CLASSROOM STUDY PACKAGE

BIOLOGY

CONTROL AND COORDINATION

JEE EXPERT

BIOLOGY

CONTROL AND COORDINATION

CONTENTS

CONTROL AND COORDINATION

INTRODUCTION :

Movements are one of the important characteristics of living beings. All plants and animals depict different kinds of movements. They may be **growth movements** in plants (e.g., growth of germinating seed enabling the seedling to come out of soil), **non-growth movements** in plants (e.g.,) folding and drooping of leaves of 'touch-me-not' plant (**Mimosa pudica**) or **non-growth movements** in animals (e.g., running of cat, children playing on swings, cow and buffalo chewing the cud etc.). All movements in living organisms, in fact, occur in response to changes in the environment (or environmental factors).

The changes in the environment (or environmental factors) to which the organisms respond and react are called stimuli (singular stimulus).

All the living organisms show the irritability or sensitiveness. It is the property to give response to the stimulus. The stimulus can be external or internal. The living organisms adapt themselves to the external and internal factors with proper adjustment. This adjustment of the vital activities of life is called co-ordination. The working of one system is co-ordinate with that of other system .e.g., During eating our body performs several kinds of coordinated activities. The nose differentiates the smell of food and hand serve as the organs of ingestion. the alimentary canal and glands help in the digestion of food. Thus various organs perform co-ordinate activities.

Environmental factors such as light , heat, cold, touch, taste, smell, sound, water current, force of gravity etc. act as stimuli to induce responses and reactions in all living organisms. For instance, plants grow towards sunshine, cat is running after a mouse or awayu from a dog, children are getting fun and pleasure out of swinging and cow and buffalo chew the cud to break tough food in order to digest it better. Similarly, we close our eyes on explosure to bright light or we withdraw our hand when we suddenly touch a hot object. In all these examples, we find that movements (responses and reactions) in living organisms occur to provide advatage to them.

Different organisms respond and react to stimuli differently. Most of the plants do not have nervous system and they, therefore, do not possess any special strucutre for the perception of external stimuli. Also, most of them cannot move from one place to another because they are fixed to the substratum or soil by roots or root-like structures. Still, plants respond/react to the external stimuli. They do so due to the action of plant hormones. The plant hormones coordinate their behaviour either by affecting the growth of the plants slowly (e.g., plants respond to light by bending towards it) or by affecting the shape of plant cells by changing the amount of water in them (e.g., responses of **'touch-me-not' plant, Mimosa pudica** to touch by 'folding-up' and drooping its leaves). On the other hand, respones of different animals to light, touch or other stimuli vary a great deal.

Among animals, simple organisms respond to external stimuli by moving towards them (**positive response**) or away from them (**negative response**). Amoeba (a single celled organism), for instance, reacts to the presence of food by moving towards the food particle (positive chemotaxis). Also, number of amoebae respond to heat stimulus and tend to collect together in moderately warm water (positive thermotaxis). But, all single - celled organisms including Amoeba react to the mechanical obstacles by avoiding them (negative response). In multicellular animals, however, the responses to stimuli are not as simple as depicted by simple unicellular organisms. These animals possess nervous system and muscles. They, therefore, show movements in response to external stimuli in different ways. Higher animals have complex body structure. When they respond to various stimuli each response to a sepcific stimulus generally involves many organs of their bodies. For instance, during ingestion (taking in of food), eyes locate the food, nose registers its smell, hands pick up the food to bring it into the mouth, the latter opens to receive the food, teeth and jaw attached to muscles help in the mastication of food, saliva moistens it and starts the digestion process while the tongue perceives the taste of food and moves the bolus. Therefore, it is necessary that all the concerned organs (parts) of the body should work in a systematic manner to produce the response.

The working together of various organs (parts) of the body of an organism in a proper manner to produce proper reaction to a stimulus is called coordination.

For proper control and coordination, higher organisms in fact, have evolved two systems : **Nervous System** and **endocrine system** (hormonal system). Plants do not have nervous system and hence they possess only chemical control and coordination. On the other hand, higher multicellular animals have both nervous and chemical control and coordination.

Control and co-ordination also help to maintain a steady state of stability and steady state within an organism in constantly changing environment. The mechanism of maintaining internal steady state is called **homeostasis**. A mountaineer feels lack of oxygen a high altitudes In order to cope with this condition, more number of RBCs are produced. It is the internal environment (physiologically) that adjusts to the external stress i.e. lack of oxygen. Similarly mammals are capable of maintaining a constant body temperature. The vital activities of an organism are controlled by endocrine system and nervous system. There are two types of co-ordinations i.e., nervous and hormonal co-ordination. In animals both hormones and neurons (structural and functional unit of nervous system) are involved in regulating and coordinating the various vital activities. In plants only chemical (phytohormones) co-ordination is present.

COORDINATION IN PLANTS :

Plants do not have nervous system, muscles and sense organs like animals. Still they can respond and react to various environmental stimuli like light, water gravity, water , touch, chemicals etc. plants show 2 different types of movement in response to various stimuli.

i. Movement are independent of growth. E.g. 'touch-me-not' plant (sensitive plant) in response to touch

ii. Movement is depended on growth. E.g. Directional movement of seedling in which, root going down and stem coming up.

Both these movements are affected by the action of plant hormones (phytohormones). Thus plant posses chemical coordination.

Plant movement : The movements in plants are not as apparent as In case of animals. Plants generally show movement at a very slow rate. The higher plants are fixed by roots on land. They cannot move from one place to another hence they show movement of their organs only.

i. Nastonastic Movement :

In tropism, a plant part either moves towards the stimulus or away from the stimulus. However, in some plants, the movement of the plant part is neither towards the stimulus nor away from the stimulus. That is, the movement of plant part in some plants is not in a particular direction with respect to stimulus. The movement of a plant part in response to an external stimulus in which the direction of response is not determined by the direction of stimulus is called **nastic movement**. Nastic movements of plants are also called **nasties**. The nastic movements of plants are induced by stimuli such as heat, light, touch (or contact), etc. The main difference between tropic and nastic movements is that tropic movement is a directional movement of a plant part but nastic movement is not a directional movement of the plant part with respect to the stimulus. The direction of nastic movement is *not* determined by the direction from which the stimulus is applied. In nastic movement, from whichever direction the stimulus is applied, it affects all the parts of the organ of a plant equally and they always move in the same direction. Nastic movements are mostly exhibited by the flat organs of the plants like 'leaves' and 'petals of flowers'. Some of the examples of the nastic movements of plants (or nasties) are given below :

(i) The folding up of the leaves of a sensitive plant *(Mimosa pudica)* on touching is an example of nastic movement. Here the stimulus is touch.

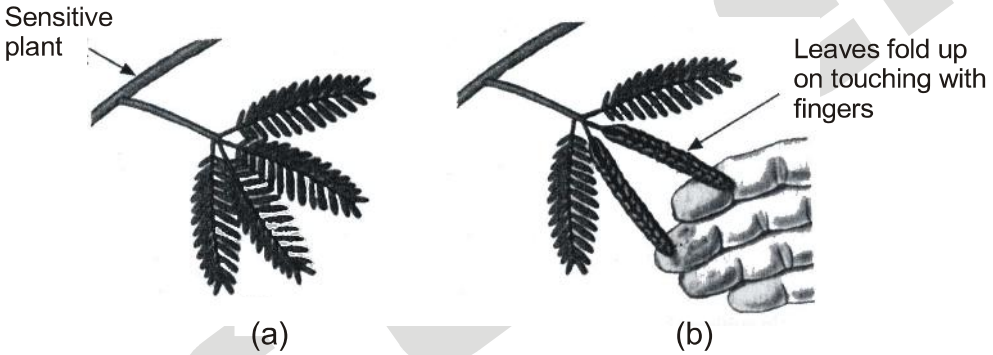
(ii) The opening up of the petals of dandelion flowers in morning in bright light and closing in the evening when the light fades is an example of *nastic* movement. In this case the stimulus is light.

(iii) The closing of the petals of moonflower in the morning in bright light and opening at dark when the light fades is also an example of *nastic* movement. In this case also the stimulus is light.

All tropisms are growth movements but all nasties (or nastic movements) are not growth movements. Nastic movements may or may not be growth movements. For example, the folding up of the leaves of a sensitive plant on touching is not a growth movement but the opening and closing of petals of flowers by the action of sunlight is a growth movement.

We have just said that most of the movements of the plant parts are caused by their growth. Now, since the growth of a plant part is usually a slow process, therefore, most of the movements of plant parts are very slow. There are, however, some exceptions. We will now describe the movement of a plant part (leaves) which is unusually fast and takes place almost immediately. It is the folding up of the leaves of a sensitive plant when touched with a finger (or any other object). This is discussed below under the topic on thigmonasty.

The non-directional movement of a plant part in response to the touch of an object is called **thigmonasty**. In other words, thigmonasty is the nastic movement of a plant part in response to touch. Thus,the stimulus in thigmonasty is the 'touch'. An example of the nastic movement in plants caused by touch (or thigmonasty) is provided by the sensitive plant (Mimosa pudica) which is also known as touch-me-not plant. It is called chhui-mui in Hindi. If we touch the leaves (or rather leaflets) of the sensitive plant with our fingers, then its leaves fold up and droop almost immediately. The folding up of the leaves of sensitive plant on touching, is an example of nastic movements in plants (in which the stimulus is the 'touch' of our fingers).

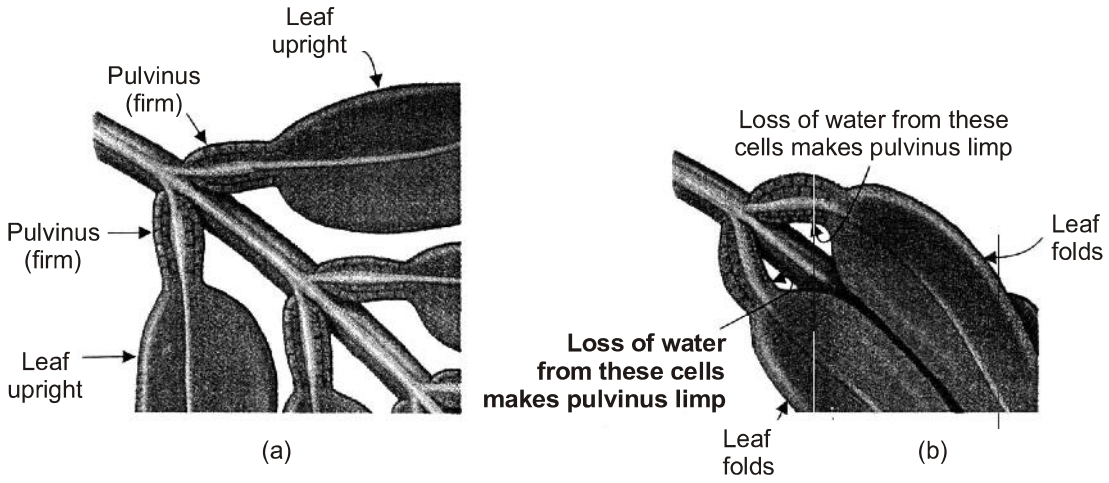


Diagrams to show the nastic movements in the leaves of sensitive plant (Mimosa pudica) caused by 'touch'

When we touch the leaves of this sensitive plant with our fingers, then these leaves of sensitive plant fold up at once as shown in figure(b). In this case, touch of our fingers is the stimulus and the leaves respond by 'folding up'. That the folding of leaves of a sensitive plant is not a case of tropism (like thigmotropism) because in this case the direction of movement of leaves does not depend on the direction of stimulus (touch). We will now describe how the leaves of a sensitive plant fold up when touched.

The sensitive plant has pad-like swellings called 'pulvini' at the base of each leaf (The singular of pulvini is pulvinus). The pulvini contain a lot of water in their cells. Due to the internal 'water pressure' in them (called turgor), all the pulvini are very firm and hold the leaves above them upright (see Figure) The pulvini have also large intercellular spaces (empty spaces) between their cells. **The folding up of the leaves of a sensitive plant on touching is due to the sudden loss of water from pad-like swellings called 'pulvini' present at the base of all leaves of the sensitive plant which make the pulvini lose their firmness causing the leaves to droop and fall.** This happens as follows.

When the leaves of sensitive plant (having pulvini at their base) are touched with a finger, then an electrical impulse is generated which travels through ordinary cells (because there are no nerve cells in



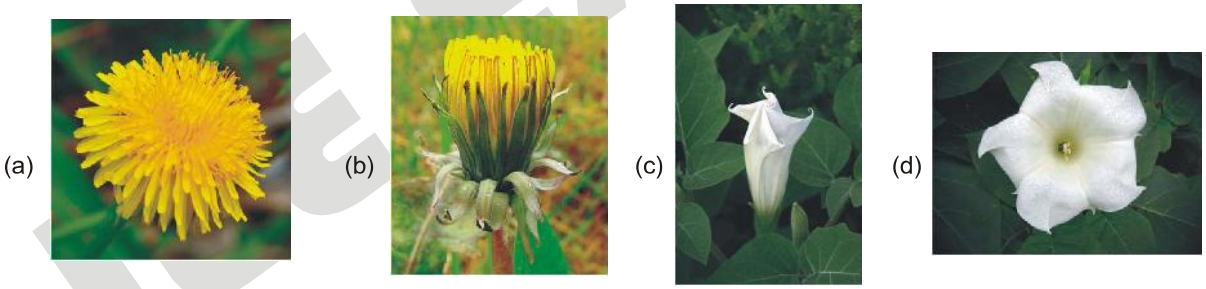
The leaves of sensitive plant fold due to the loss of water from pulvinus at their base

sensitive plant or other plants). This electrical impulse acts on a plant hormone. The plant hormone makes the water migrate from the cells of one half of a pulvinus to the intercellular spaces in the other half of pulvinus. This loss of water from half of pulvinus causes the pulvinus to lose its firmness making the leaf to fold. Similarly, all the pulvini lose firmness and become limp due to which all the leaves above them collapse and fold up.

At a gap of 15 to 30 minutes after the leaves have folded, water usually diffuse back into same cells of pulvinus from which it left, and the leaf returns to its original position.

(i) Photonasty :

The non-directional movement of a plant part (usually petals of flowers) in response to light is called photonasty. In other words, photonasty is the nastic movement of a plant part (like petals of flowers) in response to light. Thus, the stimulus in photonasty is light. A **dandelion flower** opens up in the morning in bright light but closes in the evening when the light fades and it gets dark. The opening



(a) Dandelion flower opens the petals in bright light during the daytime

(b) Dandelion flower closes the petals at dusk (or night) when it gets dark

(c) Moonflower closes the petals during the daytime when there is bright light

(d) Moonflower opens the petals at dusk (or night) when it get dark and there is no light

Nastic movements of petals of dandelion flower in response to light. This is an example of photonasty

Nastic movements of petals of moonflower in response to light. Another example of photonasty

and closing of petals of dandelion flowers in response to the intensity of light is an example of nastic movement in which the stimulus is light. In other words, it is an example of photonasty. The **moonflower** behaves exactly opposite to that of dandelion flowers in respect of response to light. The petals of moonflower close during the day when there is bright light but open up at night when it is dark and there is no light. This is also an example of photonasty.

The opening and closing of flowers in response to light (or photonasty) are growth movements. Petals open when their inner surfaces grow more than their outer surfaces. On the other hand, petals close when their outer surfaces grow more than their inner surfaces.

(ii). Seismonastic Movement :

Such movements occur in respond to touch (shock). These movements are very quick and are best seen in touch-me-not plant (Mimosa pudica) also called as sensitive plant. If we touch leaves of this plant with our fingers, we find that its leaves immediately fold up and drop. After some time, the leaves regain their original status. Here no growth is involved. Instead plant changes their shape by changing the amount of water in them, resulting folding up and drooping of leaves.

(iii). Tropical Movements :

Directional movement or orientations of specific part of a plant in response to external stimuli are called tropisms or tropic movements. They are of following types :

(a) Phototropism : It is the directional movement or orientation of the plant part in response to light stimulus. If plant moves towards light it is called as **positive phototropism** and if the plant moves away from light it is called as **negative phototropism**.

Examples :

(i) roots of plant always move away from light (negative phototropism)

(ii) shoot of plants always moves towards light.(positive phototropism)

(b) Geotropism : It is the directional movement or orientation of the plant part in response to gravity. If the plant part moves in direction of gravity it is alled as positive Geotropism and if it moves away it is called as negative geotropism.

Examples : (i) roots of a plant moves downwards in the soil in the direction of gravity (positive geotropism)

(ii) shoots of a plant moves upwards against the direction of gravity (negative geotropism)

(c) Chemotropism : It is the directional movement or orientation of the plant part in response to chemical stimuli. If plant moves towards chemical stimuli it is called as positive Chemotropism and if it moves away it is called as negative chemotropism.

Examples : (i) During the process of fertilization, growth of pollen tube towards the ovule.

(d) Hydrotropism : It is the directional movement or orientation of the plant part in response to water stimulus. If plant moves towards water stimulus it is called as positive hydrotropism and if the plant moves away from water stimulus it is called as negative hydrotropism.

Example : Bending of roots towards the water signifies positive hydrotropism

Experiment :

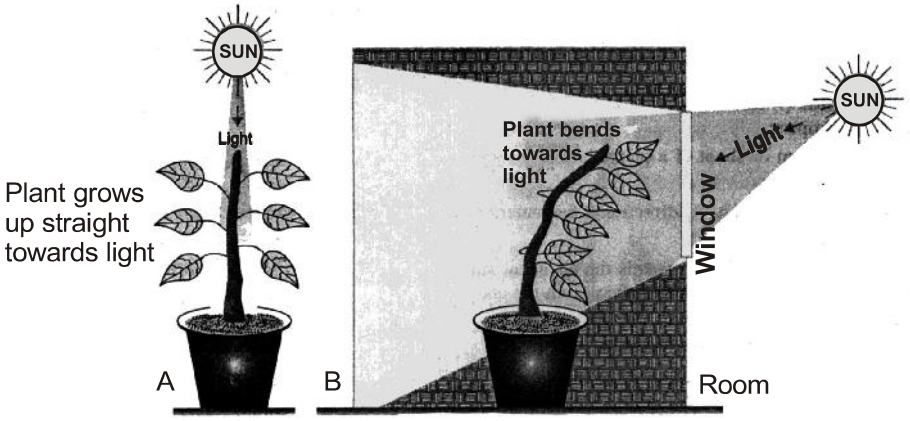
Demonstration of response of plant to various stimuls

(i) Phototropism : Plants are autotrophs therefore they respond to light by growing towards it. Plants also turn their leaves towards the sun to ensure that the latter gets maximum sunlight. This phenomenon can be explained by an experiment.

Take 2 potted plants. Place one plant in the open so that it receives the sunlight coming from above. Place the other plant in a room near the window in such a way that is receive sunlight from one side only, i.e. through window.

Aftersome days by observing both plants we come to knw that the first plant has grown up straight towards light and second plant has grown by bending towards the light.

Thus the stem of the plant respond to light by showing growth movement towards light (positive phototropism)



Experiment to show response of a plant to light (Phototropism)

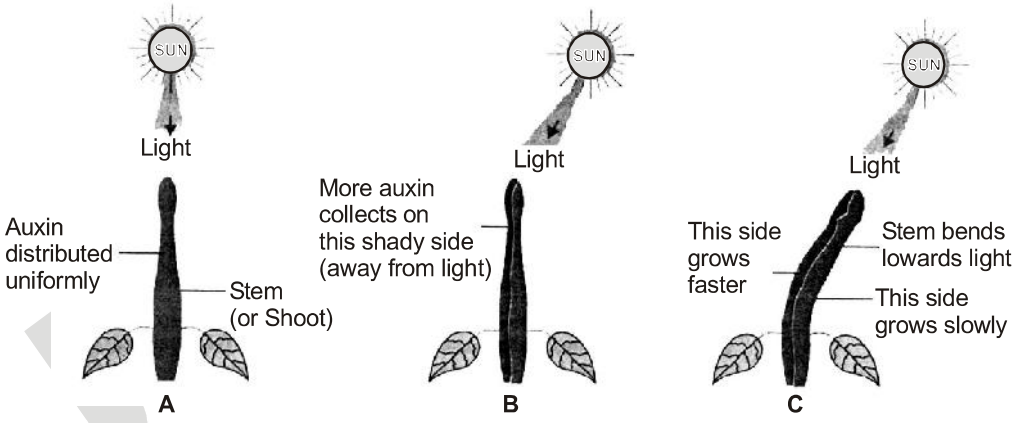
(ii) Directional movement due to growh in response to touch :

(a) Role of auxin hormone in phototropic movement involving growth

In phototropism the gowth is towards sunlight. This growth movement is caused by the action of auxin hormons. This hormone is synthesise by meristematics cells at the tip of the stem.

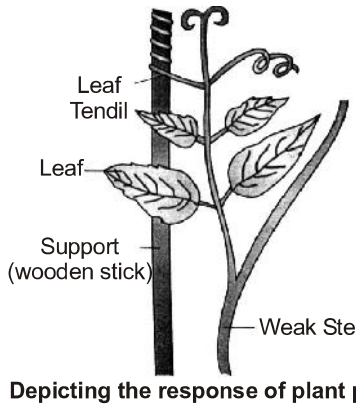
Auxin diffuse uniformly down the stem in plant kept in the open and receiving sunlight from above. Due to the presence of auxin equally on both sides the stem grows up straight because both sides of stem growth at the same space.

The second plant received light only from one side throught the window. In this case, the auxin moved from the tip of stem and concentrated more on the side does not receiving light. Due to the presence of more auxins the shady side of stem grew faster than the sie of the stem receiving light. As a result the stem bent towards the direction of light.



Experiment to show effect of auxin on the growth of a plant in response to light (Phototropism)

(b) Pea plant has weak stem. The pea plant needs support to climb up. The pea plant develops tendrils which helps it to climb up other plants or fences or other support. These tendrils are sensitive to touch. As tendrils come in contact with any support, the part of the tendril, the part of the tendril away from the support grows faster than the part in contact with the support. As a result the tendrils circles around the support and clings to it. This movement of tendril is supported by a plant hormone known as Auxins.



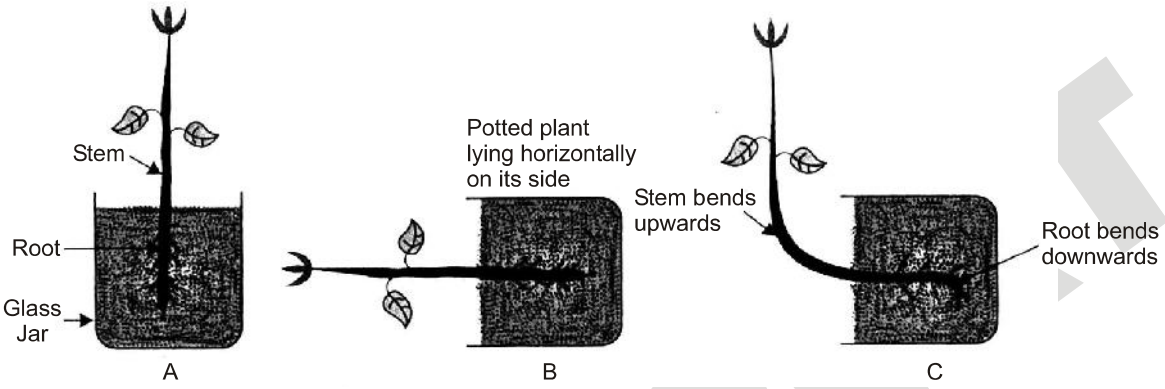
Depicting the response of plant part (tendril) to touch stimulus

(iii) Response of plants to gravity :

Gravity refers to the force with which the earth pulls all the things towards it. It acts in the downward direction. The plant part responds to gravity by either moving towards or away from earth. This phenomenon is called **geotropism**.

To prove this take 2 potted plants in a transparent jar. Keep the potted plant growing in transparent jar straight on the ground. Observe that stem growing upwards and roots downwards. Now place this potted plant horizontally on its side on the ground and observe the position of growing stem and the root. Keep the plant in this position for few days.

After few days we can observe that stem and root parallel to the ground, now growing according to its nature. Means stem bended upward away from earth and root bended downwards towards earth.



Experiment to show response of a plant to gravity (Geotropism)

(iv) Response of plant to chemicals (chemotropism) :

Plants also respond to chemicals substances. The ripe carpel of a flower (female reproductive part of flower) secrets a sugary substance(chemical) into style towards ovary. The pollen grains which fall on stigma respond to this chemical sugary substance by growing pollen tubes in the downward direction in the style of the carpel. Generally one pollen is successful in elongating its pollen tube to reach the ovule in the overy of the flower.

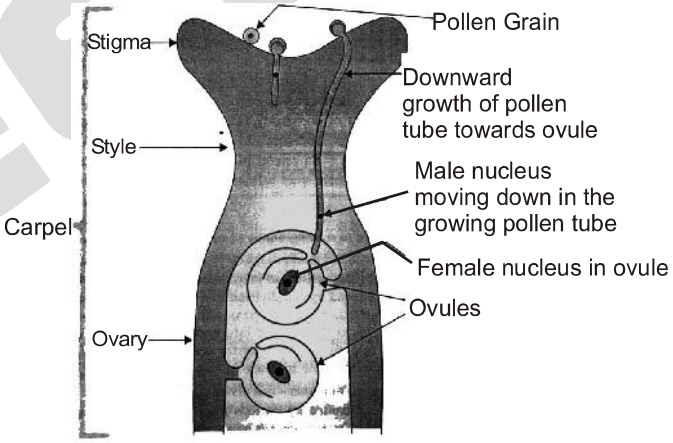
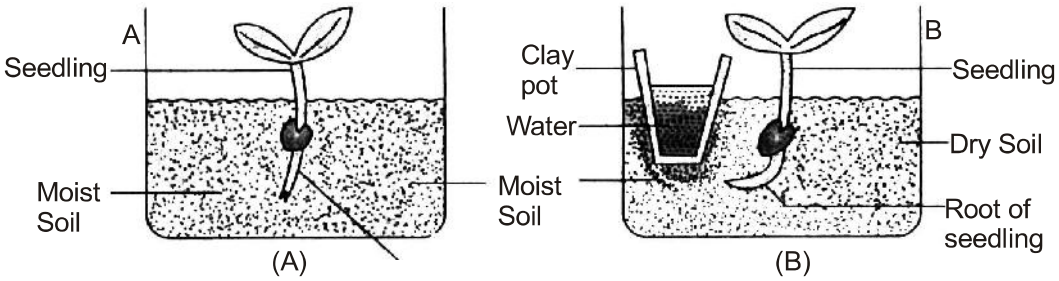


Diagram to show the response of a 'pollen' to chemical secreted by stigma (Chemostropism)

(v) Respond of roots of plant towards water (hydrotropism)

The roots of plant moves towards water and therefore depict positive hydrotropism. Such type of response can be demonstrate by an experiment.

Take 2 glass trough A and B and fill them with soil upto two-third level. Plant a tiny seedling in each trough. Now place a small clay pot in soil in trough B. water soil daily in tough A uniformly/ however in trough B, put water daily in clay pot only. After few days, carefully dig up he seedling in both glass. You will notice that 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.



Experiment to reveal the response of root of plant to water (hydrotropism)

Plant Hormones (Phytohormones) :

Plant hormones or phytohormones ('phyto' means plant) are naturally occuring organic chemical substances present in plants 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.** 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 phytohormones are synthesized in minute quantities in one part of the plant body and these simply diffuse to another part where they influence specific physiological processes.

Now a days, several manufactured chemicals (synthetic plant hormones) are also available. They resemble the phytohormones in molecular structure and physiological action. These are called **growth regulators.**

GROWTH :

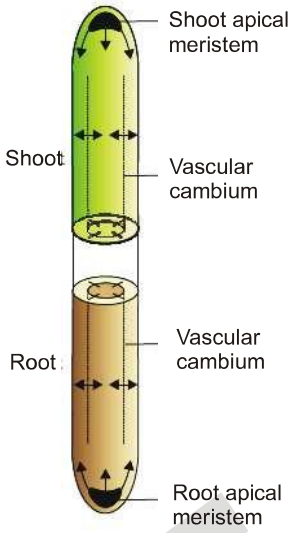
Growth in plants mainly occurs by the activity of meristematic cells (continuously dividing cells). The new cells are continually produced by cell division in a meristem. There is a meristem at the apex of every root (root apex) and shoot (shoot apex). Some plants have intercalary meristems (e.g., grasses have such meristems at the base of internodes) and vascular cambium too. The latter causes increase in girth in plants. The daughter cells. derived from cell division in the meristems, enlarge and bring about visible increase in size of the plant.

Growth is regarded as one of the most fundamental and conspicuous characteristics of a living being. **What is growth**? Growth can be defined as an irreversible permanent increase in size of an organ or its parts or even of an individual cell. Generally, growth is accompanied by metabolic processes (both anabolic and catabolic), that occur at the expense of energy. Therefore, for example, expansion of a leaf is growth.

Plant Growth Generally is Indeterminate :

Plant growth is unique because plants retain the capacity for unlimited growth throughout their life. This ability of the plants is due to the presence of meristems at certain locations in their body. The cells of such meristems have the capacity to divide and self-perpetuate. The product, however, soon looses the capacity to divide and such cells make up the plant body.

This form of growth where in new cells are always being added to the plant body by the activity of the meristem is called **the open form of growth**.



Diagrammatic representation of locations of root apical meristem. Shoot apical meristem and vascular cambium. Arrows exhibit the direction of growth of cells and organ

What would happen if the meristem ceases to divide? Meristems are responsible for the primary growth of the plants and principally contribute to the elongation of the plants along their axis. In dicotyledonous plants and gymnosperms, the lateral meristems, vascular cambium and cork-cambium appear later in life. These are the meristems that cause the increase in the girth of the organs in which they are active. This is known as **secondary growth of the plant**

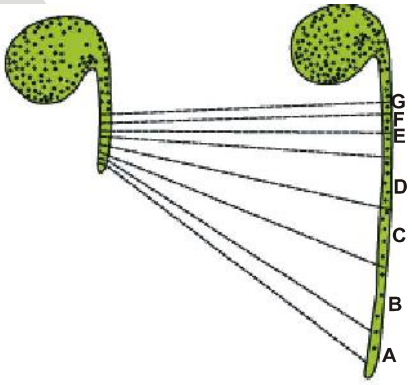
Growth is Measurable :

Growth, at a cellular level, is principally a consequence of increase in the amount of protoplasm. Since increase in protoplasm is difficult to measure directly, one generally measures some quantity which is more or less proportional to it. Growth is, therefore, measured by a variety of parameters some of which are: increase in fresh weight, dry weight, length, area, volume and cell number. It is amazing to know that one single maize root apical mersitem can give rise to more than 17,500 new cells per hour, whereas cells in a watermelon may increase in size by upto 3,50,000 times. In the former, growth is expressed as increase in cell number; the latter expresses growth as increase in size of the cell.

While the growth of a pollen tube is measured in terms of its length, an increase in surface area denotes the growth in a dorsiventral leaf.

Phases of Growth :

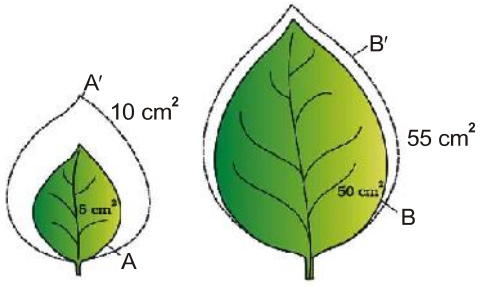
The period of growth is generally divided into three phases, namely, meristematic, elongation and maturation. Let us understand this by looking at the root tips. The constantly dividing cells, both at the root apex and the shoot apex, represent the meristematic phase of growth. The cells in this region are rich in protoplasm, possess large conspicuous nuclei. Their cell walls are primary in nature, thin and cellulosic with abundant plasmodesmatal connections. The cells proximal (just next, away from the tip) to the meristematic zone represent the phase of elongation. Increased vacuolation, cell enlargement and new cell wall deposition are the characteristics of the cells in this phase.



Detection of zones of elongation by the parallel line technique. Zones A, B, C, D immediately behind the apex have elongated most

Further away from the apex, i.e., more proximal to the phase of elongation, lies the portion of axis which is undergoing the phase of maturation. The cells of this zone, attain their maximal size in terms of wall thickening and protoplasmic modifications.

Quantitative comparisons between the growth of living system can also be made in two ways : (i) measurement and the comparison of total growth per unit time is called the **absolute growth rate.** (ii) The growth of the given system per unit time expressed on a common basis, e.g., per unit initial parameter is called the **relative growth rate**. In Figure two leaves, A and B, are drawn that are of different sizes but shows absolute increase in area in the given time to give leaves, A1 and B1. However, one of them shows much higher relative growth rate.



Diagrammatic comparison of absolute and relative growth rates. Both leaves A and B have increased their area by 5 cm^2 in a given time to produce A′, B′ leaves.

There are three phases of cell growth in plants - cell division, cell enlargement and cell maturation (cell differentiation). These are controlled by various phytohormones.

Following are five major types of phytophormones (or plant growth substances) which are involved in the control and coordination in plants :

1. Auxins 2. Gibberellins 3. Cytokinins 4. Abscisic acid (ABA) 5. Ethene (ethylene).

On the basis of their effect, plant hormones (phytohormones) can be divided into **two groups :**

1. Growth promoters. These stimulate the plant growth, e.g., auxins, gibberellins, cytokinins and ethylene.

2. Growth Inhibitor's. These inhibit or retard the plant growth, e.g., Abscisic acid (ABA).

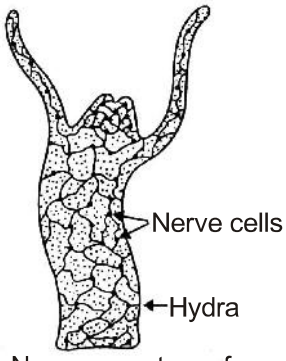
The synthesis and action of various plant hormones are influenced by internal stimuli. Some prominent actions of these plant hormones are mentioned below :

(i) Dormancy and breaking of dormancy.
(ii) Growth of root, stem and leaves.
(iii) Opening and closing of stomata (stomatal movements) in leaves.
(iv) Flowering of plants.
(v) Growth and ripening of fruits.
(vi) Movements in plants (e.g., tropic movements and nastic movements).
(vii) Apical dominance.
(viii) Parthenocarpy.

Each plant hormone performs specific functions. These are listed in the following table

S.No.	Plant Hormones	Functions
1.	**Auxins** (naturally occuring auxin is indole 3-acetic acid)	• These **promote cell enlargement** and cell differentiation in plants • These also promote stem and fruit growth. • These regulate important plant movements, i.e., tropisms. • These induce **parthenocarpy** (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 wtih 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. • It promotes yellowing and senescence of leaves.
5.	**Abscisic Acid** (ABA)	• It **promotes the dormancy in seeds** and buds and thus **inhibits growth.** • It also **promotes the closing of stomata** and thus **effects wilting of leaves.**

COORDINATION IN ANIMALS :



Nervous system of Hydra. (Please note the network of nerve cells throughout the body of hydra)

Unicellular organisms respond to environmental stimuli by moving towards or away from the source of stimulus. Such responeses of unicellular organisms (e.g. Amoeba) are termed as **taxes** (singular **taxis).** If they move towards the source of stimulus, their response is termed **positive taxis** and if they move away from the source of stimulus, their response is termed **negative taxis.** The responses of multicellular animals to stimuli, however, are not as simple. Evolution of multicellularity in animals necessitated the development of some system for the control and coordination of the activities of various cells of the body. Such a control and coordination, in fact, requires

(i) Gathering information about changes in the external environment,

(ii) Transmitting this information to the internal cells located away from the body surface, and

(iii) Exchange of information between the cells situated away from each other.

In lower multicellular animals, the coordination takes place through the nervous system. However, in higher animals, coordination takes place through two types of control systems : **nervous system and endocrine system**.

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

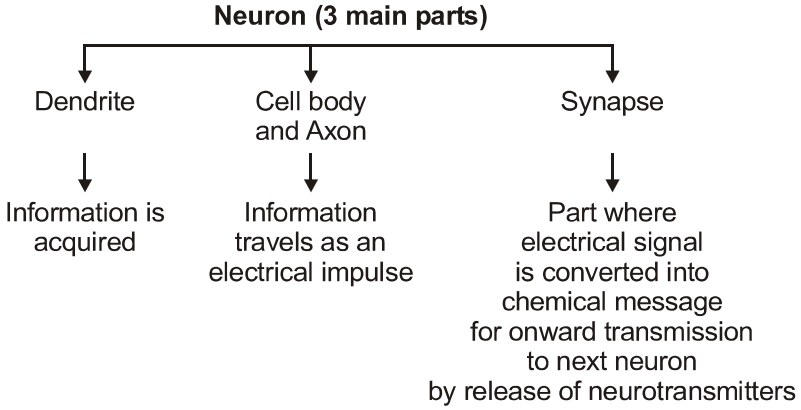
2. Endocrine System. The endocrine system consists of specialized glands **(endocrine glands)** which bring about control by sending chemical messengers termed **hormones.** The hormonal control is usually slow acting and its effect is diffuse.

NERVOUS SYSTEM IN ANIMALS :

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

Nerve cells or neurons are, in fact, the structural and functional untis of nervous system.

In higher multicellular animals, the nervous tissue consists of **nerve cell** or **neurons, nerve fibres,** bundle of nerve fibres forming **nerves,** packing cells **(neuroglia),** and **neurosecretory cells.**



Structure of Neuron : Neuron is the structural and functional unit of nervous system It has a special structure to receive, conduct and transmit impulses. But, it varies greatly in size and shape. Neurons are, in fact, the largest cells present in the human body, sometimes reaching 90 – 100 cm.

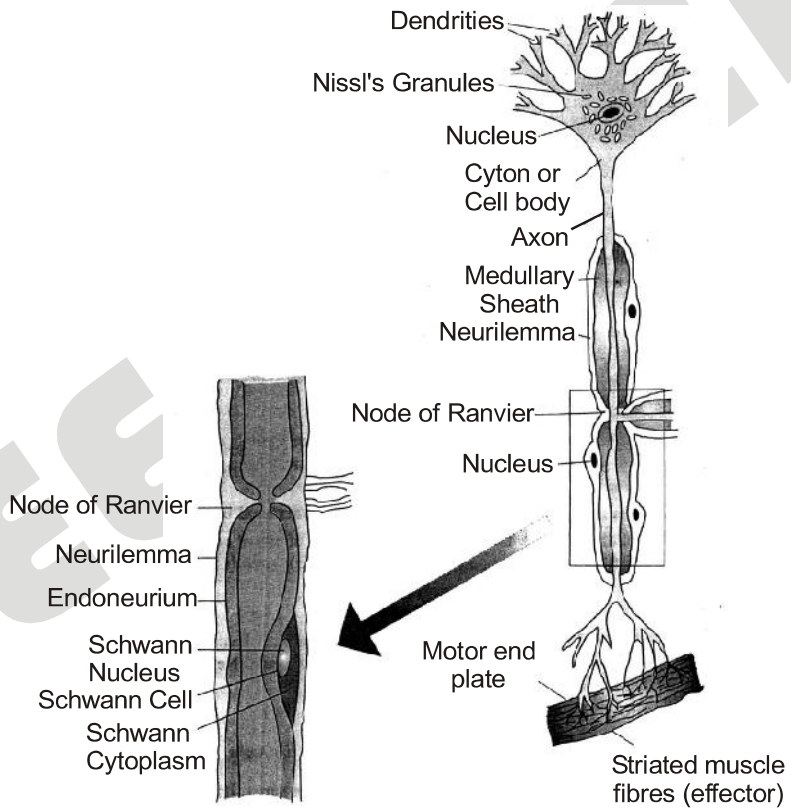
A neuron consists of **three** prominent parts :

(i) Cell body, (ii) Dendrites (singular dendron), and (iii) Axon.

(i) Cell body : The cell body of a neuron is also called **cyton or soma.** It is broad, rounded, pyriform of stellate part of the neuron. It has abundant cytoplasm, called **neuroplasm** and a relatively large, spherical **nucleus.** the cytoplasm has mitochondria, Golgi apparatus, neurofibrils, neurotubules, and special granules called **Nissl's granules.** These Nissl's granules are characteristic of nerve cells. Centrioles are, however, absent in neurons. Cell body is concerned with metabolic maintenance and growth. It also receives nerve impulses from dendrites and transmits them to axon.

(ii) Dendrites (singular **dendron**). These are several short, tapering, much branched protoplasmic processes stretching out from the cell body of a neuron. Dendrites are the parts of neuron where sensation (information) is acquired. The infromation then travels as an electric impulse towards the cell body. Dendrites contain Nissl's granules and neurofibrils.

(iii) Axon : It is a single, very long cylindrical protoplasmic process (nerve fibre) of uniform diameter arising from the cell body. At its terminal end, axon is highly branched. The terminal branches are called **terminal arborization.** Axon terminals are oftern knob-like and these may end in nerve fibres (forming neuromuscular junction) or glands or form synapses with dendrites of other neurons. The axon conducts nerve impulses away from the cell body.



Structure of a neuron (nerve cell)

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 may have an additional insulating and protective sheath of **myelin** around it. It is **nerve fibres** and those without this sheath are termed **non-myelinated nerve fibres.** Myelinated nerve fibres posses unmyelinated areas called **nodes of Ranvier.**

Functions :

(i) To receive the information from environment
(ii) To receive the information from various body parts. (Stimuli, Response)
(iii) To act accordingly through muscles and glands.

Stimulus : Any change in environment or within that bring about the reaction eg: touching a hot plate.
Response : The reaction of our body to these changes. eg. withdrawal of our hand
Receptors : Are specialised tips of some nerve cells that detect the information from the environment.

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

- They do not divide.
- From shortly after birth, new neurons do not develop.
- They do not repaired, when injured.
- They use only glucose as a respiratory substrate.
- They die if deprived of oxygen for over 5 minutes.

Table : Differences between Dendrites and Axons

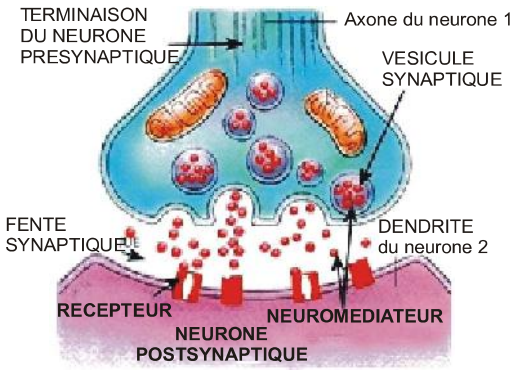
Dendrites	Axons
1. These are short, tapering processes.	1. These are long, uniform processes.
2. Number of dendrites arise directly from the receiving surface of cell body.	2. A single axon arises from the discharging end of a cell body.
3. The end taper and do not have knobs at the tips of branches.	3. Terminal branches of each axon enlarged to form knobs.
4. These contain Nissl's granules and neurofibrils.	4. These do not posses Nissl's granules. However, neurofibrils are present.
5. These acquire sensations and send nerve impulses to the cell body.	5. These carry nerve impulses away from the cell body.

Dendrites of a neuron acquires the information. The information then travels as nerve impulses from dentron to cell body, axon and finally to Dendron of the other neuron through a synapse.

Synapse :

The neurons are not connected. There occurs a very minute gap between terminal portion of axon of one neuron and the Dendron of other neuron. This minute gap is called as synapse. At the synapse, axon terminal comes in close proximity to the Dendron terminal of next neuron. Axon terminal expanded to form **pre-synaptic knob**. on the other hand, the dendrite terminal forms **post-synaptic depression.** In between the two, lies a narrow fluid filled space called as **synaptic cleft**. As the nerve impulse reaches the presynaptic knob, the synaptic vesicles get stimulated to release neurotransmitter in the synaptic cleft. The neurotransmitter molecule diffuse across the minute gap to come in contact with post-synaptic membrane. In this way, nerve impulse passes across the minute gap to stimulate dendrons 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 side. It carries impulse across the synapse and pass it to the dendrons 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.



MECHANISM OF SYNAPSE

Protective Covering :

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 proteted by **vertebral column**. There are also present additional protective coverings called **meanings** between the brain or spinal cord and their respective bony cases. **Cerebrospinal fluid** - it is colourless, clear, slightly alkaline fluid, present in the ventricles of the brain, central canal of spinal cord and spaces between the meanings. It protects the CNS from shocks and keep it moist.

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 • Involuntary actions • Voluntary actions

Reflex Action : Reflex action wad discovered by **Marshal Hall** (1833). These are nerve mediated, automatic involuntary actions that occur without the will of an animal.

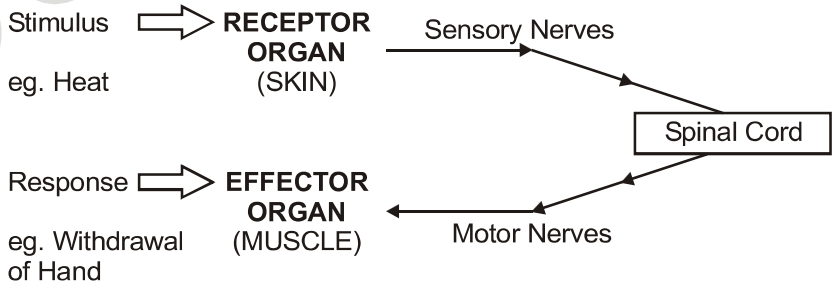
A reflex action may be defined as a spontaneous, automatic and mechanical response to a stimulus, acting on a specific receptor, without the will of an animal.

Need for reflex Action : The recptors, present on various body parts, receive stimuli and transmit information in the form of nerve impulses to the central nervous system. Latter has various coordination centre where the information is processed. The processing is done on the basis of information and experiences already stored. The message is then sent by coordination centres through motor neurons to appropriate regions of the body which accordingly respond and react. The whole process takes some time. However, in certain situations, sensation requires immediate response as time used for processing may cause harm to the body. In such situations, reflex actions occur.

Examples. Blinking of eyes, movement of diaphragm during respiration, withdrawl of hand or foot everytime if it is suddenly pinched or pricked with a needle or touched by a hot object, coughing, yawning sneezing etc. are all reflex actions. A gentle strike below the knee cap, while sitting with freely hanging legs, kicks the leg forward (knee-jerk reflex) is another example of reflex action. Similarly, watering of mouth on seeing the food, when hungry, is also a freflex action.

• What Happens in Reflex Actions ?

In reflex action, fine tips (dendrites) of receptors (sensory neurons) quickly relay a message (electric impulse) via sensory nerves to the sipnal cord. The spinal cord then sends information (impulse) via motor nerves to effectors (muscles or glands) which show response. The path taken by nerve impulses in a reflex action is called **reflex arc**



Thus, reflex actions generally involve spinal cord for quick response to specific stimulus. However, information input also goes on to reach the brain where thinking process occurs.

• Reflex Arc

The path taken by nerve impulse in a reflex action is called **reflex arc**

It consists of five parts :

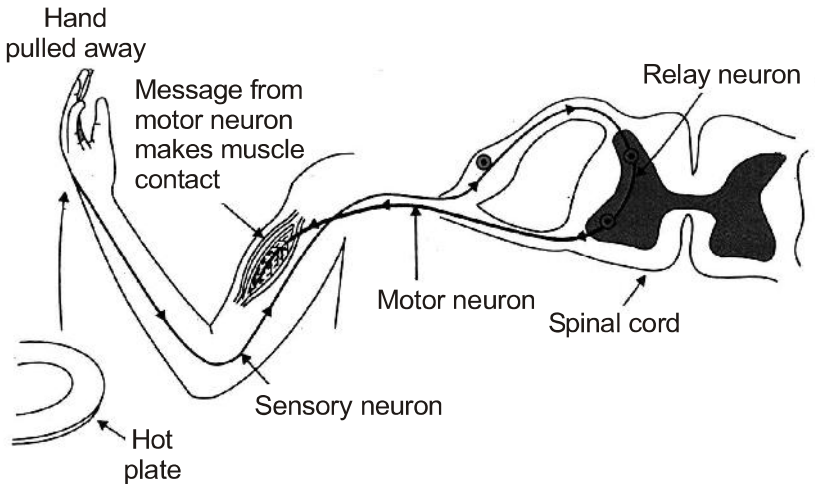


Diagram to show the reflex action and its path (which is called reflex arc)

(i) Receptor. It is a specific group of cells or organ, the neurons of which receive a stimulus and set up a sensory impulse.

(ii) Sensory (Afferent) Nerve. It carries sensory impulse from the receptor to the central nervous system.

(iii) A portion of central Nervous System. It is spinal cord or brain. Its neurons analyse and interpret the sensory impulse and set up an appropriate motor impulse. Accordingly, reflexes are termed spinal reflexes or **cerebral reflexes.**

(iv) Motor (efferent) Nerve. It carries motor impulse from the central nervous system to specific effectors (muscle fibres or gland cells).

(v Effector. It may be muscle fibres or gland cells. Here, impulse terminates and response occurs as per instructions received from central nervous system.

Mechanism of reflex arc : When our hand accidently touches a hot object, the heat is sensed by thermoreceptors present in the skin of hand. The stimulus triggers nerve impulse in sensory (recptor) neuron. It transmits message to the spinal cord. In the spinal cord, impulse is passed on to the relay (connector) neuron which, in turn, passes it to the motor neuron. The motor neuron transmits the instruction to a muscle in our arm. The arm muscle contracts and pulls our hand away from the hot object. Such reflexes which involve spinal cord are also termed **spinal reflexes.**

Reflex actions generally involve spinal cord. Hence, majority of the reflexes are **spinal reflexes.** However, there are some reflexes which involve brain. Such reflexes are termed **cerebral reflexes.** For example, when bright light is focused in our eyes, the recptors relay impulses via sensory nerves to the CNS and the latter transmits message (in the form of impulses) to the effectors (muscles in the eye). These muscles reduce the size of the pupil. Thus, contraction of pupil of human eye in the presence of bright light is an example of cerebral reflex. Other examples of cerebral reflexes are salivation at sight or smell of food and peristalsis.

• Significance of Reflex Action

1. It checks overloading and overtaxing of brain.

2. It results in quick response to otherwise harmful stimuli without the processing done by coordinating centres of central nervous system.

3. It has a survival value.

DIFFERENCE BETWEEN REFLEX ACTION AND WALKING

Reflex Action	Walking
1. It is inborn (inherited) and present in the individual since birth.	**1.** It is not inherited and is acquired through learning.
2. It is automatic and occurs without the will of individual	**2.** It is under the control of cerebellum part of brain and occurs with the will of individual.
3. It cannot be changed.	**3.** It can be changed.

Involuntary Actions : Involuntary muscular actions are performed by the animal without its will. These occur automatically and the animal has no choice in it. Such actions are meant for controlling and coordinating the functioning of internal organs. Many of these involuntary actions are controlled by the midbrain 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.

Voluntary Actions : Voluntary muscular actions are performed by the animal with its will. 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.

CHEMICAL COORDINATION IN ANIMALS :

- Chemical coordination in animals is brought about by the secretions of **endocrine glands**.
- Endocrine glands are **ducless glands** which secrete the chemical substances called **hormones**, directly pour into the blood.
- Any chemical substance which is formed in the tissues of endocrine glands are carried by the blood to other parts of the body for its specific actions is termed as hormone.
- The first hormone discovered was secretin of duodenal lining. It was discovered by **william M.Bayliss** and **E.H. Starling** but the term hormone was given by starling.
- An organ which responds to such a hormone is known as **target organ**.

(a) Characteristics of Hormones :

(i) They are the secretions of endocrine glands.

(ii) They are produced at a place and act on target organs which are mainly away from their source.

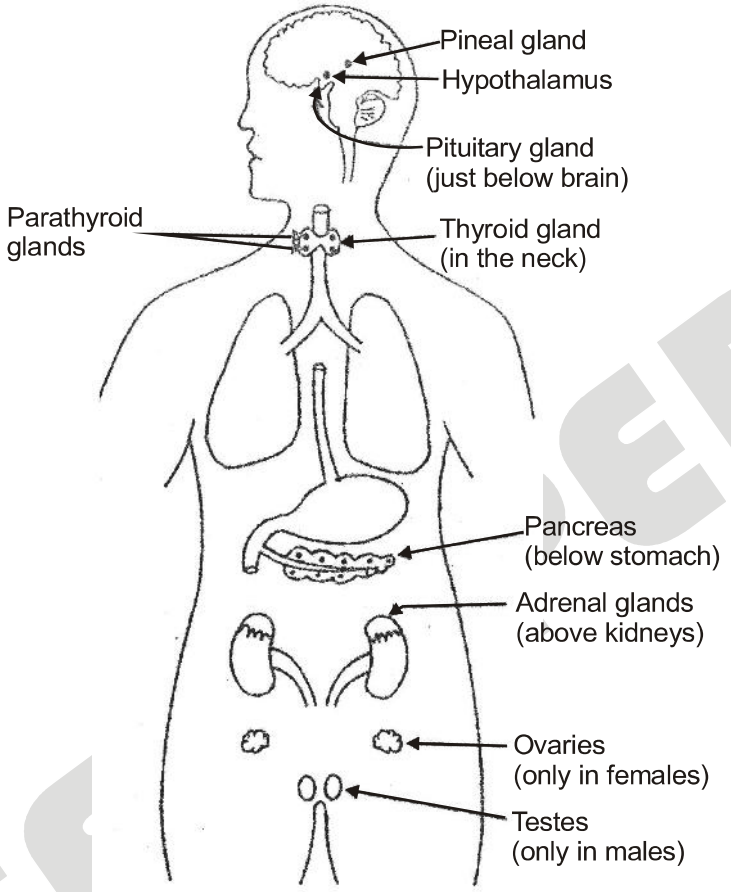
(iii) They are poured directly into the blood stream.

(iv) They are required in very small quantities.

ENDOCRINE GLANDS :

- **Various endocrine glands of human beings are as follows** :

(i)	Pituitary gland (or Hypophysis)	**(ii)**	Pineal gland
(iii)	Thyroid gland	**(iv)**	Parathyroid gland
(v)	Thymus gland	**(vi)**	Adrenal gland
(vii)	Pancreas	**(viii)**	Ovaries
(ix)	Testes		



The positions of endocrine glands in the human body

(a) Pituitary Gland (or Hypophysis) :

- It is a small ovoid structure attached to the base of brain (hypothalamus) by a short stalk called **infundibulum** placed just behind the optic chiasma where the optic nerve from each eye meet.
- Pituitary gland is also known as the **master gland** as it controls other endocrine glands.
- This gland consists of three lobes-anterior, middle and posterior.
- Each lobe of the pituitary gland secretes different sets of hormones.

(i) Hormones of anterior pituitary :

(A) Growth hormone (GH) : This hormone promotes and regulates the process of growth in the body.

- It's deficiency during chldhood leads to **dwarfism** and over secretion leads to **gigantism**.

(B) Thyroid stimulating hormone (TSH) : As is clear from its name it controls the functioning of thyroid gland.

- It stimulates thyroid gland to secrete thyroxine.

(C) **Follicle stimulating hormone (FSH) :** It stimulates the production of gametes.

(ii) Hormones of middle pituitary :

Melanocyte stimulating hormone (MSH) : This is the only hormone secreted by middle pituitary which controls the growth and development of **melanocytes** responsible for skin colour.

(iii) Hormones of posterior pituitary :

(A) Vasopressin or Antidiuretic hormone (ADH) : This causes the reabsorption of water into the blood from the collecting tubules of the kidneys, thereby concentrating the urine and reducing its volume.

(B) **Oxytocin :** This hormone stimulates **uterus** contractions at the time of child birth and causes release of milk from mammary glands.

- It is also known as **birth hormone** or **milk ejecting hormone**.

(b) Pineal Gland :

- It is a small gland reddish-grey in colour, about the size of a pea, attached to the roof of the brain.
- It contributes in regulating gonadal development. It controls development & concentration of melanin.

(c) Thyroid Gland :

The thyroid gland consists of two lobes joined together by an isthmus.

- It is situated in the lower part of the neck and when enlarged it forms **goitre**. Two hormones secreted by the thyroid gland are :

(i) Thyroxine : It is the principal hormone secreted by the thyroid gland.

- Its main role is to increases the metabolic rate of the organs and tissues of the whole body.
- The basal metabolic rate (B.M.R.) is increased in **hyperthyroidism** and reduced in **hypothyroidism**.
- **Hypothyroidism :** It is the condition caused by thyroid hormone deficiency in adults.
- Iodine deficiency causes simple goitre.
- **Hyperthyroidism :** Excessive amount of thyroxine is poured into the blood this condition being known as **toxic goitre**

Importance of Iodised salt :

Iodine mineral is essential part of thyroine hormone so it is important that we must consume iodised salt as in turn it is essential for thyroid gland as it controls carbohydrate, proteins and fat metabolism for best balance of growth deficiency of iodine might cause disease called **goitre.**

(d) Parathyroid Gland :

- These are small ovoid pea shaped glands. They lie on the posterior surface of the thyroid gland.
- It also controls the excretion of phosphates in the urine, probably by reducing tubular reabsorption of phosphorus by the kidney tubule.

(e) Thymus Gland :

- This gland is situated in the thorax in midline under the sternum in front of trachea.
- It secretes a hormone namely thymosin.
- It is one of the sites of lymphocyte formation in children.
- It helps in producing antibodies.

(f) Adrenal Gland :

- These are two small semilunar structures lying one each on upper pole of the kidneys. That is why they are also known as **supra renal glands**.

- Each gland consists of two structurally & physiologically separate parts known as **cortex and medulla**.
- Cortex secretes three different kinds of hormones known as corticosteroids.
- **Adrenal medulla :** It secretes two hormones.

(i) Adrenaline : It is a stress hormone causes increase in systolic blood pressure, dilation of coronary blood vessels, increased sweating and increase in metabolic rate.

- It brings **restlessness**, muscle fatigue and anixety.

(ii) Noradrenaline : It is general vasoconstrictor, increases both systolic and diastolic pressures.

- Both of these hormones are helpful in emergency conditions. Thus are called as **"fight or flight response".**

(g) Pancreas : Pancreas is the only heterocrine gland in the human body.

- It acts as **exocrine** as it secretes pancreatic juice which is poured into the duodenum with the help of pancreatic duct.
- The **endocrine** tissue of the pancreas is in the form of clumps of secretory cells known as the **islets of Langerhans**.
- The islet cells are of three types -alpha, beta and delta.

(i) The alpha cells of pancreas secrete glucagon, the metabolic effects of which are opposite to those of insulin.

- It causes the breakdown of liver glycogen, thereby releasing glucose into the blood stream.

Insulin is secreted by the beta cells and like other hormones, passes directly into the blood.

- Insulin is required to convert glucose into glycogen (glycogenesis) and store it in liver.
- Deficiency of insulin due to defect in islets of Langerhans results in diabetes mellitus, a condition in which blood glucose is high and is passed in the urine.

(iii) The third hormone somatostatin is secreted by the delta cells of the islets of Langerhans.

- It is able to inhibit the secretion of many hormones.
- As it inhibits the release of growth hormone of pituitary gland.
- It is also known as growth hormone release inhibiting hormone **(GHRIH)**.

Table : Difference between diabetes mellitus and Diabetes insipidus

	Diabetes mellitus	Diabetes Insipidus
1	Sugar level of blood is high	Sugar level of blood is normal
2	There is excretion of sugar in urine	Sugar is not excreted in urine
3	It is due to deficiency of insulin	It is caused by deficiency of ADH or antidiruretic hormone
4	Urine has normal concentration	Urine is dilute

(h) Ovaries :

Ovaries secrete three hormone :

(i) Oestrogen : controls the secretion of oestrogen by

- This hormone effects the development of female secondary sex characters.

(ii) Progesterone :

- Progesterone prepares the uterus for receiving the embryo.

- This hormone is essential for the maintenance of pregnancy and is therefore called **pregnancy hormone**

(iii) Relaxin : This hormone is secreted during later stages of pregnancy and leads to relaxation of muscles of the pelvic area to enable easy child birth and reduce the pressure on the foetus.

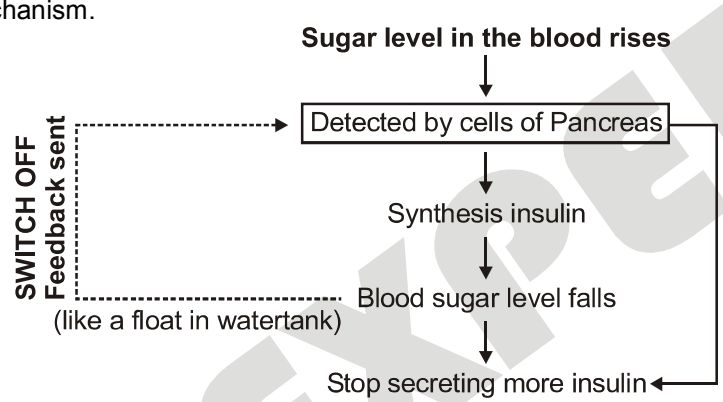
(i) Testes :

- Testosterone is the main testicular hormone secreted by interstitial cells of the testis.
- It is mainly concerned with the development and maintenance of male secondary sex characters and enhancing the process of spermatogenesis (sperm formation).

FEEDBACK MECHANISM

Blood - Glucose - Homeostasis :

Makes sure that hormones should be secreted in precise quantities and at right time, which is regulated by feedback mechanism.



FEEDBACK MECHANISM

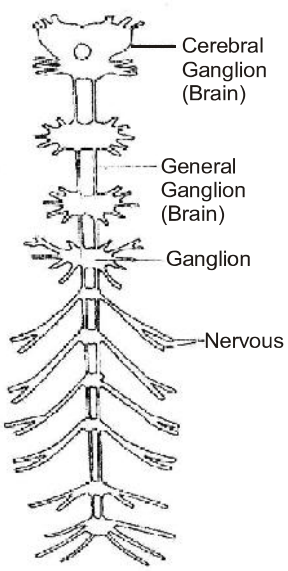
NERVOUS CO-ORDINATION IN ANIMALS :

In animals two kinds of co-ordination -nervous & chemical are present. The nervous co-ordination is brought about by the nervous system and the chemical co-ordination by hormones. Both the systems work an integrated system.

• **Nervous system in animals :** Except, Sponges, all multicellular animals posses simple or complex nervous system. In all these animals, nervous system is comprised of specialized cells called neurons or nerve cells to respond to stimuli and coordinate animal activities. Nerve cells are the structural & Functional units of nervous system.

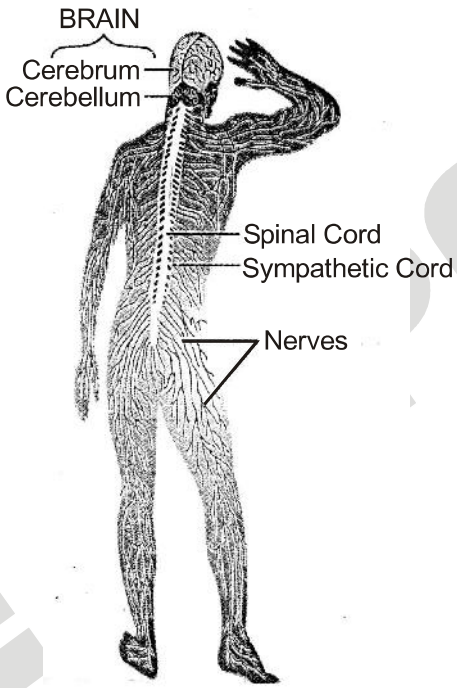
• **Nervous system of Hydra :** Hydra belongs to phylum Cridaria (Coelenterate) of the group invertebrate. The nervous system in hydra is merely a network of nerve cells joined to one another and spread throughout the body between the two germ layers, outer epidermis & inner gastrodermis. **This network is called as nerve net.** When the body of hydra receives certain stimulus at a particular region from the environment, the nerve cells present at the region send impulses in all the direction through the network of nerve cell spread throughout the body. In this way, nerve network coordinates responses to different stimuli in Hydra without the existence of central control region i.e. brain.

• **Nervous system is grasshopper (a Insect) :** In insets, the nervous system consist of a brain, ganglia (singular ganglion) & nerve cord. A mass of nerve cells is called ganglion. The nerve cord run along the entire length of the body. At interval, it has ganglia. Small nerves are given out from each ganglion. Near the anterior end of the insect body, a large bilobed ganglion, called the brain, is present. Thus, the nervous system of grass hopper consist of a brain, a long nerve cord, the ganglia and nerves spreading form the nerve cord.



Nervous system of Grass hopper

HUMAN NERVOUS SYSTEM



Human Nervous System

COMPONENTS OF THE NERVOUS SYSTEM

Nervous System

Central Nervous System (CNS)

Brain
Largest part, two hemispheres, highly convoluted, outer grey and inner white matter

Spinal cord
(Lies within neural canal inner grey and outer white)
Conveys nerve impulse from the periphery to the brain and motor impulses from the brain to the periphery. Also concerned with reflex action

Peripheral Nervous System (PNS)
(*carries impulses to and from (CNS)*)

Cranial nerves
(12 pairs)

Spinal nerves
(31 pairs)

Autonomic Nervous System (ANS)

Sympathetic
Dilates pupil, constricts blood vessels of skin stimulates sweat glands, accelerates heart beat, releases sugar from liver

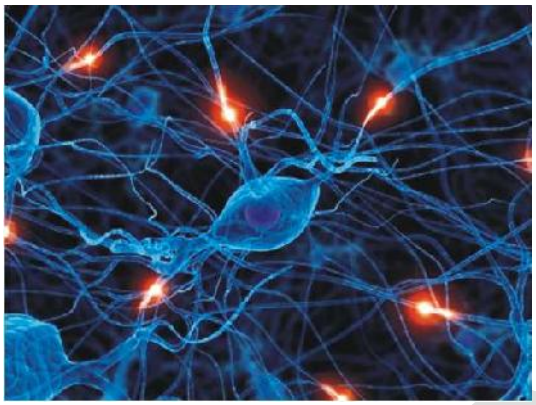
Parasympathetic
Restores normal body conditions

CENTRAL NERVOUS SYSTEM

The central nervous system is made up of the brain and spinal cord which is the continuation of the brain.

BRAIN

- It is the part of the central nervous system that is present in the head and protected by the skull, dorsally and laterally. The box that houses the brain within the skull is called the **cranium or brain box**.
- It has three main regions the **fore brain, the mid brain and the hind brain**. The three regions have different parts that have specific functions.



Brain cells

- **Fore brain**

It is made up of cerebrum, hypothalamus, thalamus and olfactory lobes.

(i) Cerebrum

• It is the largest and main thinking part of the brain and is made up of two hemispheres called the **cerebral hemispheres**.

• It controls the action of the voluntary muscles.

Cerebrum is responsible for the intelligence, memory, consciousness and will power.

(ii) Thalamus

• It is an area which coordinates the sensory impulses from the various sense organs – eyes, ears and skin and then relays it to the cerebrum. It acts as a relay centre.

(iii) Hypothalamus

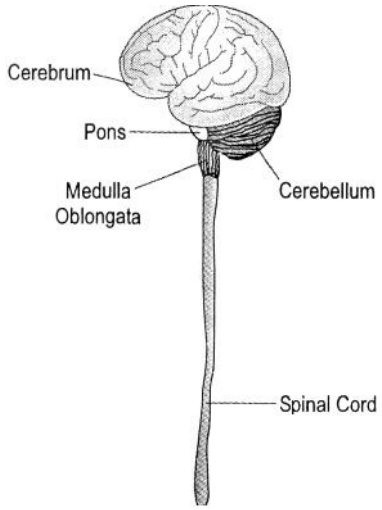
• It controls the heart rate, blood pressure, body temperature and peristalsis.

• It also has centres that control emotions, hunger, thirst, fatigue, sleep, body temperature and sweating.

• It secrets neurohormones which regulate the secretion of pituitary.

(iv) Olfactory lobes

• They are widely spread club shaped structure which occurs on the inferior surface or base of the cerebrum. It is related with olfaction (smell sensations).



Mid brain

It provides a passage for the different neurons going in and coming out of the cerebrum.

Hind brain

It consists of **cerebellium**, pons varoli and medulla oblongata.

(i) Cerebellum

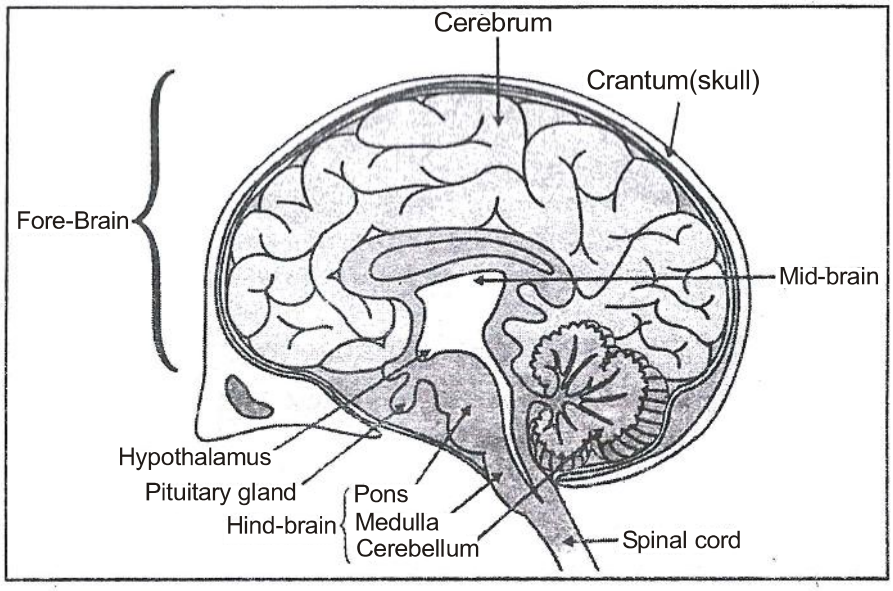
- It is the second largest part of the brain.
- It is responsible for maintaining the balance while walking, swimming, riding etc.
- It is also responsible for precision and the fine control of the voluntary movements.

(ii) Pons

- Pons literally means bridge. It is hidden as it is well protected because of its importance.
- It has the breathing centre.

(iii) Meulla oblongata

- Medulla oblongata is the posterior main part of the brain which lie below the cerebellum.
- It also controls involuntary activities such as sneezing, coughing, swallowing, salivation and vomiting.
- It has both breathing and cardiovascular centres.
- It controls rate of heart beat and expansion & contraction of blood vessels to regulate blood pressure.



Sagital (median) section of human brain

SPINAL CORD

- It is a collection of nervous tissue running along the back bone. It is protected by the vertebral column. It is a continuation of the brain.
- The function of the spinal cord are :
  - Coordinating simple spinal reflexes.
  - Coordinating automatic reflexes like the contraction of the bladder.
  - Conducting messages from muscles and skin to the brain.
  - Conducting messages from brain to the trunk and limbs.
- Both brain and spinal cord are protected from mechanical injury and shock by bony cases around them. Brain is covered by the cranium or brain box of skull. Spinal cord is similarly covered by vertebral column. Additional protective covering called **meaninges** (singular meninx) occur between brain or spinal cord and the surrounding skeleton. They are three in number – **duramater**, **arachnoid** and **piamater** from outside to inside.

CEREBROSPINAL FLUID

- It is clear colourless slightly alkaline fluid that occurs in the ventricles of brain, central canal of spinal cord and subarachnoid space around the two, cerebrospinal fluid is filtered out from blood.
- The fluid is rich in nutrients, minerals, hormones, and respiratory gases.
- It supplies food and oxygen to different parts of the brain and spinal cord.
- It picks up carbon dioxide, urea and other waste products from CNS
- It carries hormones to and from the brain.
- It keeps CNS moist and protects it from shocks
- By its buoancy, it reduces the weight of brain.

ELECTRO ENCEPHALOGRAM (EEG) :

An instrument called electro encephalograph can record electrical activity of brain. The activity of brain is recorded as electrical potentials such a record is called Electro Encephalogram. By placing two electrodes on the scalp and leading via suitable amplifier to ink writing device, record of four different types of waves is obtained. These waves are named as **alpha, beta, delta and theta** and vary in frequency. These waves give the characteristic activity of brain which is very useful for clinical purposes.

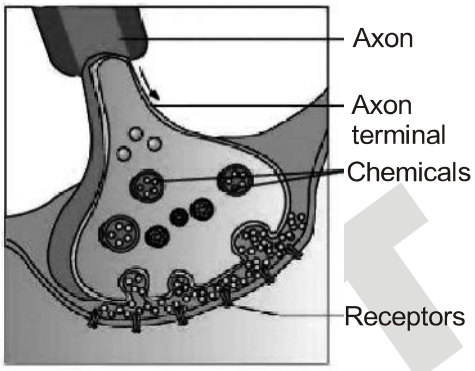
NCERT SOLVED QUESTIONS

Q.1 What is the difference between a reflex action and walking ?

Ans. A reflex action is a rapid, automatic response to a stimulus. It does not involve any thinking. For example, we close our eyes immediately when the bright light is focused. Walking, on the other hand, is a voluntary action. It is under our conscious control.

Q.2 What happens at the synapse between two neurons ?

Ans. A very small gap that occurs between the last portion of axon of one neuron and the dendron of the other neuron is known as a synapse. It acts as a one way valve to transmit impulses in one direction only. This uni-directional transfer of impulses occurs as the chemicals are produced in only one side of the neuron i.e., the axon's side. From axon, the impulses travel across the synapse to the dendron of the other neuron.



A synapse or neuromuscular junction

Q.3 Which part of the brain maintains posture and equilibrium of the body ?

Ans. Cerebellum, a part of hindbrain is responsible for maintaining posture and equilibrium of the body.

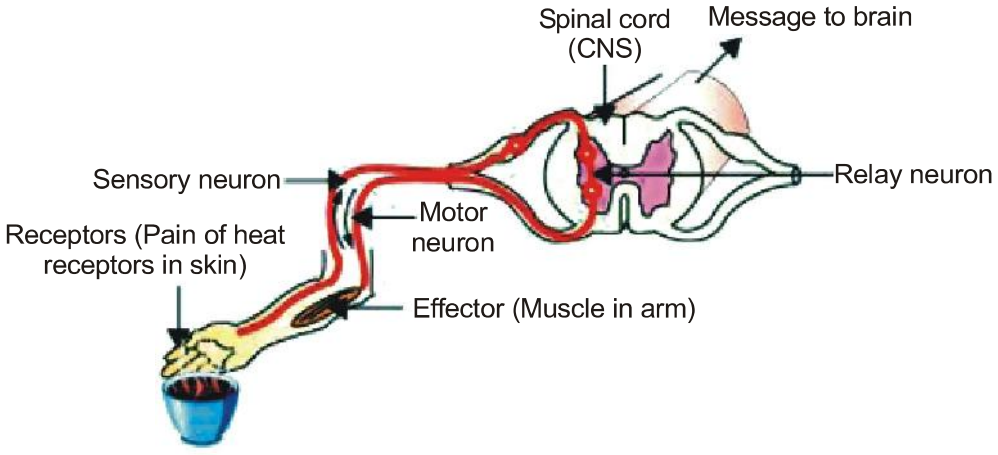
Q.4 How do we detect the smell of an ***agarbatti*** **(incense stick) ?**

Ans. The thinking part of our brain is the forebrain. It has separate areas that are specialized for hearing, smelling, sight, taste, touch, etc. The forebrain also has regions that collect information or impulses from the various receptors. When the smell of an incense stick reaches us, our forebrain detects it. Then, the forebrain interprets it by putting it together with the information received from other receptors and also with the information already stored in the brain.

Q.5 What is the role of the brain in reflex action?

Ans. Reflex actions are sudden responses, which do not involve any thinking. For example, when we touch a hot object, we withdraw our hand immediately without thinking as thinking may take time which would be enough to get us burnt.

The sensory nerves that detect the heat are connected to the nerves that move the muscles of the hand. Such a connection of detecting the signal from the nerves (input) and responding to it quickly (output) is called a reflex arc. The reflex arcs -connections present between the input and output nerves - meet in a bundle in the spinal cord.



Reflex action/arc

Reflex arc

Reflex arcs are formed in the spinal cord and the information (input) reaches the brain. The brain is only aware of the signal and the response that has taken place. However, the brain has no role to play in the creation of the response but it can react accordingly in future for the same type of stimuli.

Q.6 What are plant hormones?

Ans. Plant hormones or phytohormones are naturally occurring organic substances. These are synthesized in one part of the plant body (in minute quantities) and are translocated to other parts when required. The five major types of phytohormones are auxins, gibberellins, cytokinins, abscisic acid, and ethylene.

Q.7 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 the sensitive plant, *Mimosa pudica* or "touch me not", occurs in response to touch or contact stimuli. This movement is independent of growth. The movement of shoot towards light is known as phototropism. This type of movement is directional and is growth dependent.

Q.8 Give an example of a plant hormone that promotes growth.

Ans. Auxin is an example of growth-promoting plant hormone.

Q.9 How do auxins promote the growth of a tendril around a support?

Ans. Auxin is synthesized at the shoot tip. It helps the cell grow longer. When a tendril comes in contact with a support, auxin stimulates faster growth of the cells on the opposite side, so that the tendril forms a coil around the support. This makes the tendrils appear as a watch spring.

Q.10 Design an experiment to demonstrate hydrotropism.

Ans. Refer Page no. 8 & 9

Q.11 How does chemical coordination take place in animals?

Ans. Chemical coordination takes place in animals with the help of hormones.Hormone is the chemical messenger that regulates the physiological processes in living organisms. It is secreted by glands. The regulation of physiological processes, and control and coordination by hormones comes under the endocrine system. The nervous system along with the endocrine system in our body controls and coordinates the physiological processes.

Q.12 Why is the use of iodised salt advisable?

Ans. Iodine stimulates the thyroid gland to produce thyroxin hormone. It regulates carbohydrate, fat, and protein metabolism in our body. Deficiency of this hormone results in the enlargement of the thyroid gland. This can lead to goitre, a disease characterized by swollen neck. Therefore, iodised salt is advised for normal functioning of the thyroid gland.

Q.13 How does our body respond when adrenaline is secreted into the blood ?

Ans. Adrenalin is a hormone secreted by the adrenal glands in case of any danger or emergency or any kinds of stress. It is secreted directly into the blood and is transported to different parts of the body.

When secreted in large amounts, it speeds up the heartbeat and hence supplies more oxygen to the muscles. The breathing rate also increases due to contractions of diaphragm and rib muscles. It also increases the blood pressure. All these responses enable the body to deal with any stress or emergency.

Q.14 Why are some patients of diabetes treated by giving injections of insulin?

Diabetes is a disease in which the level of sugar in the blood is too high. Insulin, a hormone secreted by the pancreas, helps in regulating the blood sugar levels. This is the reason why diabetic patients are treated by giving injections of insulin.

Q.15 What is the function of receptors in our body? Think of situations where receptors do not work properly. What problems are likely to arise?

Ans. Receptors are sensory structures (organs/tissues or cells) present all over the body. The receptors are either grouped in case of eye or ear, or scattered in case of skin.

Functions of receptors :

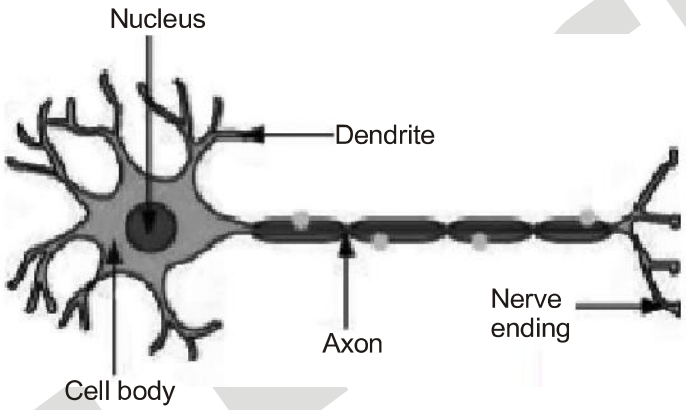
(i) They sense the external stimuli such as heat or pain.

(ii) They also trigger an impulse in the sensory neuron which sends message to the spinal cord.

When the receptors are damaged, the external stimuli transferring signals to the brain are not felt. For example, in the case of damaged receptors, if we accidentally touch any hot object, then our hands might get burnt as damaged receptors cannot perceive the external stimuli of heat and pain.

Q.16 Draw the structure of a neuron and explain its function.

Ans. Neurons are the functional units of the nervous system. The three main parts of a neuron are axon, dendrite, and cell body.



Structure of a neuron

Functions of the three parts of a neuron :

Axon : It conducts messages away from the cell body.

Dendrite : It receives information from axon of another cell and conducts the messages towards the cell body.

Cell body : It contains nucleus, mitochondria, and other organelles. It is mainly concerned with the maintenance and growth.

Q.17 How does phototropism occur in plants?

Ans. The growth movement in plants in response to light stimulus is known as phototropism.The shoots show positive phototropism and the roots show negative phototropism. This means that the shoots bend towards the source of light whereas the roots bend away from the light source.

Some examples of phototropism are as follows :

(a) The flower head of sunflower is positively phototropic and hence it moves from east to west along with the sun.

(b) The ovary stalk of groundnut is positively phototropic before fertilization and becomes negatively phototropic after fertilization, so that the fruit is formed underground.

Q.18 Which signals will get disrupted in case of a spinal cord injury?

Ans. The reflex arc connections between the input and output nerves meet in a bundle in the spinal cord. In fact, nerves from all over the body meet in a bundle in the spinal cord on their way to the brain. In case of any injury to the spinal cord, the signals coming from the nerves as well as the signals coming to the receptors will be disrupted.

Q.19 How does chemical coordination occur in plants?

Ans. In animals, control and coordination occur with the help of nervous system. However, plants do not have a nervous system.

Plants respond to stimuli by showing movements. The growth, development, and responses to the environment in plants is controlled and coordinated by a special class of chemical substances known as hormones. These hormones are produced in one part of the plant body and are translocated to other needy parts. For example, a hormone produced in roots is translocated to other parts when required. The five major types of phytohormone are auxins, gibberellins, cytokinins, abscisic acid, and ethylene. These phytohormones are either growth promoters (such as auxins, gibberellins, cytokinins, and ethylene) or growth inhibitors such as abscisic acid.

Q.20 What is the need for a system of control and coordination in an organism?

Ans. The maintenance of the body functions in response to changes in the body by working together of various integrated body systems is known as coordination. All the movements that occur in response to stimuli are carefully coordinated and controlled. In animals, the control and coordination movements are provided by nervous and muscular systems. The nervous system sends messages to and away from the brain. The spinal cord plays an important role in the relay of messages. In the absence of this system of control and coordination, our body will not be able to function properly. For example, when we accidentally touch a hot utensil, we immediately withdraw our hand. In the absence of nerve transmission, we will not withdraw our hand and may get burnt.

Q.21 How are involuntary actions and reflex actions different from each other?

Ans. Involuntary actions cannot be consciously controlled. For example, we cannot consciously control the movement of food in the alimentary canal. These actions are however directly under the control of the brain. On the other hand, the reflex actions such as closing of eyes immediately when bright light is focused show sudden response and do not involve any thinking. This means that unlike involuntary actions, the reflex actions are not under the control of brain.

Q.22 Compare and contrast nervous and hormonal mechanisms for control and coordination in animals.

	Nervous system mechanism		**Hormonal system mechanism**
1.	The information is conveyed in the form of electric impulse.	**1.**	The information is conveyed in the form of chemical messengers.
2.	The axons and dendrites transmit the information through a coordinated effort.	**2.**	The information is transmitted or transported through blood.
3.	The flow of information is rapid and the response is quick.	**3.**	The information travels slowly and the response is slow.
4.	Its effects are short lived.	**4.**	It has prolonged effects.

Q.23 What is the difference between the manner in which movement takes place in a sensitive plant and the movement in our legs ?

	Movement in sensitive plants		**Movement in our legs**
1.	The movementthat takes place in a sensitive plant such *as* Mimosapudica occurs in response to touch (stimulus).	**1.**	Movement in our legs is an example of voluntary actions.
2.	For this movement, the information is transmitted from cell to cell by electro-chemical signals as plants do not have any specialised tissue for conduction of impulses.	**2.**	The signal or messages for these actions are passed to the brain and hence are consciously controlled.
3.	For this movement to occur, the plant cells change shape by changing the amount of water in them.	**3.**	In animal muscle cells, some proteins are found which allow the movement to occur.

Q.24 What will happen if (i) Ligaments are over stretched ?

(i) Apical meristem is cut or damaged ?(iii) Striated muscles contract rapidly for a long time ?

Ans. (i) Sprain will occur,

(ii) Growth of plant in length will stop.

(iii) Fatigue will occur due to accumulation of lactic acid.

Q.25 What will happen if (i) bone is dipped in HCl ? (ii) bone is dried ? (iii) heparin is absent in the blood ?

Ans. (i) If bone is dipped in HCl, mineral matter will dissolve and only organic matter will be left.

(ii) When bone is dried, organic matter is destroyed and mineral matter is left.

(iii) Heparin is an anticoagulant present in the blood. If heparin is absent, blood clotting will occur inside the blood vessels.