The Nervous System

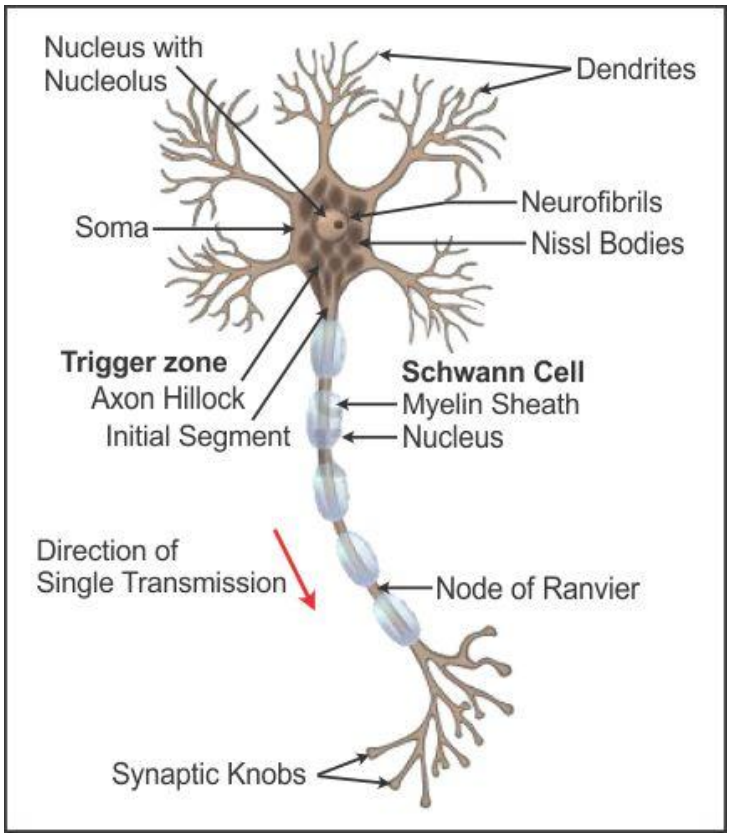
Our nervous system consists of the brain, spinal cord, sense receptors and nerves.

Functions of the Nervous System

- Keeps us informed about the outside world through sensory organs.
- Controls and harmonises all voluntary muscular activities, e.g. running and writing.
- Enables us to remember, think and reason.

Neuron: The Unit of the Nervous System

Structure of the Neuron



The three main parts of the neuron are as follows:

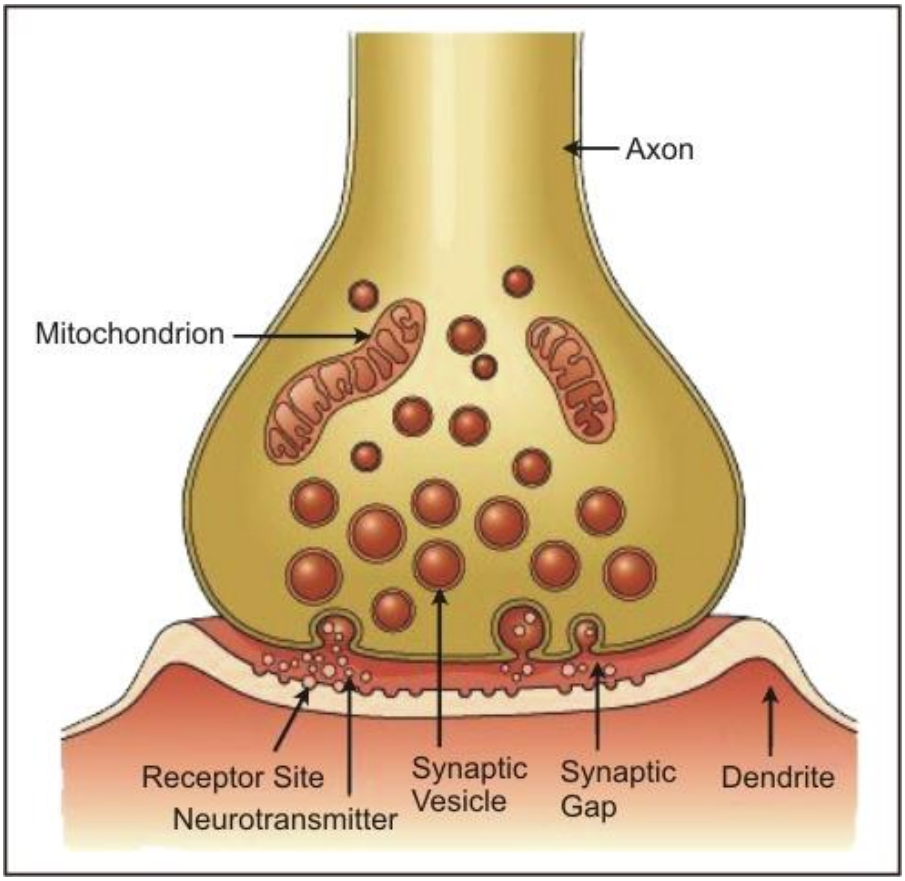
- Cell Body: It has a well-defined nucleus and granular cytoplasm.
- Dendrites: They are the branched cytoplasmic projections of the cell body.
- Axon:
  - It is a long process of the cell body.
  - The axon is covered by a myelin sheath.
  - The myelin sheath shows gaps throughout its length known as **Nodes of Ranvier**.

Some Basic Terms

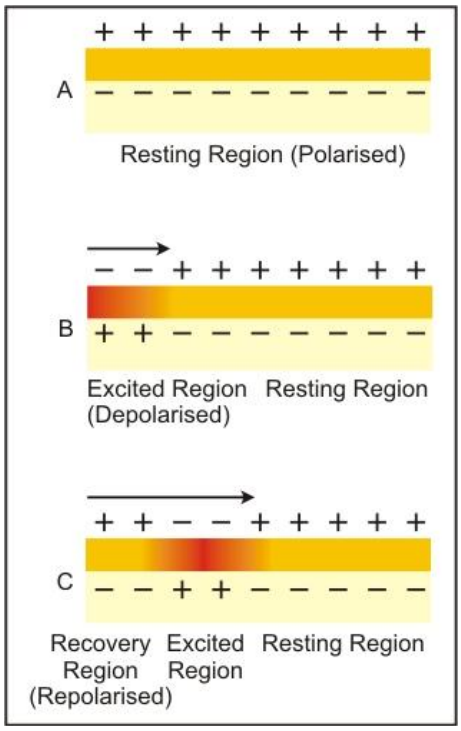
Stimulus: An agent or sudden changes of the external or internal environment which results in a change in an organism or any of its body parts.
Response: The change in organisms resulting from a stimulus.
Impulse: A wave of irritability, i.e. an electrical disturbance, which sweeps over the nerve cell.
Receptors: The nerve cells which set up waves of impulses towards the central nervous system on receiving the stimulus.
Effectors: Muscles or glands which contract or secrete substances on receiving an impulse from the brain or the spinal cord.

Synapse

- A **synapse** is the point of contact between the terminal branches of the axon of a neuron and the dendrites of another neuron.
- As the nerve impulse reaches the axon terminal of one neuron, the neurotransmitter **acetylcholine** is released by the bulbs present in the axon.
- Acetylcholine is then broken down by an enzyme to ensure that the synapse is ready for the transmission of the next nerve impulse.



Transmission of Nerve Impulse



In the **resting condition**, the outer side of the nerve fibre carries a positive charge, i.e. more Na^+ ions outside the axon membrane. This is called the **polarised state** or **polarisation of the nerve fibre**.

On stimulation, the axon membrane at the site of stimulation becomes more permeable to Na^+ ions. Thus, Na^+ ions move inwards and results in loss of polarisation which is known as **depolarised state** or **depolarisation of the nerve fibre**. Such a region of the nerve fibre is known as the **excited region**.

The **point of depolarisation** becomes the stimulus for the next region of the axon membrane which in turn becomes depolarised.

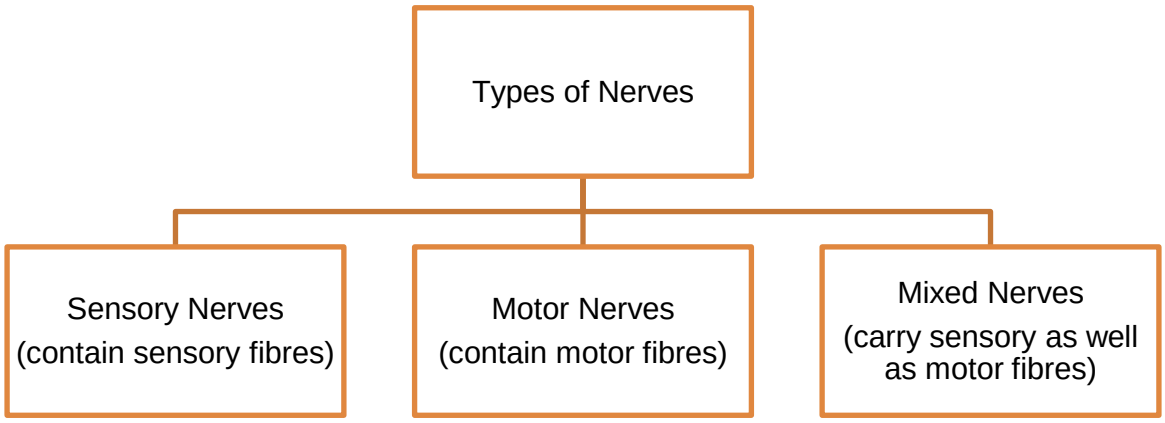
The previous region on the membrane becomes **repolarised** due to the active transport of Na^+ ions to the outside of the membrane.

Types of Neurons

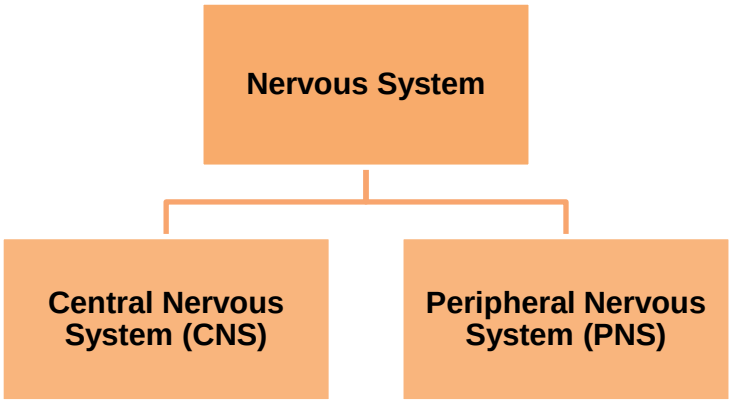
- Sensory Neurons: Convey the impulse from the receptors (sense organs) to the main nervous system (the brain or spinal cord).
- Motor Neurons: Carry impulse from the main nervous system to an effector, i.e. muscle or gland.
- Associated Neurons: They interconnect sensory and motor neurons.

Types of Nerves

A **nerve** is a bundle of nerve fibres (axons) of separate neurons enclosed in a tubular sheath.
Ganglia are an aggregation of the nerve cells (cell bodies) from which the nerve fibres may arise or enter.



Division of the Nervous System



The Central Nervous System

The central nervous system includes the brain and the spinal cord.

The Brain

- The human brain is well protected inside the cranium or the skull.
- In adults, it weighs about 1.35 kg
- It is protected by three meninges—dura mater, arachnoid and pia mater.
- The space between the covering membranes, central spaces of the brain and the central canal of the spinal cord consists of **cerebrospinal fluid** which protects the brain from shocks.

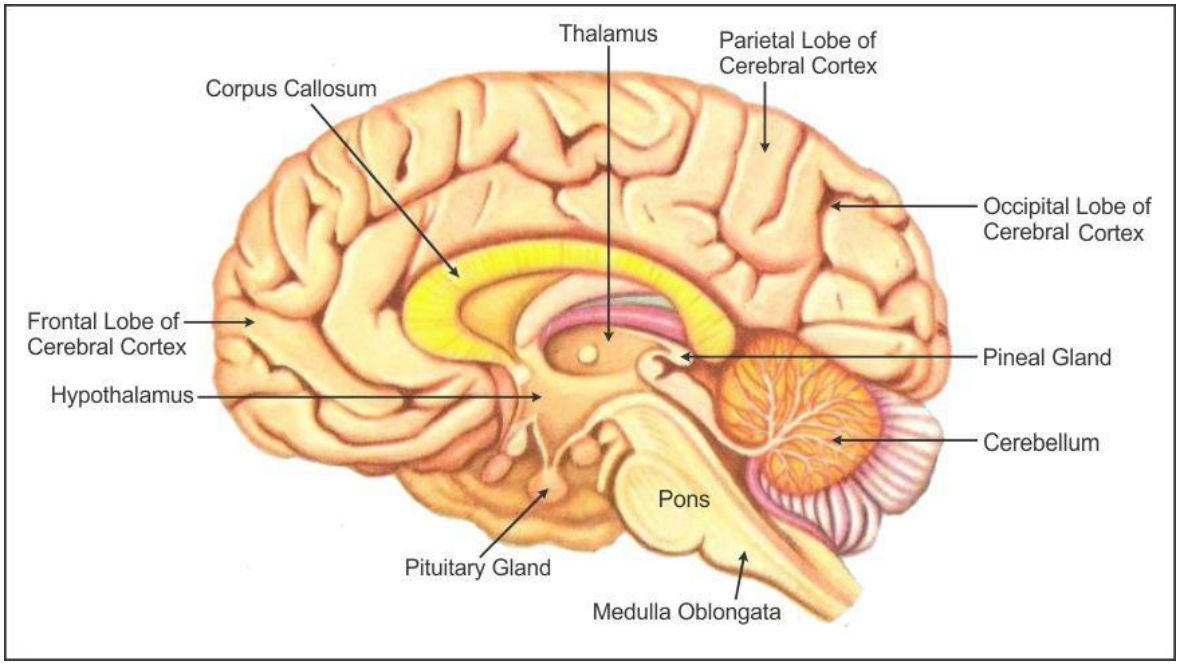
Three Primary Regions of the Brain

- **Forebrain**
  - The cerebrum is the centre of intelligence, memory, consciousness, will power and voluntary actions.
  - The **thalamus** relays pain and pressure impulses to the cerebrum.
  - The **hypothalamus** controls the body temperature and the activity of the pituitary gland.

- **Midbrain**
  - This small tube-like part is responsible for reflexes involving the eyes and ears.

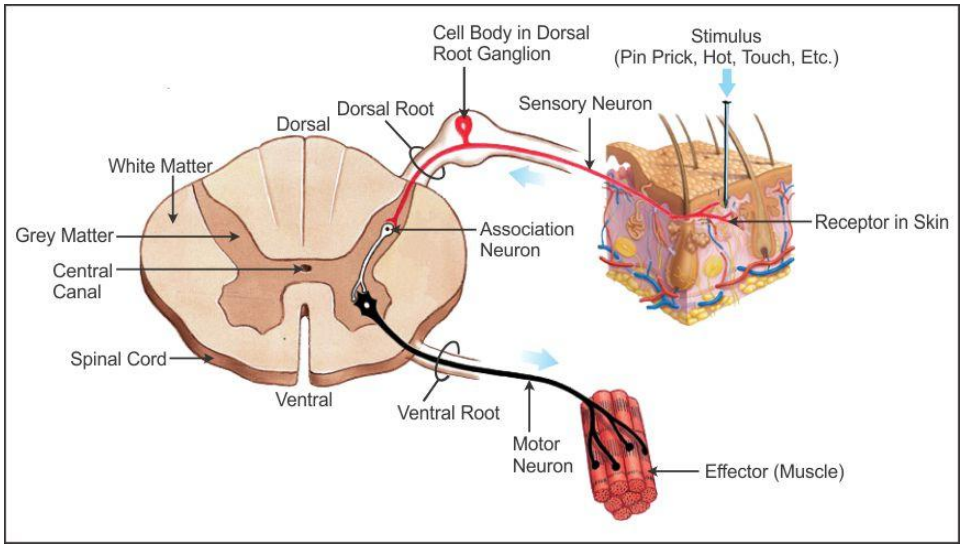
- **Hind Brain**
  - The **cerebellum** coordinates muscular activity and balance of the body.
  - The **pons** carries impulses from one hemisphere to the other hemisphere and coordinates muscular movements on both sides of the body**.**
  - The **medulla oblongata** controls the activities of internal organs, heartbeat, breathing etc.

Parts of the Brain



1. Cerebrum	• The largest portion of the brain. • It is divided into two cerebral hemispheres connected to each other by the **corpus callosum.** • The cortex contains cell bodies of the neuron and is greyish in colour; hence, it is called **grey matter.** • The grey matter has many folds (i.e. **gyri**) and grooves (i.e. **sulci**). • The medulla consists of the axons of the nerve fibres and is called **white matter.**
2. Cerebellum	• Located at the base of the cerebrum. • In a median section, its white matter appears like a branching tree.
3. Medulla Oblongata	• Located at the base of the skull. • It is roughly triangular. • It continues behind the brain as the spinal cord. • Injury to the medulla oblongata results in death.

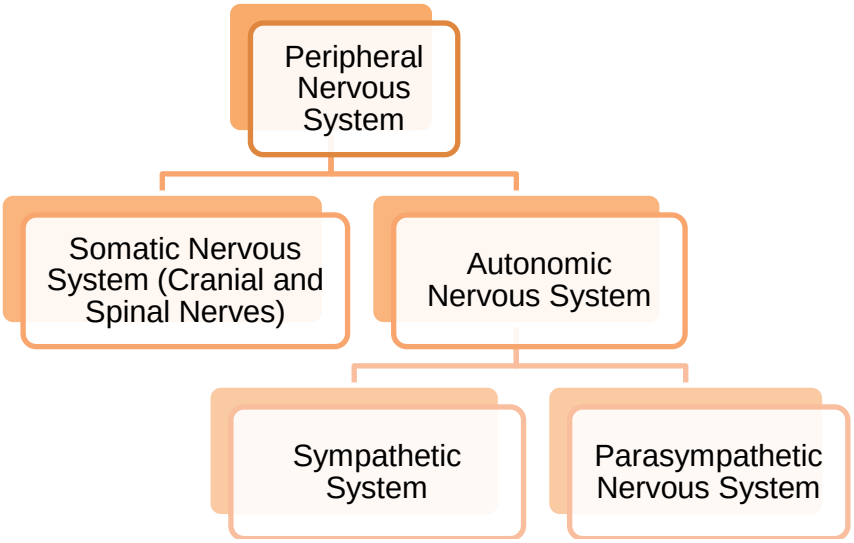
The Spinal Cord



- Lies within the neural canal of the vertebrae.
- The grey matter is on the inner side and the white matter is on the outer side of the spinal cord.
- Similar to the brain, it is covered with three meninges—dura mater, arachnoid and pia mater.
- Functions:
  - Responsible for reflexes below the neck.
  - Conducts sensory impulses from the skin and muscles to the brain.
  - Conducts motor responses from the brain to muscles of the trunk and limbs.

Peripheral Nervous System

The peripheral nervous system consists of nerves which carry impulses to and from the central nervous system.

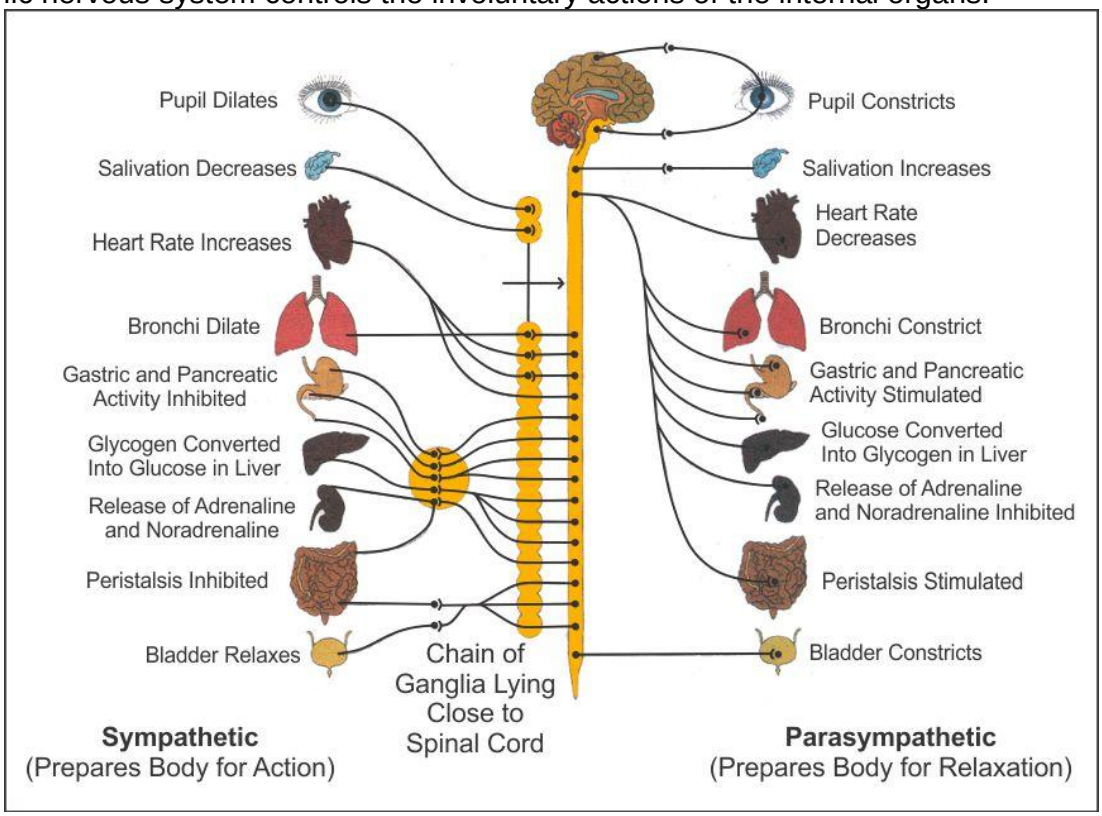


Somatic Nervous System

- Cranial Nerves: 12 pairs emerge from the brain.
- Spinal Nerves: 31 pairs: 8 pairs in the neck region, 12 pairs in the thorax, 5 pairs in the lumbar region, 5 pairs in the sacral region and 1 pair in the coccygeal region.

Autonomic Nervous System

The autonomic nervous system controls the involuntary actions of the internal organs.



Sympathetic Nervous System	Parasympathetic Nervous System
• Nerves arise from the spinal cord between the neck and waist regions.	• Located anteriorly in the head and neck while posteriorly in the sacral region.
Sympathetic and parasympathetic systems have functions which are opposite to each other.	

Opposite Effects of the Two Systems

Organs	Sympathetic System	Parasympathetic System
Heart	Accelerates heart beat	Retards heart beat
Intestines	Peristalsis decreased	Peristalsis increased
Lacrimal (Tear) Glands	Stimulates secretion	Inhibits secretion
Pupil of Eyes	Dilation	Constriction

Reflexes

The reflex action is an automatic, quick and involuntary action in the body brought about by a stimulus.

Difference between Reflexes/Involuntary Actions and Voluntary Actions

Reflexes (Involuntary Actions)	Voluntary Actions
• Initiated by some stimulus such as touch, pain, pressure, heat, light etc.	• Initiated by a willing thought.
• Commands originate in the spinal cord, autonomic nervous system and a few in the brain as well.	• Commands originate in the brain.

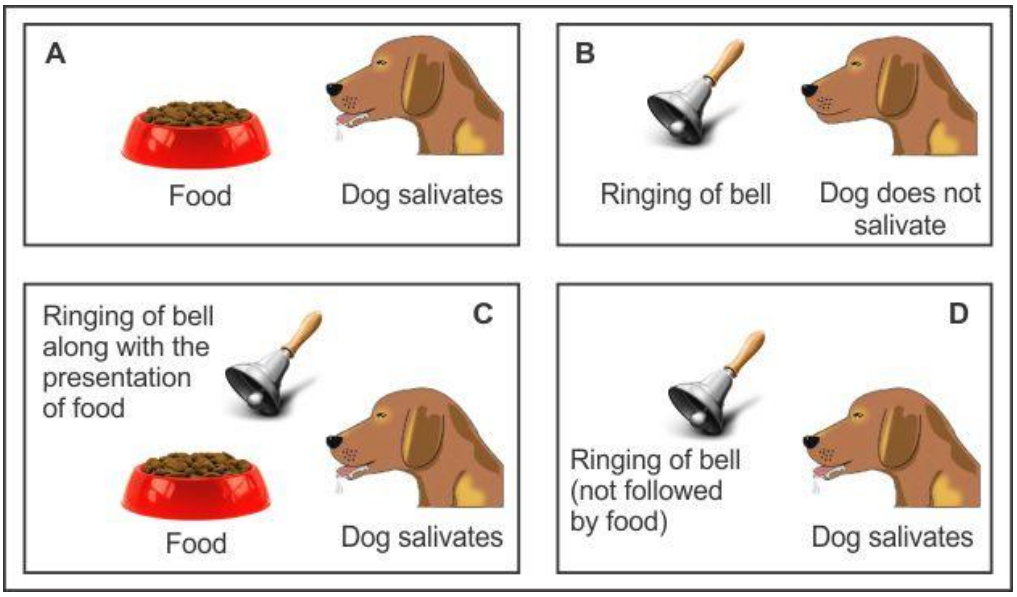
Some examples of reflexes:

- Shivering when it is too cold or sweating when it is too hot.
- Non-stop beating of the heart.
- Instant withdrawal of the hand when it accidently touches a hot iron.
- Dilation of the pupil in eyes when looking in the dark.

Types of Reflexes

Natural (Inborn) Reflex	Conditioned (Acquired) Reflex
• Previous experience or learning is not required.	• Develops during lifetime due to experiences.
• Similar in all humans.	• Differs from individual to individual as it depends on experience and learning.
• Salivation, peristalsis, swallowing.	• Salivation just by the smell of food.

Pavlov's Experiment



Nervous Pathways in Reflexes

A reflex action must be quick to give quick response. Therefore, the pathway for receiving and sending information must be short.
A reflex arc can be represented as follows:
Stimulus → receptor in the sense organs → afferent (sensory) nerve fibre → CNS (spinal cord/brain) → efferent (motor) nerve fibre → muscle/gland → Response

The Sense Organs

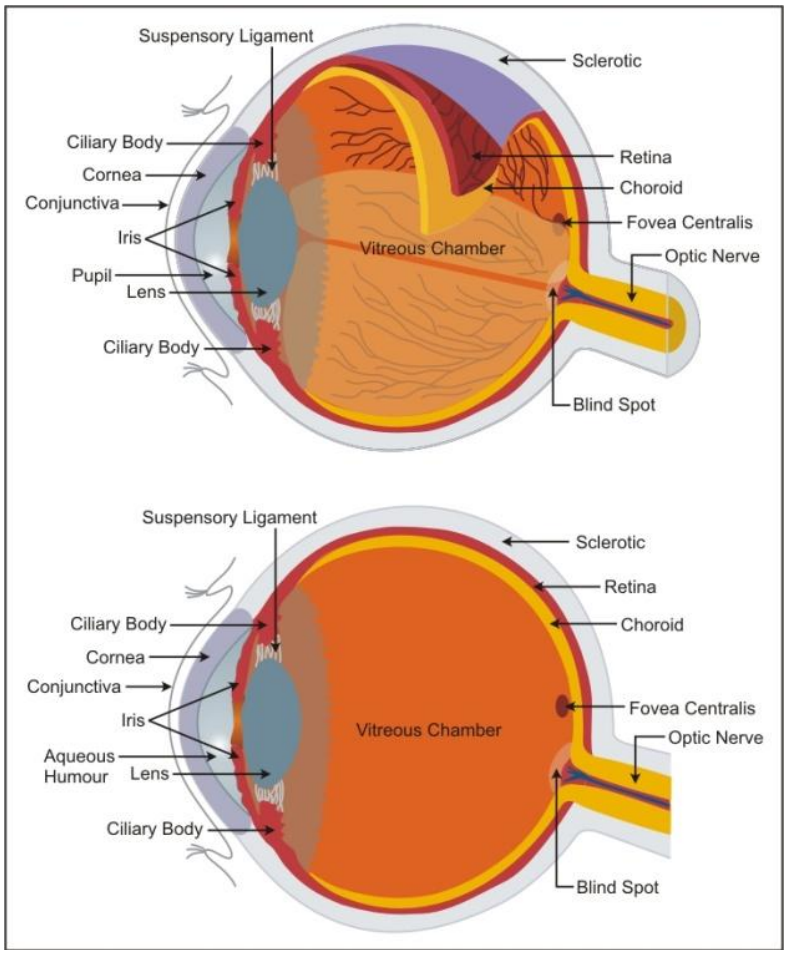
The **sense organs** enable us to be aware of the condition of the environment.
A **receptor** is any specialised tissue or cell sensitive to a specific stimulus.

Mechanoreceptors	Receptors of touch, i.e. pressure on the skin due to mechanical change.
Chemoreceptors	Receptors of taste of the tongue and smell of the nose due to chemical influence.
Photoreceptors	Receptors of light present in rods and cones of the retina of eyes.
Thermoreceptors	Heat and cold receptors in the skin due to change in temperature.

The Eyes

- The two eyes are located in deep sockets called orbits.
- The upper and lower moveable eyelids protect the front surface of the eyes.
- There are 6–12 tear glands.
- Functions of the tear glands are
  - Lubricate the surface of the eye
  - Wash away the dust particles
- A thin membrane which covers the entire front part of the eyes is called conjunctiva.
- Due to viral infection of the conjunctiva, we suffer from eye disease called **conjunctivitis**.

Structure of the Eyeball



The wall of the eyeball is composed of the following three concentric layers:

1. Sclerotic Layer (Outer Layer)
    - The white visible portion of the eyeball is nothing but the sclera.
    - The sclera covers the coloured part of the eye, i.e. the cornea.

2. Choroid Layer (Middle Layer)
    - Richly supplied with blood vessels to provide proper nourishment.
    - Choroid expands in the front to form a **ciliary body**.
    - Iris is also a part of the choroid.
    - The iris partially covers the lens. It leaves a circular opening in the centre called a **pupil**.
    - The muscles of the iris regulate the size of the pupil. Thus, the pupil regulates the amount of light entering the eye.

3. Retina (Inner Layer)
    - It has two types of sense cells—rods and cones.
    - The rod cells are sensitive to dim light and do not respond to colour.
    - The cone cells are sensitive to bright light and are responsible for colour vision.

Comparison between Rods and Cones

Rods	Cones
• More in number.	• Less in number.
• Located at the periphery of the retina.	• Located in the centre of the retina.
• Rapid generation of light-sensitive pigment **rhodopsin**.	• Slow generation of light-sensitive pigment **iodopsin**.

Yellow Spot and Blind Spot

Yellow Spot	Blind Spot
• Contains maximum number of sensory cells, particularly cones.	• It does not contain any sensory cells.
• This is the region of colour vision and the brightest vision.	• This is the region of no vision.

Lens

- It is transparent, biconvex and crystalline.
- It is held by a suspensory ligament which attaches the lens to the ciliary body.

Aqueous and Vitreous Chambers

The lens divides the inner cavity of the eye ball into two chambers:

Aqueous Chamber	Vitreous Chamber
• Front chamber between the lens and the cornea.	• Larger chamber behind the lens.
• Filled with clear, watery liquid called **aqueous humour.**	• Filled with transparent, jelly-like fluid called **vitreous humour**.
• It refracts light.	• It protects the retina and its nerve endings.

Four Major Steps in Seeing an Object

Light rays reflected from the object enter the eyes through transparent structures.

↓

First, the curvature of the cornea converges the rays to some extent, and then the lens converges them further.

The image on the retina is inverted and real.

↓

The light energy produces chemical changes in rods and cones which send the nerve impulse. This nerve impulse is sent to the cerebrum through the optic nerve. The cerebrum gives the sensation of sight.

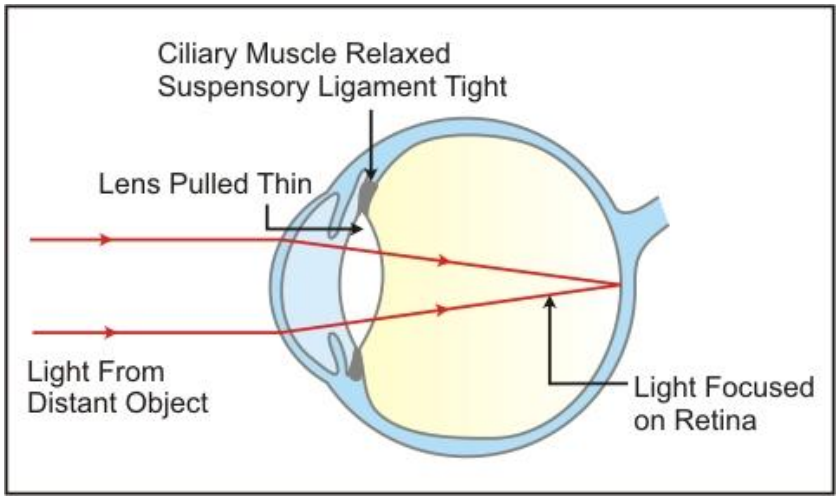
↓

The brain interprets the inverted image on the retina, and the obect is seen upright.

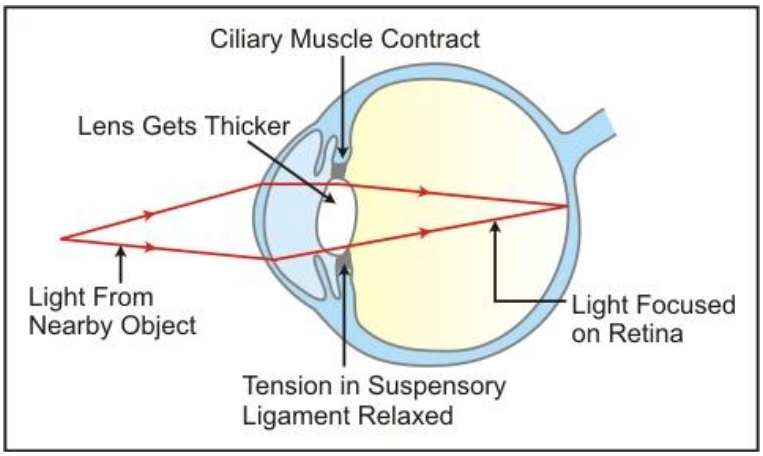
Accommodation Vision

The process of focusing the eyes at different distances is called **accommodation**.
This is brought about by change in the curvature of the lens.

- For distant vision, the lens is more flattened.
  The lens remains stretched by the suspensory ligaments.



- For near vision, the lens becomes convex and rounded.
  The ciliary muscles contract and pull the ciliary body forward. This releases the tension of suspensory ligaments, making the lens convex and rounded.



Light and Dark Adaptation

Dark Adaptation

When we pass from a brightly lit area to a dark area, we experience difficulty in seeing the objects for a short while. This is called **dark adaptation**

Light Adaptation

When we pass from a dark area to a brightly lit area, we experience a dazzling effect for a short period. This is called **light adaptation**.

Common Defects of the Eyes

	Defects of the Eyes	
1.	**Myopia (Short-sightedness)**	• Near objects are seen clearly, but distant objects appear blurred. • The lens is too curved. • Myopia is corrected by suitable concave lens
2.	**Hyperopia (Hypermetropia/long-sightedness)**	• Difficulty in seeing nearer objects. • The lens is too flat.
3.	**Astigmatism**	• Some parts of the object are seen in focus, while others appear blurred.
4.	**Presbyopia**	• Observed in older people. Near objects cannot be seen clearly.
5.	**Cataract**	• The lens turns opaque and the vision is reduced.
6.	**Colour blindness**	• Colour blind people cannot distinguish between certain colours such as red and green.
7.	**Night blindness**	• Difficulty in seeing in dim light. • Due to non-formation of rhodopsin in rod cells.
8.	**Squint**	• The eyes converge leading to cross eyes.

Stereoscopic Vision

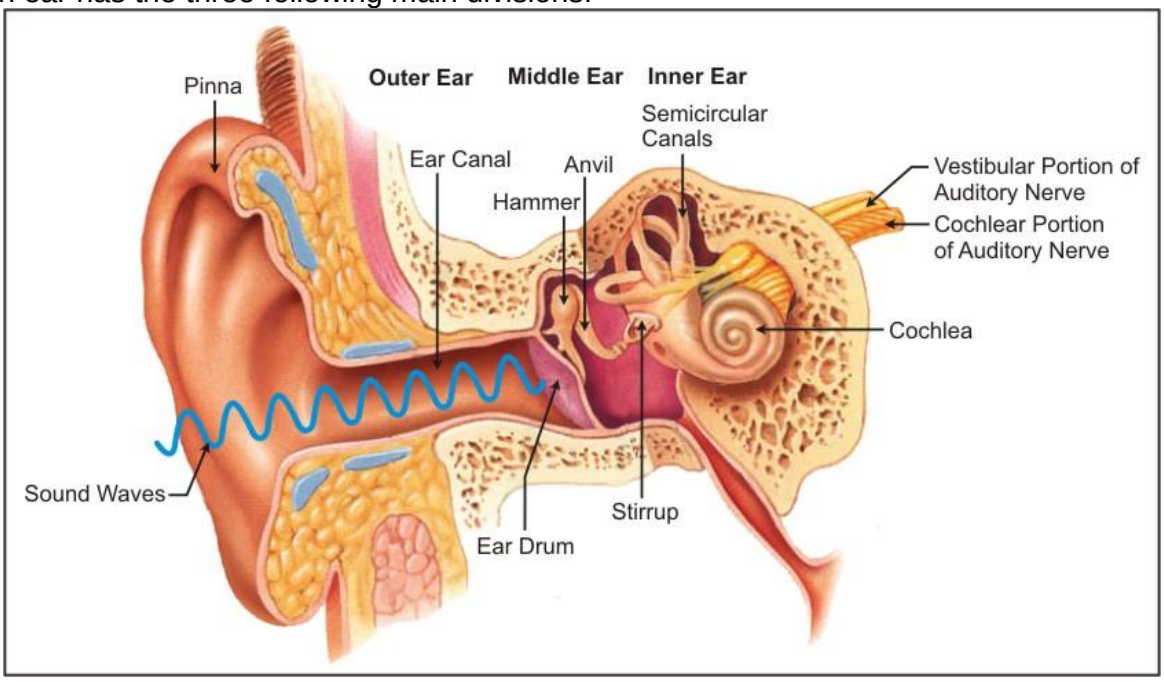
Humans, monkeys and apes can perceive depth or the relative distance of objects. This is due to simultaneous focusing of an object in both eyes. The images of both eyes are overlapping and give a 3-dimensional effect.

After-images

When one looks at a brightly coloured object and then looks at a dark surface, an image of the object in the same colour will persist. This is known as **persistence image** or **after-image**.

The Ear

The human ear has the three following main divisions:



1. Outer Ear
   - Consists of pinna/auricle and auditory canal.
2. Middle Ear
   - Contains three ear ossicles—malleus (hammer), incus (anvil) and stapes (stirrup)—and the eustachian tube.
   - The eustachian tube connects the cavity of the middle ear with the throat.

3. Inner Ear
   - Also known as **membranous labyrinth**.
   - Contains cochlea and the semicircular canals.
   - The cavity of cochlea is divided into three parallel canals. The middle canal consists of the **organ of corti** which is responsible for hearing.
   - Ends of the semicircular canals widen to form an **ampulla**.
   - The ampulla contains sensory cells.
   - The short stem joining the bases of semicircular canals to the cochlea is called the **vestibule**.
   - The vestibule contains two sacs—utriculus and sacculus.

Functions of the Ear

Two functions of the ears are **hearing** and **body balance**.

1. Hearing

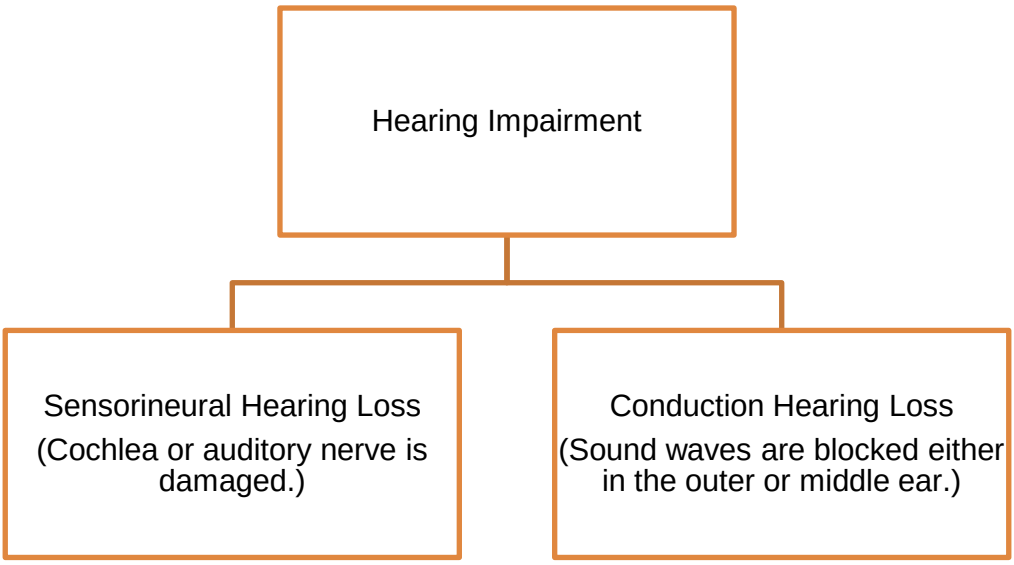
The pinna collects sound waves and conducts them through the external auditory canal. They finally strike on the ear drum and the vibration is set.

Eustachian Tube	• Equalises the air pressure on either side of the ear drum.
Ear Drum	• Sets the three ear ossicles into vibration.
Vibration of Stapes	• Transmits vibration to the membrane of the oval window.
Oval Window	• Sets the fluid in the cochlear canal into vibration.
Cochlea	• Sensory cells of cochlea transmit impulses to the auditory nerve.

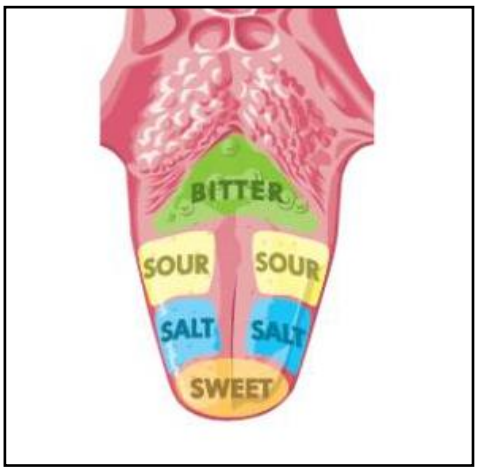
2. Body Balance

- The sensory cells in the semicircular canals are concerned with dynamic equilibrium, i.e. when the body is in motion.
- The sensory cells in utriculus and sacculus are concerned with static equilibrium, i.e. when the body is stationary.

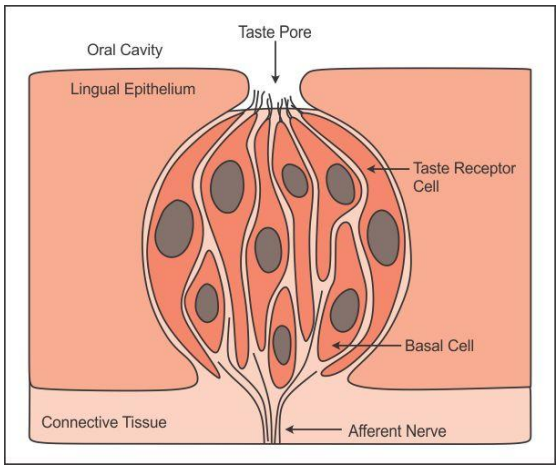
Hearing Impairment



The Sense of Taste



Different Taste Areas of Tongue



Taste Bud

- The sense of taste is located in the taste buds of the tongue.
- A taste bud is an ovoid group of sensory cells.
- Substances enter the pore and stimulate the sensory hair of the sensory cells.

The Sense of Smell

- The sense of smell is located in the epithelial layer of the nasal chamber.
- The sense cells for smell have hair-like projections.
- These hair-like projections respond to particles dissolved in the mucous secretion of the nose.
- The impulse from these cells is then transmitted to the brain via the olfactory nerve.