



CHAPTER

14

CONTROL AND CO-ORDINATION IN LIVING BEINGS

14.1. Co-ordination in Animals

Irritability or sensitivity is one of the characteristic features of the living organisms. The living organisms have the ability to respond to a stimulus. They respond to changes in the environment. When the temperature around us is very low we feel cold and like to use warm cloth. When a teacher teaches a lesson in the class he speaks somewhat loudly so that every student can hear him. But when a student in the class wants to say something to his friend he whispers rather than shouting loudly. A cat, on seeing a rat, moves very silently and slowly at the beginning so that the rat might not see him but when nearer the cat will jump suddenly to catch the rat. It is seen that in all organisms some degree of control and internal co-ordination is necessary in order to ensure that the events of the stimulus and response bear some mutual relationship. In multicellular organisms, specialised tissues are present to perform control and co-ordination activities.

14.1.1. Nervous System

In animals, control and co-ordination activities are performed by the nervous and muscular tissues. When we touch a hot object, we will feel the heat and respond to it. Then how do we know that we are touching a hot object? Some of the nerve cells have specialised tips which detect all the information from our environment. These receptors are usually located in our sense organs, such as the skin, the tongue, the nose, the ear and the eye. Thus, the olfactory receptors of the nose will detect smell, the gustatory receptors of the tongue will detect taste and so on.

The information received at the end of the dendritic tip of a nerve cell (Fig. 14.1.) sets off a chemical reaction that creates an electrical impulse. This impulse passes from the dendrite to the cell body, then it moves along the axon to its end. At the end of the axon, the electrical impulse sets off the release of some chemicals. The chemicals cross a gap known as **synapse** and start a similar electrical impulse in a dendrite of the next neuron. A similar synapse

finally allows delivery of such impulses from neurons to other cells such as muscle cells or glands. Thus, the nervous tissue is made up of an organised network of nerve cells or neurons and is specialised for conducting information via electrical impulses from one part of the body to another.

The brain and spinal cord constitute the central nervous system. The brain is divided into three major regions, namely the fore-brain, mid-brain and hind-brain.

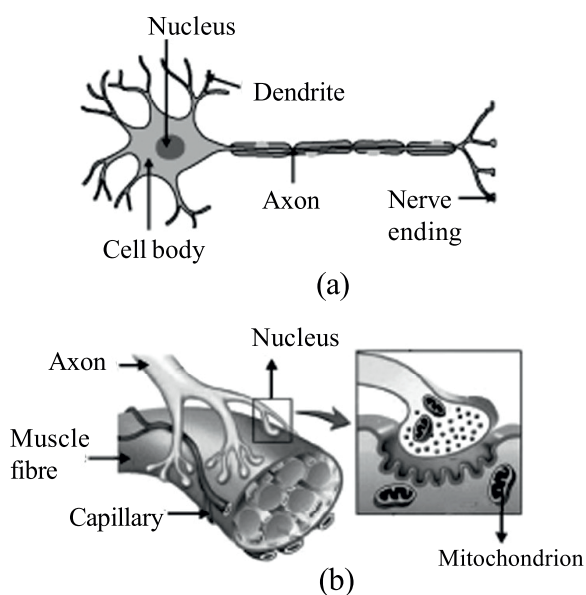


Fig. 14.1. (a) Structure of neuron (b) Neuromuscular junctions

We human beings think about our actions. Doing something like running, walking, talking, writing etc. are examples of voluntary actions which are based on deciding what to do next. For these the brain has to send messages to muscles. This is the second way in which the nervous system communicates with the muscles. There is another nervous system known as peripheral nervous system which constitutes the cranial nerves arising from the brain and spinal nerves arising from the spinal cord. The communication between the central nervous system and the other parts of the body is facilitated by the peripheral nervous system.

The main thinking part of the brain is the fore-brain. It has regions which receive sensory impulses from various receptors. The fore-brain has separate areas specialised for smell, hearing, sight and so on.

There are separate areas of association where the sensory information is interpreted by putting it together with information from other receptors as well as with information that is already stored in the brain. Then, a question arises on how response and the information are passed on to the motor areas which control the movement of voluntary muscles, for example the muscle of the hand or leg.

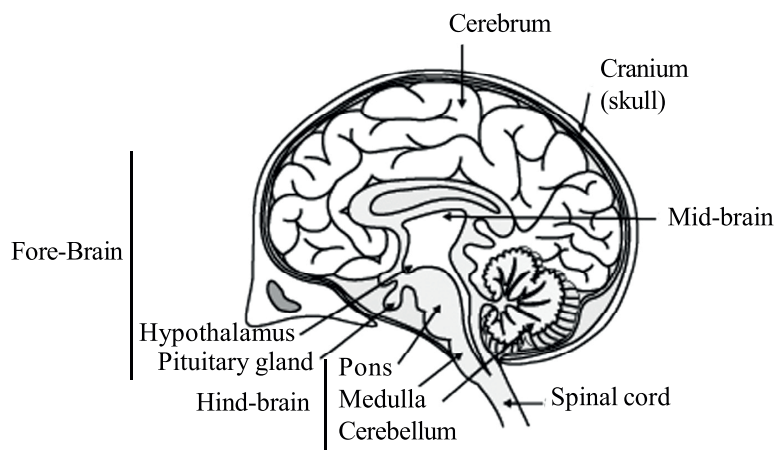


Fig. 14.2. Human brain

There are certain sensations which are different from seeing or hearing etc. for example, feeling of fullness of our stomach. The sensation of being full is because of a centre associated with hunger, which is a separate part of the fore-brain. Mid-brain is comparatively a small region. It controls the reflex movement. The change in eye pupil size and shape of the eye lens are controlled in this region of the brain.

On the other hand, there are other actions that we cannot control easily by thinking about them. For example, our mouth waters when we see food we like, our heart beat or we breathe without thinking about it. These involuntary actions are controlled by the medulla in the hind-brain.

The brain which is very important for a variety of activities, is a delicate organ and needs to be protected. It is protected by a bony box, the cranium. In between the bony covering and the brain there is a fluid filled space which provides further shock absorption. The spinal cord is lodged inside the vertebral column.

14.1.2. Reflex Action

When we walk accidentally on an inverted nail and pierces the foot we feel pain and suddenly remove our leg from it without thinking anything about it. Such an involuntary sudden action in response to something in the environment

is the **reflex action**. In another example when our hand touches a hot object or a burning charcoal, we suddenly remove the hand automatically without thinking about it. The sudden response in these pain or heat is done in such a way that the nerves that detect pain or heat are connected to the nerves that move muscles in a simpler way, the process of detecting the signal or the input and responding to it by an output action might be completed quickly. Such a connection is commonly called a **reflex arc** (Fig .14.3.). Nerves from all over the body meet in a bundle in the spinal cord on their way to the brain. Such

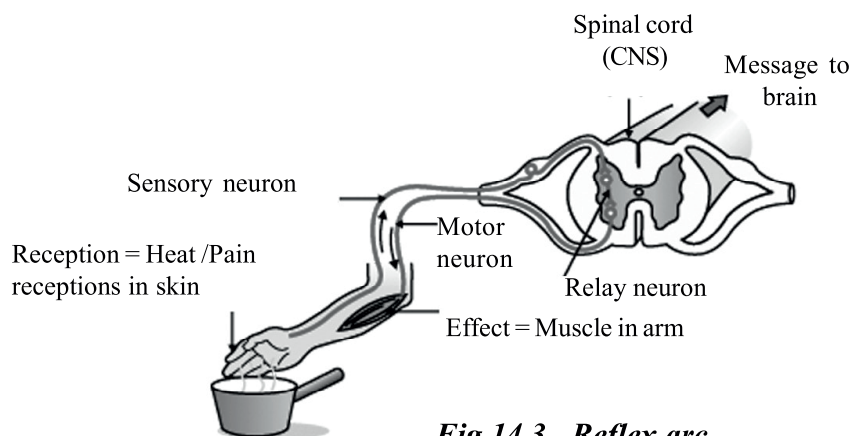


Fig.14.3. Reflex arc

reflex arcs are formed in this spinal cord itself, although the information input also goes on to reach the brain.

14.1.3. Conditioned Reflexes

Conditioned reflexes are the acquired reflexes during the lifetime of an individual. These are not constant that they may disappear or reappear again. They depend on previous experience. They are not transmitted by heredity.

Ivan Pavlov, a Russian Physiologist, for the first time discovered the existence of conditioned reflexes.

14.1.4. Pavlov's Experiment on conditioned reflex

Pavlov conducted his experiment on a dog. He used to ring a bell every time just before the food was placed in front of the dog. The dog gradually learnt to associate the bell with food. Later when the bell was rung, the dog would salivate even though no food was placed (Fig.14.4).

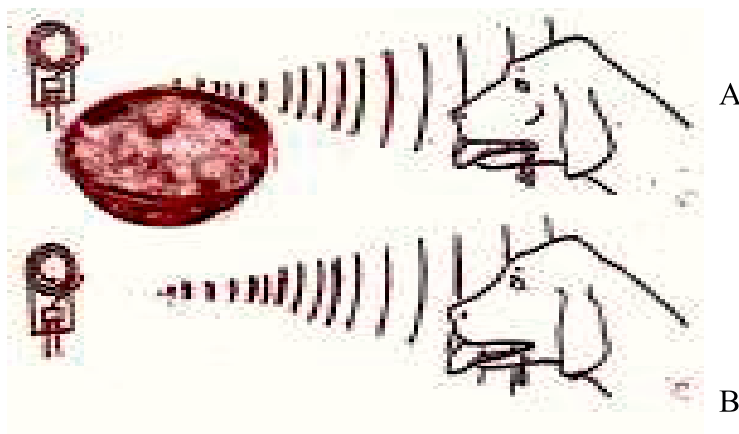


Fig.14.4. Pavlov's experiment on conditioned reflex.

A. The dog salivated at the sight of the food with a sound of a bell.

B. The dog salivated at the sound of the bell even though no food was placed.

14.1.5. Chemical Co-ordination – Animal hormones

In animals control and co-ordination is done not only by the nervous system but also by the hormones. The hormones are secreted by the endocrine glands (ductless glands) of the body (Fig. 14.5.). Different hormones perform different functions of co-ordination in the animal body. Among human beings there are very short (dwarf) individuals and sometimes extremely tall (giant) individuals while majority are of normal size. These conditions are related with a pituitary hormone, known as growth hormone. If the secretion of this hormone is optimum during the childhood there will be normal growth of the individual. If the secretion of this hormone is less during childhood it will lead to dwarfism. If there is excessive secretion during growth period, it will result to extremely tall individual (gigantism).

Nowadays diabetes is very common among us. This is also caused due to inadequate production of a hormone known as insulin secreted by the pancreas. It maintains normal blood sugar level in the body. If there is insufficient secretion of insulin the sugar level in the blood becomes high and we suffer from diabetes.

Another example of chemical co-ordination is the role of the thyroid hormone, the thyroxine, in the growth of an individual. Nowadays we use iodised salts in our diet. Iodine is needed by the thyroid gland to make thyroxine hormone. Thyroxine regulates carbohydrates, protein and fat balance for growth.

If there is deficiency of iodine in our diet there will be no synthesis of this thyroid hormone. In such a condition, one may suffer from goitre, the characteristic symptom being a swollen neck.

Adrenaline is a hormone secreted by the adrenal gland. The action of this hormone is widespread throughout the body. It prepares the animal for situations of 'fight or flight'. It facilitates the response to sudden demands imposed by stress such as pain, shock, cold, low blood sugar, low blood pressure, anger, passion etc. Adrenaline, being a hormone, is secreted directly into the blood and carried to different parts of the body. The target organs on which it acts include the heart. As a result the heart beats faster resulting in supply of more oxygen to the muscles. The blood supply to the digestive system and skin is reduced due to contraction of muscles around small arteries in these organs and diverted to skeletal muscles. The breathing rate also increases. As a result of these responses, the animal body is ready to face with the hard situation. Thus, this hormone participates in the a chemical control and co-ordination in our body.

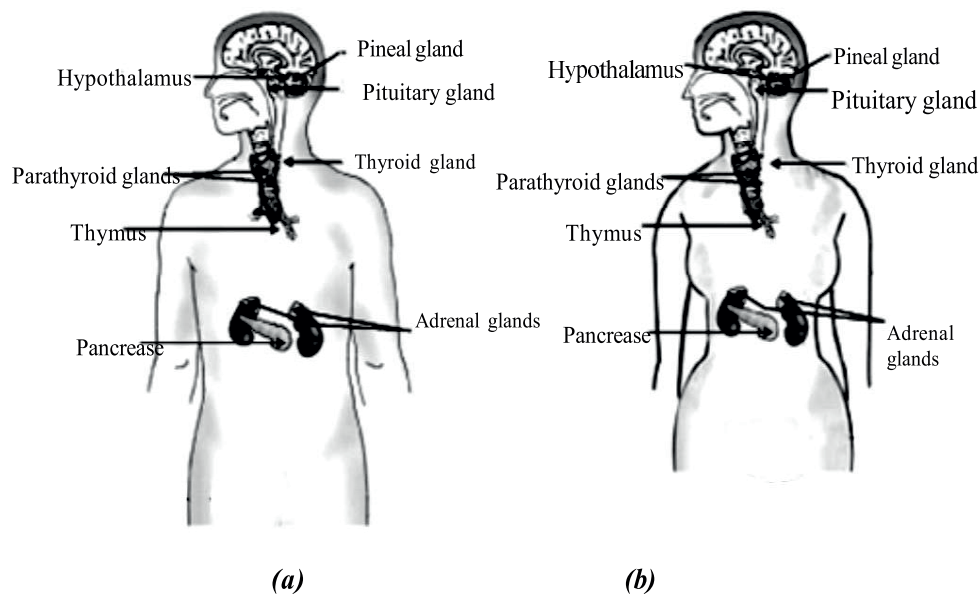


Fig .14.5. Endocrine glands in human beings (a) male, (b) female.

You might have experienced the changes in your general appearance as well as that of your friends as you reach 10–12 years of age. These changes are associated with puberty and these are resulted by the secretion of testosterone in males and oestrogen in females.

Let us answer these.

1. What is a reflex action ?
2. What happens at the synapse between two neurons ?
3. Why should we use iodised salt ?
4. Why are some patients of diabetes treated by giving injections of insulin ?

14.2. Co-ordination in Plants

Nervous system is the controlling and co-ordinating unit of body activities in animals. But plants have no nervous system. Then, how do plants respond to stimuli ? When a sensitive plant (*Mimosa pudica*) leaflets are touched, they fold up and drop. In germinating seeds, the root goes down the soil and the stem comes up into the air. The response to touch is very quick in sensitive plants without involving any growth. But the directional movement of a seedling is caused by growth which shows a slow movement.

How many kinds of movements are recognized in plants ?

14.2.1. Immediate response to stimuli

The leaves in sensitive plants move in response to touch. This plant does not possess nervous tissue or muscle tissue. How does the plant feel the touch ? How do the leaves move in response?



Fig. 14.6. Sensitive Plants (*Mimosa pudica*)

If you touch the plant and examine the part of the plant actually moves. The movement happens to a point different from the point of touch. So, information that a touch has occurred must be communicated. Unlike in animals, plants do not have specialised tissues for collection of information. Instead of specialised proteins found in animals, the plant cells change shape by changing

the amount of water in them. The swelling and shrinking due to water pressure makes a change in the shape of plant.

14.2.2. Movement due to growth

A pea plant climb itself with the help of tendrils. When a tendril comes into contact with any support, the side of the tendril in contact with the object ceases to grow as rapidly as the side of the tendril away from the object. So the tendril can encircle an object and thus clings to it. Plants can respond to stimuli and grow slowly in a particular direction. This directional growth makes a plant

appears as if it is moving. **Tropism** is the movement of curvature brought about by more growth on one side and less growth on opposite side of plant organ induced by some external stimuli. Depending upon the nature of stimuli the tropism can be phototropism (light induced), geotropism (induced by gravitational force), hydrotropism (water induced), thigmotropism (touch induced) and chemotropism (chemical induced).

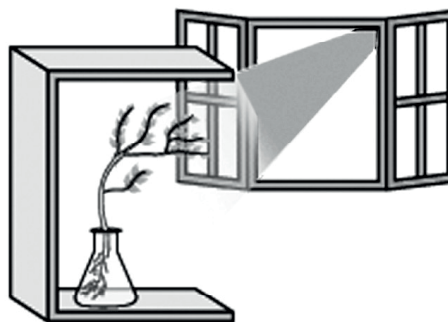


Fig.14.7. Stem is positively phototropic.

Activity 14.1.

- ☞ Take a potted plant and keep the potted plant in a room near an open window.
- ☞ Observe after 2 or 3 days.
- ☞ The stem is seen bending towards the open window.

What conclusion you can draw from this activity ?

Environmental factors like light, gravity, water etc. are responsible for the directional movement in plants. In phototropic movement shoots bend towards light while roots respond by bending away from light. So the directional or tropic movement can be either towards the stimulus or away from it.

14.2.3. Why do roots grow towards the soil ?

The tropic movements in response to gravity are called **geotropism**. In plants the primary roots grow down into the soil and are positively geotropic. On the other hand, the primary stems are negatively geotropic (Fig. 14.8.).

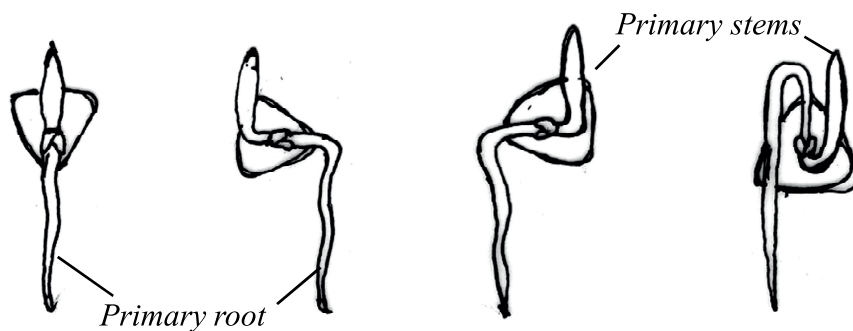


Fig. 14.8. Geotropism in maize seed.

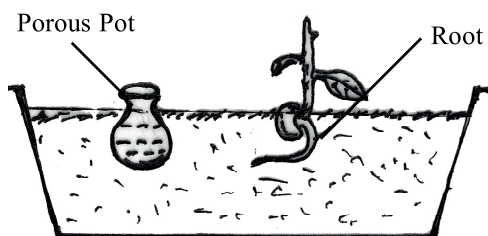


Fig. 14.9. Hydrotropism in germinating seed

Activity 14.2.

- ☞ Take a vessel nearly filled with sand.
- ☞ On one side immersed a porous pot filled with water.
- ☞ Place a germinating seed away from the porous pot in the vessel.
- ☞ Examine the germinating seed after 4 to 5 days.

How the root elongates ?

It has been observed that roots grow vertically downwards due to gravitational pull. Then, the root bends towards the porous pot, showing a tendency to grow towards the source of moisture (Fig.14.9.). So, the root is said to be positively hydrotropic. Hydrotropism is stronger than geotropism.

One example of the chemotropism is the growth of pollen tube through stigma and style, towards ovule with the stimulus of chemical substances present in the carpel.

How the information is communicated in the body of multicellular plants? The movement in sensitive plant in response to touch is very quick, whereas growth related movements in plants are quite slow. If the response to stimuli is to be made quickly, information must be transferred very fast. It can be easily achieved by means of electrical impulses. But electrical impulses can reach only those cells that are connected by nervous tissues. Once an electrical impulse

is generated in a cell and transmitted, it takes more time to reset its mechanism before it can generate and transmit a new impulse. Moreover, cell can not continuously create and transport electrical impulses.

In multicellular organisms, the control and co-ordination is done by the release of certain chemical compounds from the stimulated cells. These compounds are detected by other cells around it by using special molecules on their surface then, they would be able to recognise information and even transmit it. This is a slow system but regardless of nervous connection. The co-ordination in growth, development and respond to environment in plant is done with the help of different compounds or plant hormones. They are synthesised at places away from where they act and simply diffuse to the area of action.

14.2.4. Plant hormones

What are plant hormones ? How do they act on plants? The growth of the stem towards light in Fig.14.7., is the action of a hormone called **Auxin**. It is synthesized at the shoot tip. Auxin diffuses towards the shade side of the stem. The higher concentration of auxin stimulates the cells to grow longer on the side of the shoot which is away from light. So, the plant bends towards light. No growth can occur in plant without auxin.

Auxins in plants are to stimulate the elongation of cells in shoot. Similarly **Gibberellins** also help in the growth of stem by inducing elongation of internodes. **Cytokinins** stimulates cell division and also cause the enlargement of cells and promote seed germination.

All the above hormones are growth promoters. But plants also need signals to stop growing. **Abscisic acid** (ABA) is a powerful growth inhibitor and can induce bud dormancy in varieties of plants. There are significant evidence to support that ABA controls geotropic response of roots.

Ethylene also acts as a plant hormone and can prevent the longitudinal elongation of stem and roots but is associated with radial enlargement of tissues. It can hasten post harvest maturation of fruits.

14.2.5. Apical dominance

It is common observation in vascular plants, specially the taller ones, that if the apical bud is intact and growing, the lateral buds remain suppressed. Removal of apical bud causes fast growth of lateral buds.

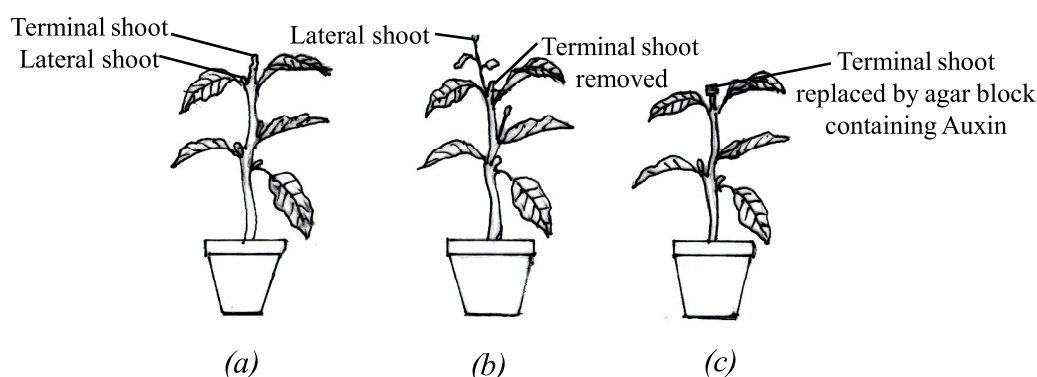


Fig.14.10. Apical dominance in Plants (a,b&c)

Let us observe the three potted plants (Fig. 14.10.). The first pot is kept as control, so growth of lateral buds are suppressed. The terminal shoot is removed from the second pot and the lateral buds commence to grow. What is the inhibitor which suppresses the growth of lateral bud?

Apical dominance seems to result from the downward transport of auxin produced in the apical meristem.

In the third potted plant terminal shoot is replaced by an agar block containing auxin showing the inhibition of lateral bud. A plain block of agar has no such effect. What inference can you narrate from the above observations?

Let us answer these.

1. What is the factor responsible for the movement of leaves in the sensitive plants ?
2. What are plant hormones ?
3. How do auxins promote the growth of tendril around a support ?
4. Give an example of chemotropism.

POINTS TO REMEMBER

- ⇒ Control and co-ordination are the functions of the hormones and nervous system in our bodies.
- ⇒ The responses of the nervous system can be classified as reflex action, voluntary action or involuntary action.

- ⇒ The nervous system uses electrical impulse to transmit messages.
- ⇒ The nervous system gets information from our sense organs and acts through our muscles.
- ⇒ Plants do not have nervous system, but some plants can response to external stimuli.
- ⇒ Stem moves upward towards light whereas root moves downward away from light.
- ⇒ Chemical co-ordination is seen in both plants and animals.
- ⇒ Hormones are organic substances which are synthesized in minute quantities in one part of the plant body and transported to another part where they influence specific physiological processes.
- ⇒ Auxin is responsible for apical dominance in plants.

EXERCISES

1. How does phototropism occur in plants?
2. Why do roots grow towards the soil ? Explain with three points.
3. Explain the function of two growth inhibitors in plants.
4. In what way auxin is involved in the process of apical dominance ?
5. What is the name of the gap between the two neurons ?
6. What is the function of receptors in our body ? What will be the conditions if the receptor are not properly working ?
7. How do the reflex actions differ from the involuntary actions ?
8. Explain the functions of any three hormones in human being.

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