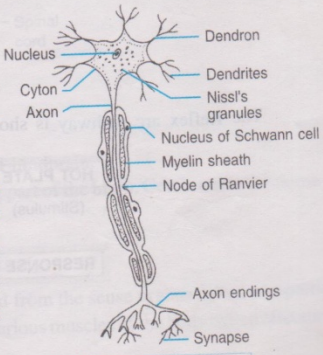
5 Control and Coordination

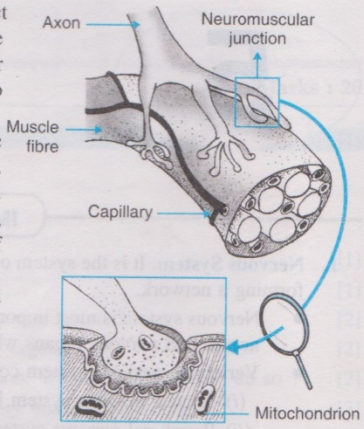
IMPORTANT TERMS AND CONCEPTS

1. **Nervous System.** It is the system of conducting tissues that receives the stimulus and transmits it to other parts of the body forming a network.
   - Nervous system is most important for regulation, control and coordination of body functions. It comprises of neurons, nerves and nervous organs which controls, links and coordinates the activities of different organs of the body.
   - Vertebrate nervous system consists of two parts :
     (*i*) Central nervous system including brain and spinal cord.
     (*ii*) Peripheral nervous system including cranial, spinal and visceral nerves.
2. **Functions of the Nervous System :**
   (*i*) It regulates involuntary actions.
   (*ii*) It controls and coordinates voluntary muscular activities.
   (*iii*) It keeps us informed about the outside world through the sense organs.
   (*iv*) It enables us to think, reason and remember.
   (*v*) It controls all the reflex actions in our body, thus protecting it from harm.
3. **Receptor.** It is a cell or group of cells specialised to detect a particular stimulus and to initiate the transmission of impulses *via* the sensory nerves.
   - The eyes, ears, nose, tongue and skin all contain specific receptors responding to external stimuli.
   - There are five receptors or sense organs through which the animals receive stimuli or external informations.
   - These receptors are photoreceptors for light (eyes), phonoreceptors for sounds (ears), gustatory receptors for taste (tongue), olfactoreceptors for smell (nose) and thigmoreceptors for touch (skin).
   - The receptors pass information to the brain through a type of nerve cells called sensory neurons.
   - **Motor neurons** transmit information from the brain to the effector organs, mainly muscles and glands.
4. **Unit of Nervous System.** The units which make up the nervous system are called nerve cells or neurons. So, neurons are the structural and functional unit of the nervous system.
   - Neuron is the largest cell in the body.
   - Neurons carry messages in the form of electrical signals called nerve impulses.
   - Neuron is an elongated branched cell having three components — Cell body, Dendrites and Axon.
     (*i*) **Cell body or Cyton.** It is like a typical cell containing a central nucleus and surrounding cytoplasm. Around the nucleus there are granules called Nissl's granules. Stimulus is changed into impulse in the cyton.
     (*ii*) **Dendrites.** They are short and branched processes connected to the cyton. They receive sensation or stimulus, which may be physical, chemical, mechanical or electrical.
     (*iii*) **Axon.** It is the longest part of the neuron. It is a single, elongated fibre arising from one side of cyton. It conducts impulses away from the cell body. The plasma membrane of an axon is covered by a protective sheath called myelin sheath. It is broken into constrictions called the Nodes of Ranvier. The axon endings are branched and are called synaptic terminals.
5. **Synapse.** It is the junction between two adjacent neurons or nerve cells, *i.e.*, between the axon ending of one and the dendrites of the next.
6. **Nerve Impulse.** It is the information in the form of chemical and electrical signals passing through neurons. These impulses are carried by dendrites towards the cell body.



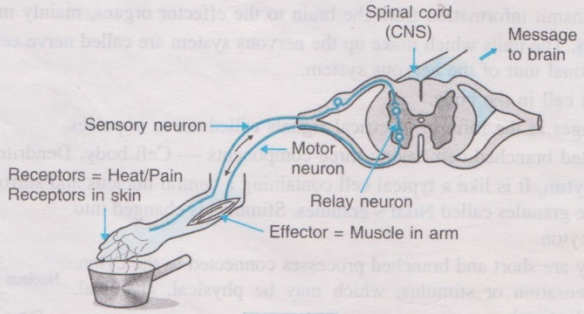
A nerve cell (Neuron)

7. **Neuromuscular Junction.** It is the point where a muscle fibre comes in contact with a motor neuron carrying nerve impulses from the central nervous system. The impulses travel from the neuron to the muscle fibre by means of a neurotransmitter in the same way as the transmission of impulses across a synapse between two neurons.



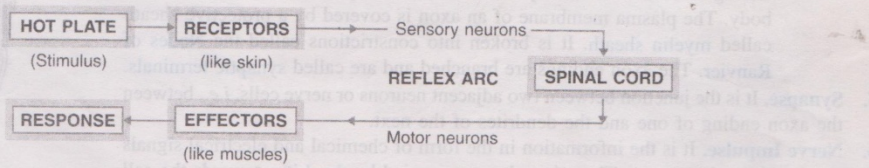
Neuromuscular junction

8. **Transmission of Nerve Impulse.** The information acquired at the end of the dendritic tip of a neuron sets off a chemical reaction which creates an electrical impulse. This impulse travels from the dendrite to the cyton along the axon to its end. At the end of the axon, the electrical impulse sets off the release of some chemicals, which cross the synapse and start a similar electrical impulse in a dendrite of the next neuron. In this way nerve impulses travel in the body.
9. **Voluntary Action.** These are the actions which need thinking and are performed knowingly, *i.e.*, are controlled by conscious thought, like speaking to a friend, writing a letter, etc.
10. **Involuntary Action.** These are not under the control of the will of an individual and are automatic response to a stimulus which is not under the voluntary control of the brain, like touching a hot plate unknowingly.
11. **Reflex Action.** It is defined as an unconscious, automatic and involuntary response of effectors, *i.e.*, muscles and glands, to a stimulus, which is monitored through the spinal cord.
12. **Mechanism of Reflex Action.** It involves the following steps :
    (*i*) Receptor organ like skin perceives the stimulus and activates a sensory nerve impulse.
    (*ii*) Sensory organ carries message in the form of sensory impulse to the spinal cord.
    (*iii*) The spinal cord acts as modulator. The neurons of spinal cord transmit the sensory nerve impulse to motor neuron.
    (*iv*) Motor nerve conducts these impulses to the effectors like leg muscles which responds by pulling back the organ away from the harmful stimulus.
13. **Advantages of Reflex Action.**
    (*i*) It enables the body to give quick responses to harmful stimuli and thus protects our body.
    (*ii*) It minimises the overloading of brain.
14. **Reflex Arc.** It is the pathway taken by the nerve impulses and responses in a reflex action, *i.e.*, from the receptor organs like skin to the spinal cord and from the spinal cord to the effector organs like muscles.

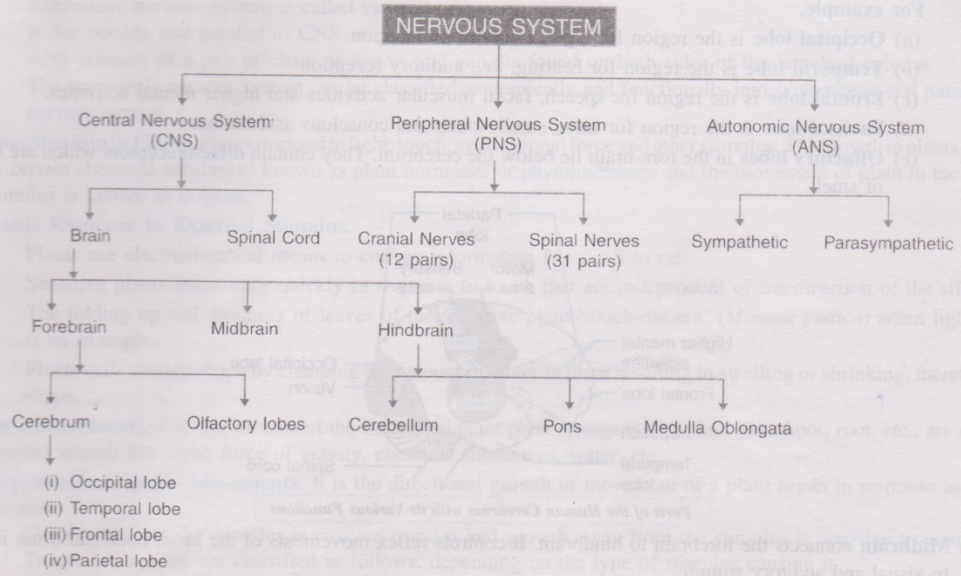


Reflex arc

The Reflex arc pathway is shown in the flow chart as follows :

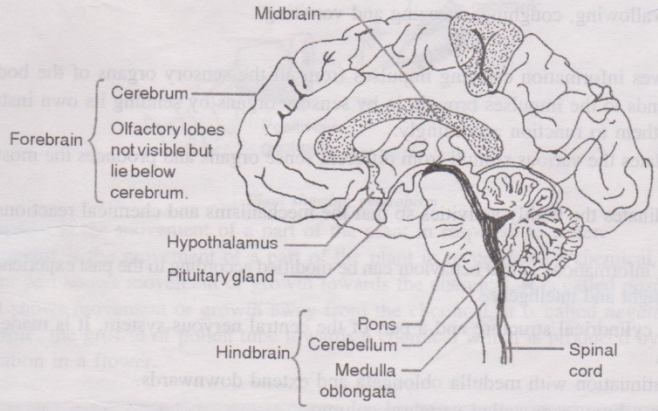


15. Human Nervous System



16. Central Nervous System. The CNS consists of the brain and the spinal cord.
The brain and the spinal cord are protected by the skeleton – brain by the cranium and spinal cord by the vertebral column.

17. Brain. It is the highest coordinating centre in the body.



Human Brain

- The brain is broadly divided into three regions : Forebrain, midbrain and hindbrain.

(*i*) **Forebrain** includes cerebrum and olfactory lobes. Forebrain is the main thinking part of the brain. Cerebrum is the dome-shaped roof of the brain.

- It is the largest part of the brain.
- Different areas of cerebrum have different functions.
  For example, the cerebrum has sensory areas where information is received from the sense organs called receptors. Similarly, cerebrum has motor areas from where instructions are sent to the various muscles of the body called effectors to do the various jobs.

- There are specific regions in cerebrum for each kind of stimulus and response.

For example,

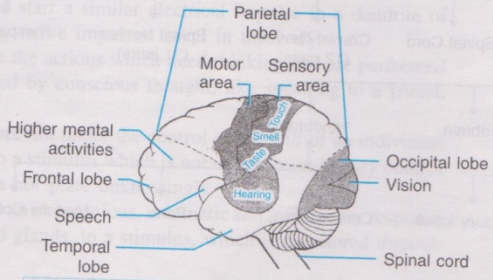
(*a*) **Occipital lobe** is the region for sight, *i.e.*, visual reception.

(*b*) **Temporal lobe** is the region for hearing, *i.e.*, auditory reception.

(*c*) **Frontal lobe** is the region for speech, facial muscular activities and higher mental activities.

(*d*) **Parietal lobe** is the region for taste, smell, touch and conscious association.

(*e*) **Olfactory lobes** in the fore-brain lie below the cerebrum. They contain olfactoreceptors which are the organs of smell.



Parts of the Human Cerebrum with its Various Functions

(*ii*) **Midbrain** connects the forebrain to hindbrain. It controls reflex movements of the head, neck and trunk in response to visual and auditory stimuli.

(*iii*) **Hindbrain.** It consists of three centres called cerebellum, pons and medulla oblongata.

- **Cerebellum** lies at the roof of the hindbrain. This region controls the coordination of body movements and posture.
- **Pons** lie just above the medulla and take part in regulating respiration.
- **Medulla oblongata** lies at the floor of the hindbrain and continues into the spinal cord. It is also the regulating centre for swallowing, coughing, sneezing and vomiting.

18. Functions of Brain

(*i*) The brain receives information carrying impulses from all the sensory organs of the body.

(*ii*) The brain responds to the impulses brought in by sensory organs by sending its own instructions to the muscles and glands causing them to function accordingly.

(*iii*) The brain correlates the various stimuli from different sense organs and produces the most appropriate and intelligent response.

(*iv*) The brain coordinates the bodily activities so that the mechanisms and chemical reactions of the body work together efficiently.

(*v*) The brain stores 'information' so that behaviour can be modified according to the past experience. This function makes brain the organ of thought and intelligence.

19. Spinal Cord. It is a cylindrical structure and a part of the central nervous system. It is made up of nerves which supply information to think.

- It begins in continuation with medulla oblongata and extend downwards.
- It is enclosed in a bony cage called vertebral column.
- A total of thirty one pairs of spinal nerves arise from the spinal cord.

20. Functions of Spinal Cord

- Spinal cord is the main centre of reflex action.
- It is concerned with the conduction of nerve impulses to and from the brain.

21. Peripheral Nervous System. It consists of the cranial and spinal nerves along with their branches.

(*i*) **Cranial nerves** arise from the brain and spread throughout the head.

- There are twelve pairs of cranial nerves.

(*ii*) **Spinal Nerves** arise from the spinal cord along most of its length and spread throughout the body.

- There are 31 pairs of spinal nerves – eight in the neck region, twelve in chest region, five in abdominal region, five in hip region and one in the coccyx region. Coccyx is the last bone of the vertebral column.

22. **Autonomic Nervous System (ANS).** It means 'self governing nervous system'.
- Autonomic nervous system is called visceral nervous system.
- It lies outside and parallel to CNS.
- ANS consists of a pair of chain of nerves and ganglia found on both sides of the vertebral column.
- The autonomic nervous system can be classified anatomically and functionally into sympathetic and parasympathetic nervous system.

23. **Coordination in Plants.** Plants respond to light, touch, gravitational force and other stimulus. The growth in plants is controlled by certain chemical substances known as plant hormones or phytohormones and the movement of plant in the direction of stimulus is known as tropism.

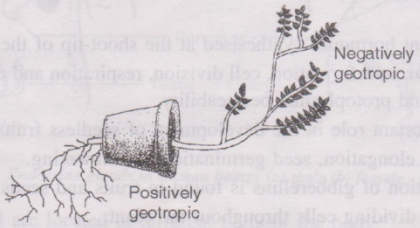
24. **Plants Response to External Stimulus.**
- Plants use electrochemical means to convey information from cell to cell.
- Sensitive plants move very quickly in response to touch that are independent of the direction of the stimuli.
- The folding up and drooping of leaves of the sensitive plant 'touch-me-not' (*Mimosa pudica*) when lightly touched is an example.
- Plants cells change shape by changing the amount of water in them resulting in swelling or shrinking, thereby changing shape.

25. **Plant Movements.** The movements of the individual plant parts or organs of a plant like shoot, root, etc., are due to some external stimuli like light, force of gravity, chemical substances, water, etc.

26. **Directional or Tropic Movements.** It is the directional growth or movement of a plant organ in response to an external stimulus.
- Growth towards the stimulus is positive tropism and growth away from the stimulus is negative tropism.
- Tropic movements are classified as follows, depending on the type of stimulus causing it :

(*i*) **Phototropism** is the movement of a part of the plant in response to light.

(*ii*) **Geotropism** is the upward and downward growth of shoots and roots in response to the pull of earth or gravity.



Plant showing geotropism

(*iii*) **Hydrotropism** is the movement of a part of the plant in response to water.

(*iv*) **Chemotropism** is the movement of a part of the plant in response to a chemical stimulus.

If the plant part shows movement or growth towards the chemical, it is called *positive chemotropism* and if the plant part shows movement or growth away from the chemical, it is called *negative chemotropism*.

For example, the growth of pollen tube towards a chemical which is produced by an ovule during the process of fertilisation in a flower.

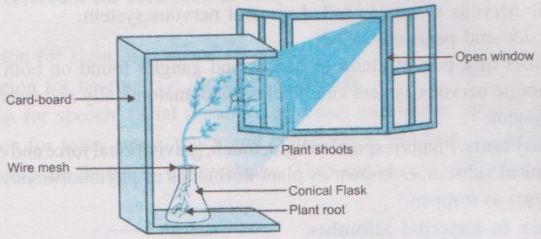
NCERT ACTIVITY

Aim : To study the response of plant to light.

Materials required : Conical flask, small piece of wire mesh, water, two or three freshly germinated bean seeds and cardboard box open from one side

Procedure :
1. Fill a conical flask with water.
2. Cover the neck of the flask with a wire mesh.
3. Place 2-3 freshly germinated bean seeds on the wire mesh.
4. Keep this flask in the cardboard box in such a manner that the open side of the box receives light coming from window.
5. Observe the plant after 2-3 days.
6. Turn the flask so that the shoots are away from light and the roots towards light.

7. Keep the apparatus undisturbed in this condition for a few days.



Response of plant to direction of light

Observation : **1.** In the first observation after 2-3 days of the experiment it is found that the shoot bends towards light and roots away from light.

2. In the second observation, when the flask was turned, it is seen after few days that the shoots have again grown by bending towards light and the roots have again grown by bending away from light.

Conclusion : This shows that the shoots of plants respond by showing growth movement towards light called *positive photostropism* and roots of plants respond by showing growth movement away from light called *negative phototropism*.

27. Plant Hormones or Phytohormones. It can be defined as a chemical substance which is produced naturally in plants and are capable of translocation and regulating one or more physiological processes when present in low concentration.

- Plant hormones help to coordinate growth, development and responses in the environment.
- They are synthesised at places away from where they act and simply diffuse in the area of action.

28. Types of Phytohormones. The major types of plant hormones which are involved in the control and coordination in plants are as follows :

(*i*) **Auxins** are the group of plant hormones synthesised at the shoot-tip of the plant body.
- It promotes cell elongation, root formation, cell division, respiration and other physiological processes like protein synthesis, water uptake and protoplasmic permeability.
- Auxins also play an important role in the development of seedless fruits.

(*ii*) **Gibberellins** stimulate stem elongation, seed germination and flowering.
- The maximum concentration of gibberellins is found in fruits and seeds.

(*iii*) **Cytokinins** are produced in dividing cells throughout the plant.
- In mature plants, cytokinins are produced in the root tips and are transported to the shoots.
- Cytokinins promote cell division and also helps in breaking the dormancy of seeds and buds and regulate the phloem transport.
- Cytokinins delay the ageing in leaves and promote the opening of stomata.

(*iv*) **Abscisic Acid (ABA) .** It is a growth inhibitor which reverses the growth-promoting effects of auxins and gibberellins. Its effect include wilting of leaves.
- It causes dormancy of seeds, tubers and bulbs.
- It promotes the closing of stomata and is responsible for the loss of RNA, proteins and chlorophylls.

29. Functions of Plant Hormones. The plant hormones regulate many functions in plants, which are as follows :

(*i*) Germination of seeds or breaking the dormancy of seeds,
(*ii*) Growth of root, stem and leaves,
(*iii*) Flowering of plants,
(*iv*) Ripening of fruits,
(*v*) Movement of stomata in leaves, and
(*vi*) Phototropism, geotropism, chemotropism and nastic movements.

30. Hormones are the chemical substances which coordinate and control the activities of living organisms and also their growth.

31. Characteristics and Functions of Hormones

(*i*) Hormones are the secretions of endocrine glands or tissues.
(*ii*) They are poured directly into the blood and carried throughout the body by blood circulatory system.

(*iii*) Hormones have their effect at the sites different from the sites where they are made. So, they are also called 'chemical messengers'.

(*iv*) They act on specific tissues or organs called 'target organs'.

(*v*) They coordinate the activities of the body and also its growth.

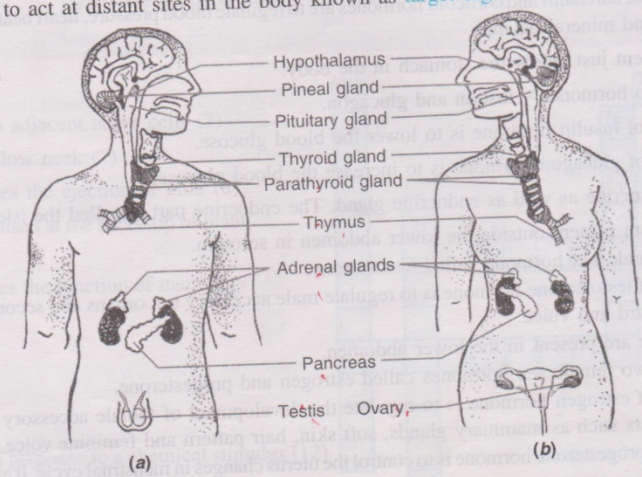
(*vi*) They are secreted in extremely minute quantities.

(*vii*) Chemically, hormones may be polypeptides and proteins, amino acids and their derivatives or steroids.

(*viii*) Hormones help the body to cope with emergency demands such as infection, trauma, dehydration, starvation, haemorrhage and extreme temperature.

2. **Hormones in Animals.** Hormones are the means of information transmission in animals. Animal hormones are a part of the endocrine system which constitute a second way of control and coordination in their body.

3. **Endocrine glands.** They are a structure or group of cells or tissue which manufacture hormones and secretes them directly into the bloodstream to act at distant sites in the body known as target organs or cells.



Endocrine glands in human beings (a) male (b) female

- They are ductless glands and are located at different parts of the body.
- The endocrine glands present in human includes hypothalamus, pituitary (hypophysis), pineal, thyroid, parathyroid, pancreas, adrenal, testes (in males) and ovaries (in females).
- Some endocrine glands like pancreas, testis and ovary perform dual functions, *i.e.*, both exocrine and endocrine functions.

(*i*) **Hypothalamus gland** is present in the brain.

- It produces 'releasing hormones'.
- It regulates the secretion of hormones from pituitary gland.

(*ii*) **Pituitary glands (Hypophysis)** is present at the base of the brain. It is also known as the master gland as it controls the other endocrine glands.

The pituitary gland secretes five hormones :

- **Growth hormone (GH)** regulates the growth and development of bones and muscles.
- **Trophic hormone** regulates the secretion of hormones from other endocrine glands like adrenal glands, thyroid gland, testes and ovaries.
- **Prolactin hormone** regulates the function of mammary glands in females.
- **Vasopressin hormone** regulates water and electrolyte balance in the body.
- **Oxytocin hormone** regulates the ejection of milk during lactation.
- **Pineal gland** is present in the brain near to the pituitary gland. It secretes melatonin hormone which delays sexual development and promotes sleep.

(*iii*) **Thyroid gland** is present just below the neck.

- Iodine is necessary for the thyroid gland to make thyroxine hormone.
- It secretes a hormone called thyroxine which regulates the metabolism of carbohydrates, fats and proteins in the body so as to provide the best balance for growth.

(*iv*) **Parathyroid glands** are four in number, which are embedded in the thyroid gland.

- They secrete a hormone called calcitonin, which regulates calcium and phosphate levels in the blood.

(*v*) Thymus are paired structure present on either side of the trachea. It secretes the hormone thymosin which activates immune responses and helps in the production of antibodies.

(*vi*) **Adrenal glands** are two in numbers, which are located one on top of each kidney.

- Adrenal glands secrete two hormones — adrenalin and corticoids.
- The functions of adrenalin and corticoid hormones are to regulate blood pressure, heart beat, breathing rate, carbohydrate metabolism and mineral balance.

(*vii*) **Pancreas** is present just below the stomach in the body.

- It secretes two hormones – insulin and glucagon.
- The function of insulin hormone is to lower the blood glucose.
- The function of glucagon hormone is to increase the blood glucose.
- Pancreas is exocrine as well as endocrine gland. The endocrine part is called the islets of langerhans.

(*viii*) **Testes** in males are present outside the lower abdomen in scrotum.

- They secrete male sex hormone called testosterone.
- The function of testosterone hormone is to regulate male accessory sex organs and secondary sexual characters like moustache, beard and voice.

(*ix*) **Ovaries** in female are present in the lower abdomen.

- They secrete two female sex hormones called estrogen and progesterone.
- The function of estrogen hormone is to regulate the development of female accessory sex organs and secondary sexual characters such as mammary glands, soft skin, hair pattern and feminine voice.
- The function of progesterone hormone is to control the uterus changes in menstrual cycle. It also helps in the maintenance of pregnancy.