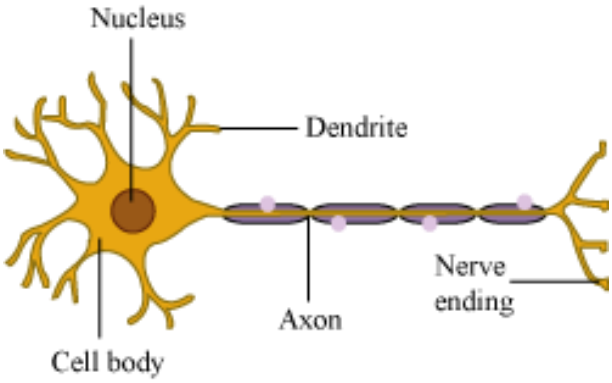
The Nervous System

Components of Nervous System

Do you know which organs make up the nervous system?

The nervous system is made up of the brain, spinal chord, and nerve cells or neurons.

Let us first study about the structure of the functional units of the nervous system i.e., the **neurons**.



Structure of a neuron

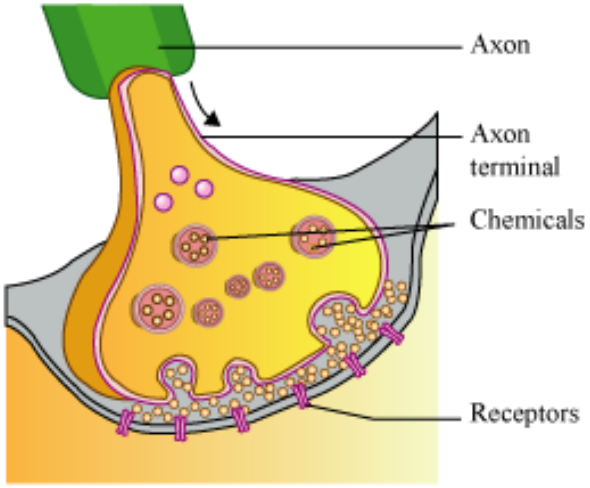
The three main parts of a neuron are the axon, dendrite, and cell body.
The **axon** conducts messages away from the cell body. The **dendrite** receives information from the next cell and conducts it towards the cell body.

The **cell body** contains the nucleus, mitochondria, and other organelles. It is mainly concerned with maintenance and growth of the cell.

Arrangement of neurons

Neurons are arranged end to end, forming a chain. This helps in the continuous transmission of impulses. Each neuron receives an impulse through its dendrite and transmits it to the next neuron in a sequence through its axon.

Neurons are not connected. **Synapse** or a small gap occurs between the axon of one neuron and dendron of the next neuron.



A synapse in the muscle fibre is also known as **neuromuscular junction**. Let us discuss the working of a synapse in detail.

Nerve
A nerve is a collection of nerve fibres (or axons) enclosed in a tubular medullary sheath. This sheath acts as an insulation and prevents mixing of impulses in the adjacent fibres.

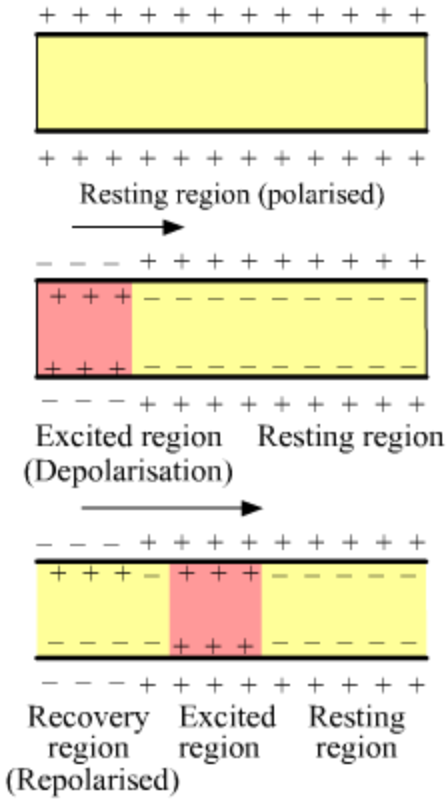
How does a nerve impulse travel?

The dendrite end of the neuron collects information and triggers a chemical reaction, which results in an electric impulse. This impulse is transmitted from the dendrite to the cell body and then to the axon. From the axon, the impulse travels to its end, where the electrical impulse sets off the release of some more chemicals.

These chemicals cross the synapse and start a similar electrical impulse in the dendrite of the next neuron. In this way, impulses are transmitted from one neuron to another to finally reach the brain.

Under normal conditions, the outer side of the nerve fibre consists of positive charge as more Na+ ions are present outside axon membrane. The neuron is then said to be in polarised state. On stimulation, the membrane becomes more permeable and Na+ ions move inside causing depolarisation.

Such a region is known as excited region. The point of depolarisation behaves as stimulus for the neighbouring area and this goes on. In the mean time, the previous area becomes repolarised due to active transport (using ATP) of Na+ ions with the help of **sodium pump**.



Conduction of nerve impulse through a nerve fibre

Human Brain - Structure and Function

The body performs various activities. **All these activities are controlled by the brain. How does the brain control all activities? Are there any divisions in the brain, which take over the control of different activities?**

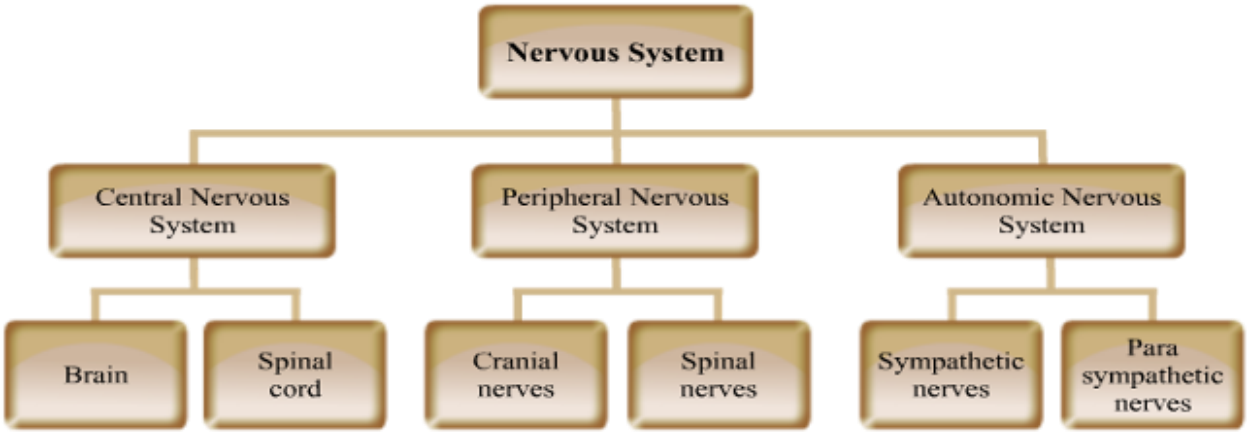
Do you know which organs make up the nervous system?

Let us explore.

The nervous system is divided into - **central nervous system (CNS) and peripheral nervous system (PNS)**. The **CNS** consists of the brain and spinal chord while the **PNS** consists of the nerves that connect the central nervous system to different parts of the body.

The central nervous system receives information from all parts of the body and also sends information to the muscles. Communication between the **CNS** and body parts is facilitated by the nerves of **PNS**.

The important components of nervous system are:



Components of human nervous system

The Central Nervous System

The central nervous system consists of the brain and the spinal cord. The brain is enclosed in a bony box called the **cranium** and spinal cord is protected by **vertebral column.**

The brain and spinal cord are externally covered by protective covering called **meninges**. It is made up of three layers namely **duramater** (outer layer), **arachnoid** (middle layer), **piamater** (inner layer).

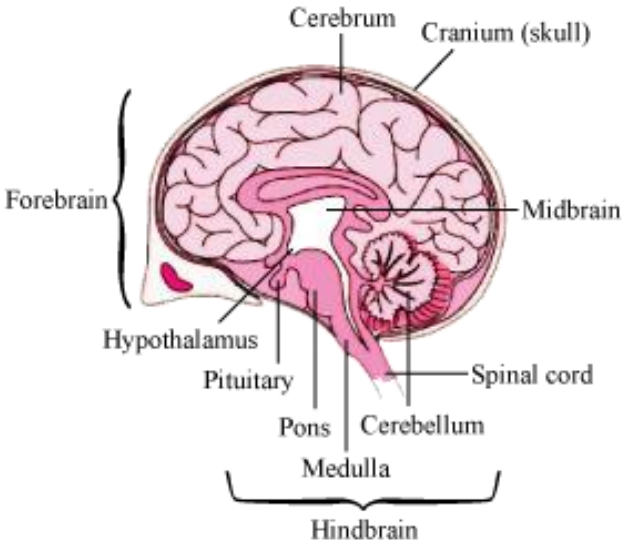
The space between meninges is filled by a watery fluid called **cerebro-spinal fluid (CSF)**. This fluid flows from the brain to spinal cord and then back to brain. It acts as a shock absorber and protects brain form injuries. It also provides nutrients to the cells in brain and spinal cord.

Human Brain

The brain is the main coordinating centre of the body. It is a part of the nervous system, which controls and monitors every organ of the body. The weight of the brain of an adult is about 1400 grams.

Different regions of the brain

The brain is divisible into three main regions—forebrain, midbrain, and hindbrain.



Forebrain

It is the main thinking part of the brain. It consists of the cerebrum, thalamus and hypothalamus. The forebrain has sensory regions, which receive sensory impulses from various receptors. It also has motor regions, which control the movement of various muscles such as leg muscles. There are separate areas in the forebrain specialized for hearing, smelling, seeing, general sensations such as pain, touch, taste, etc.

Cerebrum: The cerebrum is the largest part of the brain and constitutes four-fifth of its weight. It is divided by a deep cleft into two equal parts called left and right cerebral hemispheres.

Cerebrum has two regions, an **outer cortex** and **inner medulla**. The inner cortex is made up of cytons (nerve cell body) that give it a greyish appearance, so it is also called as **grey matter**. The medulla is composed of nerve fibres (axons and dendrites) that give it an opaque white appearance due to presence of myelin sheath covering, so is also called a **white matter**.

The cortex is provided with ridges called convolutions that increase the surface area of the cerebrum. The well developed cortex is responsible for the high degree of intelligence of the humans.

The information obtained through sense organs is stored in the cerebrum and used when needed. This ability to store information helps in retaining the memory.

A certain part of the cerebrum primarily controls intelligence, learning, memory, emotions, consciousness, thinking, and the ability to articulate speech. The forebrain is also known as the main thinking part of the brain.

In cerebrum, the nerves that come from the right side of the body are connected to the left side of cerebral hemisphere and the nerves that come from the left side of the body are connected to the right side of the cerebral hemisphere.

Therefore, organs of the right side of the body are controlled by left hemisphere and organs of the left side are controlled by the right hemisphere. Thus, injury in the left side of cerebral hemisphere results in the paralysis of organs on right side of the body and vice-versa.

Dienchephlon

It is the part of the forebrain located below the cerebrum. It includes both thalamus and hypothalamus.

Thalamus is situated between cerebral cortex and mid brain. It receives the nerve impulse form sense organs and transmits them to the upper region. It coordinates the sensory and motor signaling.

The **hypothalamus** contains many areas that control the body temperature, urge for eating and drinking, etc. Some regions of the cerebrum along with hypothalamus are involved in the regulation of sexual behaviour and expression of emotional reactions such as excitement, pleasure, fear, etc.

Midbrain

It is the small region of the brain that connects cerebrum with the hind brain. It has regions that are concerned with the sense of sight and hearing. Some regions of the midbrain transmit motor impulses to the limbs.

Hindbrain

It consists of three parts namely **pons varoli, cerebellum** and **medulla oblongata**.

Pons varoli consists of the nerve fibres that connect various portions like cerebrum, cerebellum and medulla oblongata of the brain. It has the control centers for facial expression, respiration and mastication etc. Among the twelve pairs of cranial nerves, four pairs originate from the pons varoli.

The **cerebellum**, which is a part of the hindbrain, is responsible for maintaining the posture and equilibrium of the body. It also coordinates the contraction of voluntary muscles, according to the directions of the cerebrum.

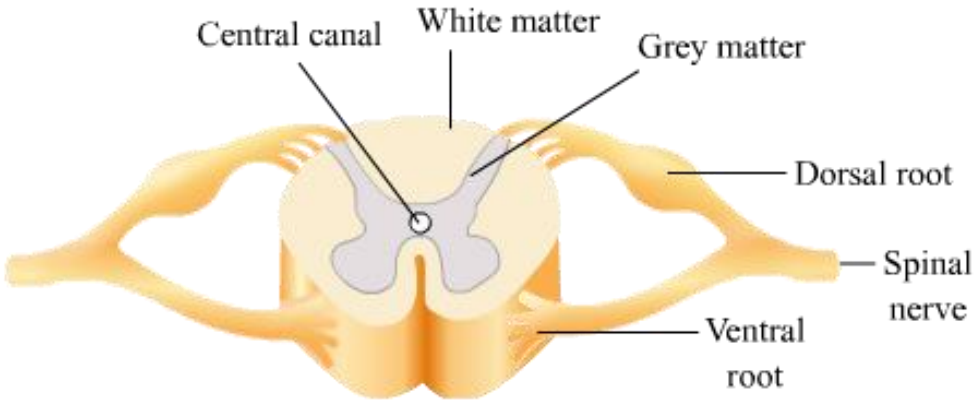
Medulla is the posterior most part of the brain and is connected to the spinal cord. Most involuntary actions such as heart beat, blood pressure, movement of food in the alimentary canal, salivation, etc. are controlled by the medulla of the hindbrain.

Spinal Cord

It is the continuation of the medulla oblongata and runs through the vertebral column. The spinal cord is made up of two similar halves fused together to form a central canal containing the cerebrospinal fluid. The outer portion of the spinal cord is known as the **white matter**, which consists of nerve fibres and the inner portion contains the cell bodies of neurons and is known as the **grey matter**.

There are thirty one pairs of spinal nerves that arise from the spinal cord. These nerves are divided into branches that reach to several parts of the body like, heart, lungs, stomach, urinary bladder, sex organs etc. The movement of limbs in the body are controlled by the spinal cord through reflex actions.

The spinal cord tapers at the end at the last vertebrae where from a collection of nerve roots originate, which are horsetail-like in appearance and hence called the **cauda equina.**



Cross section of spinal cord

Protection to the brain and spinal cord

The brain, being an important organ, requires protection. Therefore, it is enclosed in a bony box called the **cranium**. The brain inside the brain box is also surrounded by a fluid-like material, which acts as shock absorber and thus, provides further protection to the brain. Spinal cord is protected by a bony, vertical rod with several curves called the **vertebral column**.

Do You Know?

The brain transmits messages at a rate of 240 miles per hour!

There are 10 million nerve cells in our brain.

The brain uses more than 25% of the oxygen used by the human body!

As compared to other animals, the ant has the largest brain in relation to its body.

Peripheral Nervous System

It consists of the nerves arising from the brain and the spinal cord, which links the CNS to the rest of the body. It consists of two types of nerves.

- **Cranial nerves:** There are 12 pairs of cranial nerves and they emerge from the brain and reach the organs in the head region.
- **Spinal nerves:** There are 31 pairs of spinal nerves that emerge from the spinal cord and reach various parts of the body.

Messages are transferred from the brain to the spinal cord and then to the rest of the body and similarly messages from the rest of the body reach the spinal cord from where they are transferred to the brain. The spinal cord also controls all reflex actions.

Autonomic Nervous System

The autonomic nervous system helps to carry out the orders of the medulla, which controls the vital body functions.

It consists of two networks:

- **Sympathetic system**: The sympathetic nerves lead to all vital internal organs and glands. They regulate the actions of smooth muscles such as that of the stomach, intestine, and the heart.
- **Parasympathetic system**: This system is made up of the vagus and the pelvic nerves.

The sympathetic system speeds up the body functions and prepares the body for combat and escapes while the parasympathetic system counteracts to that of the sympathetic system and slows down the body functions.

Peripheral Nervous System and Autonomic Nervous System

Peripheral Nervous System (PNS)

PNS includes the nerves, which carry impulses to and from the CNS.

Nerves included in the PNS are of two types- cranial nerves and spinal nerves.

Cranial Nerves

As the name suggests, these nerves originate from the cranium. Man has 12 pairs of cranial nerves, which include all three types of nerves −sensory, motor, and connector. The information about the 12 pairs of cranial nerves is given in the following table:

Number	Name	Nature	Major functions
1.	Olfactory	Sensory	Smell
2.	Optic	Sensory	Sight
3.	Oculomotor	Motor	Movement of eyeball
4.	Trochlear	Motor	Rotation of eyeball
5.	Trigeminal	Mixed	Sensation of touch and taste
6.	Abducens	Motor	Rotation of eyeball
7.	Facial	Mixed	Taste, facial expression, saliva secretion, neck movement
8.	Auditory	Sensory	Hearing, equilibrium

9.	Glosso-pharyngeal	Mixed	Taste, saliva secretion
10.	Vagus	Mixed	Gastric and pancreatic secretion, GI movement, and visceral reflexes
11.	Spinal accessory	Motor	Muscle movement and visceral reflex
12.	Hypoglossal	Motor	Tongue movement

Spinal Nerves

- Spinal nerves are the nerves originating from the spinal cord by means of two roots- a dorsal root and a ventral root.
- All the spinal nerves are connector nerves.
- At the junction of the two roots, the sensory nerve and motor nerves separate. The sensory nerves continue into the dorsal root and the motor fibres continue into the ventral root.
- Both the roots enter the grey matter of the spinal cord.
- Man has 31 pairs of spinal nerves, which are again put into five different categories:
- Cervical (8 pairs)
- Thoracic (12 pairs)
- Lumbar (5 pairs)
- Sacral (5 pairs)
- Coccygeal (1 pair)

Autonomic Nervous System

The nerves controlling the involuntary actions of the smooth muscles and glands when we are asleep or awake constitute the ANS.

ANS is present as chains of ganglion on either side of the backbone.

Most of these ganglia are located close to or are embedded in the organ they control.

Autonomic nervous system is divided into two systems − sympathetic and parasympathetic.

Sympathetic System − Sympathetic nerves originate from the thoraco-lumbar segment of the spinal cord. It gets activated during stressful conditions and stimulates the release of noradrenalin at the nerve endings. The main functions of the system are as follows:

- Dilation of iris
- Decrease in salivation (That is why our throat dries during stress)
- Increase in rate of heartbeat, dilation of bronchi
- Causes gylcogen breakdown to glucose in liver
- Inhibition of gastric and pancreatic activities
- Inhibition of peristalsis

Parasympathetic System − It gets activated during relaxation from stress. All the effects of its activation are opposite to sympathetic system. Therefore, we can say that these two systems are antagonistic to each other.

Responses of the Nervous System

What happens when the following takes place?

- Bright light is focused on our eyes
- We accidentally touch a flame
- We are hungry and we think about our favourite meal

For all the situations mentioned above, the response would be quick and automatic. We would

- close our eyes immediately when bright light is focused on our eyes
- withdraw our hand from the flame
- start salivating on thinking about our favourite meal

This automatic action or response provoked by a stimulus is known as a **reflex action.**

The responses of the nervous system can be classified into voluntary, involuntary, and reflex actions.

The actions that can be controlled voluntarily are called **voluntary actions.** The signal or message for these actions is passed to the brain. Therefore, they are consciously controlled.

On the other hand, the movement of food in the alimentary canal or the contraction and relaxation of the blood vessels are **involuntary actions** i.e.they cannot be consciously controlled.

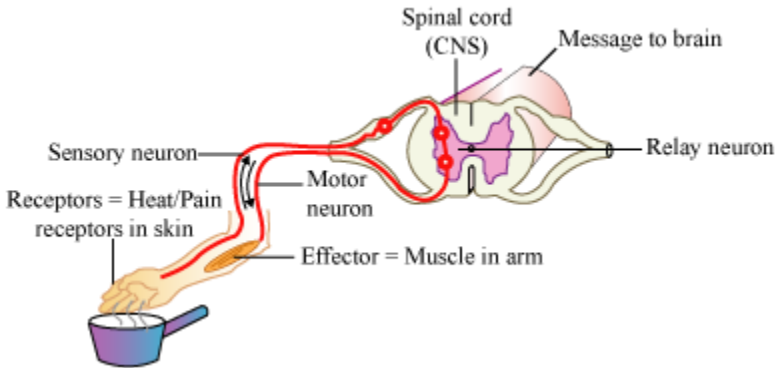
The **reflex actions**, however, show sudden responses and do not involve any thinking. This means that unlike involuntary actions, these actions are not under the control of the brain.

Reflex arc

When we accidentally touch a hot object, we withdraw our hands immediately without thinking. If we do not do this, our hands will burn.

The sensory nerves detect the heat. They are connected to the nerves, which move the muscles of the hand. Such a connection of detecting the signal from the nerves (input), and responding to it immediately (output) is called a **reflex arc**. In other words it is the pathway along which nerve impulse travels during the reflex action.

A reflex arc makes instant and automatic responses possible. It connects the input nerve and output nerve, and meets in a bundle in the spinal chord. In fact, nerves from all over the body meet in a bundle in the spinal cord, on their way to the brain. Therefore, the information input reaches the brain.



The reflex arc consists of five distinct parts and these are:

1. Receptor: It includes sense organs that receive stimulus.

2. Sensory neuron: It conducts the nerve impulse from receptor to the spinal cord or brain.

3. Association neuron: It helps to transmit nerve impulse from sensory neuron to motor neuron.

4. Motor neuron: It transmits nerve impulse to the effector organs like muscles or glands.

5. Effector: It includes muscles or glands where action takes place in response to stimulus.

Types of Reflexes

Ivan Pavlov classified all reflex responses in two categories − Unconditional and conditional reflexes.

Unconditional Reflexes − These are the inborn, unconscious responses to a given stimuli which are transferred to the next generation as well.

Some of the examples of such unconditional responses are suckling of the mother's breast by a new born body blinking of eyes when an object is brought very close to the eyes.

Condition Reflexes − Such responses are acquired during the life time of an individual. These responses are different for different organisms. These responses can be easily induced or lost depending upon the environmental conditions.

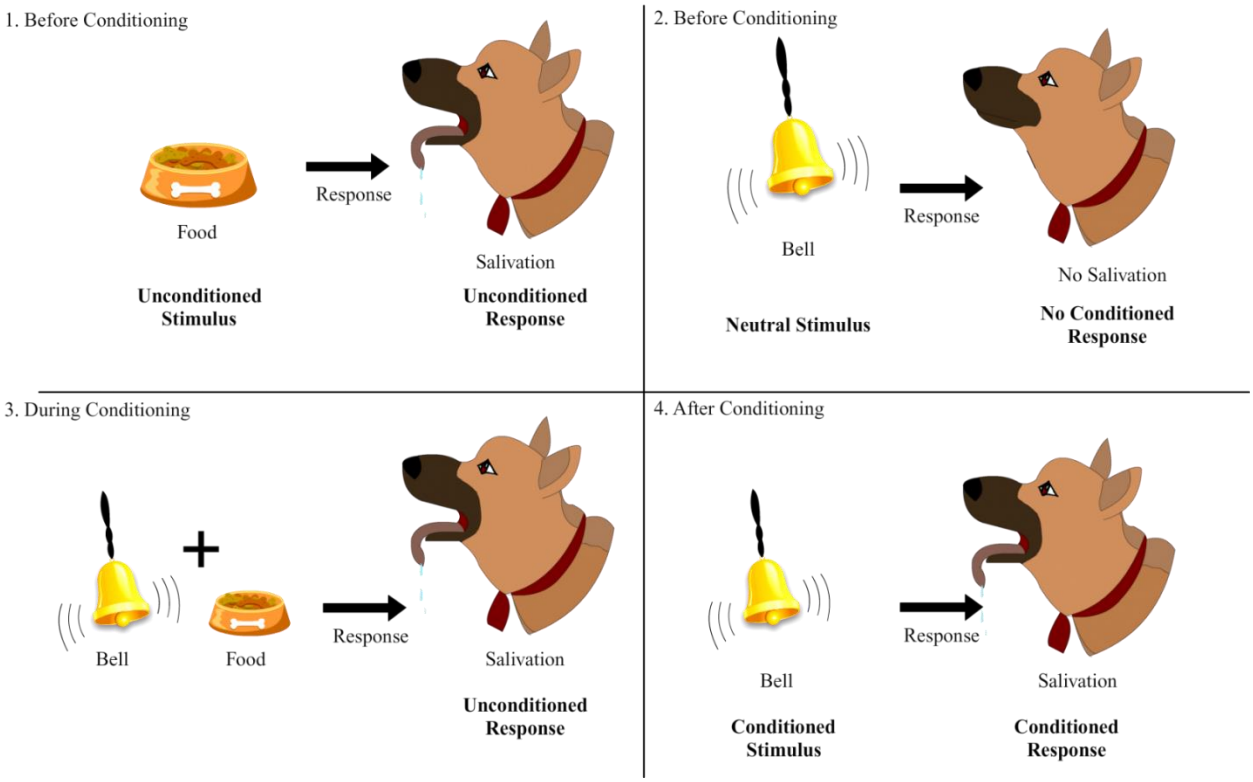
Pavlov's Experiment on a Dog

In this experiment the Russian famous biologist, Ivan Pavlov tested the conditional reflexes. He used a dog as his experiment subject and tested for the secretion of saliva

in response to ringing of a bell.

Under normal condition, dog will not secret saliva on listening the ringing of a bell or any other sound. In his experiment, Pavlov brought food and rang the bell simultaneously for a prolonged period of time.

After an adequate period of training, it was observed that the dog started secreting saliva just by listening to the bell's ringing.



Conditional reflexes are controlled by cerebral cortex.

Some of the examples of conditional or acquired reflex are learning, playing piano, typing on a computer, etc.

Structure of Human Eye

Sense Organs: Organs that helps us to be aware of our surroundings are known as sense organs. Some of the major sense organs of our body include eyes, ears, nose, tongue and skin.

Receptors: Any cell or tissue sensitive to a selective stimuli is known as receptor. Some common receptors are:

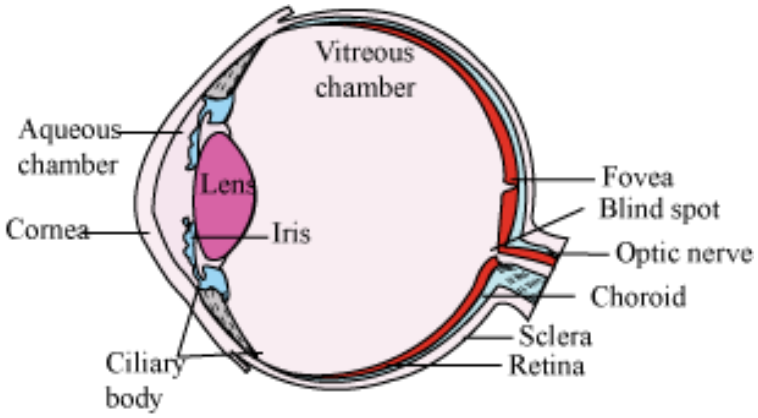
- Mechanoreceptors: Receptors for touch or pressure; found in skin
- Thermoreceptors: Receptors fro temperature; found in skin
- Chemoreceptors: Receptors of taste (in tongue) and of smell (in nose)
- Photoreceptors: Receptors of light; found in eyes (rod and cone cells)

Eye

Eye is one of the most sensitive sense organs in the human body. Our eye enables us to see this beautiful world. It consists of a lens, which is made up of living tissues. **How does our eye work? What are the nature, position and relative sizes of the images formed by the lens in the eye?**

In this section, we will learn about the structure and functioning of human eye.

Structure of human eye



The human eye is roughly spherical in shape with diameter of about 2.3 cm. It is situated in the front side of the skull in bony sockets. It is covered by the eyelids that have eye lashes which prevent dust and other substances from entering into the eye. It consists of a convex lens made up of living tissues.

Hence, human lenses are living organs contrary to the simple optical lenses. The inner region of the upper eye lid contains **Lacrymal glands,** that produces secretion known as **tears,** which keep eye surface moist and wash out dirt and other substances. Tears contain some salts and act as an antiseptic because of the presence of the enzyme **lysozyme** which kills the germs**.**

Structure of Human Eye:

The wall of the eye consists of three layers namely sclera, choroid and retina.

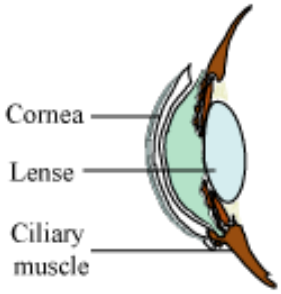
The following table lists the main parts of the human eye and their respective functions.

S. No.	Human eye part	Function
1.	Pupil	Opens and closes in order to regulate and control the amount of light
2.	Iris	Controls light level similar to the aperture of a camera
3.	Sclera	Protective outer coat
4.	Cornea	Thin membrane which provides 67% of the eye's focusing power
5.	Crystalline lens	Helps to focus light into the retina
6.	Conjunctiva	Covers the outer surface (visible part) of the eye
7.	Aqueous humour	Provides power to the cornea
8.	Vitreous humour	Provides the eye its form and shape
9.	Retina	Captures the light rays focussed by the lens and sends impulses to the brain via optic nerve

10.	Optic nerve	Transmits electrical signals to the brain
11.	Ciliary muscles	Contracts and extends in order to change the lens shape for focusing.

The **white of the eye** is known as the **sclera**. It is the tough, opaque tissue that protects the outer layer of the eye. The bulged, transparent front portion of the sclera is called **cornea**. It is protected by thin, transparent tissue known as the **conjunctiva**.

The middle layer called choroid is supplied with nerves and blood vessels. It consists of the coloured layer of tissue called **iris.** It is responsible for the colour of the eye. **Pupil** is the black, circular hole that is located at the centre of the iris.



The lens consists of layers of tissues enclosed in a tough capsule. The focus of the lens is adjusted by the ciliary muscles that suspend and hold it. The lens focuses the light rays on **retina** where inverted image of the object is formed.

Retina contains two types of cells **rods** and **cones**. Rods are sensitive to dim light and cannot differentiate between various colours while as cones are sensitive to bright light and can distinguish various colours.

Functioning of the human eye

Light rays enter the eye through the cornea. The rays are bent, refracted, and focused by the cornea, lens, and the vitreous humour. The main function of the lens is to focus

the light rays sharply on the retina. It is the outer surface of the cornea where most of the refraction of light occurs.

Iris controls the size of the pupil and the amount of light respectively. Since the eye lens is convex in nature, the resulting image is real, small, and inverted. This image is formed on the retina.

The retina converts these light rays into electrical signals with the help of light sensitive cells. These signals are sent to the brain via translated and perceived objects in an erect or upright position.

The head of the optic nerve is devoid of photosensitive cells (rods and cones). Hence, no image is formed at that point called the **blind spot** of the eye.

Lateral to the blind spot, a **yellow spot (fovea)** is present that contains large number of cone cells. At this portion of retina a most clear and sharp image is formed.

Power of Accommodation
This is a special capacity of human eye to adjust its focus depending upon the object they are seeing. This happens because of the presence of flexible ciliary muscles around the eyes that helps in adjusting the focus of the eye lens.
For distant vision the lens flattens whereas for near vision it becomes more convex.

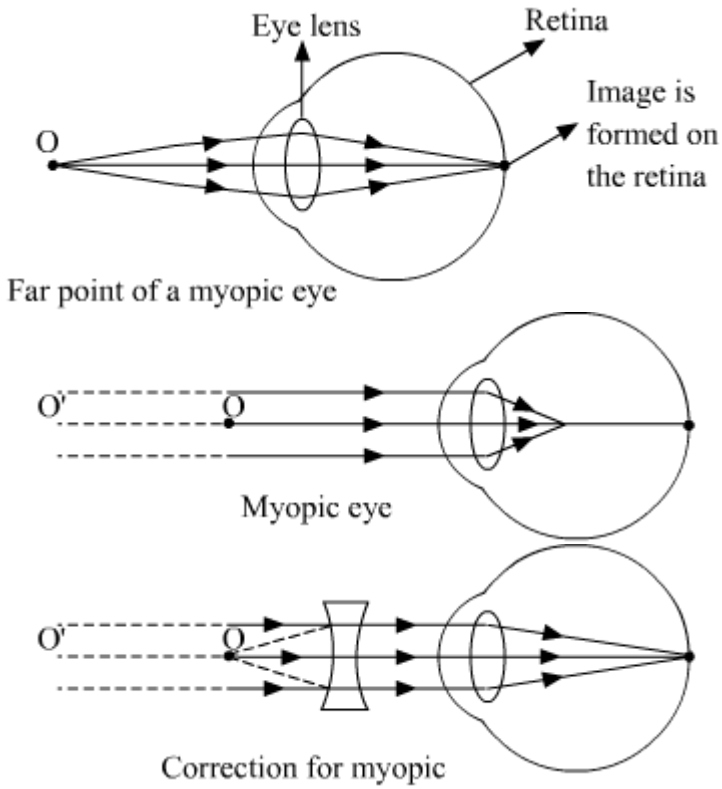
Stereoscopic Vision
Humans and monkeys/apes have a special ability to perceive depth and relative distance as they can simultaneously focus on an object with both eyes. This results in the generation of a three dimensional image in our brain. This ability is known as stereoscopic vision.

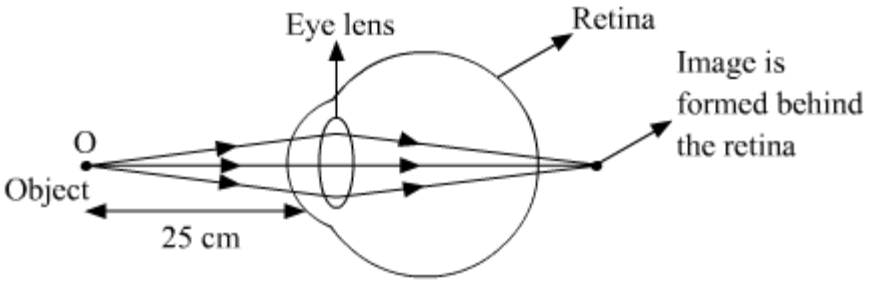
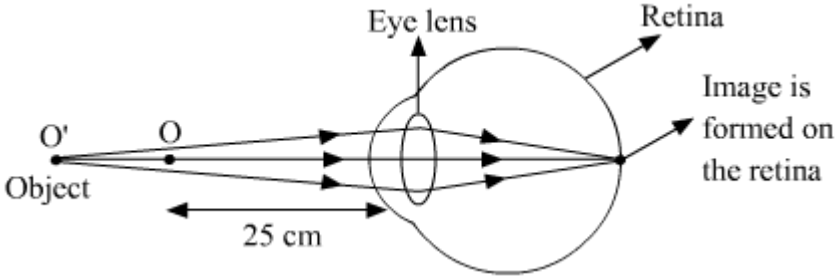
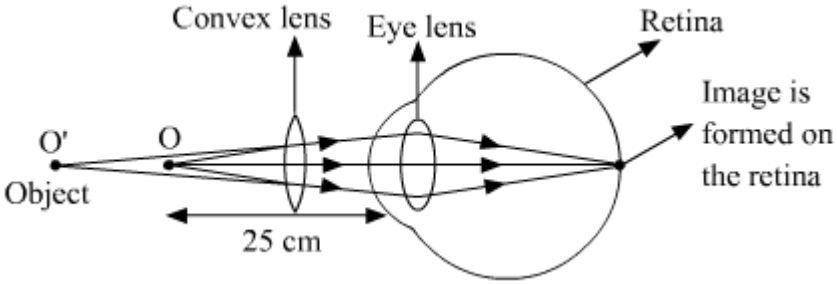
On sunny days, when you enter a dimly lit room, you are unable to see clearly for a moment. Why does this happen?

In bright light, the iris expands, thereby contracting the pupil. This happens so that only a small quantity of light enters the eye. As a result, the retina is protected from exposure to excessive light.

On entering a dimly lit room after having been in the sun for some time, the iris contracts slowly to expand the pupil. Gradually, more light is able to enter the eye. Hence, it takes a few seconds before we are able to see the objects present in the dimly lit room.

Common Defects of Eye

Defect	Characteristic features
Myopia (short-sightedness)	In this, nearby things are visible clearly, but distant things become blurred. The image of distant object is formed in front of retina because of the lens becoming too convex or due to elongation of eyeball from front to back. To correct this defect, spectacles with concave lens are used. 
Hypermetropia (long-sightedness)	In this, the nearby objects appear blurred while the distant objects are clear. The image of nearby objects is formed behind the retina because of the lens becoming too flattened or shortening of the eyeball from front to back. To correct this defect, spectacles with biconvex lens are used.

	 **Near Point of Hypermetropic eye**  **Hypermetropic eye**  **Correction of Hypermetropic eye**
Astigmatism	Uneven curvature of the cornea is responsible for imperfect image of the objects. Some objects appear clear while some appear out of focus. This is corrected by using cylindrical lens.
Glaucoma	The aqueous humour is regularly supplied by arterial capillaries and reabsorbed by venous capillaries of ciliary body. Interference with this absorption increases the intra-ocular pressure and causes excessive stretching of the eyeballs due which it becomes hard. The person first sees flashes of light and rings around the object and gradually vision decreases.

	To correct this defect, an operation is performed to drain the fluid and restore the normal pressure.
Presbyopia	In this, the lens loses its flexibility in older people and they are not able to see nearby objects clearly. This defect is corrected by wearing spectacles with convex lens.
Cataract	The protein fibres in the lens degenerate and the lens becomes opaque. The person loses clarity in the vision. This is corrected by surgically removing the defective lens and implanting with new lens.
Squint	In squint, either both the eyes converge (cross eye) or diverge (wide eye). Both these conditions cause double vision. Correction - surgery and exercises
Colour blindness	It is a genetic disorder. Person cannot differentiate between colours such as red and green.
Diabetic retinopathy	It occurs in the people with prolonged diabetes. The blood vessels of the retina may leak, close up or begin to grow due to diabetes. The blood may enter the clear jelly like fluid inside the eye ball (vitreous humour) and make it opaque causing blindness. It can be prevented by early treatment with laser beams. In some cases, virectomy (a major surgical procedure) can remove the blood and restore vision.

Let’s study a defect of eye known as presbyopia through this animation.

First Aid for the Removal of Foreign Bodies from the Eyes

- In case the foreign bodies like dust particles, flies, metal particles or saw dust of wood etc gets into the eyes, do not rub the eyes as it may cause injury to the eye ball.
- If foreign body is visisble, remove it with the help of clean and soft cloth.

- It can be also removed by pulling one eye lid over the other that results in the flow of tears. The flow of tears help to wipe the foreign particles out.

- It can be also removed by keeping the eyes in bowl of cold water or boric lotion and closing and opening the eyes several times. This also helps to wipe out the foreign paticles.

Structure of Human Ear

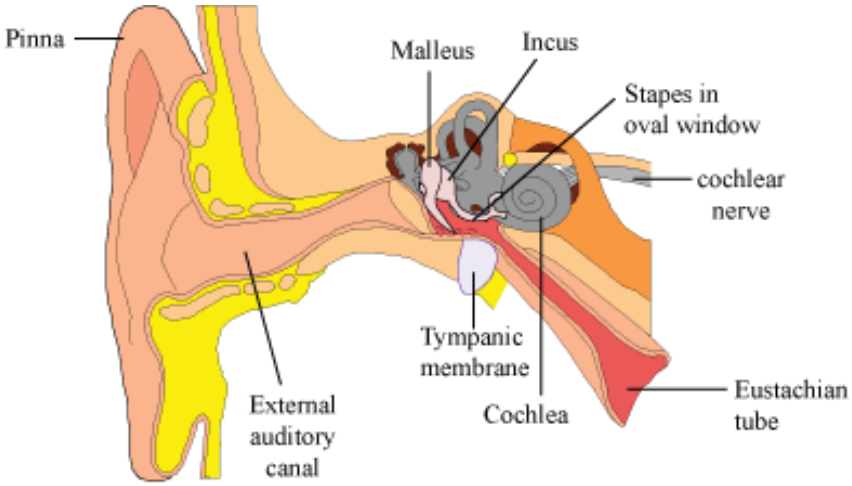
Functions of the Ears

- Hearing
- Maintenance of body balance

Anatomy of the Ear

- Divided into three major sections:

- Outer ear
- Middle ear
- Inner ear



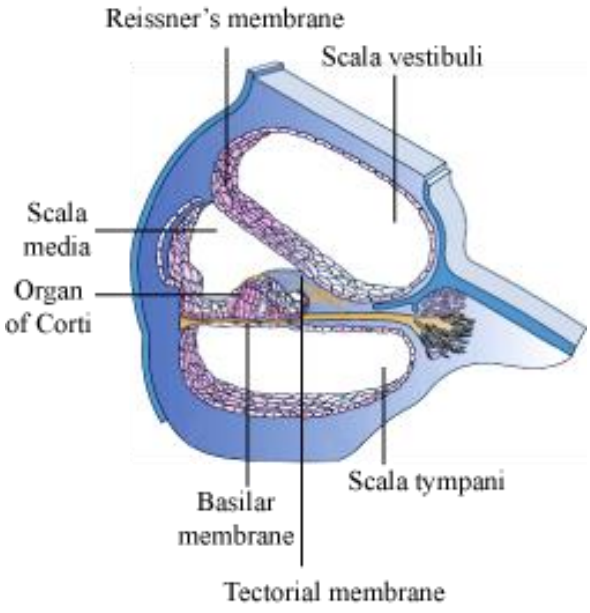
- Outer ear **=** Pinna + External auditory meatus (Canal)

- Pinna − collects the vibrations that produce sound
- Canal − leads inwards and extends up to the tympanic membrane (Ear drum)
- Wax-secreting sebaceous glands are present in the skin of the pinna and the canal.

- Middle ear: Has 3 ossicles (Malleus, Incus, Stapes)

- Malleus is attached to the ear drum and stapes is attached to the oval window of the cochlea. Middle ear communicates to the inner ear through the oval window.

- Ossicles increase efficiency of transmission of sound waves to the inner ear.
- Eustachian tube − connects the middle ear cavity with the pharynx; equalises the pressure on either sides of the ear drum
- Inner ear (labyrinth): Has 2 parts (Bony Labyrinth and Membranous Labyrinth)
- Bony Labyrinth − series of channels in which the membranous labyrinth lies
- Membranous Labyrinth − surrounded by a fluid called perilymph and filled with a fluid called endolymph
- Cochlea − coiled portion of the labyrinth
- 2 membranes surround cochlea, the reissner's membrane and the basilar membrane.
- These membranes divide the bony labyrinth into 3 parts -upper scala vestibuli, middle scala media and lower scala tympani.
- Scala media − filled with endolymph
- Scala vestibuli − ends at the oval window
  Scala tympani − ends at the round window that opens to the middle ear
- Organ of Corti − located on the basilar membrane and contains auditory receptors called hair cells (close contact with afferent nerve fibres)
- Tectorial membrane − elastic membrane present above the rows of hair cells



- Vestibular apparatus: Complex system located above the cochlea
- Composition − 3 semi-circular canals and otolith organ (has saccule and utricle)
- Base of the canals is swollen to form ampulla, which contains a projecting ridge called the crista ampullaris; it has hair cells
- Saccule and utricle − contain macula, which along with crista is responsible for maintaining the balance of the body and posture

Mechanism of Hearing

Mechanism of Hearing

External ear receives sound waves
↓
Send them to the ear drums
↓
Ear drum vibrates
↓
Vibrations transmit through the ear ossicles to the oval window
↓
Transmit onto the fluid in the cochlea
↓
Generate waves in the lymph
↓
Generate ripples in the basilar membrane
↓
Bend the hair cells and press them against the tectorial membrane
↓
Nerve impulses are generated in the associated afferent neurons
↓
Auditory nerves transmit them to the auditory cortex of the brain
↓
Brain recognises the sound

Role of Ear in Body Balancing

The fluid inside the semicircular canals moves when we turn our head. This moving fluid pushes against the sensory hair cells. This results in transmission of nerve impulse to brain through auditory nerve. The cells present in the semicircular canals are highly sensitive to dynamic equilibrium. Hence, they help us in maintaining balance of our bodies.

Senses of Smell, Touch and Taste

Sense Organs, in humans and other animals, are the faculties by which outside information is received for evaluation and response. This is accomplished by the effect of a particular stimulus on a specialized organ, which then transmits impulses to the brain via a nerve or nerves.

There are five type of senses which can be sensed by our sense organs - touch, vision, hearing, smell and taste.

These five type of senses can be categorised as general and special senses.

- General senses -
- contain general sensory receptors
- mostly modified dendritic ends of sensory neurons
- present throughout the body
- monitor most of the types of general sensory information such as tactile sensation, heat, cold, pain and muscle sense
- Special senses -
- contain special sensory receptors
- confined to the head region, sensory organs like eyes and ears and tissues of the taste buds and olfactory epithelium

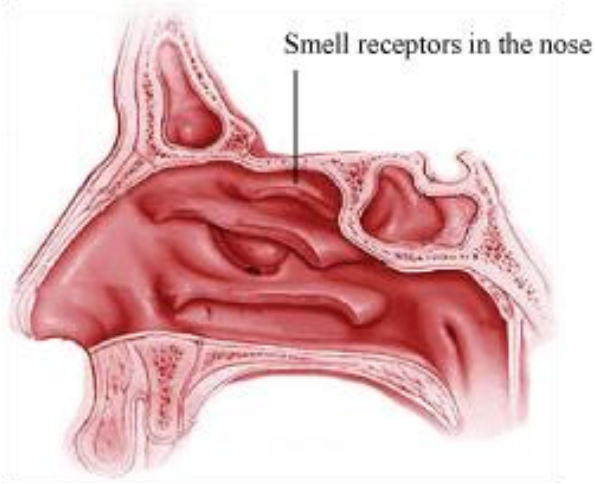
We are very much familiar with eye and ear. So let’s learn the details of other three sense organs.

Nose

The nose is the organ for smelling. The receptors for smell called olfactory receptors are present in the nose to perceive the smell. Impulses are sent to the brain by these receptors and we are able to smell things

- The receptors for smell are located in small patches is the upper portion of the nasal cavity. The mucosa of upper nasal chamber is called olfactory epithelium.
- Three types of cells present in olfactory epithelium- olfactory receptor cells, columnar supportive cells and short basal cells.

- Olfactory receptors are unusual bipolar sensory neurons.
- Thin dendrites of neurons bear clusters of 20 modified cilia which function as receptor sites.
- Cilia extend from the olfactory epithelium into the thin coat of nasal mucous secreted by the supportive cells and olfactory glands.
- Mucus present in nose acts as a solvent.
- The olfactory nerve carries the stimuli from these cells to the brain.
- The smell receptors in the nose are sensitive to chemicals and they send impulses to the brain via the olfactory nerve to the cerebrum.

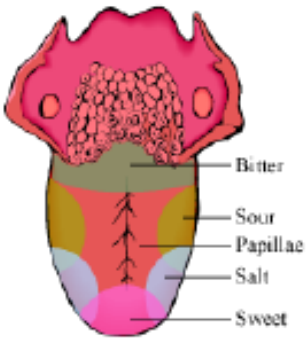


Tongue

The tongue is the sense organ responsible for taste. It has patches of sensory receptors known as taste buds. Different portions of the tongue are responsible for comprehending the different tastes.

- Nerves arise from the ends of the sensory taste buds and they together constitute the taste nerve.
- The nerve carries the signals to the brain where it is interpreted.
- The tongue has taste buds for the four basic tastes − sweet, sour, bitter and salty.
- The tip of the tongue is sensitive to sweet and salty tastes.
- The sides are sensitive to sour taste.

- The posterior portion is sensitive to bitter taste.



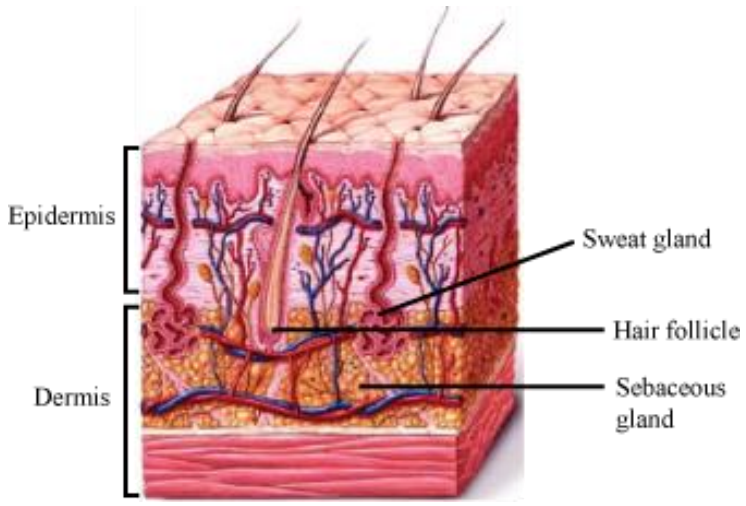
- **Mechanism of tasting -**
- dissolved chemicals contacting the microvilli bind to specific receptor proteins on it
- this depolarizes the cell
- dendrites of the associated sensory neurons coil intimately around the receptor cells and synapse with them
- a neurotransmitter is released when a receptor cell is stimulated and depolarized
- this leads to the generation of an action potential in the associated sensory neuron
- each dendrite receives signals from several receptor cells within the taste bud
- nerve fibers emerging from the taste buds pass to the brain stem
- from here the nerve impulse is relayed to the taste centre in the cerebral cortex of the brain that perceives the taste sensation

Skin

The skin is the sense organ for touch and feel. It also protects the body. It makes us aware of temperature, pressure, pain, etc

- Skin has two layers -
- The epidermis − It is the outer layer, made up of epithelial tissue and contains a brown pigment called melanin.
- Dermis − It is the inner layer and is made up of connective tissue and contains sweat glands and oil glands which give off moisture and oil which keeps the skin soft.

- It also contains hair follicles from which hair grows the skin also has nerve endings which act as touch receptors.



- Some of the receptors present in the skin are

Receptor	Response
Paciniam corpuscles	Strong pressure and vibrations
Meissner's corpuscles	Touch
Ruffini corpuscles	Heat
Root hair plexus	Touch
Krause's corpuscles	cold

Lets study some of these receptors in detail -

- Free or bare dendritic nerve endings - present throughout the epidermis taking an extensive branching or "zigzag" form. Respond chiefly to pain and temperature but some respond to pressure as well.

- Meissner's corpuscles - small receptors in which a few spiraling dendrites are surrounded by specialized capsule (Schawann) cells. Found just beneath the skin epidermis in dermal papillae and especially abundant in finger tips and soles of the feet.

- Pacinian corpuscles - large egg shaped bodies. Single dendrite surrounded by multilayers of capsule cells. Scattered deep in the dermis and in the subcutaneous tissue of the skin.

Mechanism of touch -

- an impulse or action potential is generated whenever one or more of these sensory receptors are stimulated (by heat, cold, vibrations, pressure or pain)
- impulse is then taken to the spinal cord and from there to the brain
- brain analyses the stimulus and then generates an appropriate response