# CONTROL AND COORDINATION



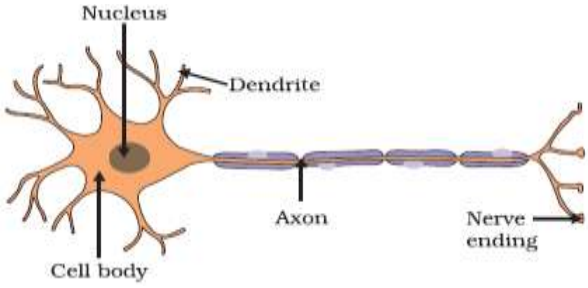
- **Stimuli**: The changes in the environment to which the organisms respond and react are called stimuli.
- **Response**: The reaction or behaviour of organisms towards any change in environment (stimulus) is called response.
- Living organisms respond and react according to the changes in the environment. The response to environmental factors (stimuli) such as light, cold and pressure varies in different organism, e.g.,
    - Plants grow out into sunshine.
    - Amoeba move towards food.
    - When bright light I focussed on our eyes, iris contacts.
    - When we touch hot object, we move our hand.
- All these movements which are responses to the environment, is carefully controlled. Each kind of a stimulus evokes an appropriate movement in response.
- Therefore, such controlled movement must be connected to the recognition of various events in the environment, followed by only the correct movement in response.
- In multicellular body organisation, specialized tissues are used to provide these controls and coordination activities. Animals have nervous system and hormonal system (endocrine system) for controlling and co-ordinating activities and muscles and gland to respond.
- Unlike animals, plants have neither a nervous system to control and co-ordinate nor muscles to respond. However, plants respond to light, touch, gravitational force and other stimuli. Growth and movements in the plants are regulated by both external and internal factors.

- **Control**: The process by which various biochemical and physiological processes in an organism are regulated is called control.
- **Co-ordination**: A living organism is made up of various organ systems, which cannot work independently so they are linked in one way or the other. Working together of all these systems is called co-ordination.

## ANIMALS – NERVOUS SYSTEM

- In animals, control and co-ordination are achieved by nervous and muscular tissues.
- **Nervous tissue** is much specialised for being stimulated and then transmitting the stimulus very rapidly from one place to another within the body in the form of electric impulse.
- It forms nervous system of the body. Brain, spinal cord and nerves are composed of nervous tissue.

## NEURON

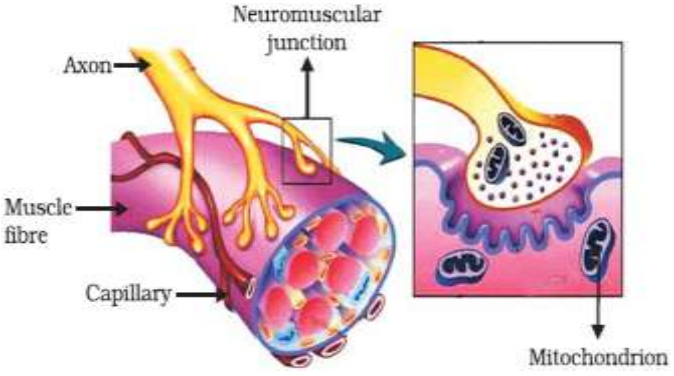



- The cells of this tissue are called nerve cells or **neurons**. A neuron consists of a **cell body** containing cytoplasm and nucleus, a single long extension from the cell body known as **axon** and many short branched parts called **dendrites**.
- The junction of two neurons is known as **synapse.** This is functional junction between two adjacent neurons. It is a narrow gap between nerve ending of an axon and dendrite of another axon.
- The stimuli at the end of the dendrite of a neuron evoke a chemical reaction that creates an electrical impulse. This impulse travels from the dendrite to the cell body and along the axon to its end.
- At the end of the axon, the electrical impulse sets off the release of some chemicals called **neurotransmitters**. These chemicals cross the gap, or synapse, and start a similar electric impulse in a dendrite of the next neuron. This is how a nerve impulse travels in body.

## RECEPTORS AND EFFECTORS

- **Receptors or Sense organs:** It is a nerve cell or group of nerve cells specialised to detect a specific stimulus, e.g., eyes, ears, nose, tongue, skin, etc.
- There are five receptors or sense organs through which the animals receive stimuli or external information. These are:
    1. Photo-receptors : for light (eyes)
    2. Phono-receptors : for sound (ears)
    3. Gustatory receptors : for taste (taste buds)
    4. Olfectro-receptors : for smell (nose)
    5. Thigmo-receptors : for touch (skin)

- **Effectors or Responding organs:** It is either muscles or gland. Our body after detecting any stimulus respond by these effectors.
- **Neuromuscular junction:** It is a point where a muscle fibre comes in contact with neurons, carrying nerve impulses from the brain. The impulses travel from the neuron to the muscle fibre by means of a neurotransmitter in the same manner as the transmission of impulses across a synapse between two neurons.

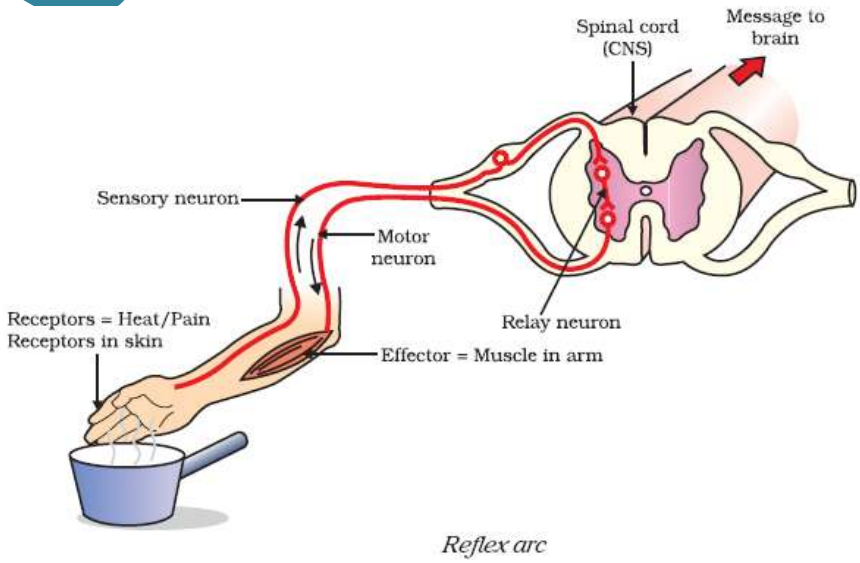


## WHAT HAPPENS IN REFLEX ACTION?

- A reflex action may be defined as a spontaneous, automatic an mechanical response to a stimulus, acting of specific receptor, without the will of an animal, e.g. -
    - Watering of mouth on seeing food, when hungry.
    - Blinking of eyes when something is thrown at our face.
    - Reduced size of pupil when strong light is focused on our eyes.
    - Withdrawal of hand or foot every time it is suddenly touched by hot object.
- **Reflex Arc:** In reflex action, receptors quickly relay a message in the form of electric impulse via sensory nerves to the spinal cord. The spinal cord then sends information (electric impulse) via motor nerves to effectors (muscles and glands). The path taken by nerve impulses in a reflex action is called reflex arc.

***Stimulus → Receptors → Sensory nerves → Spinal cord → Motor nerve → Effectors → Response***

- Reflex actions generally **involve spinal cord** for quick response to specific stimulus. There is no thinking or thought process involved in such action and response.
- Touching a burning flame is an urgent and dangerous situation for us. Thinking consciously about 'what to do' will take time as thinking is a complex and slow process and it may take enough time for us to get burnt badly. Therefore we remove our hand suddenly, escaping the thought process and saving the time.
- Reflex arcs have evolved in animals because the thinking process of the brain is not fast enough. In fact many animals have very little or none of the complex neuron network needed for thinking. So it is quite likely that reflex arcs have evolved as efficient ways of functioning in the absence of true though processes. However, even after complex neuron networks have come into existence, reflex arcs continue to be more efficient for quick response.




*Reflex arc*

# HUMAN NERVOUS SYSTEM

- Human nervous system is the most complex. It is divided into three main parts:
    - Central nervous system
    - Peripheral nervous system
    - Autonomic nervous system

## CENTRAL NERVOUS SYSTEM

- It lies along the main axis of the body. The CNS, in turn, consists of two parts:
    - **Brain**
    - **Spinal Cord.**

## PERIPHERAL NERVOUS SYSTEM

- PNS is consists of the nerves arising from the brain and spinal cords (CNS). Thus PNS carries impulses to and from the central nervous system.
- PNS consists of two sets of nerves:
    - **Cranial nerves:** These nerves are connected with the brain. They are 12 pairs in number.
    - **Spinal nerves:** These nerves emerge from the spinal cord. There are 31 pairs of spinal nerves.

## AUTONOMIC NERVOUS SYSTEM

- ANS is mainly a part of PNS, which mainly controls the involuntary action of the body. They operate automatically. It is further divided in to two parts:
    - Sympathetic nervous system
    - parasympathetic nervous system

# HUMAN BRAIN

- It is the main coordinating centre of the body. It is protected by the cranium, a bony box in the skull. Inside the cranium, the brain is covered by three membranes called meninges. The spaces between membranes are filled by cerebrospinal fluid that protects the brain from mechanical shocks.
- The brain has three major parts or regions:
    - Fore brain,

- Mid brain and
- Hind brain.

## FORE BRAIN



- The fore brain is the main thinking part of the brain. It includes: Cerebrum and Olfactory lobes.
- **Cerebrum**: It is the most complex and specialised part of the brain. It consists of two cerebral hemispheres (left and right). It has regions which receive sensory impulses from various receptors.
- In cerebrum, specific regions for each kind of stimulus and its response are located. For example:
  - **Occipital lobe** is the region for visual reception.
  - **Temporal lobe** is the region for auditory reception.
  - **Parietal lobe** is the region for touch, smell, temperature and conscious association.
  - **Frontal lobe** is the region for speech, facial muscular activities and higher mental activities.
- **Olfactory lobe**: It lies below the cerebrum. They contain olfactro-receptors which are the organs of smell.

## MID BRAIN

- It is very small region. It connects the fore brain to hind brain and represented by Optic lobe. The mid brain controls reflex movements of
  - The head, neck and trunk in response to visual and auditory stimuli, and
  - The eye muscles, changes in pupil size as well as shape of the eye lens.

## HIND BRAIN

- The hind brains consists of three regions,
  - Cerebellum,
  - Pons varolii and

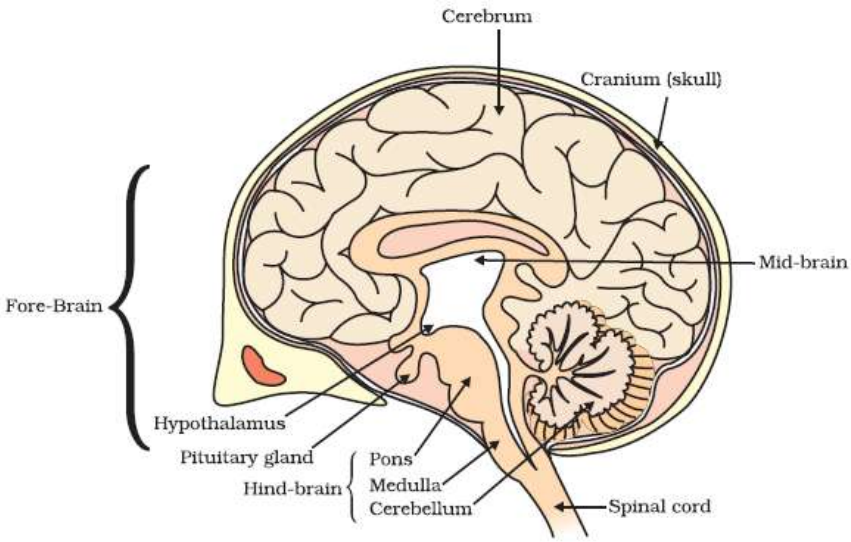



**Figure** *Human brain*

- Medulla oblongata.

- **Cerebellum**: It is involve in coordination and adjustment of movement and posture.
- **Pons**: It takes part in the regulation of respiration.
- **Medulla**: It controls rate of heart beat, breathing movements, expansion and contraction of blood vessels to regulate blood pressure, swallowing, coughing, sneezing and vomiting.



## FUNCTIONS OF BRAINS

- It receives impulses carrying information from various organs of the body.
- It correlate the various stimuli from different sense organs and produces the most appropriate and intelligent response.

## SPINAL CORD

- It is a cylindrical structure. It is in continuation with the medulla oblongata of brain and extents downwards. It is enclosed within bony vertebral column and also surrounded by meninges (like brain). A total of 31 pairs of spinal nerves arise from the spinal cord.

## FUNCTIONS OF SPINAL CORD

- It acts as the centre of reflex actions.
- It is mainly responsible for the conduction of nerve impulses to and from the brain.

## HOW DOES THE NERVOUS TISSUE CAUSE ACTION?

- Nervous tissue collects information, sends it around the body, processes information, makes decisions based on information and conveys decisions to muscles for action. When the action or movement is to be performed, muscle tissue does the final job.
- When a nerve impulse reaches the muscle, the muscle fibre move. The simplest notion of movement at the cellular level is that muscle cells will move by changing their shape so they shorten.
- The muscle cells have special proteins that change both their shape and their arrangement in the cell in response to nervous electrical impulses. When this happens, new arrangements of these proteins give the muscle cells a shorter form.

# COORDINATION IN PLANTS



- Animals have a nervous system for controlling and coordinating the activities of the body. But plants have neither a nervous system nor muscles. But they can respond and react to various stimuli such as light, gravity, water, touch, chemicals, etc.
- In fact plants respond and react to stimuli by two different types of movements:
    - One dependent on growth (e.g., when a seed germinates, the root goes down, the stem comes up into the air.)
    - Other is independent of growth. (e.g. the leaves of the 'touch me not' plant move very quickly in response to touch.)
- Plants show two different types of movement – one dependent on growth and the other independent of growth. Both these types of movements are affected by the action of chemical substances known as plants hormone or **phytohormones**.
- We can say, coordination in plants are brought by two ways:
    1. Plant Movements
    2. Phytohormones

## PLANT MOVEMENT

- Movements of the plants or parts of the plant due to some external stimuli like light, gravity, water, touch, chemical substances are known as Plant Movements.
- Plants movements are of two types:
    1. Tropic Movements
    2. Nastic movements

## TROPIC MOVEMENTS

- These are movements of a plant organ that occur in response to external stimuli either towards the stimulus or away from it.
- Tropic moments are very slow and it occurs due to growth of the plant or its organ in a particular direction, hence known as growth movement.
- Tropic moments are classified, depending on the type of stimulus causing it, into following categories:
    1. **Phototropism**: It the movement of plant part in response to light.
        - Positive phototropism: If the plant part moves in the direction of light; e.g., shoot of a plant always grows in the direction of light.
        - Negative phototropism: If the plant part moves against the direction of light; e.g., root of a plant always grows against the direction of light.
    2. **Geotropism**: It the movement of plant part in response to gravity.
        - Positive phototropism: If the plant part moves in the direction of gravity; e.g., root of a plant always grows in the direction of gravity.

- Negative phototropism: If the plant part moves against the direction of gravity; e.g., shoot of a plant always grows against the direction of gravity.

3. **Hydrotropism**: It the movement of plant part in response to water.
   - Positive hydrotropism: If the plant part moves in the direction of water; e.g., root of a plant always grows in the direction of water.
   - Negative phototropism: If the plant part moves against the direction of water; e.g., shoot of a plant always grows in the direction of water.
4. **Chemotropism**: It the movement of plant part in response to chemical stimulus.
   - Positive chemotropism: If the plant part moves in the direction of chemical stimulus; e.g., movement of algae towards food, growth of pollen tube towards ovule during fertilization in flower.
   - Negative chemotropism: If the plant part moves against the direction of chemical stimulus; e.g., bacteria or algae moving away from the harmful chemicals.
5. **Thigmotropism**: It is a growth movement of a plant part in response to touch or contact stimuli.

## NASTIC MOVEMENTS

- These are movements of a plant organ that occur in response to external stimuli neither towards the stimulus or nor away from it.
- Nastic moments are fast and it occurs as plant cells change shape by changing the amount of water in them, resulting in swelling or shrinking. It is not related to growth of the plant.
- When we touch the leaves of a chhui-mui (the 'sensitive' or 'touch-me-not' plant of the Mimosa family), they begin to fold up and droop.

## PHYTO-HORMONES

- They are the chemical substances which are produced in small quantity naturally in plants. It helps to coordinate the various activities in them. They are synthesized at places away from where they act.
- There are five major types of phyto-hormones which are involved in control and coordination in plants:
  1. **Auxins**: They are the group of the plant hormones which are synthesized at the shoot tip and help the cells to grow longer. When light comes from one side of the plant, auxins diffuses towards the shady side of the shoots. The concentration of auxin stimulates the cell to grow longer on the side of the shoots which are away from the light. Thus the plant bends towards the light (positive phototropism).
  2. **Gibberellins**: They help in the growth of the stem, in seed germination and flowering. They also induce parthenocarpy in many plants.

3. **Cytokinins**: They promote cell division in plants. They are present in greater concentration in areas of rapid cell division, such as fruits and seeds.
4. **Abscisic acid**: It is a hormone which inhibits growth. It also causes the wilting of leaves. It retards growth, promote leaves and fruit fall, causes dormancy of seeds. The activities of abscisic acid are in contrast to gibberellins and cytokinins and known as growth inhibitor.
5. **Ethylene**: It promotes growth and ripening of the fruit. It is present in gaseous form.



# HORMONES IN ANIMALS

- Hormones are chemical substances secreted in trace amount by specialized tissue called endocrine glands and are carried by blood circulation to another part of the body for its specific action.
- Characteristics of hormones:
  1. They are specific chemical messenger.
  2. They are secreted by endocrine gland.
  3. They are poured directly into the blood and carried by blood circulation.
  4. They act on specific tissue or organ called target organ.

## ENDOCRINE GLAND

- In the animal body glands may be classified on the basis of presence and absence of ducts.
  - **Exocrine gland or glands with ducts**: These glands have ducts for discharging their secretions to a target organ; they generally secrets Enzymes, e.g., salivary gland.
  - **Endocrine gland or ductless gland:** These glands do not have ducts communicating to their target organ; they pour their secretion directly into the blood to reach the target organ through blood circulation. Their secretions are known as hormones.
- Major endocrine glands present in human body are:
  1. Hypothalamus
  2. Pituitary gland
  3. Thyroid gland
  4. Parathyroid gland
  5. Adrenal gland
  6. Pancreas
  7. Testes
  8. Ovaries

## HYPOTHALAMUS

- This gland is present in brain. It secretes various **releasing hormones** which regulates the secretion of hormones from pituitary gland.

## PITUITARY GLAND

- This gland is present at the base of brain attached close to hypothalamus. It is also known as **master gland** as it controls the other endocrine glands.
- The pituitary gland secrets five hormones:
    - **Growth Hormones:** Develops muscles and bone. This hormone regulates growth and development of the body. Deficiency of this hormone leads to 'Dwarfism' or excess of this leads to extremely tall or 'Giants'.
    - **Trophic Hormones:** Regulation of the secretion of hormones from other endocrine glands.
    - **Prolactin:** Regulation of function of mammary glands in females; milk production.
    - **Oxytocin:** Regulation of ejection of milk during lactation.
    - **Vasopressin:** Regulation of water and electrolyte balance.

## THYROID GLAND

- These glands are present just below the neck. These glands secrete a hormone called **Thyroxine** which regulates carbohydrate, protein and fat metabolism in the body so as to provide the best balance for growth.
- **Iodine** is essential for the synthesis of thyroxine. Deficiency of iodine in our diet causes **goiter**, which is characterized by swollen neck.

## PARATHYROID GLAND

- These glands are four in numver which are embedded in the thyroid glands. Secretion from these glands called **parathormone** which helps to regulate the metabolism of calcium and phosphate.

## ADRENAL GLAND

- These are a pair of glands situated on upper side of each kidney. These glands secrete a hormone called **adrenaline**.
- Adrenaline is secreted at the time of emergency, hence it is called **emergency hormone**. Adrenaline is secreted directly into the blood and carried to different parts of the body. The target organs or the specific tissues on which it acts include the heart. As a result, the heart beats faster, resulting in supply of more oxygen to our muscles. The blood to the digestive system and skin is reduced due to contraction of muscles around small arteries in these organs. This diverts the blood to our skeletal muscles. The breathing rate also increases because of the contractions of the diaphragm and the rib muscles. All

these responses together enable the animal body to be ready to deal with the emergency situation.

## PANCREAS

- It lies below the stomach. It secretes two hormones – **insulin** and **glucagon**.
- The function of the insulin is to lower the blood sugar level by converting glucose in to glycogen. Deficiency of insulin leads to **diabetes**.
- The function of glucagon is to increase the blood sugar level when needed.
- Pancreas is a gland which is exocrine as well as endocrine hence called mixed gland.

## TESTES

- A pair of testes is present outside its lower abdomen in scrotum. They secrete male sex hormone called **testosterone**.
- It regulates the development of secondary sexual characters like moustache, beards, voice, etc.

## OVARIES

- A pair of ovaries lies in the lower abdomen in female. They secrete two female sex hormones called **estrogen** and **progesterone**.
- They regulate the development of secondary sexual characters of female like mammary gland, hair pattern and voice. Progesterone also maintains pregnancy.

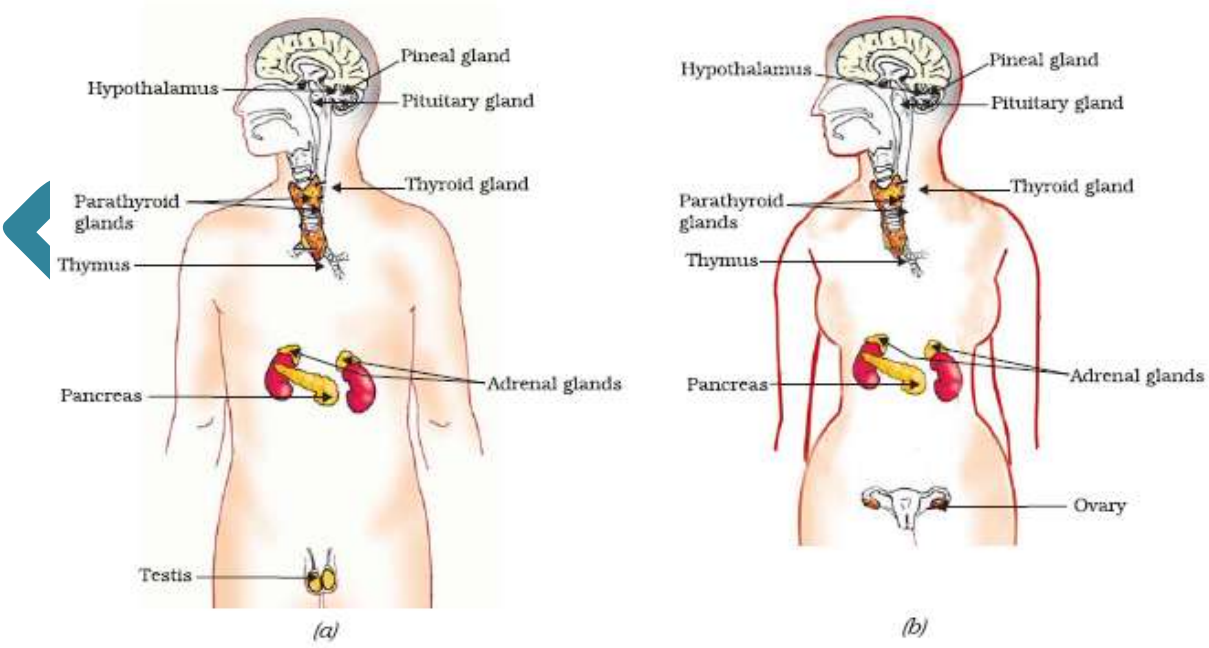



**Figure 7.7** *Endocrine glands in human beings (a) male, (b) female*