NEURAL CONTROL AND COORDINATION

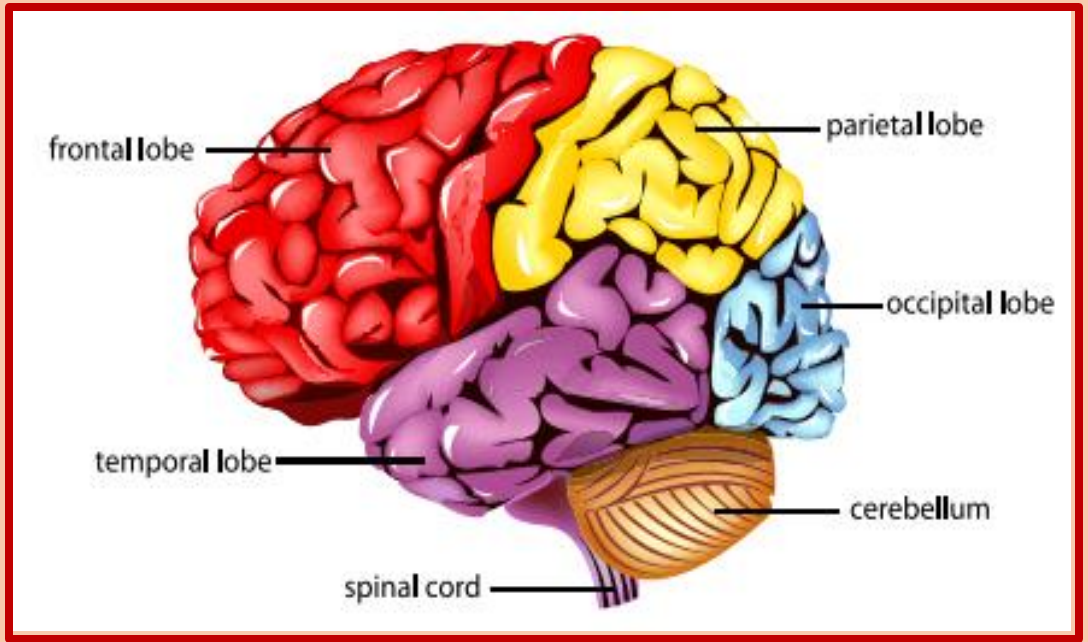
UNIT IV | Chapter 10

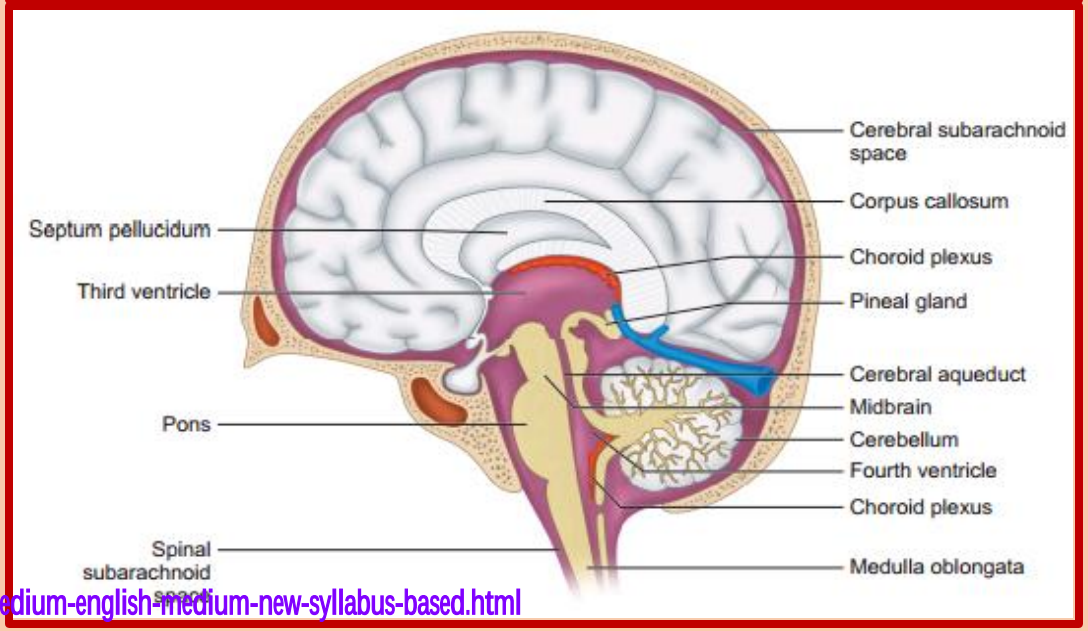
Neural Control And Coordination

Chapter Outline

10.1 Neural system
10.2 Human Neural System
10.3 Neuron as a structural and functional unit of neural system
10.4 Central neural system
10.5 Reflex action and reflex arc
10.6 Sensory reception and processing

Gamma-aminobutyric acid, or GABA, is the brain's major inhibitory neurotransmitter that reduces neuronal excitability.





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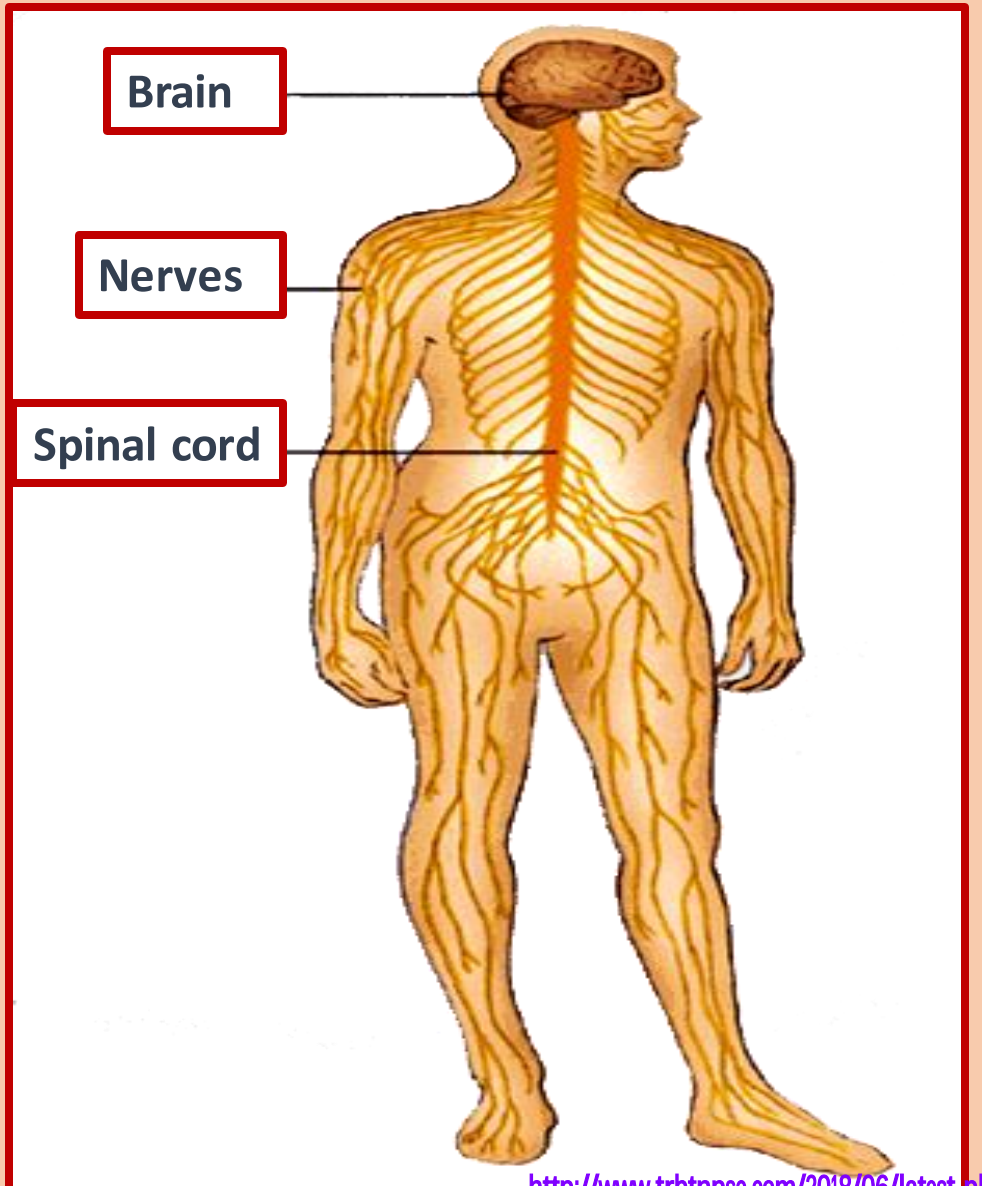
❖ Learning Objectives:

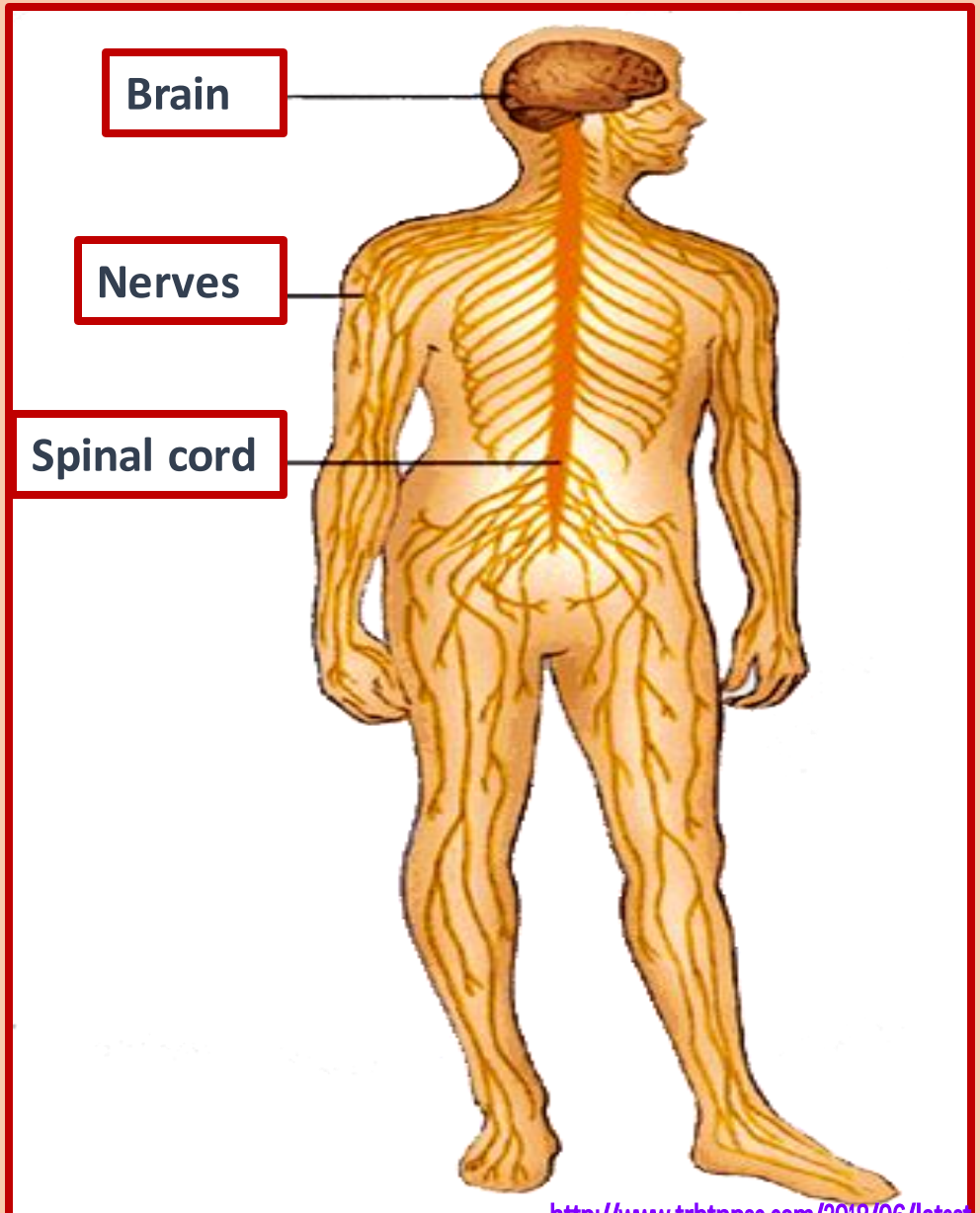
1. *Understands the structure of neuron and neural system of human beings.*
2. *Learns to differentiate the functions of sensory and motor neuron.*
3. *Understands the conduction of nerve impulses and learns the importance of myelin sheathsaltatory conduction.*
4. *Outlines the role of synapse and neuromuscular junction.*
5. *Learns the structure and functionsof central neural system.*
6. *Understands the structure, sensory reception and processing in Photo, Phono, Olfactory, Gustatory and Skin Receptors.*

NEURAL CONTROL AND COORDINATION



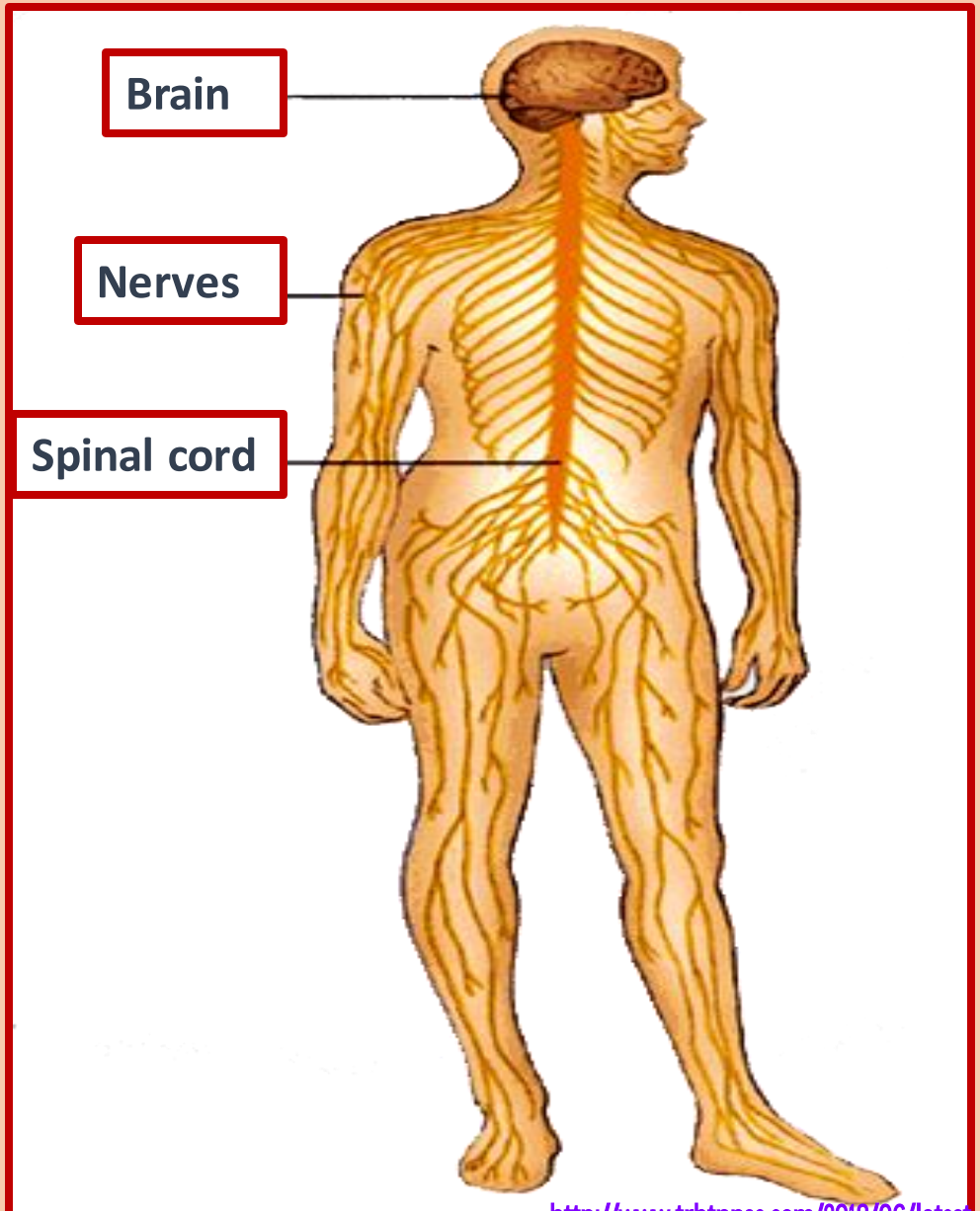
- Did you ever wonder how our body functions?
- The body maintains a stable condition even when the outside environment changes.
- Our eyes help to see things around us.
- Ears help us to hear various sounds.
- Heart beats continuously and rhythmically.
- Air goes in and out of lungs.
- Eyes shed tears when our limbs get hurt.
- Each cell of the body works in a coordinated manner.
- Do you know how it is coordinated and controlled?

NEURAL CONTROL AND COORDINATION



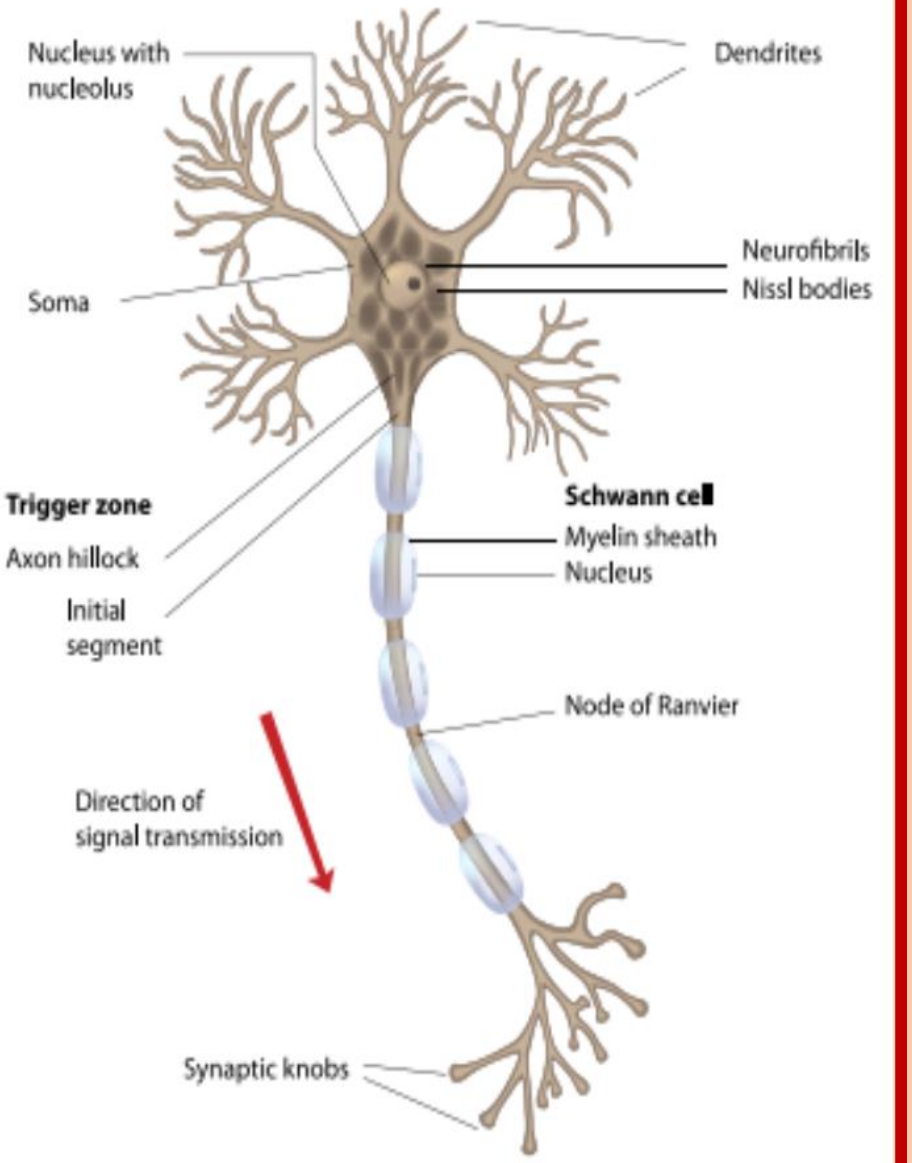
- ✓ The neural system of our body coordinates all the other systems to work together effectively and smoothly.
- ✓ Every second, diverse functions in our body are performed by the neural system.
- ✓ Day and night, millions of messages pass as stimuli through the cells of the neural system to stimulate the heart to beat; kidney to excrete waste; and mouth to relish the delicious food.

NEURAL CONTROL AND COORDINATION



- ✓ An even more remarkable feature of the neural system is its ability to respond simultaneously to several stimuli, for instance, we can play piano and sing; listen to music and do household chores.
- ✓ In all such coordinated movements, whether skilled performances or routine tasks like cycling or driving, the integrating power of the neural system is involved.
- ✓ In this chapter, you will understand how neural system is organized; how it integrates all organs and what kind of cellular events underlie its functioning.

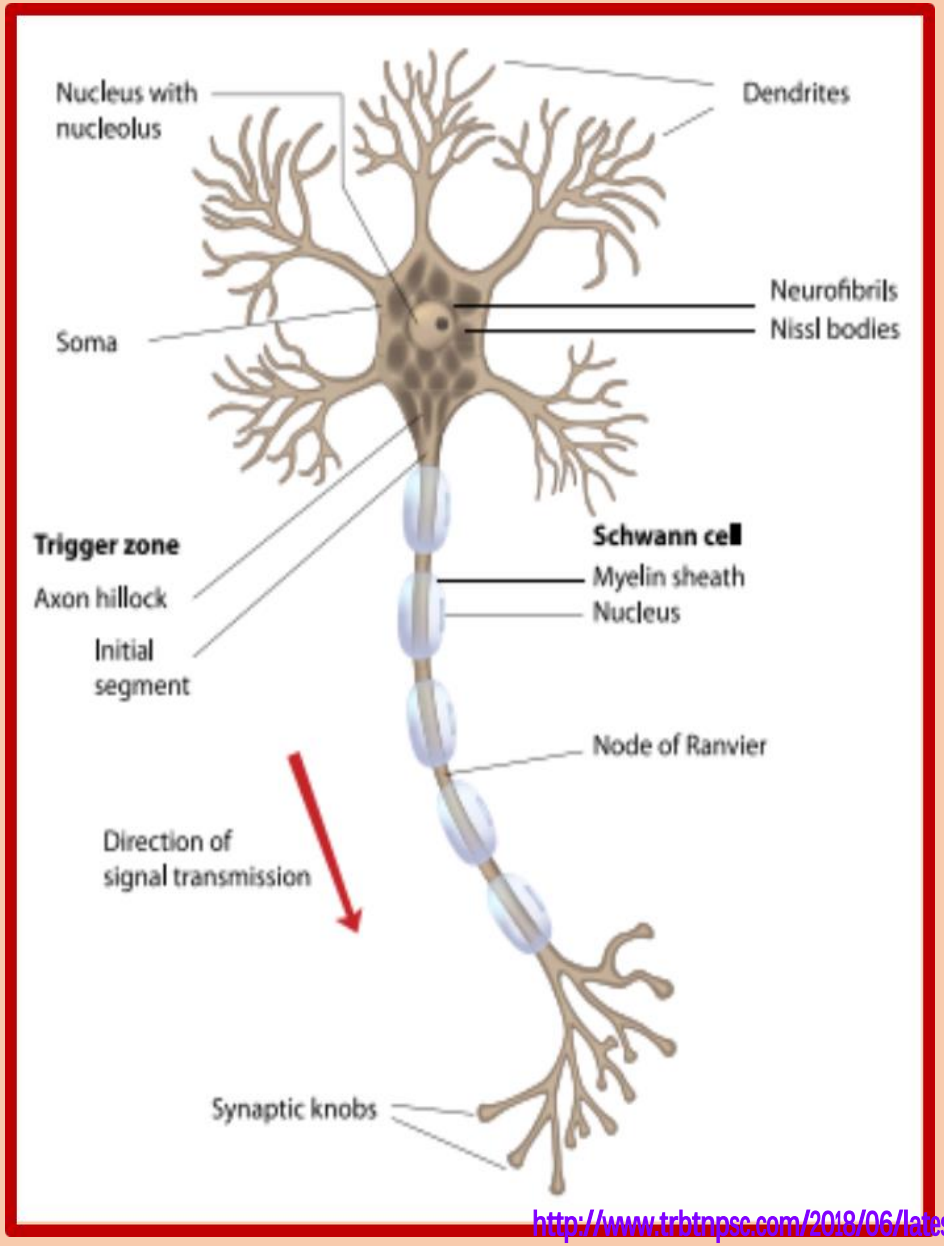
NEURAL SYSTEM



- The neural system comprises of highly specialized cells called neurons, which can detect, receive, process and transmit different kinds of stimuli.
- Simple form of neural system as nerve net is seen in lower invertebrates.
- The neural system of higher animals are well developed and performs the following basic functions:

1. Sensory functions - It receives sensory input from internal and external environment.
2. Motor functions - It transmits motor commands from the brain to the skeletal and muscular system.
3. Autonomic functions - Reflex actions.

HUMAN NEURAL SYSTEM



- The human neural system is divided into two parts.

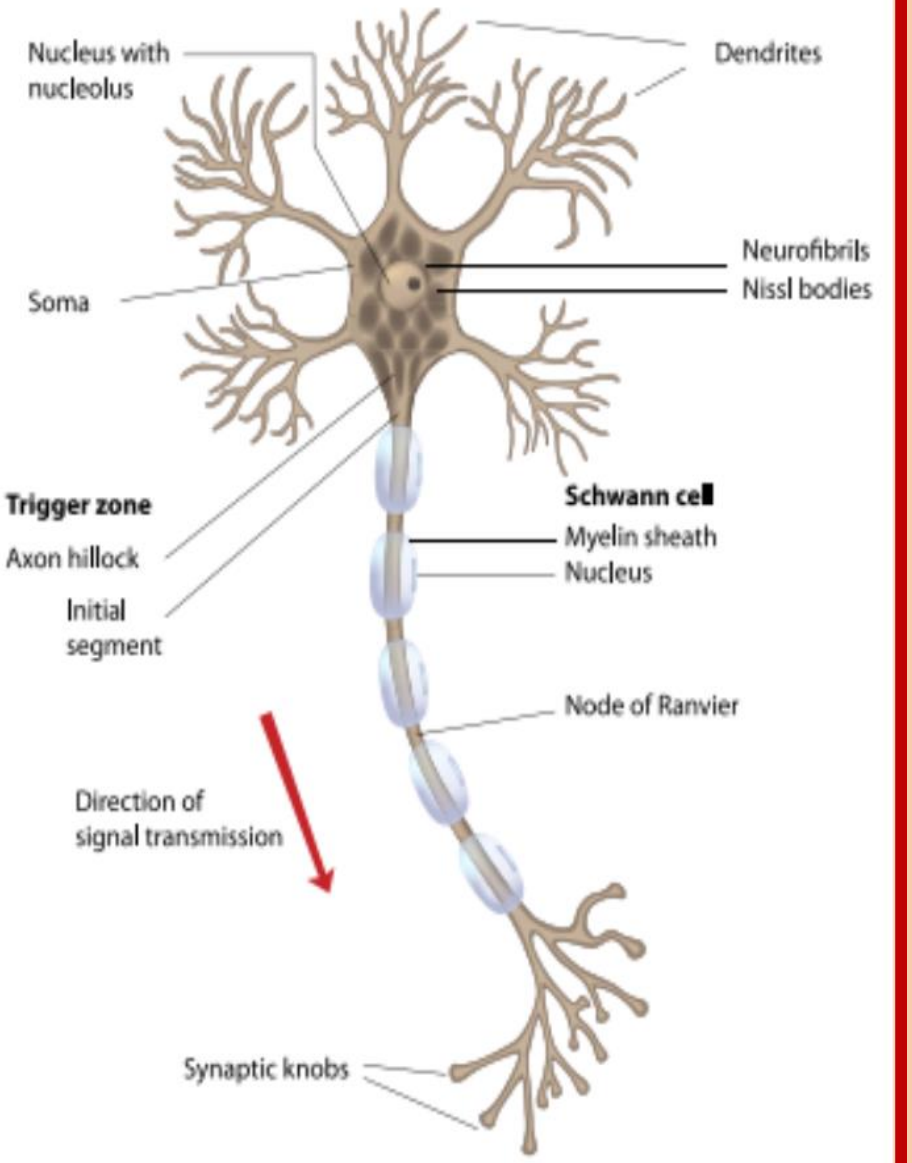
  1. The central neural system (CNS)

  2. The peripheral neural system (PNS).

- The structural and functional units of the neural system are neurons that transmit nerve impulses.

- The non-nervous special cells called neuroglia form the supporting cells of the nervous tissue.

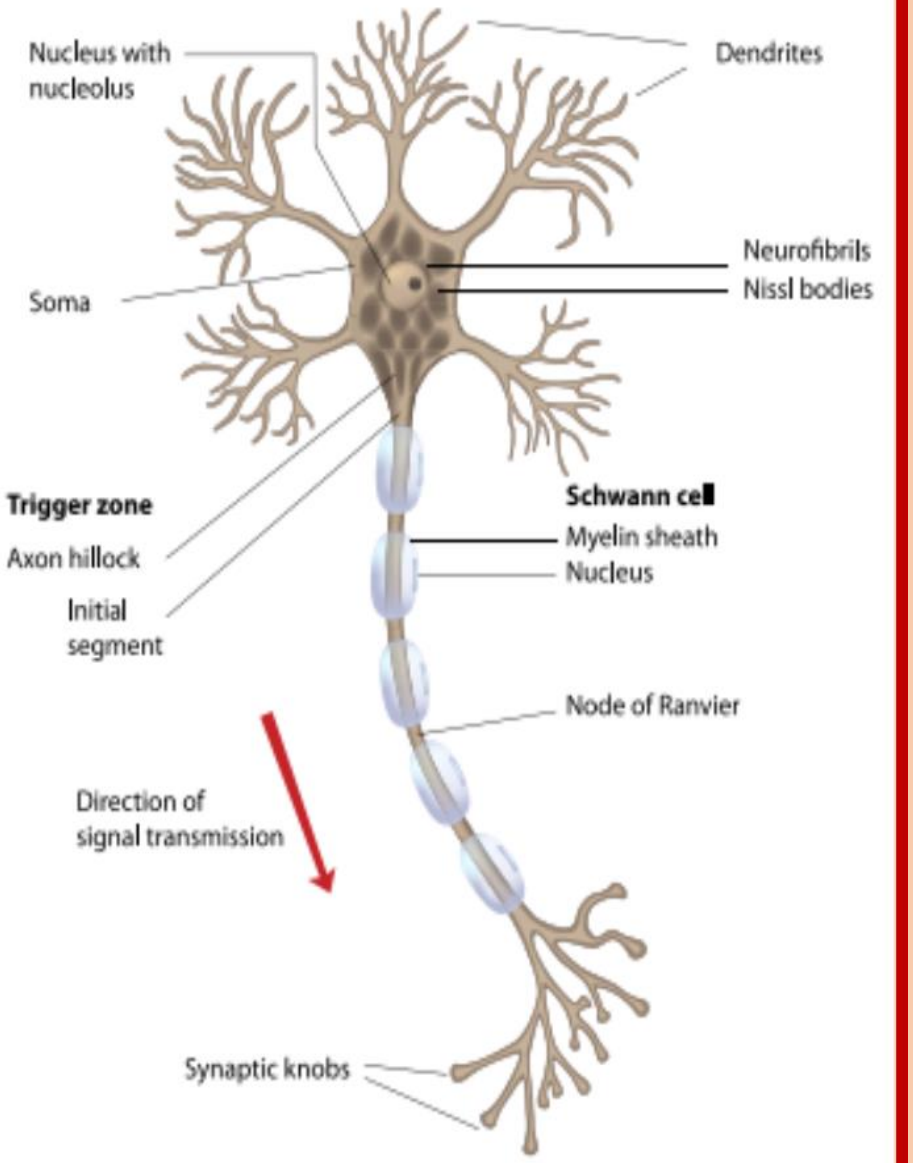
HUMAN NEURAL SYSTEM



- There are three functional classes of neurons. They are

1. The afferent neurons that take sensory impulses to the Central Neural system (CNS) from the sensory organs.
2. The efferent neurons that carry motor impulses from the CNS to the effector organs.
3. The interneurons that lie entirely within the CNS between the afferent and efferent neurons.

HUMAN NEURAL SYSTEM – FUNCTIONS OF NEUROGLIA



❖ The central neural system lacks connective tissue, so the interneuron space is filled by neuroglia.

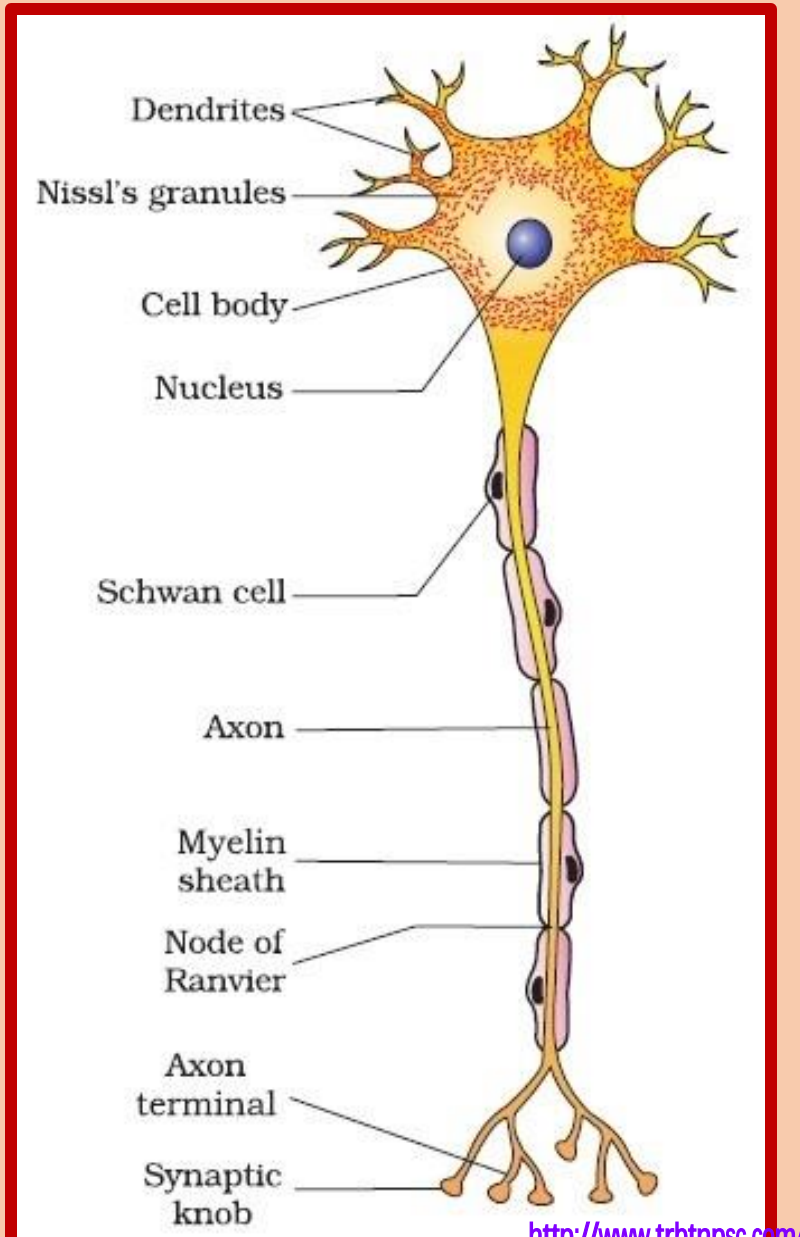
❖ They perform several functions such as

1. Providing nourishment to the surrounding neurons.
2. Involving the memory process.
3. Repairing the injured tissues due to their dividing and regenerating capacity.
4. Acting as phagocyte cells to engulf the foreign particles at the time of any injury to the brain.

HUMAN NEURAL SYSTEM

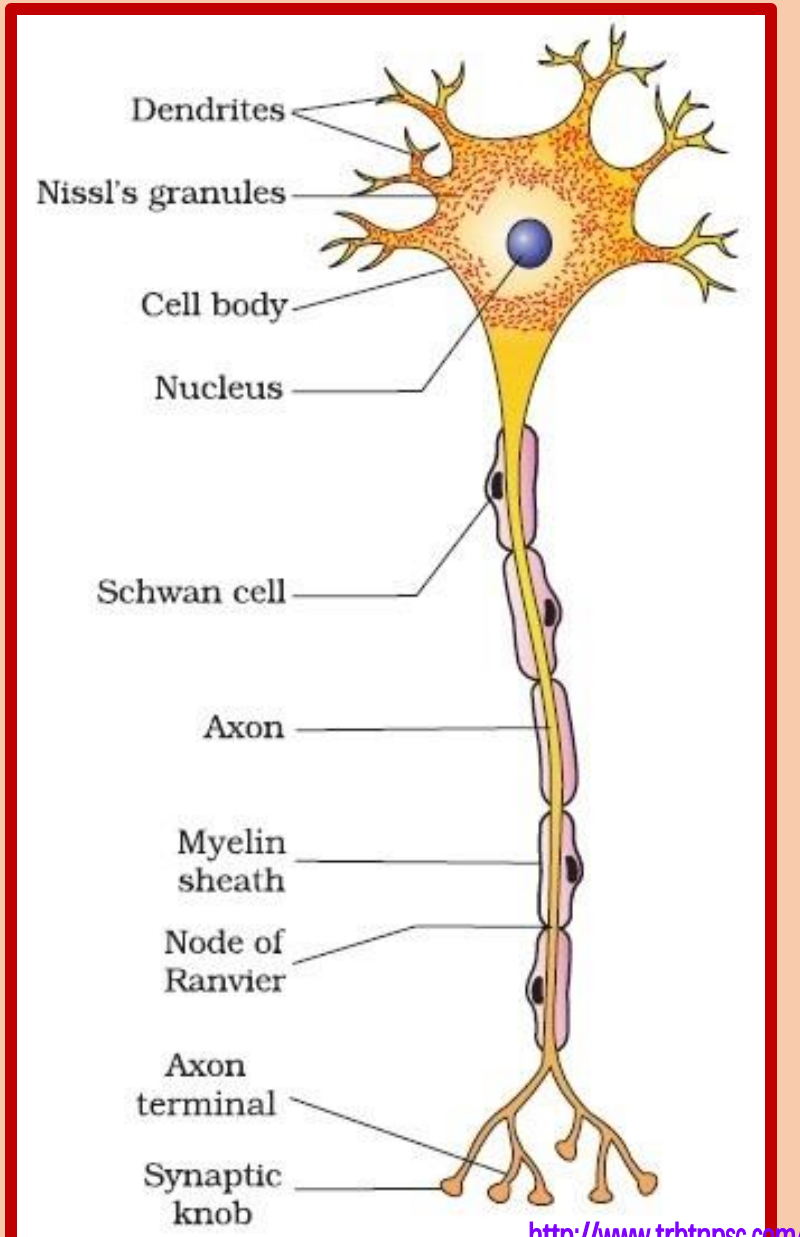
Glial cells do not lose the ability to undergo cell division; so most brain tumours of neural origin consists of glial cells. Neurons themselves do not form tumours because they are unable to divide and multiply.

STRUCTURE OF NEURONS



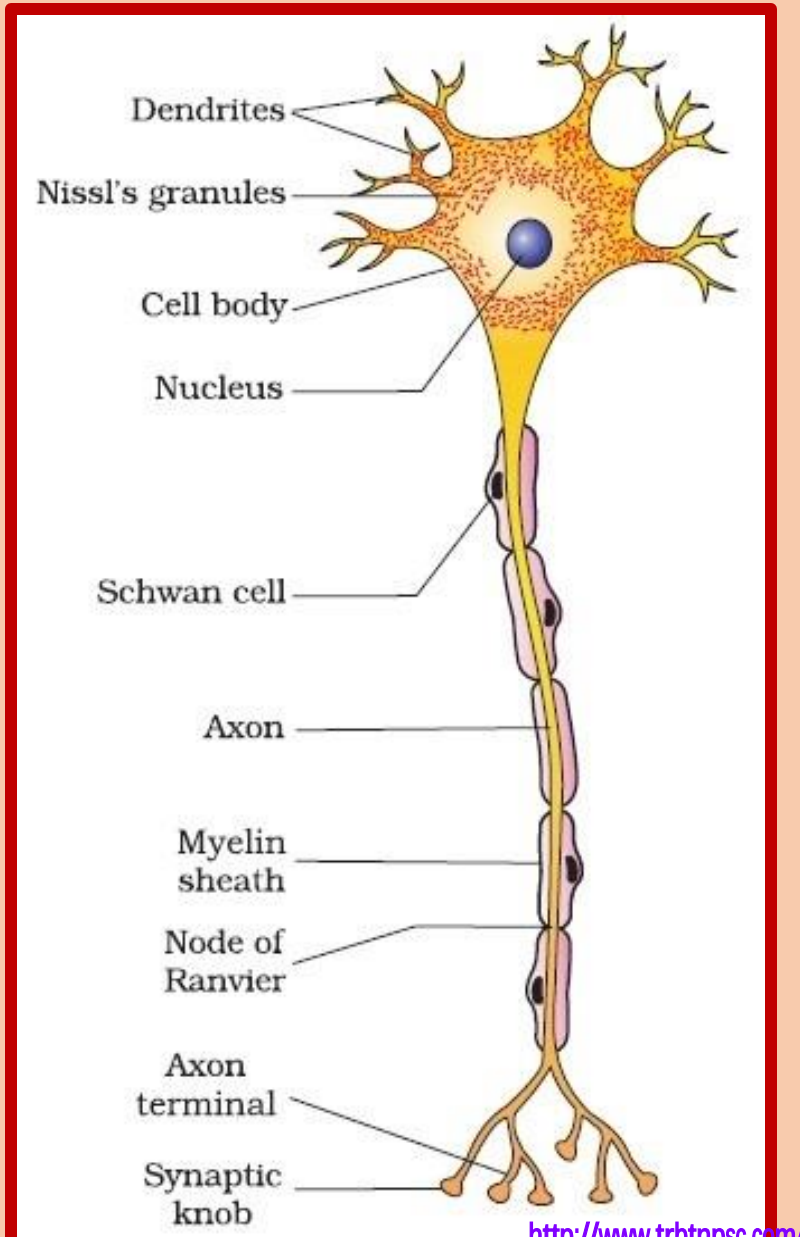
- A neuron is a microscopic structure composed of three major parts namely
  1. Cell body (soma)
  2. Dendrites
  3. Axon.
- The cell body is the spherical part of the neuron that contains all the cellular organelles as a typical cell (except centriole).
- The plasma membrane covering the neuron is called neurilemma and the axon is axolemma.
- The repeatedly branched short fibres coming out of the cell body are called dendrites, which transmit impulses towards the cell body.
- The cell body and the dendrites contain cytoplasm and granulated endoplasmic reticulum called Nissl's granules.

STRUCTURE OF NEURONS



- An axon is a long fibre that arises from a cone shaped area of the cell body called the Axon hillock and ends at the branched distal end.
- Axon hillock is the place where the nerve impulse is generated in the motor neurons.
- The axon of one-neuron branches and forms connections with many other neurons.
- An axon contains the same organelles found in the dendrites and cell body but lacks Nissl's granules and Golgi apparatus.
- The axon, particularly of peripheral nerves is surrounded by Schwann cells (a type of glial cell) to form myelin sheath, which act as an insulator.
- Myelin sheath is associated only with the axon, dendrites are always non-myelinated.

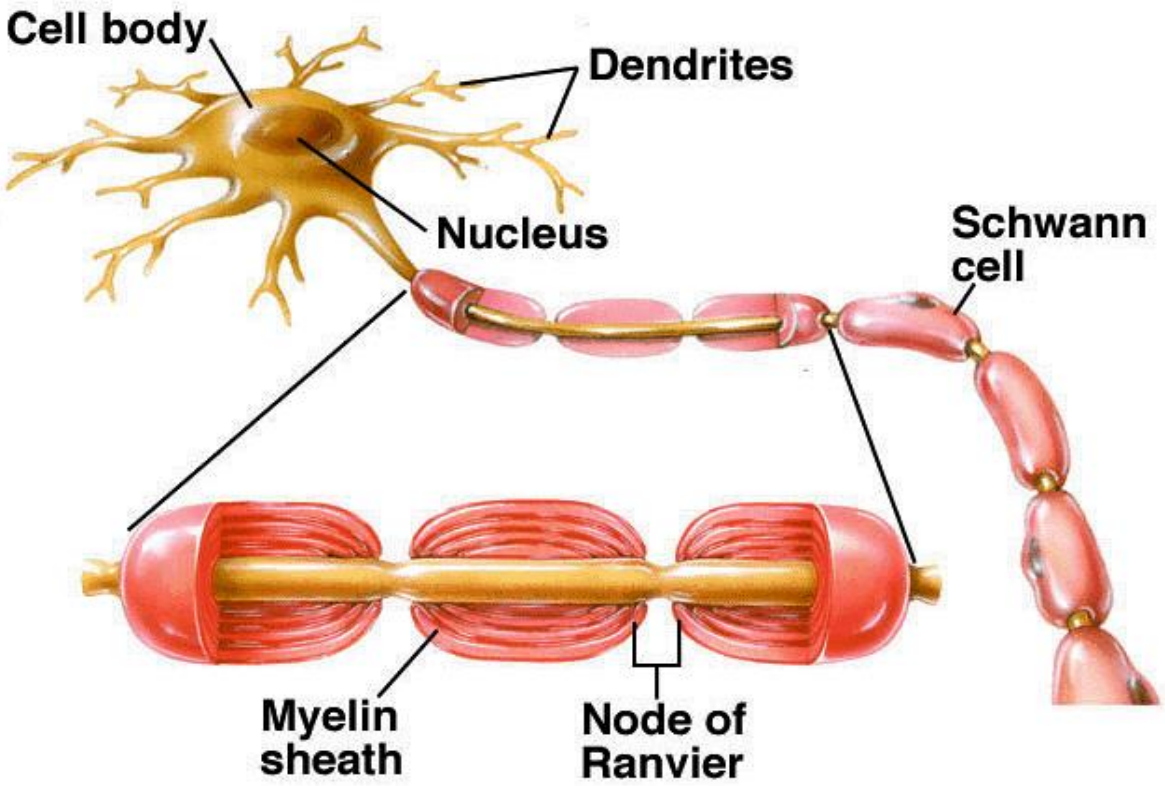
STRUCTURE OF NEURONS



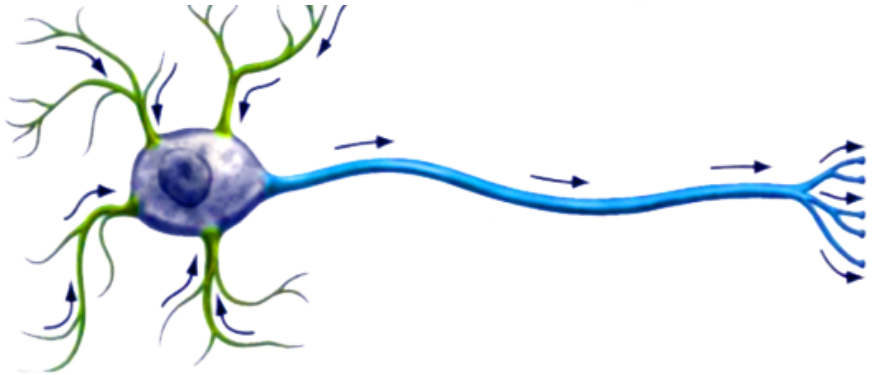
- Schwann cells are not continuous along the axon, so there are gaps in the myelin sheath between adjacent Schwanncells.
- These gaps are called Nodes of Ranvier.
- Large myelinated nerve fibres conduct impulses rapidly, whereas nonmyelinated fibres conduct impulses quite slowly.
- Each branch at the distal end of the axon terminates into a bulb like structure called synaptic knob which possesses synaptic vesicles filled with neurotransmitters.
- The axon transmits nerve impulses away from the cell body to an inter neural space or to a neuro-muscular junction.

TYPES OF AXON

Myelinated axon



Non-Myelinated axon

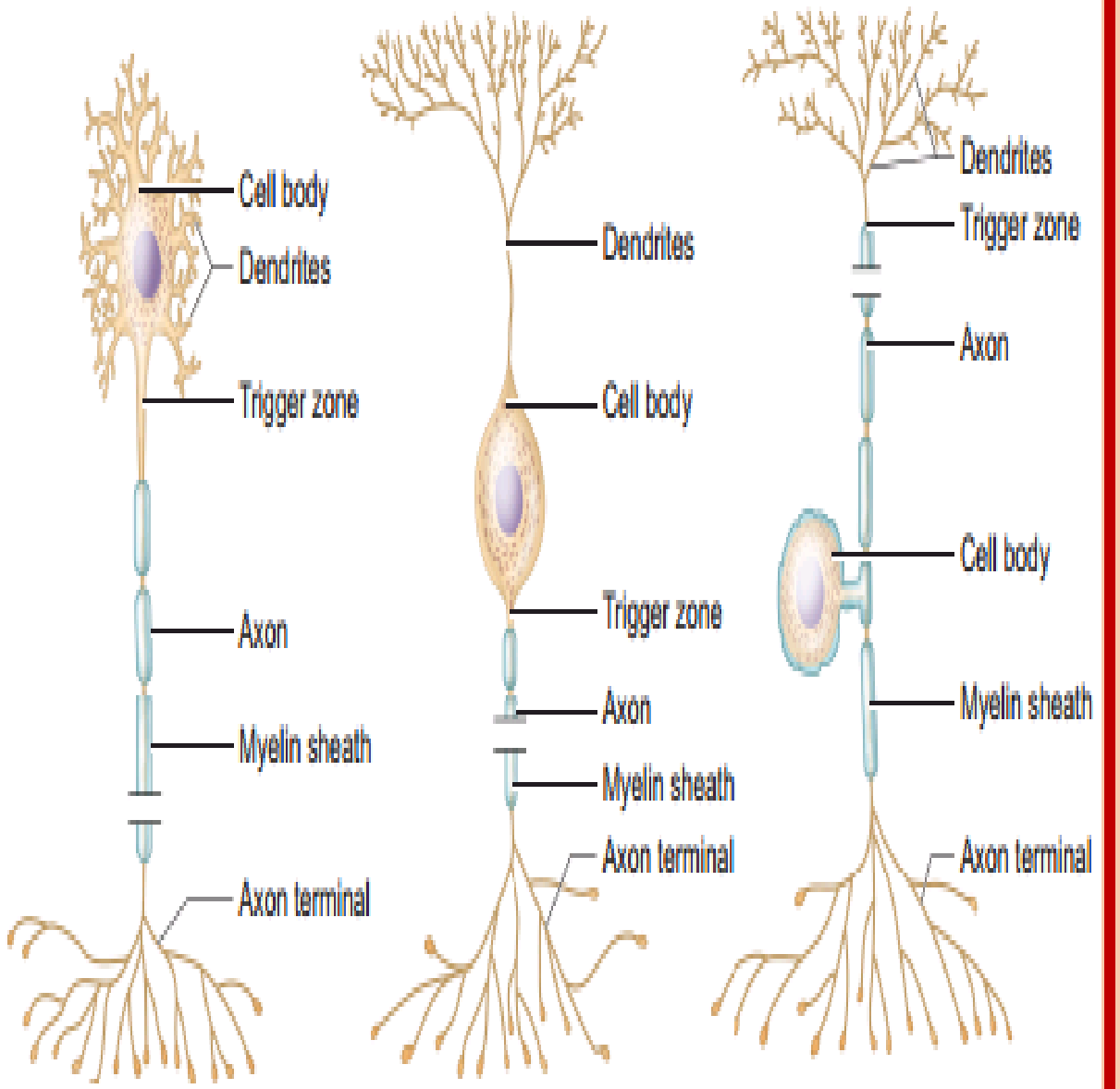


- ✓ Schwann cells present but no myelin sheath.
- ✓ The gray coloured area without myelin sheath is called *gray matter*.
- ✓ Found in *autonomous* and *somatic neural* systems.

HUMAN NEURAL SYSTEM

The longest cells in the human body are the **neurons**. The **longest** axons in the **human body**, for example, are those of the sciatic nerve, which run from the base of the spine to the big toe of each foot. These single-cell fibers may extend a meter or even longer. The axons of the inter neurons in the CNS are the shortest.

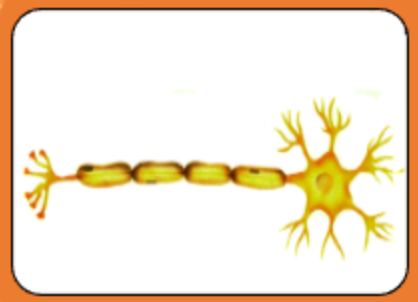
TYPES OF NEURONS



❖ The neurons are divided into three types based on number of axon and dendrites they possess.

1. Multipolar neurons have many processes with one axon and two or more dendrites. They are mostly interneurons.
2. Bipolar neurons have two processes with one axon and one dendrite. These are found in the retina of the eye, inner ear and the olfactory area of the brain.
3. Unipolar neurons have a single short process and one axon. Unipolar neurons are located in the ganglia of cranial and spinal nerves.

TYPES OF NEURON



Multipolar neuron

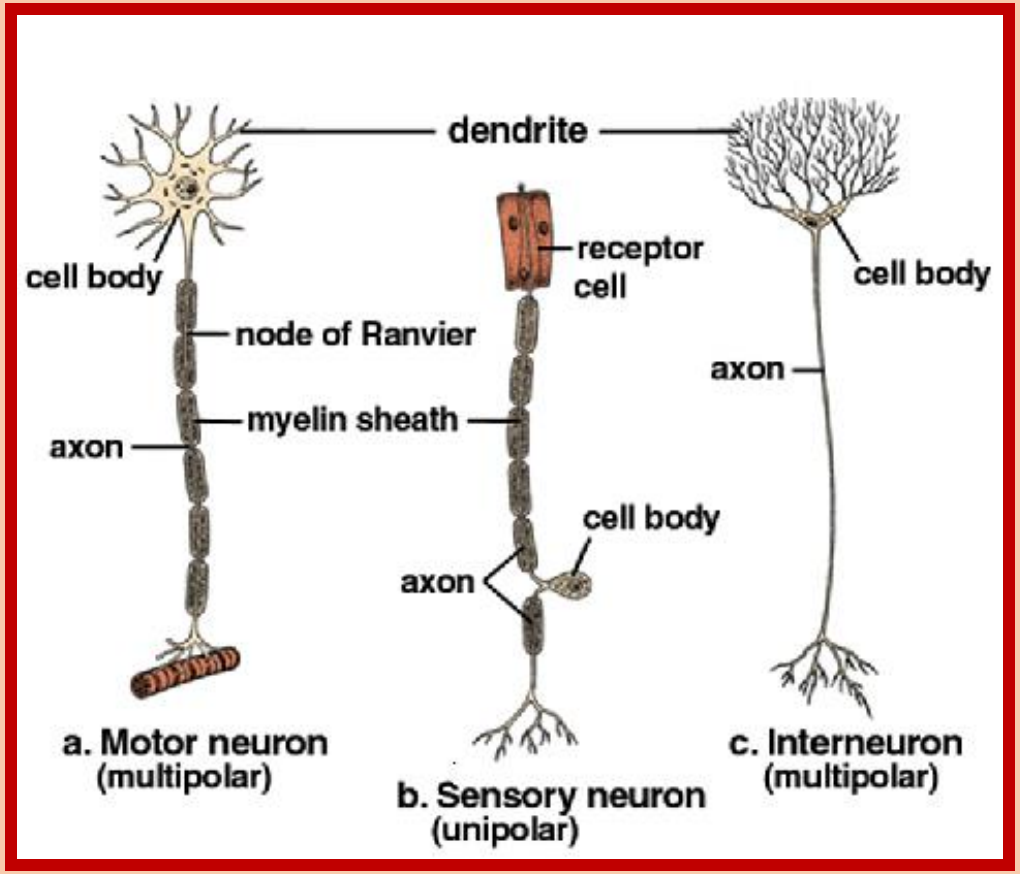
- One axon and 2 or more dendrons
- Found in the cerebral cortex

Bipolar neuron

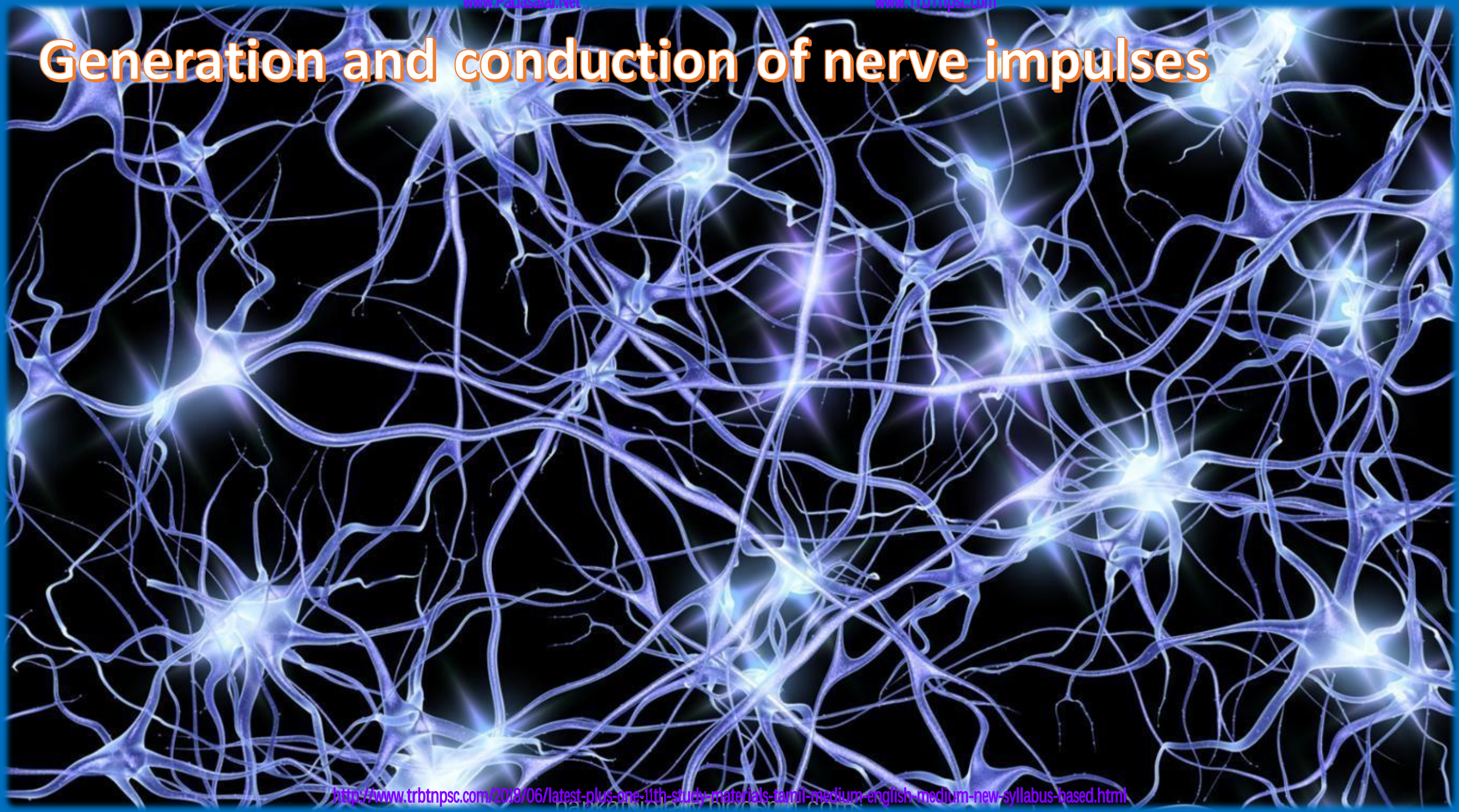
- One axon and one dendron
- Found in the retina of eye

Unipolar neuron

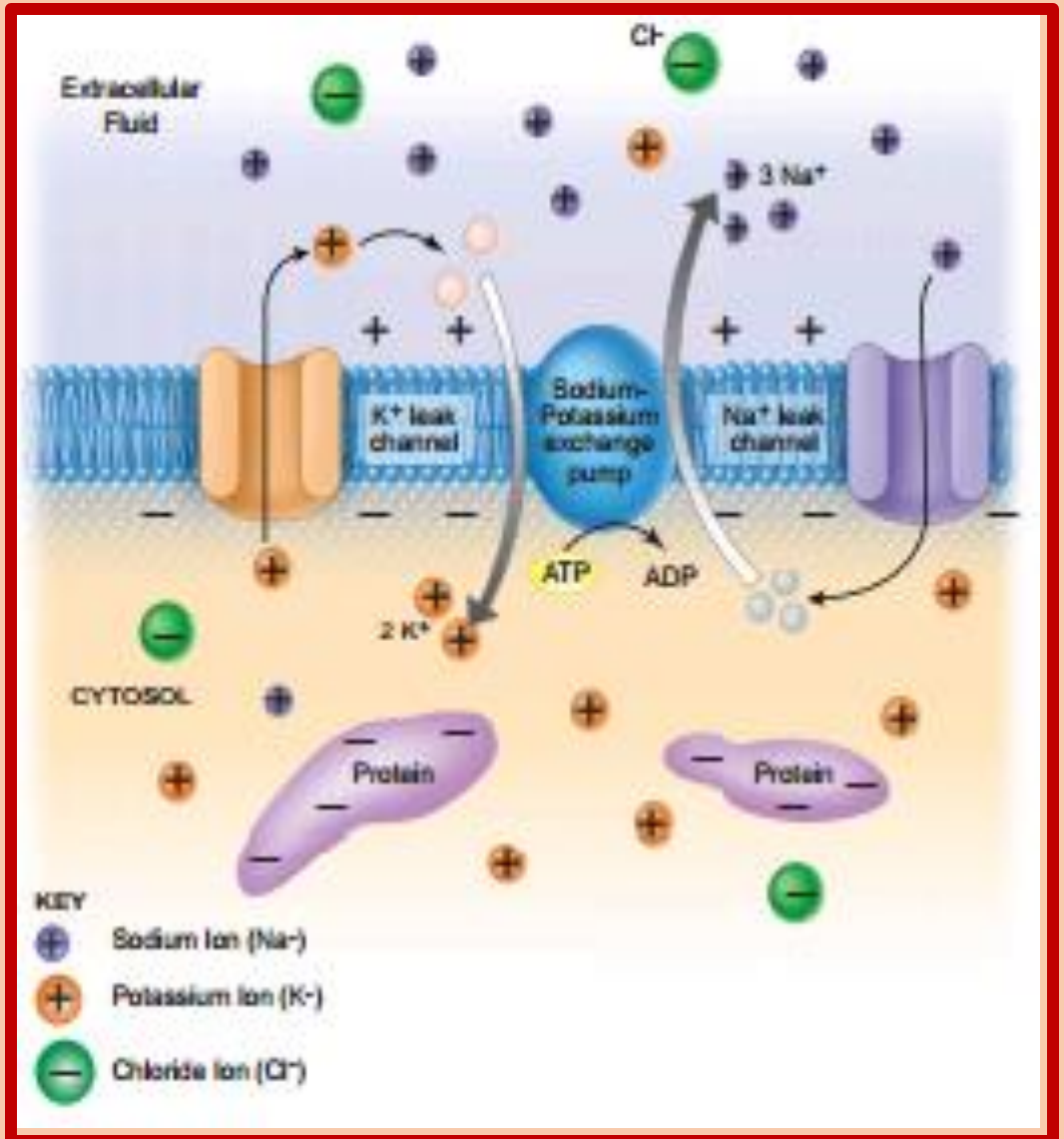
- One axon only
- Found in the embryonic stage



Generation and conduction of nerve impulses

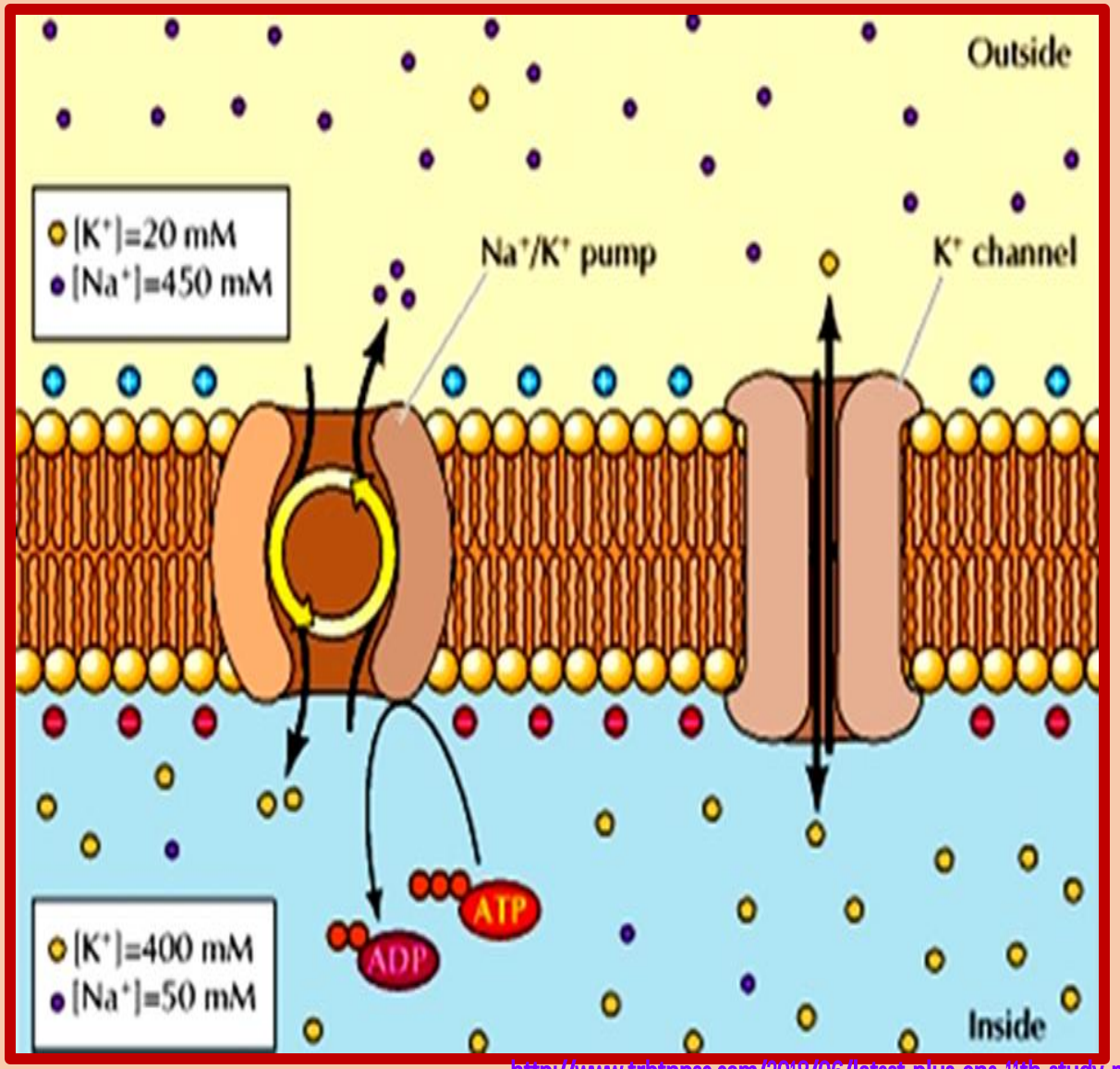


GENERATION AND CONDUCTION OF NERVE IMPULSES



- This section deals with how the nerve impulses are produced and conducted in our body.
- Sensation felt in the sensory organs are carried by the nerve fibres in the form of electrical impulses.
- A nerve impulse is a series of electrical impulses, which travel along the nerve fibre.
- Inner to the axolemma, the cytoplasm contains the intracellular fluid (ICF) with large amounts of potassium and magnesium phosphate along with negatively charged proteins and other organic molecules.
- The extra cellular fluid (ECF) found outside the axolemma contains large amounts of sodium chloride, bicarbonates, nutrients and oxygen for the cell and carbon dioxide and metabolic wastes released by the neuronal cells.

GENERATION AND CONDUCTION OF NERVE IMPULSES



- The ECF and ICF (cytosol) contains negatively charged particles (anions) and positively charged particles (cations).
- These charged particles are involved in the conduction of impulses.
- The neurons maintain an uneven distribution of various inorganic ions across their axolemma for transmission of impulses.
- This unequal distribution of ions establishes the membrane potential across the axolemma.
- The axolemma contains a variety of membrane proteins that act as ionic channels and regulates the movement of ions across the axolemma.

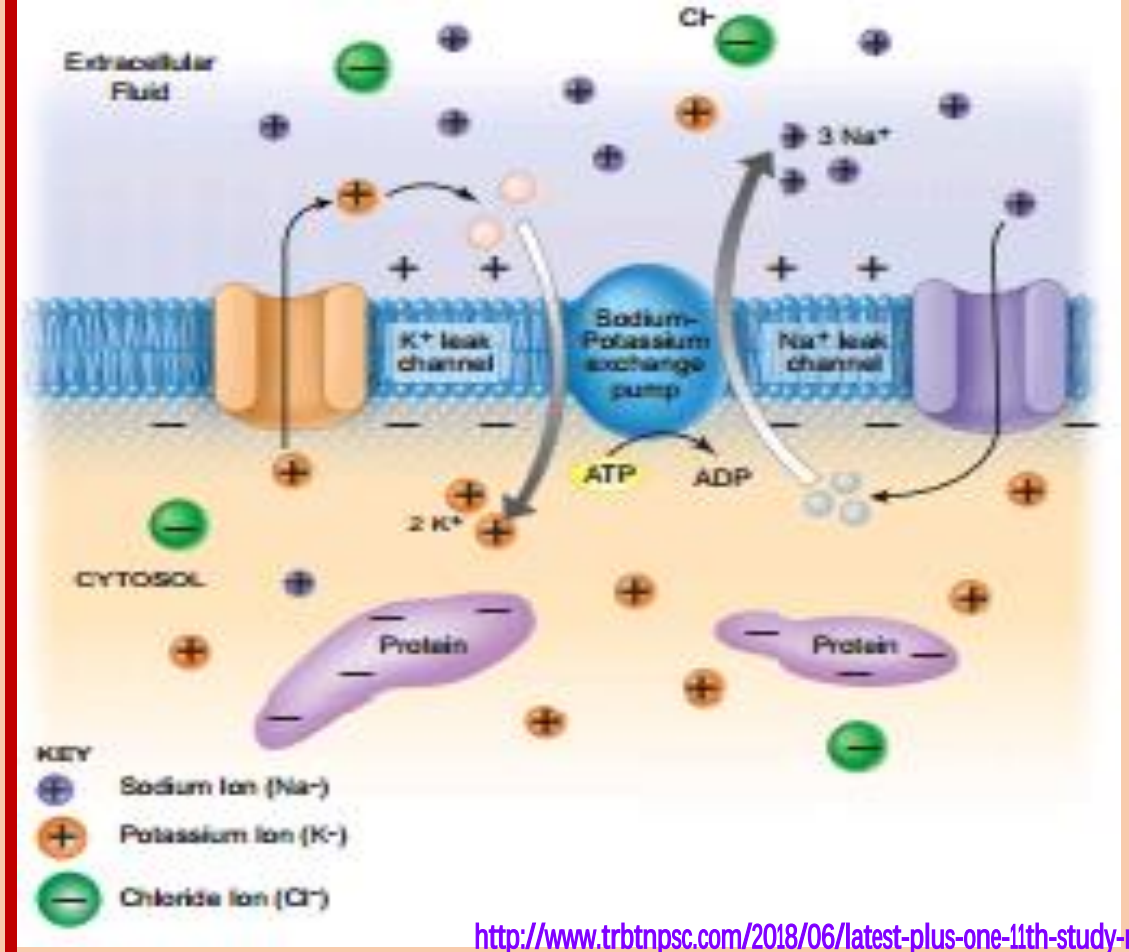
IONIC CHANNELS IN THE AXOLEMMA

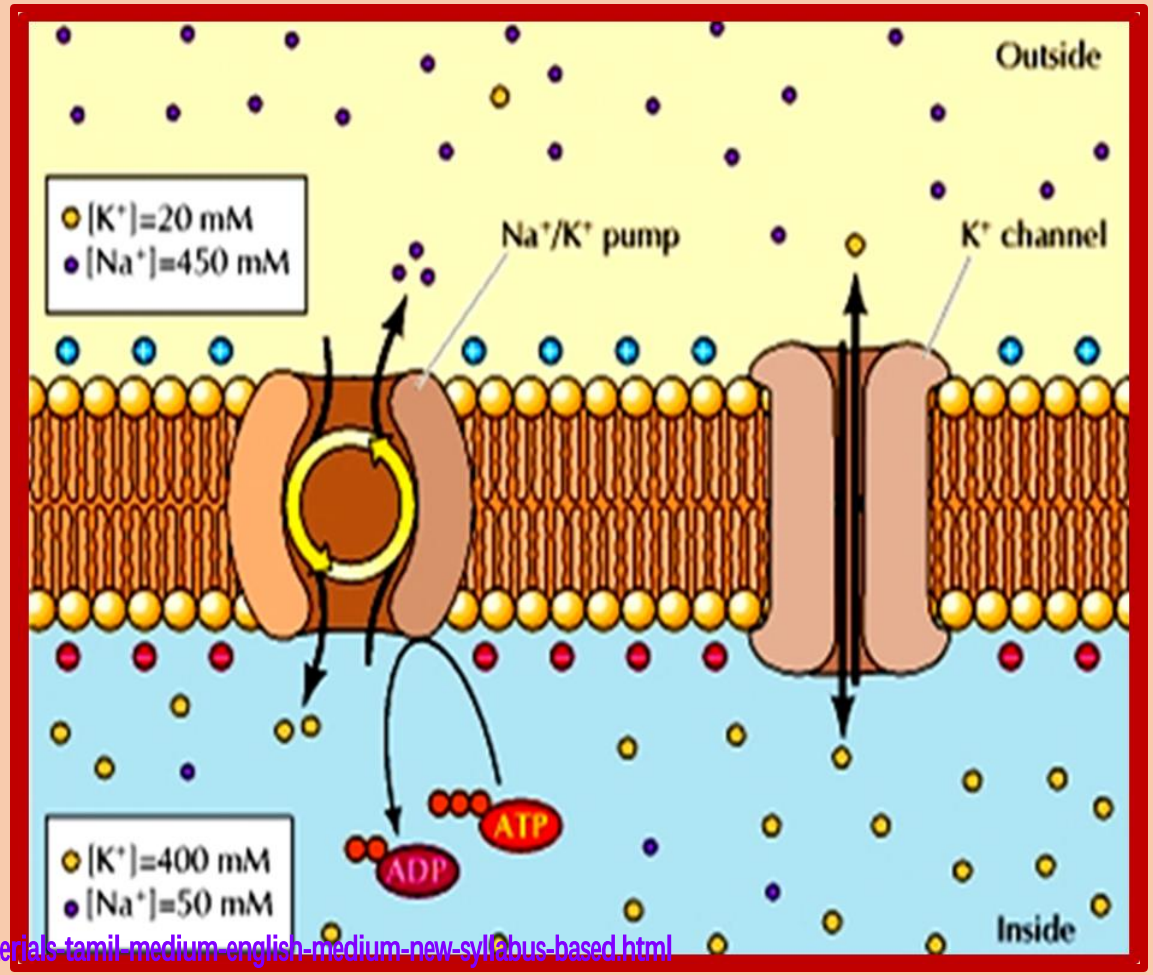
❖ **Leakage Channels** are ionic channels that remain open all the time.	❖ K+ leakage channels are more in number than the Na+ leakage channels. ❖ Sarcolemma has greater permeability to K+ ions than Na+ ions. ❖ These ions keep moving continuosly maintain the potential difference across the axolemma.
❖ **Ligand-gated Channels** are chemically gated channels which open or close in response to a chemical stimuli.	❖ They are located between the presynaptic membrane of the first axon and post synaptic membrane of the cell body of second neuron [i.e. dendrites and cell bodies]. ❖ The neurotransmitter acetylcholine opens ligand channels that allow Na+ and Ca++ ions diffuse inward and K+ ions diffuse outward.
❖ **Voltage-gated Channels** are mechanically gated channels which open in response to a physical stimulus in the form of vibration such as touch and pressure.	❖ These channels open in response to a change in membrane potential. ❖ There are two types of voltage-gated channels. i. Sodium voltage-gated channel ii. Potassium voltage-gated channel

TRANSMISSION OF IMPULSES

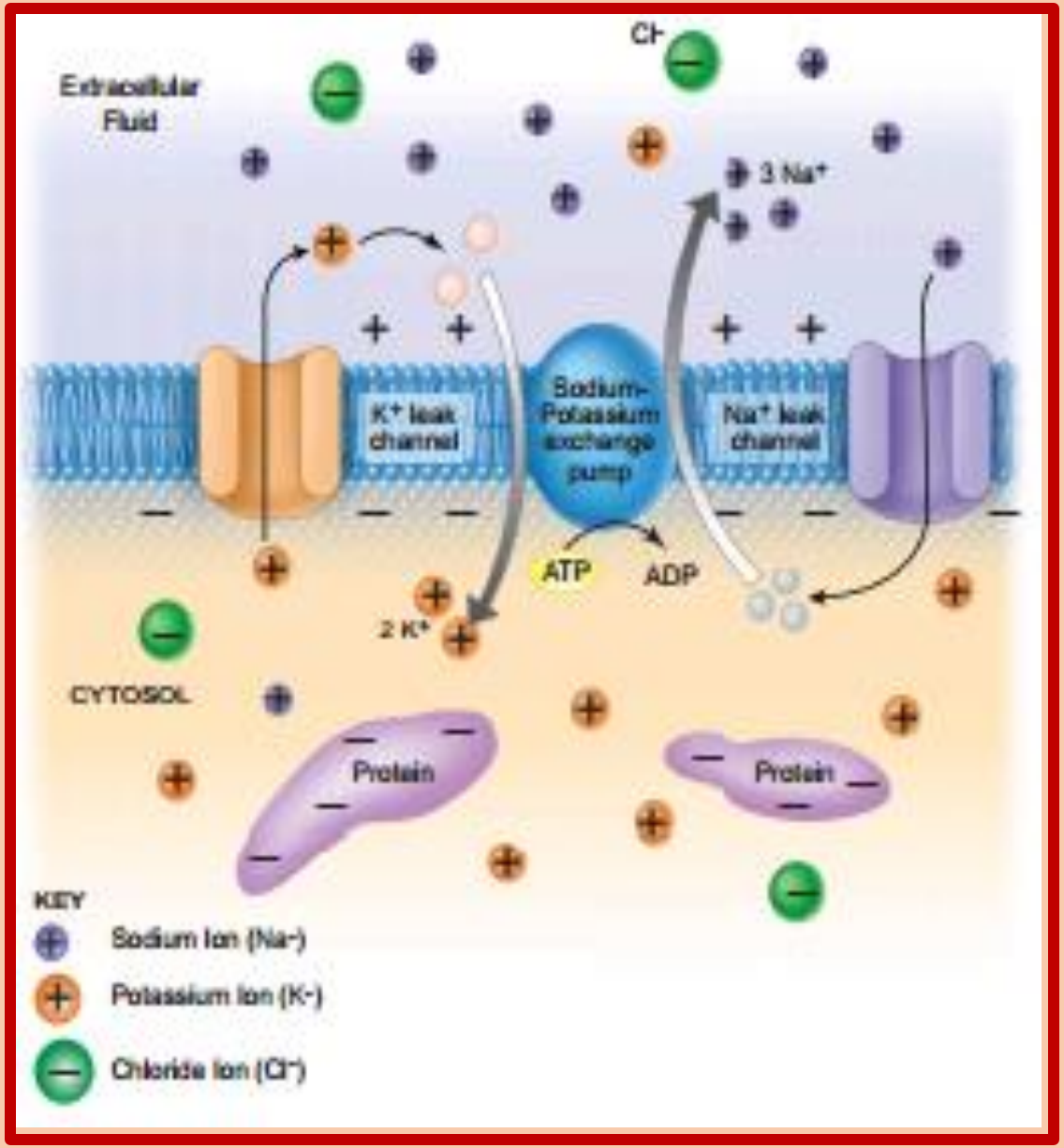
❖ The transmission of impulse involves two main phases.

1. Resting membrane potential
2. Action membrane potential.



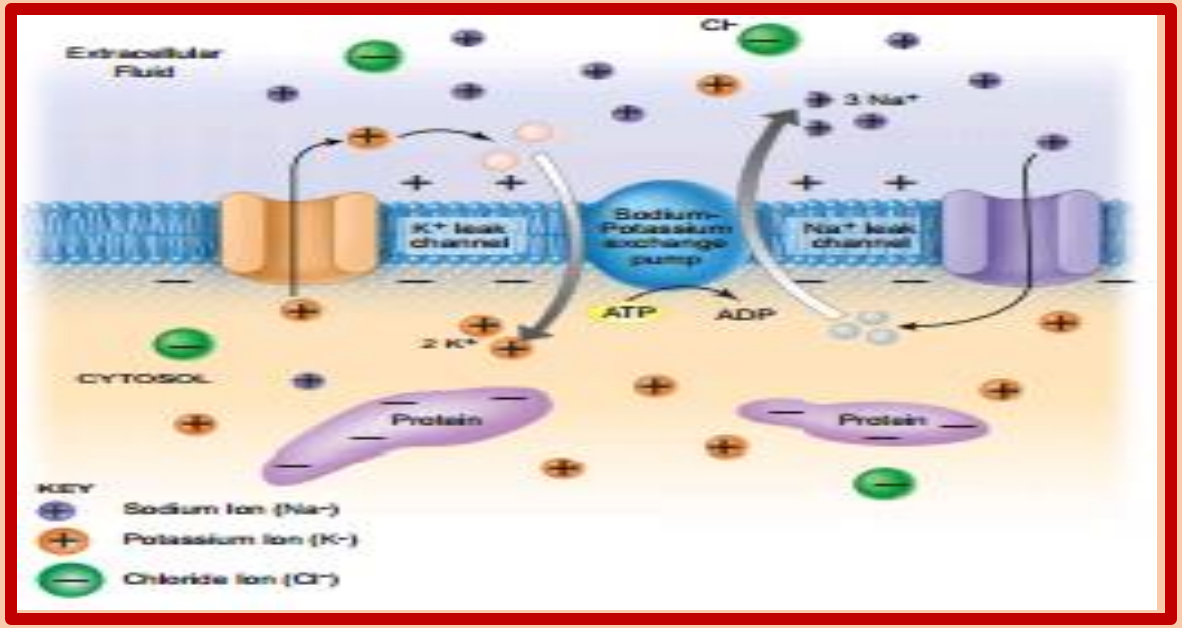


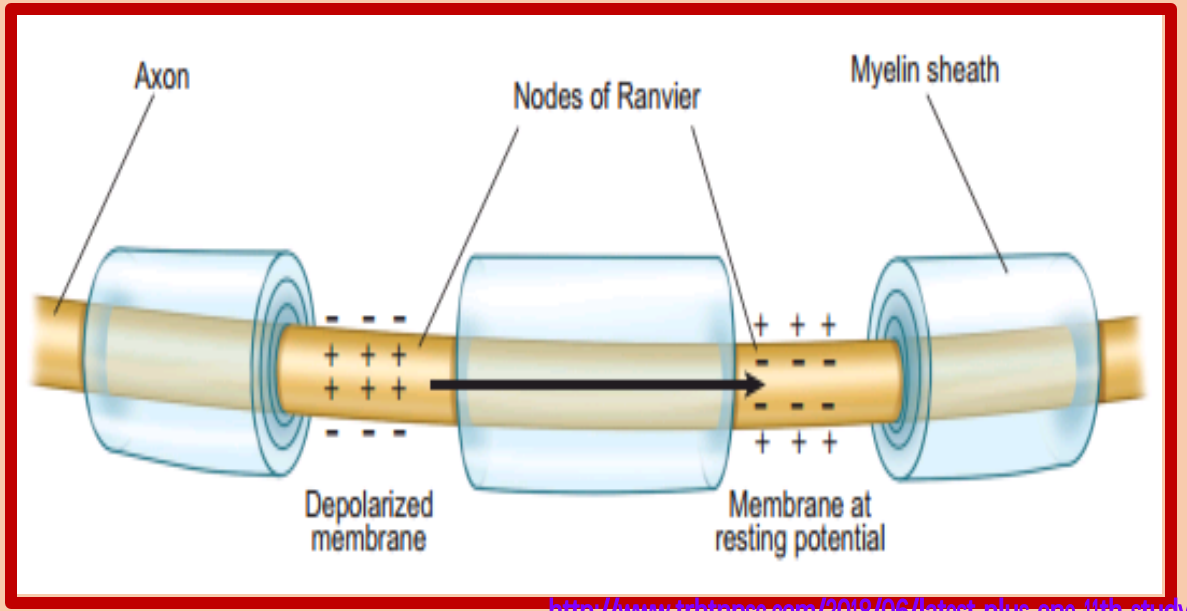
RESTING MEMBRANE POTENTIAL



- ✓ The electrical potential difference across the plasma membrane of a resting neuron is called the resting potential
- ✓ During which the interior of the cell is negative due to greater efflux of K+ outside the cell than Na+ influx into the cell.
- ✓ When the axon is not conducting any impulses i.e. in resting condition, the axon membrane is more permeable to K+ and less permeable to Na+ ions, whereas it remains impermeable to negatively charged protein ions.
- ✓ The axoplasm contains high concentration of K+ and negatively charged proteins and low concentration of Na+ ions.

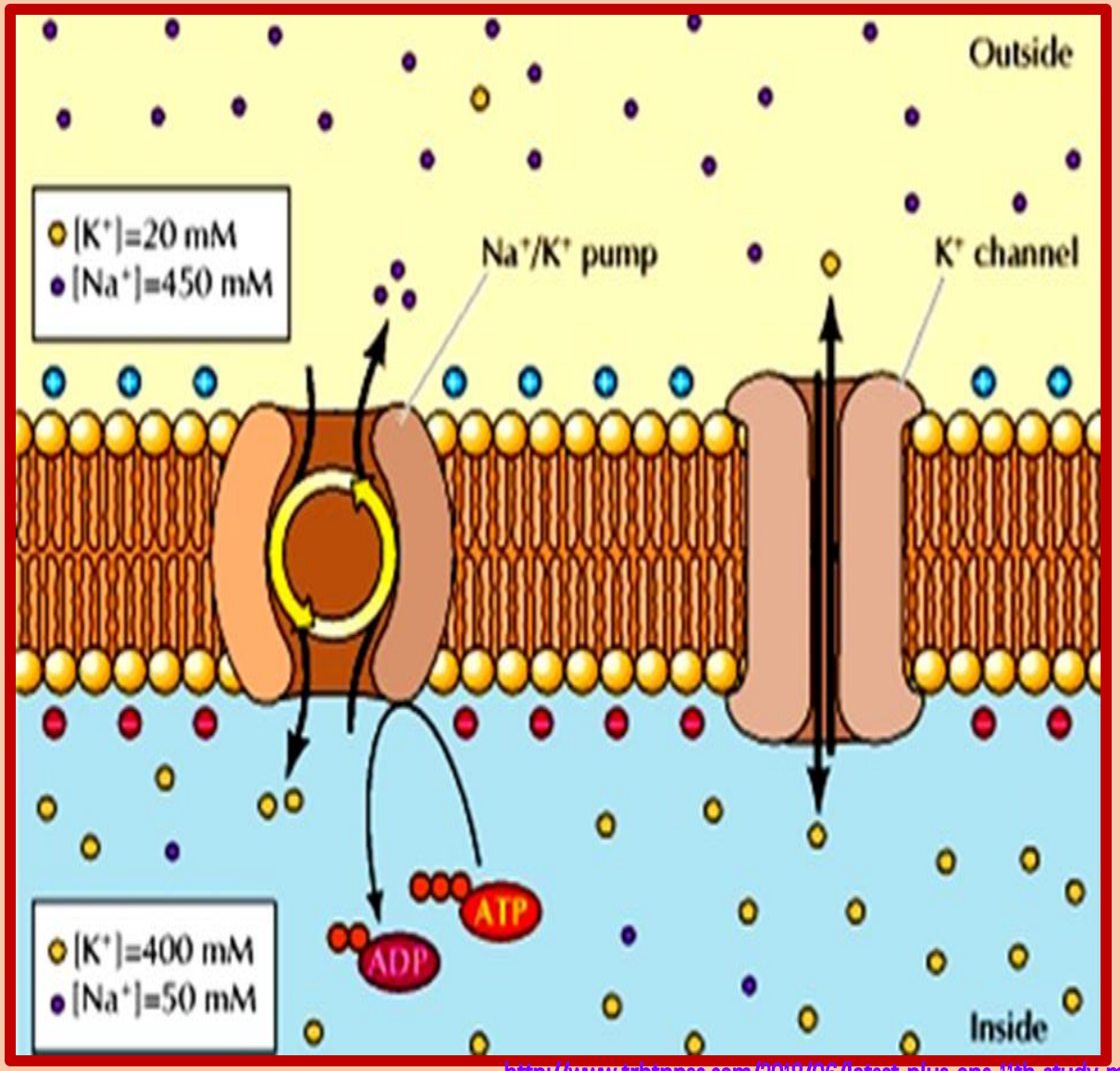
RESTING MEMBRANE POTENTIAL





- ✓ In contrast, fluid outside the axon (ECF) contains low concentration of K+and high concentration of Na+, and this forms a concentration gradient.
- ✓ This ionic gradient across the resting membrane is maintained by ATP driven Sodium-Potassium pump, which exchanges 3Na+outwards for 2K+into the cells.
- ✓ In this state, the cell membrane is said to be polarized.
- ✓ In neuron, the resting membrane potential ranges from -40mV to -90mV, and its normal value is -70mV.
- ✓ The minus sign indicates that the inside of the cell is negative with respect to the outside.

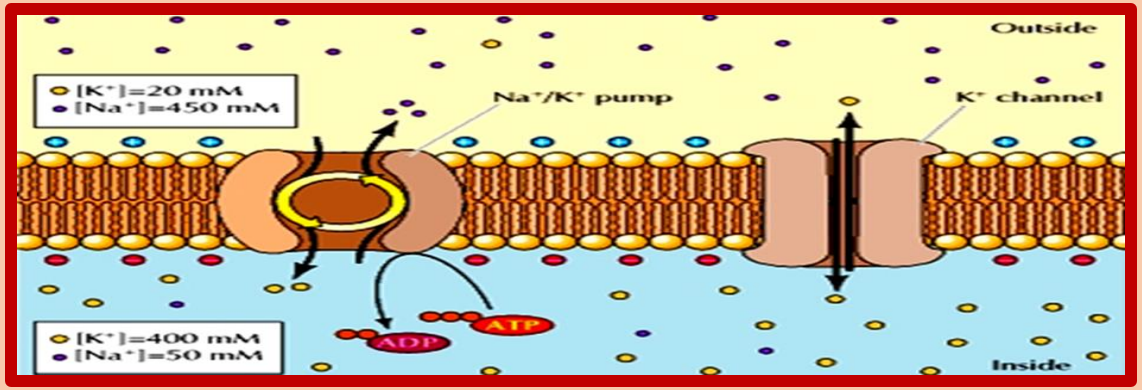
ACTION MEMBRANE POTENTIAL

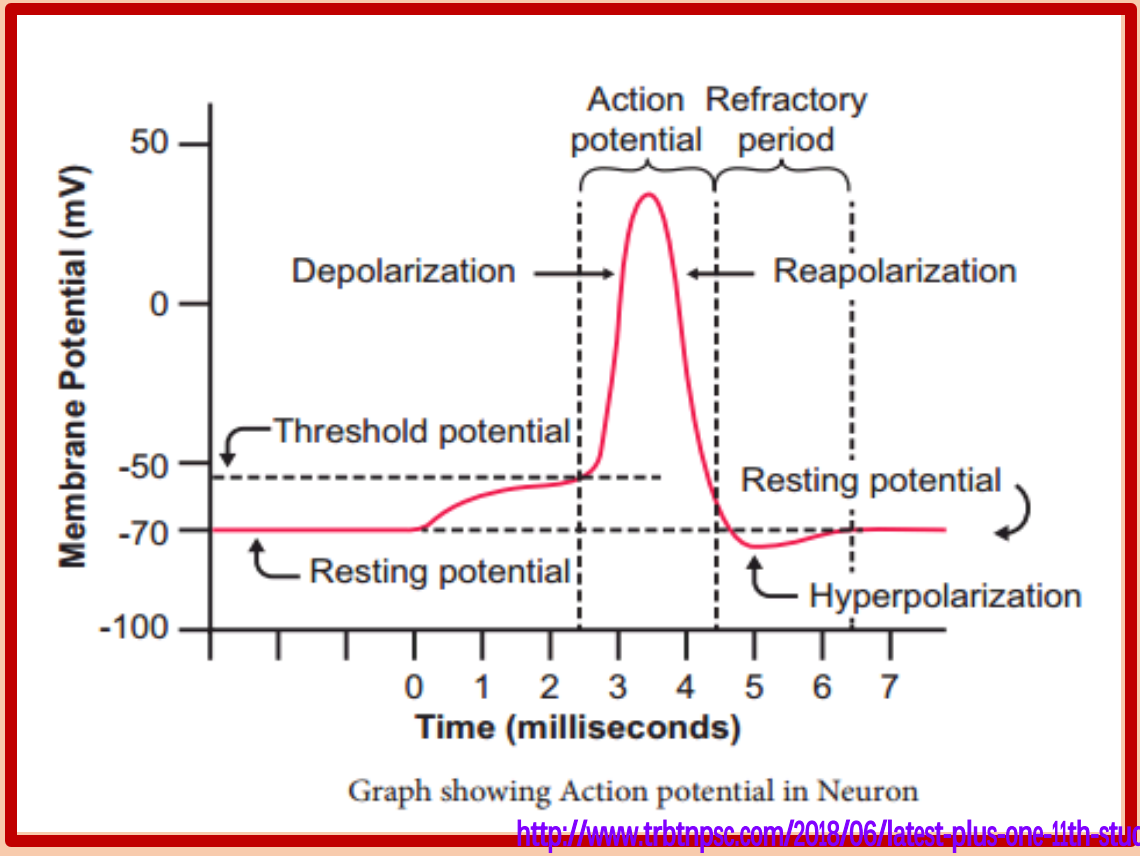


✓ An action potential occurs when a neuron sends information down an axon, away from the cell body. It includes following phases,

1. Depolarization
2. Repolarisation
3. Hyper polarization.

1. DEPOLARIZATION – REVERSAL OF POLARITY

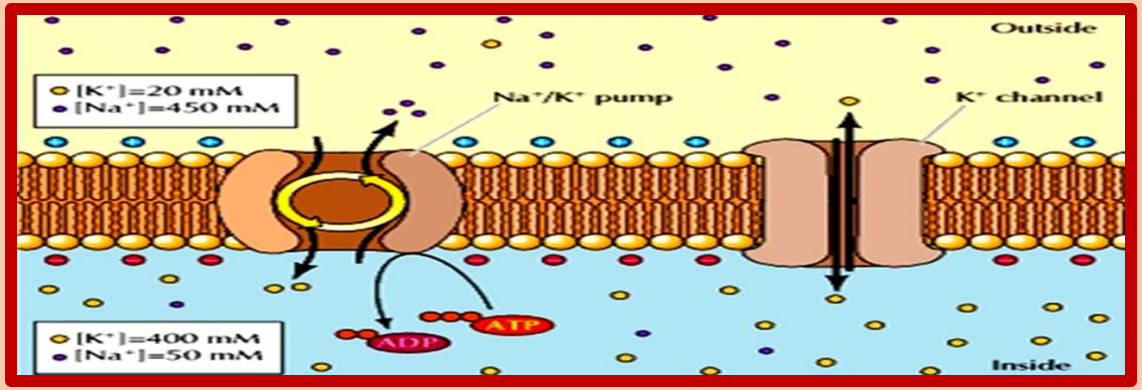


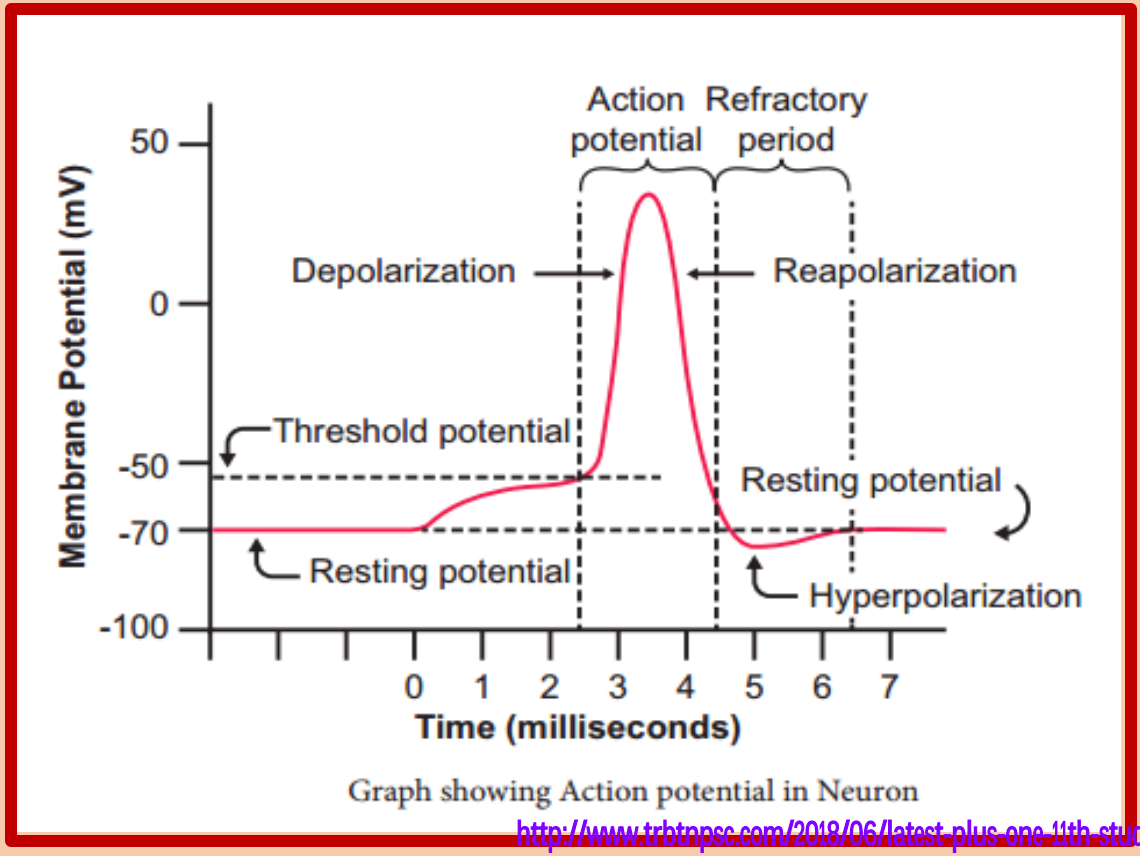


Graph showing Action potential in Neuron

- When a nerve fibre is stimulated, sodium voltage-gate opens and makes the axolemma permeable to Na+ ions, meanwhile the potassium voltage gate closes.
- As a result, the rate of flow of Na+ ions into the axoplasm exceeds the rate of flow of K+ ions to the outside fluid [ECF].
- Therefore, the axolemma becomes positively charged inside and negatively charged outside.
- This reversal of electrical charge is called Depolarization.

1. DEPOLARIZATION – REVERSAL OF POLARITY

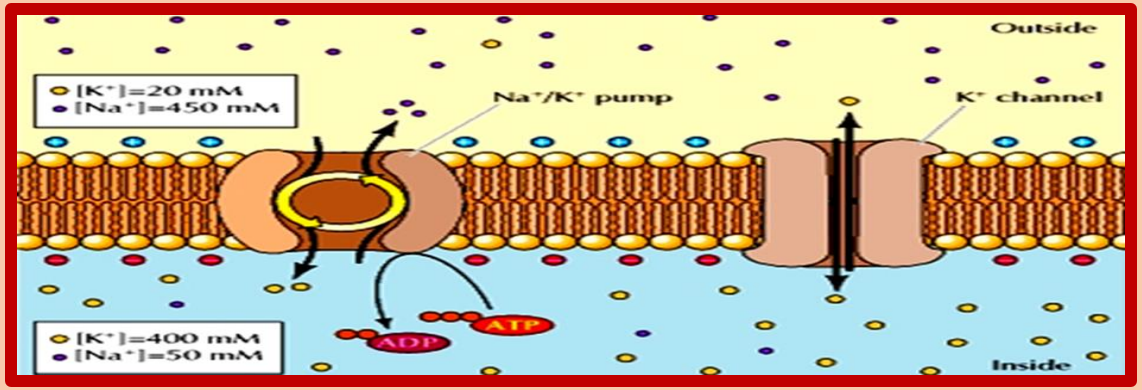


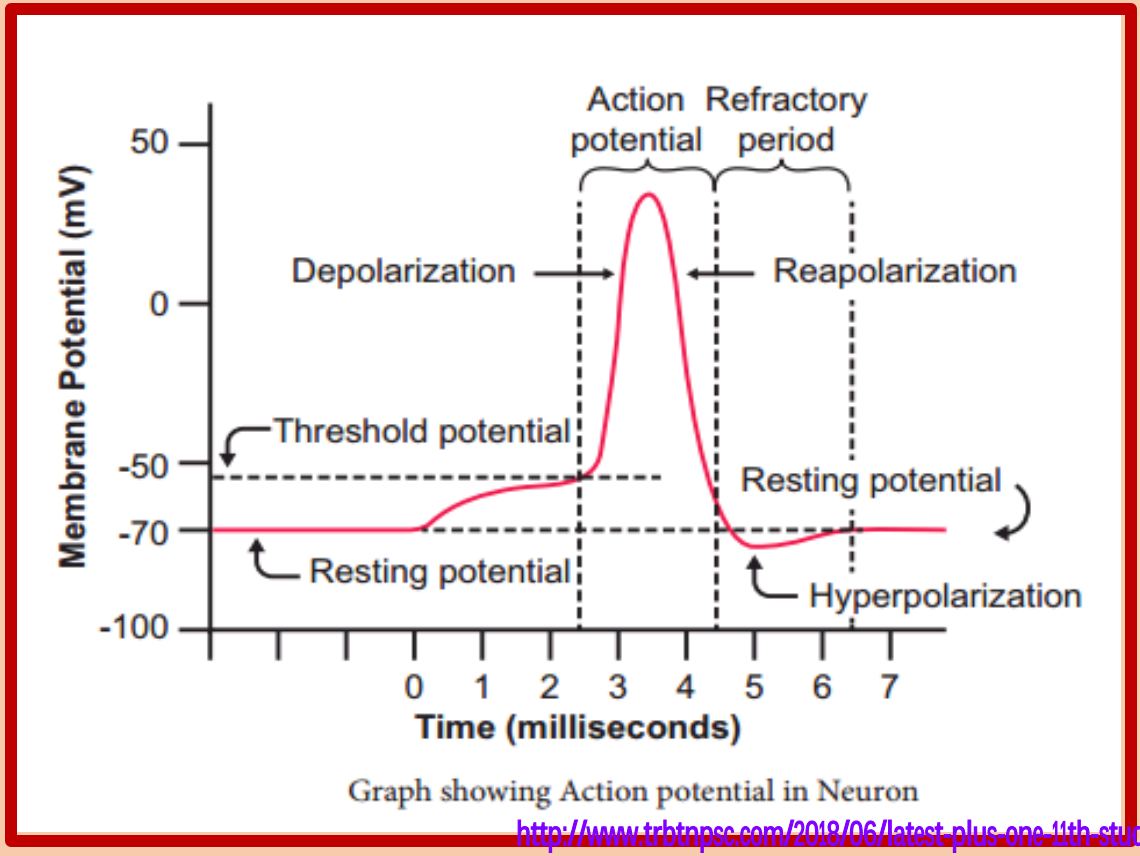


Graph showing Action potential in Neuron

- During depolarization, when enough Na+ ions enter the cell, the action potential reaches a certain level, called threshold potential [-55mV].
- The particular stimulus which is able to bring the membrane potential to threshold is called threshold stimulus.
- The action potential occurs in response to a threshold stimulus but does not occur at subthreshold stimuli. This is called all or none principle.
- Due to the rapid influx of Na+ ions, the membrane potential shoots rapidly up to +45mV which is called the Spike potential.

2. REPOLARIZATION – FALLING PHASE

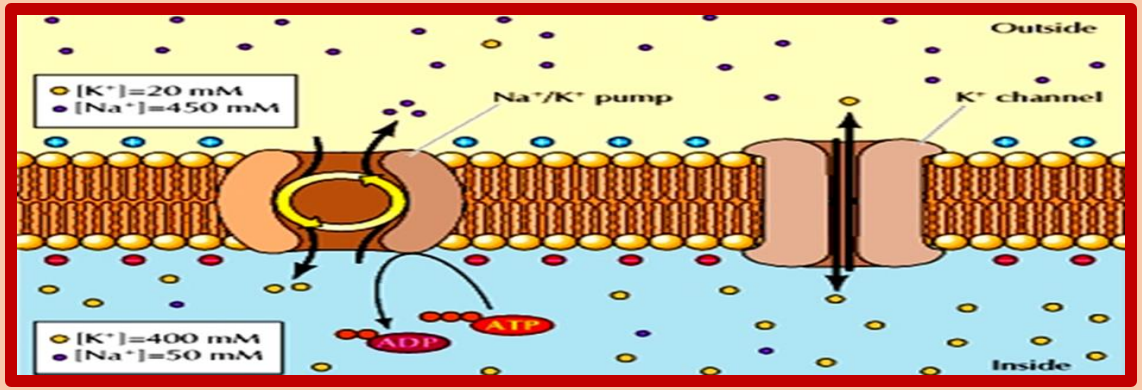


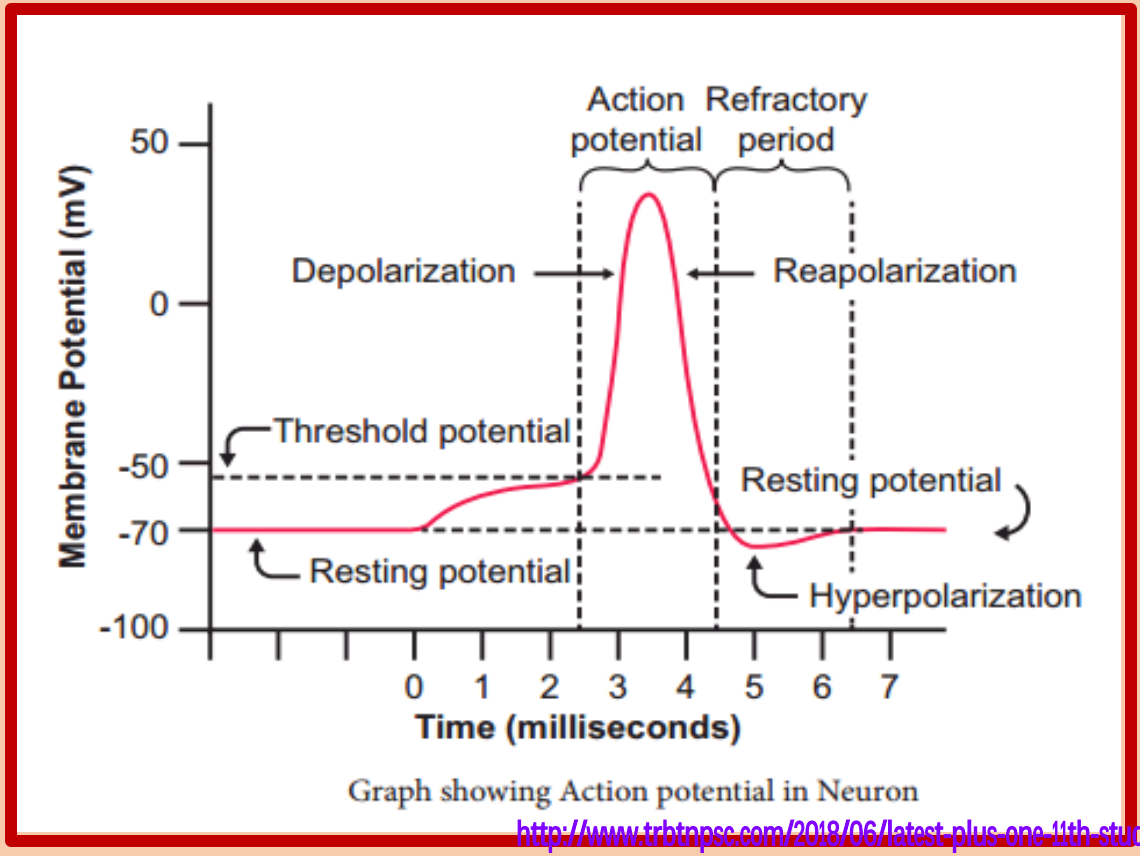


Graph showing Action potential in Neuron

- When the membrane reaches the spike potential, the sodium voltage-gate closes and potassium voltage-gate opens.
- It checks influx of Na+ions and initiates the efflux of K+ions which lowers the number of positive ions within the cell.
- Thus, the potential falls back towards the resting potential.
- The reversal of membrane potential inside the axolemma to negative occurs due to the efflux of K+ ions. This is called Repolarisation.

3. HYPERPOLARIZATION

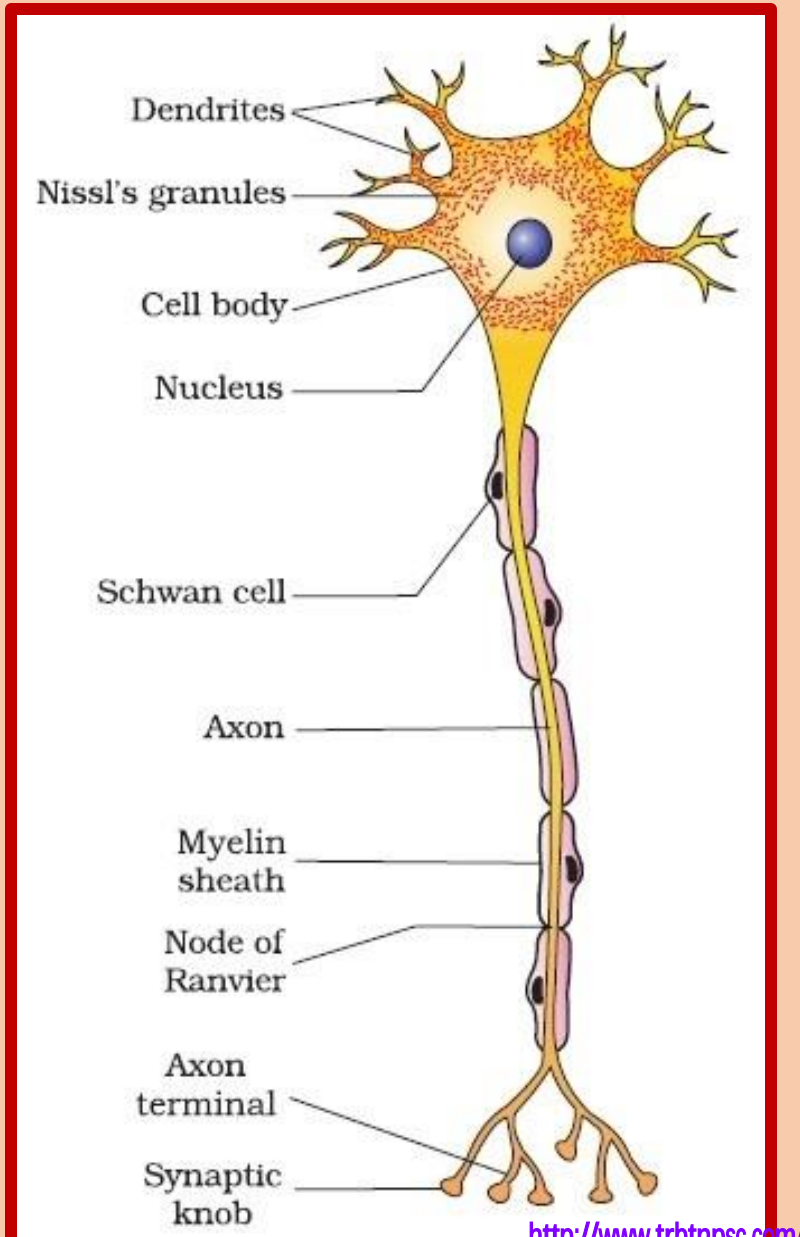




Graph showing Action potential in Neuron

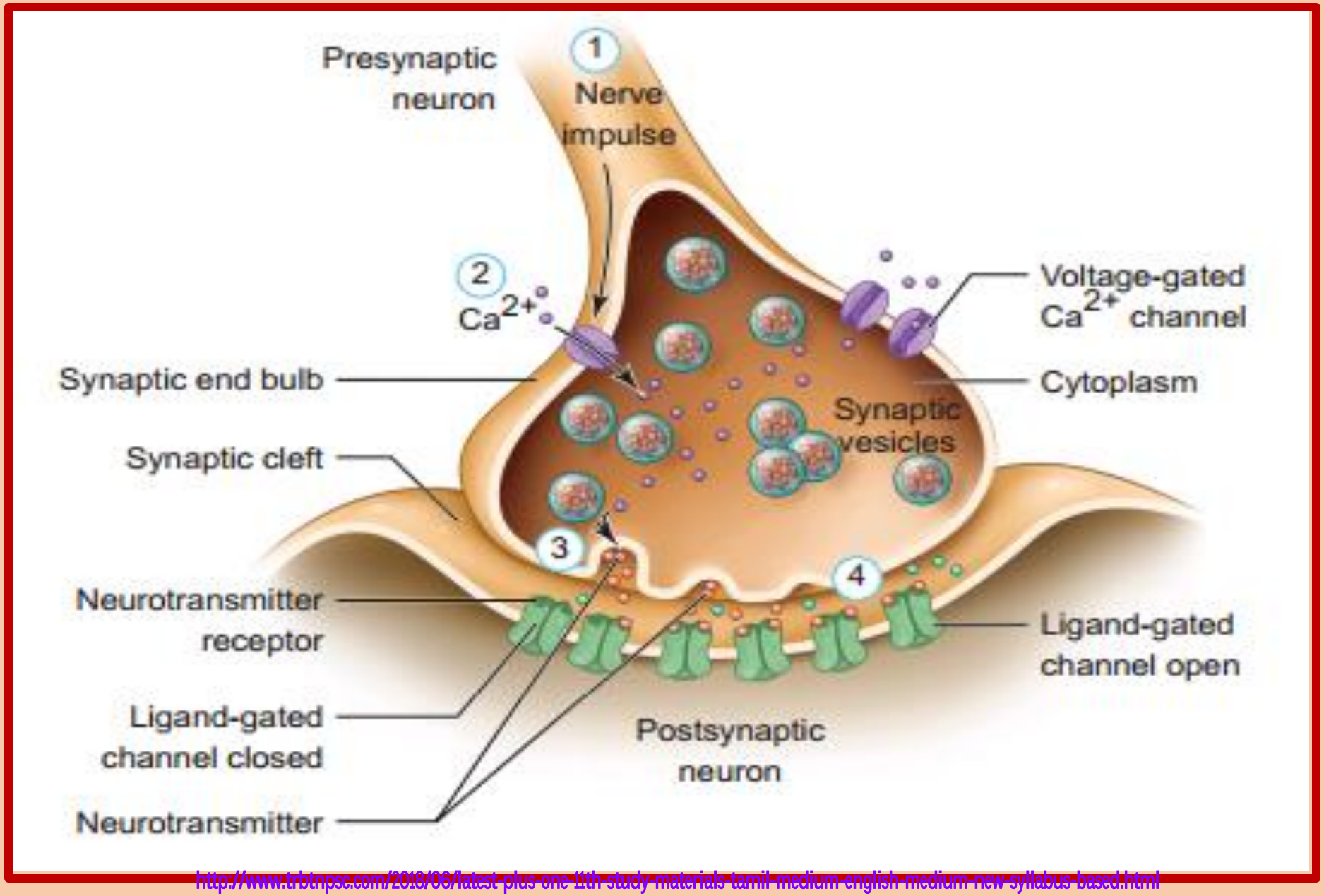
- If repolarization becomes more negative than the resting potential -70 mV to about -90 mV, it is called Hyperpolarization.
- During this, K+ ion gates are more permeable to K+ even after reaching the threshold level as it closes slowly, hence called Lazy gates.
- The membrane potential returns to its original resting state when K+ ion channels close completely.
- During hyperpolarization the Na+ voltage gateremains closed.

CONDUCTION SPEED OF NERVE IMPULSE

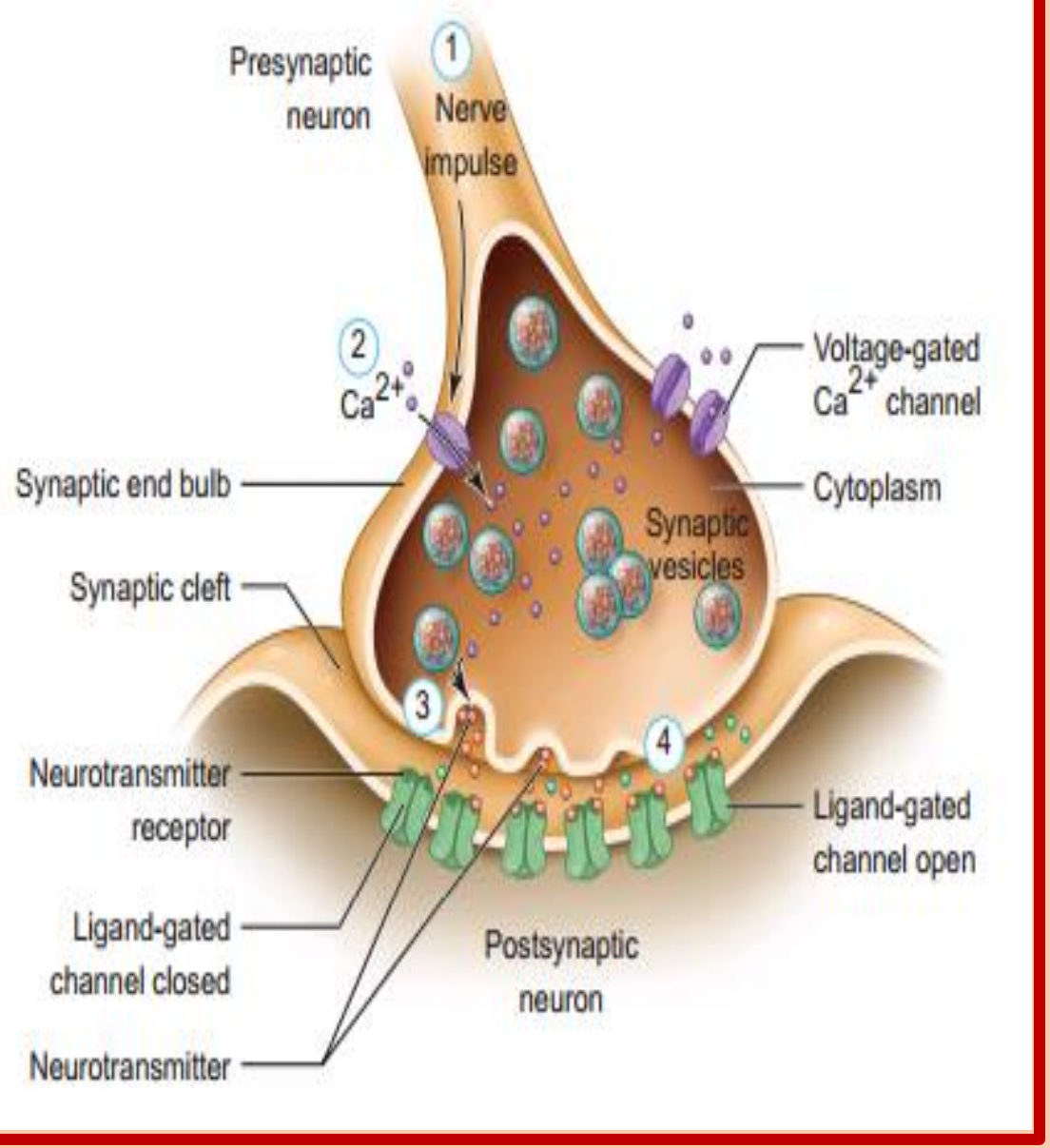


- The conduction speed of a nerve impulse depends on the diameter of axon.
- The greater the axon's diameter, the faster is the conduction.
- The myelinated axon conducts the impulse faster than the non-myelinated axon.
- The voltage-gated Na+ and K+ channels are concentrated at the nodes of Ranvier.
- As a result, the impulse jumps node to node, rather than travelling the entire length of the nerve fibre.
- This mechanism of conduction is called Saltatory Conduction.
- Nerve impulses travel at the speed of 1-300 m/s.

SYNAPTIC TRANSMISSION

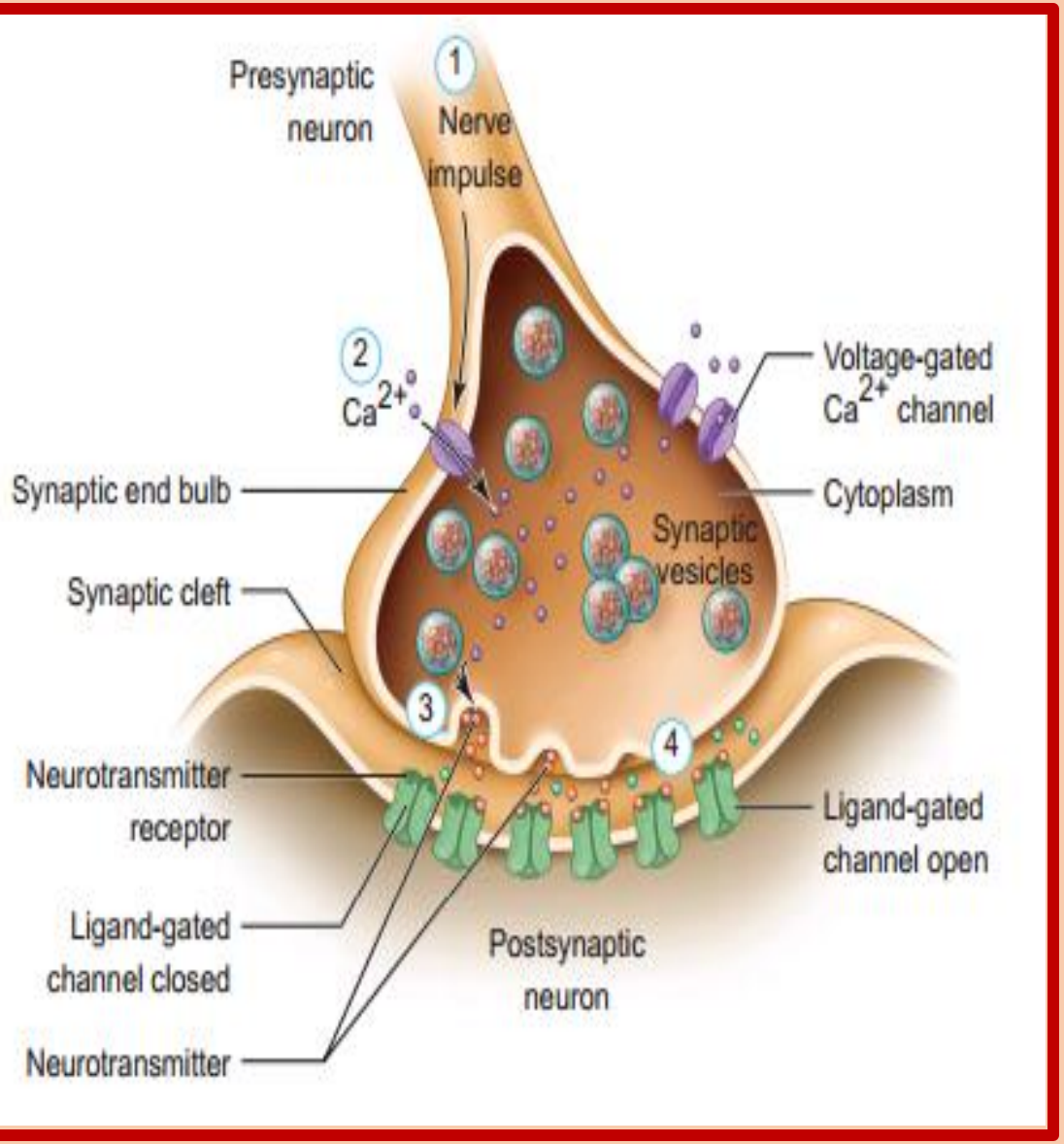


SYNAPTIC TRANSMISSION



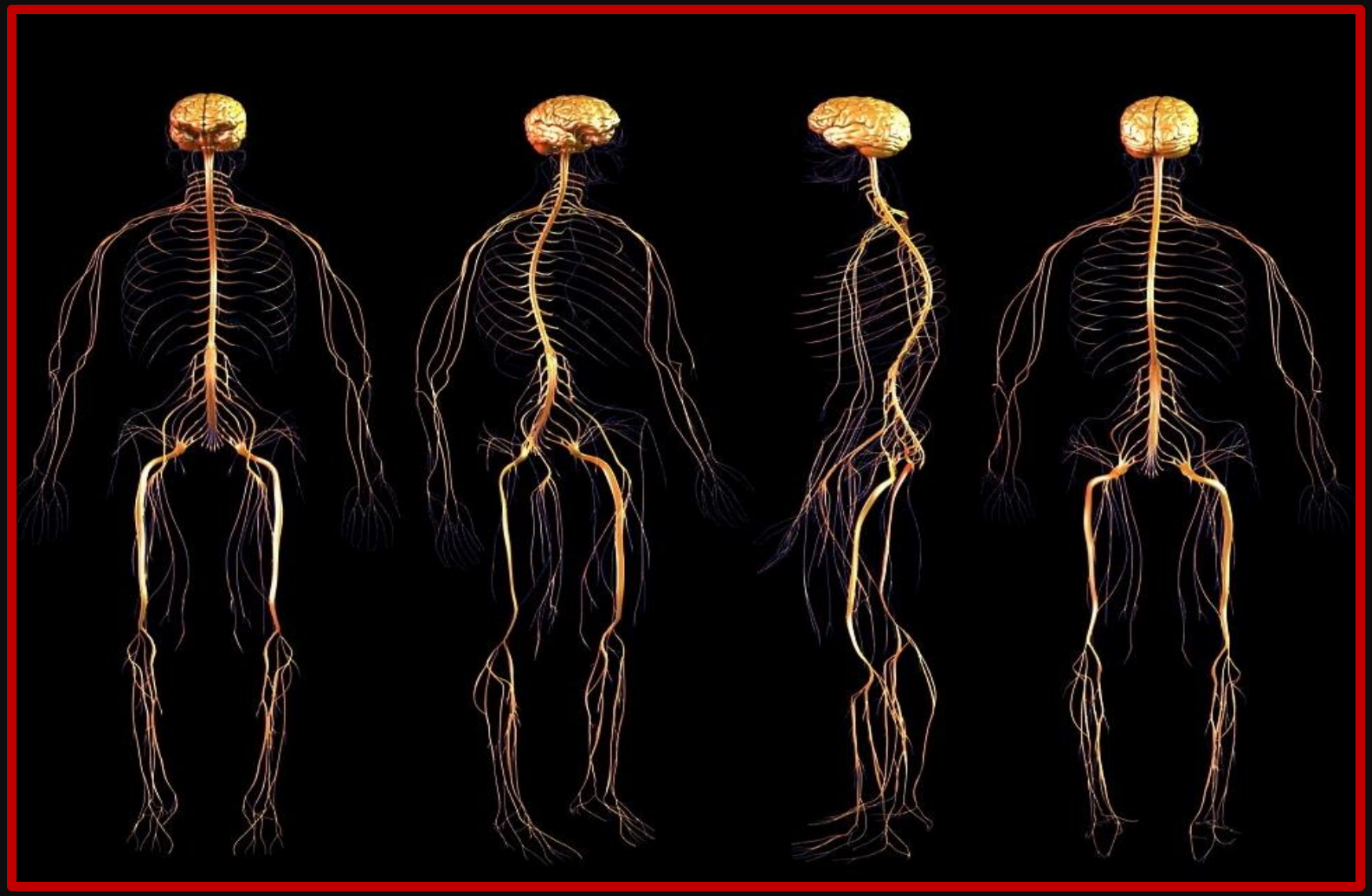
- ✓ The junction between two neurons is called a **Synapse** through which a nerve impulse is transmitted.
- ✓ The **first neuron** involved in the synapse forms the **presynaptic neuron** and the **second neuron** is the **post-synaptic neuron**.
- ✓ A small gap **between the pre and postsynaptic membranes** is called **Synaptic Cleft** that forms a structural gap and a functional bridge between neurons.
- ✓ The axon terminals contain **synaptic vesicles filled with neurotransmitters**.
- ✓ When an impulse [action potential] arrives at the axon terminals, it **depolarizes the presynaptic membrane**, opening the voltage gated calcium channels.

SYNAPTIC TRANSMISSION



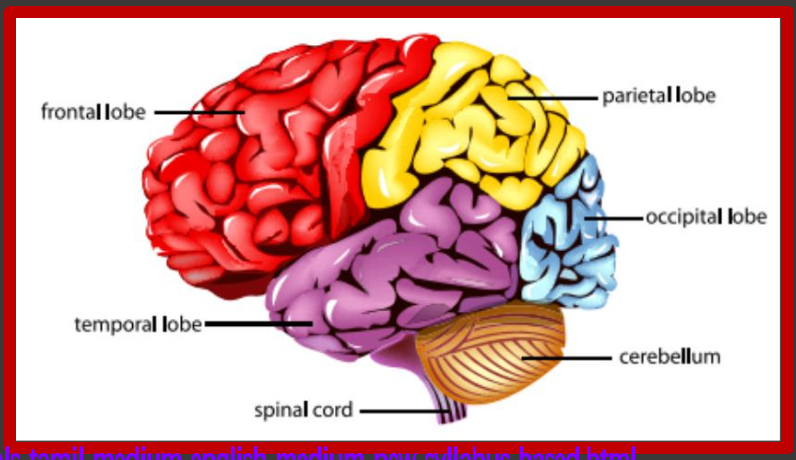
- ✓ Influx of calcium ions stimulates the synaptic vesicles towards the pre-synaptic membrane and fuses with it.
- ✓ In the neurilemma, the vesicles release their neurotransmitters into the synaptic cleft by exocytosis.
- ✓ The released neurotransmitters bind to their specific receptors on the post-synaptic membrane, responding to chemical signals.
- ✓ The entry of the ions can generate a new potential in the post-synaptic neuron, which may be either excitatory or inhibitory.
- ✓ Excitatory post-synaptic potential causes depolarization whereas inhibitory post-synaptic potential causes hyperpolarization of post-synaptic membrane.

Human Neural System

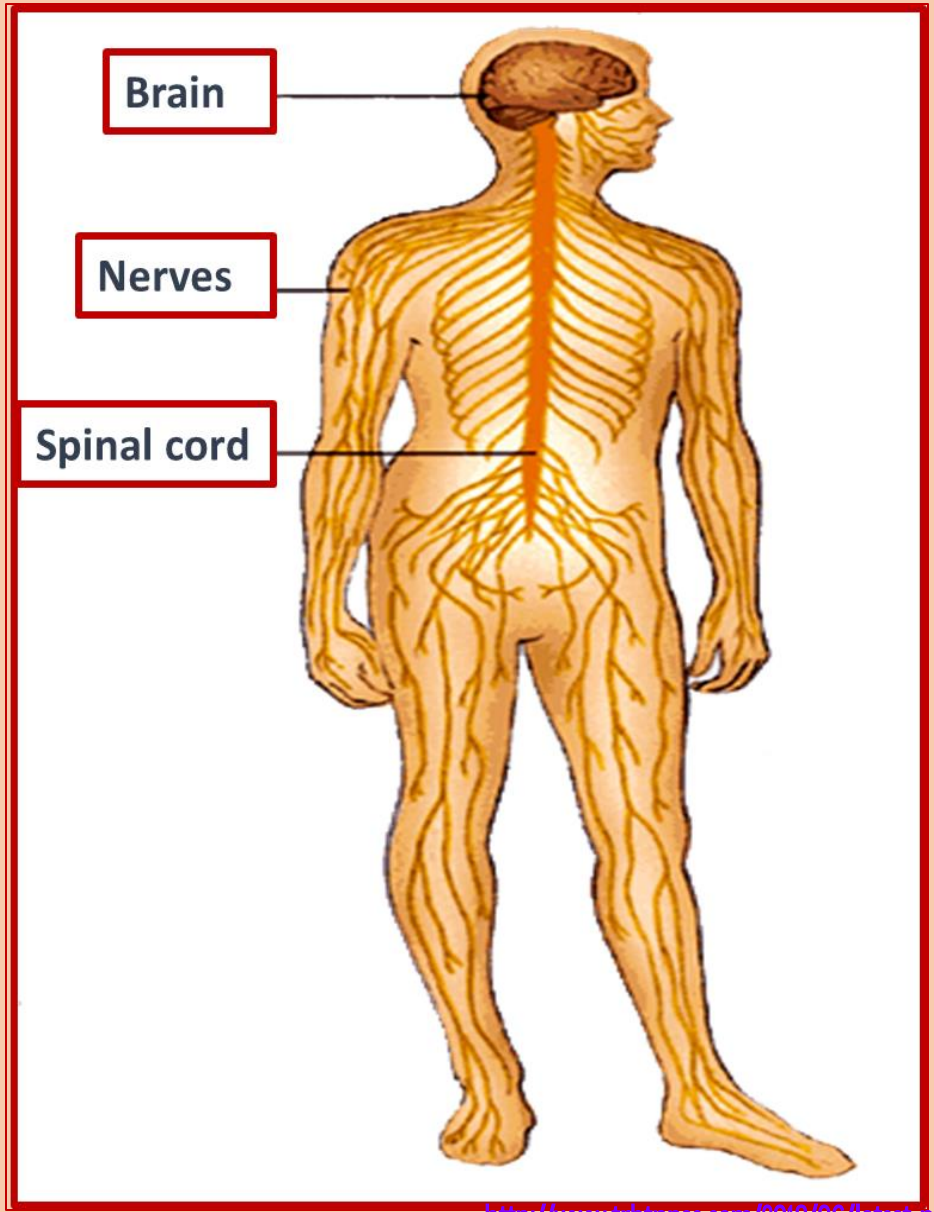


HUMAN NEURAL SYSTEM

- CENTRAL NEURAL SYSTEM (CNS)
  - BRAIN
  - SPINAL CORD
- PERIPHERAL NEURAL SYSTEM (PNS)
  - SOMATIC NEURAL SYSTEM
  - AUTONOMIC NEURAL SYSTEM

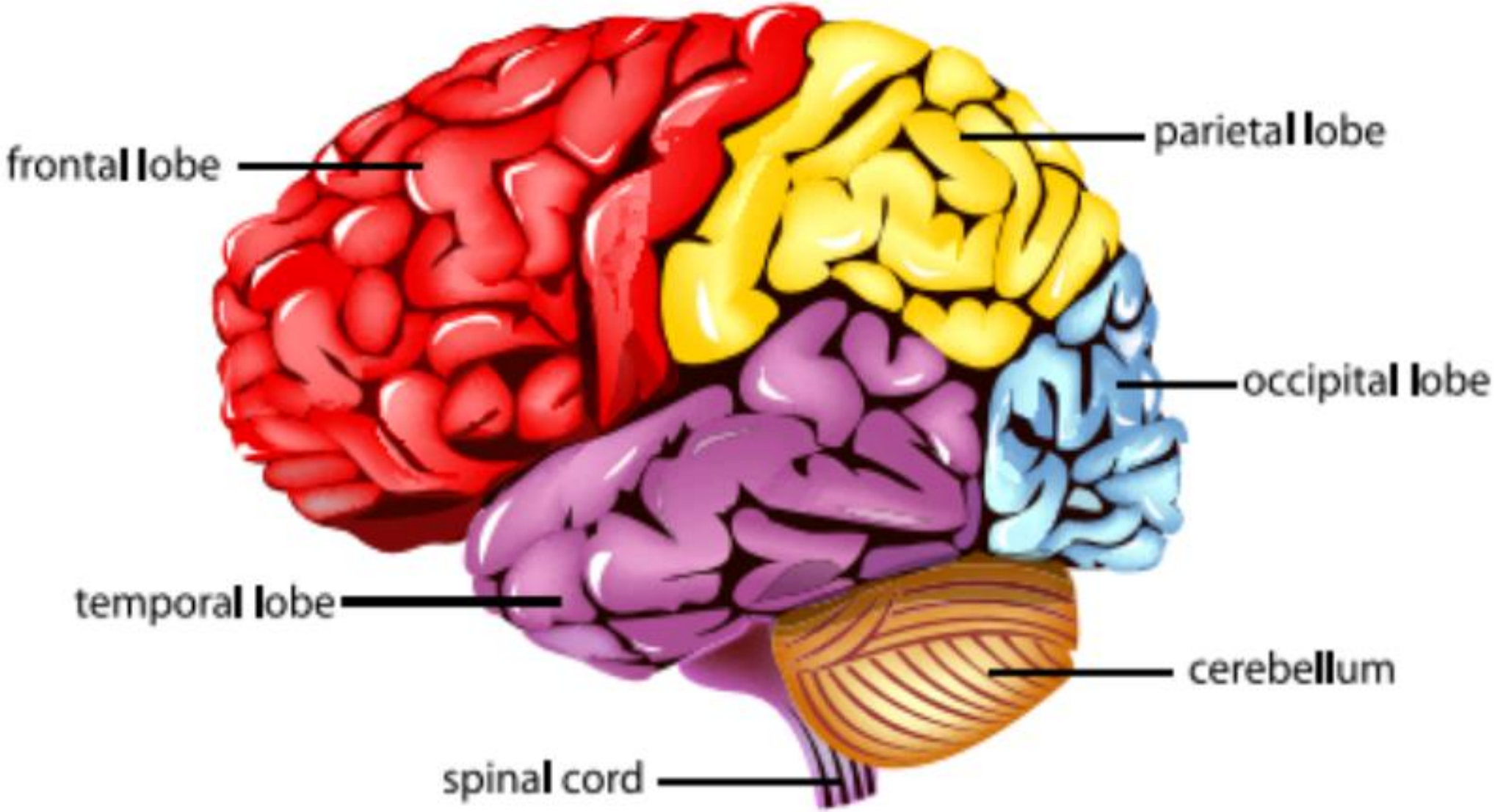


CENTRAL NEURAL SYSTEM - CNS

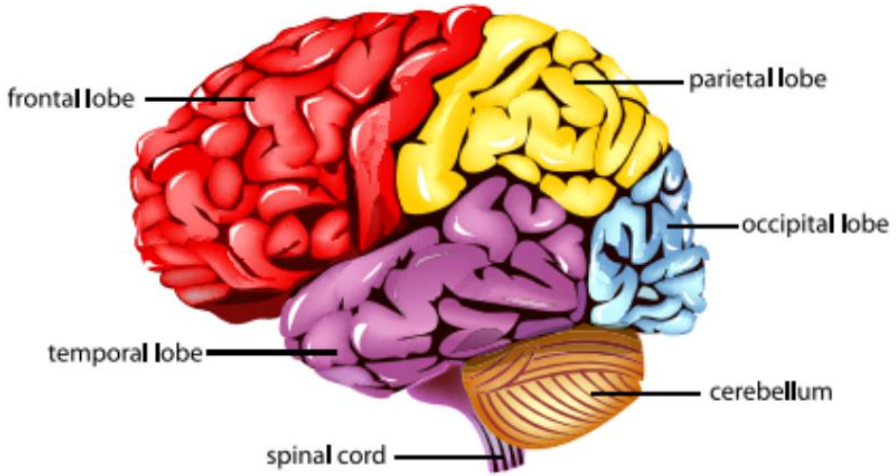


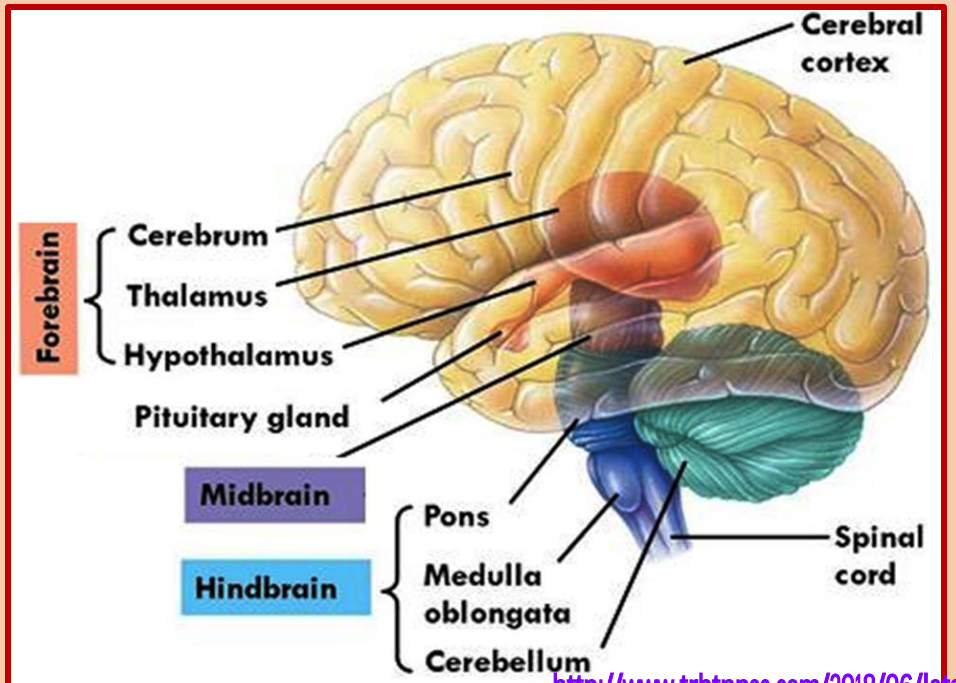
- The CNS includes the brain and the spinal cord, which are protected by the bones of the skull and vertebral column.
- During its embryonic development, CNS develops from the ectoderm.

BRAIN


frontal lobe
parietal lobe
occipital lobe
temporal lobe
cerebellum
spinal cord

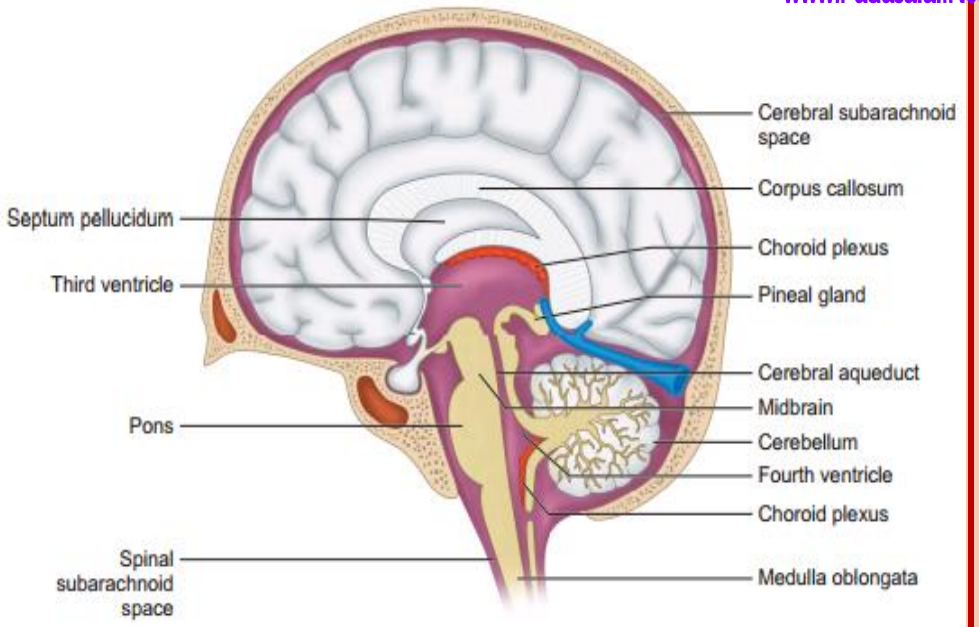
BRAIN

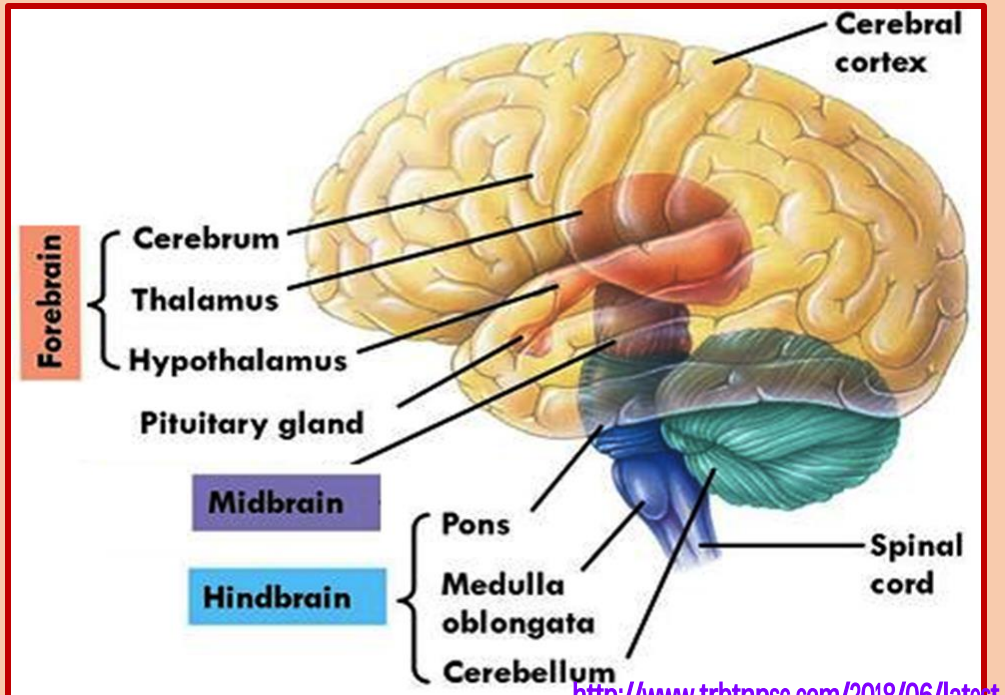




- The brain acts as the **command and control system**.
- It is the site of **information processing**.
- It is located in the **cranial cavity** and is **covered by three cranial meninges**.
  1. The outer thick layer is **Duramater** which lines the inner surface of the cranial cavity.
  2. The median thin layer is **Arachnoid mater** which is separated from the duramater by a narrow subdural space.
  3. The innermost layer is **Piamater** which is closely adhered to the brain but separated from the arachnoid mater by the subarachnoid space.
- The **brain is divided into three major regions**.
  1. Forebrain
  2. Midbrain
  3. Hindbrain.

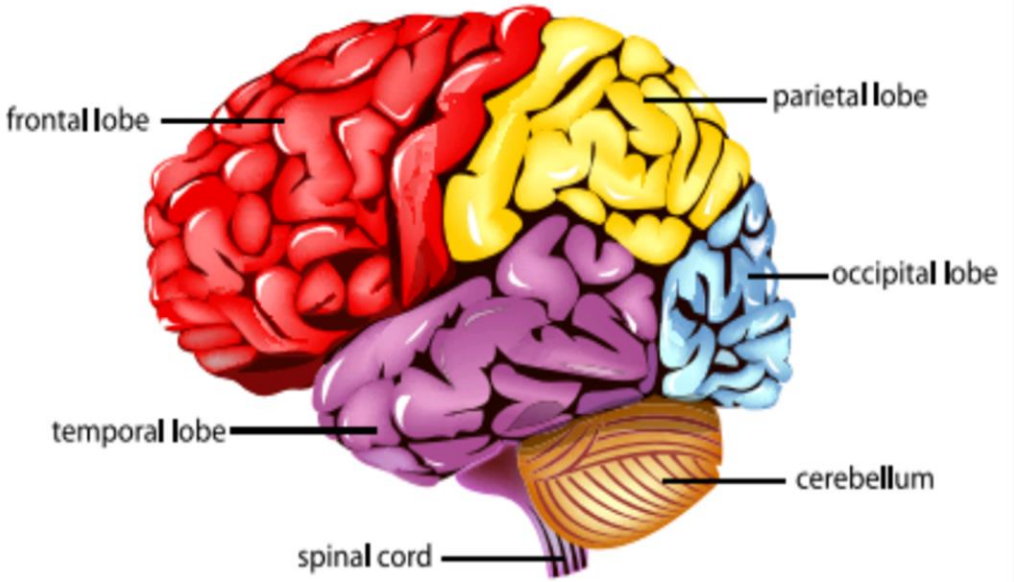
FORE BRAIN

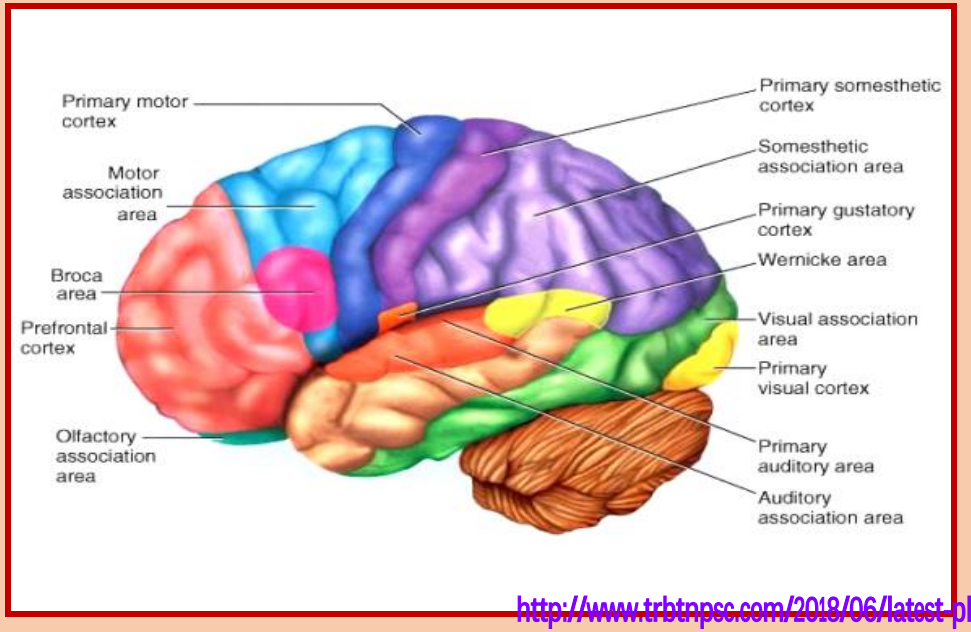




- It comprises the following regions,Cerebrum and Diencephalon.
- Cerebrum is the 'seat of intelligence' and forms the major part of the brain.
- The cerebrum consists of an outer cortex, inner medulla and basal nuclei.
- The superficial region of the cerebrum is called cerebral cortex, which looks grey due to the presence of unmyelinated nerve cells.
- Cerebral cortex consists of neuronal cell body, dendrites, associated glial and blood vessels.
- The surface of the cerebrum shows many convolutions (folds) and grooves.
- The folds are called gyri (singular gyrus), the shallow grooves between the gyri are called sulci (singular sulcus) and deep grooves are called fissures.
- These sulci and gyri increase the surface area of the cerebral cortex.

FORE BRAIN



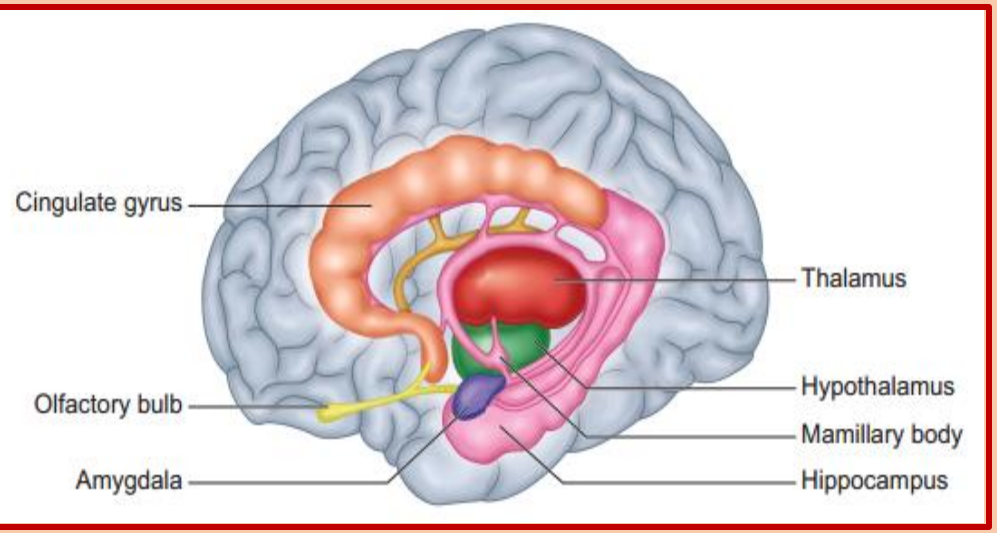


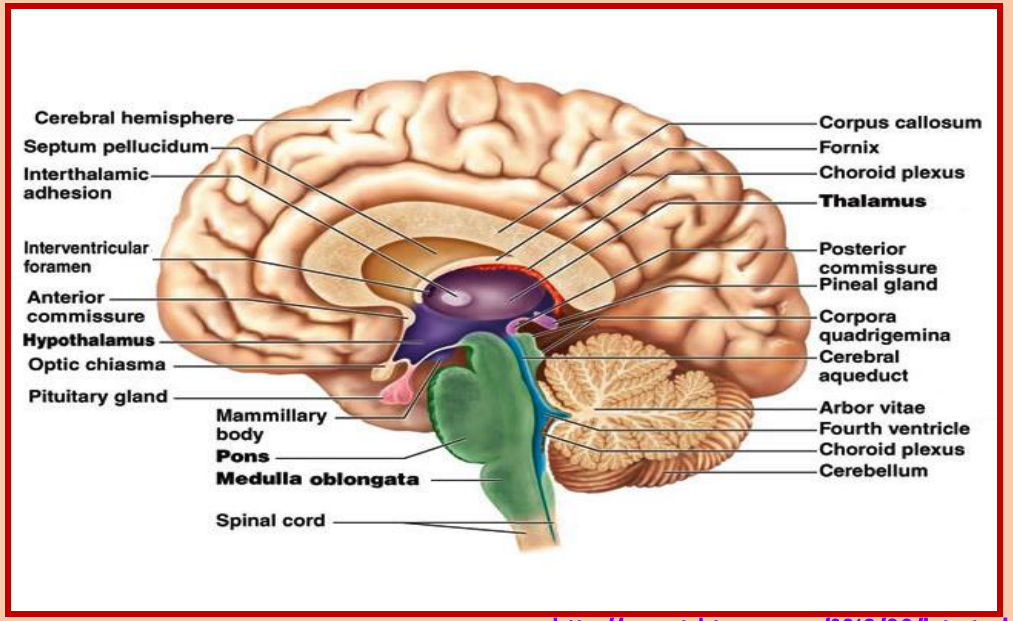
- Several sulci divide the cerebrum into eight lobes, a pair of frontals, parietals, temporals and occipital lobes.
- A median longitudinal fissure divides the cerebrum longitudinally into two cerebral hemispheres.
- A transverse fissure separates the cerebral hemispheres from the cerebellum.
- The hemispheres are connected by a tract of nerve fibres called corpus callosum.
- Cerebral cortex has three functional areas namely sensory areas occur in the parietal, temporal and occipital lobes of the cortex.
- They receive and interpret the sensory impulses.
- Motor area of the cortex which controls voluntary muscular movements lies in the posterior part of the frontal lobes.
- The areas other than sensory and motor areas are called Association areas that deal with integrative functions such as memory, communications, learning and reasoning.
- Inner to the cortex is medulla which is white in colour and acts as a nerve tract between the cortex and the diencephalon.

FUNCTIONS OF BRAIN LOBES

Structure	Functions
1. Frontal	Behaviour, Intelligence, Memory, Movement
2. Parietal	Language, Reading, Sensation
3. Temporal	Speech, Hearing, Memory
4. Occipital	Visual processing

FORE BRAIN - DIENCEPHALON

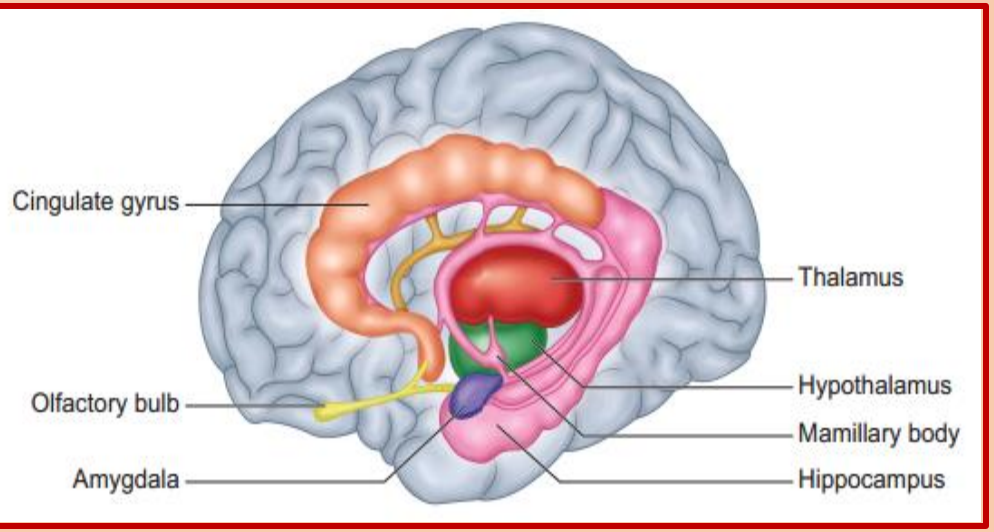


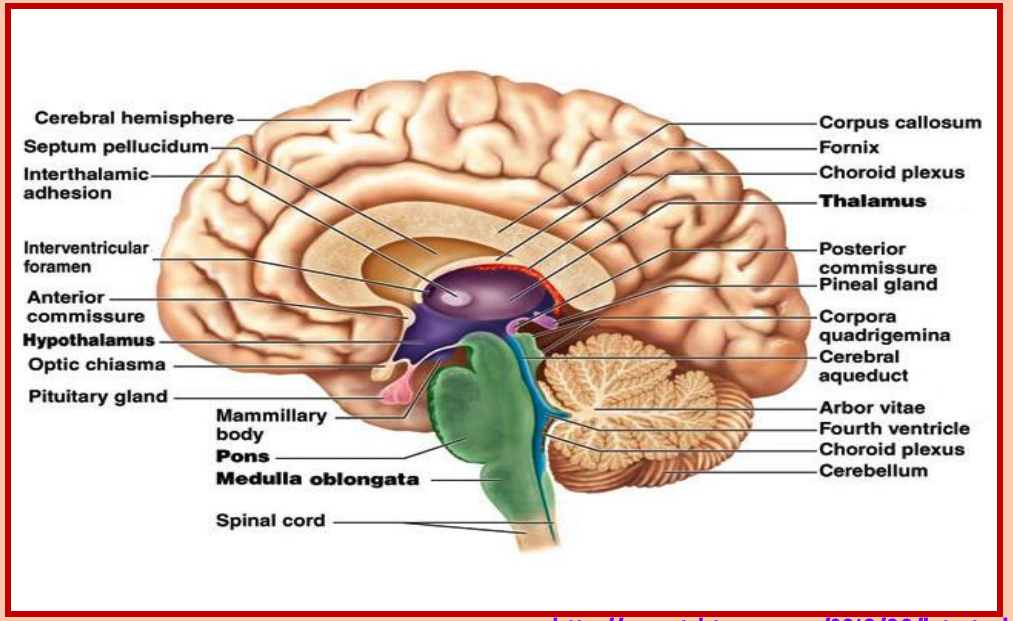


- Diencephalon consists largely of following three paired structures.

1. Epithalamus
2. Thalamus
3. Hypothalamus

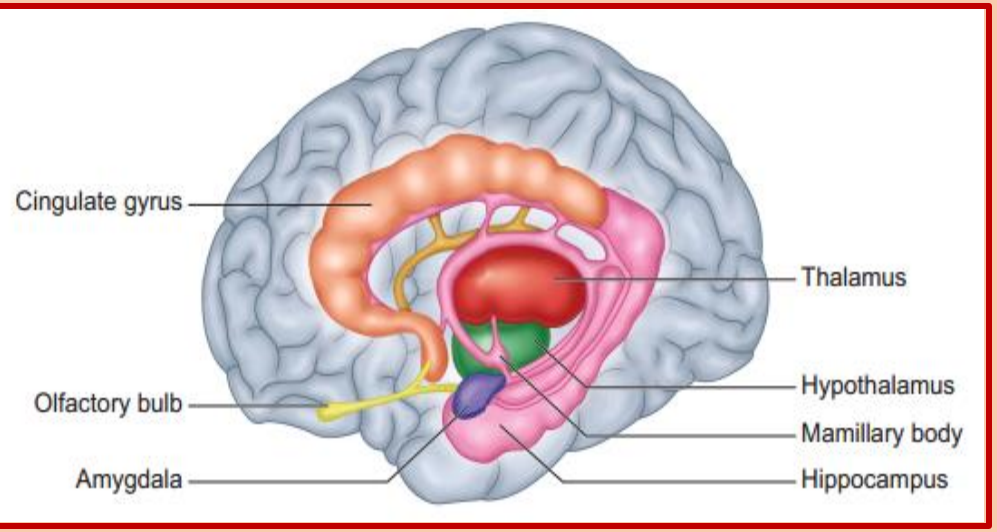
DIENCEPHALON - EPITHALAMUS

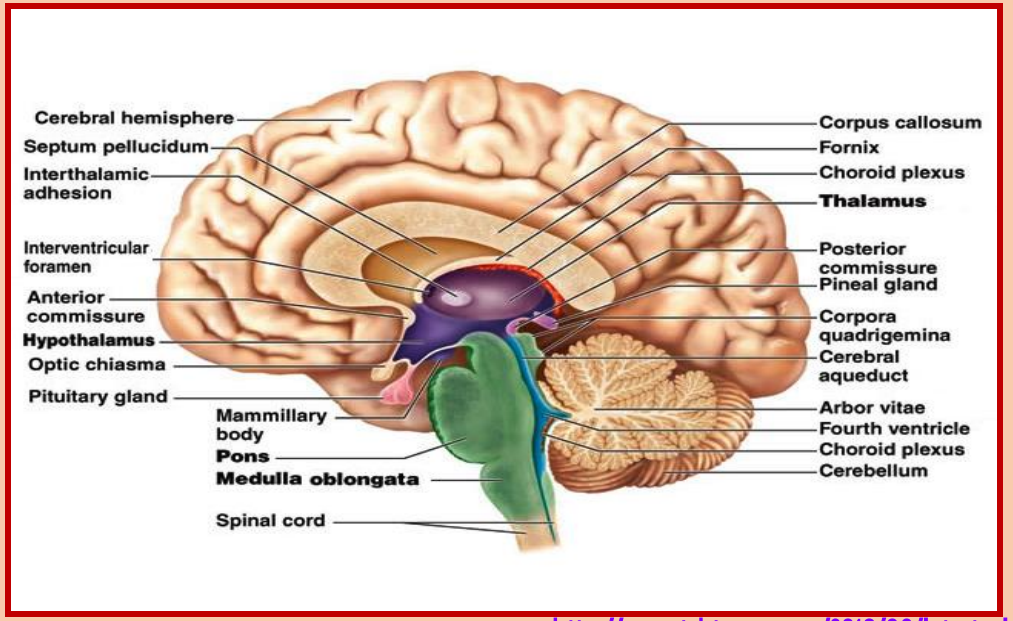




- ✓ **Epithalamus forms the roof of the diencephalon and it is a non-nervous tissue.**
- ✓ **The anterior part of epithalamus is vascular and folded to form the anterior choroid plexus.**
- ✓ **Just behind the choroid plexus, the epithalamus forms a short stalk which ends in a rounded body called pineal body which secretes the hormone, melatonin which regulates sleep and wake cycle.**

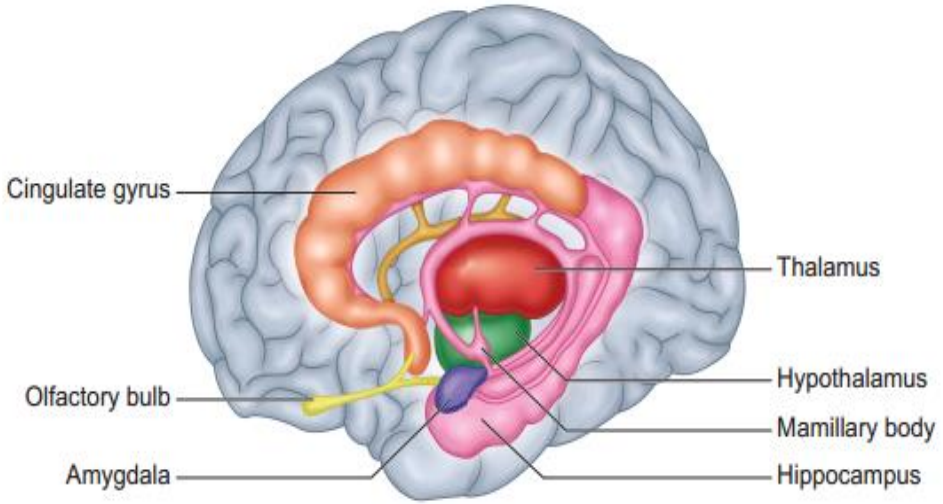
DIENCEPHALON - THALAMUS

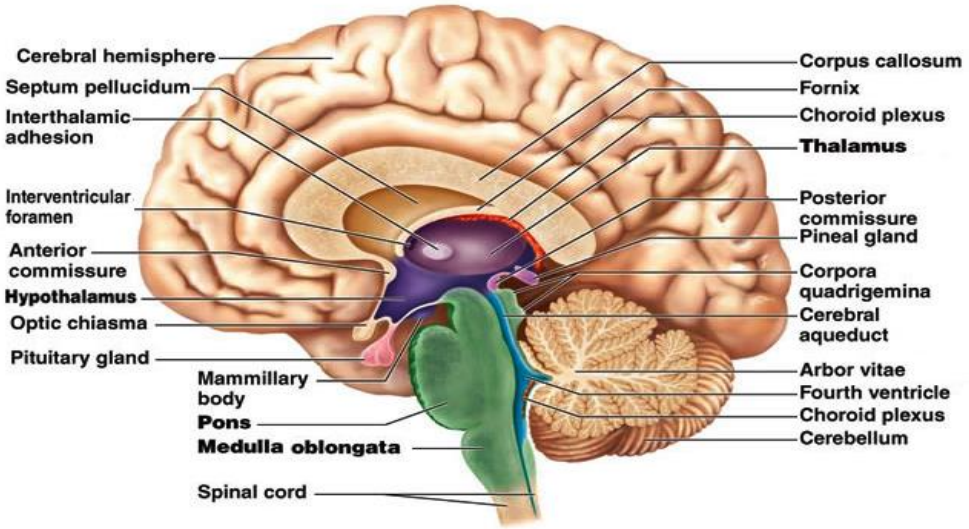




- ✓ Thalamus is composed of grey mater which serves as a relay centre for impulses between the spinal cord, brain stem and cerebrum.
- ✓ Within the thalamus, information is sorted and edited and plays a key role inlearning and memory.
- ✓ It is a major coordinating centre for sensory and motor signalling.

DIENCEPHALON - HYPOTHALAMUS





- ✓ Hypothalamus forms the floor of the diencephalon.
- ✓ The downward extension of the hypothalamus, the infundibulum connects the hypothalamus with the pituitary gland.
- ✓ The hypothalamus contains a pair of small rounded body called mammillary bodies that are involved in olfactory reflexes and emotional responses to odour.
- ✓ Hypothalamus maintains homeostasis and has many centres which control the body temperature, urge for eating and drinking.
- ✓ It also contains a group of neurosecretory cells which secrete the hypothalamic hormones.
- ✓ Hypothalamus also acts as the satiety centre.

Nervous System

The Nervous system is a complex collection of specialized nerve cells known as neurons that transmit signals between different parts of the body.

The precentral gyrus is called as **Motor Strip** that controls the **voluntary movements** of the skeletal system.

The postcentral gyrus is called as **Sensory Strip** that controls the five senses — **sight, smell, taste, touch and hearing.**

Motor strip

Sensory strip

Broca area, region of the brain that contains neurons involved in **speech function.**

Broca area

Wernicke area

Wernicke area, region of the brain that contains motor neurons involved in the **comprehension of speech.**

Gyrus

Sulcus

Cervical enlargement

The Medulla Oblongata

The Vital functional centres of medulla are:

The **cardio-vascular** center - controls the heart beat

The **respiratory center** controls the rate and rhythm of breathing.

The **vomiting, coughing, and sneezing centres**

Hippocampus plays an important role in emotion, learning and memory.

Amygdala plays role in aggression, eating, drinking and sexual behaviors.

Hypothalamus - monitors blood levels of glucose, salt, blood pressure and hormones.

Limbic Systems

A **blood brain barrier** protects the brain by preventing many foregin substances in our vascular system from reaching the brain.

Lumbar enlargement

Conus medularis

Cauda equina

Although sensations and feelings are processed in our brain, the **brain itself cannot feel pain,** as it lacks pain receptors.

The barriers does not work for some substances like **Nicotine** which rushes into the brain in mere 7 seconds and **Alcohol** on the other hand takes 6 minutes.

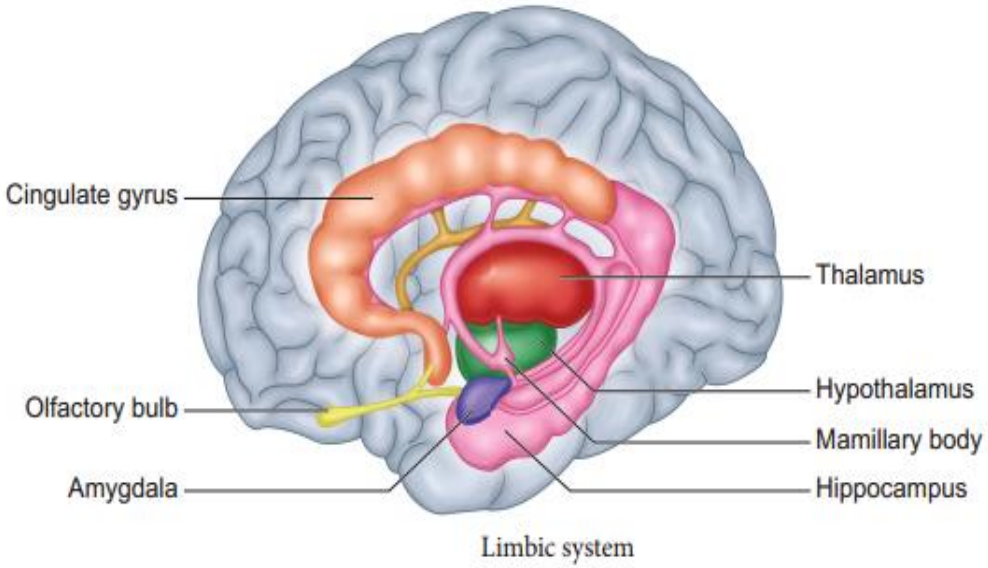
Filum terminale

75% of the total brain mass is water. It is the **fattest organ** in the body, contains **100 billion nerve cells.**

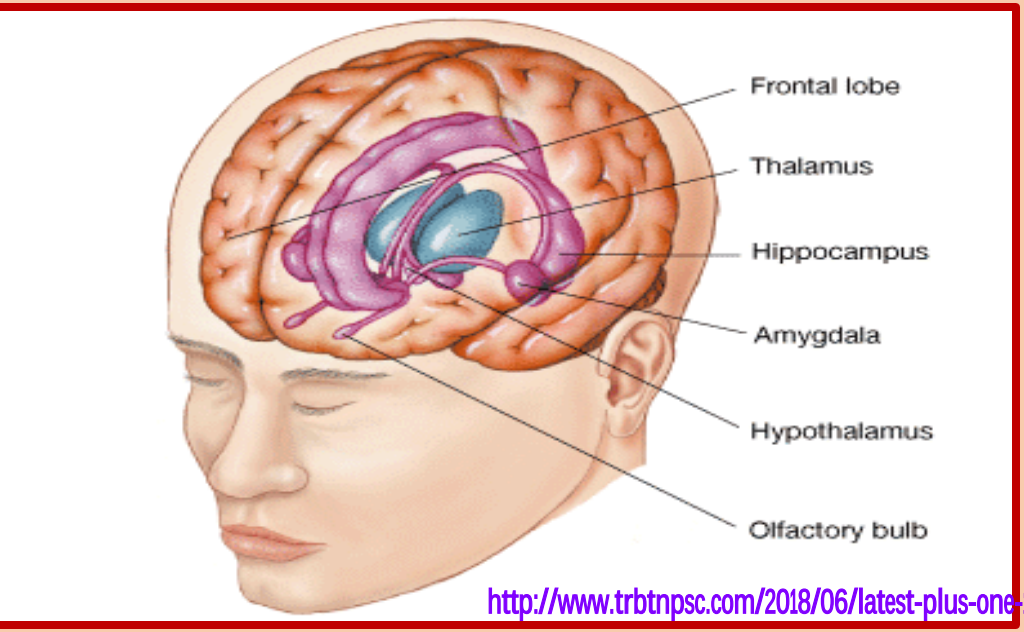
DIENCEPHALON - HYPOTHALAMUS

Depression is a functional deficiency of **seratonin** or **norepinephrine** or both. This disorder is characterized by a pervasive negative mood, loss of interest, an inability to experience pleasure and suicidal tendencies. Antidepressant drugs increase the available concentration of these neurotransmitters in the CNS. Hence depression is treatable.

LIMBIC SYSTEM

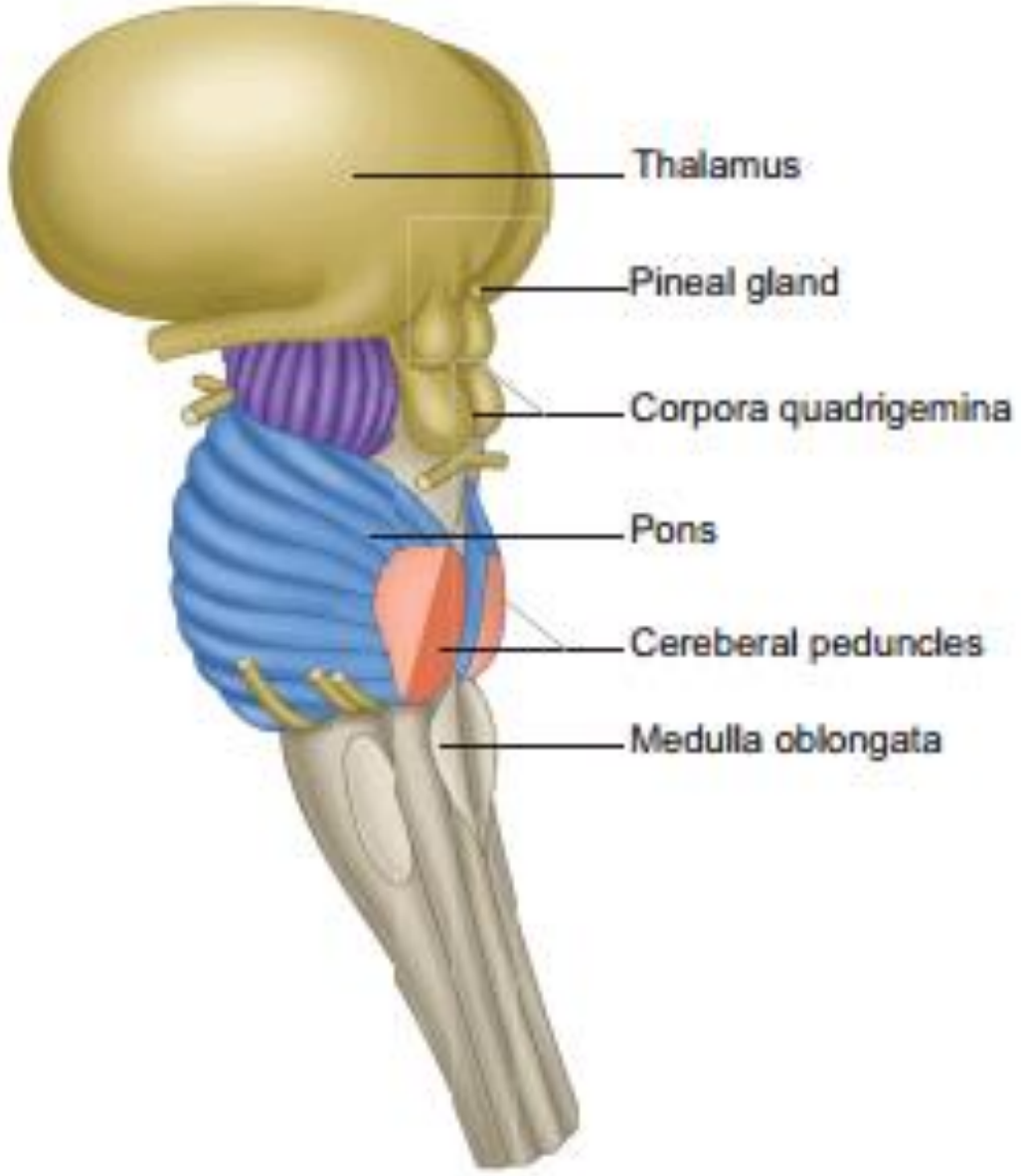


Limbic system



- ✓ The inner part of the cerebral hemisphere constitutes the limbic system.
- ✓ The main components of limbic system are olfactory bulbs, cingulate gyrus, mammillary body, amygdala, hippocampus and hypothalamus.
- ✓ The limbic system is called 'emotional brain' because it plays a primary role in the regulation of pleasure, pain, anger, fear, sexual feeling and affection.
- ✓ The hippocampus and amygdala also play a role in memory.

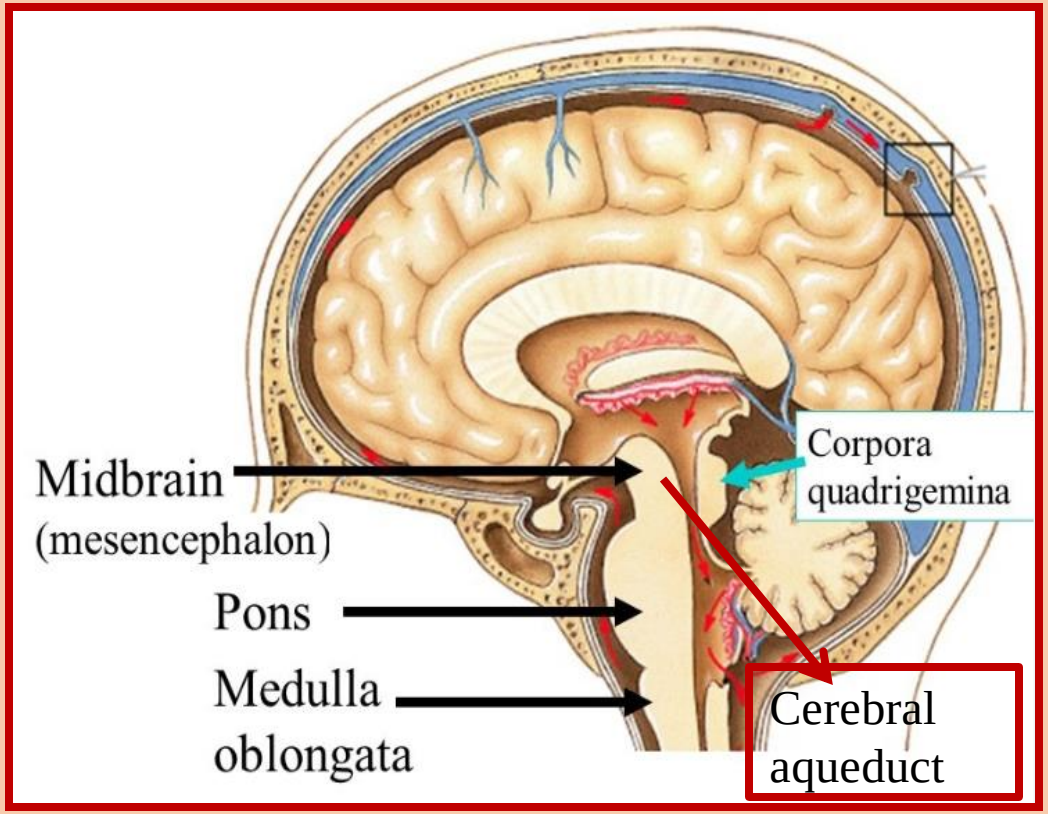
BRAIN STEM



- Brain stem is the part of the brain between the spinal cord and the diencephalon.
- It consists of three parts. They are

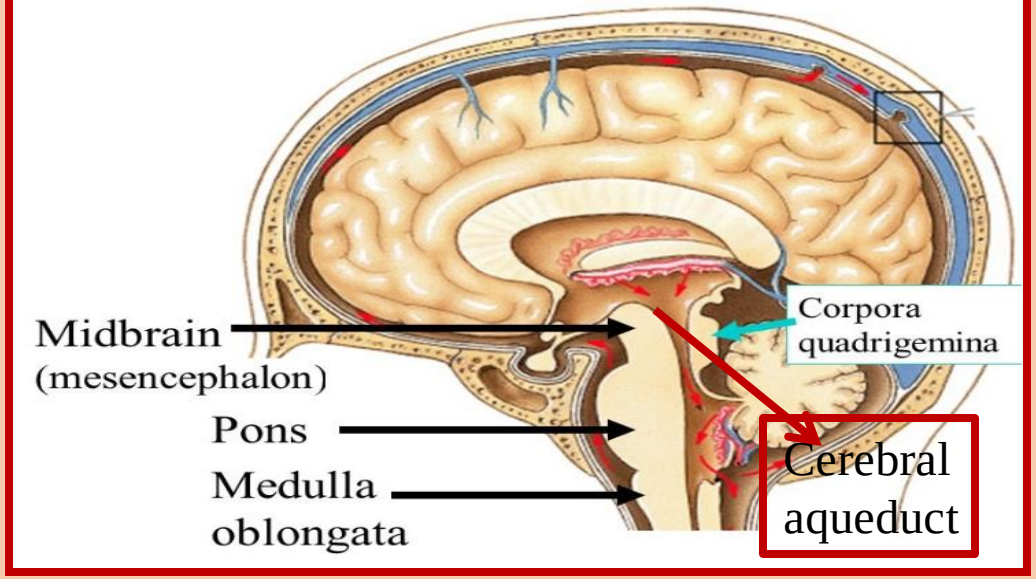
1. Mid brain
2. Pons varolii
3. Medulla oblongata

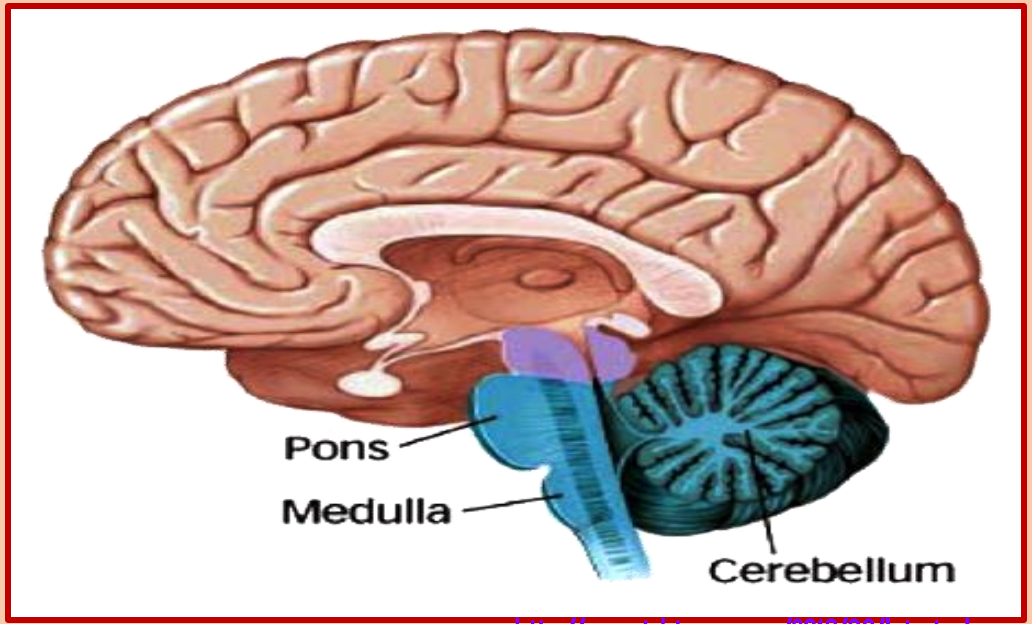
MID BRAIN



- ✓ The mid brain is located between the diencephalon and the pons.
- ✓ The lower portion of the midbrain consists of a pair of longitudinal bands of nervous tissue called cerebral peduncles which relay impulses back and forth between cerebrum, cerebellum, pons and medulla.
- ✓ The dorsal portion of the midbrain consists of four rounded bodies called corpora quadrigemina which acts as a reflex centre for vision and hearing.

HINDD BRAIN

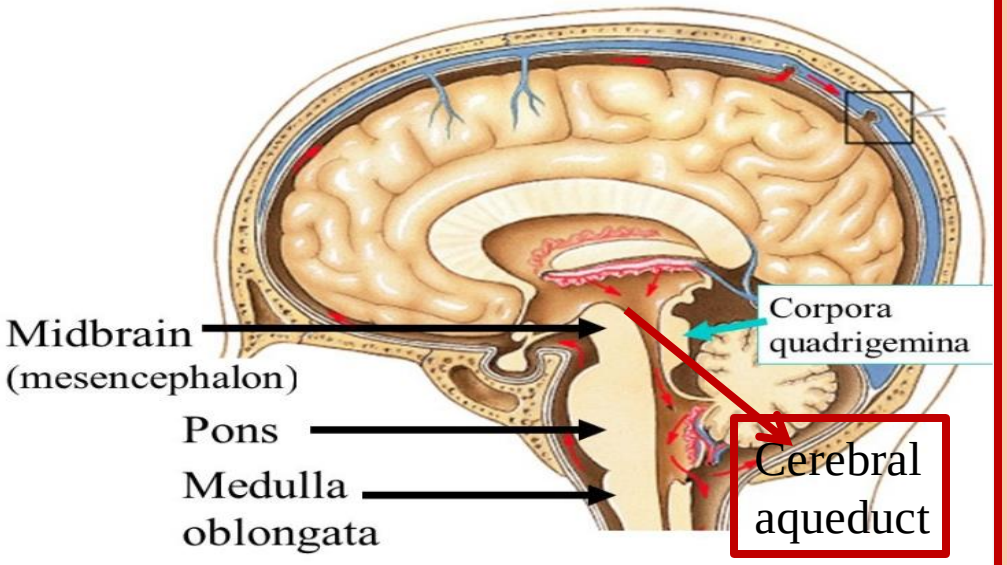


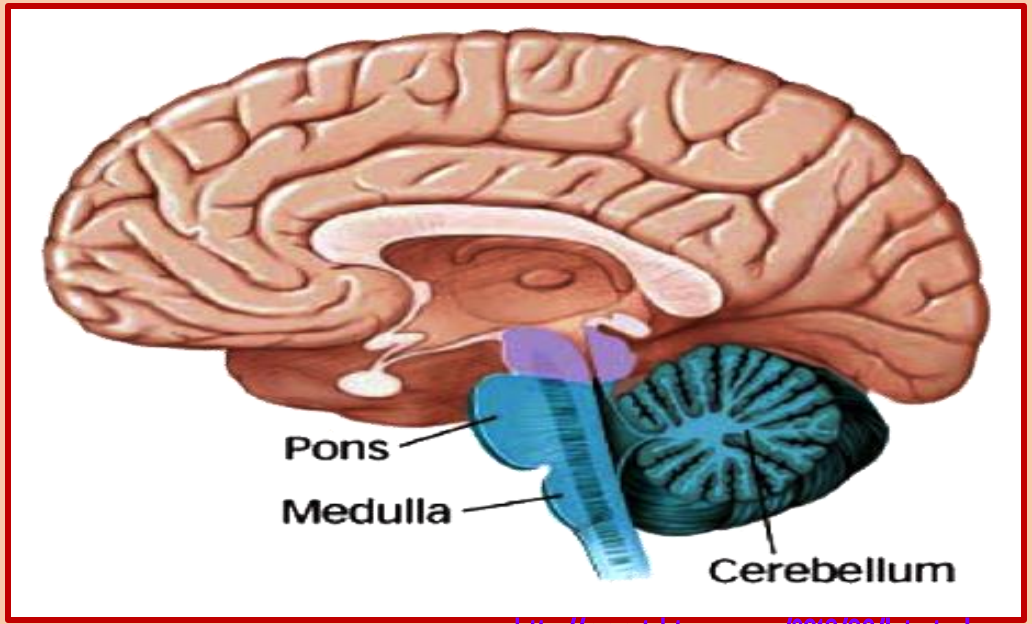


- Rhombencephalon forms the hind brain.
- It comprises of

1. Cerebellum
2. Pons varolii
3. Medulla oblongata.

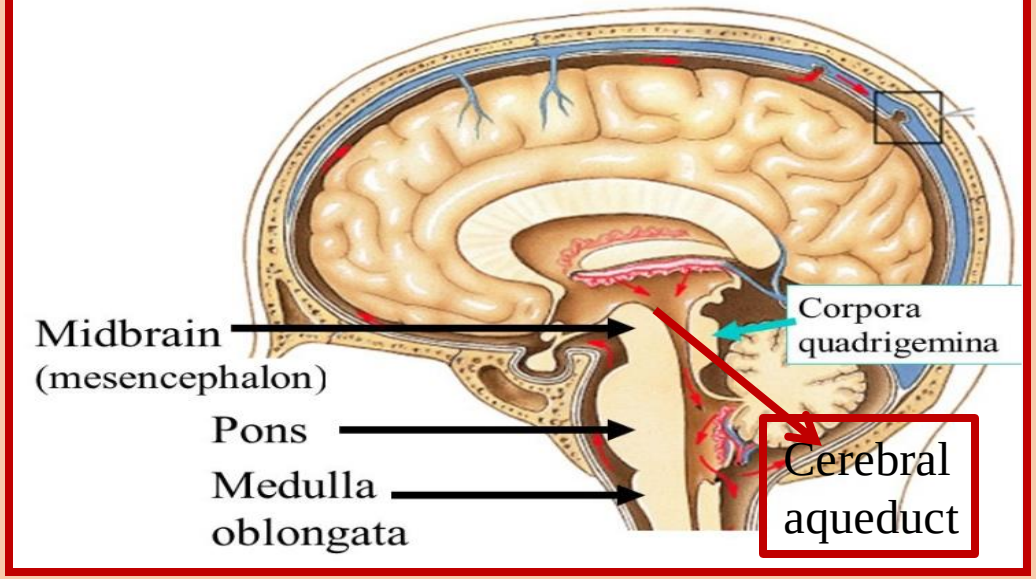
HINDD BRAIN - CEREBELLUM

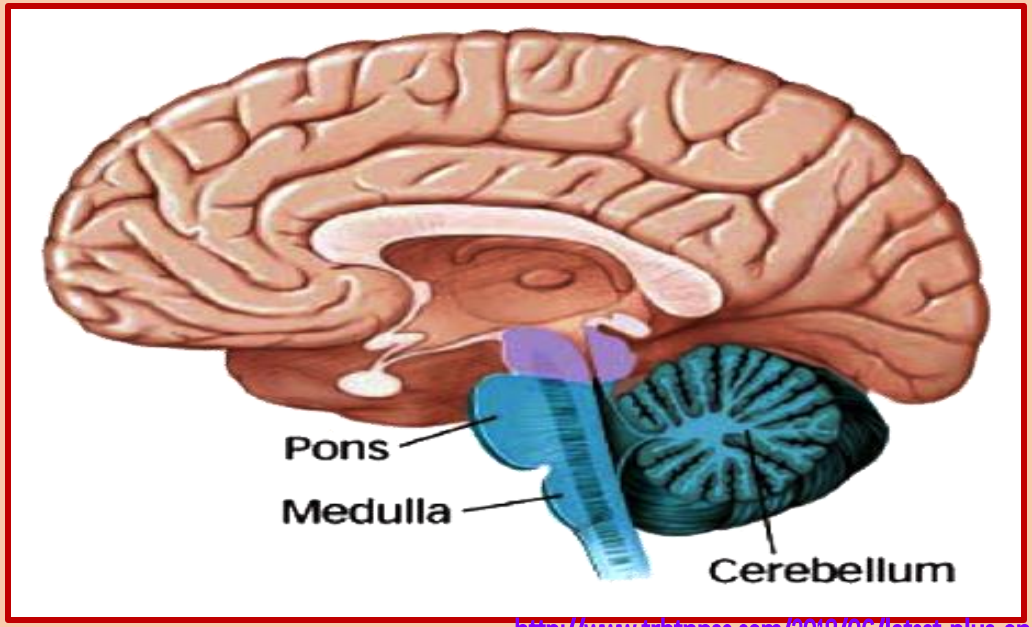




- Cerebellum is the second largest part of the brain.
- It consists of two cerebellar hemispheres and central worm shaped part and the vermis.
- The cerebellum controls and coordinates muscular movements and body equilibrium.
- Any damage to cerebellum often results in uncoordinated voluntary muscle movements.

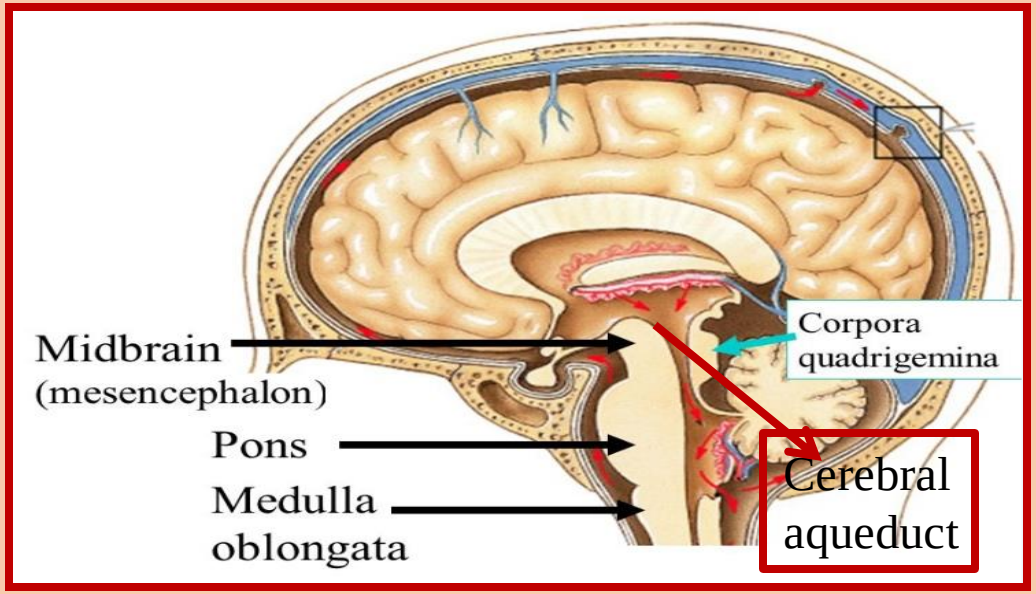
HINDD BRAIN – PONS VAROLI

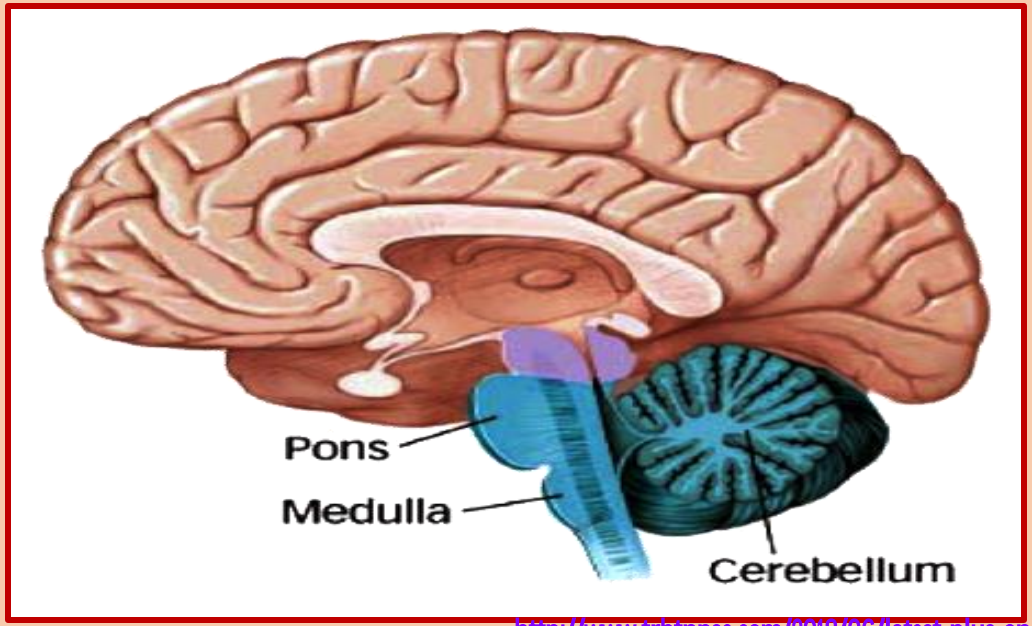




- Pons varoli lies infront of the cerebellum between the midbrain and the medulla oblongata.
- The nerve fibres in the pons varolii form a bridge between the two cerebellar hemispheres and connect the medulla oblongata with the other region of the brain.
- The respiratory nuclei found in the pons cooperate with the medulla to control respiration.

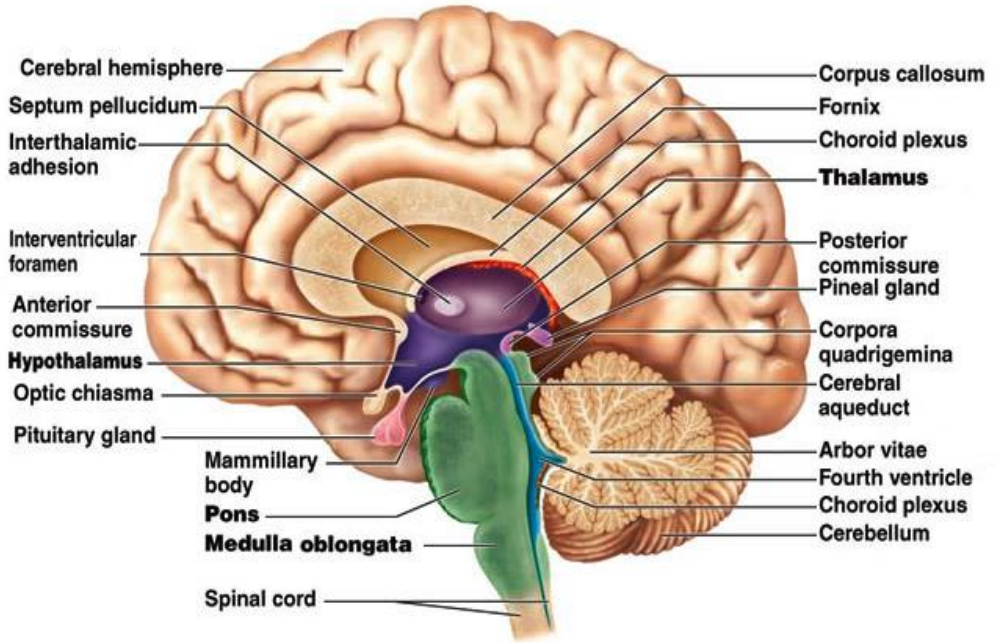
HINDD BRAIN – MEDULLA OBLONGATA





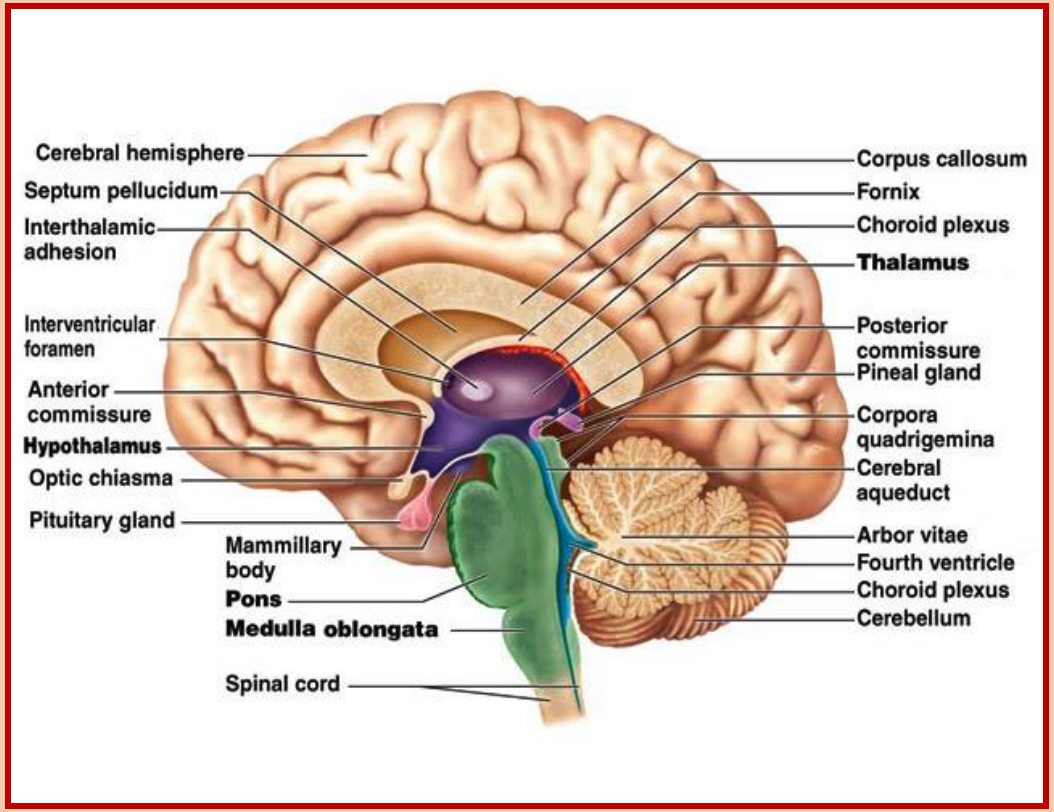
- Medulla oblongata forms the posterior most part of the brain.
- It connects the spinal cord with various parts of the brain.
- It receives and integrates signals from spinal cord and sends it to the cerebellum and thalamus.
- Medulla contains vital centres that control cardio vascular reflexes, respiration and gastric secretions.

VENTRICLES OF THE BRAIN



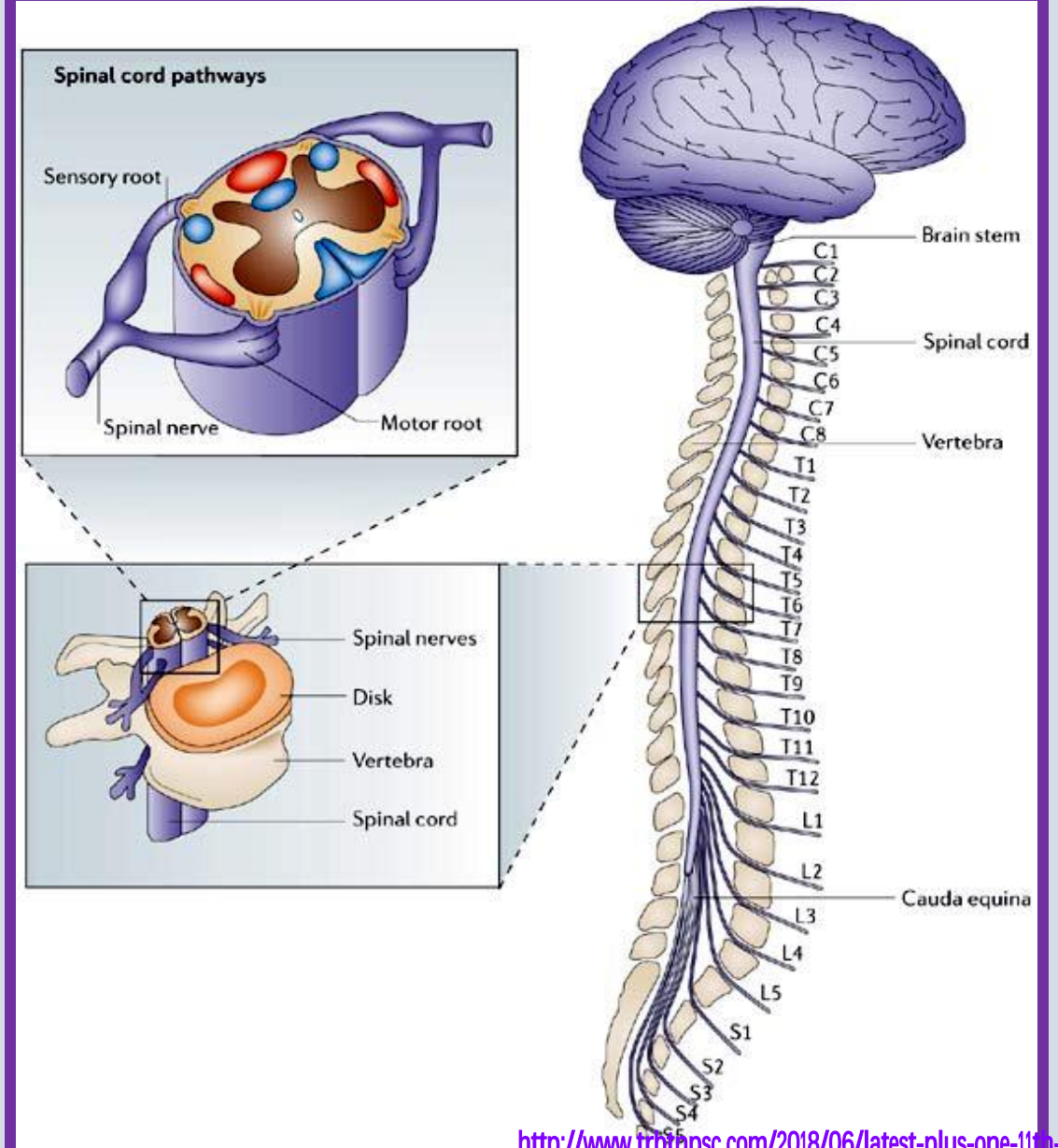
- The brain has four hollow, fluid filled spaces.
- The C- shaped space found inside each cerebral hemisphere forms the lateral ventricles I and II which are separated from each other by a thin membrane called the septum pellucidum.
- Each lateral ventricle communicates with the narrow III ventricle in the diencephalon through an opening called interventricular foramen (foramen of Monro).
- The ventricle III is continuous with the ventricle IV in the hind brain through a canal called aqueduct of Sylvius (cerebral aqueduct).

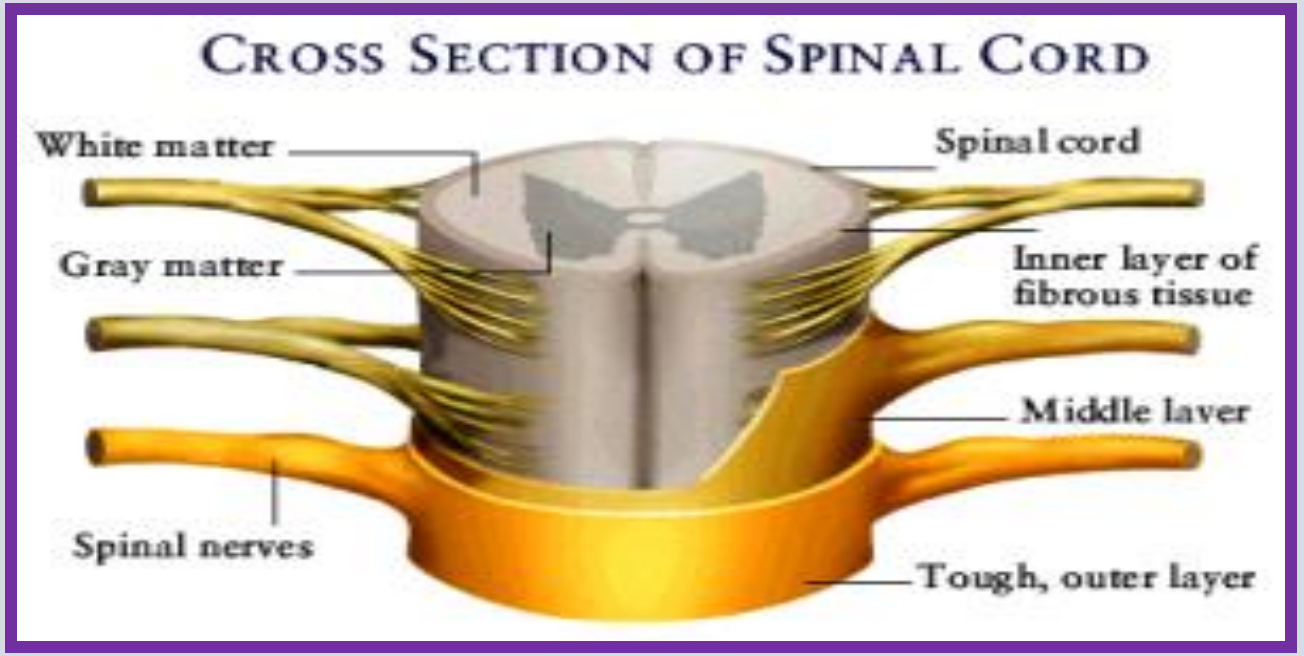
VENTRICLES OF THE BRAIN

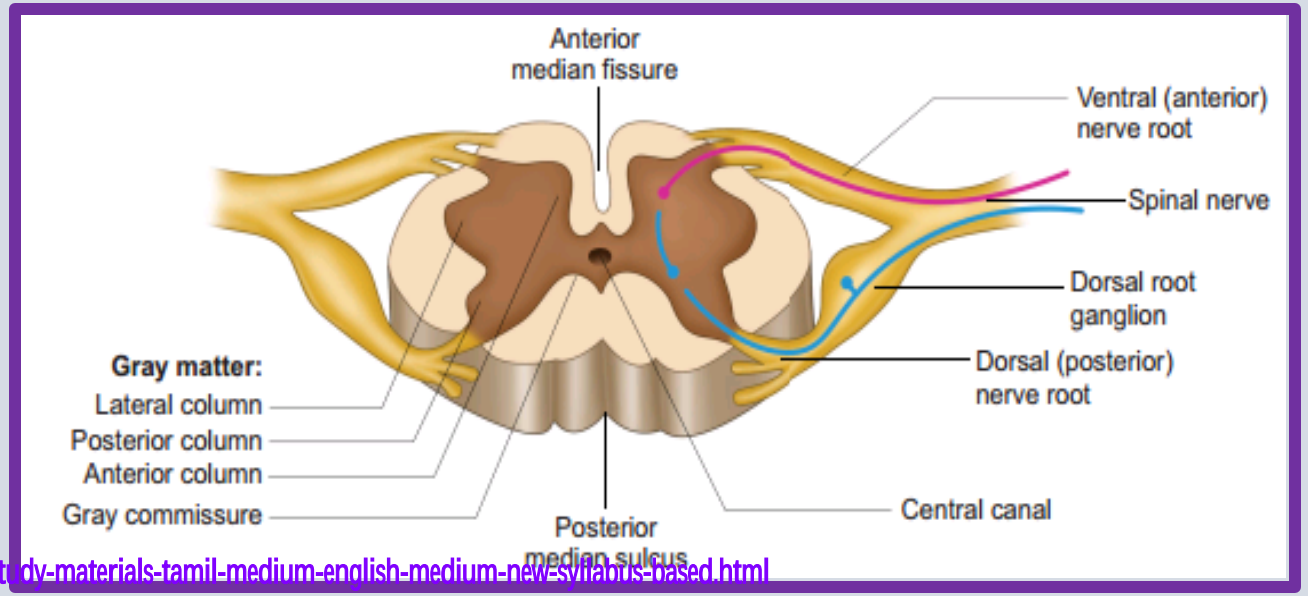


- Choroid plexus is a network of blood capillaries found in the roof of the ventricles and forms cerebro spinal fluid (CSF) from the blood.
- CSF provides buoyancy to the CNS structures.
- CSF acts as a shock absorber for the brain and spinal cord.
- It nourishes the brain cells by transporting constant supply of food and oxygen.
- It carries harmful metabolic wastes from the brain to the blood, and maintains a constant pressure inside the cranial vessels.

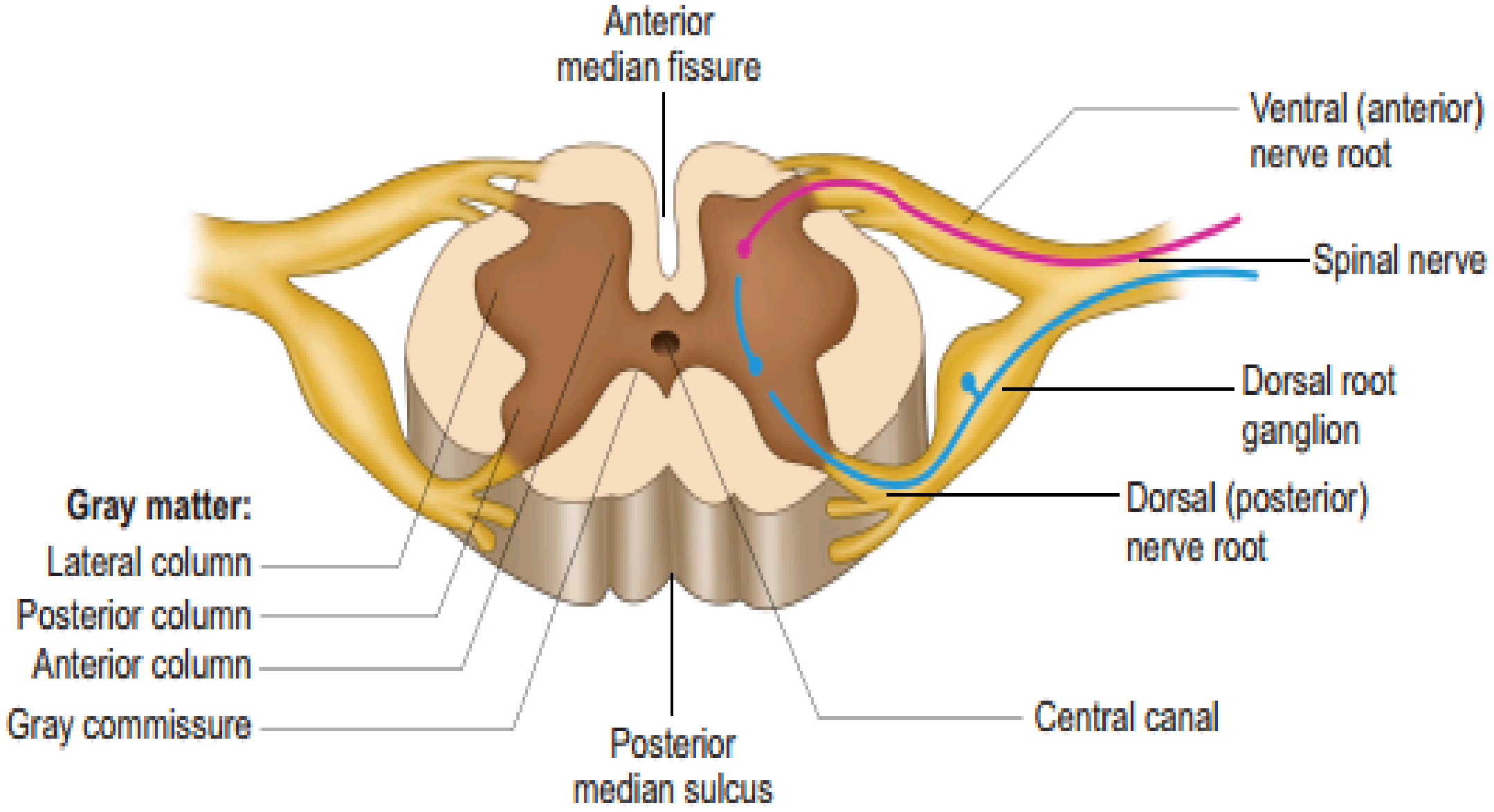
SPINAL CORD



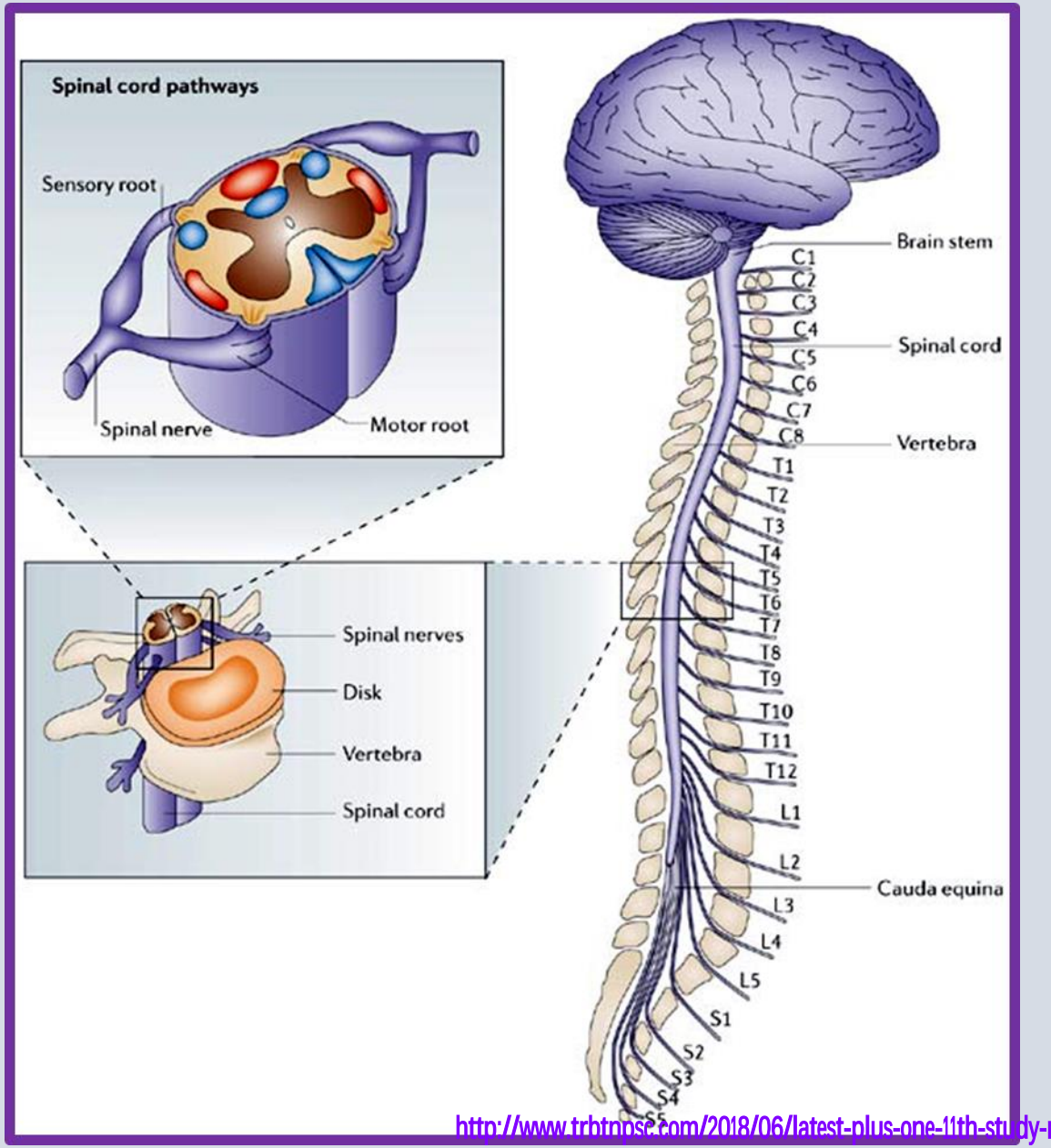




SPINAL CORD

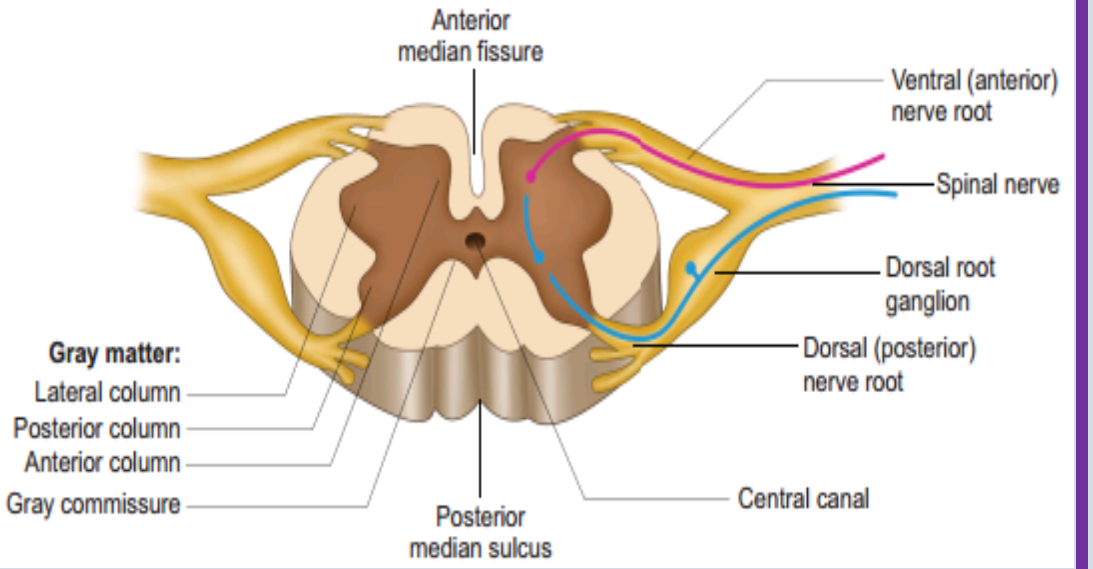


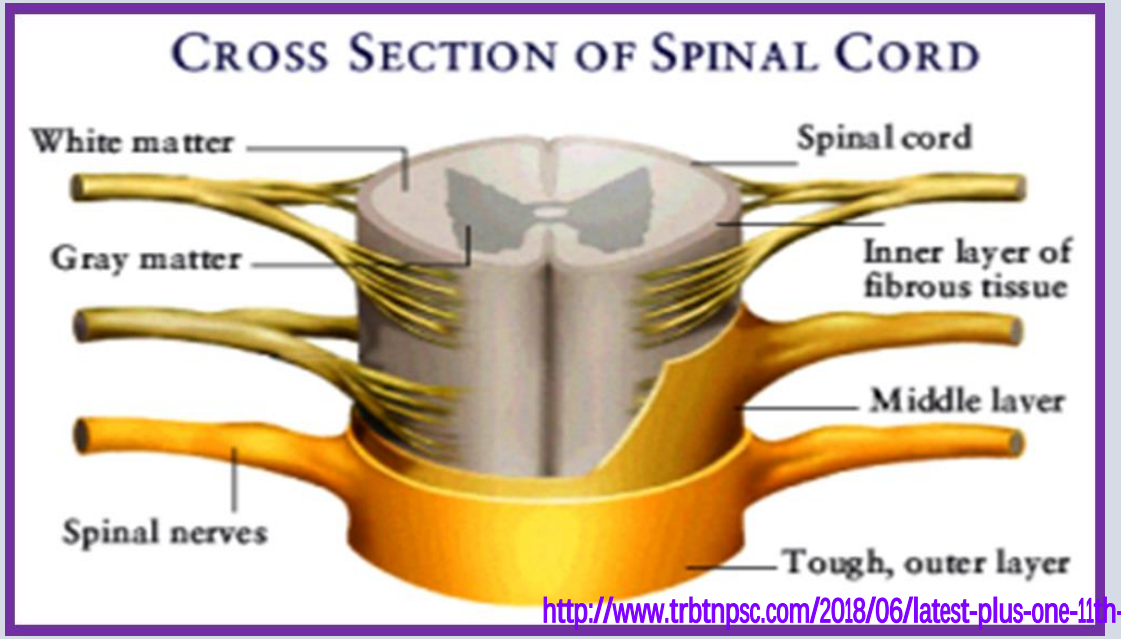
SPINAL CORD



- ✓ The spinal cord is a **long, slender, cylindrical nervous tissue**.
- ✓ It is **protected by the vertebral column** and surrounded by the three membranes as in the brain.
- ✓ The spinal cord that **extends from the brain stem into the vertebral canal of the vertebral column** up to the level of 1st or 2nd lumbar vertebra.
- ✓ So the **nerve roots of the remaining nerves are greatly elongated to exit the vertebral column at their appropriate space**.
- ✓ The thick bundle of elongated nerve roots within the lower vertebral canal is called the **cauda equina (horse's tail)** because of its appearance.

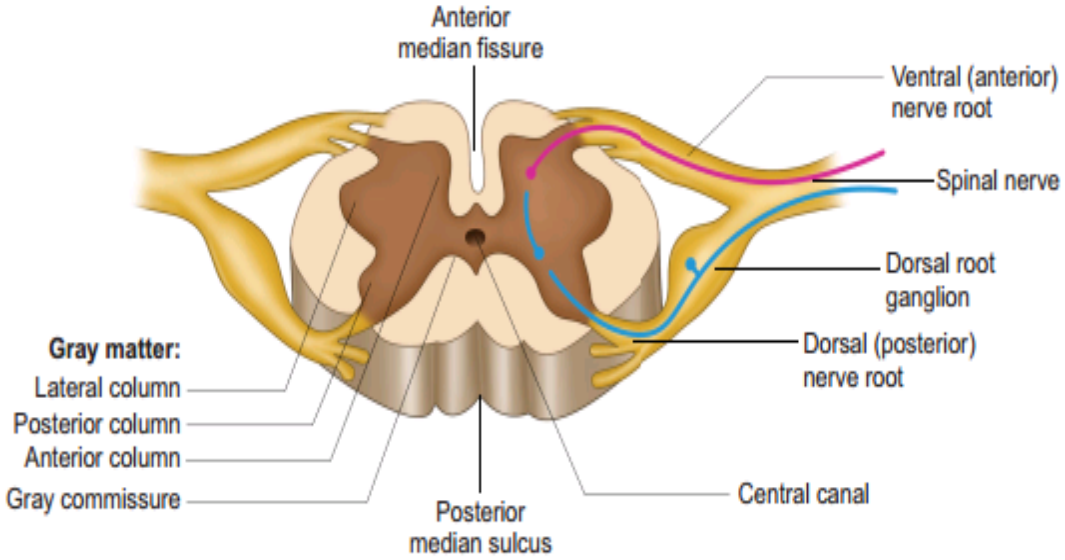
SPINAL CORD

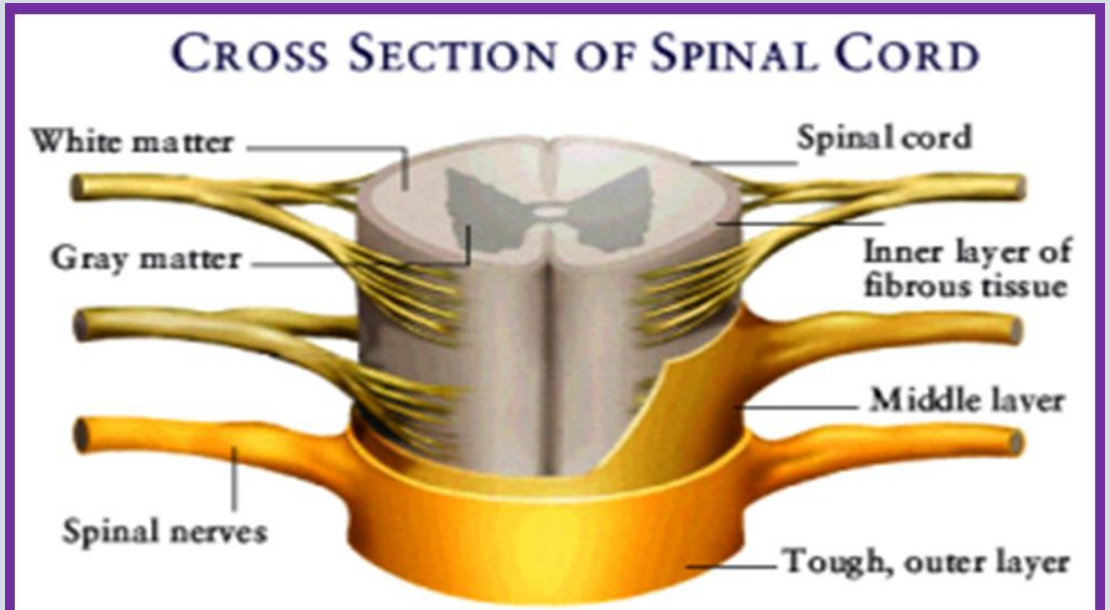




- ✓ In the cross section of spinal cord, there are **two indentations**.
  1. **The posterior median sulcus**
  2. **The anterior median fissure**
- ✓ Although there might be slight variations, the cross section of spinal cord is generally the **same throughout its length**.
- ✓ In contrast to the brain, the **grey matter in the spinal cord forms an inner butterfly shaped region surrounded by the outer white matter**.
- ✓ The grey matter consists of **neuronal cell bodies and their dendrites, interneurons and glial cells**.
- ✓ White matter consists of **bundles of nerve fibres**.
- ✓ In the center of the grey matter there is a central canal which is filled with **CSF**.
- ✓ Each half of the grey matter is divided into **a dorsal horn, a ventral horn and a lateral horn.**

SPINAL CORD



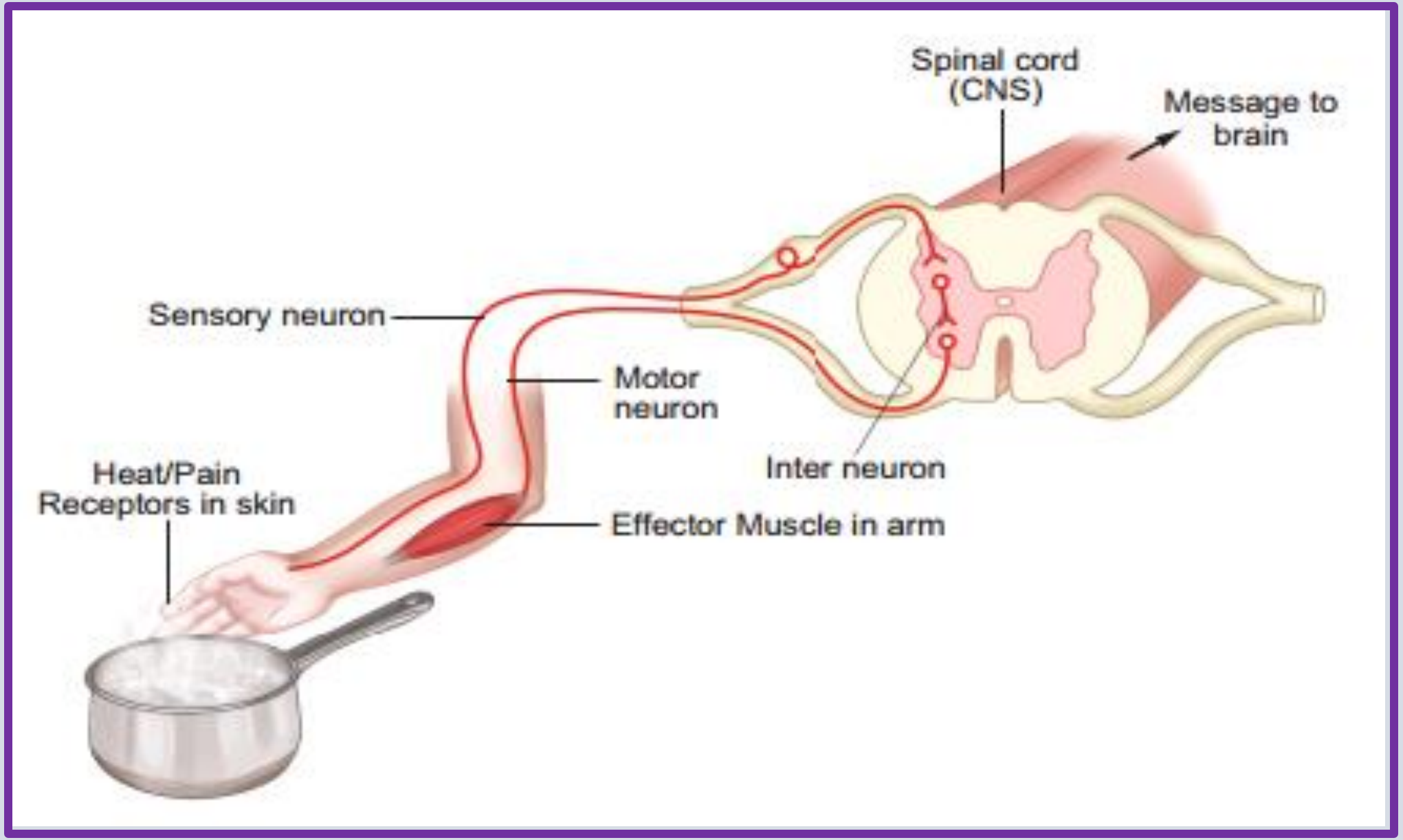


- ✓ The dorsal horn contains cell bodies of interneurons on which afferent neurons terminate.
- ✓ The ventral horn contains cell bodies of the efferent motor neurons supplying the skeletal muscle.
- ✓ Autonomic nerve fibres, supplying cardiac and smooth muscles and exocrine glands, originate from the cell bodies found in the lateral horn.
- ✓ In the white matter, the bundles of nerve fibres form two types of tracts namely ascending tracts which carry sensory impulses to the brain and descending tracts which carry motor impulses from the brain to the spinal nerves at various levels of the spinal cord.
- ✓ The spinal cord shows two enlargements, one in the cervical region and another one in the lumbosacral region.
- ✓ The cervical enlargement serves the upper limb and lumbar enlargement serves the lower limbs.

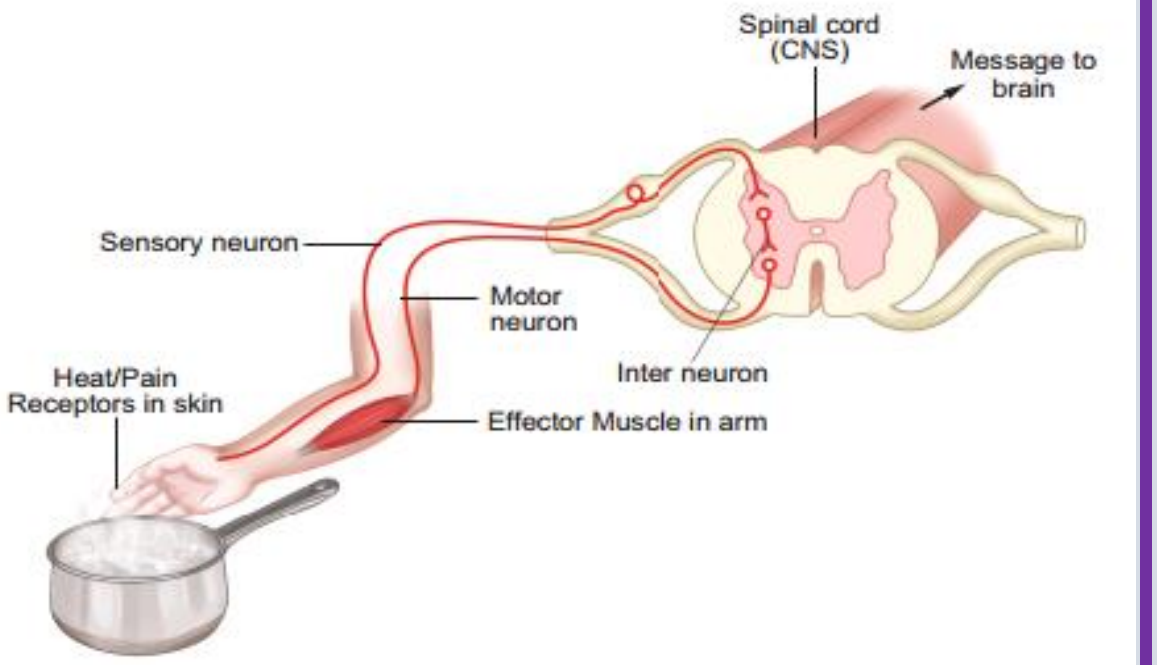
CSF

In adult, the total CSF volume is about 150 ml and is replaced every 8 hours. About 500 ml of CSF is formed daily. The choroid plexus helps cleanse the CSF by removing waste products.

REFLEX ACTION AND REFLEX ARC



REFLEX ACTION AND REFLEX ARC



- When dust falls in our eyes, the eyelids close immediately not waiting for our willingness.
- on touching a hot pan, the hand is withdrawn rapidly.
- Do you know how this happens?

- ✓ The spinal cord remains as a connecting functional nervous structure in between the brain and effector organs.
- ✓ But sometimes when a very quick response is needed, the spinal cord can effect motor initiation as the brain and brings about an effect.
- ✓ This rapid action by spinal cord is called reflex action.
- ✓ It is a fast, involuntary, unplanned sequence of actions that occurs in response to a particular stimulus.
- ✓ The nervous elements involved in carrying out the reflex action constitute a reflex arc or in other words the pathway followed by a nerve impulse to produce a reflex action is called a reflex arc.

FUNCTIONAL COMPONENTS OF A REFLEX ARC

1. **Sensory Receptor** - It is a sensory structure that responds to a specific stimulus.
2. **Sensory Neuron** - This neuron takes the sensory impulse to the grey (afferent) matter of the spinal cord through the dorsal root of the spinal cord.
3. **Interneurons** - One or two interneurons may serve to transmit the impulses from the sensory neuron to the motor neuron.
4. **Motor Neuron** - it transmits impulse from CNS to the effector organ.
5. **Effector Organs** -It may be a muscle or gland which responds to the impulse received.

TYPES OF REFLEXS

❖ There are two types of reflexes. They are 1. Unconditional reflex 2. Conditioned reflex

1.Unconditional reflex

- ✓ Unconditional reflex is an inborn reflex for an unconditioned stimulus.
- ✓ It does not need any past experience, knowledge or training to occur.
- ✓ Ex: blinking of an eye when a dust particle about to fall into it.
- ✓ Sneezing and coughing due to foreign particle entering the nose or larynx.

2. Conditioned reflex

- ✓ Conditioned reflex is a respone to a stimulus that has been acquired by learning.
- ✓ This does not naturally exists in animals.
- ✓ Only an experience makes it a part of the behaviour.
- ✓ Example: excitement of salivary gland on seeing and smelling a food.
- ✓ The conditioned reflex was first demonstrated by the Russian physiologist Pavlov in his classical conditioning experiment in a dog.
- ✓ The cerebral cortex controls the conditioned reflex.

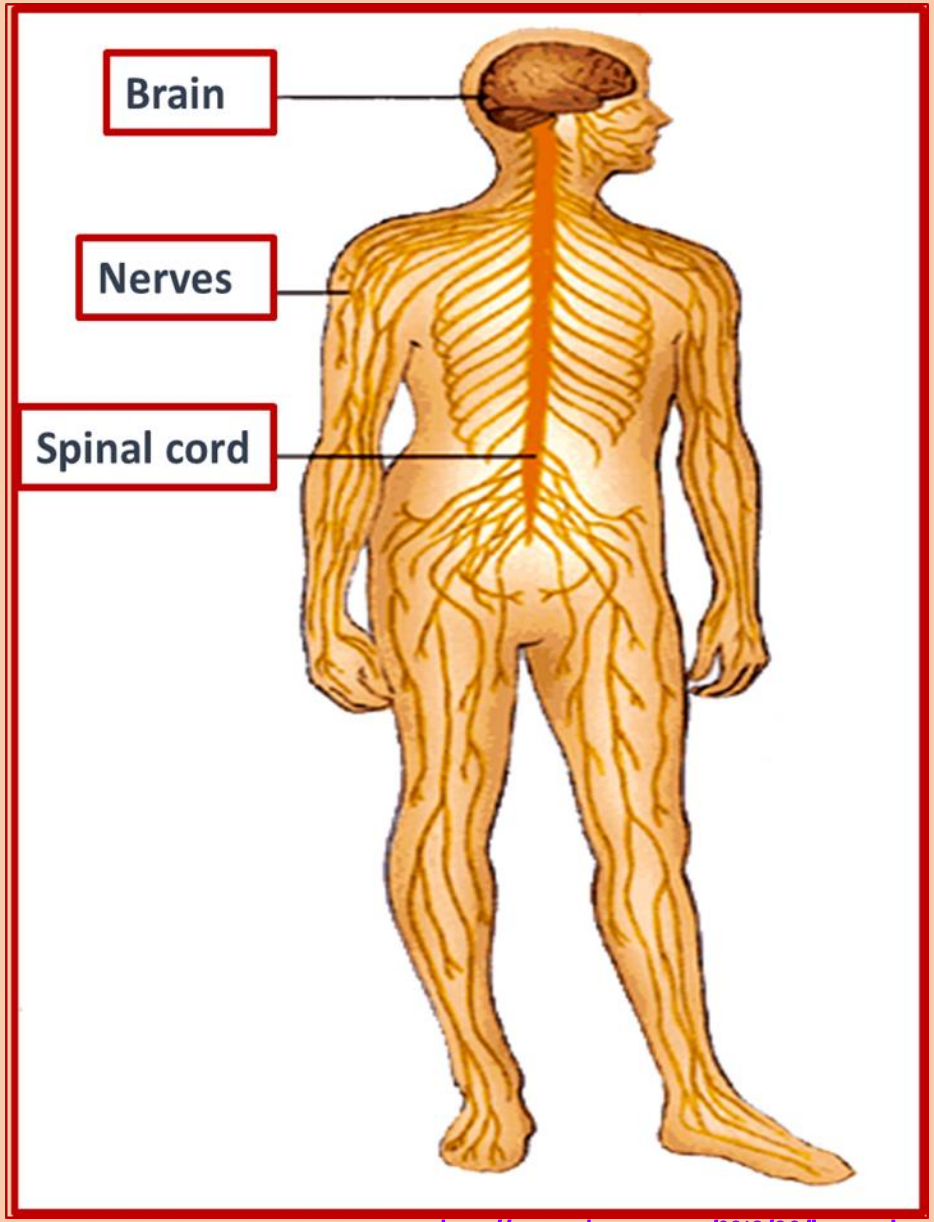
CRANIAL NERVES AND THEIR FUNCTIONS

No.	Cranial nerves	Nature of nerve	Function
I	Olfactory nerve	Sensory	Sense of smell
II	Optic nerves	Sensory	Sense of sight
III	Oculomotor nerves	Motor	Movement of the eye
IV	Trochlear nerve	Motor	Rotation of the eye ball
V	Trigeminal nerve	Sensory and motor (mixed)	Functioning of facial parts
VI	Abducens nerve	Motor	Rotation of the eye ball
VII	Facial nerve	Mixed	Functioning of facial parts
VIII	Auditory/Vestibulo-cochlear nerve	Sensory	Maintains the equilibrium of the body /Auditory function
IX	Glossopharyngeal nerve	Mixed	Taste and touch
X	Vagus	Mixed	Regulation of the visceral organs
XI	Spinal accessory	Motor	Muscular movement of Pharynx, larynx, neck and shoulder
XII	Hypoglossal	Motor	Speech and swallowing

PERIPHERAL NEURAL SYSTEM - PNS

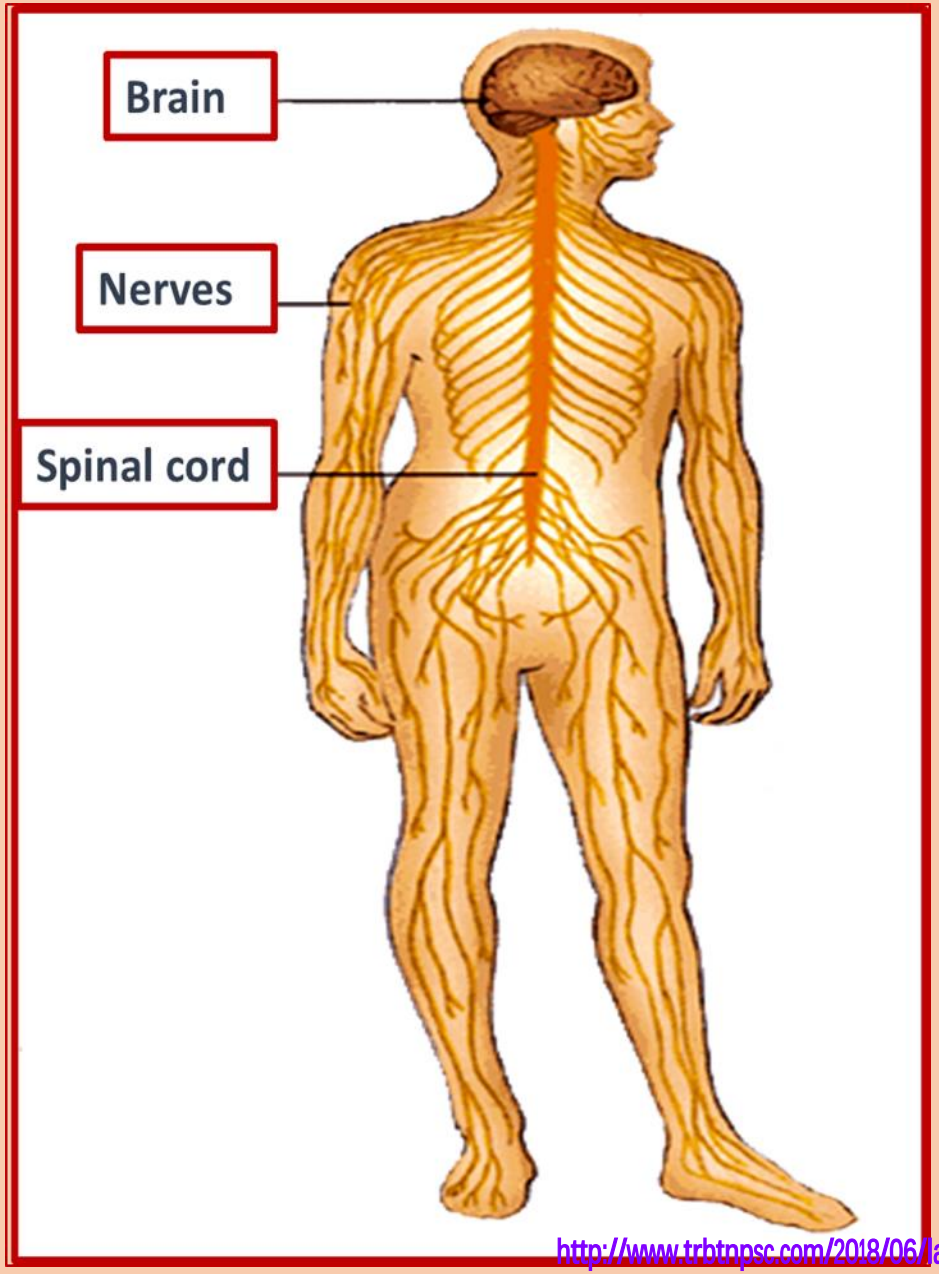
- ✓ PNS consists of all nervous tissue outside the CNS.
- ✓ Components of PNS include nerves, ganglia, enteric plexuses and sensory receptors.
- ✓ A nerve is a chord like structure that encloses several neurons inside.
- ✓ Ganglia (singular-ganglion) are small masses of nervous tissue, consisting primarily of neuron cell bodies and are located outside the brain and spinal cord.
- ✓ Enteric plexuses are extensive networks of neurons located in the walls of organs of the gastrointestinal tract.
- ✓ The neurons of these plexuses help in regulating the digestive system.
- ✓ The specialized structure that helps to respond to changes in the environment i.e. stimuli are called sensory receptor which triggers nerve impulses along the afferent fibres to CNS.
- ✓ PNS comprises of cranial nerves arising from the brain and spinal nerves arising from the spinal cord.

CRANIAL NERVES



- There are 12 pairs of cranial nerves, of which the first two pairs arise from the fore brain and the remaining 10 pairs from the mid brain.
- Other than the Vagus nerve, which extends into the abdomen, all cranial nerves serve the head and face.

SPINAL NERVES

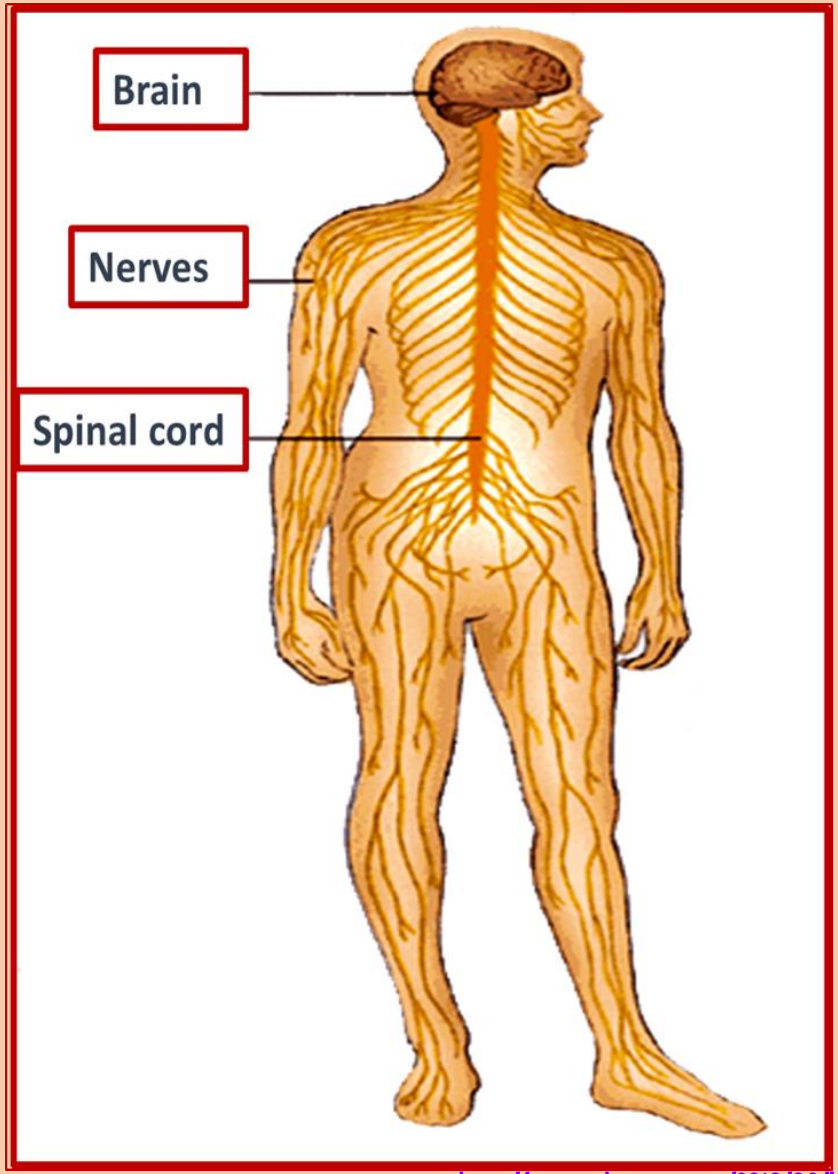


- 31 pairs of spinal nerves emerge out from the spinal cord through spaces called the intervertebral foramina found between the adjacent vertebrae.
- The spinal nerves are named according to the region of vertebral column from which they originate
  - i. Cervical nerves (8 pairs)
  - ii. Thoracic nerves (12 pairs)
  - iii. Lumbar nerves (5 pairs)
  - iv. Sacral nerves (5 pairs)
  - v. Coccygeal nerves (1 pair)
- Each spinal nerve is a mixed nerve containing both afferent (sensory) and efferent (motor) fibres.
- It originates as two roots.

1) A posterior dorsal root with a ganglion outside the spinal cord.

2) An anterior ventral root with no external ganglion.

SOMATIC NEURAL SYSTEM - SNS



- ✓ The somatic neural system (SNS or voluntary neural system) is the part of the peripheral neural system associated with the voluntary control of body movements via skeletal muscles.
- ✓ The sensory and motor nerves that innervate striated muscles form the somatic neural system.
- ✓ Major functions of the somatic neural system include voluntary movement of the muscles and organs, and reflex movements.

AUTONOMIC NEURAL SYSTEM - ANS

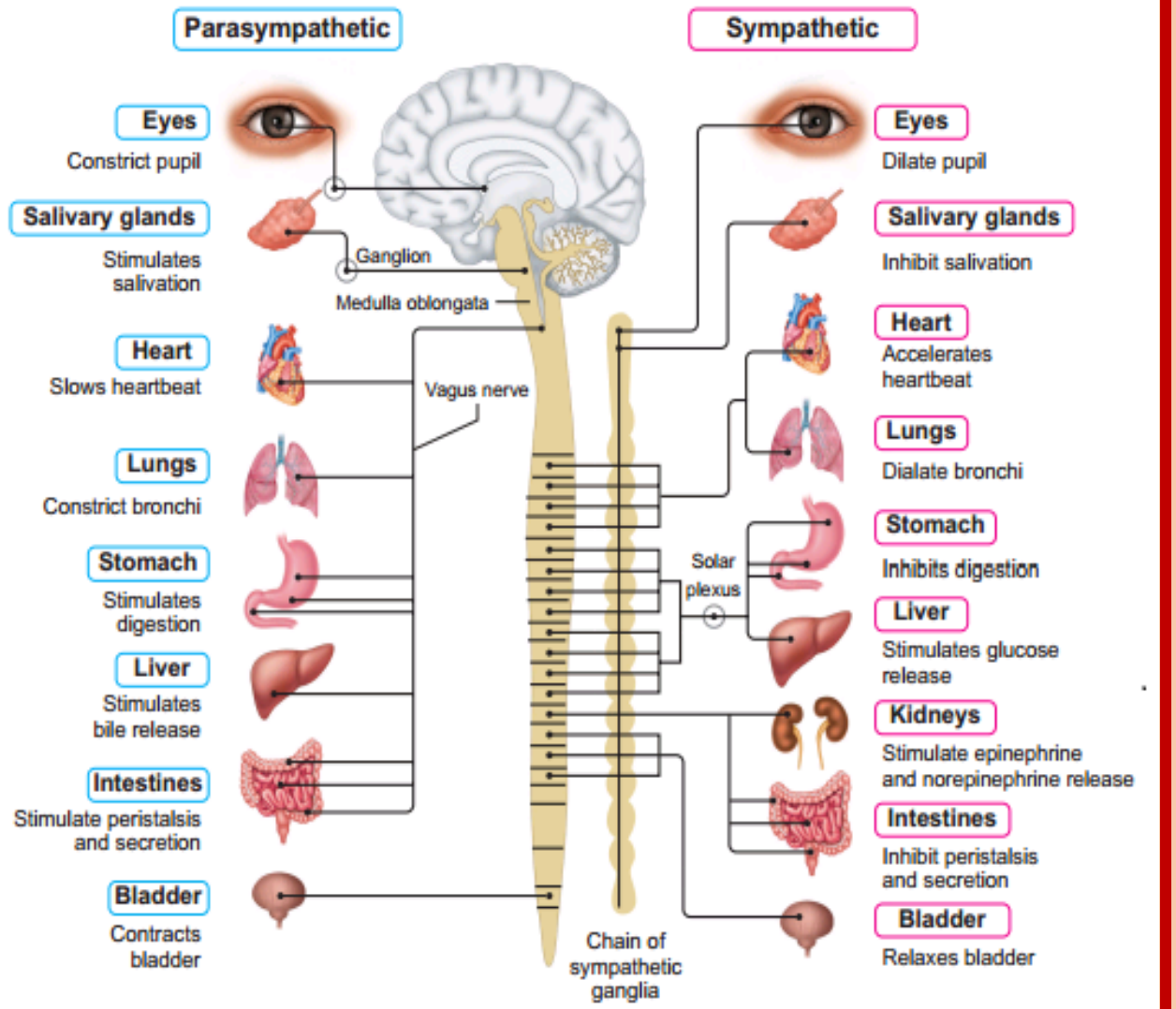


Figure 10.13 Autonomic nervous system

- ✓ The autonomic neural system is auto functioning and self governed.
- ✓ It is a part of peripheral neural system that innervates smooth muscles, glands and cardiac muscle.
- ✓ This system controls and coordinates the involuntary activities of various organs.
- ✓ ANS controlling centre is in the hypothalamus.

AUTONOMIC NEURAL SYSTEM - ANS

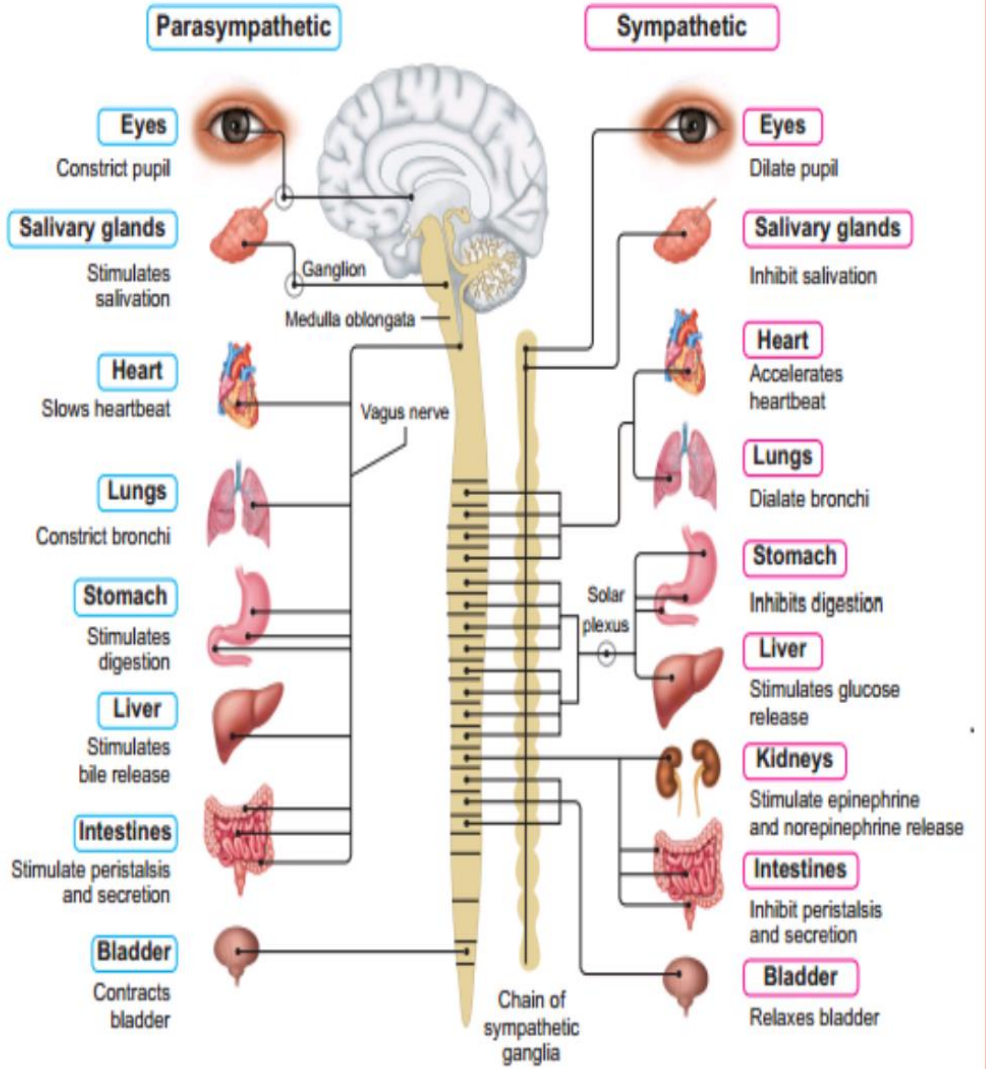


Figure 10.13 Autonomic nervous system

✓ Autonomic neural system comprises the following components.

1. Preganglionic neuron whose cell body is in the brain or spinal cord. Its myelinated axon exits the CNS as part of cranial or spinal nerve and ends in an autonomic ganglion.
2. Autonomic ganglion consists of axon of preganglionic neuron and cell bodies of postganglionic neuron.
3. Postganglionic neuron conveys nerve impulses from autonomic ganglia to visceral effector organs.

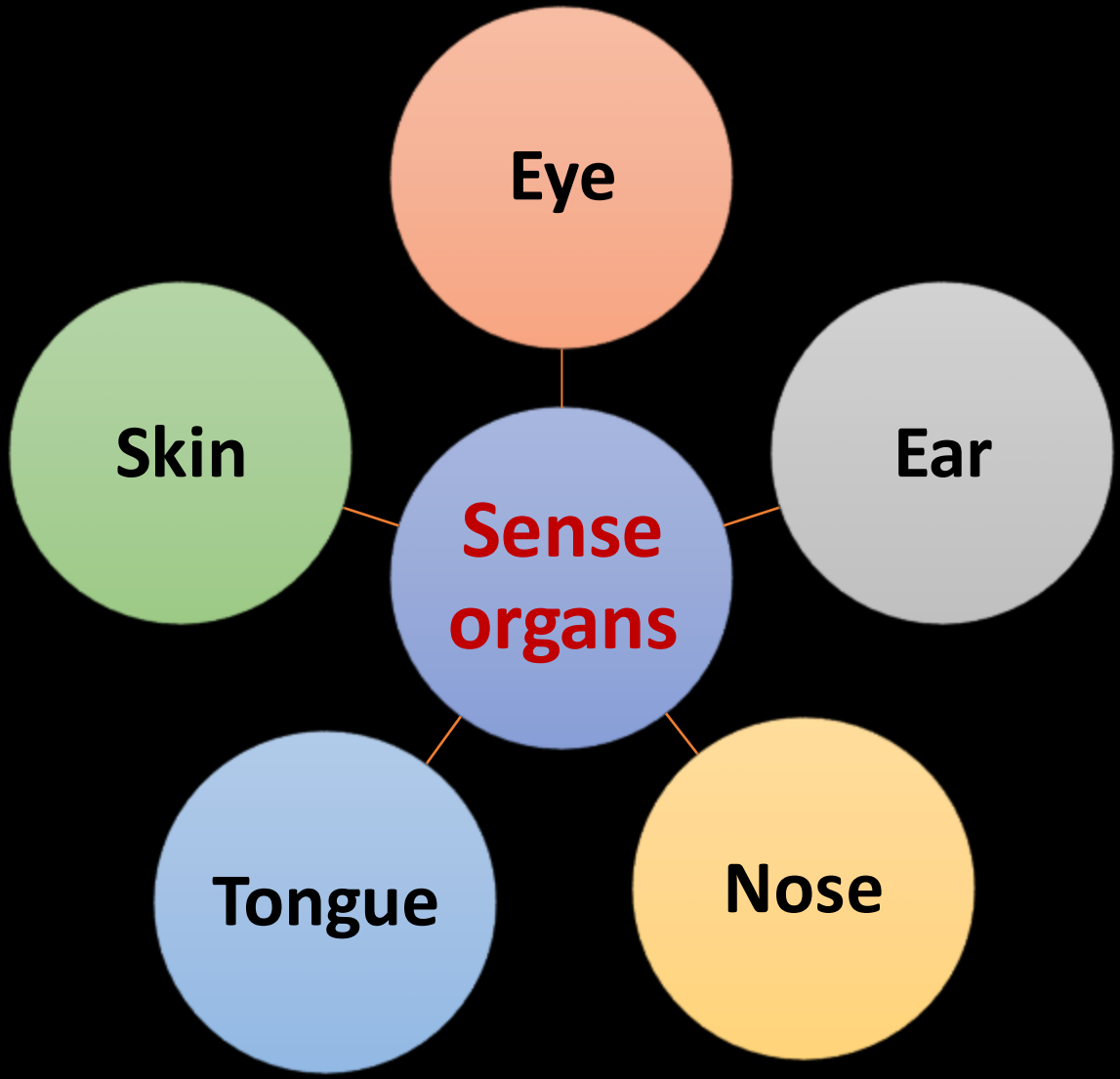
✓ The autonomic neural system consists of Sympathetic neural system and Parasympathetic neural system.

Differences between sympathetic and parasympathetic neural system

Sympathetic Neural system (SNS)	Parasympathetic Neural system (PNS)
SNS originates in the thoracic and lumbar region of the spinal cord.	PNS originates in the cranial region of the brain and the sacral region of the spinal cord.
Sympathetic ganglia are linked up to form a chain.	Its ganglia remain isolated.
Preganglionic fibres are short and the postganglionic fibres are long.	Preganglionic fibres are long and the postganglionic fibres are short.
Noradrenaline is produced at the terminal ends of the postganglionic fibres at the effector organs. Hence the system is adrenergic.	Acetylcholine is produced at the terminal ends of the postganglionic fibres at the effector organs. Hence the system is cholinergic.
Active during stressful conditions preparing the body to face them.	Active during relaxing times restoring normal activity after a stress.
The overall effect is excitatory and stimulating.	The overall effect is inhibitory.
It is considered as the flight or fight system.	It is considered as 'The Rest and Digest System' or 'The Feed and Breed System'.

SENSE ORGANS

SENSE ORGANS



These are the organs that detect the changes in the environment and convey the information to the CNS.

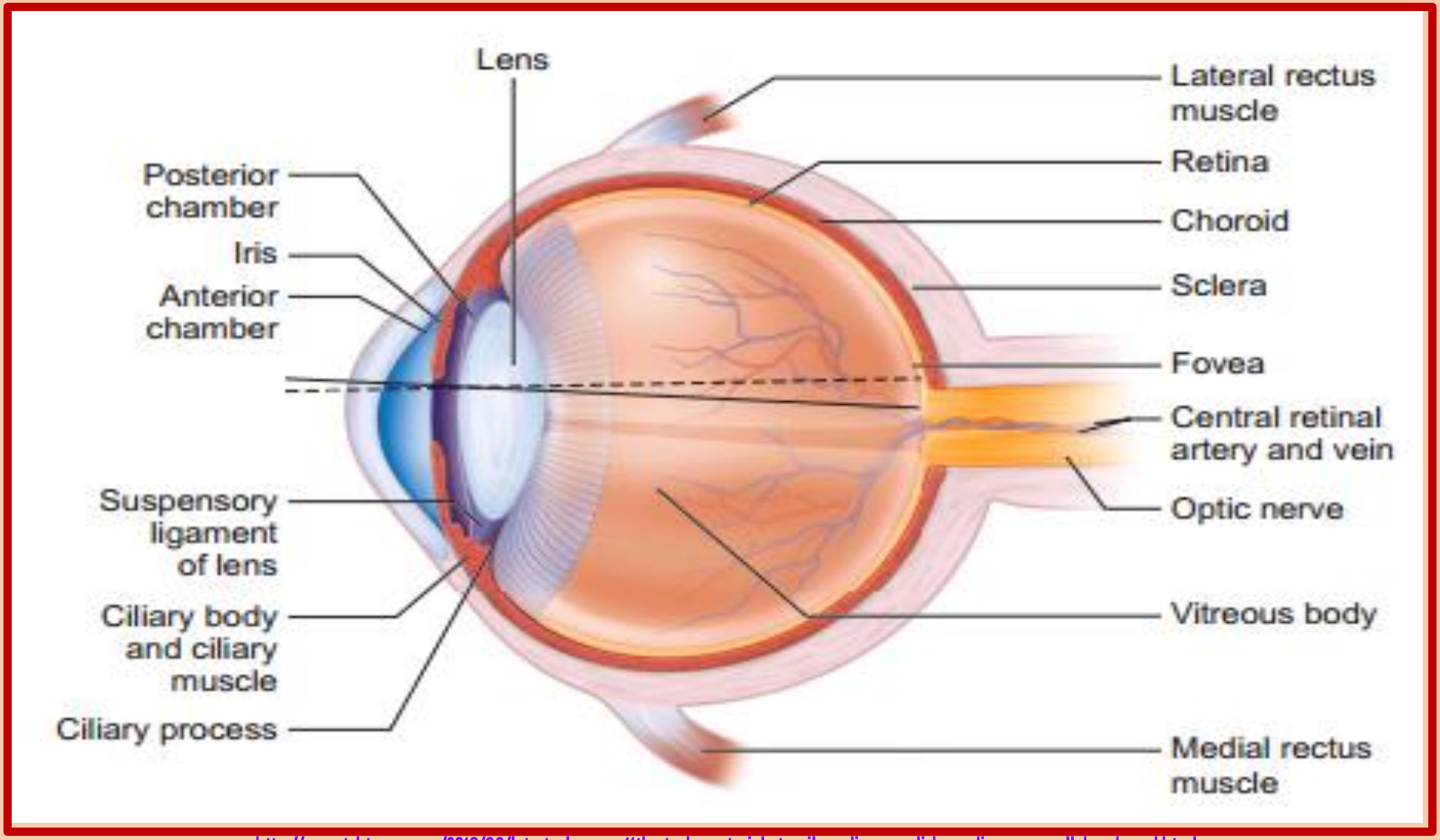
SENSORY RECEPTION AND PROCESSING

- ✓ Our senses make us aware of changes that occur in our surroundings and also within our body.
- ✓ Sensation [awareness of the stimulus] and perception [interpretation of the meaning of the stimulus] occur in the brain.
- ✓ Receptors are classified based on their location:
    1. Exteroceptors
    2. Interoceptors
- ✓ Exteroceptors are located at or near the surface of the body.
- ✓ These are sensitive to external stimuli and receive sensory inputs for hearing, vision, touch, taste and smell.
- ✓ Interoceptors are located in the visceral organs and blood vessels.
- ✓ They are sensitive to internal stimuli.
- ✓ Proprioceptors are also a kind of interoceptors.
- ✓ They provide information about position and movements of the body.
- ✓ These are located in the skeletal muscles, tendons, joints, ligaments and in connective tissue coverings of bones and muscles.

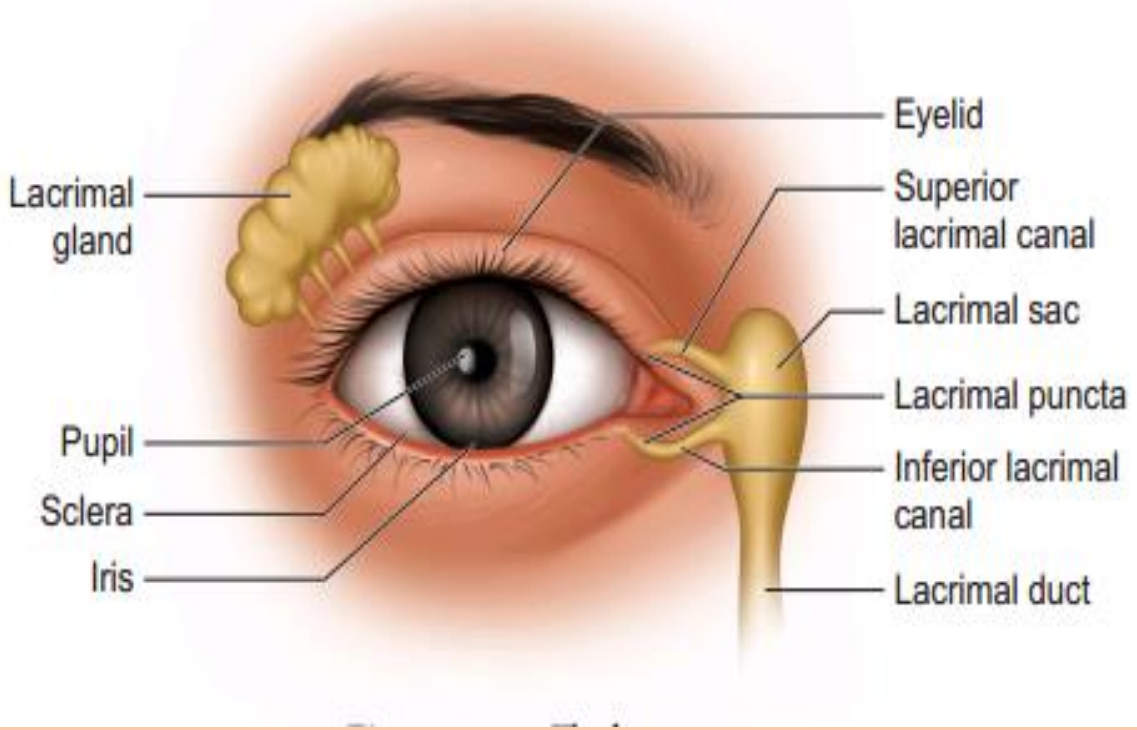
TYPES OF RECEPTORS

Receptors	Stimulus	Effector organs
Mechano receptors	Pressure and vibration	Mechano receptors are present in the cochlea of the inner ear and the semi circular canal and utriculus
Chemoreceptors	Chemicals	Taste buds in the tongue and nasal epithelium
Thermoreceptors	Temperature	Skin
Photoreceptors	Light	Rod and cone cells of the retina in the eye

PHOTORECEPTOR - EYE

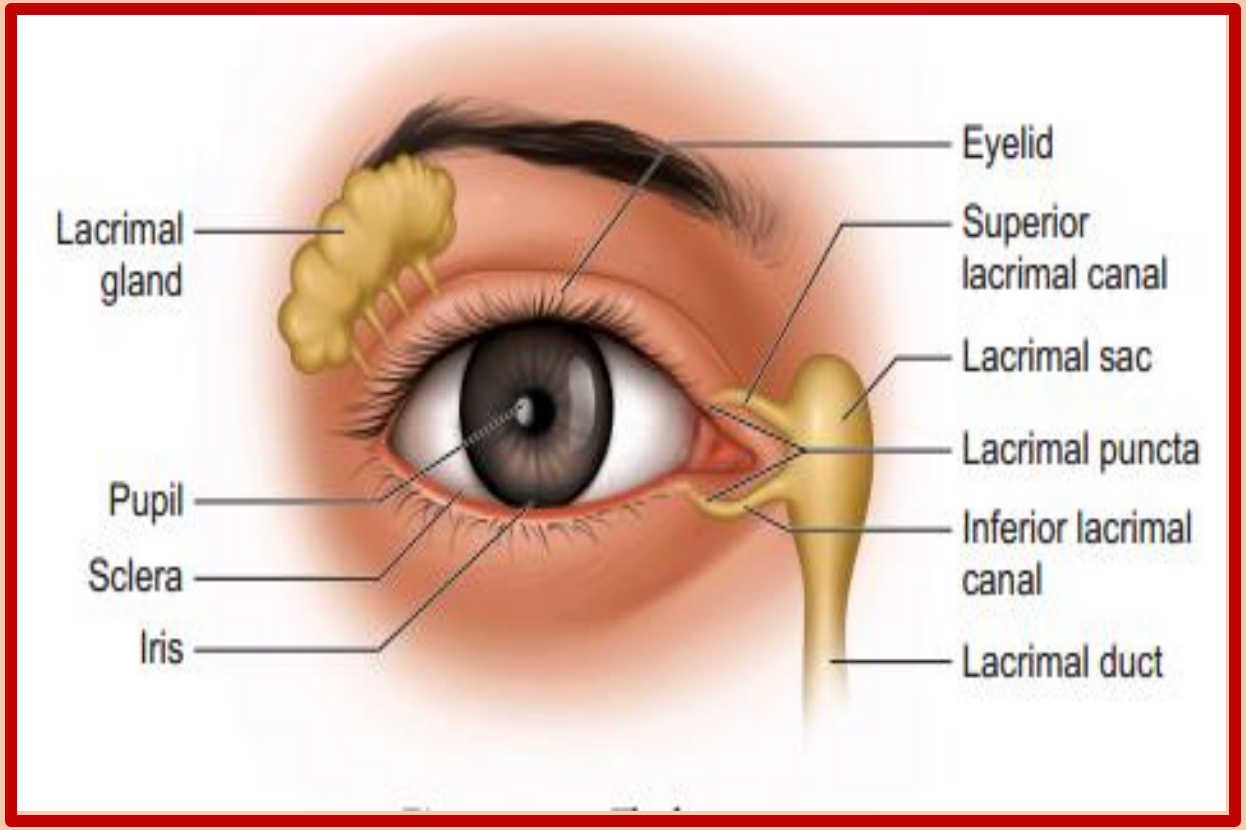


PHOTORECEPTOR - EYE



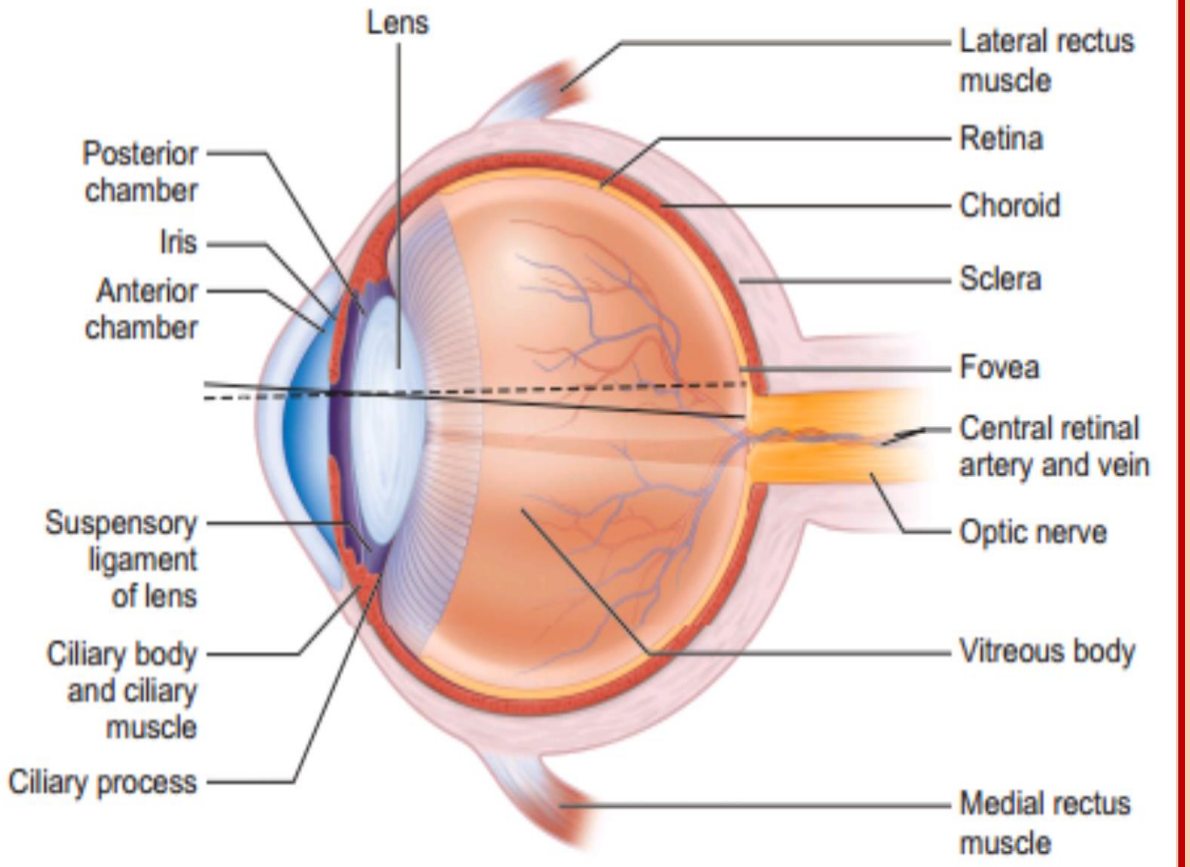
- ✓ Eye is the organ of vision.
- ✓ Located in the orbit of the skull and held in its position with the help of six extrinsic muscles.
- ✓ They are superior, inferior, lateral, median rectus muscles, superior oblique and inferior oblique muscles.
- ✓ These muscles aid in the movement of the eyes and they receive their nerve innervation from III, IV and VI cranial nerves.
- ✓ Eyelids, eye lashes and eye brows are the accessory structures useful in protecting the eyes.
- ✓ The eye lids protect the eyes from excessive light and foreign objects and spread lubricating secretions over the eyeballs.

PHOTORECEPTOR - EYE



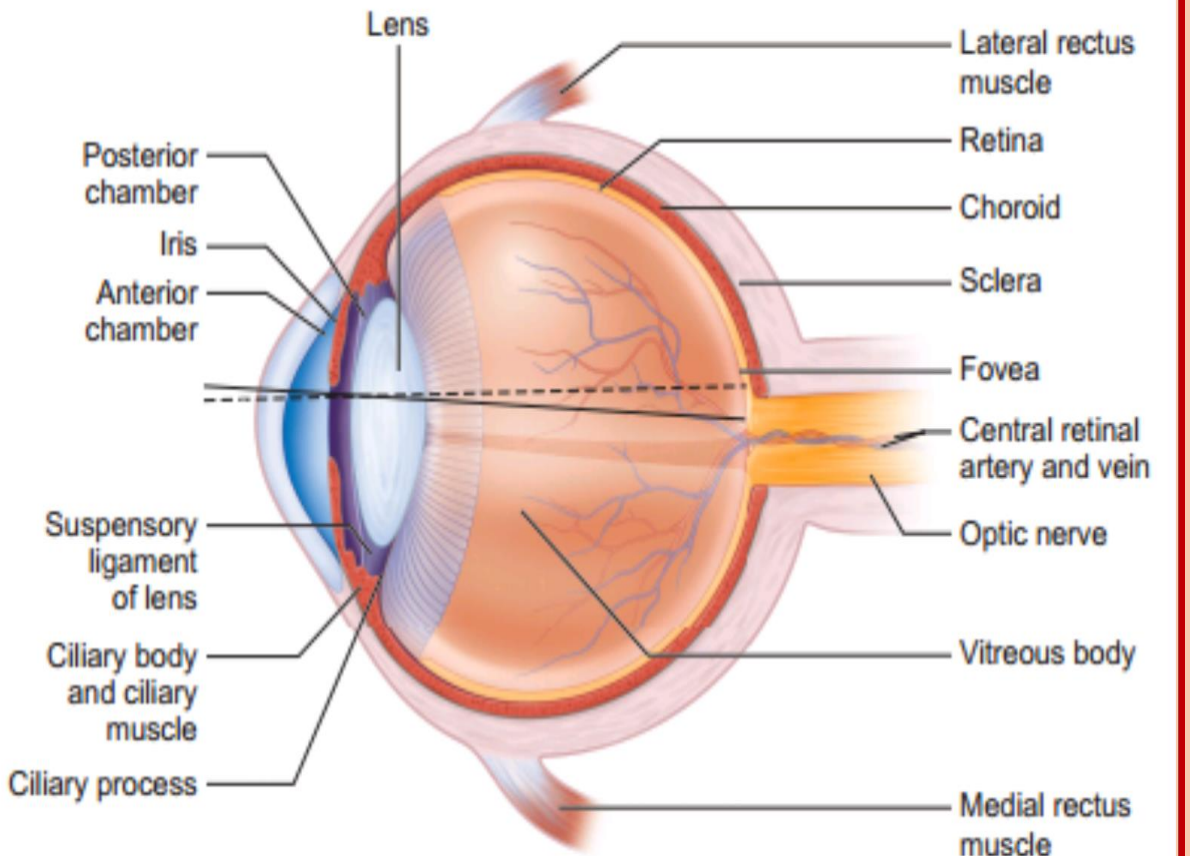
- ✓ Eyelashes and the eyebrows help to protect the eyeballs from foreign objects, perspiration and also from the direct rays of sunlight.
- ✓ Sebaceous glands at the base of the eyelashes are called ciliary glands which secrete a lubricating fluid into the hair follicles.
- ✓ Lacrymal glands, located in the upper lateral region of each orbit, secrete tears.
- ✓ Tears are secreted at the rate of 1mL/day and it contains salts, mucus and lysozyme enzyme to destroy bacteria.
- ✓ The conjunctiva is a thin, protective mucous membrane found lining the outer surface of the eyeball.

PHOTORECEPTOR - EYE



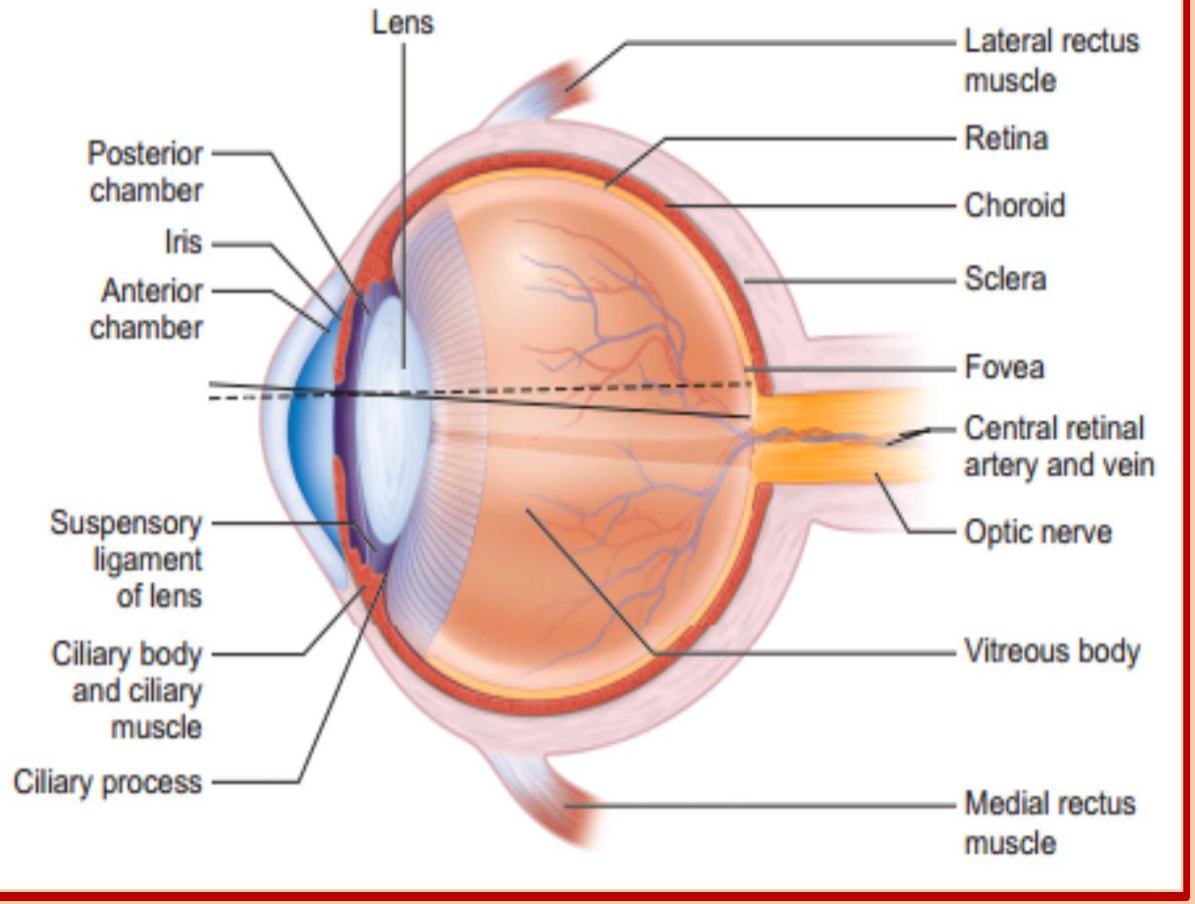
- ✓ The eye has two compartments, the anterior and posterior compartments.
- ✓ The anterior compartment has two chambers, first one lies between the cornea and iris and the second one lies between the iris and lens.
- ✓ These two chambers are filled with watery fluid called aqueous humor.
- ✓ The posterior compartment lies between the lens and retina and it is filled with a jelly like fluid called vitreous humor that helps to retain the spherical nature of the eye.
- ✓ Eye lens is transparent and biconvex, made up of long columnar epithelial cells called lens fibres.
- ✓ These cells are accumulated with the proteins called crystalline.

THE EYE BALL



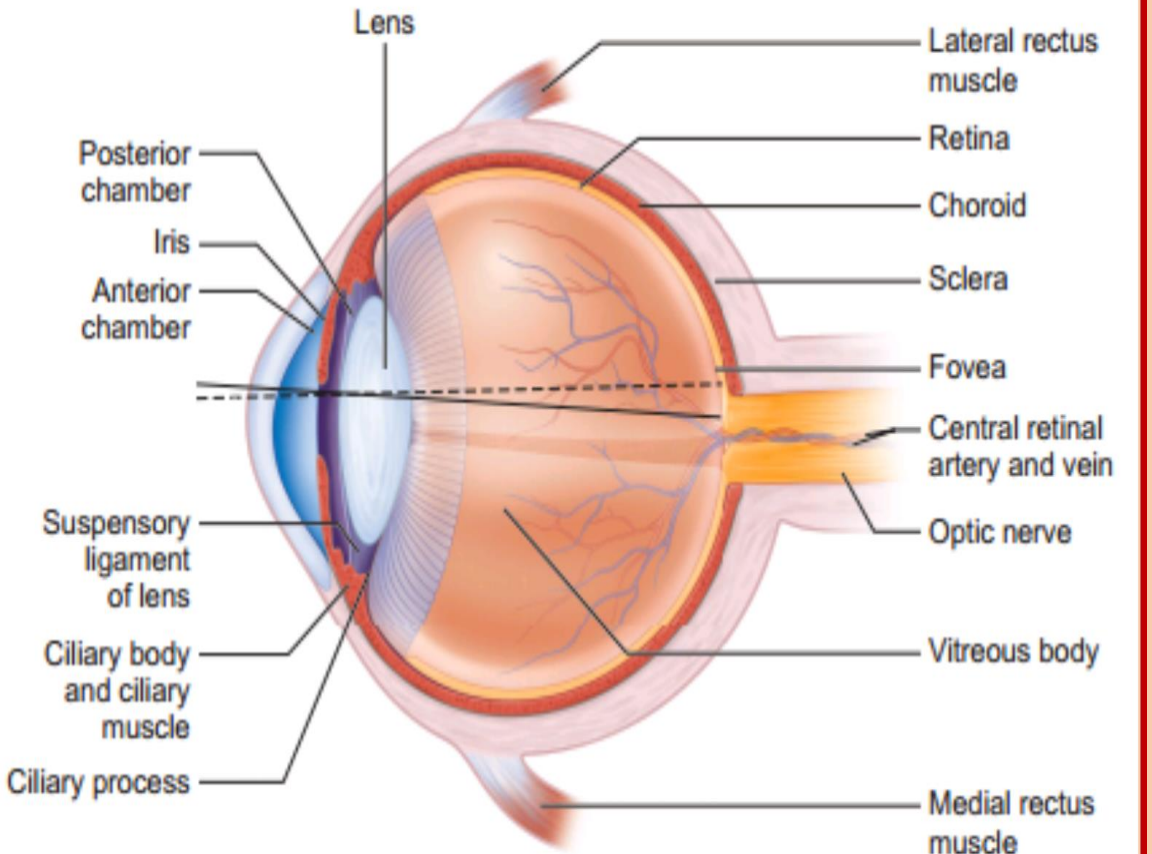
- ✓ The eye ball is spherical in nature.
- ✓ The anterior one- sixth of the eyeball is exposed, the remaining region is fitted well into the orbit.
- ✓ The wall of the eye ball consists of three layers.
  1. Fibrous Sclera
  2. Vascular Choroid
  3. Sensory Retina
- ✓ The outer coat is composed of dense non-vascular connective tissue.
- ✓ It has two regions, the anterior cornea and the posterior sclera.

THE EYE BALL



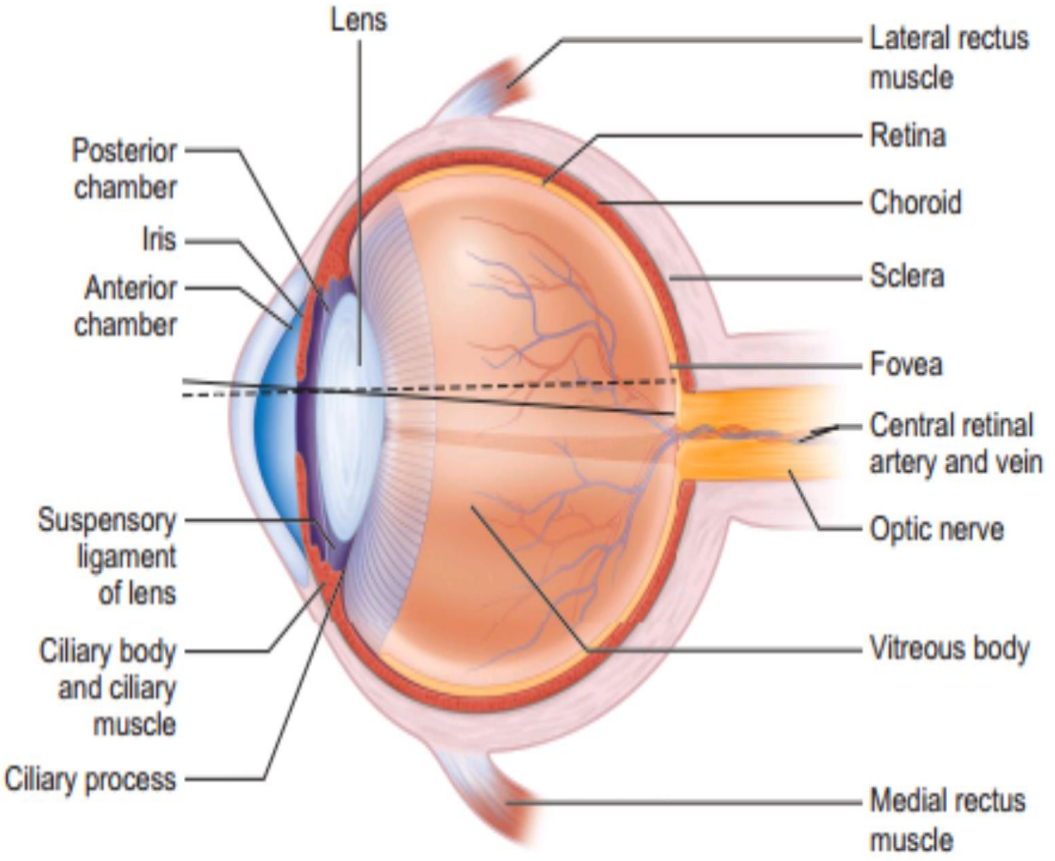
- ✓ Cornea is a non-vascular transparent coat formed of stratified squamous epithelium which helps the cornea to renew continuously as it is very vulnerable to damage from dust.
- ✓ Sclera forms the white of the eye and protects the eyeball.
- ✓ Posteriorly the sclera is innervated by the optic nerve.
- ✓ At the junction of the sclera and the cornea, is a channel called 'canal of schlemm' which continuously drains out the excess of aqueous humor.

THE EYE BALL



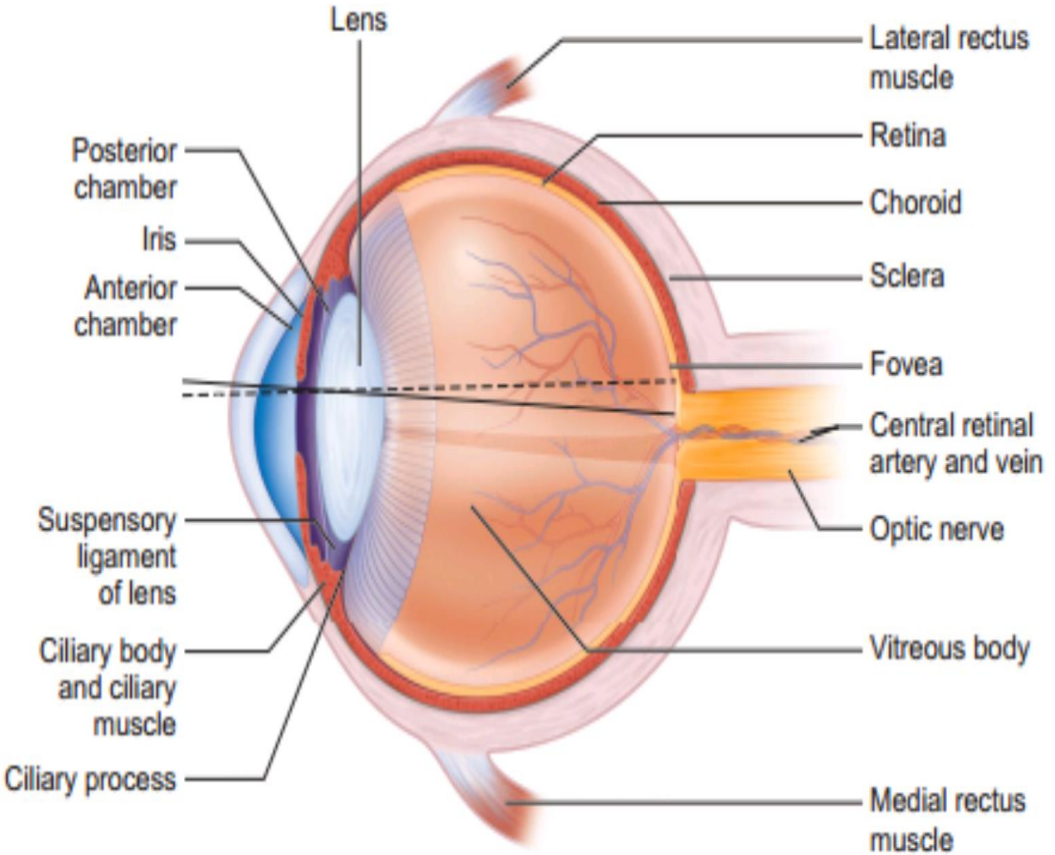
- ✓ Choroid is highly vascularized pigmented layer that nourishes all the eye layers and its pigments absorb light to prevent internal reflection.
- ✓ Anteriorly the choroid thickens to form the ciliary body and iris.
- ✓ Iris is the coloured portion of the eye lying between the cornea and lens.
- ✓ The aperture at the centre of the iris is the pupil through which the light enters the inner chamber.
- ✓ Iris is made of two types of muscles the dilator papillae (the radial muscle) and the sphincter papillae (the circular muscle).
- ✓ In the bright light, the circular muscle in the iris contract, so that the size of pupil decreases and less light enters the eye.

THE EYE BALL



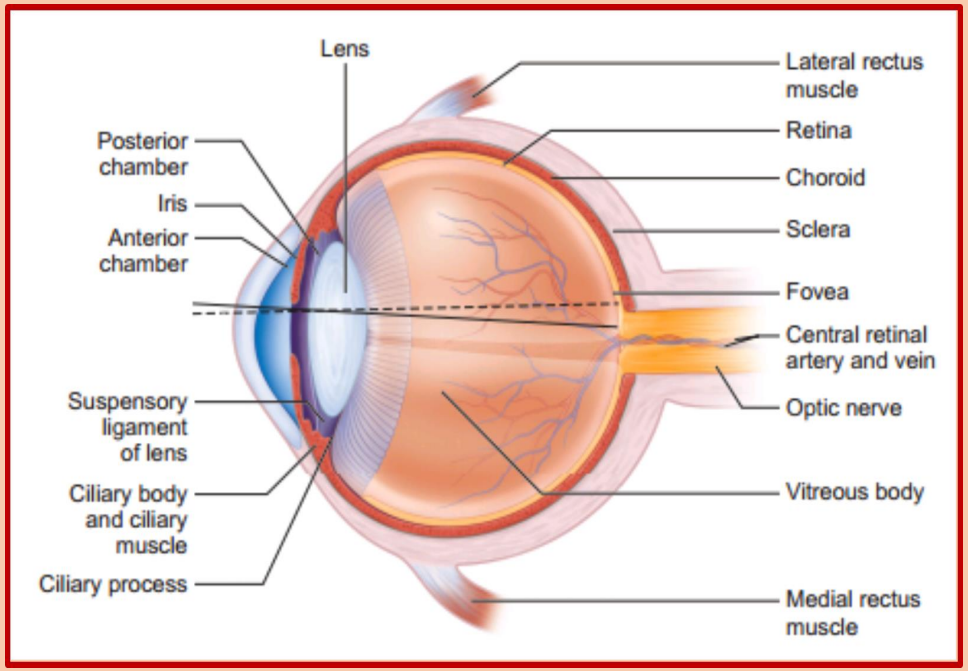
- ✓ In dim light, the radial muscle in the iris contract, so that the pupil size increases and more light enters the eye.
- ✓ Smooth muscle present in the ciliary body is called the ciliary muscle which alters the convexity of the lens for near and far vision.
- ✓ The ability of the eyes to focus objects at varying distances is called accommodation which is achieved by suspensory ligament, ciliary muscle and ciliary body.
- ✓ The suspensory ligament extends from the ciliary body and helps to hold the lens in its upright position.
- ✓ The ciliary body is provided with blood capillaries that secrete a watery fluid called aqueous humor that fills the anterior chamber.

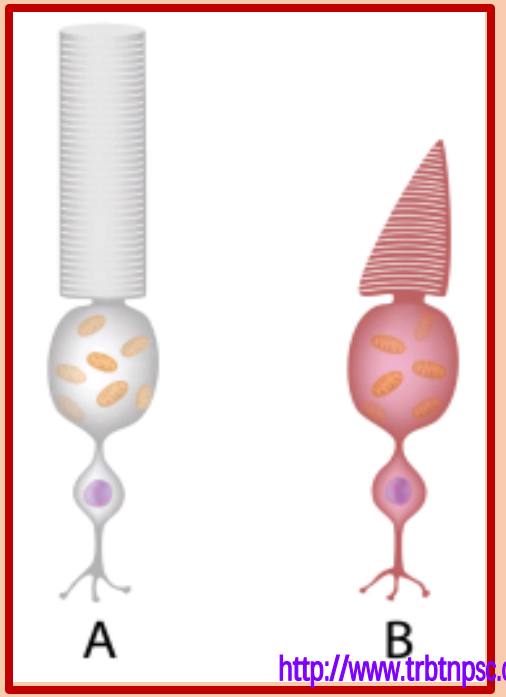
THE EYE BALL



- ✓ Retina forms the inner most layer of the eye and it contains two regions.
  1. A sheet of pigmented epithelium (non visual part)
  2. Neural visual regions.
- ✓ The neural retina layer contains three types of cells.
  1. Photoreceptor cells – cones and rods
  2. Bipolar cells
  3. Ganglion cells

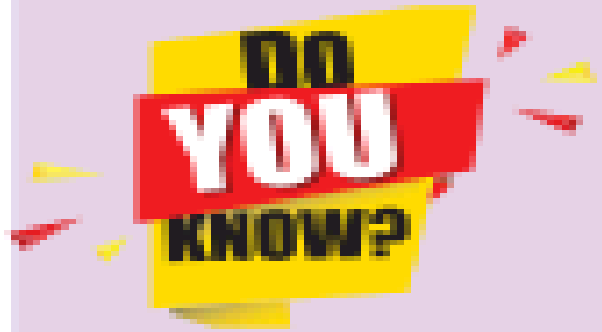
THE EYE BALL





- ✓ The yellow flat spot at the centre of the posterior region of the retina is called **macula lutea** which is responsible for **sharp detailed vision**.
- ✓ A small depression present in the centre of the yellow spot is called **fovea centralis** which contains **only cones**.
- ✓ The optic nerves and the retinal blood vessels enter the eye slightly below the posterior pole, which is **devoid of photo receptors**, hence this region is called **blind spot**.

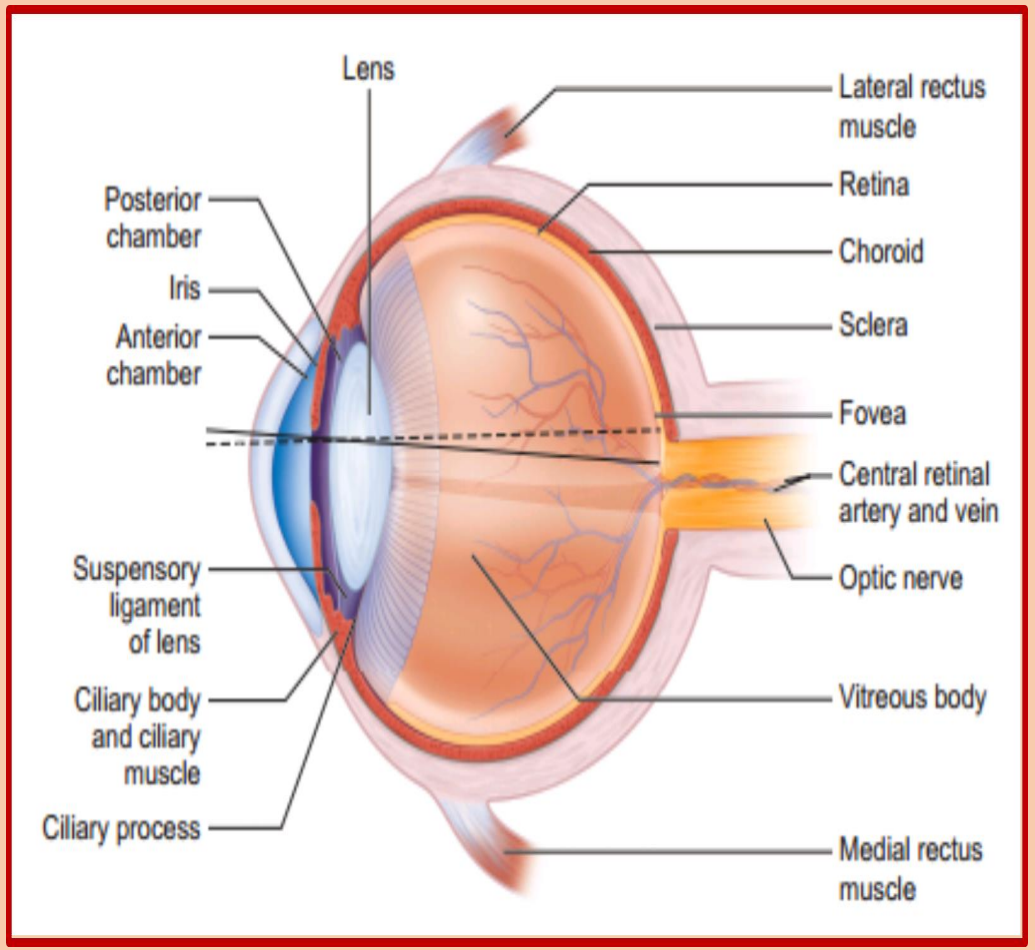
Your friend is returning home after his visit to USA. All at home are waiting for his arrival. How would you feel? State the division of ANS that predominates and mention few changes that take place in your body.



Dilation and congestion of the blood vessels of the conjunctiva due to local irritation or infection are the cause of bloodshot eye (conjunctivitis - commonly called Madras eye). Infection of ciliary glands by bacteria causes a painful, pus filled swelling called a Sty.

Aqueous humour supplies nutrients and oxygen to the lens, cornea and some retinal cells. The aqueous humor is produced and drained at the same rate, maintaining a constant intra ocular pressure of about 16 mmHg. Any block in the canal of schlemm increases the infra ocular pressure of aqueous humor and leads to 'Glaucoma' where the optic nerve and the retina are compressed due to pressure.

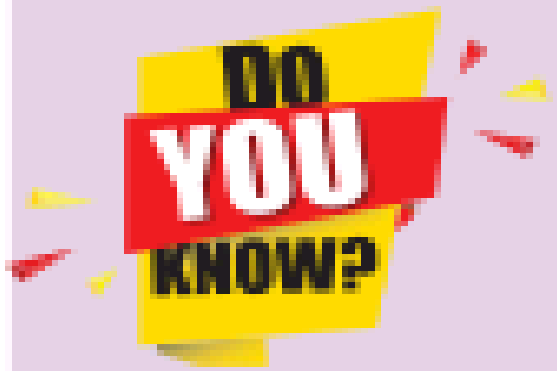
MECHANISM OF VISION



- When light enters the eyes, it gets refracted by the cornea, aqueous humor and lens and it is focused on the retina and excites the rod and cone cells.
- The photo pigment consists of Opsin, the protein part and Retinal, a derivative of vitamin A.
- Light induces dissociation of retinal from opsin and causes the structural changes in opsin.
- This generates an action potential in the photoreceptor cells and is transmitted by the optic nerves to the visual cortex of the brain, via bipolar cells, ganglia and optic nerves, for the perception of vision.

DIFFERENCE BETWEEN ROD AND CONE CELLS

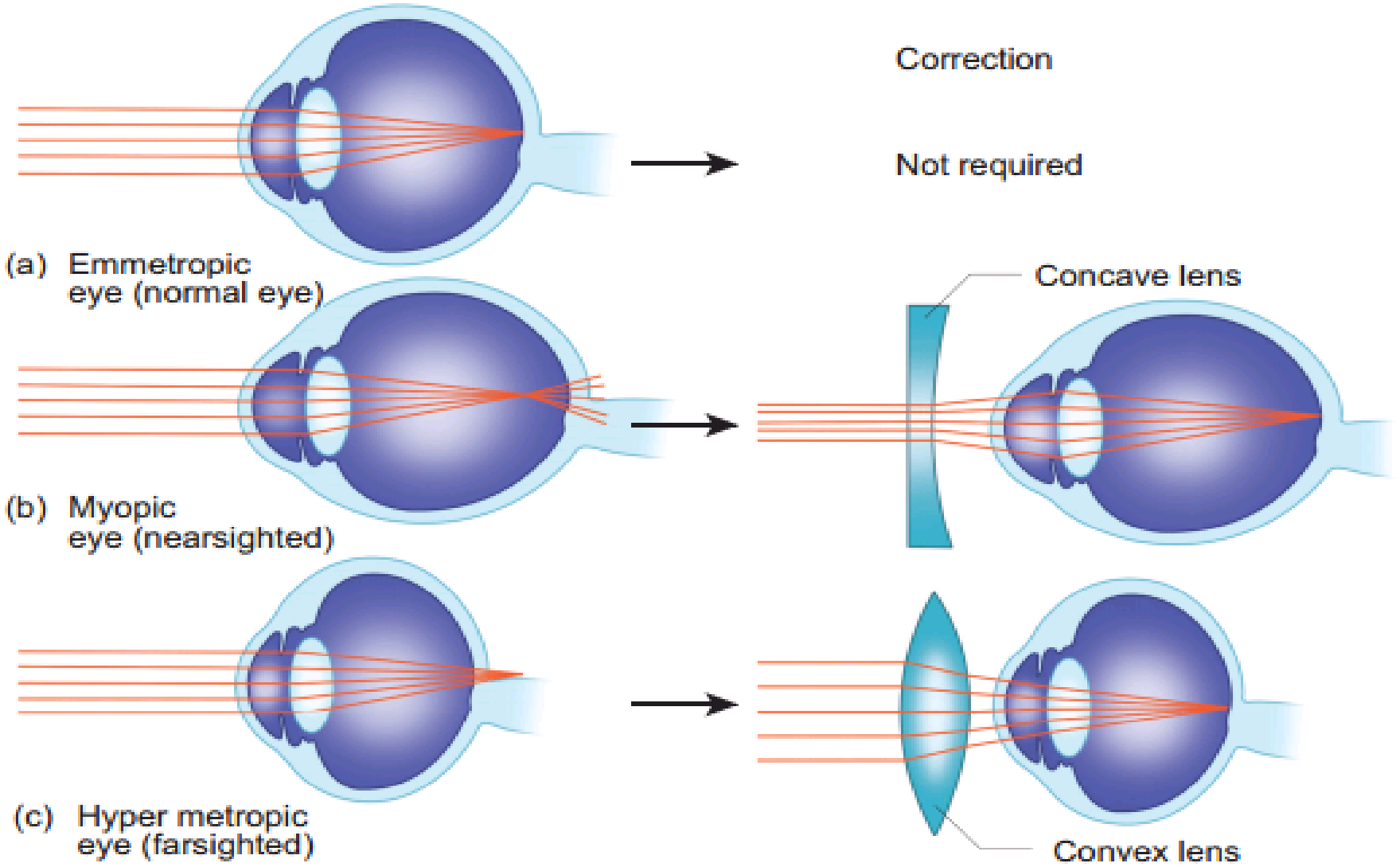
Rod cells	Cone cells
Rods are responsible for vision in dim light	The cones are responsible for colour vision and works best in the bright light.
The pigment present in the rods is rhodopsin, formed of a protein scotopsin and retinal (an aldehyde of vitamin A)	The pigment present in the cones is photopsin, formed of opsin protein and retinal.
There are about 120 millions rod cells	There may be 6-7 millions cone cells
Rods are predominant in the extra fovea region	Cones are concentrated in the fovea region



The cornea is the only tissue in the body that can be transplanted from one person to another with little or no possibility of rejection. This is because cornea does not have blood vessels.

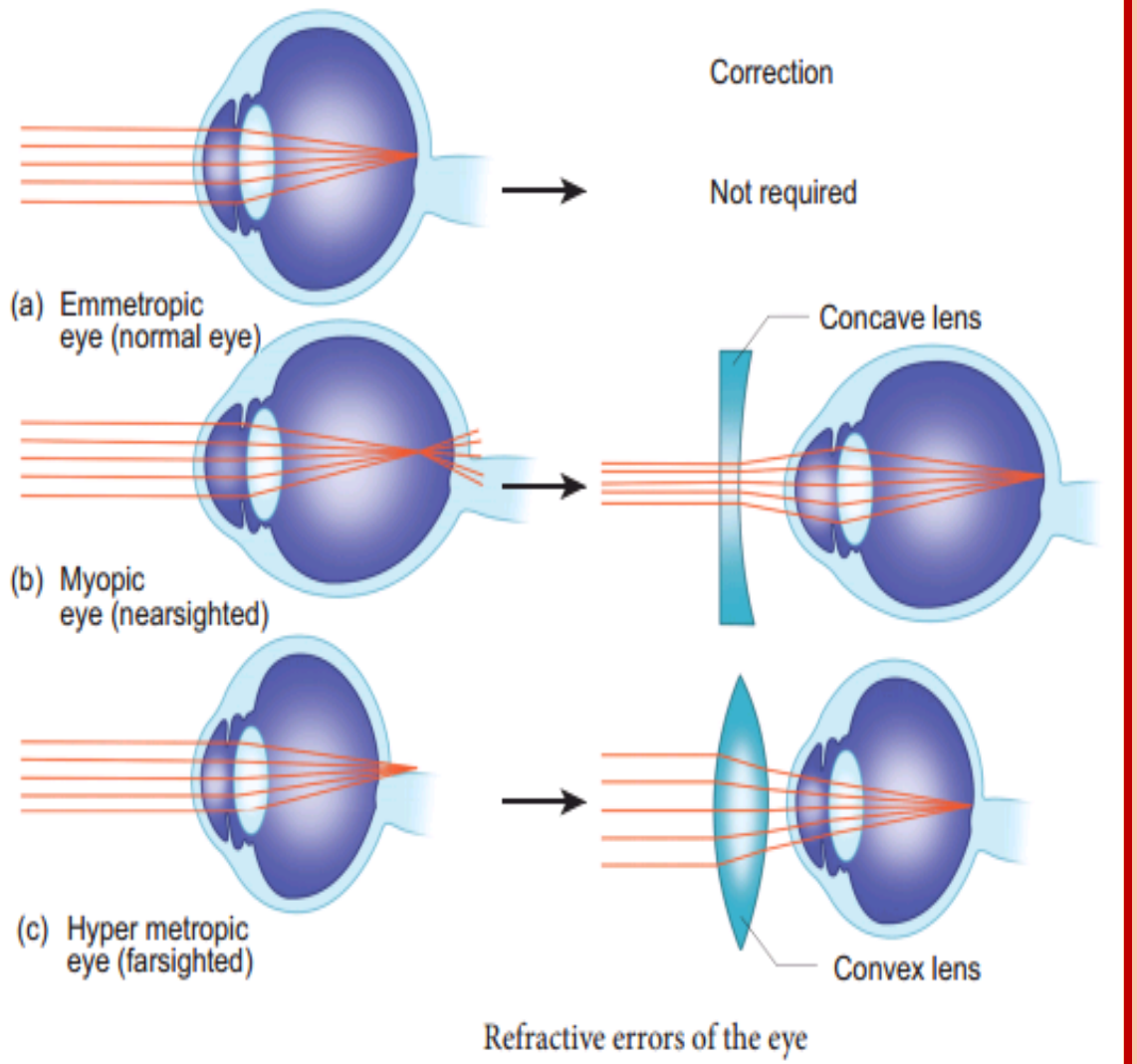
Visual pigments for colour vision are i) the red cones having the visual pigment, Erythropsin is sensitive to long wavelength close to 560 nm. ii) The green cones having the pigment, chloropsin is sensitive to medium wavelength of 530 nm iii) the blue cones having the pigment, cyanopsin is sensitive to short wavelength of 420 nm.

REFRACTIVE ERRORS OF EYE



Refractive errors of the eye

REFRACTIVE ERRORS OF EYE

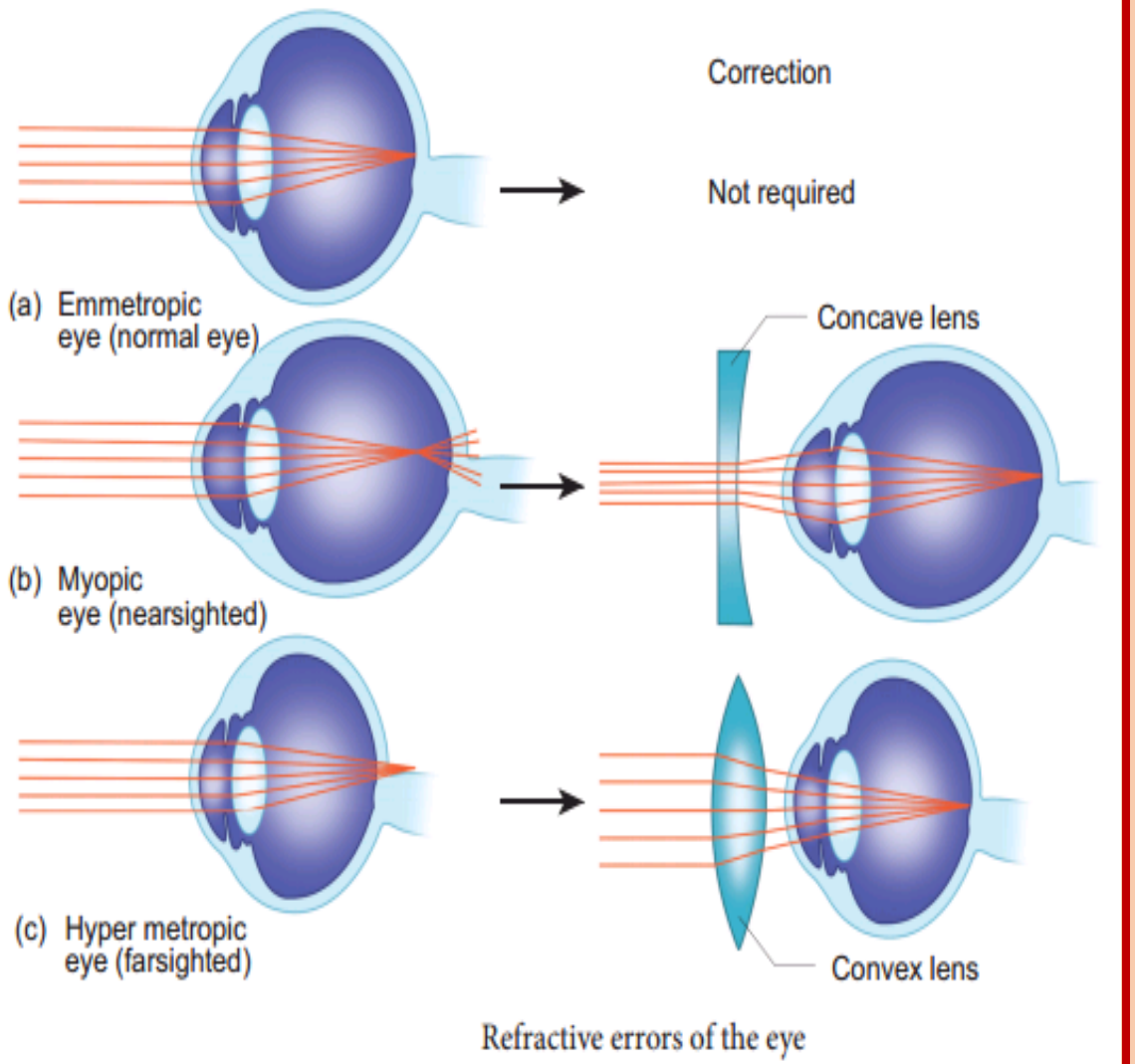


Refractive errors of the eye

1. Myopia (near sightedness):

- ✓ The affected person can see the nearby objects but not the distant objects.
- ✓ This condition may result due to an elongated eyeball or thickened lens, so that the image of distant object is formed in front of the yellow spot.
- ✓ This error can be corrected using concave lens that diverge the entering light rays and focuses it on the retina.

REFRACTIVE ERRORS OF EYE



Refractive errors of the eye

2. Hypermetropia (long sightedness):

- ✓ The affected person can see only the distant objects clearly but not the objects nearby.
- ✓ This condition results due to a shortened eyeball and thin lens, so the image of closest object is converged behind the retina.
- ✓ This defect can be overcome by using convex lens that converge the entering light rays on the retina.

REFRACTIVE ERRORS OF EYE

3. Presbyopia:

- ✓ Due to aging, the lens loses elasticity and the power of accommodation.
- ✓ Convex lenses are used to correct this defect.

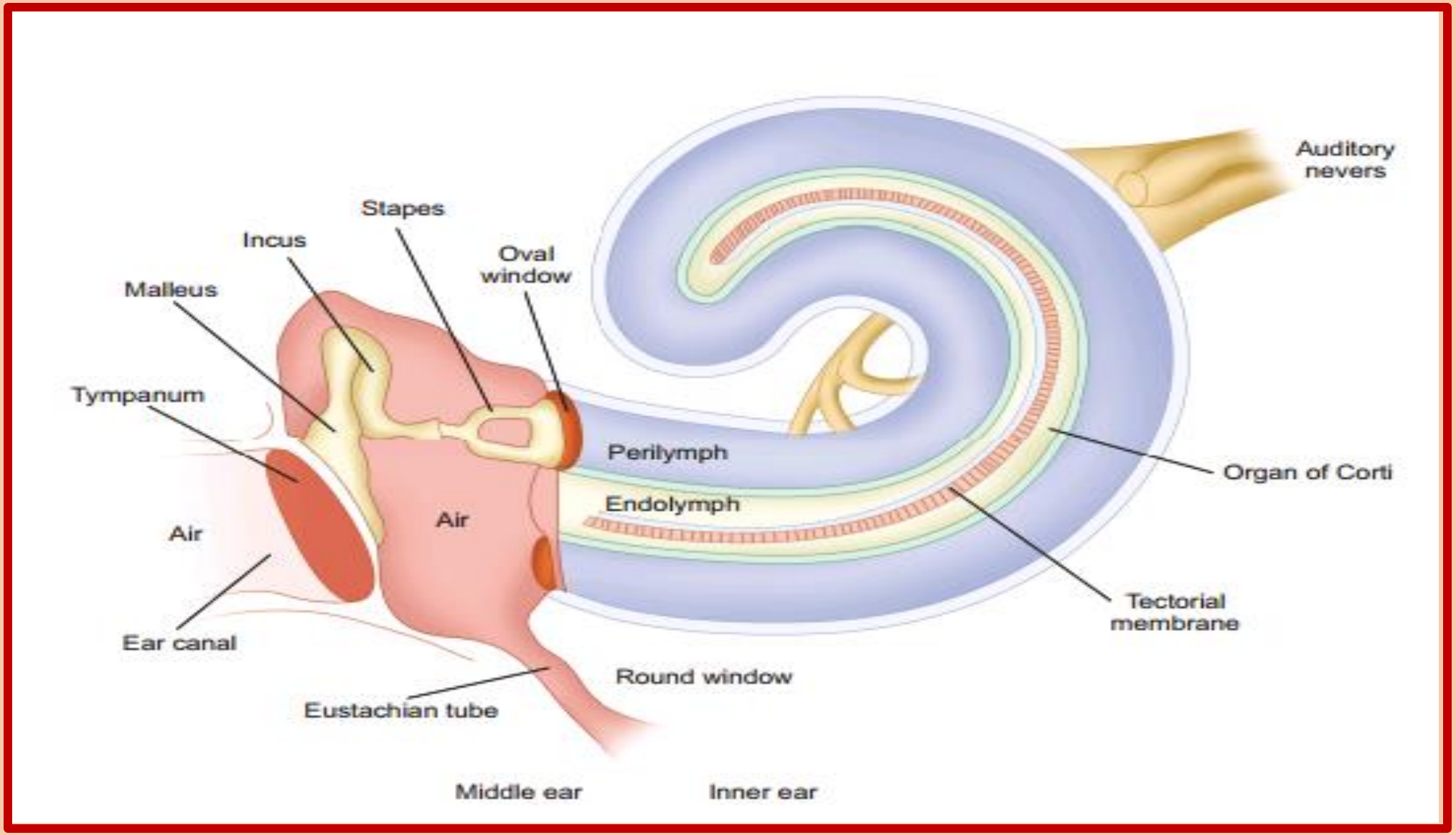
4. Astigmatism:

- ✓ Astigmatism is due to the rough (irregular) curvature of cornea or lens.
- ✓ Cylindrical glasses are used to correct this error.

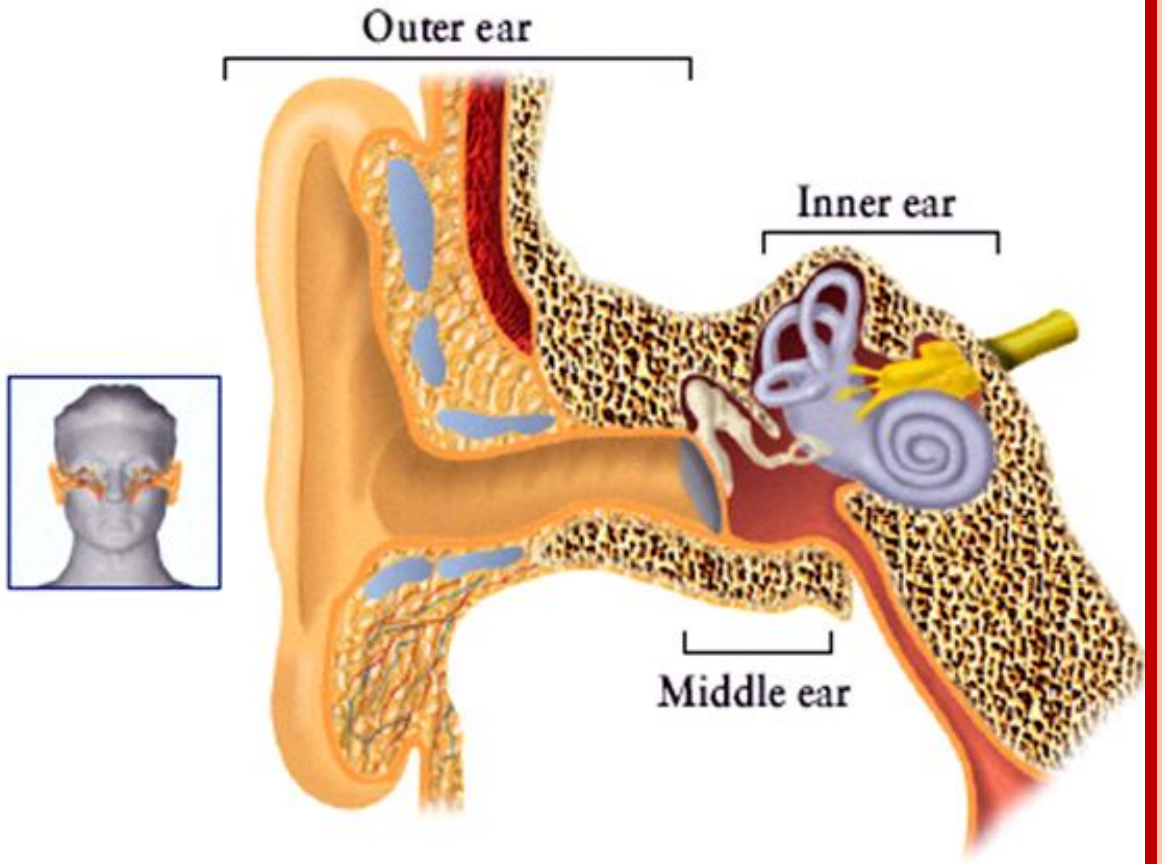
5. Cataract:

- ✓ Due to the changes in nature of protein, the lens becomes opaque.
- ✓ It can be corrected by surgical procedures.

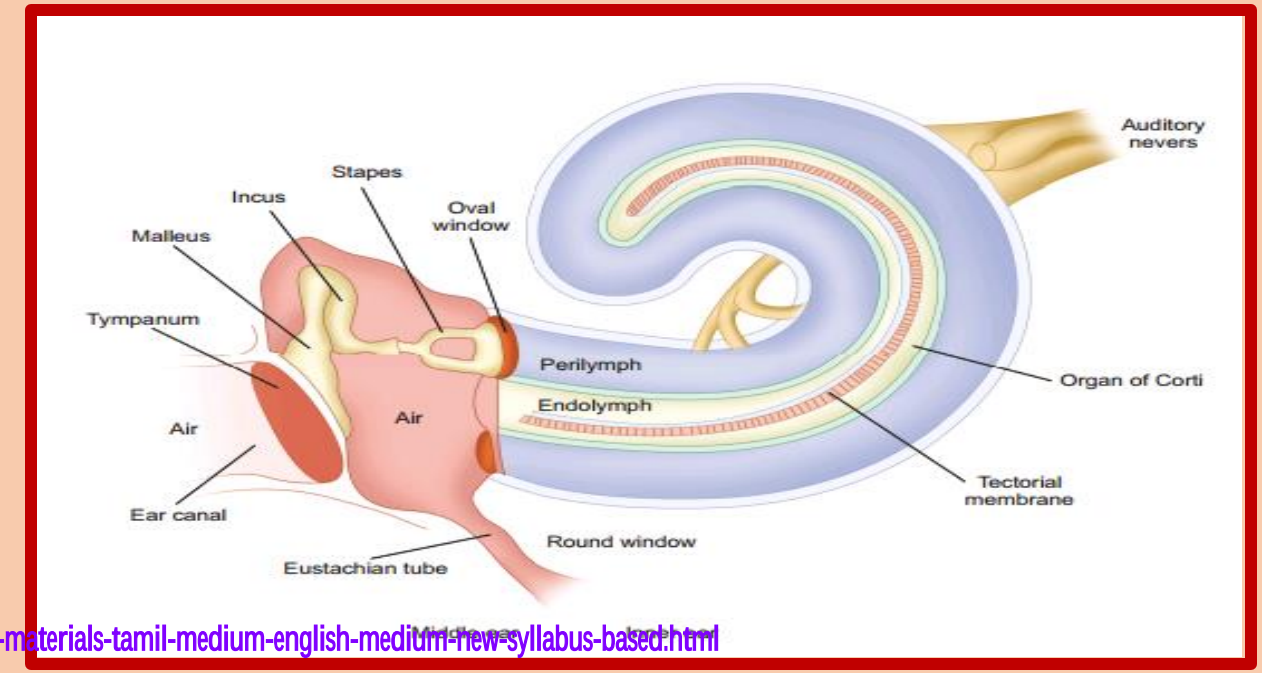
PHONOORECEPTOR - EAR



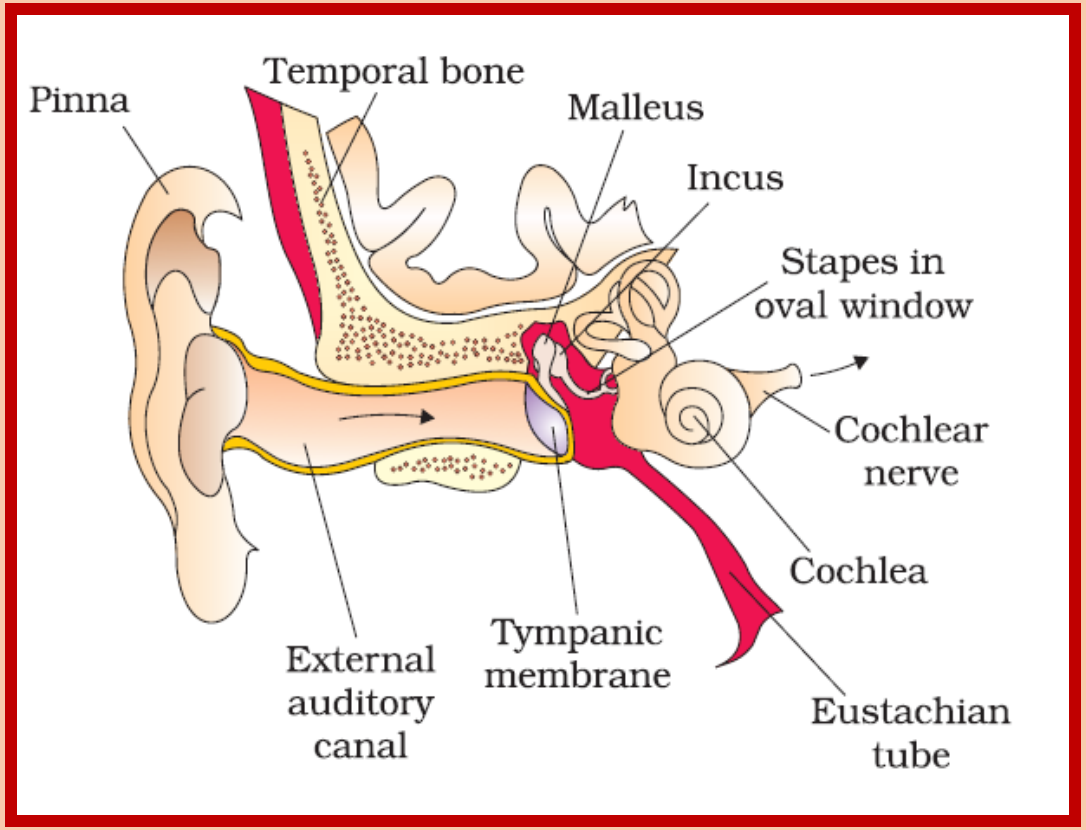
PHONOORECEPTOR - EAR



- ✓ The ear is the site of reception of two senses namely **hearing and equilibrium**.
- ✓ Anatomically, the ear is divided into **three regions**.
  1. **The external ear**
  2. **The middle ear**
  3. **Internal ear**

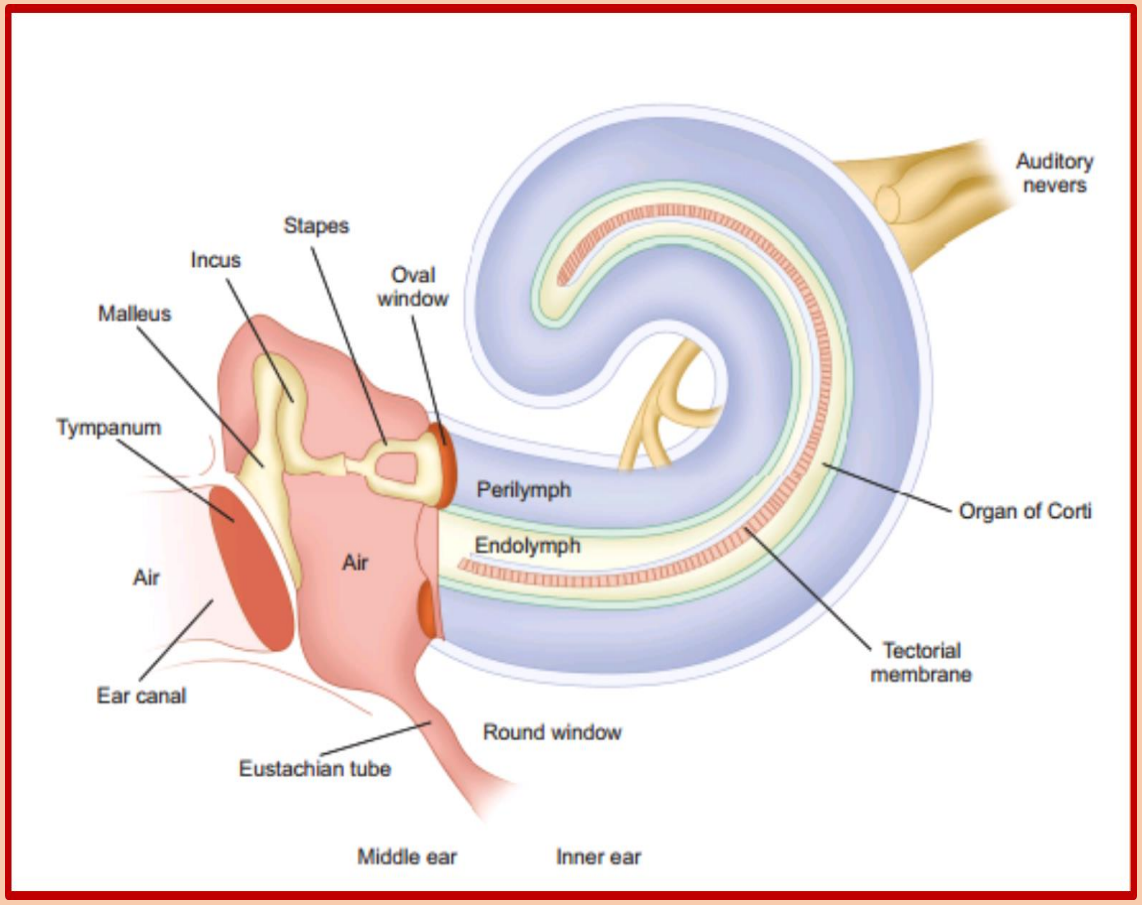


PHONOORECEPTOR – THE EXTERNAL EAR



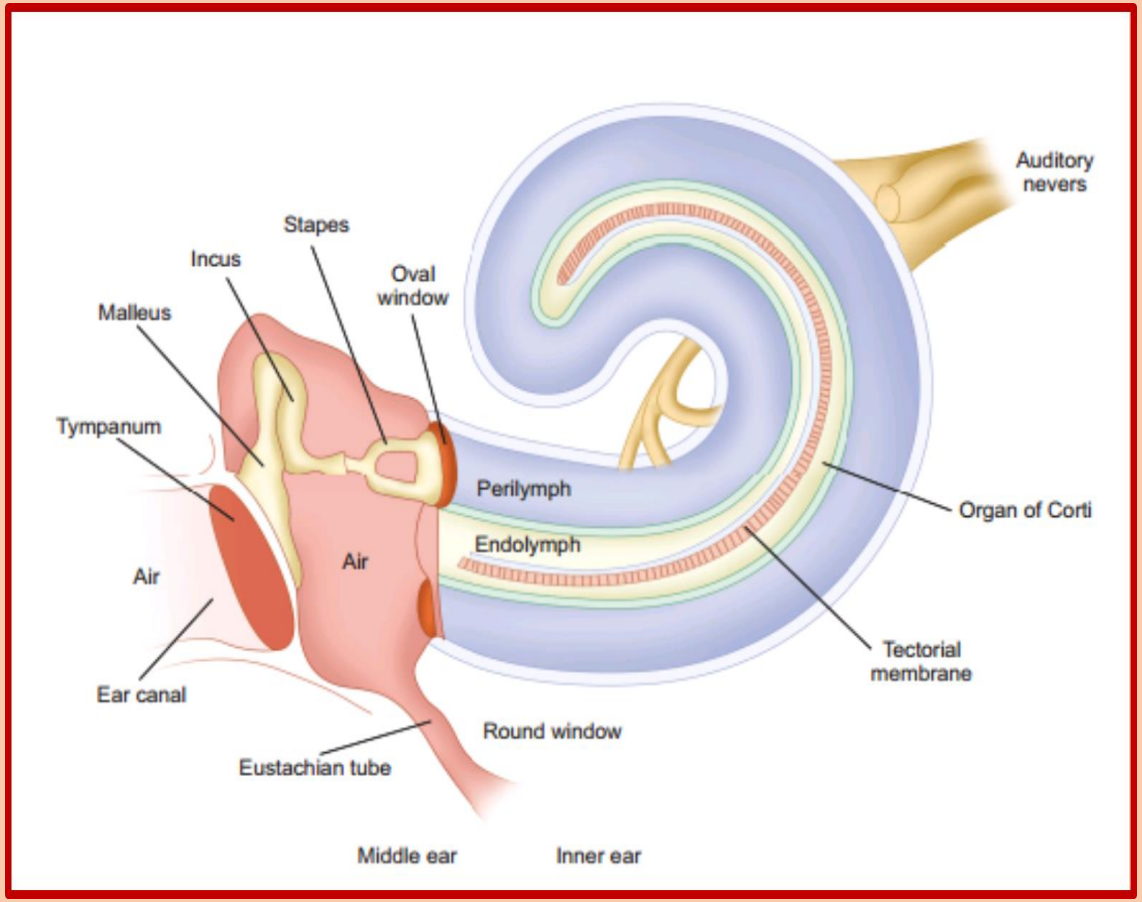
- ✓ The external ear consists of pinna, external auditory meatus and ear drum.
- ✓ The pinna is flap of elastic cartilage covered by skin.
- ✓ It collects the sound waves.
- ✓ The external auditory meatus is a curved tube that extends up to the tympanic membrane [the ear drum].
- ✓ The tympanic membrane is composed of connective tissues covered with skin outside and with mucus membrane inside.
- ✓ There are very fine hairs and wax producing sebaceous glands called ceruminous glands in the external auditory meatus.
- ✓ The combination of hair and the ear wax [cerumen] helps in preventing dust and foreign particles from entering the ear.

PHONOORECEPTOR – MIDDLE EAR



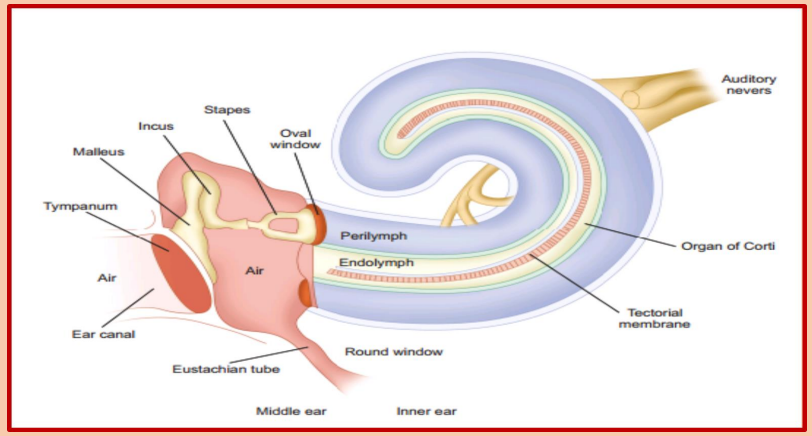
- ✓ The middle ear is a small air-filled cavity in the temporal bone.
- ✓ It is separated from the external ear by the eardrum and from the internal ear by a thin bony partition.
- ✓ The bony partition contains two small membrane covererd openings called the oval window and the round window.
- ✓ The middle ear contains three ossicles.
  1. Malleus – hammer bone
  2. Incus – anvil bone
  3. Stapes – stirrup bone
- ✓ These bones are attached to one another.

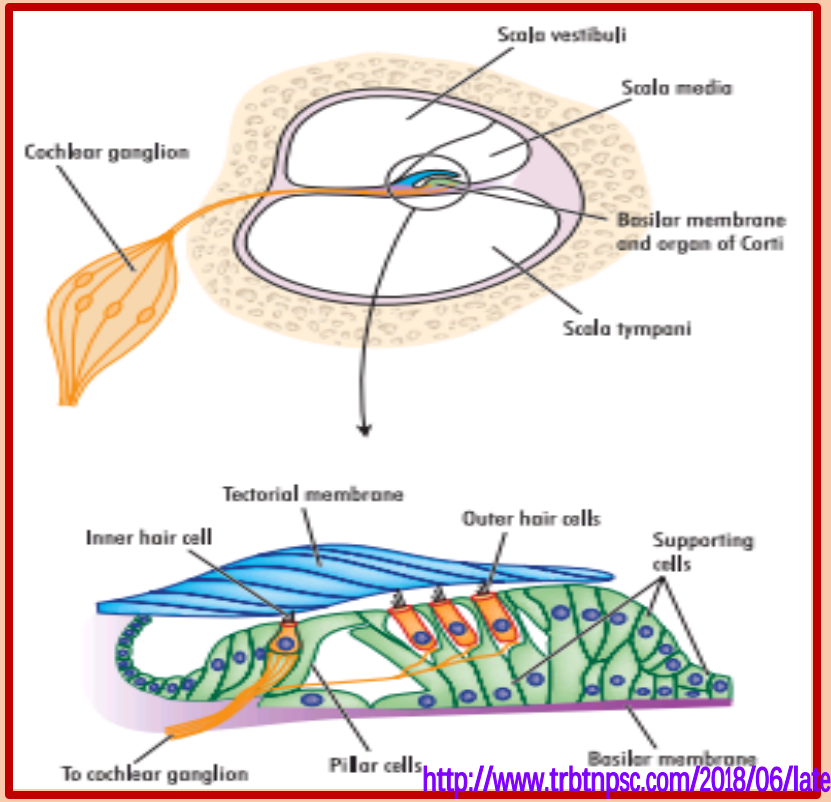
PHONOORECEPTOR – MIDDLE EAR



- ✓ The malleus is attached to the tympanic membrane and its head articulates with the incus which is the intermediate bone lying between the malleus and stapes.
- ✓ The stapes is attached to the oval window in the inner ear
- ✓ The ear ossicles transmit sound waves to the inner ear.
- ✓ A tube called Eustachian tube connects the middle ear cavity with the pharynx.
- ✓ This tube helps in equalizing the pressure of air on either sides of the ear drum.

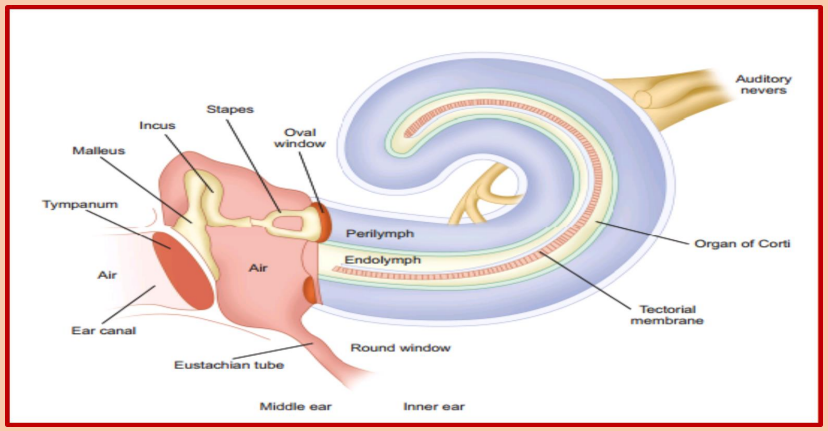
PHONOORECEPTOR – INNER EAR

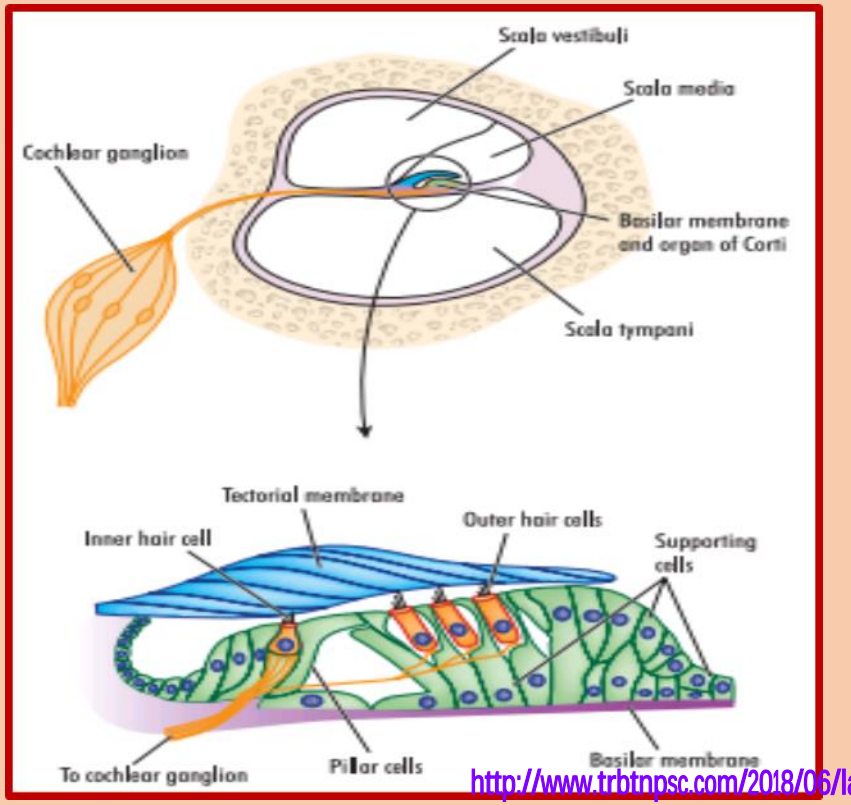




- ✓ Inner ear is the fluid filled cavity consisting of two parts, the bony labyrinth and the membranous labyrinths.
- ✓ The bony labyrinth consists of three areas.
  1. Cochlea
  2. Vestibule
  3. Semicircular canals.
- ✓ The cochlea is coiled portion consisting of 3 chambers namely
  1. Scala vestibulai – filled with perilymph
  2. Scala tympani – filled with perilymph
  3. Scala media – filled with endolymph

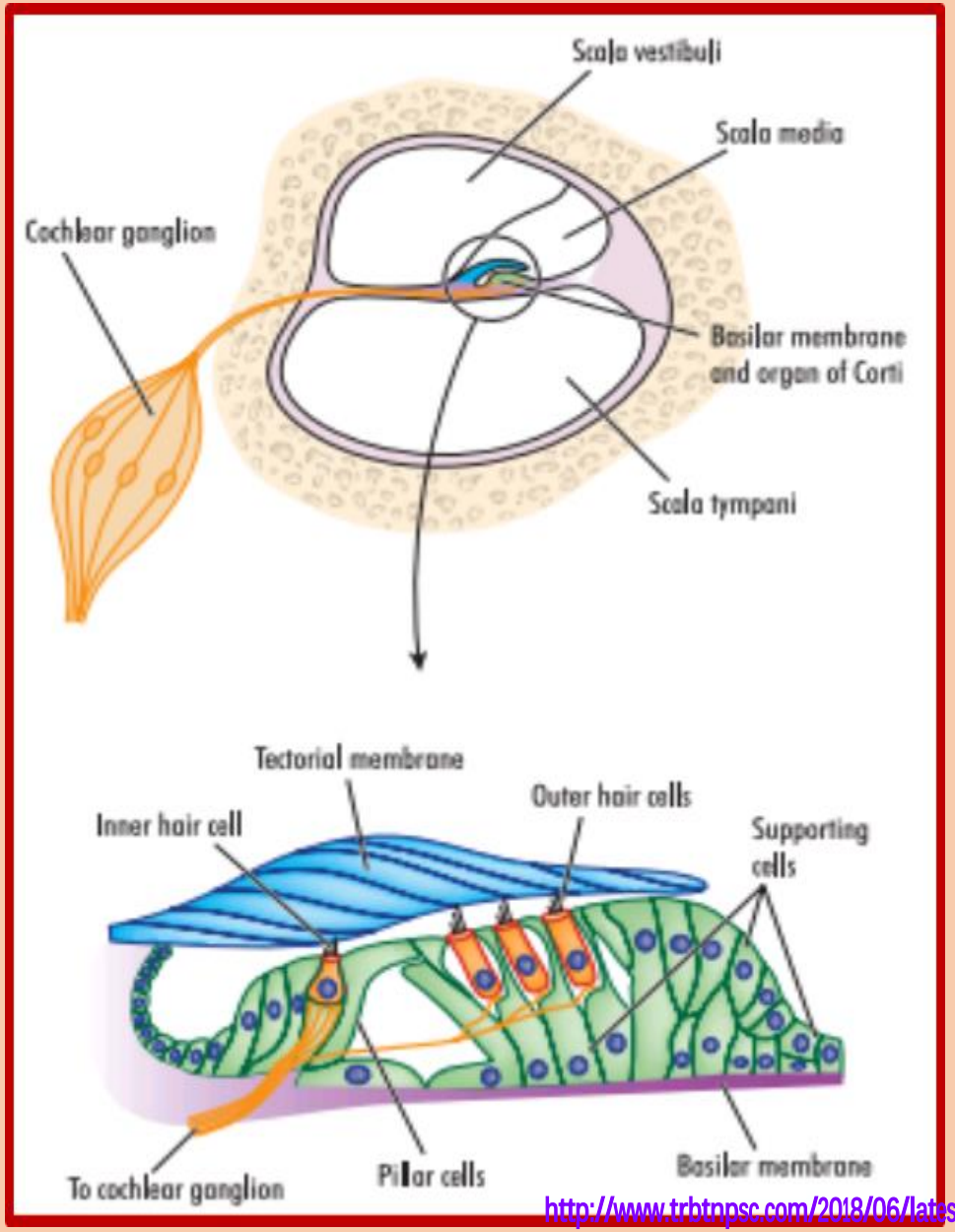
PHONOORECEPTOR – INNER EAR





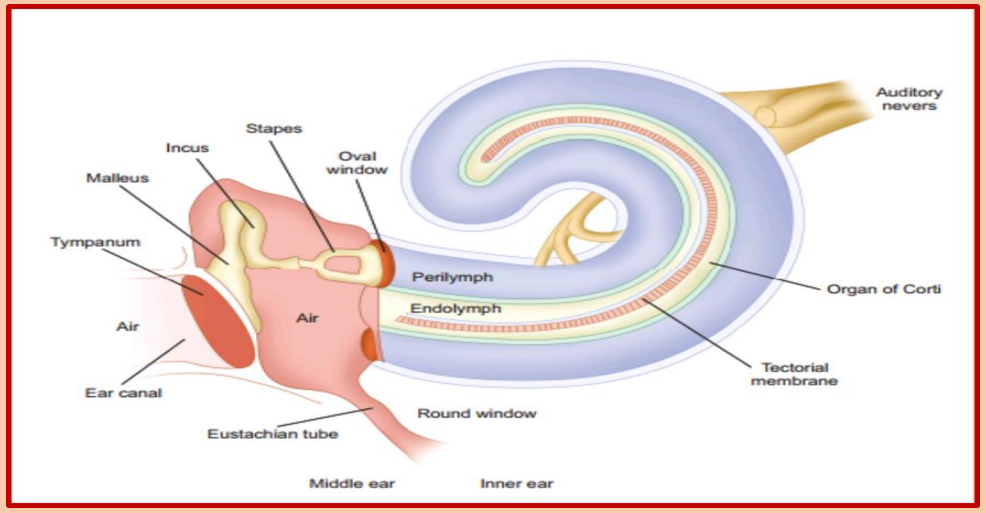
- ✓ At the base of the cochlea, the scala vestibule ends at the oval window.
- ✓ Where as the scala tympani ends at the round window of the middle ear.
- ✓ The chambers scala vestibulai and scala media are separated by a membrane called reisner's membrane.
- ✓ Where as the scala media and scala tympani are separated by a membrane called Basilar membrane.

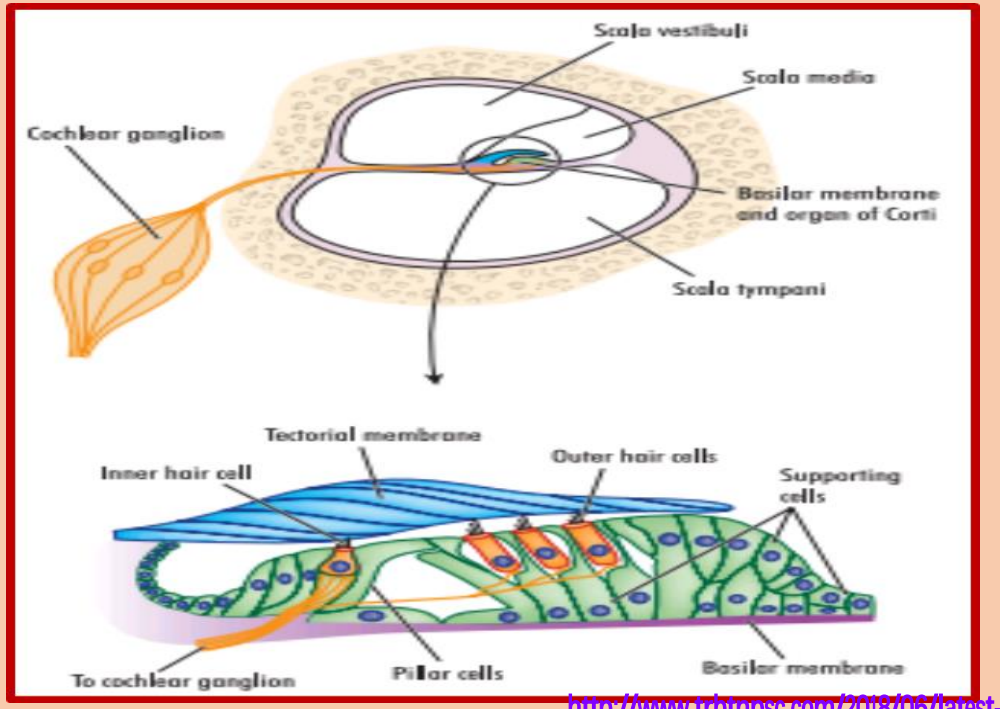
ORGAN OF CORTI



- ✓ The organ of corti is a sensory ridge located on the top of the Basilar membrane.
- ✓ It contains numerous hair cells that are arranged in four rows along the length of the basilar membrane.
- ✓ Protruding from the apical part of each hair cell is hair like structures known as stereocilia.
- ✓ During the conduction of sound wave, stereocilia makes a contact with the stiff gel membrane called tectorial membrane, a roof like structure overhanging the organ of corti throught its length.

MECHANISM OF HEARING



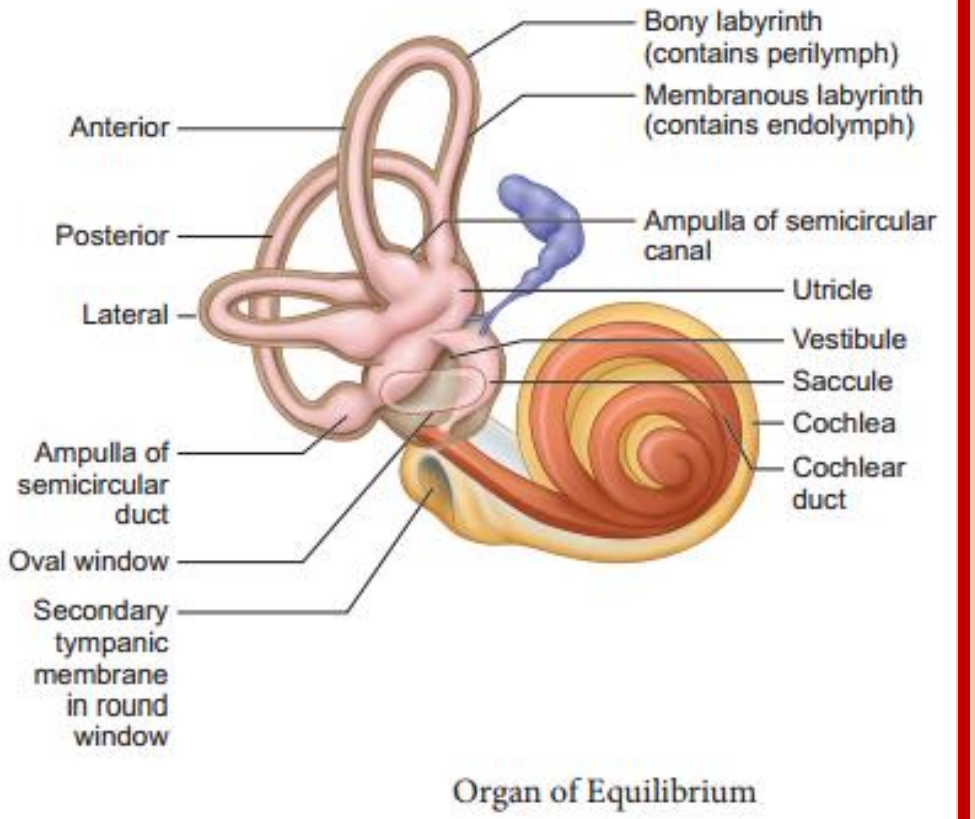


- ✓ Sound waves entering the external auditory meatus fall on the tympanic membrane.
- ✓ This causes the ear drum to vibrate and these vibrations are transmitted to the oval window through the three auditory ossicles.
- ✓ Since the tympanic membrane is 17-20 times larger than the oval window the pressure exerted on the oval window is about 20 times more than that on the tympanic membrane.
- ✓ This increased pressure generates pressure waves in the fluid of perilymph.
- ✓ This pressure causes the round window to alternately bulge outward and inward meanwhile the basilar membrane along with the organ of Corti move up and down.
- ✓ These movements of the hair alternately open and close the mechanically gated ion channels in the base of hair cells and the action potential is propagated to the brain as sound sensation through cochlear nerve.

DEFECTS OF EAR

- Deafness may be temporary or permanent.
- It can be further classified into
    1. Conductive deafness
    2. Sensory-neural deafness.
- Possible causes for conductive deafness may be due to
    i. the blockage of ear canal with earwax,
    ii. Rupture of eardrum
    iii. Middle ear infection with fluid accumulation
    iv. Restriction of ossicular movement.
- In sensory-neural deafness, the defect may be in the organ of Corti or the auditory nerve or in the ascending auditory pathways or auditory cortex.

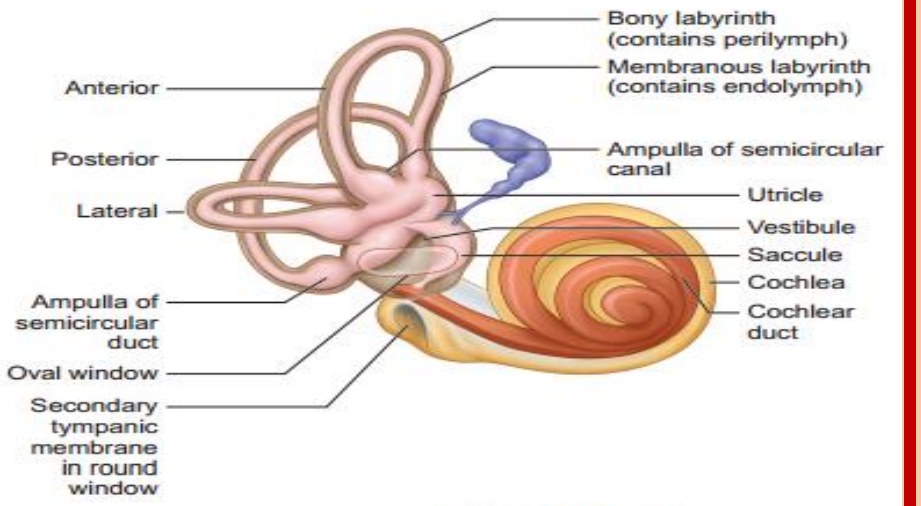
ORGAN OF EQUILIBRIUM



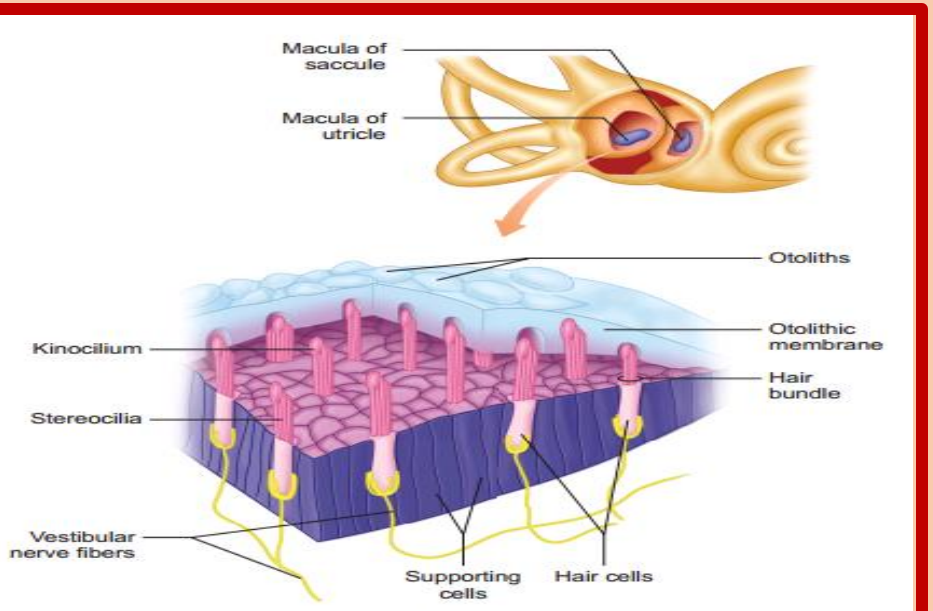
Organ of Equilibrium

- ✓ Balance is part of a sense called proprioception, which is the ability to sense the position, orientation and movement of the body.
- ✓ The organ of balance is known as the vestibular system which is located in the inner ear next to the cochlea.
- ✓ The vestibular system is composed of a series of fluid filled sacs and tubules.
- ✓ These sacs and tubules contain endolymph and are kept in the surrounding perilymph.
- ✓ These two fluids, perilymph and endolymph, respond to the mechanical forces, during changes occurring in body position and acceleration.

ORGAN OF EQUILIBRIUM



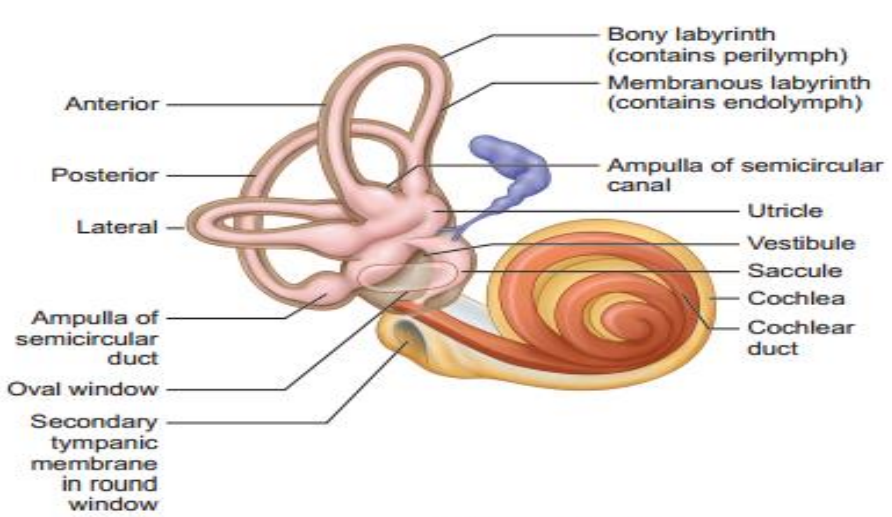
Organ of Equilibrium



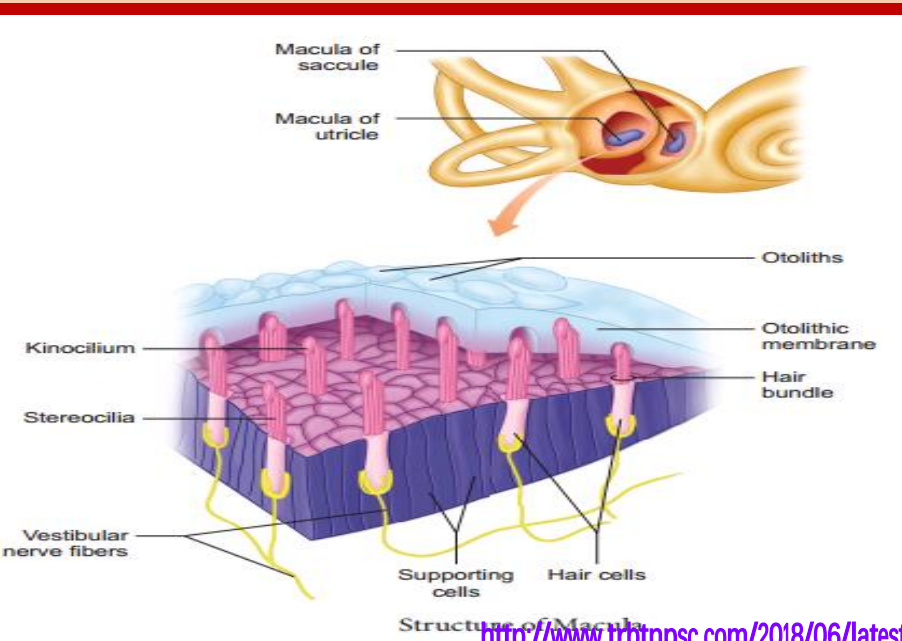
Structure of Macula

- ✓ The utricle and saccule are two membranous sacs, found nearest the cochlea and contain equilibrium receptor regions called maculae that are involved in detecting the linear movement of the head.
- ✓ The maculae contain the hair cells that act as mechanorecptors.
- ✓ These hair cells are embeded in a gelatinous otolithic membrane that contains small calcareous particles called otoliths.
- ✓ This membrane adds weight to the top of the hair cells and increase the inertia.
- ✓ The canals that lie posterior and lateral to the vestibule are semicircular canals, they are anterior, posterior and lateral canals oriented at right angles to each other.
- ✓ At one end of each semicircular canal, at its lower end has a swollen area called ampulla.
- ✓ Each ampulla has a sensory area known as crista ampullaris which is formed of sensory hair cells and supporting cells.
- ✓ The function of these canals is to detect rotational movement of the head.

ORGAN OF EQUILIBRIUM



Organ of Equilibrium



Structure of Macula

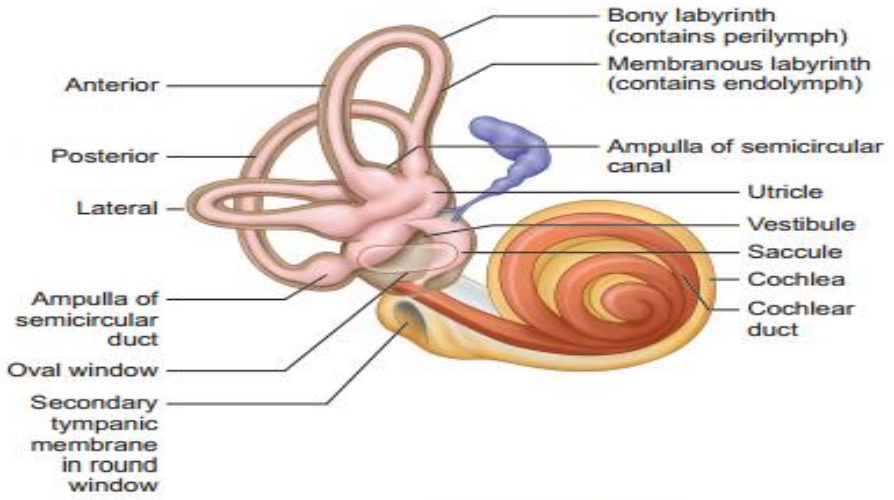
Name the parts of the organ of equilibrium involved in the following functions.

a) Linear movement of the body

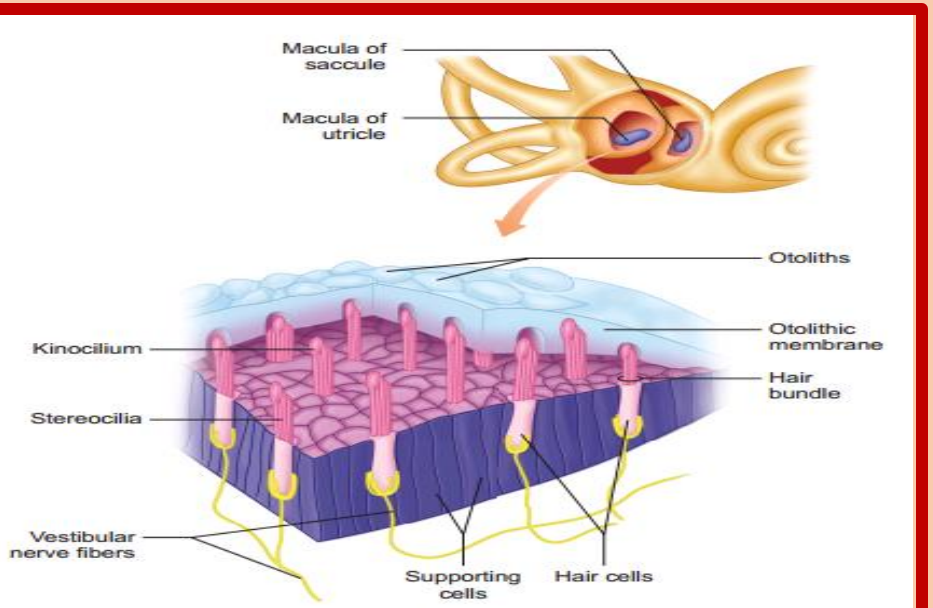
b) Changes in the body position

c) Rotational movement of the head.

ORGAN OF EQUILIBRIUM



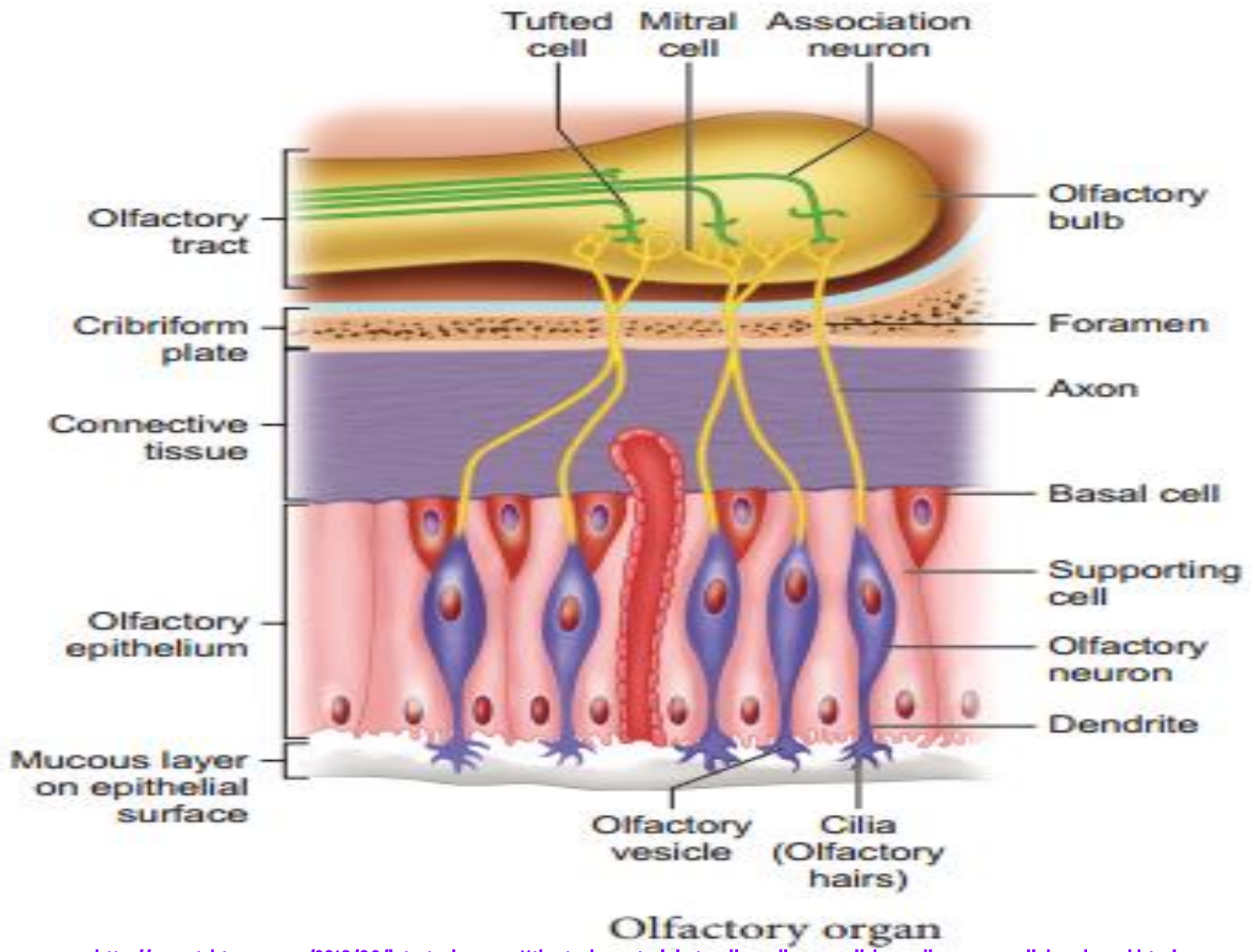
Organ of Equilibrium



Structure of Macula

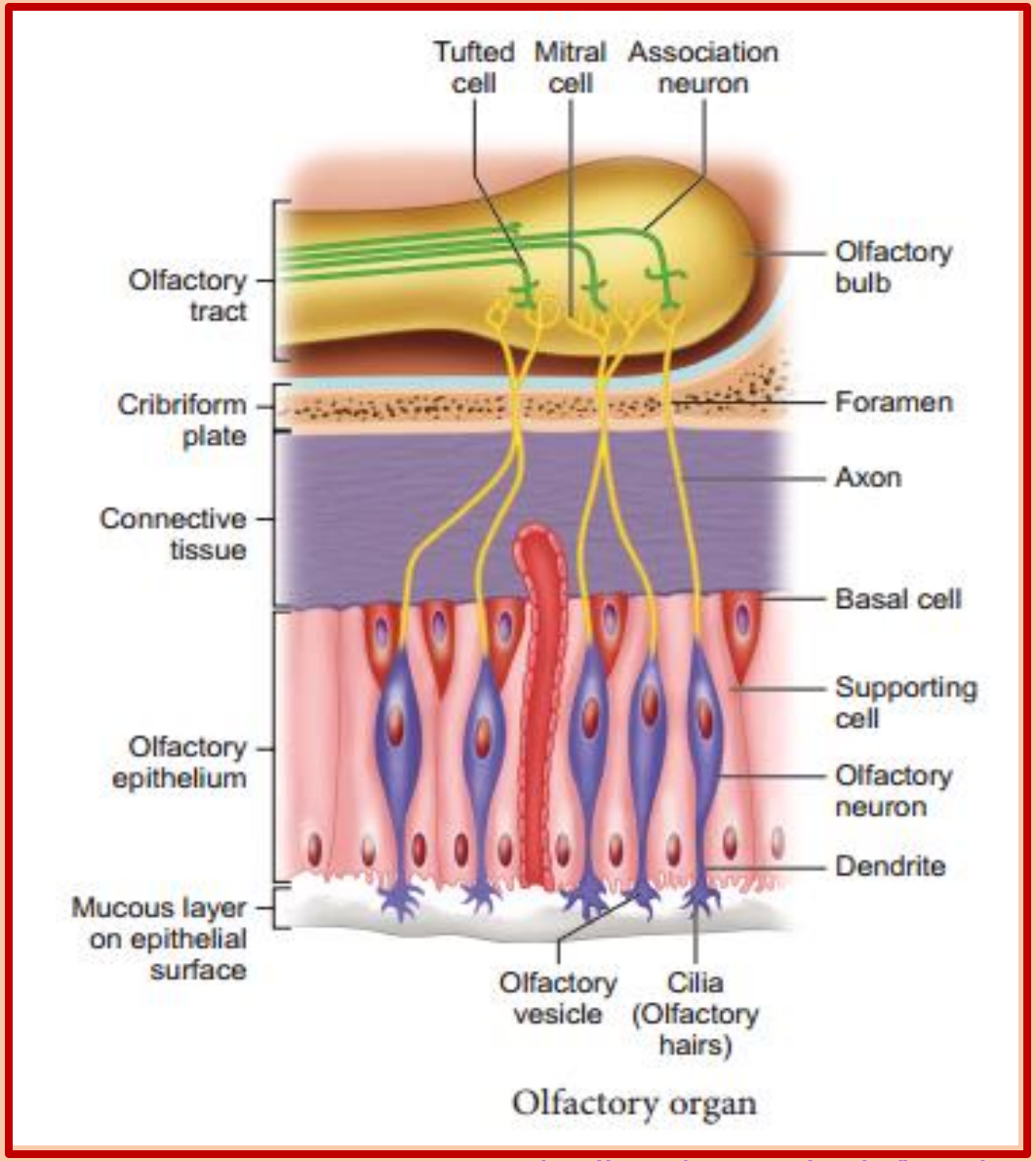
The intensity of sound is measured in decibels (dB). 0 dB is the threshold of hearing for normal ear. Severe hearing loss occurs with frequent or prolonged exposure to sound with intensities greater than 90dB. For meaningful conversations the intensity should be in the 50 dB range.

OLFACTORY RECEPTORS



Olfactory organ

OLFACTORY RECEPTORS

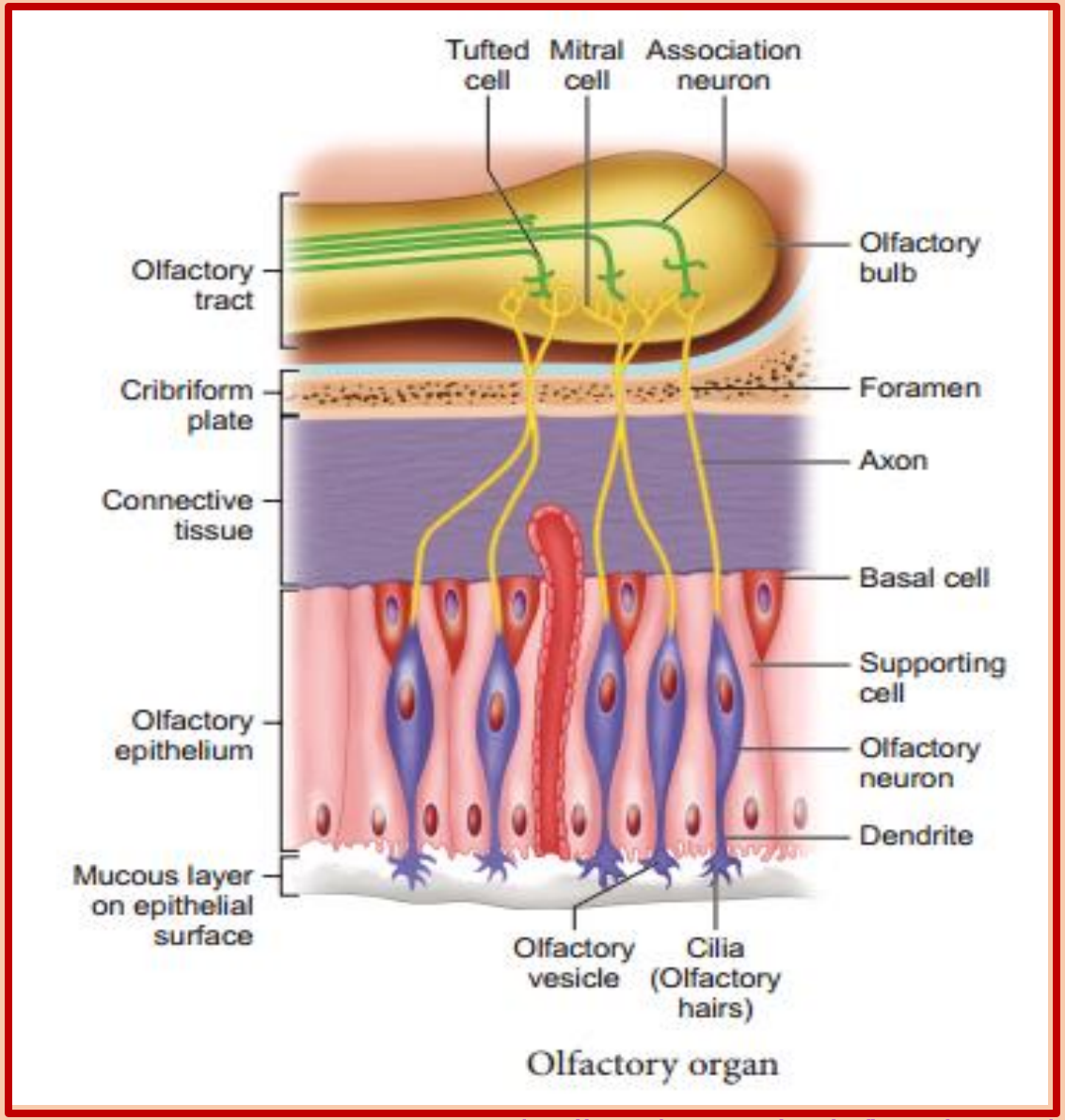


Olfactory organ

- ✓ The receptors for taste and smell are the chemoreceptors.
- ✓ The smell receptors are excited by air borne chemicals that dissolve in fluids.
- ✓ The yellow coloured patches of olfactory epithelium form the olfactory organs that are located on the roof of the nasal cavity.
- ✓ The olfactory epithelium is covered by a thin coat of mucus layer below and olfactory glands bounded connective tissues, above.
- ✓ It contains three types of cells

1. Supporting cells
2. Basal cells
3. Millions of pin shaped olfactory receptor cells (whichare unusualbipolar cells).

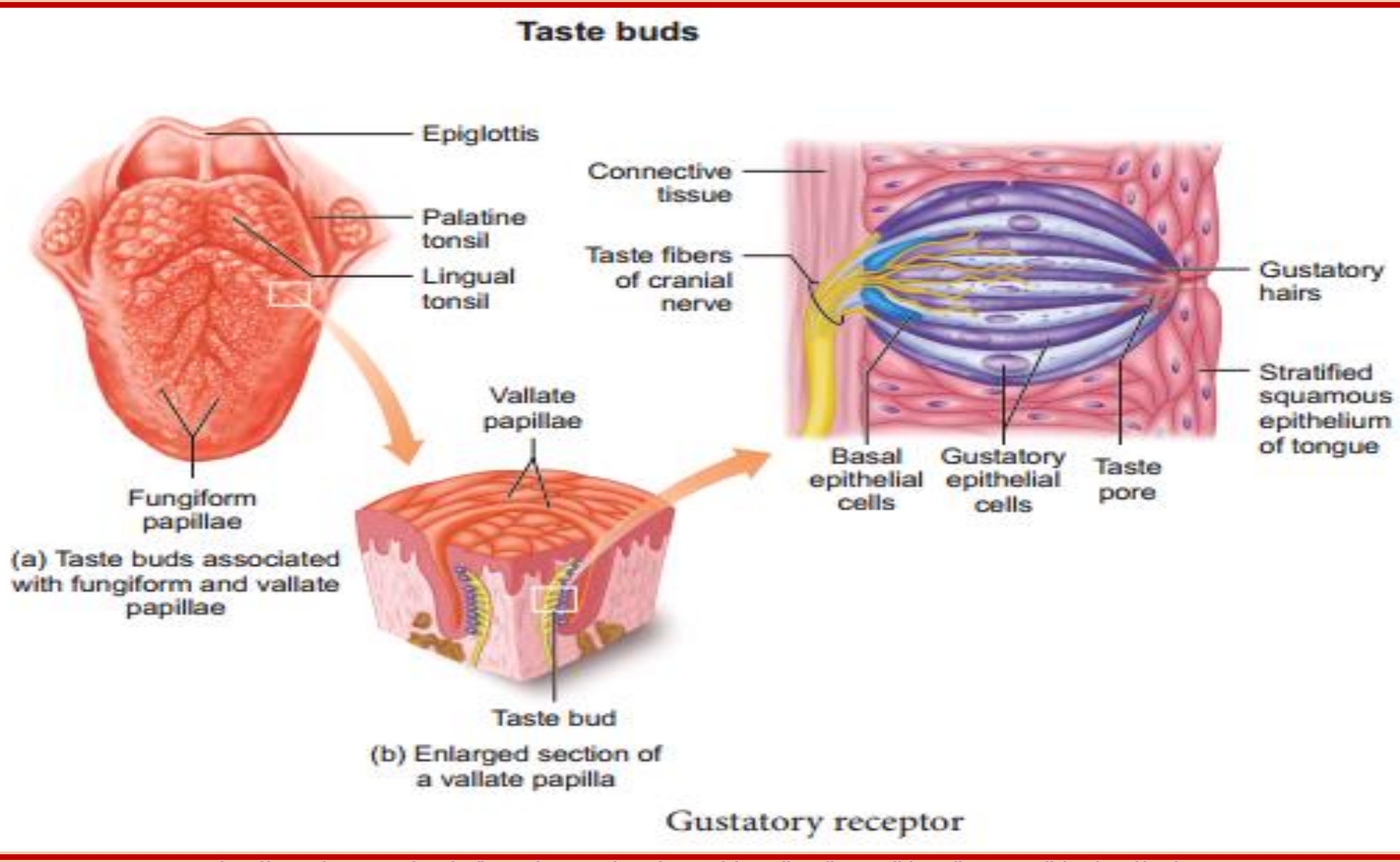
OLFACTORY RECEPTORS



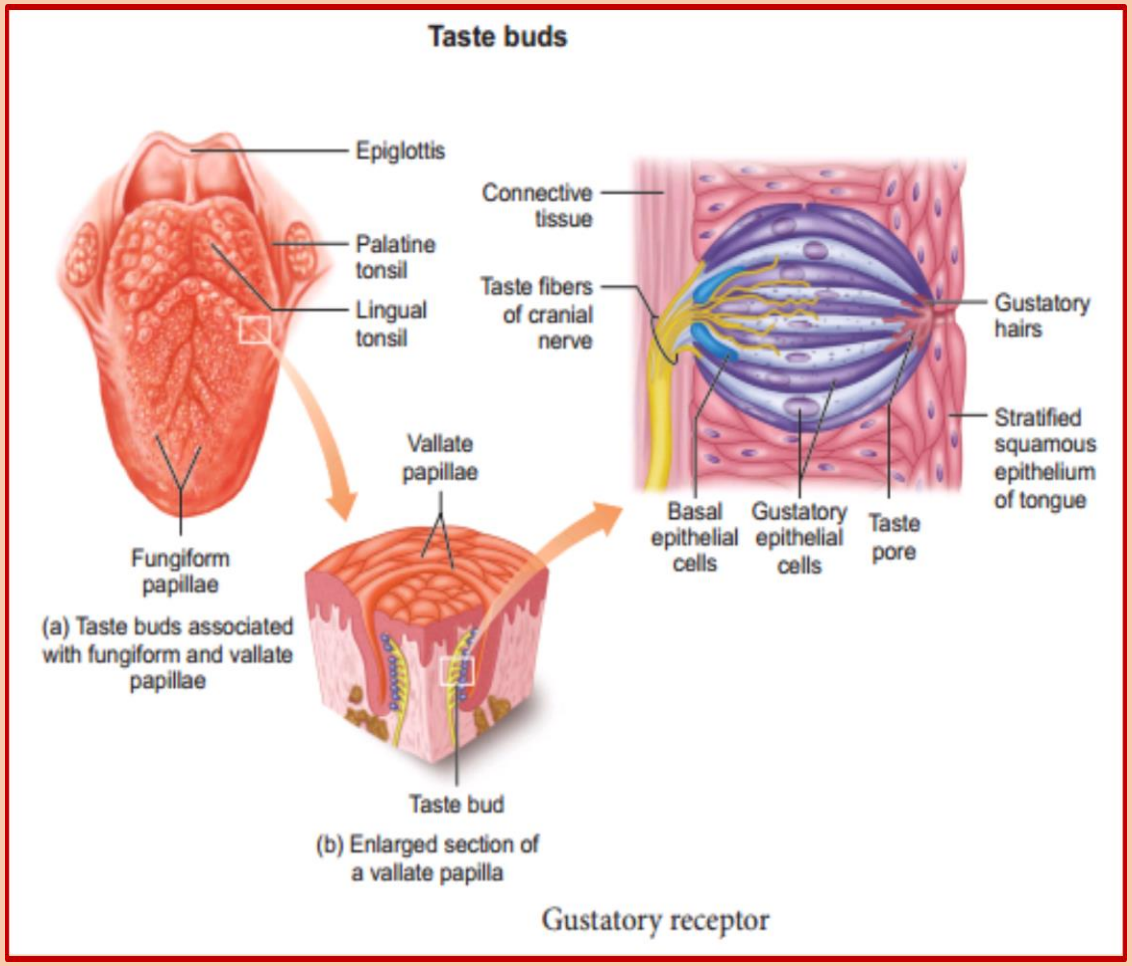
Olfactory organ

- ✓ The olfactory glands and the supporting cells secrete the mucus.
- ✓ The unmyelinated axons of the olfactory receptor cells are gathered to form the filaments of olfactory nerve [cranial nerve I] which synapse with cells of olfactory bulb.
- ✓ The impulse, through the olfactory nerves, is transmitted to the frontal lobe of the brain for identification of smell and the limbic system for the emotional responses to odour.

GUSTATORY RECEPTORS

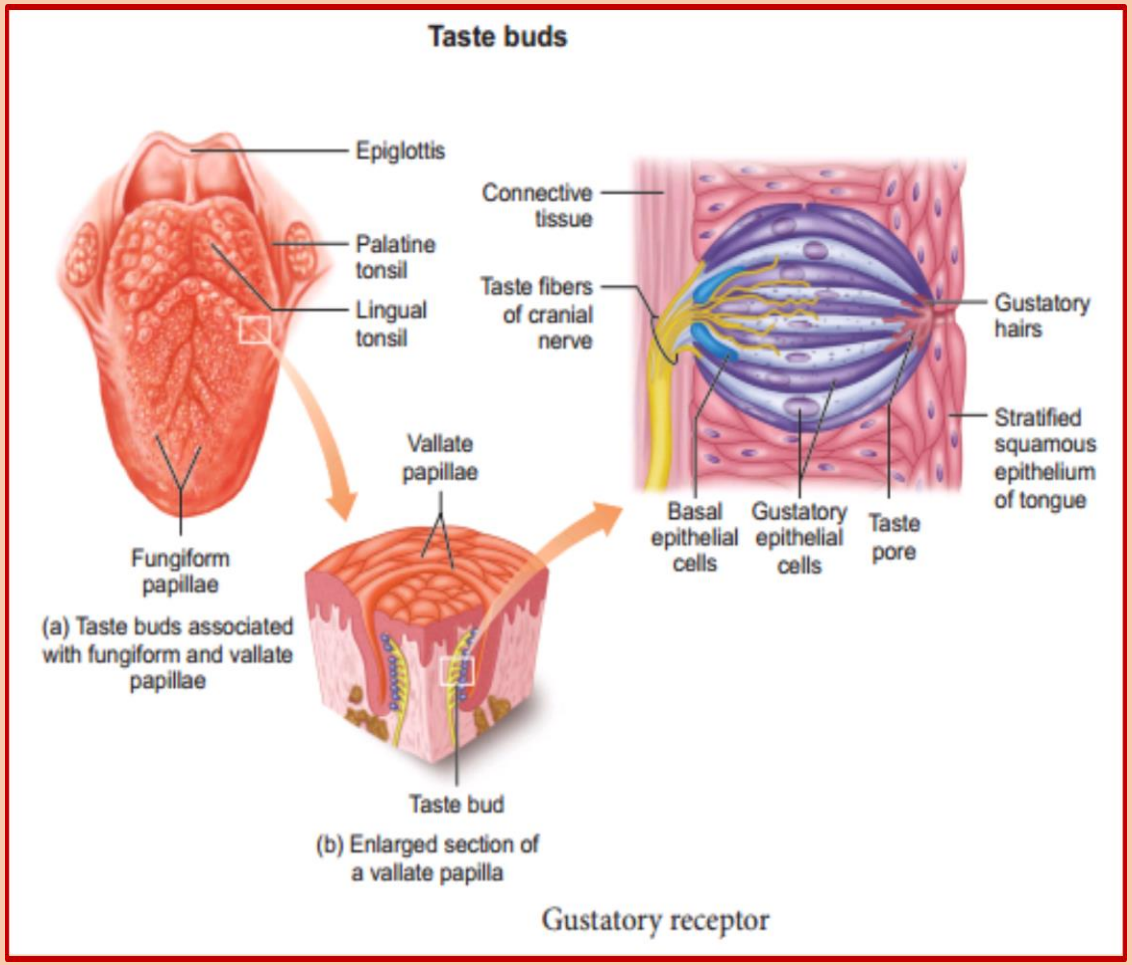


GUSTATORY RECEPTORS



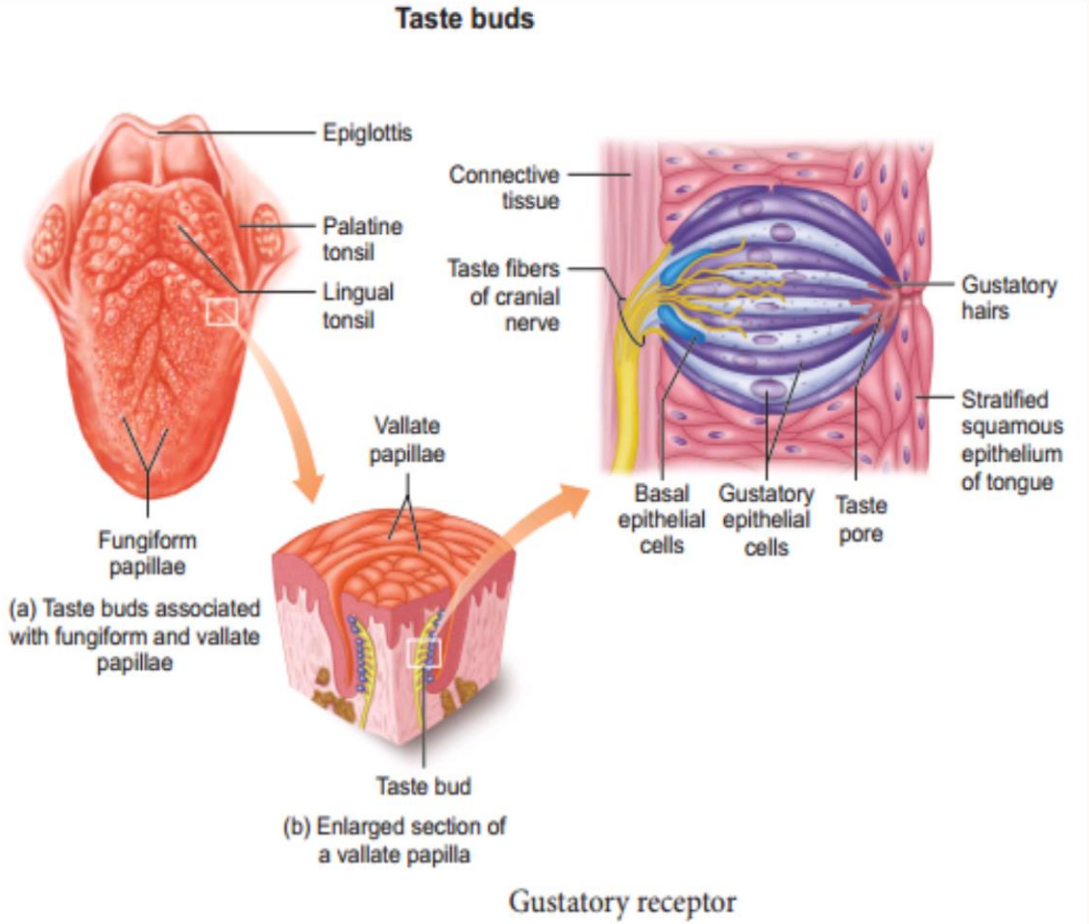
- ✓ The sense of taste is considered to be the most pleasurable of all senses.
- ✓ The tongue is provided with many small projections called papillae which give the tongue an abrasive feel.
- ✓ Taste buds are located mainly on the papillae which are scattered over the entire tongue surface.
- ✓ Most taste buds are seen on the tongue few are scattered on the soft palate, inner surface of the cheeks, pharynx and epiglottis of the larynx.

GUSTATORY RECEPTORS



- ✓ Taste buds are flask-shaped and consist of 50 – 100 epithelial cells of two major types.
  1. Gustatory epithelial cells (taste cells)
  2. Basal epithelial cells (Repairing cells)
- ✓ Long microvilli called gustatory hairs project from the tip of the gustatory cells and extends through a taste pore to the surface of the epithelium where they are bathed by saliva.
- ✓ Gustatory hairs are the sensitive portion of the gustatory cells and they have sensory dendrites which send the signal to the brain.
- ✓ The basal cells that act as stem cells, divide and differentiate into new gustatory cells.

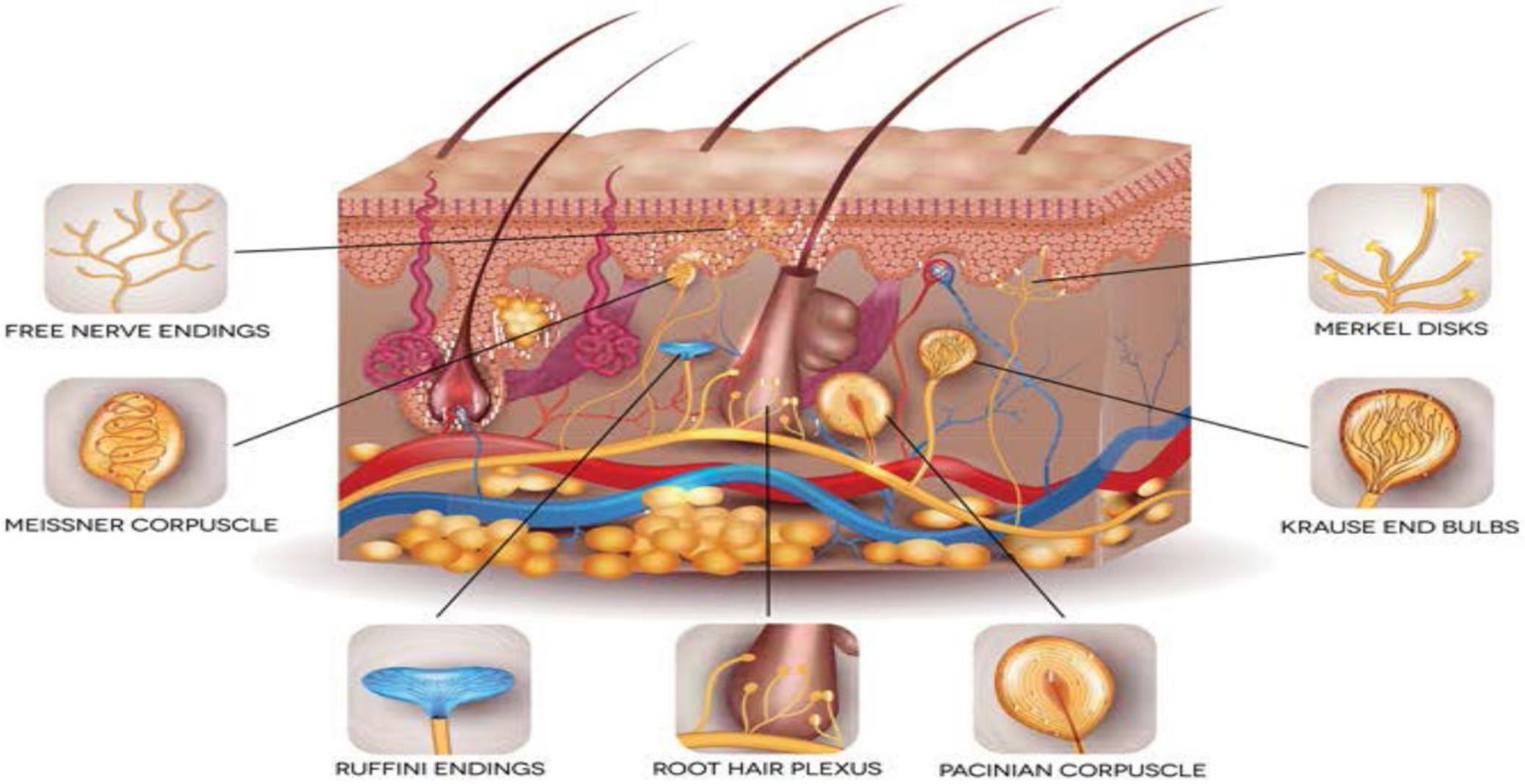
GUSTATORY RECEPTORS



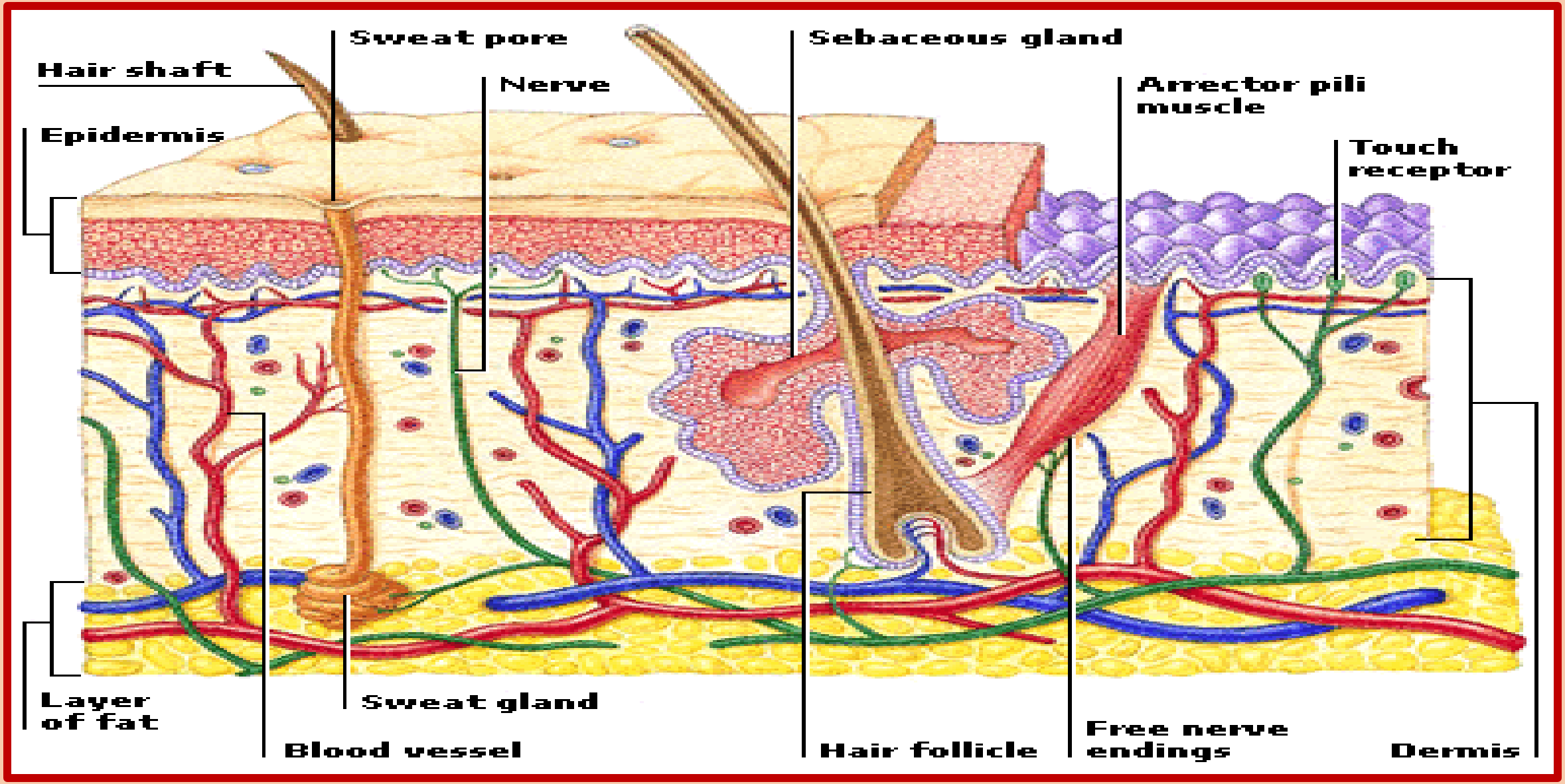
Gustatory receptor

The taste bud cells are subjected to huge amounts of friction, because of their location and are routinely burned by hot foods. These are the most dynamic cells in the body and are replaced every seven to ten days.

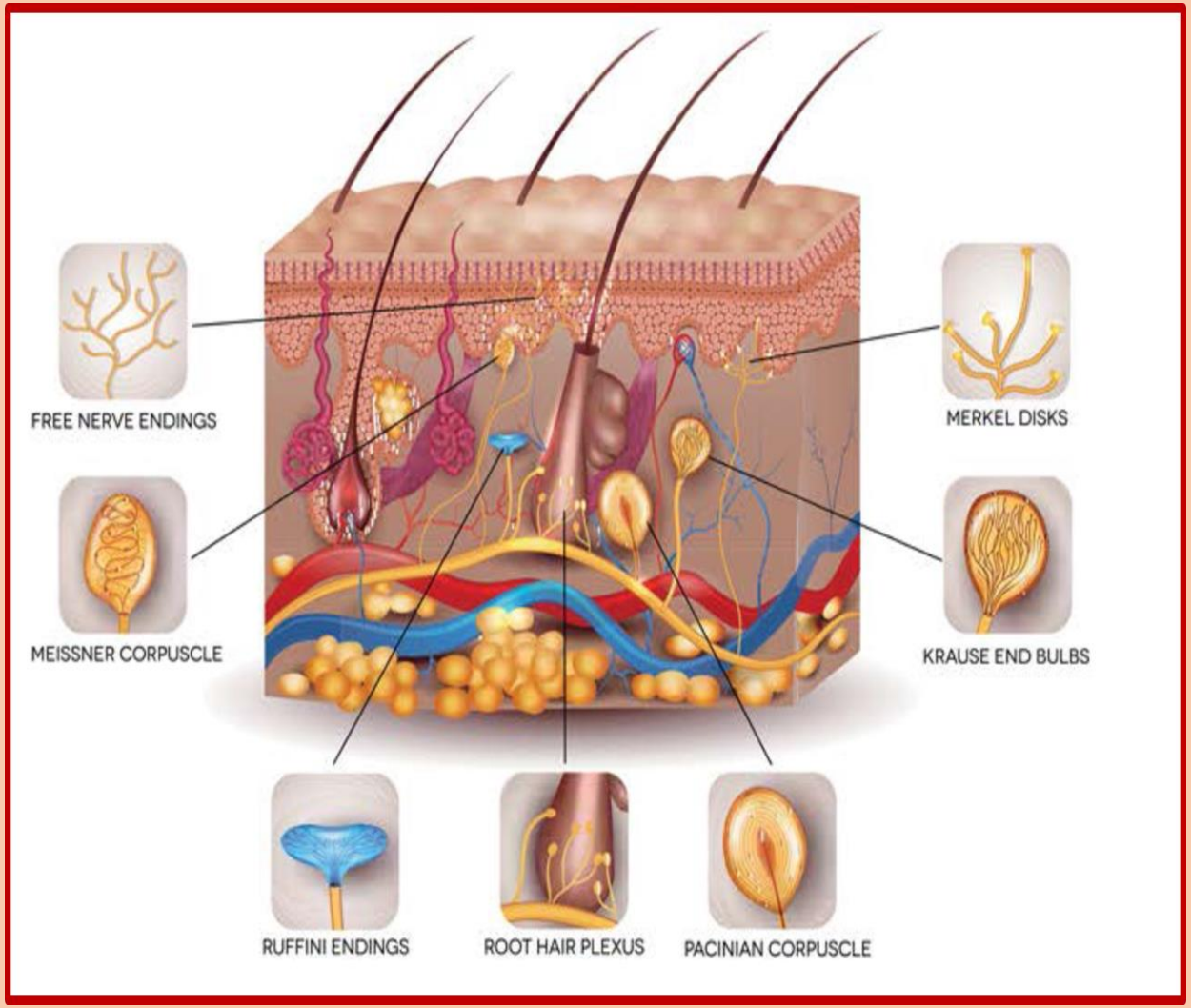
SKIN RECEPTORS



SKIN RECEPTORS



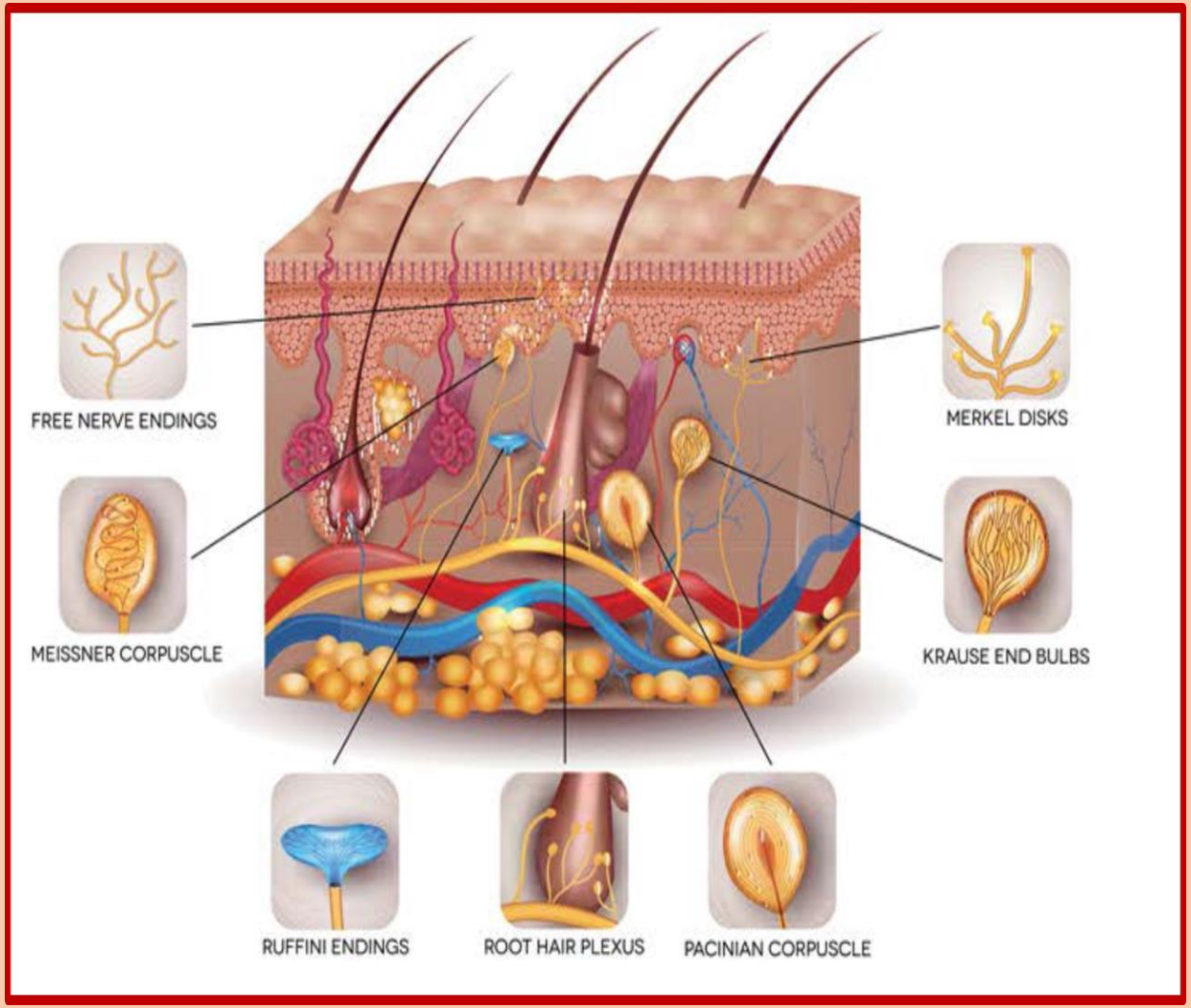
SKIN RECEPTORS



- ✓ Skin is the sensory organ of touch and is also the largest sense organ.
- ✓ This sensation comes from millions of microscopic sensory receptors located all over the skin and associated with the general sensations of contact, pressure, heat, cold and pain.
- ✓ Some parts of the body, such as the finger tips have a large number of these receptors, making them more sensitive.
- ✓ Some of the sensory receptors present in the skin are

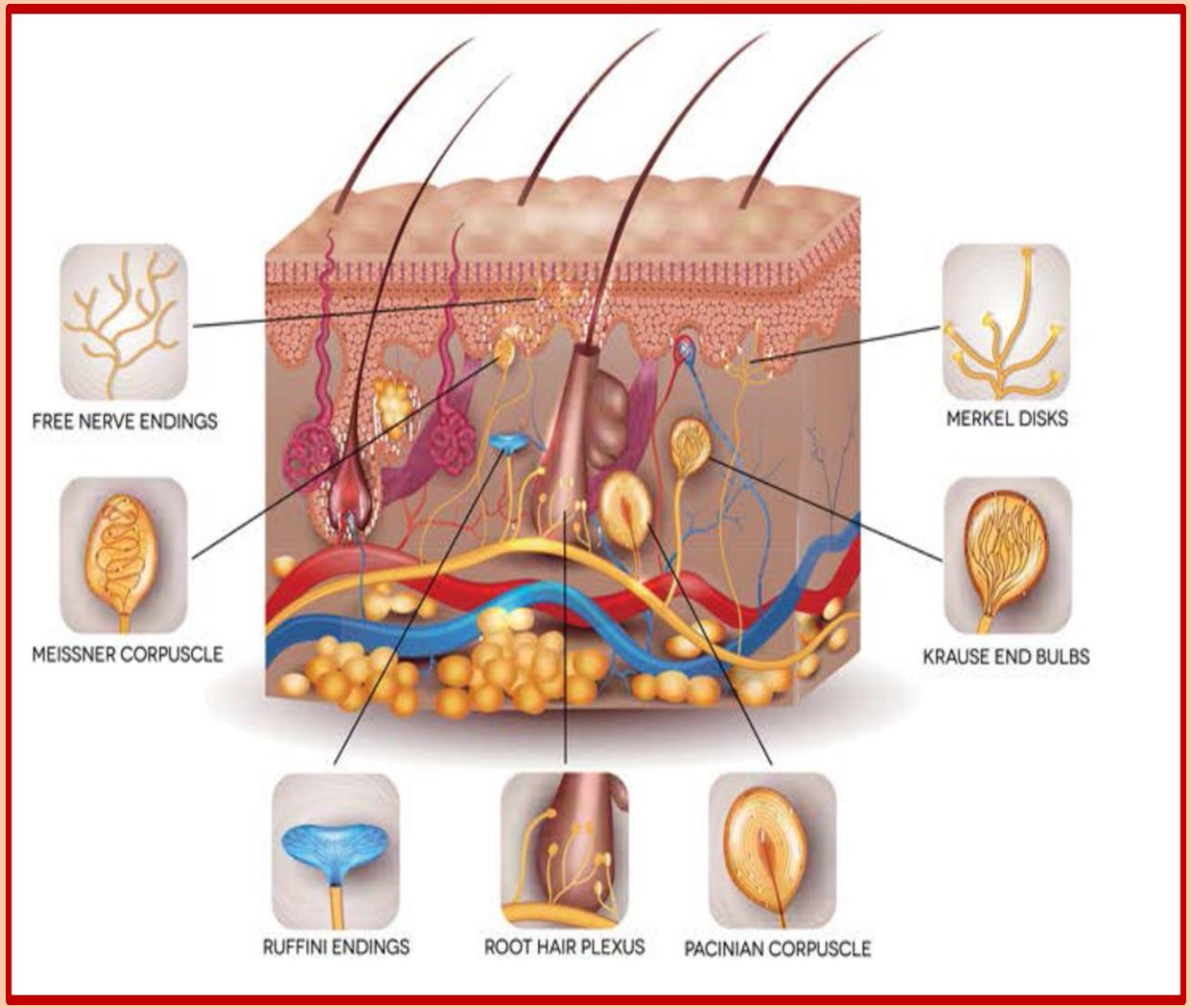
1. Tactile merkel disc
2. Hair follicle receptors
3. Meissner's corpuscles
4. Pacinian corpuscles
5. Ruffini endings
6. Krause end bulbs

SKIN RECEPTORS



- ✓ **Tactile merkel disk** is light touch receptor lying in the deeper layer of epidermis.
- ✓ **Hair follicle receptors** are light touch receptors lying around the hair follicles.
- ✓ **Meissner's corpuscles** are small light pressure receptors found just beneath the epidermis in the dermal paoillae. They are numerous in hairless skin areas such as finger tips and soles of the tips.

SKIN RECEPTORS



- ✓ **Pacinian corpuscles** are the large egg shaped receptors found scattered deep in the dermis and monitoring vibration due to pressure. It allows to detect different textures, temperature, hardness and pain.
- ✓ **Ruffini endings** which lie in the dermis responds to continuous pressure.
- ✓ **Krause end bulps** are thermoreceptors that sense temperature.

SKIN

Melanocytes are the cells responsible for producing the skin pigment, melanin, which gives skin its colour and protects it from the sun's UV rays. Vitiligo (Leucoderma) is a condition in which the melanin pigment is lost from areas of the skin, causing white patches, often with no clear cause. Vitiligo is not contagious. It can affect people of any age, gender, or ethnic group. The patches appear when melanocytes fails to synthesis melanin pigment.

நன்றி வணக்கம்

பா.சீனிவாசன்

முதுகலை விலங்கியல் ஆசிரியர்

நடராசன் தமயந்தி மேல் நிலைப் பள்ளி

நாகப்பட்டினம்

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