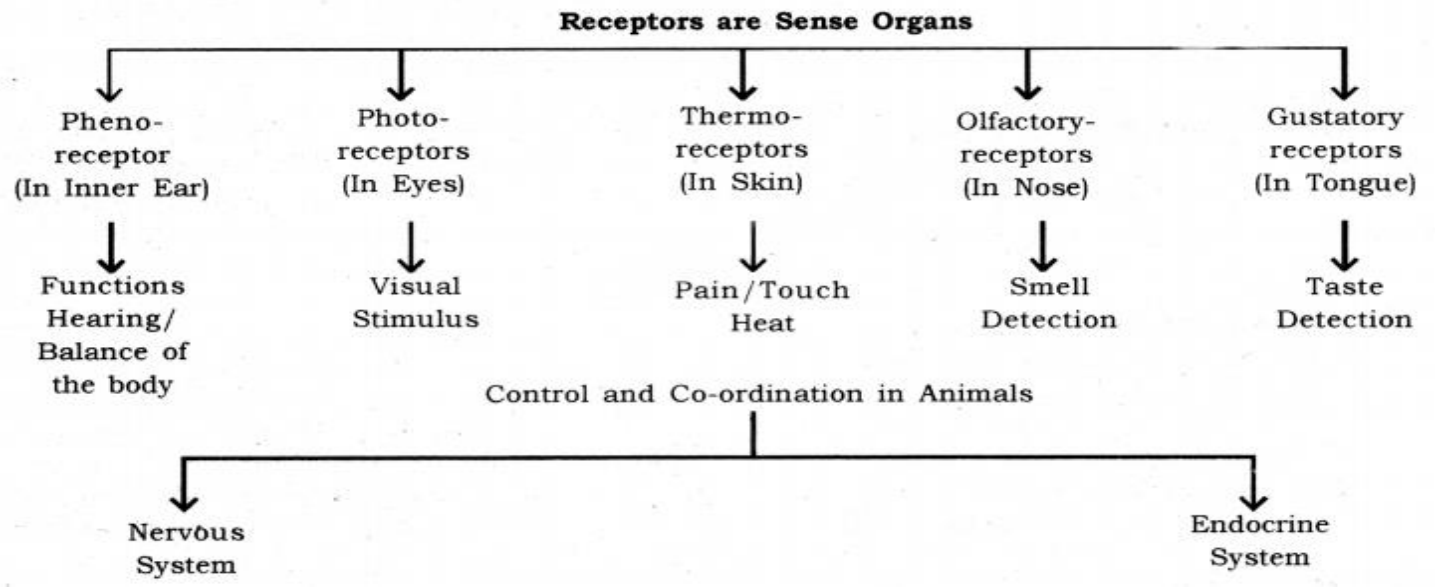
Control & Co-ordination

Living organisms respond and react to various stimuli like heat, light, cold, touch, pressure etc.
For example –

1. Take off the hand on touching a hot object.
2. Catching a ball by a fielder.

The response which a living being makes in relation to external stimuli is called control and coordination.
In animals, the nervous system and hormonal system are responsible for control and co-ordination.
Stimulus: An agent or sudden change in the external or internal environment which causes a change in an organism or any of its body parts.
Response: The change in organisms resulting from a stimulus.
Effectors: Muscles or glands which contract or secrete substances on receiving an impulse from the• brain or spinal cord.
Receptors: Receptors are group of cells present in sense organs which are sensitive to change in environment.
There are five types of receptors which are responsible for sensing the change in environment.



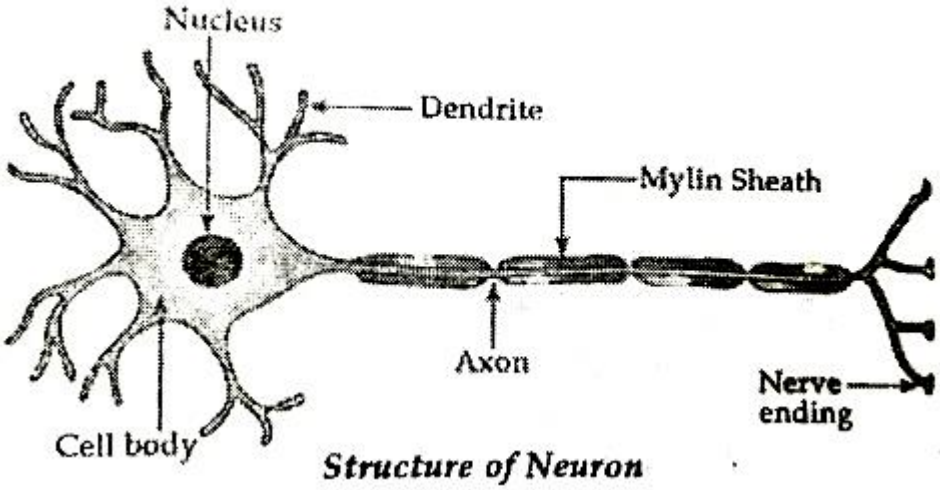
Nervous System: Nervous system is mainly composed of brain, spinal cord and nerves. The nerve cell or neuron is the structural and functional unit of the nervous system. It is Nervous System which is mainly responsible for control and coordination in complex animals

Functions of Nervous System

- Receive the information from environment by sense organs.
- Transportation of information to brain through spinal cord and nerves.
- After analyzing the information, it reacts accordingly through muscles and glands.

For example when we touch a hot object, our skin helps us to sense the heat, the nerves carry the impulse to the brain through spinal cord, and then the brain sends impulse to the muscles to contract and take off the hands.
Neuron: Neuron is a highly specialized cell which is responsible for the transmission of nerve impulses. The neuron consists of the following parts:

- **Cyton or cell body:** The cell body or cyton is somewhat star-shaped, with many hair like structures protruding out of the margin. These hair-like structures are called dendrites. Dendrites receive the nerve impulses.
- **Axon:** This is the tail of the neuron. It ends in several hair-like structures, called axon terminals. The axon terminals relay nerve impulses.
- **Myelin sheath:** There is an insulator cover around the axon. This is called myelin sheath. The myelin sheath insulates the axon against nerve impulse from the surroundings.



Structure of Neuron

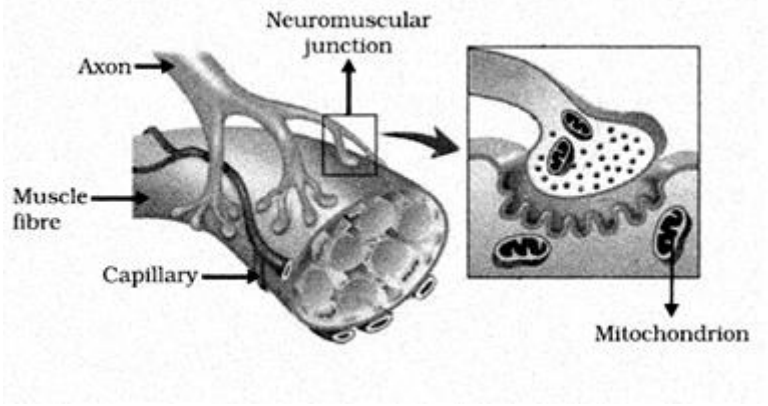
Types of neuron:

- Sensory neuron: These neurons receive signals from a sense organ.
- Motor neuron: These neurons send signals to a muscle or a gland.
- Association or relay neuron: These neurons relay the signals between sensory neuron and motor neuron.

Synapse: The point contact between the terminal branches of axon of one neuron with the dendrite of another neuron is called synapse.

Neuromuscular Junction (NMJ): NMJ is the point where a muscle fibre comes in contact with a motor neuron carrying nerve impulse from the control nervous system.

Axon terminals of a neuron and the dendrites of another neuron are separated by a fine gap, i.e. a synaptic cleft. The nerve impulse is sent across the synaptic cleft with the help of the neurotransmitter acetylcholine.



Working of Neuron:

Neurons are responsible for transmitting message from brain to body parts and vice versa. When receptors sense anything, a chemical reaction is triggered. This chemical reaction causes an electrical impulse in dendrites. This impulse travels through the body of neuron to axon endings. Tiny amount of chemical is released in synapse by axon endings when impulse reaches there. This chemical crosses the synapse and reach to tip of dendrites where it again produces electrical impulse. And then this impulse travels along neuron.

Transmission of nerve impulse: Nerve impulses travel in the following manner from one neutron to the next:

Dendrites → cell body → axon → nerve endings at the tip of axon → synapse → dendrite of next neuron.

Chemical released from axon tip of one neuron, cross the synapse or neuromuscular junction to reach the next cell.

Human Nervous System: The nervous system in humans can be divided into two main parts:

- Central nervous system
- Peripheral nervous system
- Autonomous Nervous System

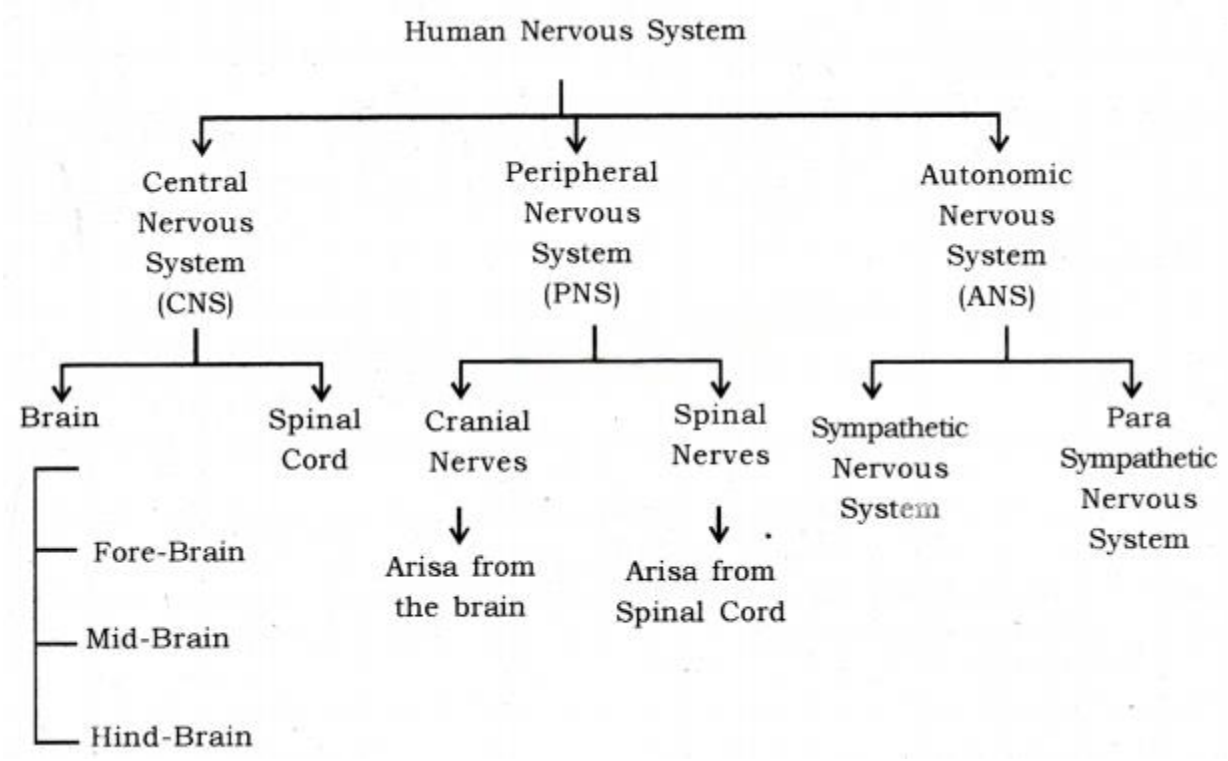
Central Nervous System (CNS): The central nervous system is composed of the brain and the spinal cord. The brain controls all the functions in the human body. The spinal cord works as the relay channel for signals between the brain and the peripheral nervous system.

Peripheral Nervous System (PNS): The peripheral nervous system is composed of the Cranial nerves, Spinal nerves and Visceral nerves.

- **Cranial Nerves:** There are 12 pairs of cranial nerves. The cranial nerves come out of the brain and go to the sense organs and muscles in the head region.
- **Spinal Nerves:** There are 31 pairs of spinal nerves. The spinal nerves come out of the spinal cord and go to the sense organs and muscles which are below the head region. These nerves carry message to brain through spinal cord.
- **Visceral Nerves:** The visceral nerves come out of the brain and spinal cord and go to the internal organs (like heart, kidney etc.)

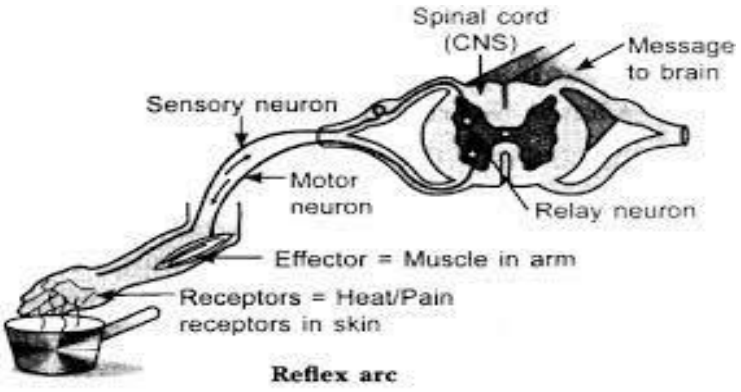
Autonomous Nervous System: The autonomous nervous system is composed of a chain of nerve ganglion which runs along the spinal cord. It controls all the involuntary actions in the human body. The autonomous nervous system can be divided into two parts:

- **Sympathetic Nervous System:** This part of the autonomous nervous system heightens the activity of an organ as per the need. For example, during running, there is an increased demand for oxygen by the body. This is fulfilled by an increased breathing rate and increased heart rate. The sympathetic nervous system works to increase the breathing rate the heart rate, in this case.
- **Parasympathetic Nervous System:** This part of the autonomous nervous system slows the down the activity of an organ and thus has a calming effect. During sleep, the breathing rate slows down and so does the heart rate. This is facilitated by the parasympathetic nervous system. It can be said that the parasympathetic nervous system helps in the conservation of energy.

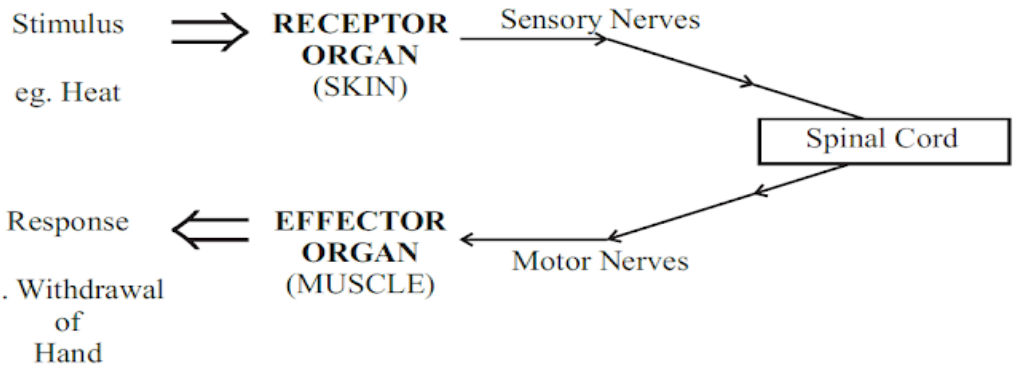


Reflex action: It is a quick, automatic and involuntary action as to the change in environment (stimulus) that involves only spinal cord. Reflex actions occur within fractions of seconds.

Reflex arc: It is the pathway through which reflex action occurs.



Reflex arc

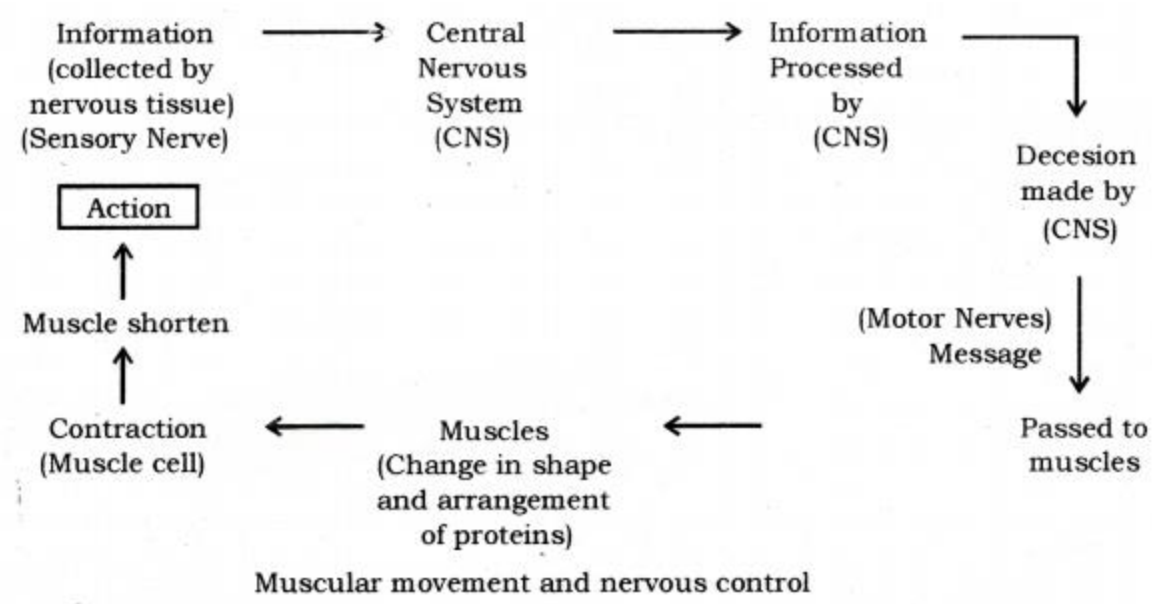


Types of Reflexes / Reflex actions

1. **Cerebral Reflex:** A cerebral / cranial reflex is one that is controlled by one of the cranial nerves and tends to take place in the facial or head area. For ex. Change in size of pupil in bright light etc.
2. **Spinal Reflex:** A spinal reflex is a reflex that involves only the spinal nerves and spinal cord and is not processed by the brain. For ex. take off the hand on touching a hot object.

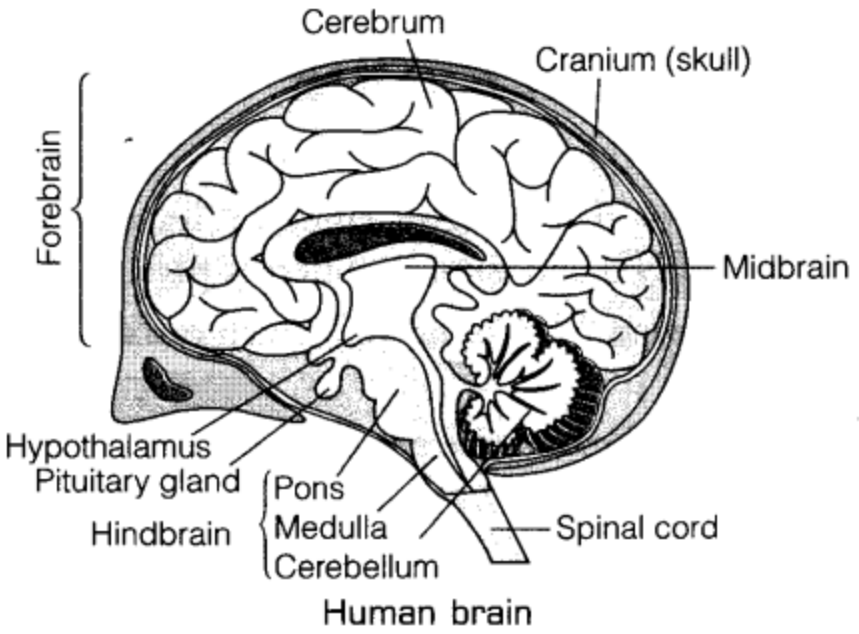
How Muscles (Effectors) cause Movement?

Muscles are made up of muscle cells which have special proteins. These proteins can change their arrangement on receiving message from brain. When they do so, shape of muscle changes. They can contract or expand. This contraction and expansion can cause movement in body parts.



Muscular movement and nervous control

Brain: Brain controls all the functions in the human body. It is surrounded by a skull/ cranium. Cerebrospinal fluid is filled between the skull and the brain. Cranium and cerebrospinal fluid protect the brain from external shocks.



Human brain

Parts of Human Brain :

- Fore-brain: It is composed of the cerebrum.
- Mid-brain: It is composed of the hypothalamus.
- Hind-brain: It is composed of the cerebellum, pons, medulla, oblongata.

Forebrain: Forebrain consists of cerebrum, hypothalamus and thalamus. Forebrain is specialized in hearing, sight, smell etc. It also controls voluntary movements in our body such as movement of leg muscles. Centre for hunger is also located in the separate part of forebrain. Cerebrum or the cerebral cortex consists of 4 lobes- parietal lobe, temporal lobe, occipital lobe and frontal lobes.

Hypothalamus: The hypothalamus lies at the base of the cerebrum. It controls sleep and wake cycle (circadian rhythm) of the body. It also controls the urges for eating and drinking.

Cerebellum: Cerebellum lies below the cerebrum and at the back of the whole structure. It coordinates the motor functions. When you are riding your bicycle, the perfect coordination between your pedalling and steering control is achieved by the cerebellum.

- It controls posture and balance.
- It controls the precision of voluntary action.

Medulla: Medulla forms the brain stem, along with the pons. It lies at the base of the brain and continues into the spinal cord. The medulla controls various involuntary functions, like hear beat respiration, etc.
It controls involuntary actions.
Example: Blood pressure, salivation, vomiting.

Pons: It relays impulses between the lower cerebellum and spinal cord, and higher parts of the brain like the cerebrum and midbrain, also regulates respiration.

Spinal Cord: Spinal cord is started at medulla (Hind brain) and extends to downward. It is enclosed by a bony structure called Vertebral column at back centre of body.

Function:

- It carries message between brain and nerves.
- It controls spinal reflexes.

Endocrine System:
The endocrine system is composed of several endocrine glands.

Glands: Glands are organs in our body which excrete a liquid substance having some different chemicals. This liquid is called secretion of the gland. Glands are of two types –

Exocrine Glands: Glands that have ducts are called **exocrine glands.** The secretions of exocrine glands reach their target by traveling through a duct (tube). Some examples of exocrine glands are sweat glands and salivary glands.

Endocrine Glands: The endocrine glands do not have ducts to carry their product to a surface. They are called ductless glands. Hormones are the chemical substances produced by endocrine glands. These glands secrete their hormones directly into the blood vessels. Blood carries the secretion to different parts.

Thus **Endocrine System** is the system of endocrine glands in our body which secretes chemical substances called "**Hormones**". This system controls various activities of our body for example growth of body.

Endocrine Glands in Body:

Endocrine Gland	**Hormone**	**Location**	**Function**
Pineal Gland	Melatonin	Close to centre of brain	Regulates sleep cycle
Hypothalamus	Secrete many hormones	Below mid brain	-Controls pituitary gland. -Controls secretion of many other glands.
Pituitary Gland	Secrete many hormones for ex. Growth hormones, thyroid stimulating hormone etc.	Below hypothalamus in brain	-Growth hormones stimulate growth of muscles, bones. -Regulates secretion of many other glands.
Thyroid Gland	Thyroxine (Iodine is necessary for secretion of thyroxine).	Around wind pipe in neck	-Regulates metabolism of carbohydrates, fats & proteins.
Parathyroid Gland	Parathormone	On thyroid gland	Regulates the level of calcium & phosphate in body.
Thymus Gland	Thymus hormone	In upper part of chest between lungs.	Plays important role in development of immune system.
Adrenal Gland	Adrenaline	On top of kidneys.	-Secretes in small amount all the time. -But sometimes for extra energy, more adrenaline hormone is secreted by it. -It prepares the body for emergency situations, excitement and anger.

Pancreas	Insulin	Below stomach	Regulates the amount of sugar in blood.
Testes (in males)	Testosterone	In scrotum	Sperm production, development of sex organs during puberty.
Ovary (in females)	Oestrogen & Progesterone	In the pelvis	Egg production, development of sex organs during puberty.

Feedback Mechanism: A type of self-regulating mechanism in which the level of one substance in body influences the level of another. Feedback mechanism takes care that right amount of hormones are secreted by glands. Whenever there is a change in the normal state, messages are sent to increase secretions if there is a fall below the normal levels or to decrease secretions if there is a rise above the normal levels to restore the normal body state. Such a mechanism is called Negative Feedback Mechanism. Example- The increase in blood sugar level stimulates the secretion of insulin so that the sugar level is maintained. If there is a fall in the blood sugar level below normal, it stimulates the secretion of glucagon. Glucagon stimulates the breakdown of glycogen to glucose, and thus the normal sugar level is maintained.

Nervous System Vs Endocrine System

Nervous System	Endocrine System
Messages are in form of electrical impulses over nerves.	Messages are in form of chemicals through blood.
Messages travel fast.	Messages travel slow.
Messages have short term effect.	Messages have long term effect.

Need for Endocrine System:

- Nervous system is not very efficient in controlling large number of organs at the same time for a particular job. In such situations endocrine system is better.
- Nervous system is not meant for sending continuous messages for long time periods. But endocrine system can easily send continuous chemical messages in slow and steady manner. So endocrine system is better for controlling slow processes such as body growth.

Control and Coordination in Plants:

Animals Vs Plants

Animals	Plants
Control and coordination is more complicated in animals.	Simpler in plants.
Animals have nervous system and endocrine system (system of hormones) for control and coordination.	Plants do not have nervous system. Different hormones are responsible for control and coordination in plants.
Animals have specific glands to secrete hormones.	Plants do not have specific glands for secretion of hormones.

Some Important Plant Hormones: Plant hormones control some aspects of the growth of plants such as cell division, cell enlargement and cell differentiation.

Phytohormones	Description
Auxins	Promote growth of plants. They are secreted by the cells present in the tip of stems and roots.
Gibberellins	Promote cell differentiation in the presence of auxins. They break seed dormancy. Stimulate elongation of shoots.
Cytokinins	Promote cell division in plants. Delay ageing of leaves. Promote opening of stomata. Promote fruit growth.
Abscisic Acid	Acts as a growth inhibitor. It promotes dormancy in seeds and buds. Promotes closing of stomata. Promotes wilting and falling of leaves. Detachment of flowers and fruits from the plants is due to abscisic acid.

Movement in Plants

Movement in plants can be divided into two main types –

1. Tropic movement 2. Nastic movement.

S.No.		Nastic movements	Tropic movements
1.	Growth	Growth independent movements	Growth dependent movements
2.	Time of action	Immediate	Slow
3.	Response to stimulus	Non-directional	Directional
4.	Reason for action	Change in turgor	Cell division
5.	Alternate name	Nastics	Tropism
6.	Examples	Folding of leaves of touch me - not (mimosa), opening and closing of stomata.	Phototropism, geotropism, hydropism, chemotropism.

Tropic movement/Tropism is the movement of plants in which direction of movement is guided by the direction of external stimulus causing the movement.

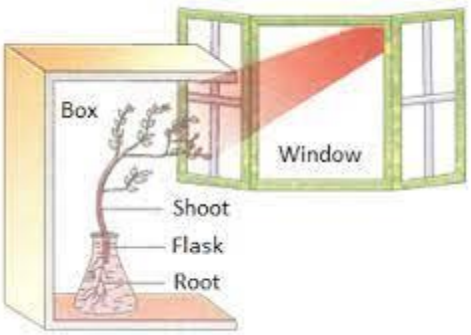
Nastic movement is the movement of plants in which direction of movement is **not** guided by the direction of any stimulus causing the movement.

Tropism/ Tropic movement

Tropic movements happen as a result of growth of a part of plant in a particular direction. Tropic movements can be of many types such as:

Phototropism

Phototropism is the growth movement of parts of plants in response to light. Growth towards a source of light is called positive phototropism. Growth away from the source of light is termed negative phototropism. Stems usually show positive phototropic movement, while roots usually show negative phototropic movement.



Mechanism of Phototropism

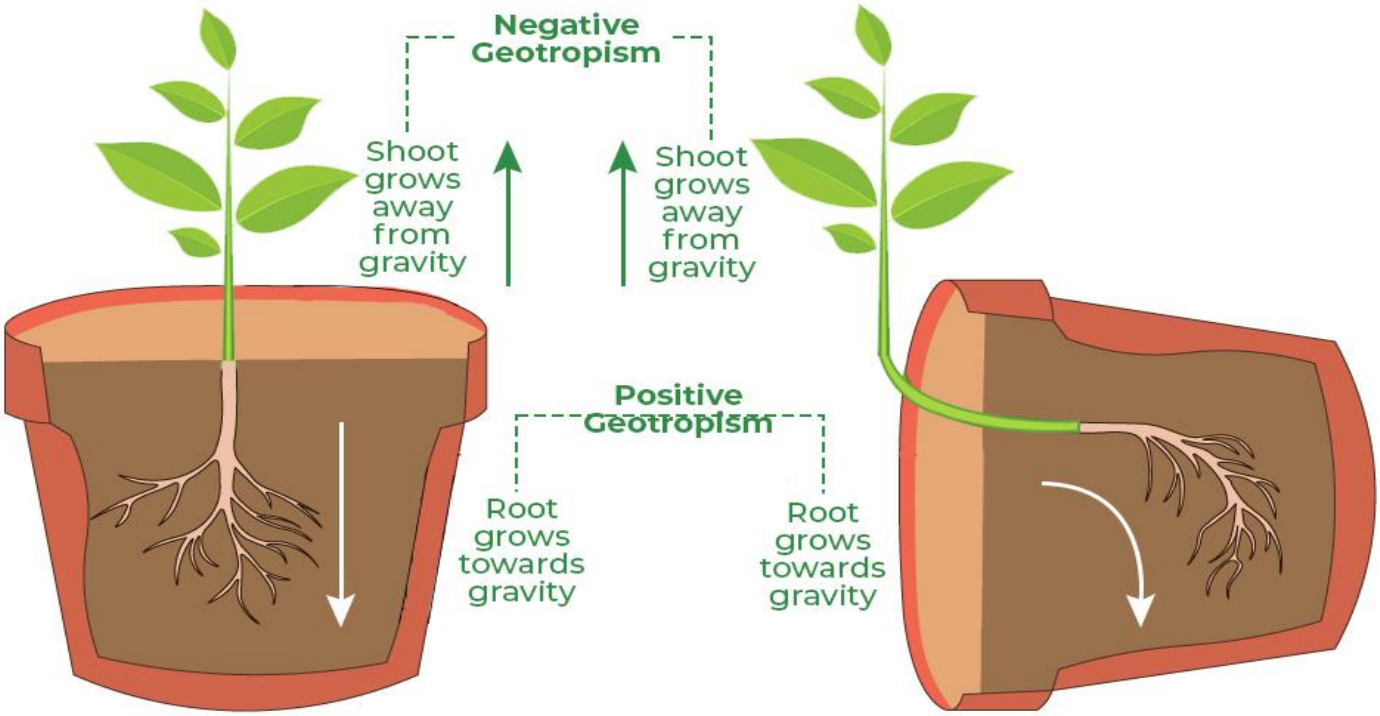
Auxin hormones cause growth in the part of stem where it is present in more amounts. But it prefers to accumulate more in regions of stem getting less light.

When light comes from top, all sides of stem get same light. Thus auxin is uniformaly distributed in stem and stem grows straight. But when light comes only from one side, auxin hormones gather on the other side and causing more growth on that side. This leads to bending of stem towards light.

Geotropism:

When steam and root of plant move against and along the direction of gravity, it is called geotropism.

Stems usually show negative geotropic movement to get light and air. Roots usually show positive geotropic movement i.e. towards the direction of the gravity to get water and nutrients from soil.



Hydrotropism:

Movement of root towards water is called hydrotropism. This shows a positive hydrotropic movement. Growth hormones in root are responsible for bending of root towards the direction of water.

Thigmotropism:

It is the growth movement of stem of some plants over a surface influenced by touch. The plant grows in a way so as it can coil around a support. Such movements are seen in creepers for ex. Money plant.
The amount of auxin reduces in the portion of steam touching the stick. More auxin is present on the other side of stem which results in more growth on that side. This leads in the bending of stem around the contact surface.

Chemotropism:

Movement of plant or parts of plant in response to a chemical stimulus is called chemotropism. In positive chemotropism, movement is toward the chemical. In negative chemotropism, movement is away from the chemical. Growth of pollen tube from pollen to ovary under the influence of chemical released by ovary is an example of chemotropism.

Nastic movement (Nasty): Nastic movements are the movements in which direction of the response is not dependent on the direction of the stimulus.

For example, when we touch the leaves of Mimosa pudica / touch-me-not plant, its leaves fold inward and droop. The drooping is independent of the direction from which the leaves are touched.

Such movements happen because when we touch the leaf, an electro-chemical signal travels to pulvinus. Pulvinus is a joint at the base of plant leaf which is tightly filled with water. Due to this, it remains firm and holds the leaf upright. When electro-chemical signal reaches to pulvinus, this signal makes pulvinus loose its water and thus firmness. So the leaf folds inward and droops. After some time the parenchyma cells of pulvini again regain their turgor pressure and opens up.