **structural** and **functional unit** of the nervous system.

Neurons

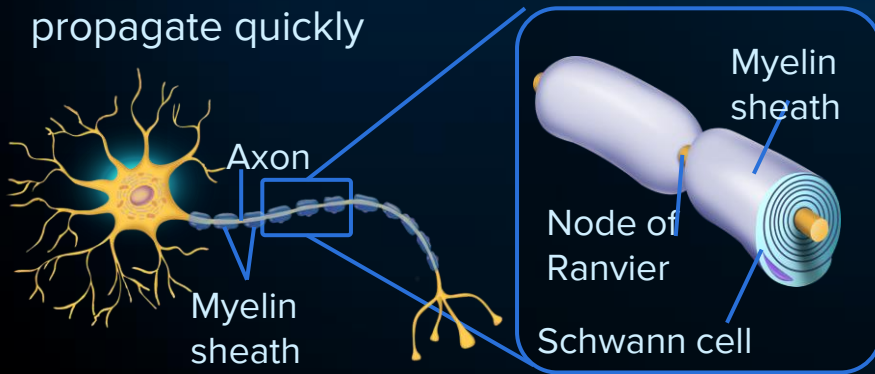
- **Nissl's granules:** Granular bodies
- **Axon:** Each branch terminates into a bulb-like structure called **synaptic knob**
- **Neurotransmitters:** Endogenous chemicals possessed by synaptic vesicles acting as chemical messengers.



Types of Neurons

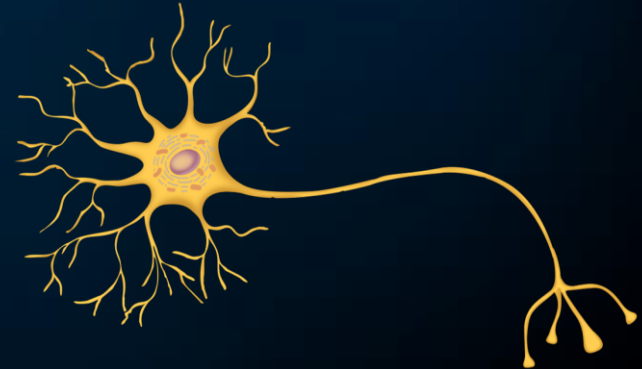
Myelinated axon

- Schwann cells form a myelin sheath around the axon
- Gaps between the adjacent Schwann cells are called **Nodes of Ranvier**
 - **Found in cranial and spinal nerves.**
- Myelin sheath throughout its length is to increase the velocity of electrical signals to propagate quickly



Non-myelinated nerve fibre

- It is enclosed by a Schwann cell which does not form a myelin sheath around the axon
- Conduction of electric impulses in such nerve fibres is slow
- **Commonly found in autonomous and somatic neural systems**

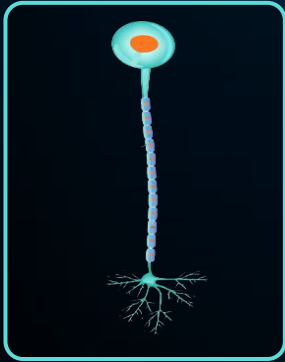




Types of Neurons

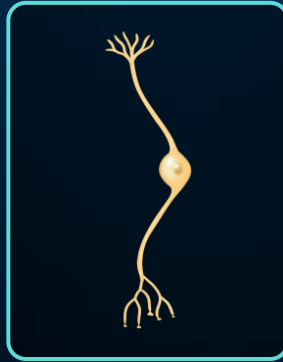
Types of neurons
(Based on the number of axons and dendrites)

Unipolar
(Cell body with one axon only)



- Found usually in the **embryonic stage**

Bipolar
(One axon and one dendrite)

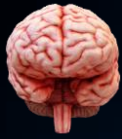


- Found in the **retina of eye**

Multipolar
(one axon and two or more dendrites)



- Found in the **cerebral cortex**



Types of Neurons

Types of neurons (Based on function)

Sensory neurons

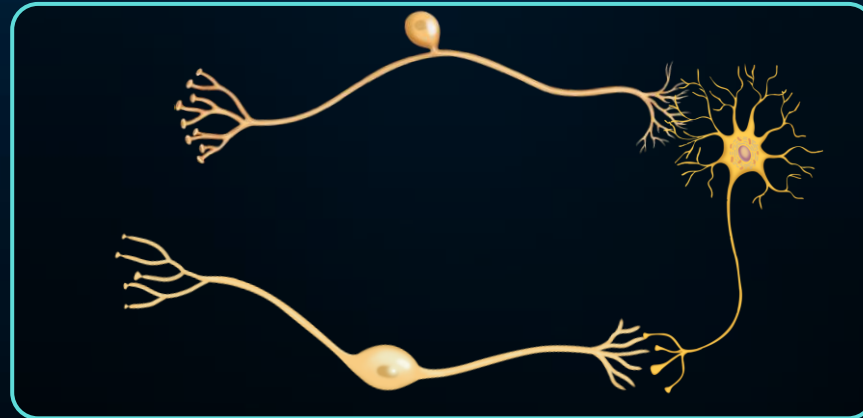
(carry signals from the outer parts of your body (periphery) into the central nervous system)

Motor neurons

(Carry signals from the central nervous system to the outer parts (muscles, skin, glands) of your body)

Interneurons

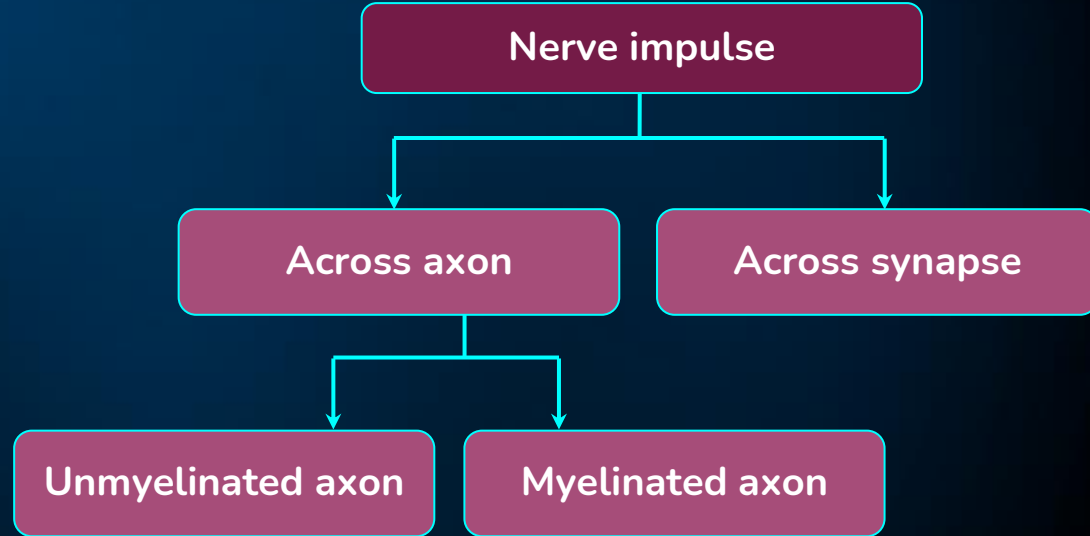
(Connect various neurons within the brain and spinal cord)





Nerve Impulses

- Neurons are excitable cells and its membrane contains different ion channels which are selectively permeable to different ions.
- Nerve impulse is the sum total of various **biochemical/ electrical changes** occurring in a nerve fiber in response to a stimuli.
- Its propagation along the nerve fiber is called **transmission**.





Generation of Nerve Impulse



Ion channels

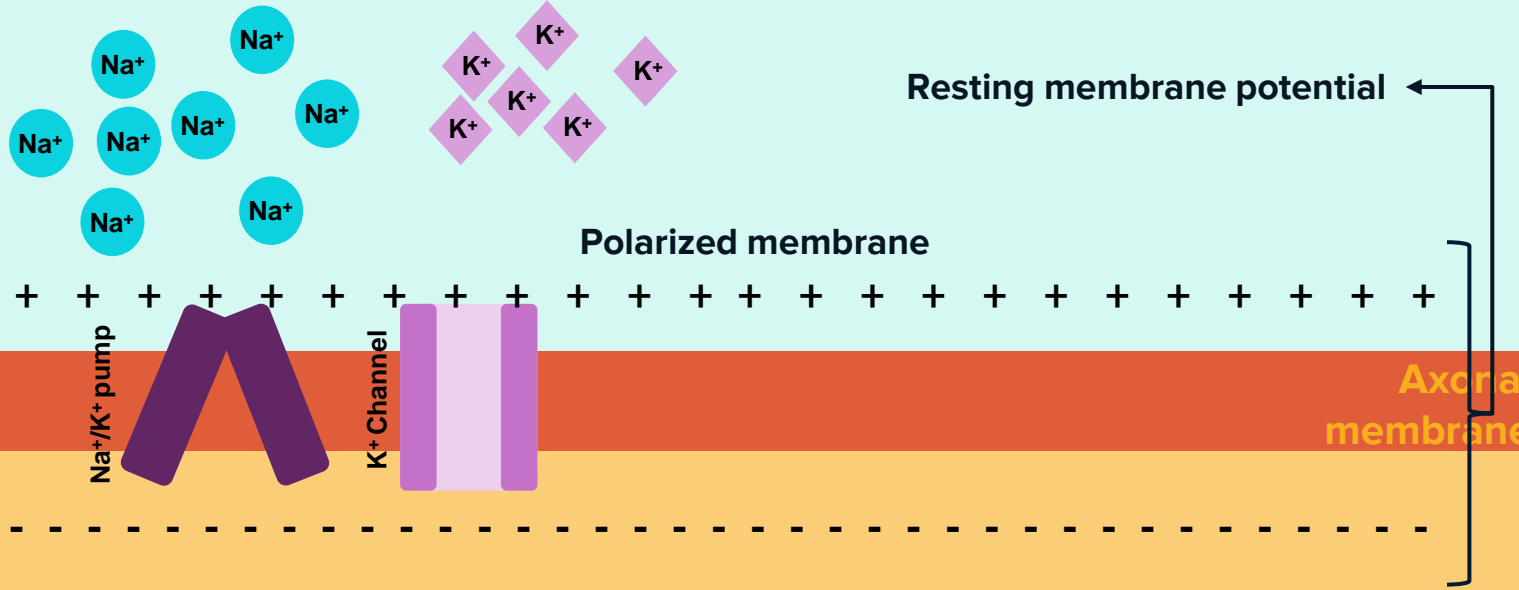
- **Lipid bilayer of axonal membrane** is a good electrical insulator so the main paths for current to flow across the membrane are through the **ion channels**.
- When ion channels are **open**, they allow specific ions to move across the plasma membrane, down their **electrochemical gradient**.
- As ions move, they create a flow of **electrical current** that can change the membrane potential.
- Ion channels open and close due to the presence of “**gates**”.
- The gate is a **part of the channel protein** that can seal the channel pore shut or move aside to open the pore.

Resting Membrane Potential (RMP)

- It exists because of a small **buildup of negative ions** in the cytosol inside of the membrane and an equal buildup of positive ions in the extracellular fluid.
- Such a separation of positive and negative electrical charges is a form of potential energy, which is measured in volts or millivolts.
- In neurons, the resting membrane potential ranges from **-40 to -90 mV**.
- **A typical value is -70 mV.**
- The minus sign indicates that the **inside of the cell is negative** relative to the outside.
- A cell that exhibits a membrane potential is said to be **polarized**.

Resting Membrane Potential (RMP)

Extracellular space



Resting membrane potential

Polarized membrane

Axonal membrane

Na⁺/K⁺ pump

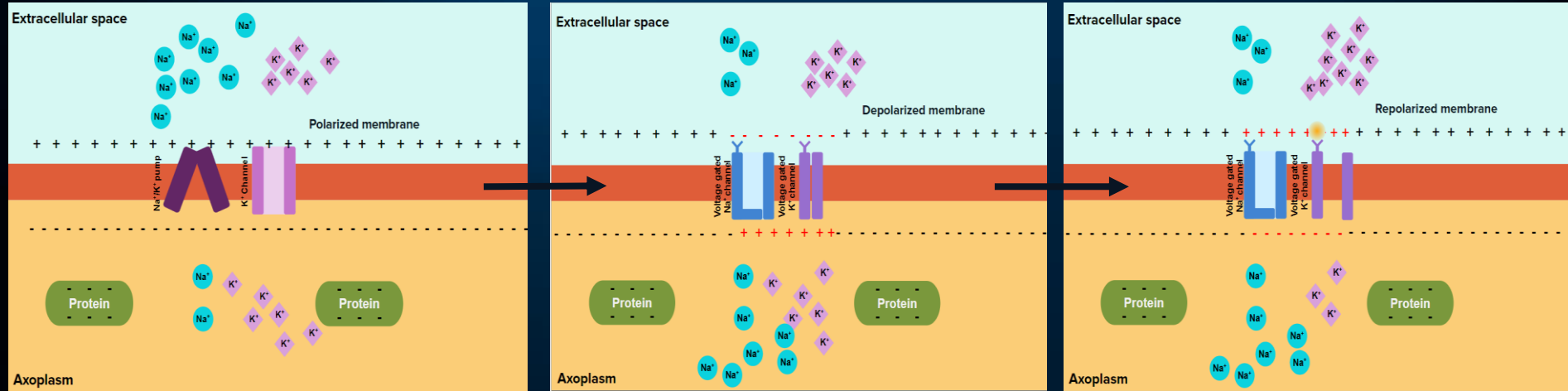
K⁺ Channel

Protein

Protein

Axoplasm

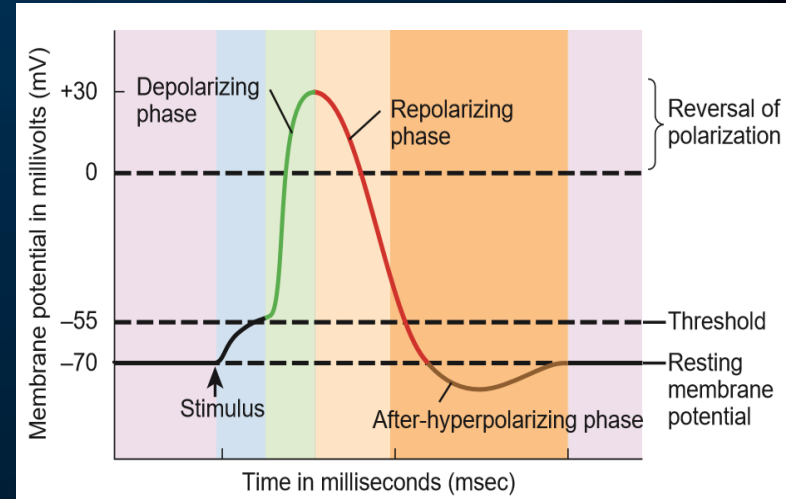
Action Potential



Resting membrane potential

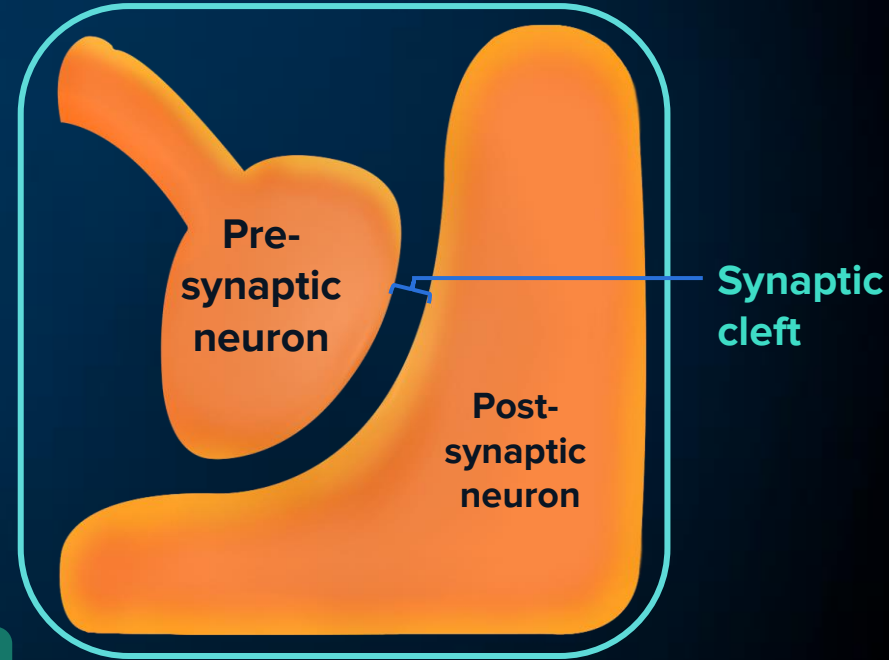
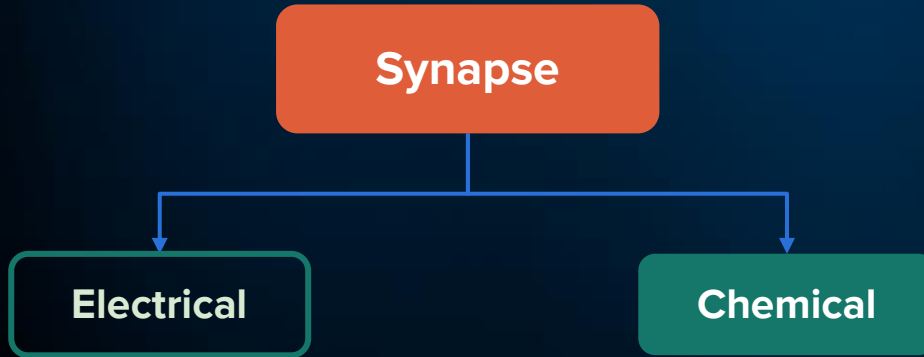
Action Potential

- ❖ An action potential or impulse is a **sequence of rapidly occurring events** that reverse the membrane potential and then eventually restore it to the resting state.
- ❖ An action potential has two main phases:
 - ❖ Depolarizing phase
 - ❖ Repolarizing phase
- ❑ During the **depolarizing phase**, the negative membrane potential becomes less negative, reaches zero, and then becomes positive.
- ❑ During the **repolarizing phase**, the membrane potential is restored to the resting state of -70 mV.
- ❑ Following the repolarizing phase there may be an after-hyperpolarizing phase, during which the membrane potential temporarily becomes more negative than the resting level.



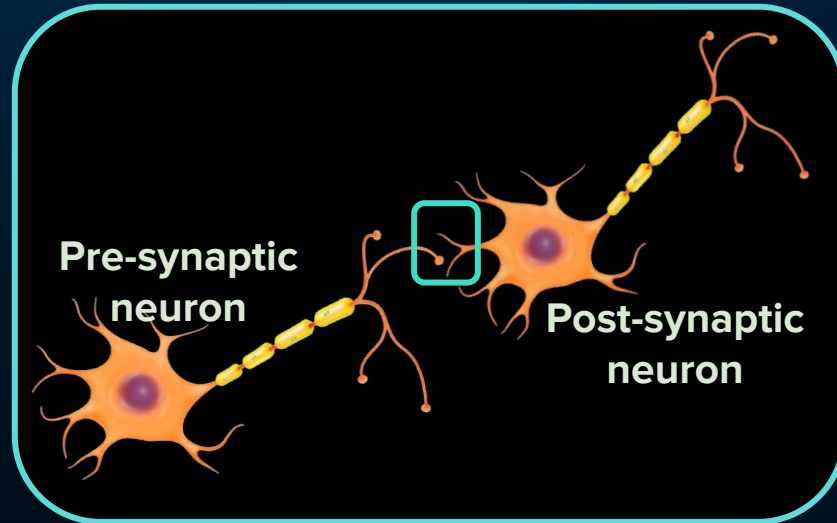
Transmission of Impulse

- A synapse is formed by the membranes of a pre-synaptic neuron and a post-synaptic neuron
- There are two types of Synapse:



Transmission of Impulse

- Neurons communicate with one another at junctions called **synapses**.
- A synapse is formed by the membranes of a pre-synaptic neuron and a post-synaptic neuron.
- Impulse is transmitted from one neuron to another at the synapse.



Types of Transmission

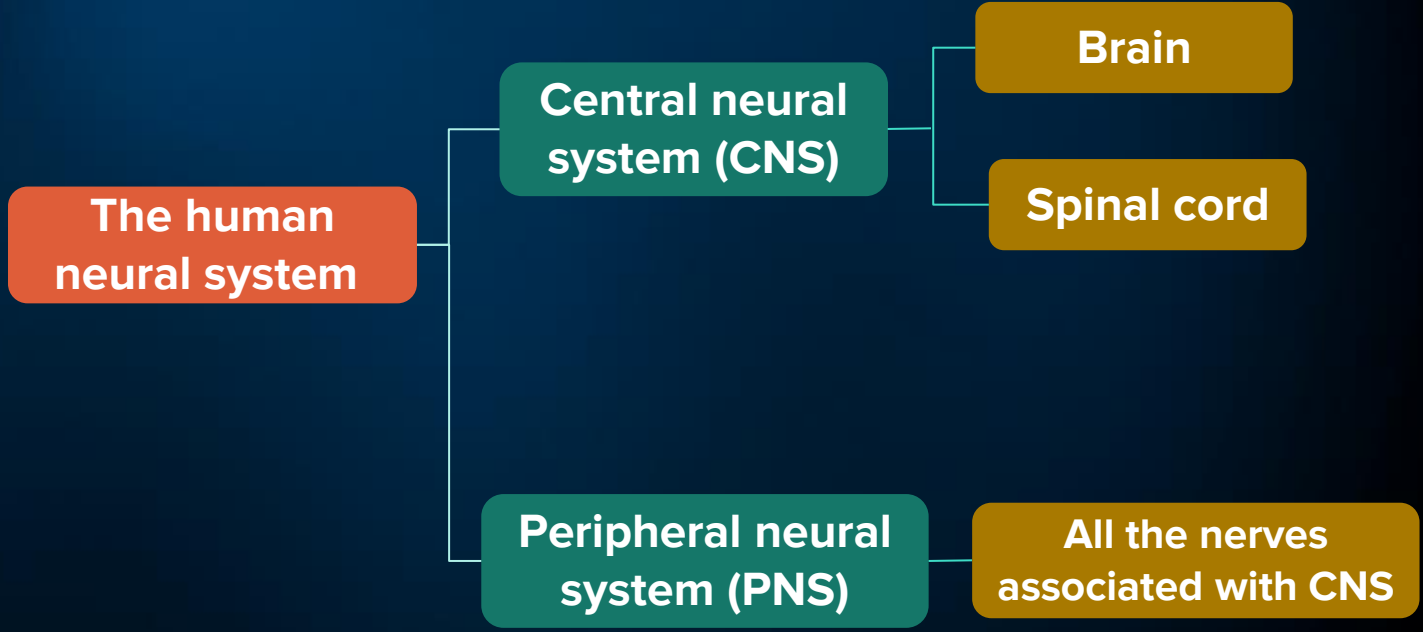
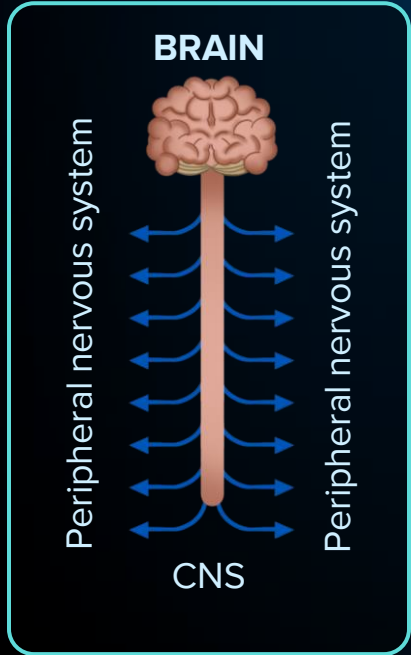


- Pre-and post synaptic neurons are in very **close proximity**.
- Flow of ions occurs directly from one neuron to another.
- Impulse transmission across an electrical synapse is **faster** than chemical synapse.
- Electrical synapses are **rare** in our system.

- Pre-and post synaptic neurons are **separated** and fluid-filled space called **synaptic cleft**.
- Chemical transmission involves release of chemical messengers known as **neurotransmitters**.
- Impulse transmission across a chemical synapse is **slower** than electrical synapse.
- Chemical transmission is **more common**, and more complicated, than electrical transmission.

Human Neural System

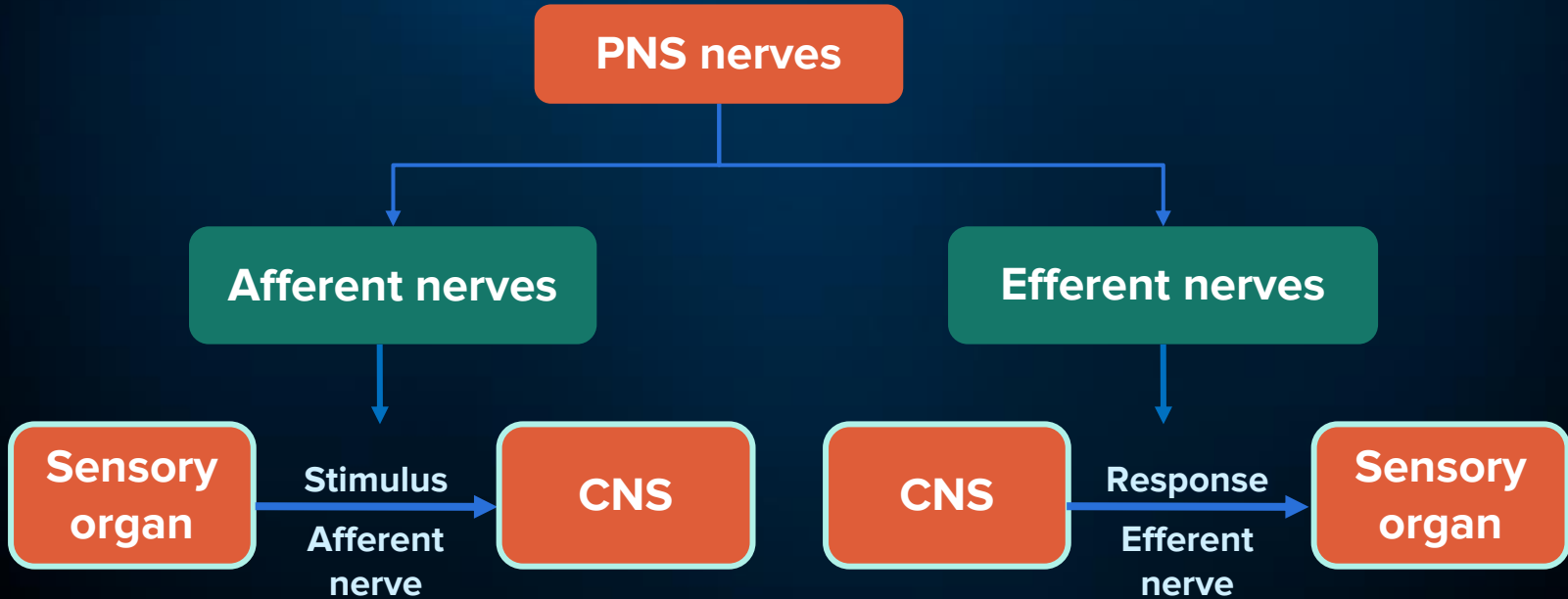
- The human nervous system is divided into two parts





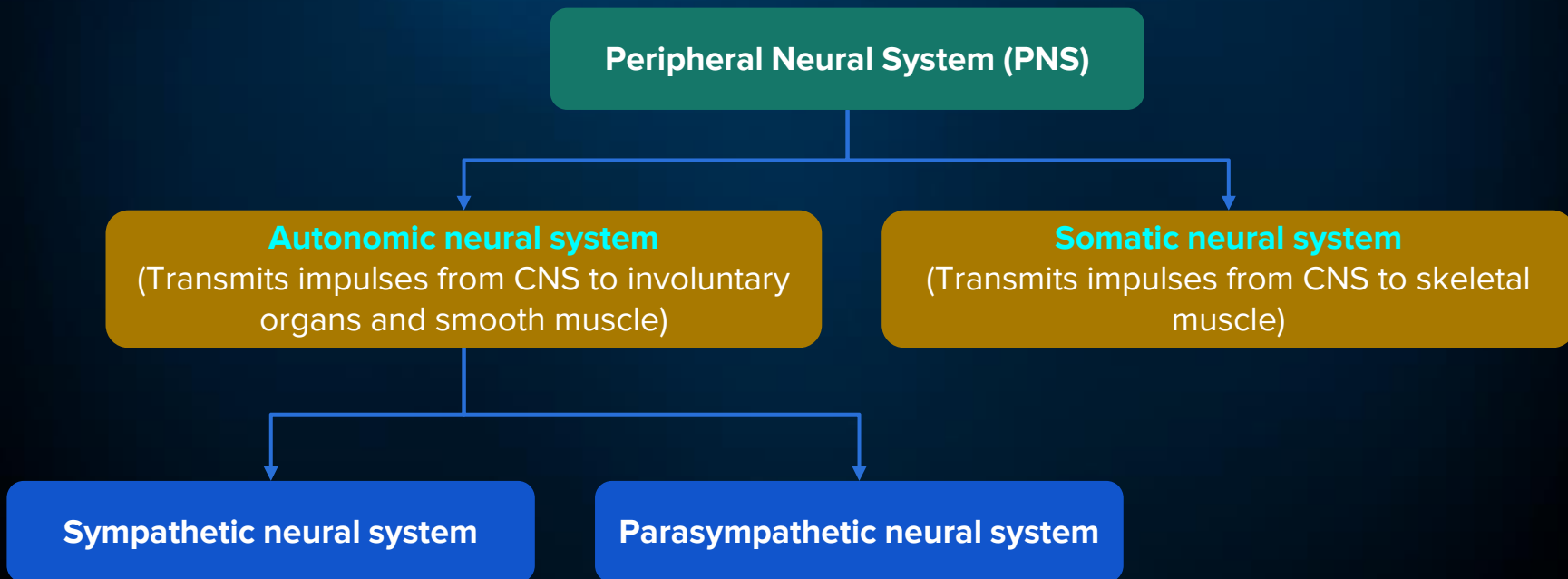
Human Neural System

- The nerve fibres of PNS are divided into types:



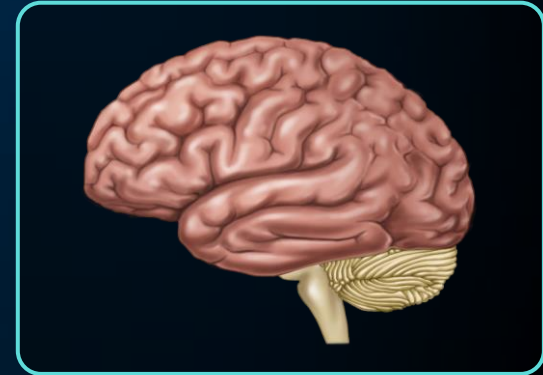
Human Neural System

- PNS is divided into two divisions



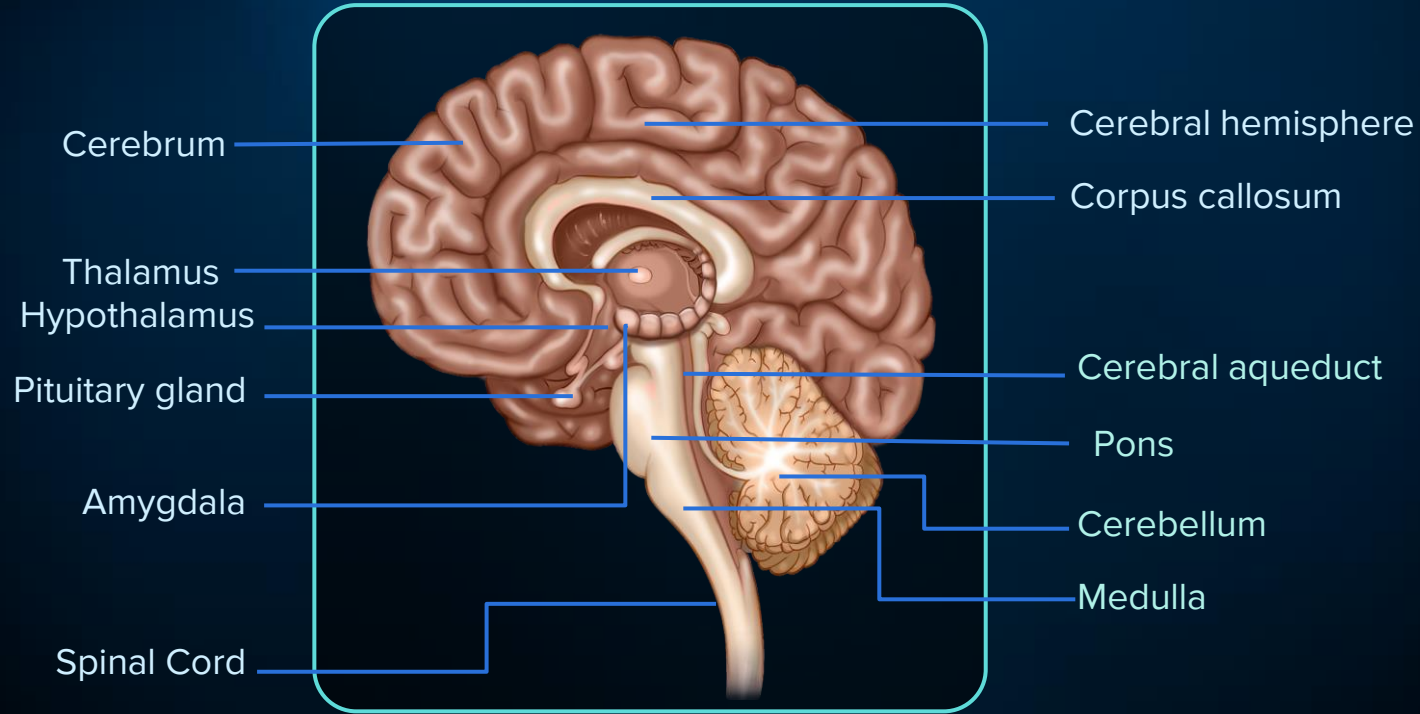
Central Neural System

- **Brain is the central information processing organ**, it controls:
 - Voluntary organs movement
 - balance of the body
 - functioning of vital involuntary organs
 - thermoregulation
 - hunger and thirst
 - circadian (24-hours) rhythms of the body
 - endocrine glands and human behaviours



Central Neural System

● Brain



Central Neural System

- The human **skull** is composed of the bones and cartilage that **surround the brain and make up the upper part of the head.**
- The **purpose of the skull is to protect the brain** and to support and provide structures for the parts of the face.
- Brain and spinal cord are protected and supported by three **meningeal layers.**
 - Protect brain from trauma injury
 - Provide a support system for blood vessels, nerves, cerebrospinal fluids

Meninges

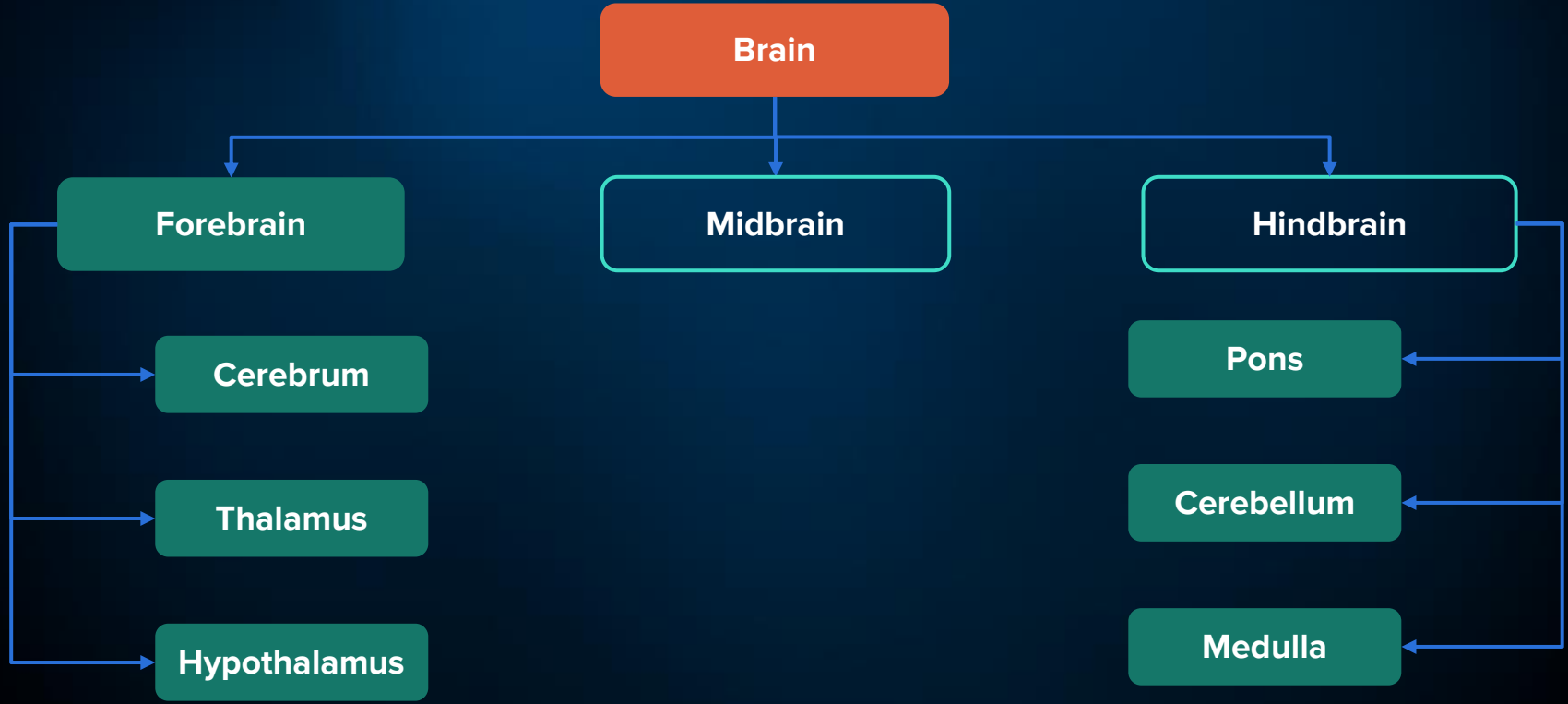
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graph TD; A[Meninges] --> B[Dura mater - outermost, toughest and avascular layer]; A --> C[Arachnoid mater - Thin middle layer, webby in appearance]; A --> D[Pia mater - Innermost, most delicate, has pain receptors and capillaries]
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Dura mater - outermost, toughest and avascular layer

Arachnoid mater - Thin middle layer, webby in appearance

Pia mater - Innermost, most delicate, has pain receptors and capillaries

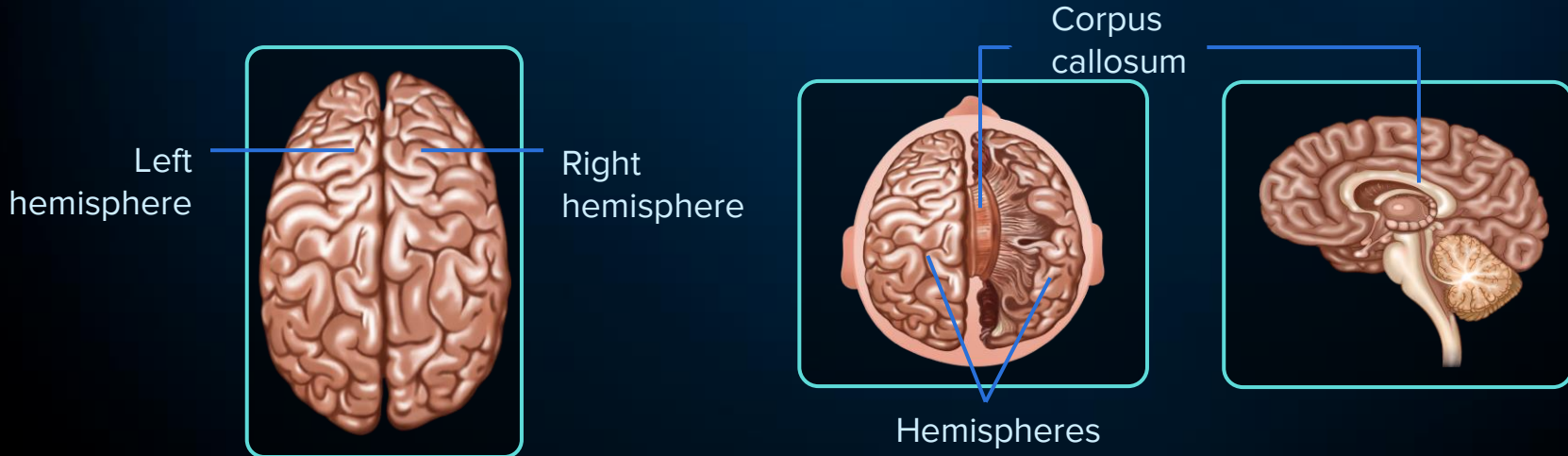
Central Neural System



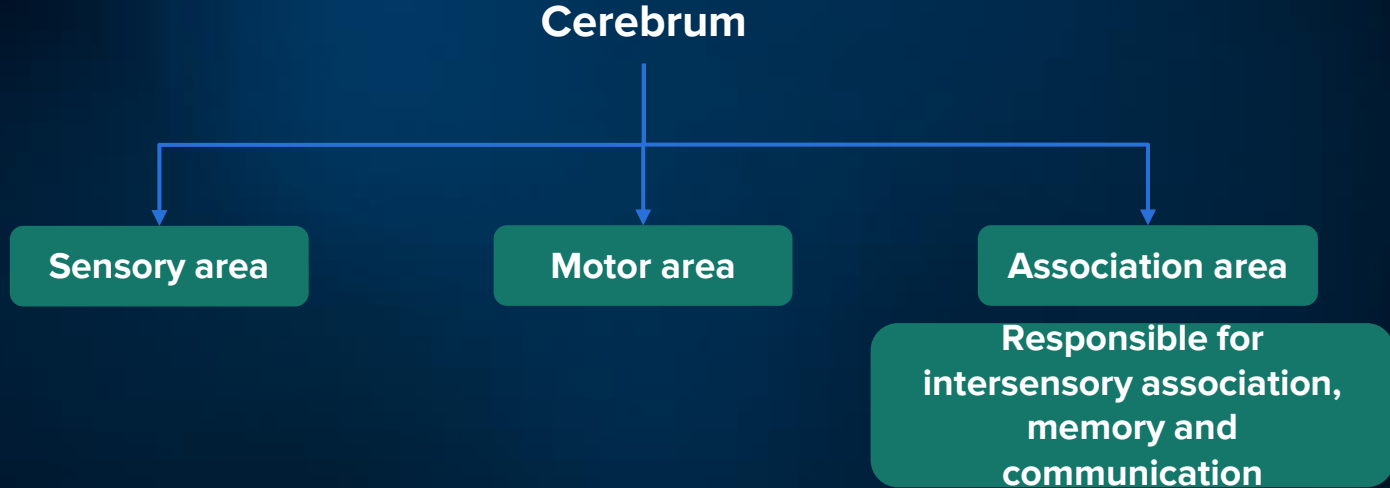
Forebrain

Cerebrum

- Major part of the brain
- Divided into 2 parts - **right** and **left cerebral hemispheres**
- Right and left hemispheres connected by **corpus callosum**
- Corpus callosum is present only in mammals



Forebrain

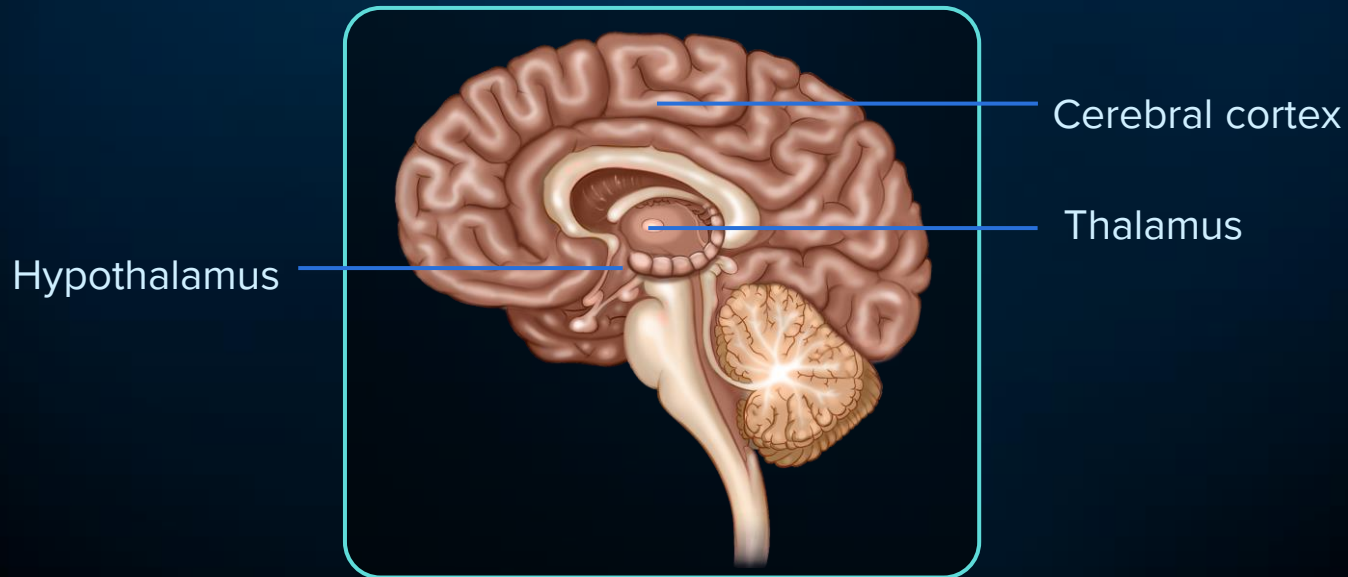


- Outer layer is the **cerebral cortex** and the inner layer is **cerebral medulla**.
- **Grey matter** - Outer layer -neuronal cell bodies
- **White matter** - Inner layer- myelinated axon bodies

Forebrain

Thalamus

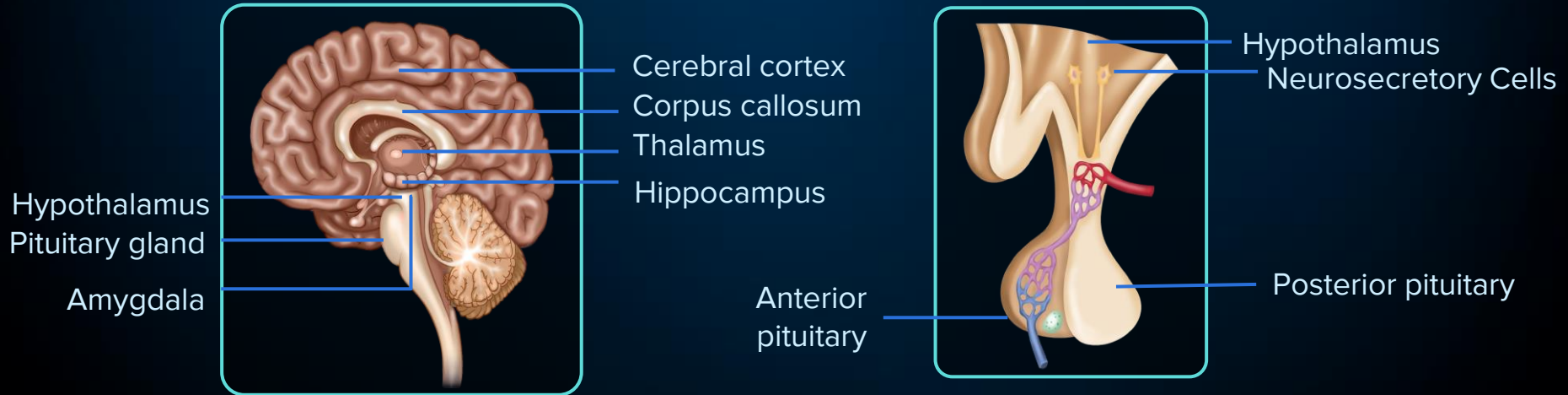
Cerebrum wraps around a structure called thalamus, which is a major coordinating centre or relay centre for sensory and motor signalling.



Forebrain

Hypothalamus

- **Hypothalamus** lies at the base of the thalamus.
- Neurosecretory structure, secretes hormones called hypothalamic hormones.
- Has both neural and endocrine functions



Forebrain

Hypothalamus

- It is highly vascular & regulates behavior essential for survival of species i.e., feeding, fighting, fleeing, mating (sex desire/ libido).
- It has
 - **Hunger centre** (lateral hypothalamus)
 - **Satiety centre** (ventromedial hypothalamus)
 - **Thirst centre**
 - **Osmoregulatory centre**
- It regulates body temperature i.e., it is **thermoregulatory centre**.
- It regulates **emotional reactions**.

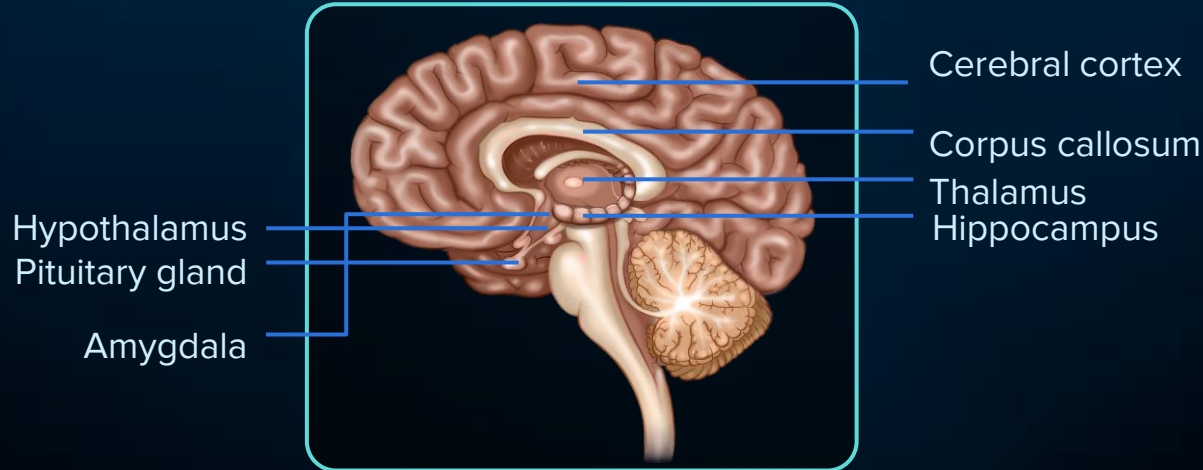
Forebrain

Cerebrum

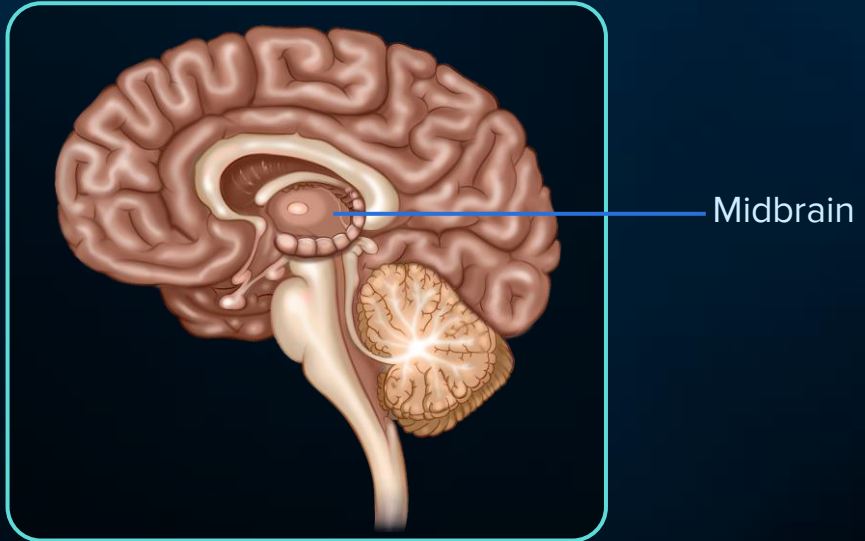
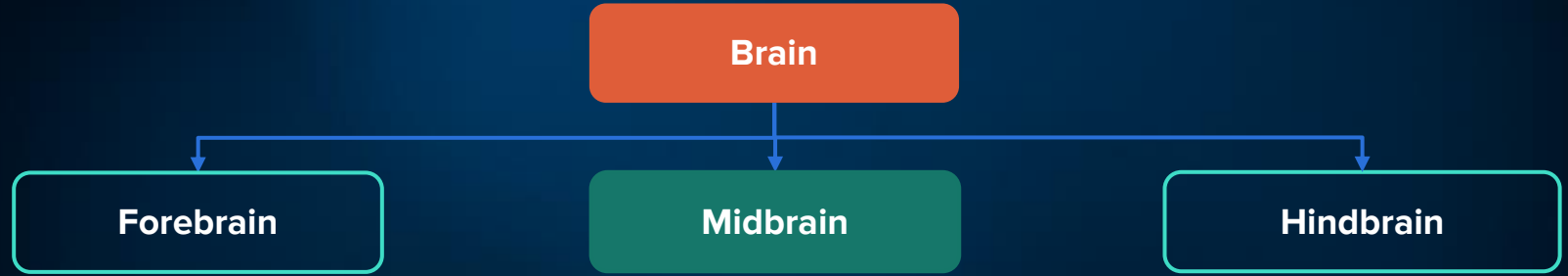
- The inner parts of cerebral hemispheres and a group of associated structures like amygdala, hippocampus form the limbic system or limbic lobe

Limbic System

- The regulation of sexual behaviour, expression of emotional reactions (e.g., excitement, pleasure, rage and fear), and motivation.

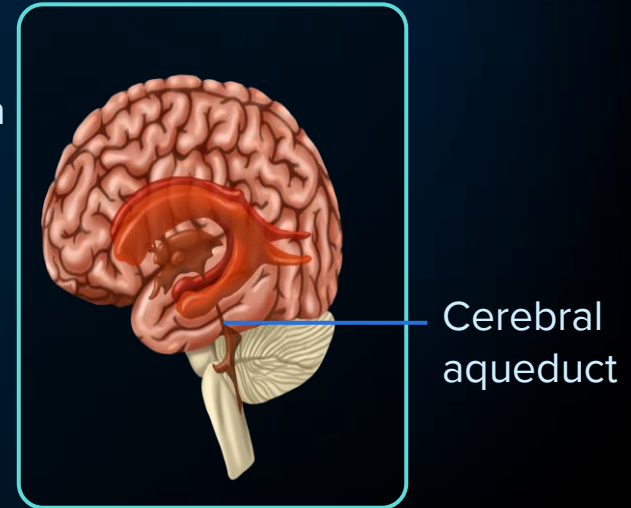
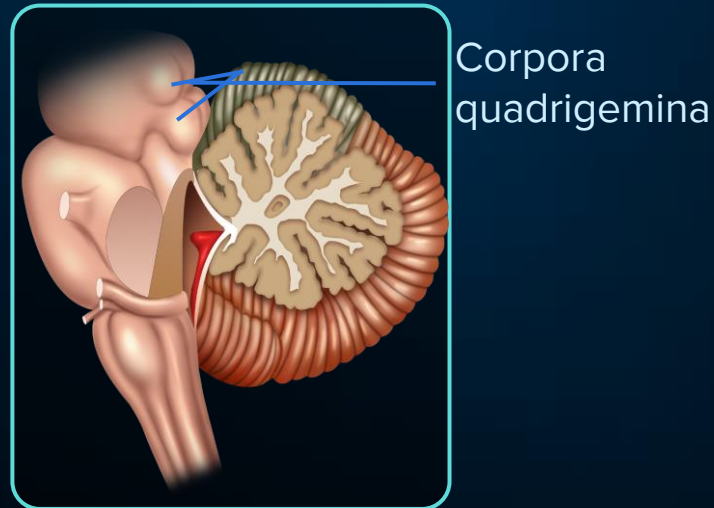
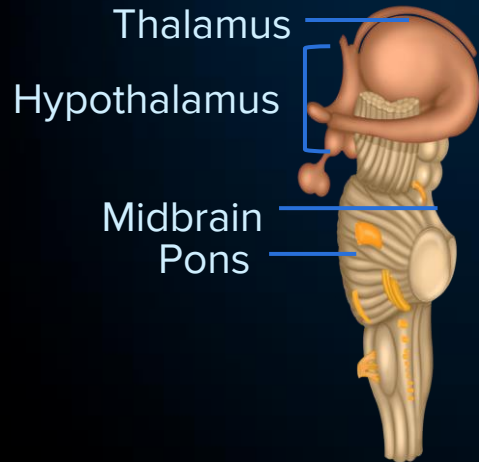


Midbrain

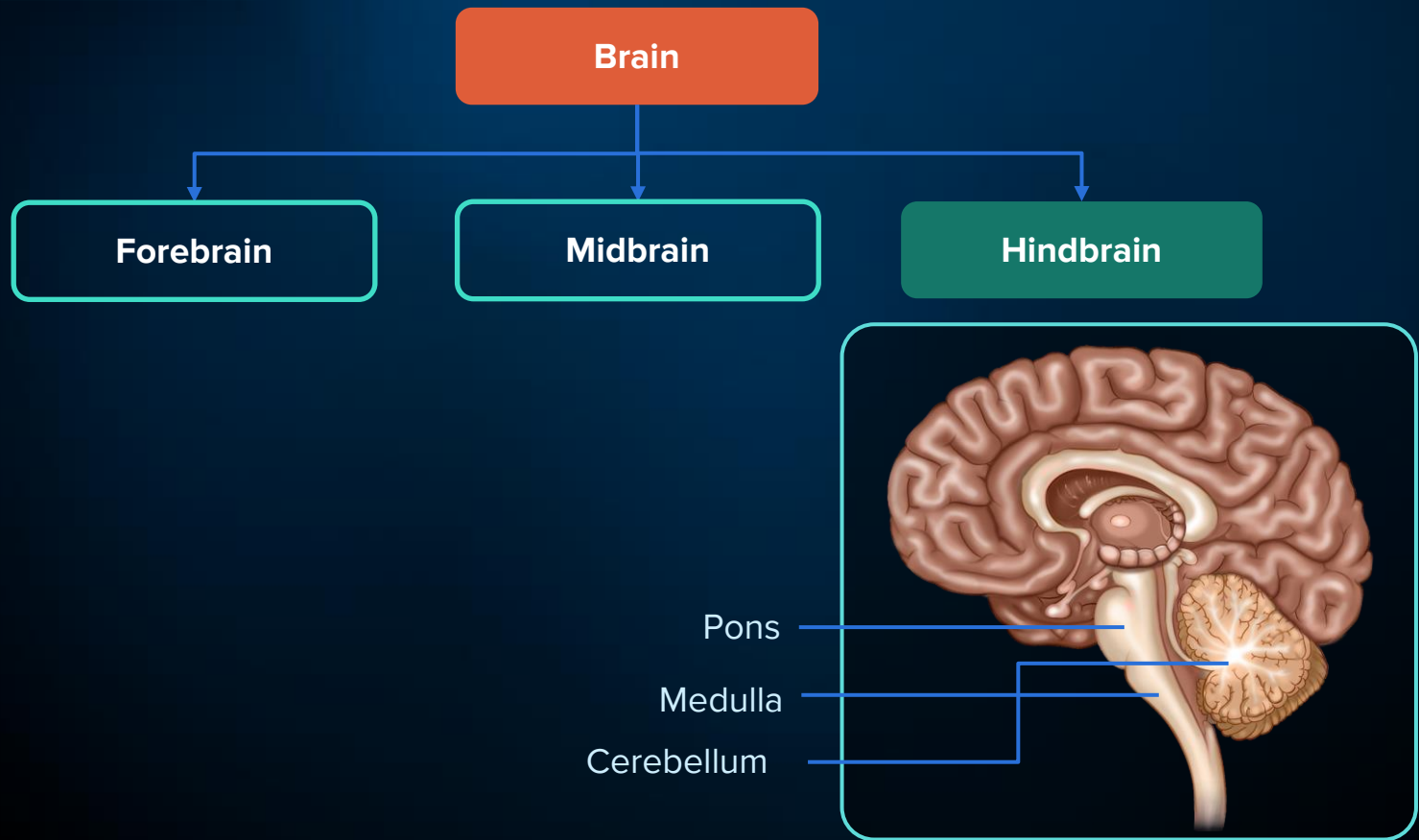


Midbrain

- Located between the **thalamus/hypothalamus** of the forebrain and **pons** of the hindbrain
- The dorsal portion of the midbrain consists mainly of four round swellings (lobes) called **corpora quadrigemina**
- A canal called the **cerebral aqueduct** passes through midbrain
- Contains the cerebrospinal fluid

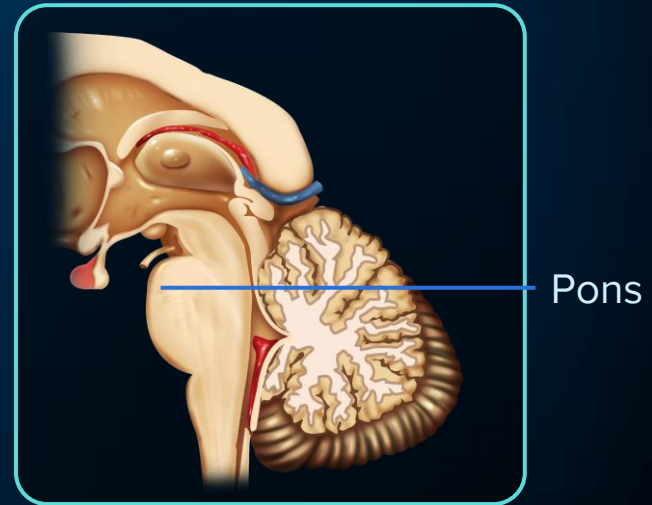


Parts of the Brain



Hindbrain

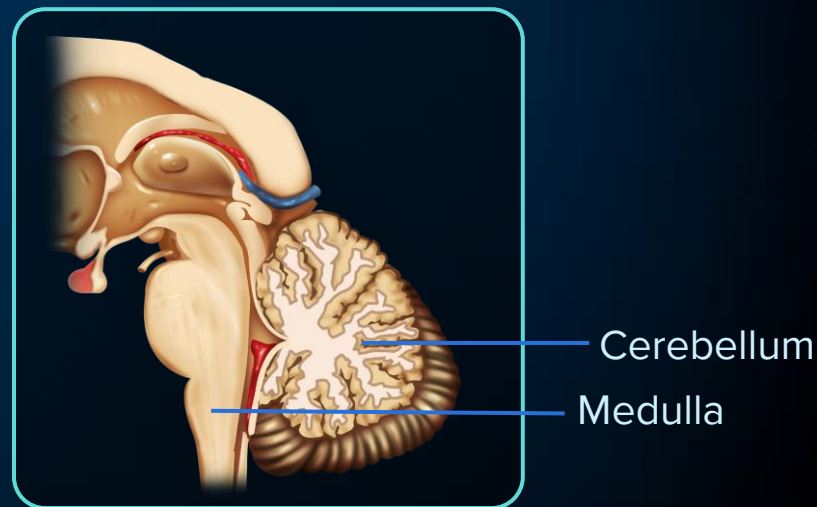
- **Pons connects** different areas of brain.
- It has **apneustic area** and **pneumotaxic area** for **regulating respiration**.
- **Cerebellum** is highly developed in humans for **maintaining equilibrium and erect posture**.
- Its surface is extremely **convoluted** to facilitate more neurons
- **Medulla oblongata** is continuous with superior part of the **spinal cord**.
- It **controls** several vital functions such as **cardiovascular, respiratory and gastric**.



Hindbrain

Cerebellum & Medulla

- Cerebellum is **second largest** part of brain (also called little brain).
- It is highly developed in humans for maintaining
 - **equilibrium**
 - **balance**
 - **erect posture**
- Regions of medulla regulate vital activities including the cardiovascular center and the medullary rhythmicity area.
- The **cardiovascular center** regulates the rate and force of the heartbeat and the diameter of blood vessels.
- The **medullary rhythmicity area** of the **respiratory center** adjusts the basic rhythm of breathing.



Hindbrain

- Midbrain and parts of hindbrain like pons and medulla form the brainstem

Vomiting

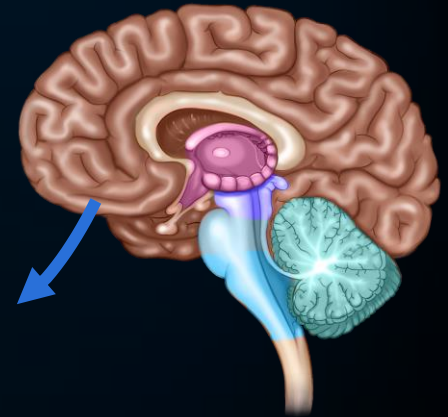
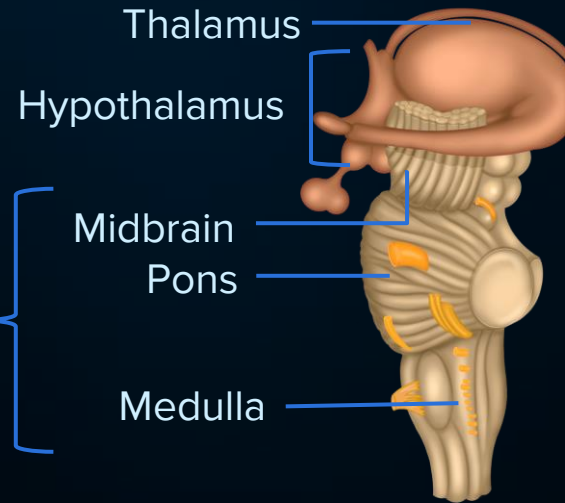
Swallowing

Sneezing

Coughing

Hiccupping

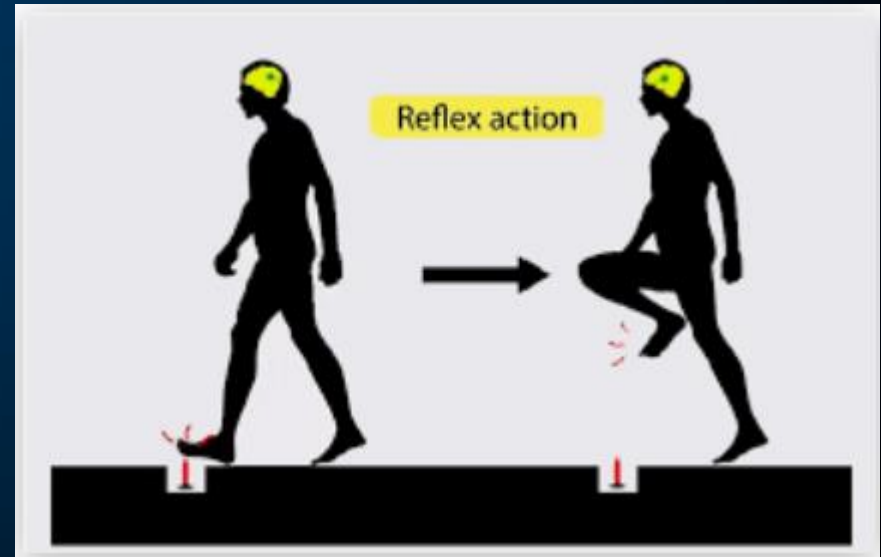
Brain
stem





Reflex Action and Reflex Arc

- Reflex action is the process of spontaneous response to a stimulus without intervention of will
- Automatic mechanical response in response to the stimulus
- Response to **peripheral nervous stimulation**
- Requires involvement of a **part of CNS**





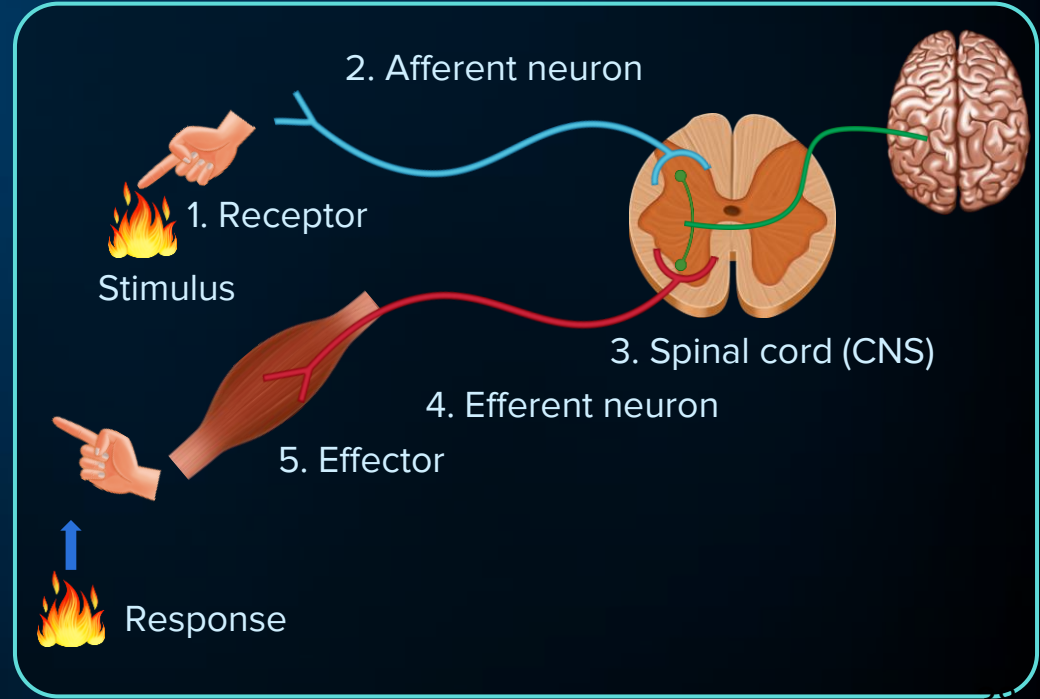
Reflex Action- Mechanism

Reflex arc:

It is the nerve pathway or chain, between the receptor and the effector organ, which controls a reflex.

Reflex action:

The process of spontaneous response to a peripheral nervous stimulation that occurs without intervention of will and requires a part of CNS (spinal cord and brain).



Reflex arc



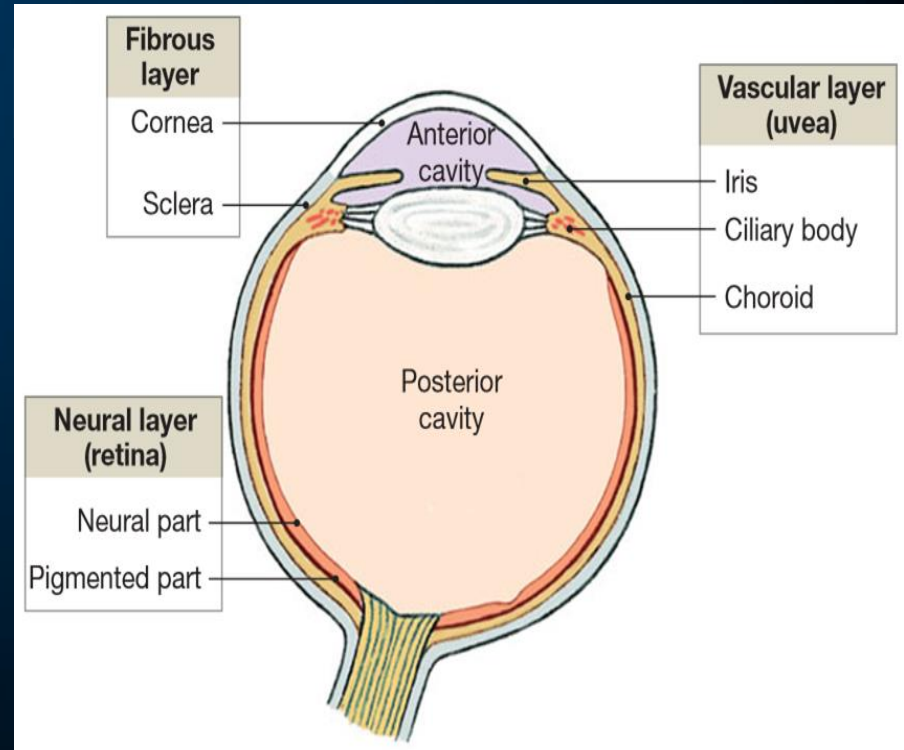
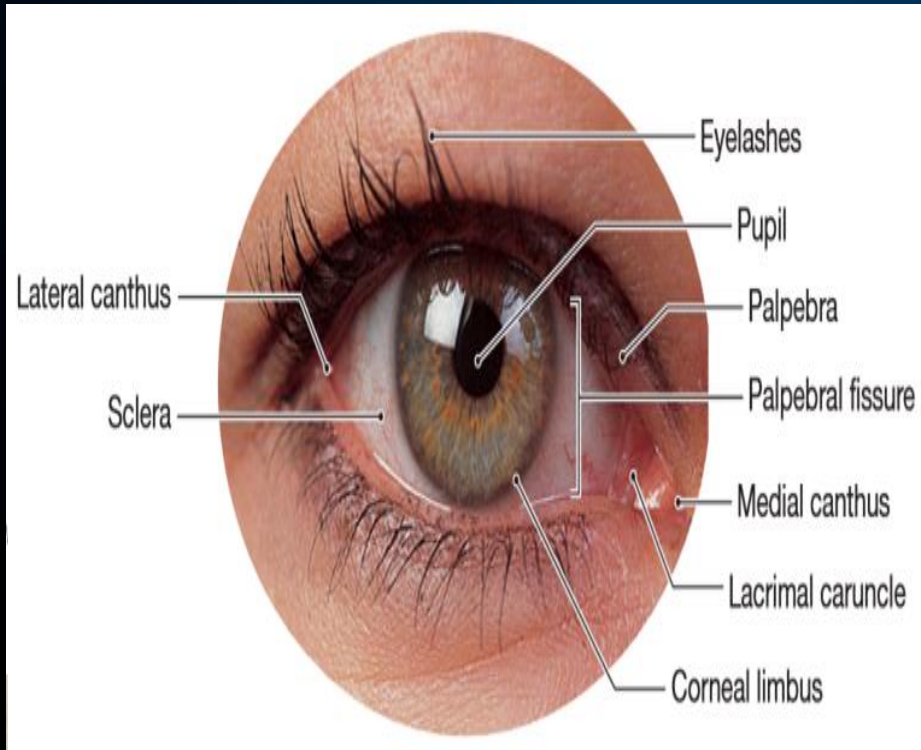
Sensory Reception and Processing

- **Detect** all changes in the environment
- **Send signals** to CNS - processed and analysed by brain
- Major sensory organs:
 - Eyes
 - Ears

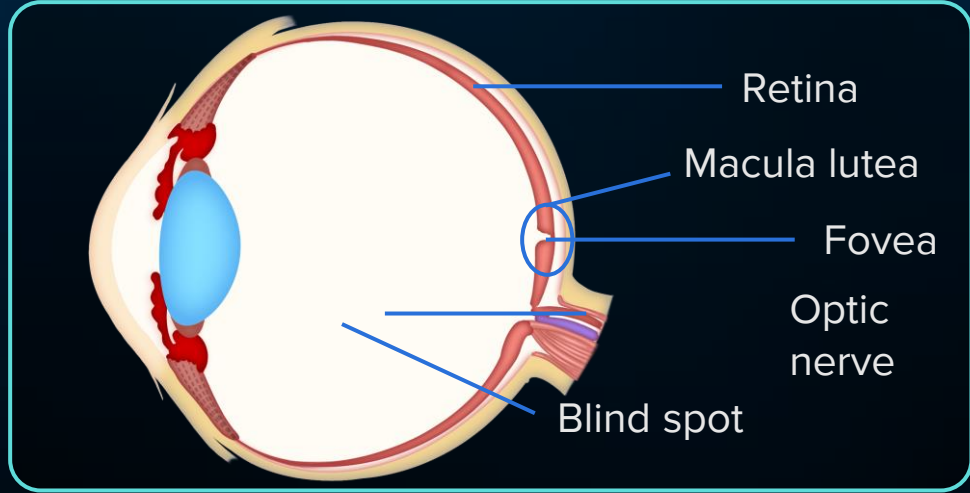
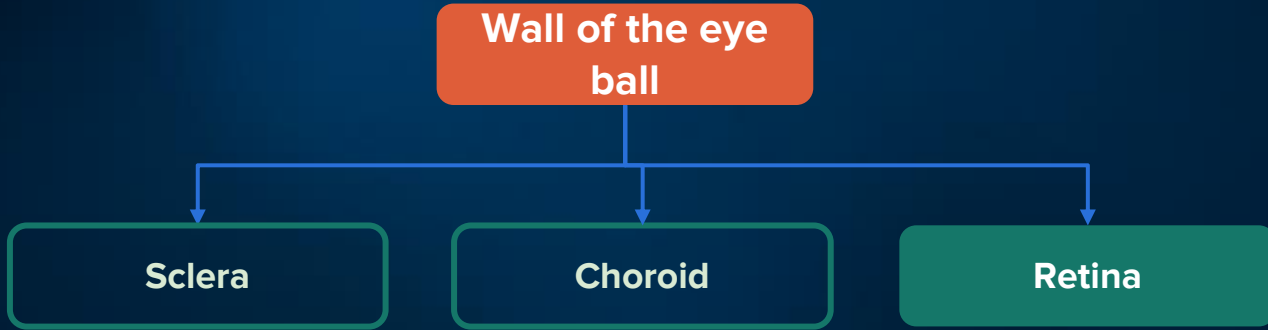


Eye

- Paired eyes located in sockets of the skull – **Orbits**
- Adult human eye ball- **Spherical structure**



Eye - Structure



Eye – Structure

Sclera

- External layer
- Composed of dense **connective tissue**
- It is the “**white**” of the eye.
- It covers the entire eyeball except the cornea

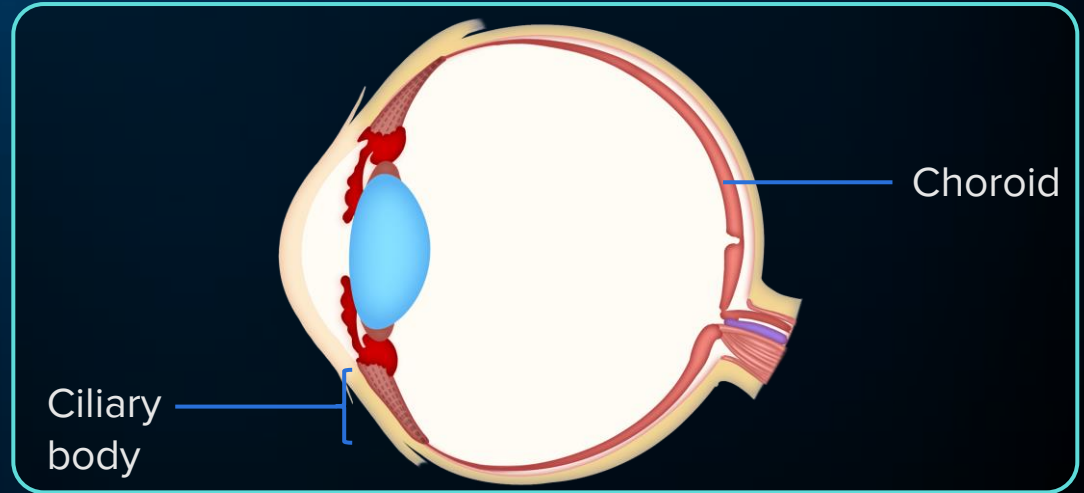
Cornea

- Anterior portion of sclera layer- **cornea**
- **Transparent layer**
- It allows **free entry of light.**
- It is curved and helps to focus light onto retina.
- Cornea provides **maximum refraction to light.**

Eye – Structure

Choroid

- Middle layer which contains **blood vessels**
- Bluish in color
- Thinner posterior part
- Thicker anterior part- **ciliary body**



Eye – Structure

Iris

- Pigmented and opaque structure formed by ciliary body
- Visible **coloured portion** of eye
- It is suspended between cornea and lens and is attached at its outer margin to the ciliary processes.
- The amount of **melanin** in the iris determines the eye color.
- Pupil is the hole in the center of the iris.
- **Muscles of the iris regulate the diameter of the pupil**

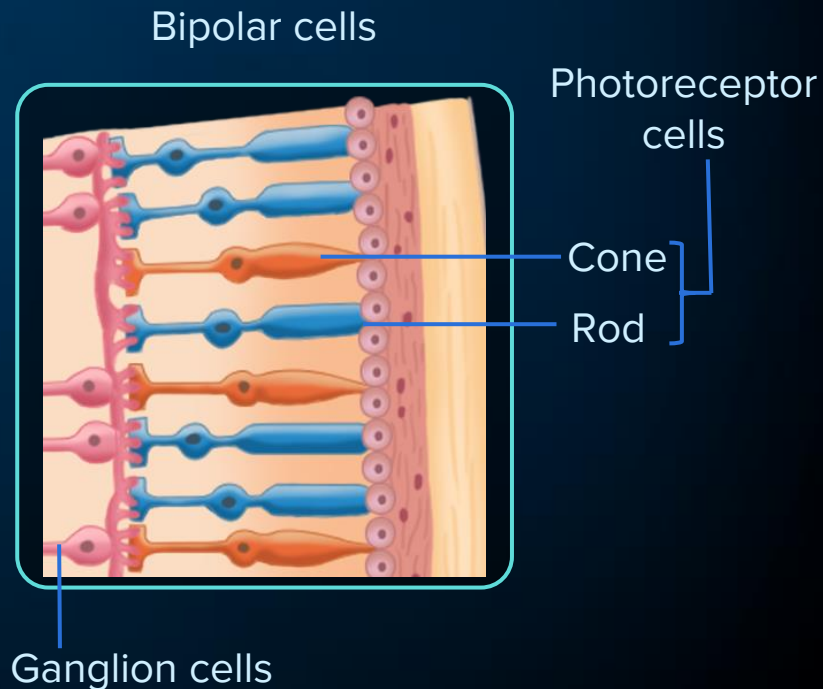
Eye – Structure

Retina

- Has three layers of neural cells
- Ganglion cells
- Bipolar cells
- Photoreceptor cells

Photoreceptor cells:

- Two types- **Rods** and **cones**
- These are modified bipolar neurons.
- These cells contain the **photopigments** (light sensitive pigments).



Eye – Structure

Rods	Cones
<ul style="list-style-type: none">➤ Contains purplish-red protein-Rhodopsin (Vit A derivative)	<ul style="list-style-type: none">➤ Contains iodopsin pigment
<ul style="list-style-type: none">➤ Function of the rods-Scotopic vision	<ul style="list-style-type: none">➤ Functions of cones- Photopic vision and colour vision
<ul style="list-style-type: none">➤ Inner segment has the main metabolic machinery like mitochondria, Golgi etc.	<ul style="list-style-type: none">➤ 3 types- respond to green, red and blue lights➤ When stimulated equally- white light sensation

Eye - Structure

Retina

Optic nerves:

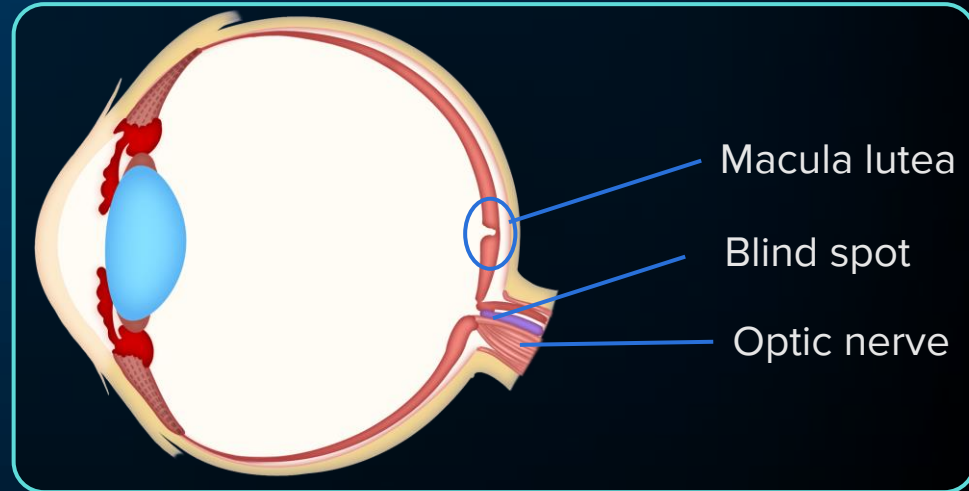
- Located at the back of the eye
- Connects eye to brain

Blind spot:

- Posterior pole where optic nerves leave and retinal blood vessels enter
- **Photoreceptor cells absent**

Macula lutea:

- Yellowish area of retina
- Image formed at yellow spot



Eye - Structure

Fovea:

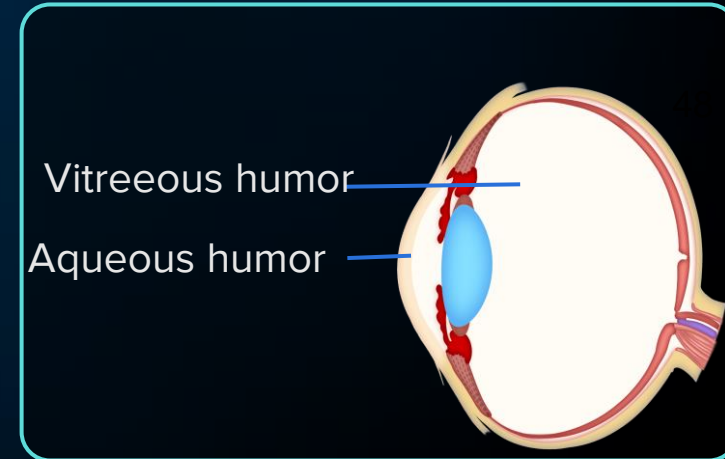
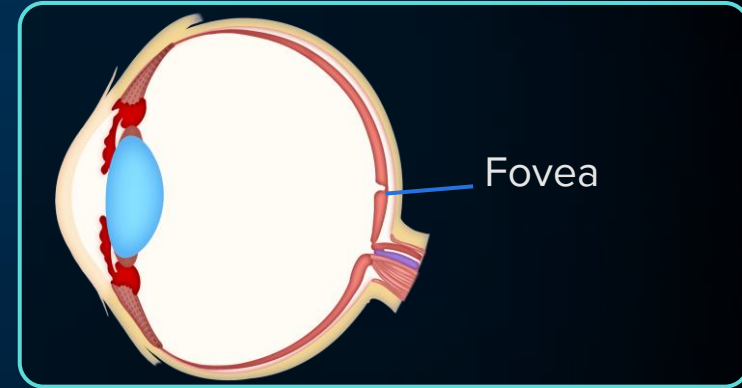
- **Shallow depression** in the middle of macula lutea
- Thinned out portion of retina
- Cones densely packed – **Greatest visual resolution**

Aqueous humor:

- **Space between cornea and lens** – Aqueous chamber
- Aqueous chamber contains thin watery fluid – **Aqueous humor**

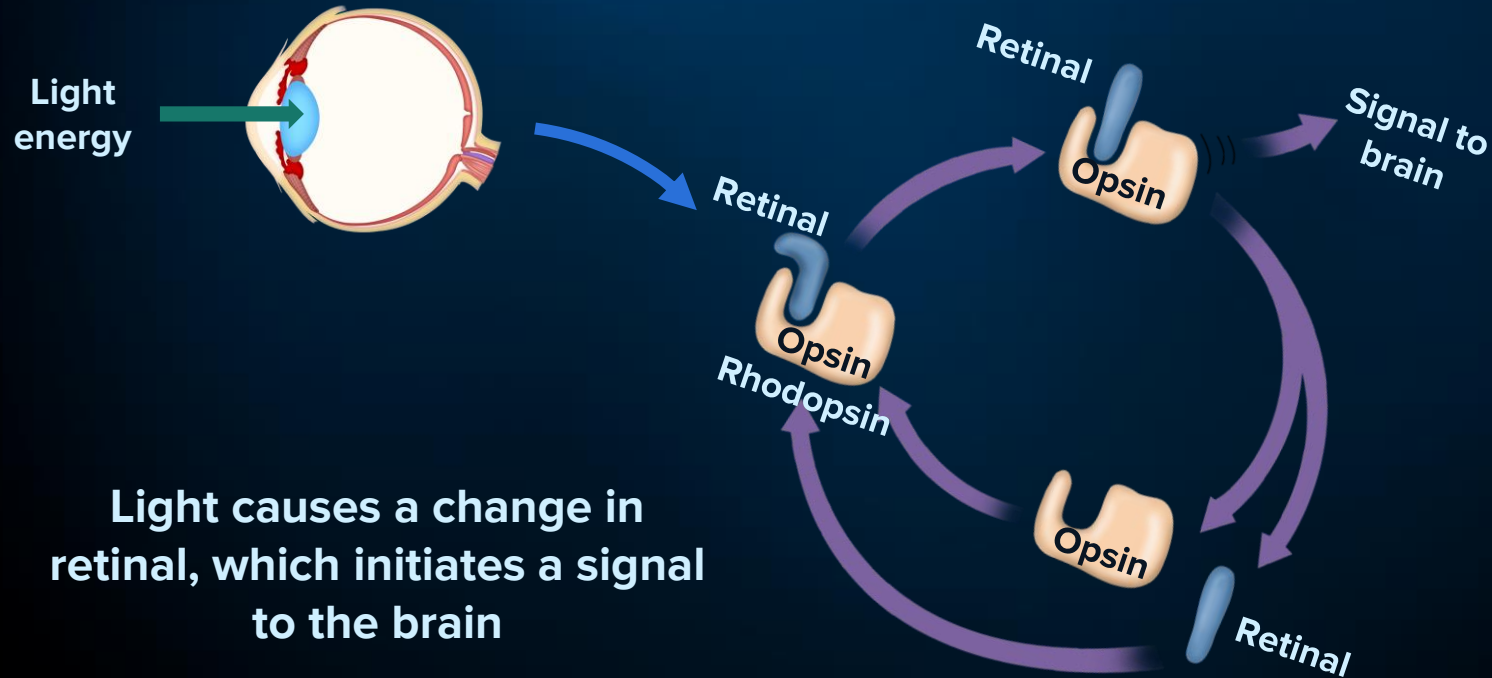
Vitreous Chamber

- **Space between lens and retina** – Vitreous chamber
- Vitreous chamber contains transparent gel – **Vitreous humor**



Mechanism of Vision

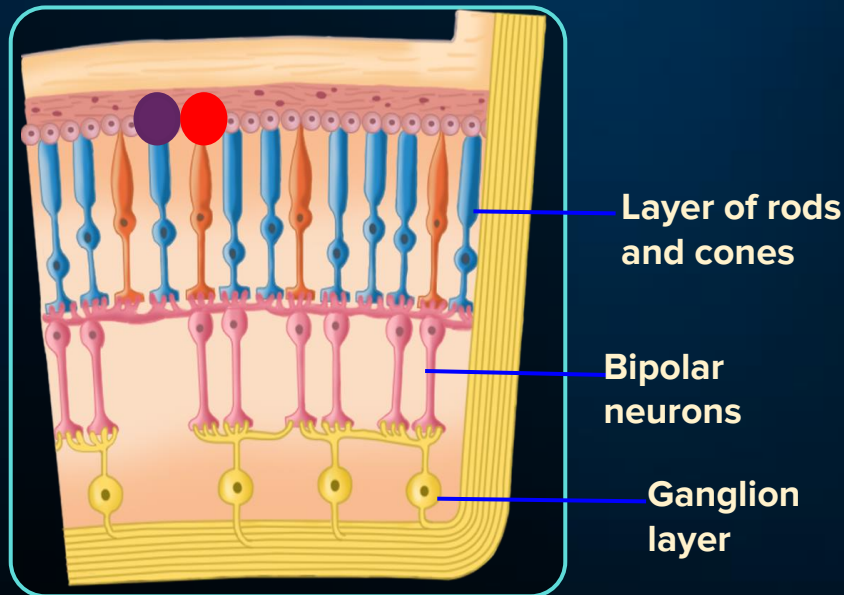
- Photopigments (Rhodopsin) = Opsin (Protein) + Retinal (Aldehyde of vitamin A)



Light causes a change in retinal, which initiates a signal to the brain

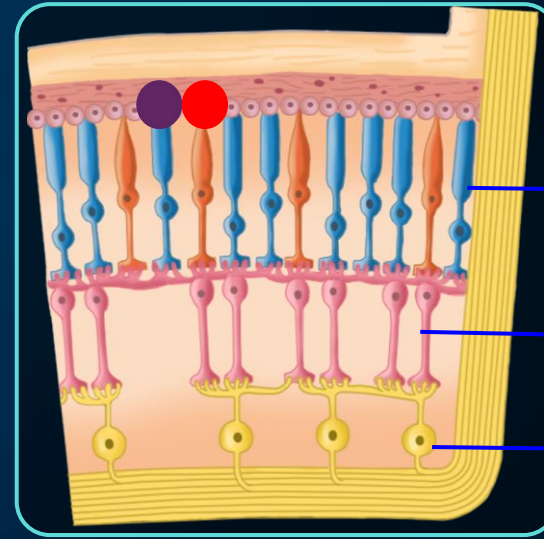
Mechanism of Vision

- Potential differences are generated at the photoreceptor cells
- This generates an action potential at the ganglion cells through the bipolar cells.



Mechanism of Vision

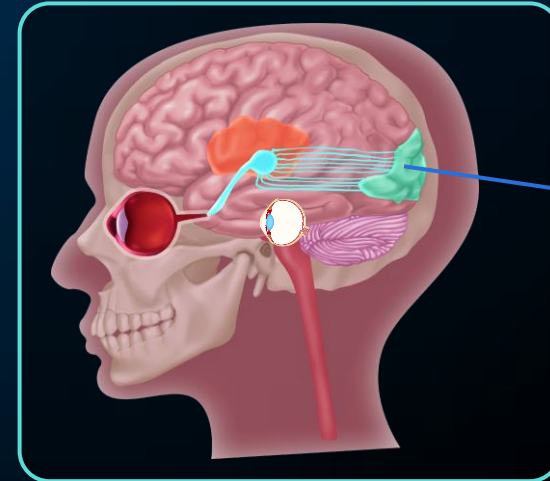
- Potential differences are generated at the photoreceptor cells
- This generates an action potential at the ganglion cells through the bipolar cells.
- Optic nerves transmit the action potential to the visual cortex of the brain.
- Here the impulses are processed and analysed and the image is identified based on the earlier memory.



Layer of rods and cones

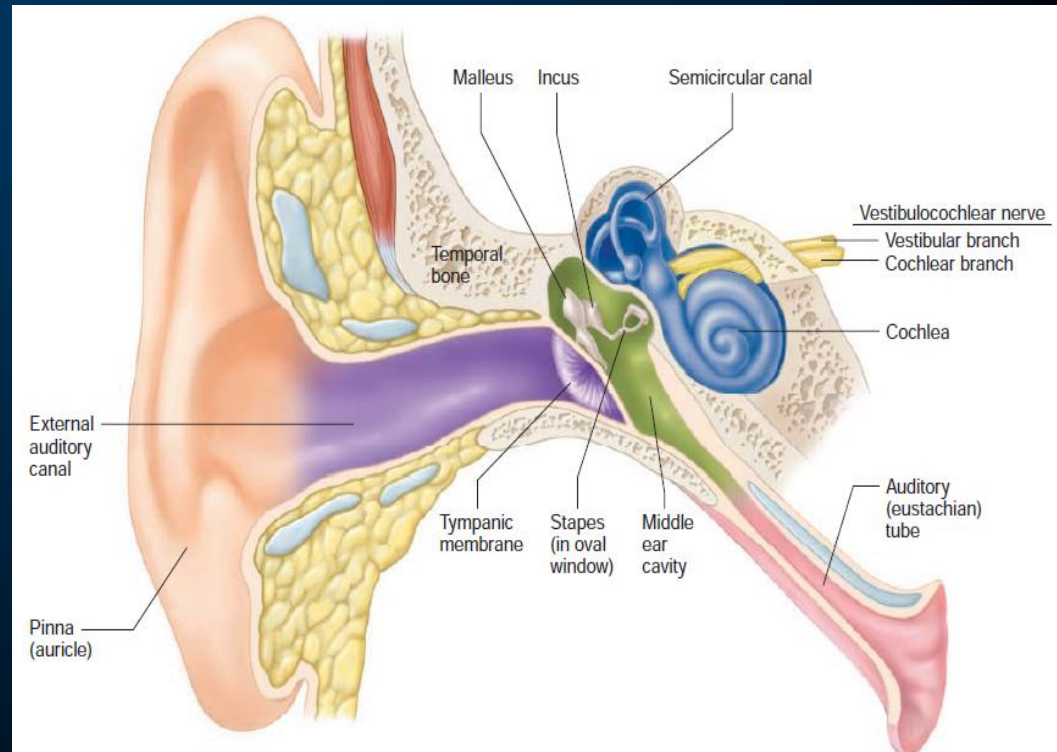
Bipolar neurons

Ganglion layer

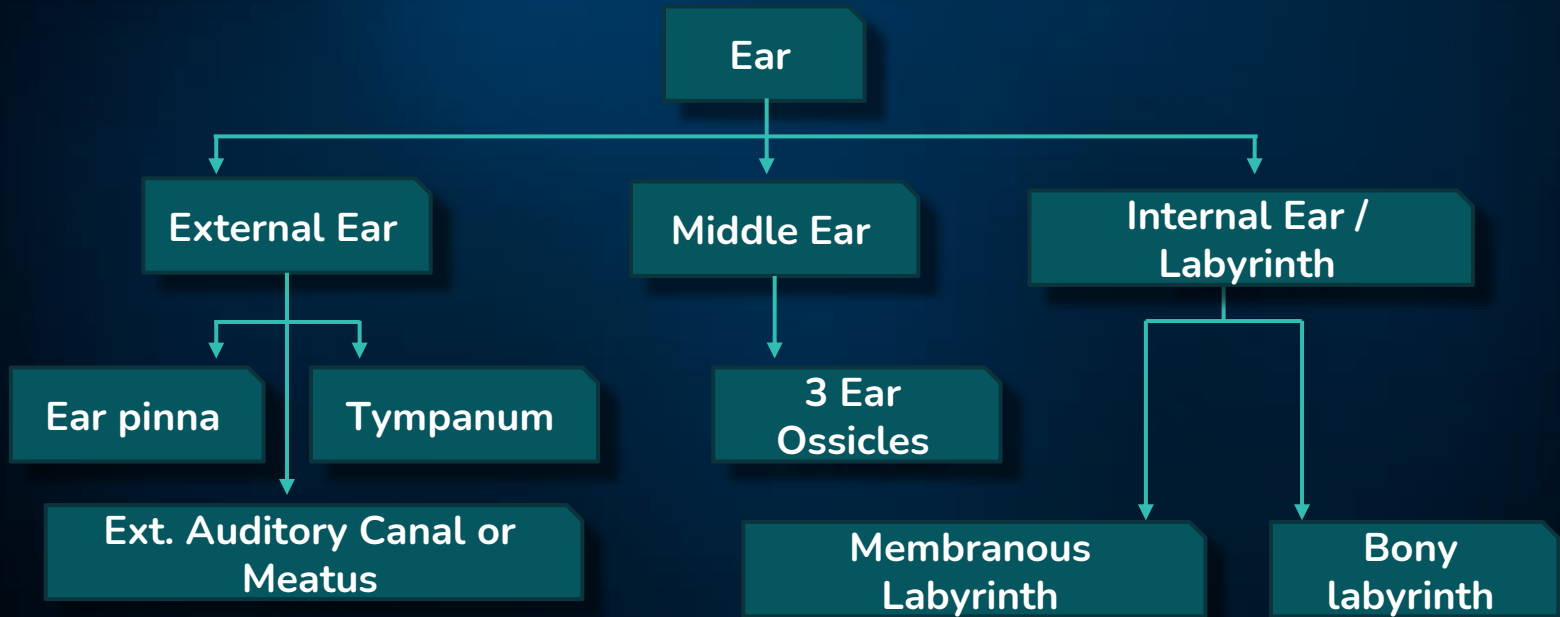


Visual cortex

Ear



Ear



Outer ear



Pinna (Auricle)	External auditory meatus (canal)	Tympanic membrane (Ear drum)
<ul style="list-style-type: none">● Has fine hair and wax-secreting glands.● Collects sound waves● Present in mammals except whales, dolphins, etc● Many mammals can move their ear pinna in the direction of sound.● In humans it is relatively immobile because auricular muscles of pinna are vestigial.	<ul style="list-style-type: none">● Has fine hair and wax-secreting glands● Extends up to the ear drum	<ul style="list-style-type: none">● Tympanic membrane or eardrum is a thin, semi transparent partition between the external auditory canal and middle ear.● It is covered by epidermis and lined by simple cuboidal epithelium.● It vibrates in response to sound waves.● For tympanum to vibrate freely air pressure must be equal on both sides.

Middle ear

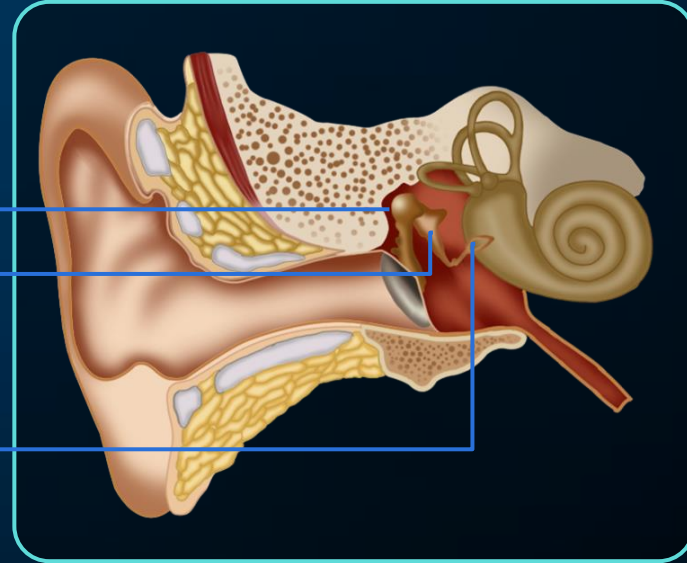
Malleus

- Attached to ear drum

Incus

Stapes

- Attached to oval window of cochlea

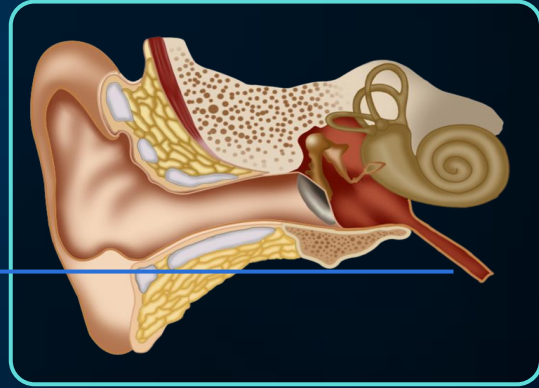


Ear ossicles **increase efficiency of transmission** of sound waves to inner ear

Middle ear

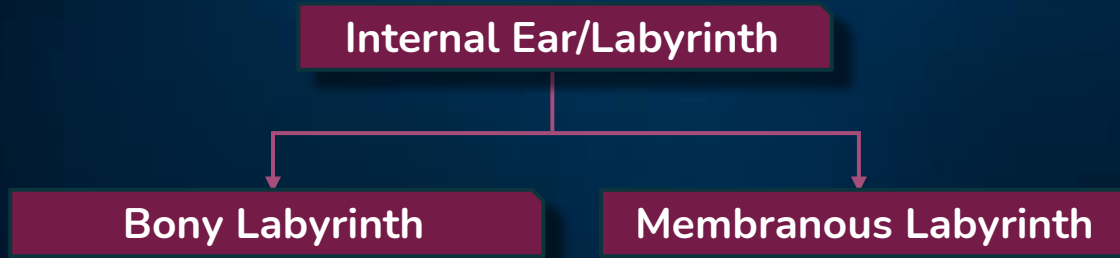
Eustachian tube

- Connects middle ear cavity with nasopharynx
- Helps in **equalising pressure** on both sides of tympanum.
- It normally remains closed but opens during chewing, swallowing, yawning, coughing, sneezing and changes in altitude.



Inner Ear

- It is also called labyrinth because of its complicated series of canals.
- Structurally, it consists of two main divisions:



- **Bony labyrinth** is a series of cavities in the petrous portion of the temporal bone divided into three areas:
 - **Semicircular canals.**
 - **Vestibule** (both of which contain receptors for equilibrium)
 - **Cochlea** (contains receptors for hearing).
- Bony labyrinth is lined with periosteum and contains **perilymph**.

Inner Ear

Endolymph

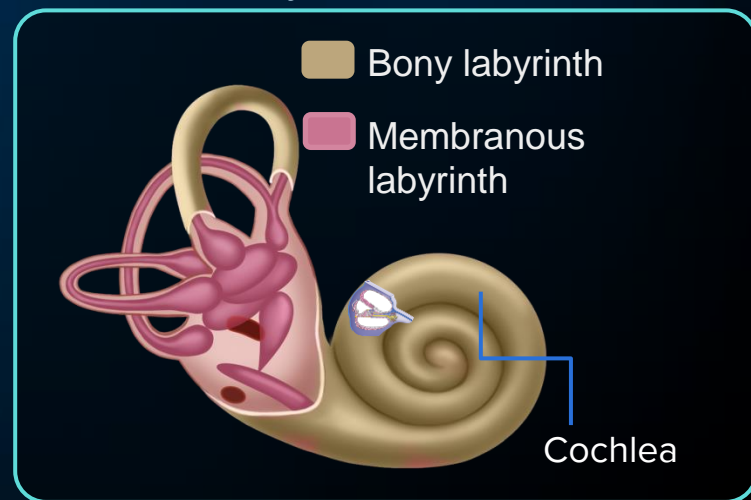
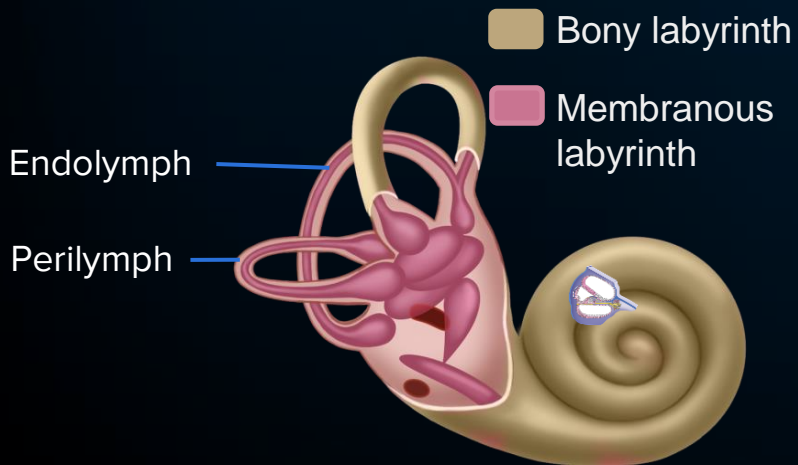
- Filled in membranous labyrinth

Perilymph

- Surrounds membranous labyrinth

Cochlea

- Coiled portion of labyrinth
- Cochlea is a bony spiral canal that resembles a snail's shell.
- It makes almost three turns around a central bony core called modiolus.



Inner Ear

Inner ear

Scala vestibuli

- Ends at oval window

Scala media

- Filled with endolymph

Scala tympani

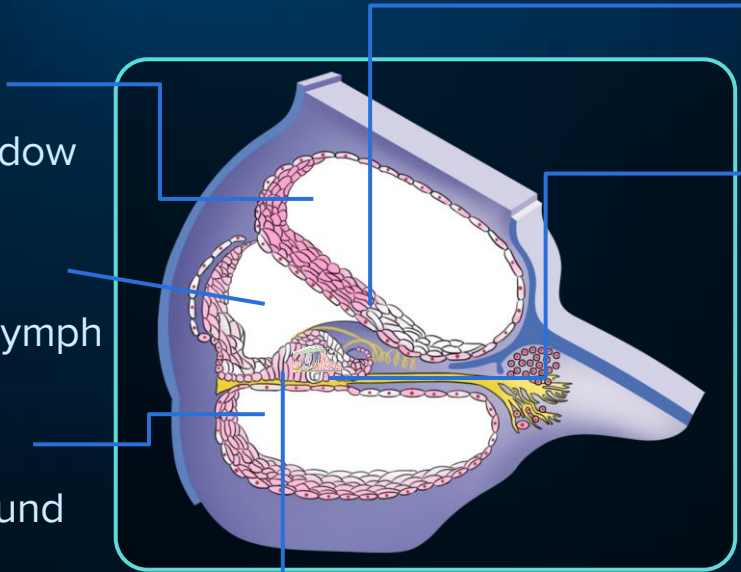
- Terminates at round window

Organ of Corti

Reissner's membrane

Basilar membrane

Divide the surrounding perilymph



Inner Ear

Inner ear

Stereo cilia

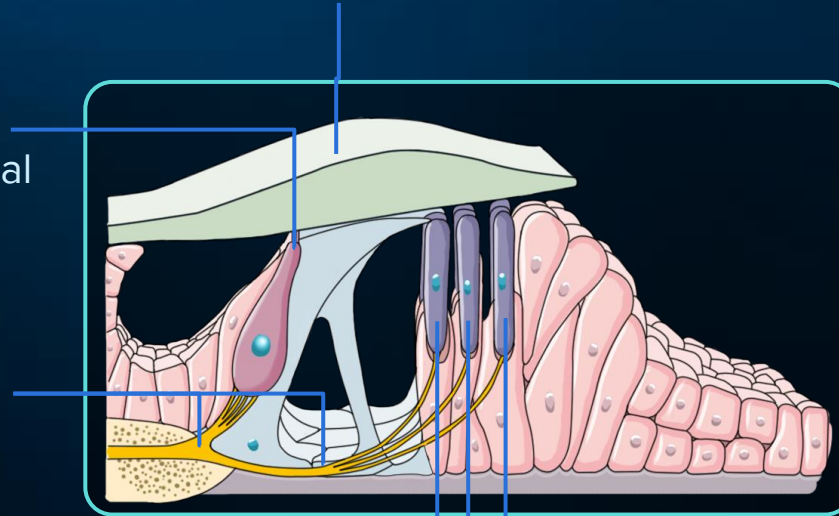
- Projected from apical part of hair cell

Afferent nerve fibres

- Present at the base of nerve fibres

Tectorial membrane

- Thin elastic membranes



Hair cells

- Auditory receptors

Inner Ear

Inner ear

3 Semi-circular canals

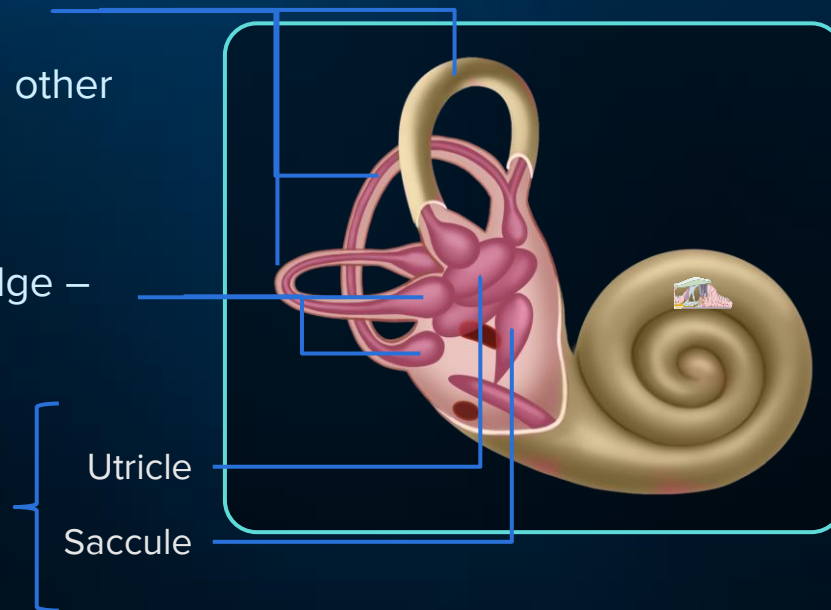
- At right angles to each other

Ampulla

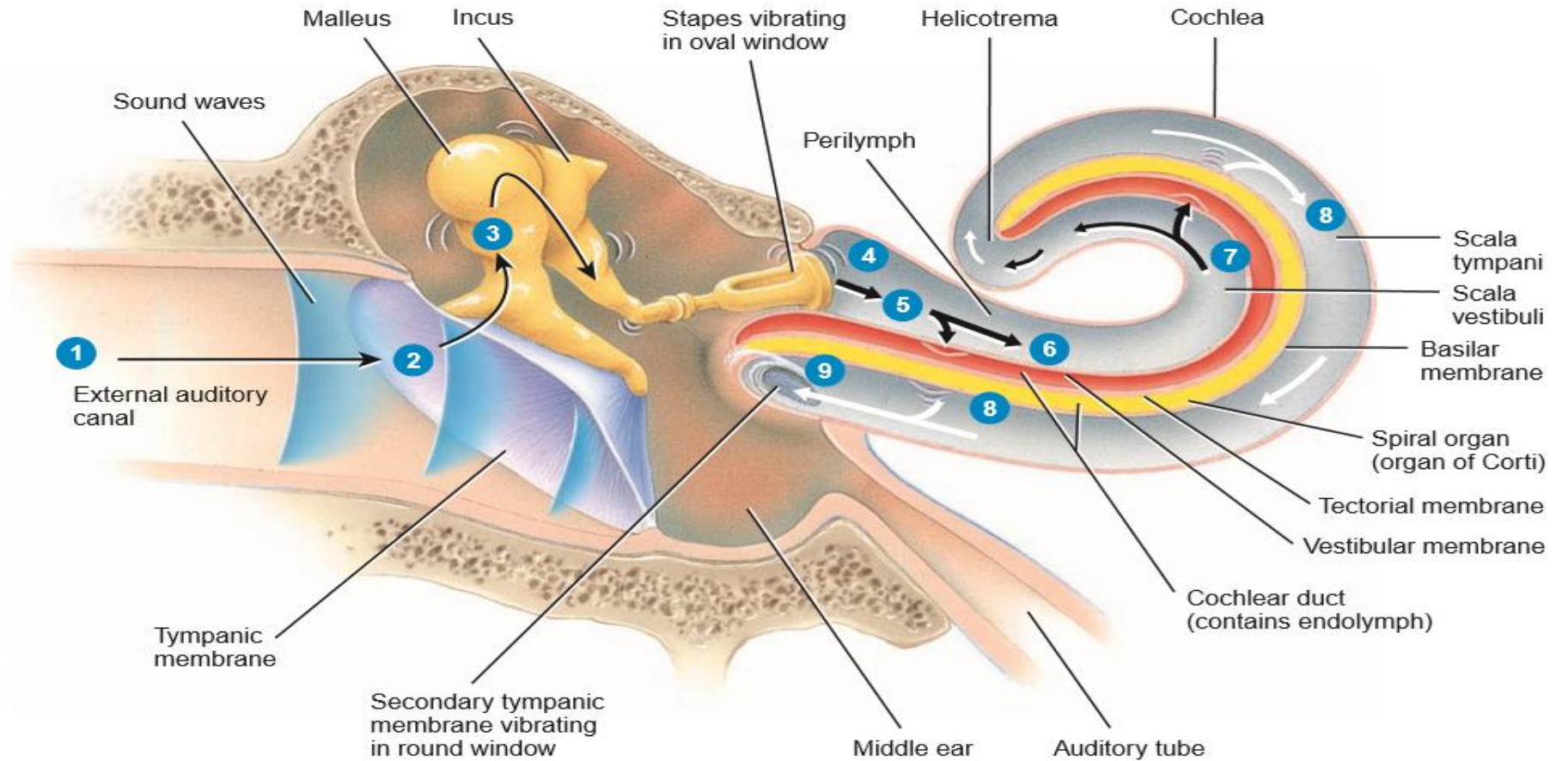
- Contains projecting ridge – **crista ampullaris**

Otolith organs

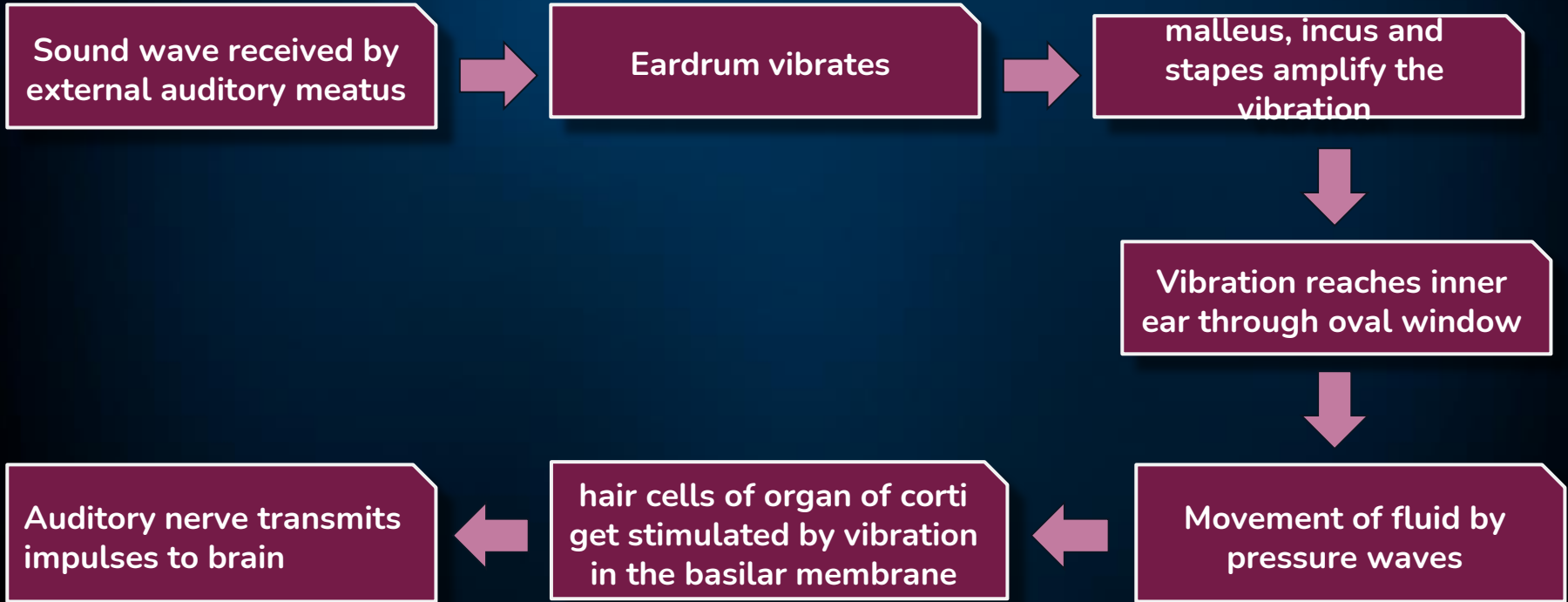
- Contains projecting ridge - **macula**



Mechanism of Hearing

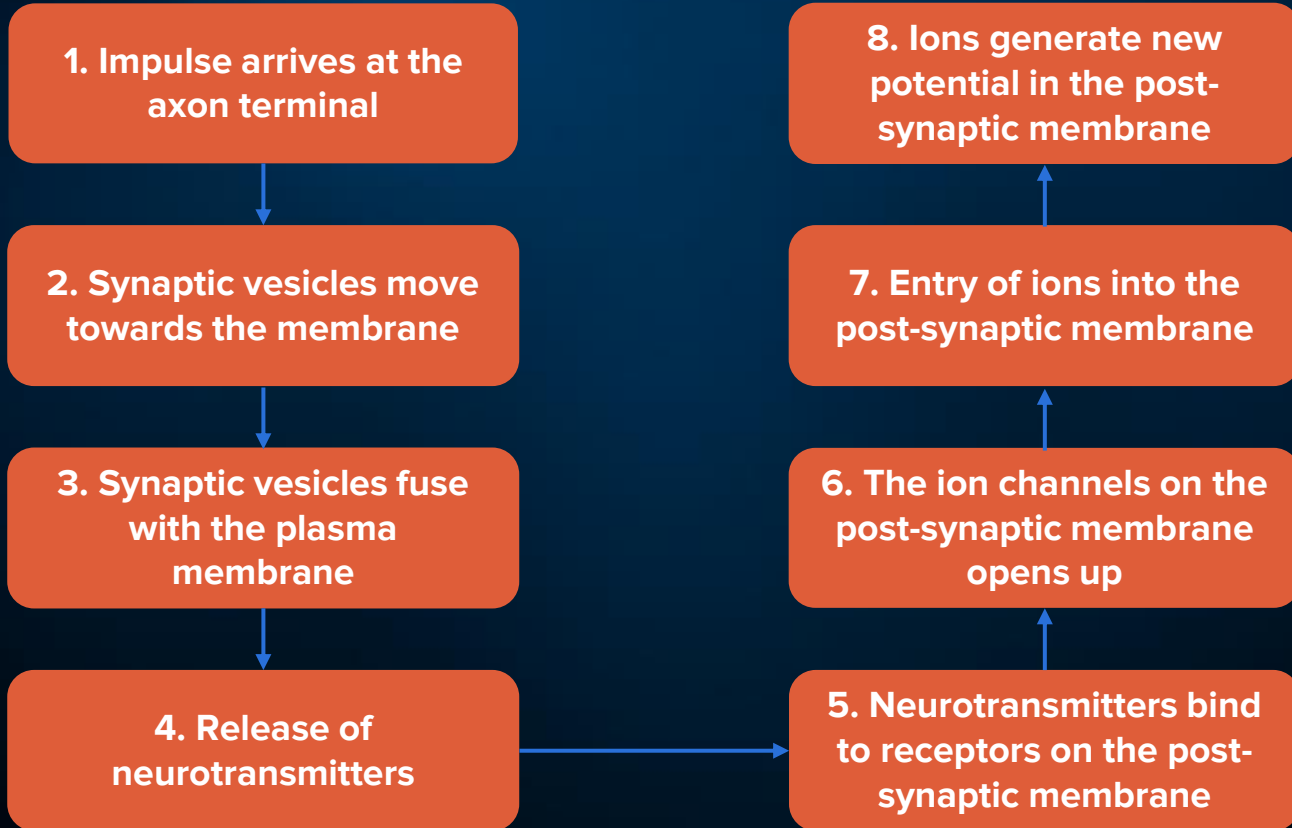


Mechanism of Hearing





Summary – Transmission of Impulse



Human Nervous System

