Control and Co-ordination

All living organisms including plants and animals respond and react to environmental factors or stimuli. The method of reacting to stimuli is not similar in plants and animals. They react to stimuli in different ways. For example, plants bend towards light but animals do not bend towards light. The animal Amoeba react to the presence of food by moving towards the food particle. The animals can react to stimuli in many different ways because they have a nervous system and an endocrine system involving hormones. The plants, however, react to stimuli in a very limited way. This is because the plants do not have a nervous system like the animals have. The plants use only the hormones for producing reaction to external stimuli.

The working together of the various organs of an organism in a systematic manner so as to produce a proper response to the stimulus, is called coordination. There is a necessity to develop some system for control and coordination of various body organs. In multicellular organisms, specialized tissues are used for control and coordination activities. Control and coordination in animals are provides by nervous, muscular and endocrine system. Chemical coordination is seen in both plants and animals and is responsible for growth and development.

CONTROL AND COORDINATION IN PLANTS

Plants, like animals, need internal coordination if their growth and development is to proceed in an orderly manner. In plants, control and coordination is not as highly developed as in animals. Plants cannot think, analyze or memorize as human beings because they lack brain and other parts of nervous system. However, plants respond to external stimuli like light, touch, gravitational force and other stimuli. Plants, in fact, show two different types of movements in response to various stimuli. One type of movements are independent of growth (e.g., movement of leaves of 'touch-me-not' plant, also called chhui-mui or 'sensitive plant', in response to touch). Other types of movements are dependent on growth (e.g., directional movement of seedling with root downwards and stem coming .up). Both these types of movements are affected by the action of plant hormones (phytohormones). In other words, plants coordinate their responses against environmental stimuli by using hormones. Plants, thus, possess only chemical coordination. The mode of action of hormones in plants is different from that in animals. In plants, the hormones coordinate their behavior in two ways:

(i) Affecting the growth of the plant and as a result part of the plant shows movement, and

(ii) Affecting the shape of plant cells by changing the amount of water in them (turgor changes), resulting in swelling or shrinking. Thus, growth and movements in plants are regulated by both external (environmental stimuli) and internal (hormones) factors.

PLANT MOVEMENTS

The movements in plant are not as apparent as in case of animals. Plants show two different types of movements:

(i) Movements independent of growth (Nastic movements).

(ii) Movement due to growth (Tropic movements or tropism).

Nastic movements

These are non-directional induced variation movements that occur due to turgor changes. These reveal immediate response to stimulus but do not involve growth. Nastic movements include seismonastic and nyctinastic movement.

(i) Seismonastic movements

Such movements occur in response to touch (shock). These movements are very quick and are best seen in 'touch-me-not' plant (Mimosa pudica), also called 'Chhui-mui' or 'Lajwanti' or 'sensitive plant'. As the 'touch-me-not'plant responds to touch stimulus, this phenomenon is also commonly called thigmonasty.

(ii) Nyctinastic movements

The movements involving the diurnal variation in the position of flowers and leaves of many plants in day and night are called nyctinastic or sleep movements. Nyctinastic movements include photonastic movements and thermonastic movements.

(a) Photonastic movements: If the diurnal variations in the position of plant parts (e.g., flowers and leaves of plants) are caused by the light stimulus, such non-directional movements are called photonastic movements. Example is dandelion flower. It opens up in the morning in bright light and closes in the evening when the light fades.

(b) Thermonastic movements: If the diurnal variations in the position of plant parts (e.g., flowers and leaves of plants) are caused by the change in temperature of the surroundings, such non-directional movements are called thermonastic movements.

Tropic movements or Tropisms

Directional movements or orientations of specific part of a plant in response to external stimuli are called tropisms or tropic movements. Tropic movements are very slow. The movement of the plant part can be either towards the stimulus or away from the stimulus.

- If the movement of the plant part is towards the stimulus, it is termed as positive tropism.
- If the movement of the plant part is away from the stimulus, it is termed as negative tropism.

Types of tropism

Light, force of gravity, chemical substances and water are the four common stimuli in the environment to which the plants respond. The responses of plants to these stimuli are termed as (i) phototropism (light), (ii) geotropism (gravity), (iii) chemotropism (chemical) and (iv) hydrotropism (water) respectively.

(i) Phototropism is the movement of a part of the plant in response to light. Shoots generally grow towards light and are said to be positively phototropic, while roots grow away from light and are said to be negatively phototropic.

(ii) Geotropism is the upward and downward growth of shoots and roots in response to the pull of earth or gravity. If the plant part moves in the direction of gravity, it is called positive geotropism. Alternatively, if the plant part moves against the direction of gravity, it is termed as negative geotropism.

Fig.: 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 movements or growth towards the chemical, it is called positive chemotropism and if the plant part shows movements 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 fertilization in a flower is an example of positive chemotropism.

ACTIVITY CORNER

To show response of plant parts to light (phototropism)

Materials required: Conical flask, water, wire mesh, 2-3 freshly germinated bean seeds, cardboard box open from one side.

Procedure: Take a conical flask- fill it with water. Cover the neck of the flask with a wire mesh. Now, keeps two or three freshly germinated seeds on the wire mesh. Keeps this flask in the cardboard box (open from one side) in such a manner that the open side of the box faces light coming from the window. Observe the plant after few days. Now, turn the flask so that the shoots are away from light and the roots towards light. Leave it undisturbed in this position for a few days and then observe the difference if any.

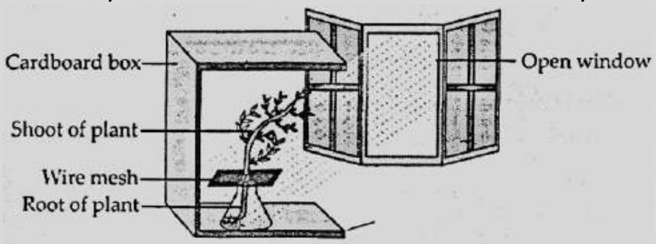


Fig.: Depicting response of the plant to the direction of light

Observations: (i) When the flask is placed in the

Observation: (i) When the flask is placed in the cardboard (open from one side) in a manner that the open side of box face light coming from the window, the shoots of freshly germinated seeds have shown growth by bending towards light (positive phototaxis) and rots have shown growth by bending away from light (negative phototaxis).

(ii) When the flask was turned in a manner that the shoots; moved away from light and roots moved towards light, it was found that after few days shoots have again grown by bending towards light and the roots have grown again by bending away from light. Towards light and the roots have grown again by bending -away 'from: light.

Conclusion: This experiment, therefore, shows that the shoots of plant respond by showing growth movement towards light (positive phototropism) and roots of plants respond by showing growth movement away from light (negative phototropism.)

To study the effects of gravity (geotropism).

Materials required: Small young potted plant, transparent bottle containing mineral solution, stand.

Procedure 1: Transfer a small young potted plant in the transparent bottle containing mineral solution. Observe the growth of roots and shoot of the plant

Observation 1: Young roots grow downward towards gravity and the young shoot grows upward against the gravity.

Procedure 2: Fix the bottle upside down with the help of stand and observe the growth of shoot and root.

Observation 2: Once again the roots start growing downward towards the gravity and the shoot starts growing upward against the gravity

Conclusion: This experiment, therefore, concludes that roots are positively geotropic while shoots are negatively geotropic.

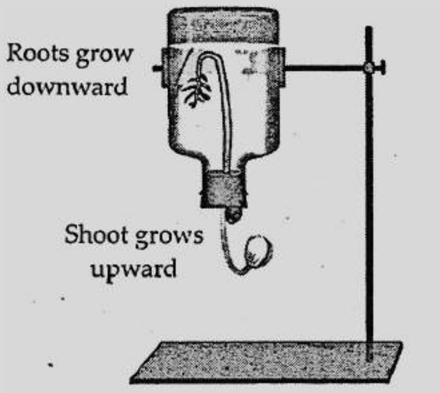
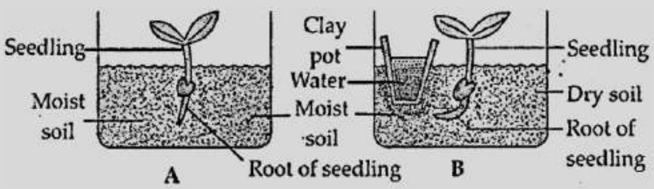


Fig. : Plant showing geotropism

To show the response of plant parts to water (hydrotropism)

Materials required: Plant a tiny seedling in each trough A and trough B. Now, place a small clay pot in the soil in trough B. Water the soil daily in trough A uniformly. However, in trough b, put water daily in clay pot only.

After few days carefully dig up the seedlings in both the glass troughs without damaging their roots.



Observation: In trough A, the root of seedling is straight. However, in trough B, the root of seedling is bent towards the direction of clay pot containing water.

Conclusion: In trough A, soil is watered uniformly daily. Therefore, the root of seedling gets water equally from all sides. Hence, it grows straight downwards. On the other hand, in trough B, the root of seedling only gets water that oozes out of clay pot buried in soil. Therefore, in trough B, the root of seedling grows by bending towards the direction of clay pot.

This experiment, thus, reveals the response of root of seedling (plant part) towards water (hydrotropism).

ILLUSTRATION

1. Design an experiment to demonstrate hydrotropism.

Ans. 1.Take a tin box with a hole at the bottom

2. Fill it with moist saw dust.

3. Sow some gram seeds in it. Keep the tin box in a tilted position

4. When seeds start germinating, water the saw dust only in the lower side of tin box.

It is seen that the roots of germinating seeds (radicle) moves towards the wet saw dust. This shows that roots are positively hydrotropic.

2. How is the movement of leaves of the sensitive plant different from the movement of a shoot towards light?

Ans.: The movement of leaves of sensitive plant is neither towards, nor away from the stimulus like touch, etc. It is a non- directional movement (nastic movement), while movement of shoot is towards the stimulus like light, etc.

It is a directional movement (tropic movement).

3. Define thermonastic movements.

Ans.: If the diurnal variations in the position of plant (e.g.., flowers and leaves of plants) are caused by the change in temperature of the surroundings, such non - directional movements are called thermonastic movements.

PLANT HORMONES OR PHYTOHORMONES

Phytohormone is a chemical substance which is produced naturally in plants and is capable of translocation and regulating one or more physiological processes when present in low concentration. Plant hormones help to coordinate growth, development and responses to the environment. Plant hormones are also known as plant growth substances or plant growth regulators. Besides growth, various other activities such as promotion of dormancy, breaking of dormancy, opening and closing of stomata, falling of leaves, fruit growth, fruit ripening, ageing in plants, tropisms and nastic movements, etc. are controlled by various phytohormones. These are synthesized at places away from where they act and simply diffuse to the area of action.

Types of phytohormones

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

Table: Plant hormones and their functions

	Plant hormones	Functions
1.	**Auxins** (Naturally occurring auxin is iodole 3-acetic acid)	These promote cell enlargement and cell differentiation in plants. These promote stem and fruit growth. These regulate important plant growth movements, *i.e.,* tropisms. These induce pathenocarpy *(i.e.,* the formation of seedless fruits without fertilization) in number of plants.
2.	**Gibberellins** (Gibberellic acid)	These promote cell enlargement and cell differentiation in plants in the presence of auxins. These also promote growth in stems and fruits. Rosette plants *(i.e.,* plants that show profuse leaf developments but reduced internode growth) show bolting and flowering when treated with gibberellins. These also induce parthenocarpy in many plants.
3.	**Cytokinins**	These promote cell division in plants. These play vital role in the morphogenesis in plants. These help in breaking the dormancy of seeds and buds. These delay the ageing in leaves. These promote the opening of stomata. These also promote fruit growth.
4.	**Ethene** (Ethylene)	It promotes growth and ripening of fruits. It helps in breaking the dormancy in buds and seeds. It stimulates the formation of separation layer (abscission zone) in leaves, flowers and fruits.
5.	**Abscisic acid** (ABA)	It promotes yellowing and senescence of leaves. It promotes the dormancy in seeds and buds and thus inhibits growth. It also promotes the closing of stomata and thus affects wilting of leaves. It also promotes the falling of leaves (abscission) and senescence in leaves.

ILLUSTRATION

4. What are plant hormones?

Ans.: plant hormones are chemicals present in plants which help to coordinate growth, development and responses to stimuli and environment. For example, auxins, gibberellins, cytokinins, abscisic acids are different plant hormones.

5. Give an example of a plant hormone that promotes growth.

Ans.: Auxin is the plant hormone that helpls in cell growth and elongation.

6. How do auxins promote the growth of a tendril around a support?

Ans.: When tendrils come in contact with any support, the part of the tendril in contact with the object does not growl as rapidly as the part of the tendril away from the object. This is caused by the action of auxin hormone. Less auxin occurs on the side of contact as compared to the free side. As a result, auxin promoters growth on the free side and the tendrils coil around the support.

7. Name various plant hormones.

Ans.: The various plant hormones are auxins, gibberellins, cytokinins, ethylene and abscisic acid.

8. Why plant hormones are also called plant growth regulators?

Ans.: Plant hormones or phytohormones ('Phyto'means plant) are naturally occurring organic chemical substances present in plnats which bring about control and coordination of various activities in them. They do so by controlling one or the other aspect of growth of the plant. Therefore, plant hormones are also known as plant growth substances or plant growth regulators.

Role of auxin in phototropism

Plants respond to light by showing growth movement towards light (phototropism). This growth movement of the plant part (stem) is caused by the action of auxin hormone. The auxin hormone is synthesized by the meristematic tissue at the tip of the stem (or tip of the shoot). It is illustrated below:

(i) Auxin diffuses uniformly down the stem in plant kept in the open and receiving sunlight from above. Due to presence of auxin equally on both the sides, the stem grows up straight because both the sides of the stem show growth at the same pace (Figure A).

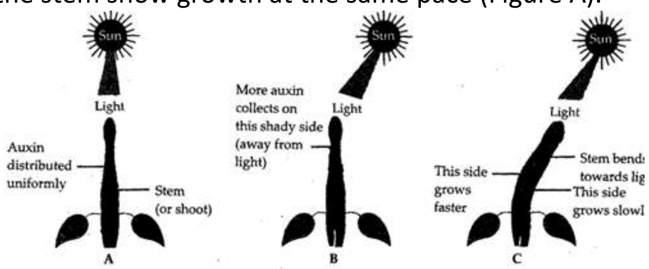


Fig. Effect of auxin on the growth of a plant in response to light (Phototropism)

(ii) The second plant received light only from one side. In this case, the auxin hormone moved from the tip of stem and concentrated more on the side not receiving light (shady side, i.e., the side of stem away from light). Due to presence of more auxin hormone, the shady side of stem grew faster than the side of stem receiving light. As a result, the stem bent towards the direction of light.

CONTROL AND COORDINATION IN ANIMALS

In animals two kinds of coordination — nervous and chemical — are present. The nervous coordination is brought about by the nervous system and the chemical coordination by hormones. In lower animals like Hydra and insects, coordination is through the nervous system. But in higher animals (the vertebrates) the coordination takes place through both the nervous system as well as the hormonal system.

The nervous system is composed of specialized cells called neurons (nerve cells) which exercise control by sending electrical signals called nerve impulses. The nervous control is speedy and flexible but its effect is localized.

The endocrine system consists of specialized glands (endocrine glands) which bring about control by sending chemical messengers termed hormones. The hormonal control is usually slow acting and its effect is diffuse.

NERVOUS SYSTEM

Except sponges, all multicellular animals possess simple or complex nervous system. In all these animals, nervous system is comprised of nervous tissue having specialized cells called neurons or nerve cells to respond to stimuli and coordinate animals' activities.

Nerve cells or neurons are, in fact, the structural and functional units of nervous system. In higher multicellular animals, the nervous tissue consists of nerve cells or neurons, nerve fibres, bundle of nerve fibres forming nerves, packing cells (neuroglia), ependymal cells and neurosecretory cells.

Structure of neuron

The units which make up the nervous system are called nerve cells or neurons. Neuron is the largest cell in the body. It carries messages in the form of electrical signals called nerve impulses. Neuron is and elongated branched cell having three components – cell body dendrites and axon

(i) Cell body or Cyton: Cell body is like a typical cell containing a central nucleus and surrounding cyto-plasm. Around the nucleus there are granules called Nissl's grnules. The cytoplasm has mitochondria, Golgi apparatus, neurofibrils: neurotubules. Cell body is concerned with metabolic maintenance and growth. It also receives nerve impulses from dendrites and transmits them to axon.

(ii) Dendrites: Dendrites are several short, tapering, much branched protoplasmic processes stretching out from the cell body of a neuron. They receive sensation or stimulus, which may be physical, chemical, mechanical or electrical. The stimulus is passed onto cyton.

(iii) Axon: Axon 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 axon endings are highly branched and the terminal branches are called terminal arborizations. Axon terminals are often knob-like and these may end in nerve fibres (forming neuromuscular junction) or glands or form synapses with dendrites of other neurons.

Axon is covered with one or two sheaths. Sheathed axon is termed nerve fibre. The cell membrane of the axon is called axolemma and its cytoplasm is termed axoplasm. It lacks Nissl's granules. However, neurofibrils are present. The single sheath present over the axon is made of Schwann cells and is called neurilemma. The axon has an insulating and protective sheath of myelin around it. Nerve fibres (axons) having myelin sheath are termed myelinated nerve fibres and those without this sheath are termed non-myelinated nerve fibres. Myelinated nerve fibres conduct impulses more efficiently than non-myelinated nerve fibres. At intervals, myelinated nerve fibres possess unmyelinated areas called **nodes of Ranvier.**

Neurons transmit messages in the form of nerve impulses. They have following special properties:

(i) They do not divide.

(ii) From shortly after birth, new neurons do not develop.

(iii) They are not repaired, when injured.

(iv) They use only glucose as a respiratory substrate.

(v) They die if deprived of oxygen for over five minutes.

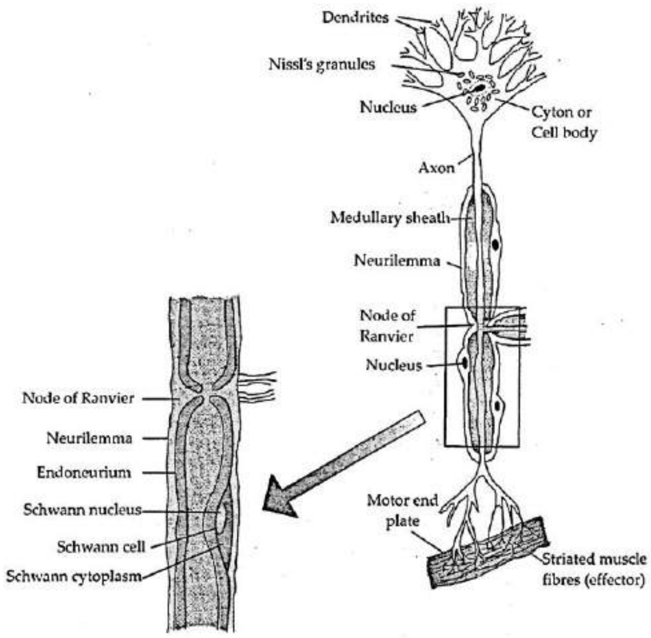


Fig.: Structure of a neuron (nerve cell)

Synapse

Synapse is the functional junction between neurons. It is the point of contact between the terminal branches of the axon of one neuron with the dendrites of another neuron. There is no Mitochondrion. Presynaptic cytoplasmic connection between the two and it is thought that the impulse is transmitted across the synapse by chemical means.

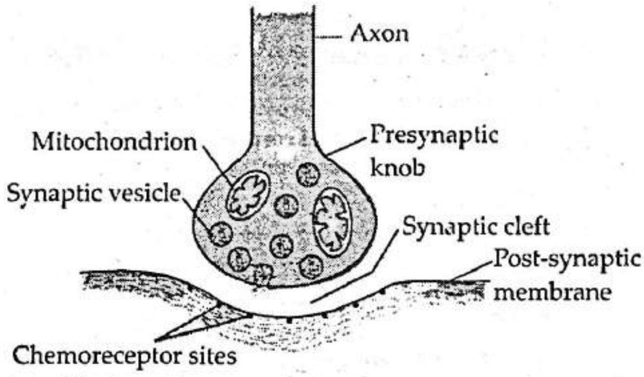


Fig.: Impulse transmission across a synapse.

At the synapse, axon terminal comes in close proximity to the dendron terminal of next neuron. Axon terminal is expanded to form presynaptic knob. On the other hand, the dendrite terminal forms post-synaptic depression. In between the two, lies a narrow fluid filled space called synaptic cleft. As the nerve impulse reaches the presynaptic knob, the synaptic vesicles get stimulated to release neurotransmitter in the synaptic cleft. The neurotransmitter molecules diffuse across the gap to come in contact with post-synaptic membrane. In this way, nerve impulse passes across the gap come in contact with post – synaptic membrane. In this way, nerve impulse passes across the minute gap to stimulate dendron of other neuron. The synapse acts as a one-way valve to conduct impulse in one direction only. This is so because chemical substance called neurotransmitter is secreted only on one side of the gap i.e., on axon's side. It carries impulse across the synapse and passes it to the dendron of the other neuron. In this way, impulses travel across the neurons only in one direction, i.e., from axon of one neuron to dendron of other neuron through a synapse.

Types of neurons

The neurons are of three types: (i) sensory (receptor) neurons, (ii) motor (effector) neurons, and (iii) relaying (connector) neurons.

(i) Sensory (receptor) neurons: These often occur in sense organs, and receive stimuli by their dendrites. The sensory neurons transmit impulses towards the central nervous system (brain and spinal cord) through their axons.

(ii) Motor (effector) neurons: The dendrites of these neurons synapse with axons of sensory neurons in central nervous system. They transmit impulses from central nervous system towards effectors (muscles or glands). The latter respond to stimuli.

(iii) Relaying (connector) neurons: These occur in the central nervous system (brain and spinal cord). These serve as links between sensory and motor neurons for distant transmission of nerve impulses.

SENSORY RECEPTORS

All higher chordate animals (vertebrates) receive a variety of external stimuli through specialized neurons termed sensory receptors or sensory neurons. These sensory receptors may be simple in structure or most complex sense organs.

These are cell or group of cells specialized 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), photoreceptors for sounds (ears), gustatory receptors for taste (tongue), olfactoreceptors for smell (nose) and thigmoreceptors for touch (skin). The receptors pass information to the brain. The brain transmits motor impulses to appropriate effectors (muscles or glands) which produce suitable responses.

REFLEX ACTIONS, INVOLUNTARY AND VOLUNTARY ACTIONS

Specific change in the environment evokes an appropriate response in the form of movement/ action in all living organisms. Such movements/actions in these organisms are carefully controlled. Animals perform three types of actions. These actions are: reflex actions, voluntary actions and involuntary actions.

(i) 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. The journey (a - d) of reflex action is called reflex arc.

(a) Receptor organ like skin perceives the stimulus and activates a sensory nerve impulse.

(b)Sensory organ carries message in Spinal cord (CNS) Message to brain the form of sensory impulse to the spinal cord.

(c) The spinal cord acts as modulator. The neurons of spinal cord transmit the sensory nerve impulse to motor neuron

(d) Motor nerve conducts these impulses to the effectors like leg muscles which responds by pulling back the organ away from the stimulus.

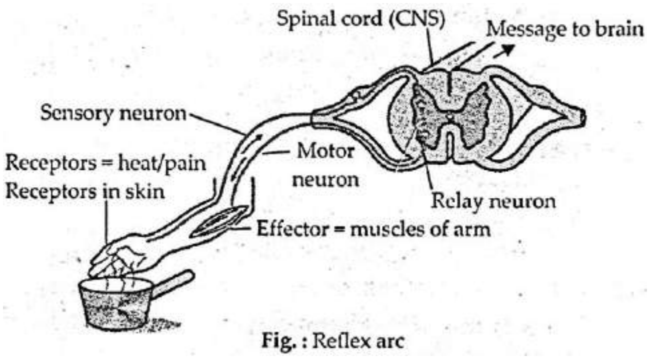


Fig. : Reflex arc

Reflex are: 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.

Some common examples of reflex action are:

- Blinking of eyes in response to a foreign particle that has entered the eye. - Sneezing or coughing, if any unwanted particle enters the nose or throat.
- Watering of mouth at the sight of tasty food.
- Immediate withdrawal of hand if a person touches a hot object unknowingly.
- Withdrawal of the leg by a person walking bare feet if happens to step on a nail.

Advantages of reflex action:

(a) Enables the body to give quick responses to harmful stimuli and thus protects our body.

(b) Minimises the overloading of brain.

(ii) Voluntary actions: These are the actions which need thinking and are performed knowingly, i.e., are controlled by conscious thought. In each voluntary action, the animal exercises its choice so that the same stimulus may receive different responses at different times depending upon the situation. For instance, on seeing a snake in the way, one may run away on first occasion or call for help on second-occasion or try to kill it to save himself on the third occasion. All such actions are voluntary actions that are controlled by cerebellum part of hind brain. Similarly, walking in a straight line, riding a bicycle, picking up a pencil are also voluntary actions controlled by cerebellum. This part of the brain is responsible for precision of voluntary actions and maintains the posture and balance of the body.

(iii) Involuntary actions: 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. Such actions are meant for controlling and coordinating the functioning of internal organs. Many of these involuntary actions are controlled by the mid brain and hind brain. Regular beating of heart, blood pressure, movements of diaphragm during normal respiration, peristaltic movements in the oesophagus, salivation, vomiting, movement of the internal viscera etc. are all involuntary actions and are controlled by hind brain.

HUMAN NERVOUS SYSTEM

Nervous system in humans consists of three parts:

(i) Central nervous system (CNS) consisting of brain and spinal cord. The brain and spinal cord receive information from all parts of the body and integrate it.

(ii) Peripheral nervous system (PNS) consisting of nerves that arise from brain (cranial nerves) and from spinal cord (spinal nerves). Through the nerves, the nervous system communicates with the muscles.

(iii) Autonomic nervous system (ANS) made up of parasympathetic and sympathetic nervous systems. Though connected with the CNS, it works independently and regulates involuntary activities of the body like heartbeat, and peristaltic movements of alimentary canal.

Central nervous system (CNS)

The CNS consists of 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.

Brain

Brain is the highest coordinating centre in the body. It is situated in the cranial cavity of the skull in the head region of the body. The bones of cranium or brain box protect this delicate organ from mechanical injury. Inside the box, the brain is contained in a fluid-filled balloon which provides further shock absorption.

The brain is soft, whitish organ. It weighs 1.2 - 1.4 kg and forms about 98% of the weight of the whole central nervous system. It has about 100 billion neurons (nerve cells). Brain is surrounded by three membranes called meninges which provide protection to it. The space between these three meninges is filled with cerebrospinal fluid which protects the brain from mechanical shocks.

The brain is broadly divided into three regions: Fore brain, mid brain and hind brain.

(i) Fore brain (prosencephalon): Fore brain includes cerebrum (cerebral hemispheres), olfactory lobes and diencephalon. Fore brain is the main thinking part of the brain.

(a) Cerebrum: It the largest part of the brain and is proportionately larger in humans than in any other animal. It consists of two cerebral hemispheres (right and left) joined together by a broad curved thick band of nerve fibres called corpus callousum. Each cerebral hemisphere is divided into four lobes. These lobes control different activities of the body like those of muscular activities, touch, smell, temperature, hearing and sight.

For example,

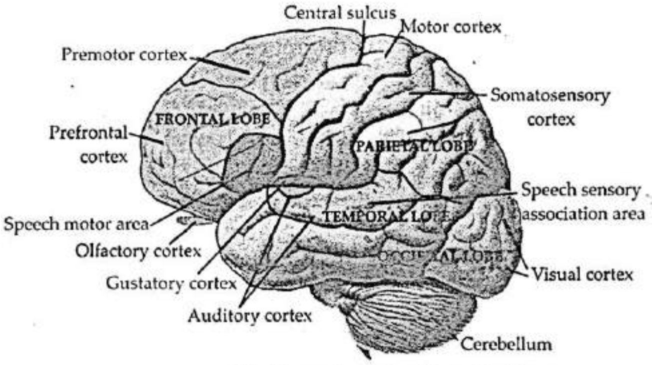


Fig.: Human brain showing major lobes

- **Occipital lobe** is the region for sight, i.e., visual reception.
- **Temporal lobe** is the region for hearing i.e., auditory reception.
- **Frontal lobe** is the region for speech, facial muscular activities and higher mental activities.
- **Parietal lobe** is the region for taste, smell, touch and conscious association.

The cerebral hemispheres have an outer region of densely packed nerve cells called cerebral cortex. This is the region of various kinds of activities. These are broadly classified into three areas — the sensory areas, the motor areas and the association areas. The sensory areas receive impulses from receptors and register impressions of what we hear, see or feel. The motor areas transmit impulses to various organs and control voluntary movement like those of limbs and face. The association areas give the ability to register impressions and respond by interpreting past experiments. These are associated with hunger, memory, learning, reasoning and intelligence. Cerebrum, thus, is the most important part of the brain as this is the seat of mental abilities, memory, reasoning, speech and consciousness.

(b) Olfactory lobes: The anterior part of the brain is formed by a pair of short club-shaped structures, the olfactory lobes. Each lobe consists cerebral hemisphere and are, therefore, only visible in the ventral view of the brain. A pair of olfactory nerves arises from the olfactory lobes. Olfactory lobes are concerned with the sense of smell.

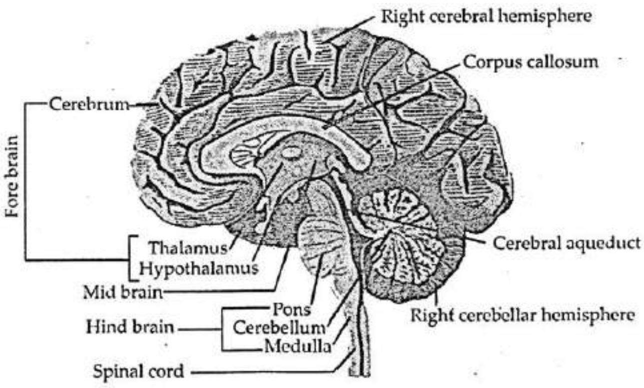


Fig.: Medial aspect of adult human brain in sagittal section.

(c) Diencephalon: It lies on the inferior side of the cerebrum and thus is visible in the ventral view of the brain. Its roof is called epithalamus, sides are called thalami and its floor is termed hypothalamus. Diencephalon has a narrow cavity called third ventricle. Hypothesis (pituitary) is attached by a stalk or infundibulum to the hypothalamus region. Hypothalamus has control centres for hunger/ thirst, fatigue, sleep, body temperature, sweating and emotions. It secretes neurohormones which regulate the secretions of anterior lobe of pituitary.

(ii) Mid brain (Mesencephalon): It connects the fore brain to hind brain. It is significantly small region. It consists of two fibre tracts called crura cerebri and two swellings called superior and inferior colliculi on each side. The fibrous tracts, i.e., crura cerebri connect hind brain with the fore brain. The four swellings of both sides are together known as corpora quadrigemina. The two superior colliculi have centres for auditory reflexes. The mid brain controls reflex movements of:

- the head, neck and trunk in response to visual and auditory stimuli, and
- the eye muscles; changes in pupil size as well as shape of the eye lens.

(iii) Hind brain (Rhombencephalon): It consists of three parts called cerebellum, pons and medulla oblongata. Cerebellum lies at the roof of the hind brain. 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 hind brain and continues into the spinal cord. It controls rate of heart beat, breathing movements, expansion and contraction of blood vessels to regulate blood pressure, swallowing, coughing, sneezing and vomiting.

Table: Differences between cerebrum and cerebellum

	Cerebrum	Cerebellum
1.	It is the part of fore brain.	It is the part of hind brain.
2.	It is the largest part constituting 80% of the brain.	It is much smaller, constituting 12.5% of the brain.
3.	It forms the front, superior and lateral sides of the brain	It lies in the posterior region of the brain.
4.	It has two parts called cerebral hemispheres.	It has three parts: two lateral cerebellar hemispheres and one central vermis.
5.	It has two cavities called lateral ventricles.	Cavity is nearly absent.
6.	Cerebrum is the seat of intelligence and memory.	Cerebellum coordinates muscular activity.
7.	It controls movements, speech, sight, smell, taste, hearing, intelligence, etc.	It maintains equilibrium of the body.

Function of brain

The functions of brain are given below:

(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.

Spinal cord

Spinal cord extends from the medulla oblongata portion of the brain to the lumbar region, passing through the neural canal of the vertebral column. It is cylindrical in shape and from each segment of the spinal cord, two spinal nerves arise. In man, 31 pairs of spinal nerves are present. Each spinal nerve is a mixed nerve and possesses both sensory and motor fibres.

Functions of spinal cord

The functions of spinal cord are given below:
(i) Spinal cord is the main centre of reflex action.
(ii) It is concerned with the conduction of nerve impulses to and from the brain.

Peripheral nervous system (PNS)

Peripheral nervous system constitute the cranial and spinal nerves along with their branches.

- Cranial nerves arise from the brain and spread throughout the head. There are **twelve pairs** of cranial nerves. Cranial nerves I, II and VIII are **sensory nerves;** cranial nerves III, IV, VI, XI and XII are **motor nerves;** and cranial nerves V, VII, IX and X are **mixed nerves** (containing both sensory and motor nerve fibres).
- 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. These are all mixed **nerves** as they carry both sensory and motor nerve fibres.

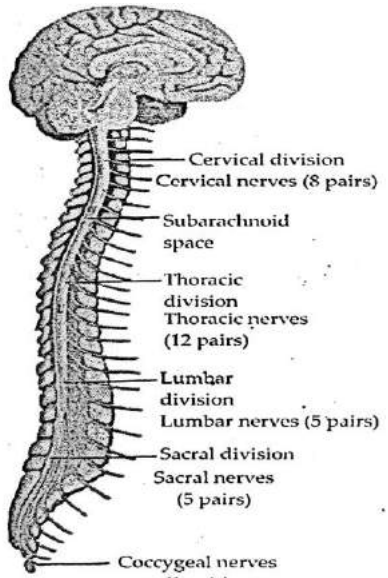


Fig.: Spinal nerves

Autonomic nervous system (ANS)

Autonomic nervous system means 'self-governing nervous system'. It operates automatically or involuntarily. It includes all those responses against stimuli which are not under the control of animal involuntary activities). Visceral nerves of autonomic nervous system control the activities of internal gans. Autonomic nervous system, therefore, is also termed as visceral nervous system.
The autonomic nervous system can be classified anatomically and functionally into sympathetic and parasympathetic nervous system. The smooth uscles of various internal organs receive both sympathetic and parasympathetic nerve fibres. Both the systems have involuntary opposing effects. If one system exerts stimulatory effect on an organ the other system exerts inhibitory effect on that organ. Their effects are tabulated in the given table.

Table: Effects of sympathetic system and parasympathetic system

Organ	Sympathetic system	Parasympathetic system
Heart	Increases contraction and rate of heart beat.	Decreases contraction and rate of heart beat.
Blood vessels	Constriction of blood vessels.	Dilation of blood vessels.
Lungs	Dilates bronchi and bronchioles.	Constricts bronchi and bronchioles.
Eyes	Dilates pupils.	Constricts pupils.
Stomach	Inhibits secretion of gastric juice in stomach.	Stimulates secretion of gastric juice in stomach.
Salivary glands	Inhibits secretion of saliva in the bucal cavity.	Stimulates secretion of saliva in the buccal cavity
Urinary bladder	Relaxation.	Contraction.

Some important facts

- Brain is the highest coordination centre of human body.
- Human brain is about 1200-1400 gm in weight and has more than 100 billion (10^{10}) neurons.
- Left half of brain controls right side of body and vice versa.

- Lobes of human brain are hollow and their cavities are called ventricles.
- Hypothalamus is commonly called thermostat of body as it helps in regulation of body as it helps in regulation of body temperature.
- **Optic chiasma** is cross of two optic nerves in front of hypothalamus
- Cavity of vertebral column in which spinal cord lies, is called neural canal.
- Spinal cord acts as a link between brain and peripheral nerve.
- **Meningitis** is inflammation of meningeal membranes.
- Cerebellum is also called little brain
- **Brain stem** is formed of mid brain, pons and medulla oblongata.
- **Vagus (x) cranial nerve** is longest cranial nerve and is the only cranial nerve which extends upto abdomen.
- Near the sarcolemma, an axonal ending of motor nerve fibre forms a flat motor end plate to conduct the electrical impulses.
- Reflex arcs between the input nerve and the output nerve are formed in the spinal cord, although the spinal cord sends certain information inputs to the brain through ascending nerve fibres.

ILLUSTRATION

9 What is the difference between a reflex action and walking?

Ans. Reflex action takes place without thought, i.e., it gives a reaction to stimuli. It is controlled of one neuron and dendrites of another. At synapse, by the spinal cord. It is an involuntary action, Walking takes place after thought, i.e., according to our wishes. It is controlled by a part of hind brain called cerebellum. It is a voluntary action,

10 What happens at the synapse between two neurons?

Ans. Synapse is the gap between nerve ending of one neuron and dendrites of another. At synapse, the electrical impulse generated at dendrites of a neuron is passed on to dendrite of another neuron in the form of chemicals by axon ending of the first neuron. Synapse ensures that nerve impulse travels only in one direction. A Similar synapse allows the delivery of impulse from the neuron to the other cells, like muscle cells.

11 Which part of the brain maintains posture and equilibrium of the body?

Ans.: Cerebellum, which is a part of the hind brain maintains posture and equilibrium of the body.

12 How do we detect the smell of an agarbatti (incense stick)?

Ans.: Smell of and incense stick is detected by the olfactory receptors located in the fore brain.

13 What is the role of the brain in reflex action?

Ans.: Nerves from all over the body meet in a bundle in the spinal cord on their way to the brain. Reflex arcs are formed in this spinal cord itself, although the information input also goes on to reach the brain

CHEMICAL COORDINATION IN ANIMALS

In animals, the message, communicated in the form of nerve impulses, from receptors (sensory neurons) to central nervous system and from latter to the effectors (muscles and glands) is very quick. The nervous coordination in animals, however, has certain limitations. For instance, - Nerve impulses can reach only those animal cells which are connected by nervous tissue, and - Such cells, after generation and transmission of nerve impulses, take some time to reset their mechanisms before a new impulse is generated and transmitted.

In other words, cells cannot continuously generate and transmit electrical impulses. This is the reason why most multicellular organisms use another means of communication between cells, commonly termed chemical communication. The stimulated cells release a chemical directly into the blood. Other body tissue cells have the means to detect this chemical using special molecules (receptors) present either on their surfaces or inside their cytoplasm. The message is then transmitted and these chemicals produce their effects.

Chemical communication is, however, slow but it can potentially reach all the cells of the body regardless of nervous connections. These chemicals are called hormones and are secreted by various endocrine glands. The latter constitute endocrine system. Hormonal information, like nervous system, is meant for internal communication and regulation of animal body functions. However, there are some basic differences between the two controlling systems. Still, the two systems (nervous system and endocrine system) operate in a coordinated way on many occasions. Many important functions of the endocrine system are, in fact, under the control of nervous system. Therefore, the two systems are often collectively termed as neuroendocrine system.

Table: Differences between nervous and hormonal information

	Nervous information	Hormonal information
1.	It is sent as an electrical impulse along axons, and as a chemical across synapse.	It is sent as a chemical messenger via blood stream.
2.	Information ravels rapidly, in milliseconds.	Information travels slowly.
3.	Information is directed to specific receptors - one or a few nerve fibres, gland cells or other neurons, i.e., it is addressed by name.	Information is spread throughout the body by blood from which the target cells or organs pick it up, i.e., it is addressed to 'whom it may concern'.
4.	It gets response immediately.	It gets response usually slowly.
5.	Its effects are short-lived.	Its effects are generally more prolonged.

Just as in plants, certain hormones control the life activities in animals. These hormones are produced in special organs called endocrine glands. Endocrine glands are also called ductless glands as they have no ducts and their secretions are poured directly into the blood. Endocrine glands though present in different regions of the body, work in coordination as an integrated system. A variety of chemical substances/ called hormones, are secreted in trace amounts by endocrine glands.

Hormones, therefore, are chemical substances secreted in trace amounts by endocrine glands and are the means of information transmission.

In animals, in. addition to ductless endocrine glands, some glands with ducts are also present. These glands, like the pancrease, ovaries and testis, have ducts and are called exocrine glands. As a matter of fact, pancreas, ovaries and testes are both exocrine as well as endocrine glands.

The hormones in animals show following characteristic feates:

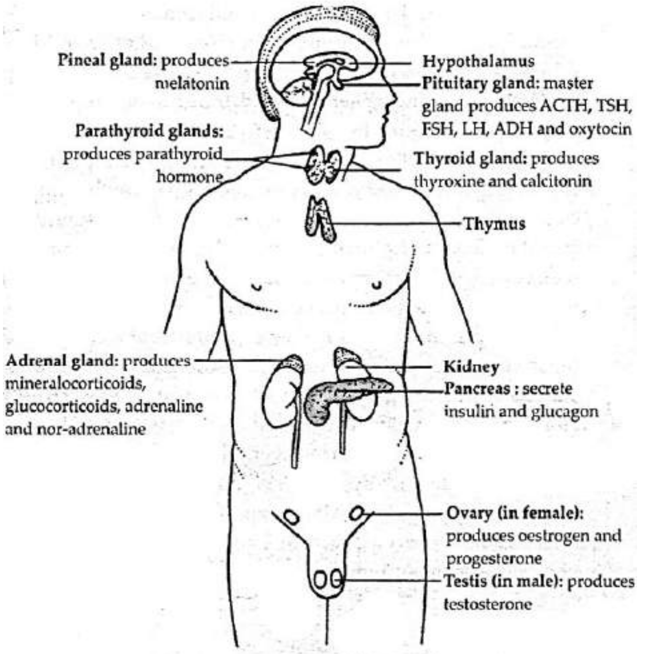


Fig. : Location of endocrine glands in our body

(i) They are synthesized by endocrine glands.

(ii) They are produced at a place other than the site of action. They travel through blood to other parts where they cause changes.

(iii) They are secreted directly into the blood stream.

(iv) They act on specific tissues or organs. The tissues or organs that respond to the hormones are called as **target organs.**

(v) They are secreted in response to changes in the external or the internal environment of the body and are also called as **chemical messengers**

(vi) They may stimulate or inhibit the activity of the target organ, thus regulating its activity.

(vii) They are effective in minute quantities, often in trace amounts which are difficult to detect at times.

(vii) They are effective in minute quantities, often in trace amounts which are difficult to detect at times.

(viii) Excess or deficiency of a hormone may lead to serious consequences.

Human endocrine glands

The major endocrine glands, their secretions, principal functions of the various hormones secreted by them are listed in the given table.

Table: Major hormones secreted in the human body, their sources and principal function

Endocrine glands and their locations	Hormones secreted	Principal functions
HEAD REGION		
1. Hypothalamus	Thyrotrophin-releasing hormone (T-RH)	
2. Pituitary gland • It has three lobes. It is attached to the lower surface of the brain. (i) Anterior lobe • It produces six hormones.	(a) Growth hormone (GH) or Somatotrophic hormone (STH)	Controls the overall development or growth of the body, muscles, bones and tissues. Lack of this hormone (hypoactivity) causes dwarfness. Its excessive secretion (hyperactivity) causes excessive growth of bones making the person very tall (gigantism).
.	(b) Thyroid stimulating hormone (TSH)	Controls the growth and functioning of the thyroid gland. Stimulates the thyroid gland to produce thyroxine.
	(c) Adrenocorticotrophic hormone (ACTH)	Stimulates the adrenal cortex to secrete its hormones.
	(d) Follicle stimulating hormone (FSH)	In males, it stimulates the process of spermatogenesis (sperm formation). In females, it stimulates the follicle cells in the ovaries to develop into mature eggs and also stimulates them to produce oestrogen.
	(e) Luteinising hormone (LH) (FSH and LH are together called gonadotropins')	In males, it stimulates the secretion of male hormone, testosterone (sex hormone in males). In females, it stimulates the secretion of oestrogen and progesterone (sex hormones in females).
	(f) Prolactin hormone (PRL)	Enhances mammary gland development and milk production in females.
(ii) Intermediate lobe	Melanocyte stimulating hormone (MSH)	Stimulates the synthesis of melanin in the skin.
(iii)Posterior lobe	(a) Oxytocin	Stimulates contraction of smooth muscles at the time of child birth. It also helps in milk ejection (lactation) from the mammary glands.
	(b) Vasopressin or Antidiuretic hormone (ADH)	Regulates water and electrolyte balance in body fluids.
3. Pineal gland • It lies between the two cerebral hemispheres of the brain.	Melatoni	Regulates the working of gonads
NECK & CHEST REGION		
4. Thyroid gland • It is situated in the neck region on the ventral side of the body. It has two lateral lobes one on either side of the trachea.	(a) Thyroxine or T_4 of (b) Triiodothyro- of nine or T_3 (c)Calcitonin. Parathyroid hormone (PTH) or	T_4 T_3 & T_4 stimulates the rate of cellular oxidation and metabolism. Calcitonin lowers calcium level when by suppressing release of calcium ions from the bones, calcium level is high in blood.

5. Parathyroid gland • These are four small oval bodies which lie embedded in the lobes of the thyroid gland.	parathormone.	Regulates calcium and phosphate levels in the blood. When blood calcium level is below normal, it mobilizes the release of calcium into the blood from bones. It has an action opposite to that of calcitonin on calcium metabolism.
6. Thymus gland • It is situated in the upper chest near the front side of the heart. • It atrophies in the adult.	Thymosin	Stimulates the development and differentiation of lymphocytes (white blood cells).
ABDOMINAL REGION **7. Adrenal gland** • In human beings, a pair of adrenal glands are present, one on top of each kidney, so, also called suprarenals. Each adrenal gland has an outer part called the cortex and an inner-part, medulla.		
(i) Adrenal cortex • It secretes 3 groups of steroid hormones.	(a) Glucocorticoids	Regulates the metabolism of protein, fats and carbohydrates in the body and the level of blood sugar. Regulates heart rate and blood pressure.
	(b) Mineralocorti - coids (Aldosterone)	Regulates water and mineral balance in body.
	(c) Sex corticoids	Stimulates the development of secondary sexual characters both in males and females.
(ii)Adrenal medulla A • It secretes 2 hormones.	Adrenaline Epinephrine) and Nor-adrenaline (Nor-epinephrine)	Both these hormones together control emotions, ear, anger, blood pressure, heart beat, espiration and relaxation of smooth muscles. Regulates the coversion of glucose to glycogen; e., it lowers blood glucose level.
8. Pancreas It is a compound gland in the abdominal region located posterior to the stomach. Its (b endocrine part is Islets of Langerhans, which secretes 2 hormones	(a) Insulin	Regulates the conversion of glucose to glycogent; i.e., it lowers blood glucose level.
	(b) Glucagon g	Regulates the conversion of glycogen back to glucose i.e., it increases blood glucose level.
9. Ovaries • These are a pair of organs present in the lower abdominal region in females.	Progesterone and Oestrogen	Plays an important role in ovulation. These help in the preparation of uterus for the reception of fertilized ovum. These hormones also help in the maintenance of pregnancy. Oestrogens are responsible for development of secondary sexual characteristics in females like mammary gland, voice, hair pattern, etc.
10. Testes	Testosterone	Regulates the growth, development and functioning of accessory sex organs and

• These are extra- abdominal in position. • The interstitial or Leydig cells present in testes produce the male hormone.		controls the secondary sexual characteristics in males, such as enlargement of penis and scrotum, growth of facial and pubic hair, and enlargement of larynx that causes deepening of voice.

Table: Summary of hypothalamic hormones and pituitary response

	Hypothalamic hormones	Response of pituitary Thyroid	Target organ
1.	Thyrotrophin-releasing hormone (T-RH)	stimulating hormone (TSH) secretion	Thyroid
2.	Andrenocorticotrophin- releasing hormone (A-RH)	Adrenocorticotrophic hormone (ACTH) secretion	Adrenal cortex
3.	Follicle stimulating hormone- releasing hormone (FSH-RH)	Follicle stimulating hormone (FSH) secretion	Ovary/Testis
4.	Luteinising hormone- releasing hormone (LH-RH)	Luteinising hormone (LH) secretion	Ovary/Testis
5.	Growth hormone-releasing hormone (GH-RH)	Growth hormone (GH) or somatotrophic hormone (STH) secretion	Most tissues
6.	Growth hormone release- inhibiting hormone (GH- RIH) or somatostatin	Growth hormone secretion inhibited	–
7.	Prolactin-releasing hormone (P-RH)	Prolactin hormone (PH) or luteotrophic hormone (LTH) secretion	Mammary glands
8.	Prolactin release-inhibiting hormone (P-RIH)	Prolactin secretion inhibited	–

DISORDERS OF ENDOCRINE GLAND

Disorders of pituitary

(i) Dwarfism: Dwarfism is caused due to deficiency of growth hormone from early age.

(ii) Gigantism: It is giant size of the youngs with very tall skeleton and proportionally large muscles and viscera. It is caused due to excess secretion of growth hormone from childhood.

(iii) Acromegaly: It is caused due to excess secretion of growth hormone after adolescence. Acromegaly in adults leads to overgrowth of the jaw bones and bowing of me spine (backbone).

(iv) Diabetes insipidus: Deficiency of ADH reduces reabsorption of water and increases urine output/ causing excessive thirst. This disorder is called diabetes insipidus. No glucose is lost in the urine of such a patient.

Improper secretion of thyroid hormones

(i) Grave's disease (exophthalmic goitre): It is caused by hyper secretion (over secretion) of thyroid hormones due to enlargement of thyroid gland. Excess of thyroid hormones increases metabolic rate and accelerates oxidation. This results in quick consumption of food, leaving nothing for storage and causing emaciation (excessive leanness).

(ii) Simple goitre (iodine deficiency goitre or endemic goitre): It is the enlargement of thyroid gland accompanied with cretinism or myxoedema. It is caused due to dietary deficiency of iodine. The disease is common in hilly areas. It causes enlargement of thyroid gland. Swollen neck is one of the symptoms of this disorder. Addition of iodides to the table salt prevents the disorder. In our country, common salt is iodised to provide required iodine to the thyroid gland.

(iii) Myxoedema: It is caused by deficiency of thyroid hormones in adults. It is more common in women than in men.

(iv) Cretinism: Hypothyroidism (hypoactivity of thyroid gland) causes cretinism in young children. Its symptoms are stunted growth, short club-like fingers, deformed bones and teeth. Skin is rough, dry and wrinkled with scanty hair growth. Pot-bellied abdomen. Idiocy of varying degree is observed.

Deficiency of insulin

Diabetes mellitus: Deficiency of insulin hormone in the body causes a disease known as diabetes mellitus. In this disease, the patient excretes sugar (glucose) in urine, feels excessive thirst and also does excessive urination.

ILLUSTRATION

14. How does chemical coordination take place in animals?

Ans. In animals, chemical coordination is maintained by hormones secreted by endocrine glands, which function as chemical messengers. They are released by endocrine glands directly into the blood without any involvement of special ducts from where they reach the target tissue or organ to act. These organs and tissues then responses and enables the body to deal with different situation.

15. Why is the use of iodized salt advisable?

Ans. Iodine is necessary for the thyroid gland to make thyroxine hormone. Thyroxine regulates carbohydrates, protein, and fat metabolism in the body so as to provide the best balance for growth. If iodine is deficient in our diet, there is a possibility that we might suffer from goiter. The thyroid gland enlarges causing swelling in the neck. Iodized common salt contains proper content of iodine. Thus, to avoid deficiency of iodine, iodized salt is recommended.

16. How does our body respond when adrenaline is secreted into the blood?

Ans. Adrenaline hormone is secreted in large amounts when a person is frightened, or mentally disturbed. When it reaches the heart, it beats faster to supply more oxygen to our muscles. The breathing rate also increases because of the contraction of diaphragm and the rib muscles. It also raises the blood pressure, and allows more glucose to enter into the blood. All these responses together enable our body to deal with the emergency situations.

17. Why are some patients of diabetes treated by giving injections of insulin?

Ans. Diabetes is caused due to less or no secretion of hormone inulin by pancreas. In such a person, blood sugar level is high. Insulin converts extra sugar present in blood into glycogen. Thus, patients suffering from diabetes are given insulin injection to control their blood sugar level.

CONCEPT MAP

Control and Coordination in Plants

- In plants control and coordination is not highly developed, however, they respond to external stimuli.
- They show two types of movements in response to various stimuli.

Types of movement

Independent of growth

- *E.g.*, movement of leaves.

Dependent on growth

- *E.g.*, directional movement of seedling with roots downward and stem upwards.

- Both types of movements are affected by hormones called plant hormones or phytohormones.

Nastic movements

- Occurs due to turgor changes and reveal immediate response to stimulus, but do not involve growth.

Types

Seismonastic movements

- Movement occurs in response to touch.

Nyctinastic movements

- Movement occurs in response to diurnal variations in the position of plant parts.

Photonastic movements

- Diurnal variations caused by the light stimulus.

Thermonastic movements

- Diurnal variations caused by change in temperature.

Plant hormones

- These are chemicals produced naturally in plants which are responsible for growth, development and responses to the environment.

Types

- Auxins
- Gibberellins
- Cytokinins
- Ethylene
- Abscisic Acid

Tropic movements or Tropism

- Occurs in response to external stimuli and are involve in growth.

Types

Phototropism

- Movement in response to light.

Geotropism

- Movement in response to gravity.

Chemotropism

- Movement in response to chemical stimulus.

Hydrotropism

- Movement in response to water.

CONCEPT MAP

Control and Coordination in Animals

- It is of two types : **nervous** and **chemical.**
- Nervous coordination is brought by **nervous system** and the chemical coordination by **endocrine system.**
- These two systems operate in a coordinated way on many occasions; so also called **neuroendocrine system.**

Nervous system

Neuron/ Nerve cell
- Functional unit of nervous system.
- Components: **Cyton**, **Dendrites**, **Axon**
- Types of neuron: Sensory neurons, Motor neurons, Relaying neurons

Central nervous system (CNS)
- **Brain**
  - Fore brain, Mid brain, Hind brain
  - Cerebrum, Olfactory lobes, Diencephalon
    - Cerebrum: Occipital lobe, Temporal lobe, Frontal lobe, Parietal lobe
    - Diencephalon: Epithalamus, Thalami, Hypothalamus
- **Spinal cord**

Peripheral nervous system (PNS)
- Cranial nerves (12 pairs)
- Spinal nerves (31 pairs)

Autonomic nervous system (ANS)
- Sympathetic nervous system
- Parasympathetic nervous system

Endocrine system

- Consists of various endocrine glands and their respective hormones.
- Hormones are chemical substances which are the means of information transmission.

Endocrine glands (Types)

Hypothalamus
- Secretes inhibiting and releasing hormones.

Pituitary gland (Components)
- **Anterior lobe**
  - Secretes GH/STH, TSH, ACTH, FSH, LH, PRL.
- **Intermediate lobe**
  - Secretes MSH.
- **Posterior lobe**
  - Secretes oxytocin and vasopressin.

Pineal gland
- Secretes melatonin

Thyroid gland
- Secretes T_4, T_3 and calcitonin.

Parathyroid gland
- Secretes PTH.

Thymus gland
- Secretes thymosin.

Pancreas
- Secretes insulin and glucagon.

Adrenal gland
- **Adrenal medulla**
  - Secretes epinephrine and nor-epinephrine.
- **Adrenal cortex**
  - Secretes glucocorticoids, mineralocorticoids and sex corticoids.

Ovaries
- Secretes progesterone and oestrogen.

Testes
- Secretes testosterone.

ESSENTIAL POINTS For COMPETITIVE EXAMS

PHOTOPERIODISM

- The duration of sunlight regulates the germination of seeds and flowering in plants. The length of the day (in hours) during which the sunlight is available to the plants is called photopenod the effect of photopenod on the germination of seeds and flowering in plants is called photoperiodism.
- Photoperiod acts as a stimulus for plants. The plants respond to this stimulus with the help of a special kind of pigment present in them in very small amounts. This special pigment is called phytochrome which is a blue-green pigment. Seeds of many plants germinate only if they are exposed to particular day length of light showing involvement of phytochrome pigment, e.g., seeds of lettuce.
- Photopenod exerts significant effect in the flowering of plants. Gamer and Allard (1920) recognized three classes of plants according to their photoperiodic responses :
  (i) Short day plants (SDP): Such plants need longer dark periods for flowering, e.g., tobacco, rice, dahlia, soyabean tec.
  (ii) Long day plants (LDF): Such plants need shorter dark periods for flowering, e.g., wheat, oat, radish, tettuce etc.
  (iii) Long day plants (LDP): Such plants are not dependent on photopenod for flowering, e.g., tomato sunflower etc.

VERNALISATION

- There are plants for which flowering is either quantitatively or qualitatively dependent on exposure to low temperature. This phenomenon is termed vernalisation. It prevents precocious reproductive development late in the growing season, and enables the plant to have sufficient time to reach maturity.
- Site of vernalisation is apical meristematic cells, e.g., shoot tip, embryo tips, root apex, etc
- As a result of vernalisation, a flowering hormone called vemalin is formed (reported by Melchers), but vemalin has never been isolated.

Importance of vernalisation

- Crops can be grown earlier. Juvenile or vegetative period is shortened and brings about early flowering.
- Plants can be grown in such regions where normally they do not grow.
- Yield of the plant is increased.
- Resistant to cold and frost is increased.
- Resistance to fungal diseases is increased.

ABSCISSION

- It is a natural shedding of leaves, fruits or flowers from the plants without any response to injury but due to change in hormonal balance.
- A special narrow zone called abscission zone develops in the area of future abscission It may have a shallow growth or different colour. Both xylem and phloem get blocked initially by tyioses and callose respectively.
- It produces degenerative changes, phloem plugs soon dissolve and various nutrients present in abscising organ pass back into the plant.

SEED DORMANCY

- Seeds of some plants like rice/ maize, germinate immediately after reaching the ground Seed of Citrus and Rhizophora germinate "in situ". This is called vivipary.
- But in majority of plants seeds remain in an inactive state and germinate only after a specific period of rest. Such inactive state is called dormancy or quiescence
- Dormancy may be denned as, "the inactive state of the seed in which growth of the embryo is temporarily suspended for a specific length of time".
- After the onset of specific conditions, seed dormancy is broken. Dormancy of seed can break naturally or it can be induced artificially.

PHYTOHORMONES

- Gibberellin was first reported from the fungus *Gibberella fujikuroi* which causes bakanae disease (foolish seedling) in rice.
- Most commonly found gibberellin is gibberellic acid-3 (GA_3).
- First natural cytokinin reported was zeitin. Natural cytokinins are also found in coconut water and apple fruit extract.
- Kinetin is a synthetic cytokinin.

- Climacteric fruits release ethylene phytohormone during their ripening, e.g., apple, banana etc
- Abscisic acid (ABA) is also called dormin and tress hormone.
- **Morphactins** are a group of artificially synthesized substances which affect morphology and hence called morphactms. These contain "fluorene ring" in their structure. Generally these are growth inhibitors.
- Haberlandt (1913) reported that injured plant cells release a chemical substance (wound hormone), which stimulate the adjacent cells to divide rapidly in order to heal up the wound English *et. al* (1939) finally isolated and crystallized this wound hormone and named it as traumatic acid.
- **Florigen** is unidentified hypothetical flowering hormone thought to be present in photo induced leaves of plants. This hormone neither has been isolated not its chemical nature has been determined.

NERVOUS COORDINATION IN LOWER ORGANISMS

- In coelenterates (e.g., Hydra), diffused nervous system is present. It is formed of epidermal nerve net and gastro dermal nerve net of nerve cells present on outer and inner border of a gelatinous layer, called mesoglea.
- In flatworms (e.g., Planaria, liver fluke, tape worm, etc.), nervous system is of ladder type It is formed of a ganglionated nerve ring (a ganglion is a mass of neurons) and the nerve cords. The latter are interconnected by a number of transverse connectives.
- Annelids (e.g., earthworm) were the first animals to have a well-organized centralized nervous system. This comprises a circum-phaiyngeal nerve ring and a nerve cord. Nerve ring is formed of a bilobed brain dorsal to pharynx and a bilobed subphaiyngeal ganglia ventral to pharynx which are interconnected by a pair of circum pharyngeal connectives. Nerve cord is ventral single ganglionated and lies below the alimentary canal. Each ganglion gives nerves to different parts of the body
- In insects (e.g., cockroach, grasshopper, etc.) central nervous system is similar to that of annelids except:
  - Nerve ring is circum-oesophageal (i.e., around the oesophagus).
  - Nerve cords are ventral solid, ganglionated but double. Two nerve cords remain separate except at the ganglia.

PROTECTIVE COVERINGS

- Both brain and spinal cord are protected from mechanical injury and shock by bony cases around them. Brain is protected by cranium while spinal cord is protected by vertebral column. There are also present additional protective coverings called meninges (singular meninx) between the brain or spinal cord and their respective bony cases.
- There are 3 meninges in humans - piamater, arachnoid and duramater.
- Duramater is the outermost double layered thick and tough, non-vascular meninx. It lines the cranial cavity.
- Arachnoid is thin, webby and slightly vascular middle sheath. There is a space between duramater and arachnoid named as subdural space that is filled with fluid (not cerebrospinal fluid).
- Piamater is the inner one and thinnest of all meninges. It is vascular and pigmented sheath that lies in contact with brain.

CEREBROSPINAL FLUID

- Cerebrospinal fluid is a clear, colourless, slightly alkaline fluid present in the ventricles of the brain, central canal of spinal cord and spaces between the meninges. It protects the CNS from shocks and keeps it moist.
- It also carries harmful metabolic wastes, drugs and other substances from the brain to the blood.
- CSF also maintains a constant pressure inside the cranium inspite of variation in the pressure of blood in the cranial vessels.

ELECTROENCEPHALOGRAPH

- Electroencephalograph is an instrument which records the electrical activity of the brain in the form of a graph of electric potentials generated with time. Such a record is called electroencephalogram (EEG). The electroencephalogram (EEG) of a patient is done by placing two electrodes of electroencephalograph instrument on the scalp of the patient. Then, a record of four different types of waves (alpha, beta, delta and theta) is produced on the graph paper. These waves vary in their frequency. These waves give the characteristic activity of the brain of a person. The EEG of a patient is useful to diagnose brain ailments.

DISORDERS OF NERVOUS SYSTEM

- **Poliomyelitis:** Poliomyelitis is an acute viral infection that destroys the cell bodies of motor neurons in the anterior horn of the spinal cord.
- **Meningitis:** Meningitis, an inflammation of the meninges, is usually caused by an infectious organism. Several kinds of bacteria and viruses can infect the meninges.
- **Neuritis:** Neuritis is a general term for disturbances of the peripheral nervous system.
- **Multiple sclerosis:** Multiple sclerosis is a progressive degenerative disease of central nervous system.
- **Sciatica:** It is an irritation or neuritis of the sciatic nerve. In fact it is pain along the sciatic nerve.
- **Neuralgia:** Neuralgia is pain in a circumscribed area innervated by a sensory nerve of the peripheral nervous system.
- **Parkinson's disease:** It is caused by the destruction of the neurons of basal ganglia that produce the neurotransmitter dopamine. Thus dopamine is reduced in the brain. Symptoms include tremors and shakes in the limbs, a slowing of voluntary movements and feeling of depression.
- **Wilson's disease:** Along with all symptoms of Parkinson's disease, there is degeneration of liver tissues also.
- **Alzheimer's disease (AD):** It is caused due to destruction of vast numbers of neurons in the hippocampus (a part of brain). Evidence suggests that it is due to a combination of genetic factors, environmental or lifestyle factors and the ageing process.
  - There is loss of neurotransmitter acetylcholine.
  - Individuals with AD initially have trouble remembering recent events. In the later stages, the patients may fail to recognize their spouse or children.
- **Schizophrenia:** It is a severe mental illness characterized by a disintegration of the process of thinking, of contact with reality, and of emotional responsiveness. Positive symptoms, such as delusions and hallucinations (especially of voices), are common.

TYPES OF GLANDS

- Animals have three types of glands as following :

  (i) Exocrine glands have ducts for discharging their secretions on to the body surface or into the cavities in the body. Sweat and sebaceous glands in the skin, salivary glands around the buccal cavity, gastric glands in the stomach wall, and liver are some examples of exocrine glands.

  (ii) Endocrine glands lack ducts and pass their secretions into the surrounding blood for transport to the site of action. They are also called ductless glands. Pituitary, thyroid, parathyroid glands, adrenal glands etc. are examples of endocrine glands.

  (iii) Heterocrine glands consist of both exocrine tissue and endocrine tissue. The exocrine tissue sends its secretion or product by way of a duct; the endocrine tissue discharges its secretion into the blood. Pancreas and gonads (testes and ovaries) are examples of heterocrine glands. The endocrine portion of pancreas secretes insulin and glucagon hormones. On the other hand, the exocrine portion secretes pancreatic juice containing digestive enzymes (trypsin, lipase and amylase) into the pancreatic duct that leads to the alimentary canal.
- Similarly, endocrine portion of the testis (male gonad) secretes testosterone hormone while the exocrine part releases sperms (male gametes) into the duct.
- Ovaries (female gonad) too have endocrine as well as exocrine tissues; the former secretes estrogen and progesterone hormones, and the latter release ova (female gametes) into the duct.

HOMEOSTASIS AND FEED BACK

- Homeostasis means keeping the internal chemical environment of the body constant. Hormones help to maintain homeostasis by their integrated action and feedback control. Feedback control is mostly negative, and rarely positive.

Negative feedback control

- In a negative feedback control, synthesis of a hormone slows or halts when its level in the blood rises above normal. The given example of blood-glucose homeostasis is cited to explain the negative feedback control.

  Blood-glucose homeostasis: When we eat a Carbohydrate-rich meal blood sugar level is increased. It stimulates pancreas gland to secrete insulin. The latter stimulates the target cells to take up extra glucose which is either utilized in cell respiration or is stored as glycogen. In this way, blood-glucose level is brought back to normal

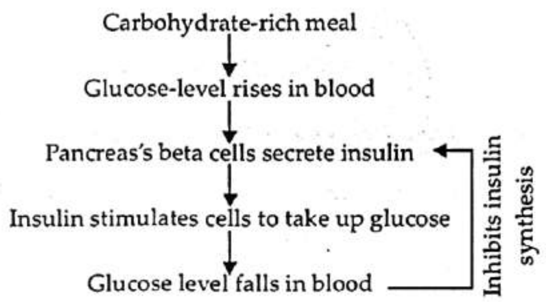


Fig. : Negative feedback control of blood-glucose level.

Positive feedback control

- In the positive feedback control, an accumulating biochemical substance increase its own production.
- For example, at the onset of labour pain in female before child birth, uterine contraction stimulates the release of oxytocin hormone from posterior lobe of pituitary gland. The latter intensifies uterine contractions. The contractions further stimulate the production of oxytocin. The cycle of increase stops suddenly after birth of the baby.

MODE OF ACTION OF HORMONES

- The secretion of hormone from an endocrine gland is controlled by its circulating level in the blood.
- Action of hormones are carried via the blood throughout the entire body, yet they affect only certain cells.
- The specific cells that respond to a given hormone have receptor sites for that hormone. This is a sort of lock and key mechanism.
- If a hormone fits the receptor site, then there will be an effect. All the cells that have receptor sites for a given hormone make up the target tissue for that hormone.
- In some cases, the target tissue is localized in a single, gland or organ. In other cases, the target tissue is diffused and scattered throughout the body so that many areas are affected. Hormones bring about their characteristic effects on target cells by modifying cellular activities.
- Hormones can be classified by the location of the receptor and by the nature of the signal or second messenger used to mediate hormone action within the cell.

HORMONES OF KIDNEYS

- The kidneys secrete three hormones: renin, erythropoietin and calcitriol.
- Whenever the rate of ultrafiltration falls, the cells of their juxtaglomerular complex secrete and release into blood a compound named renin. It acts upon a plasma-protein, angiotensinogen, separating a compound, called angiotensin-II from it.
- Angiotensin-II accelerates heart beat and constricts arterioles, thereby increasing blood pressure. This enhances the rate of ultrafiltration.
- Simultaneously, the angiotensin-II stimulates adrenal cortex to secrete aldosterone and enhances water and sodium reabsorption from nephrons. These factors also elevate blood pressure.
- The oxygen shortage stimulates the kidney cells to secrete a hormone named erythropoietin (a circulating glycoprotein) into the blood.
- Erythropoietin stimulates the bone marrow to increase the production of RBCs.
- Vitamin D exists in two forms: calciferol or D_2 and cholecalciferol or D_3
- Calcitriol is the active form of vitamin cholecalciferol (D_3). It promotes absorption of Ca^{2+} and phosphorus in the small intestine and accelerates bone formation.

CELLS OF PANCREAS

- Pancreas has groups of cells called islets of Langerhans. These produce endocrine secretions. Four kinds of cells have been identified in the islets.
  (i) Alpha cells (about 15 %) produce glucagon.
  (ii) Beta cells (about 65 %) produce insulin.
  (iii)Delta cells or D-cells (about 5 %) produce somatostatin (SS).
  (iv) Pancreatic polypeptide cells or PP cells or F cells (15 %), produce pancreatic polypeptide (PP).
- Somatostatin seems to suppress the release of hormones from the pancreas and digestive tract.
- Pancreatic polypeptide inhibits the release of digestive secretion of the pancreas.

HORMONES OF THYROID

- Thyroid hormones are produced by the secretory cells lining the follicle and stored in the colloid (homogenous materials in follicles) until needed. So each follicle accumulates a storage form of the circulating thyroid hormones - thyroglobulin.

- Thyroglobulin is a large protein molecule that contains multiple copies of one amino acid tyrosine.
- Thyroid gland produces two hormones - thyroxine (T_4) and tri-iodothyronine (T_3) together called (homogenous material in follicles) thyroidal hormone. Both are iodinated forms of an amino acid called tyrosine. T_3 and T_4 contain 3 and 4 iodine atoms respectively. T_3 is more potent and active than T_4

GLANDS OF EMERGENCY

- The medulla of the adrenal glands secretes two hormones: nor-epinephrine (noradrenaline) and epinephrine (adrenaline).
- Nor-epinephrine (Nor-adrenaline) regulates the blood pressure under normal condition. It causes constriction of essentially all the blood vessels of the body. It causes increased activity; of the heart, inhibition of gastrointestmal tract, dilation of the pupils of the eyes and so forth.
- Epinephrine (Adrenaline) is secreted at the time of emergency. Hence it is also called emergency hormone. It causes almost the same effects as those caused by nor-epinephrine, but the effects; differ in the following respects.
  - First, epinephrine has a greater effect on cardiac activity than norepinephrine.
  - Second, epinephrine causes only weak constriction of the blood vessels of the muscles.
  - A third difference is that epinephrine probably has several times as great metabolic effect as nor-epinephrine.
- Because of the role of their hormones, the adrenal glands are also called 'glands of emergency’.
- The above role of adrenaline and nor-adrenaline is often called "fight or flight reaction". It prepares the body to face stress or danger.