CONTROL AND COORDINATION

All living organisms (plants and animals) respond and react to changes in the environment around them. The changes to which organism respond and react are called STIMULI. The response of organism to a stimulus is usually in the form of some kind of movement of their body part.

- Both plants and animals react to stimuli but in different ways. The animals can react to stimuli in many different ways because they have nervous system and endocrine system. While the plants react to stimuli in a very limited way because they don't have nervous system to react. The plants use only hormones for producing reaction to external stimuli
- The working together of the various organs of a organism in a systematic manner so as to produce a proper response to stimulus is called COORDINATION.

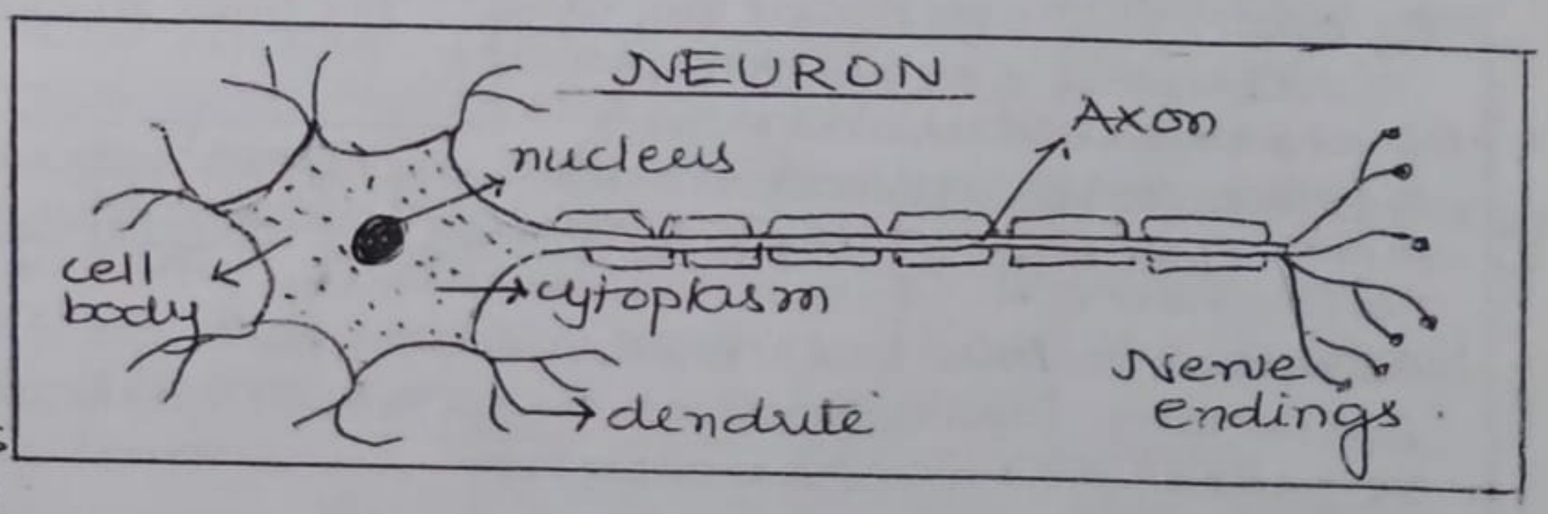
CONTROL AND COORDINATION IN ANIMALS

Control and coordination in simple multicellular animals takes place only through the nervous system while in higher animals it takes place through nervous system as well as endocrine system

(1) NERVOUS SYSTEM - The functions of nervous system are -
(i) to control and coordinates voluntary muscular activities
(ii) to regulate involuntary activities.
(iii) to enable us to think, reason and remember.
(iv) to control all the reflex actions in our body.

THE UNIT OF NERVOUS SYSTEM : NEURON - The structural and functional unit of nervous system is neuron. (or nerve cell).
It has three components -.
(a) cell body (b) dendrites and (c) axon.

The cell body of neuron is like a typical animal cell which contains cytoplasm and nucleus.
A number of long and thin fibres are stretching out from the cell body of neuron. The shorter fibres on the body of a neuron are called dendrites. The longest fibre is called axon. The axon is covered by a fat covering called myelin sheath. The sheath helps in insulation of axon and fast conduction of nerve impulses.



RECEPTORS AND EFFECTORS - There are five sense organs in our body which contain receptors. A RECEPTOR is a cell (or a group of cells) in a sense organ which is sensitive to a particular type of stimulus (or a particular type of change in environment) such as temperature, light etc. Different types of receptors are -
(i) Phonoreceptor (for sound)
(ii) photoreceptor (for light)

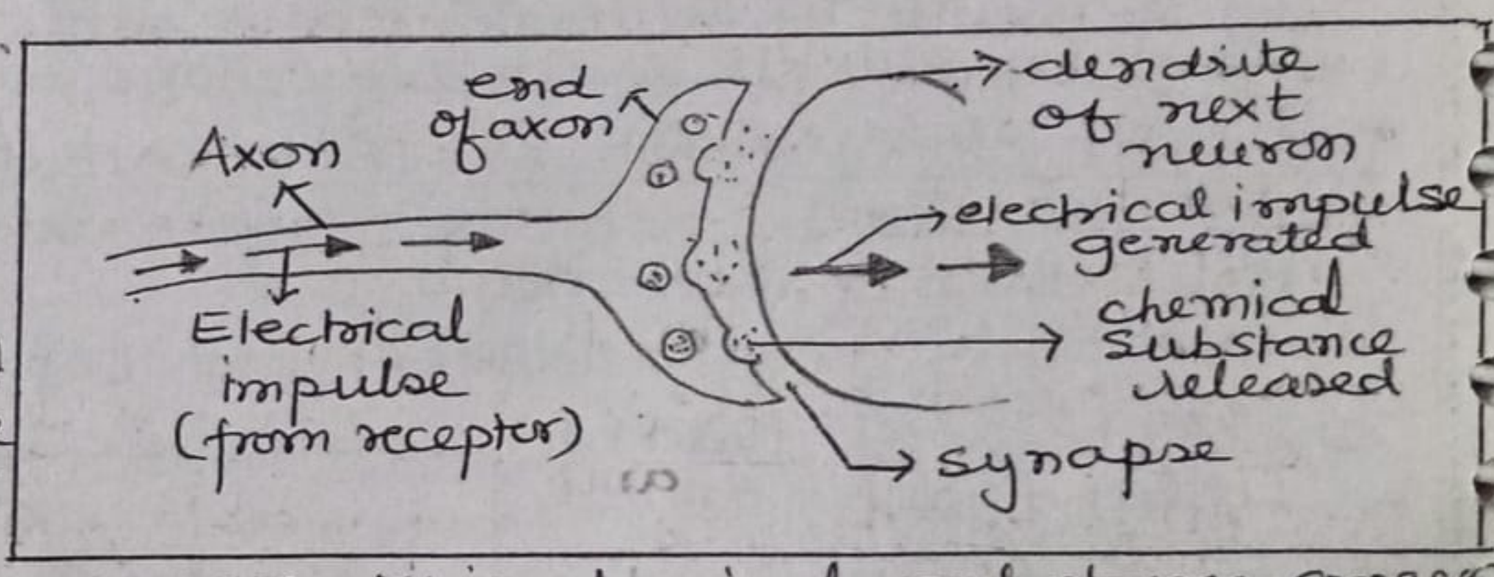
(iii) Olfactoreceptor (for smell)
(iv) gustatoreceptor (for taste)
(v) thermoreceptors (for heat)

An EFFECTOR is a part of a body which can respond to a stimulus according to the instructions sent from the nervous system (spinal cord and brain). The effectors are mainly the muscles and glands of the body.

TYPES OF NEURONS - Neurons are of three types -
(i) Sensory neurons - transmit impulse from the sensory cells (or receptors) to central nervous system (brain and spinal cord)
(ii) Motor neurons - transmit impulse from central nervous system to muscles (or effectors).
(iii) Relay neuron - are present in brain or spinal cord and served as a link between sensory and motor neurons.

CONDUCTION OF NERVE IMPULSE - Any two neurons in the nervous system do not join to one another completely. There is always a very small gap between the two neurons. This gap is called SYNAPSE. Thus it is defined as the functional junction between two neurons. The information passing through neurons are in the form of chemical and electrical signals called NERVE IMPULSE.

- The receptor in a sense organ is in touch with the dendrite of sensory neuron. When a stimulus acts on a receptor, a chemical reaction is set off which produces an electrical impulse in it. This impulse travels from the dendrite of sensory neuron to its cell body and then along its axon. At the end of axon the electrical impulse releases small amount of chemical substance (neurotransmitter) into the synapse. This chemical substance crosses the gap and starts a similar electrical impulse in the dendrite of next neuron. From the dendrite, this electrical impulse is carried to the cell body and then to the end of axon of second neuron. This process goes on till the electrical impulse reaches the relay neuron in spinal cord and brain. The relay neurons and motor neurons connect in a similar way to bring electrical impulses from the brain and spinal cord to the effectors like muscles and glands.



REFLEX ACTION - It is the simplest form of response in the nervous system in which same stimulus produces same response every time. It is defined as a quick involuntary response to an external or internal stimulus, generally without involvement of brain.
- A REFLEX ARC is the shortest route that can be taken by a impulse from a receptor to an effector. It consists of following components -
(i) receptor
(ii) sensory neuron

(iii) spinal cord.
(iv) motor neuron
(v) effector.

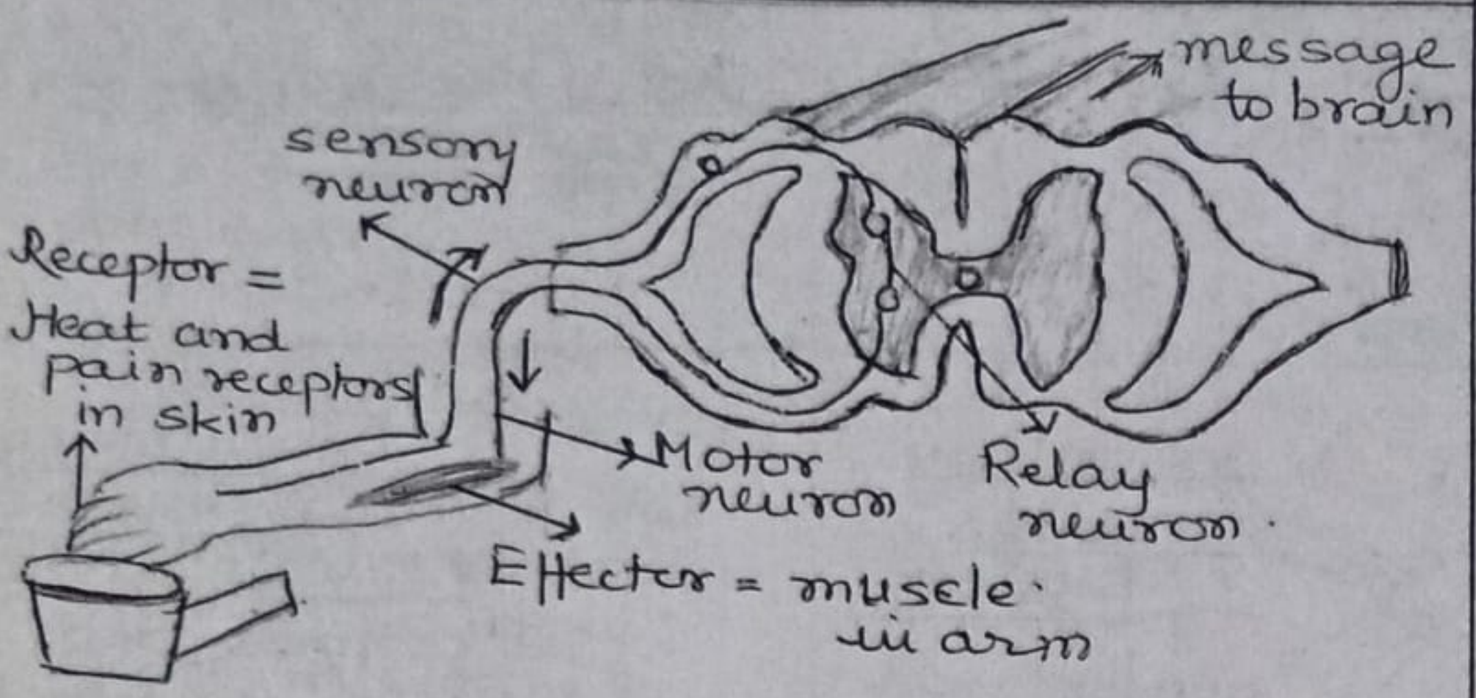
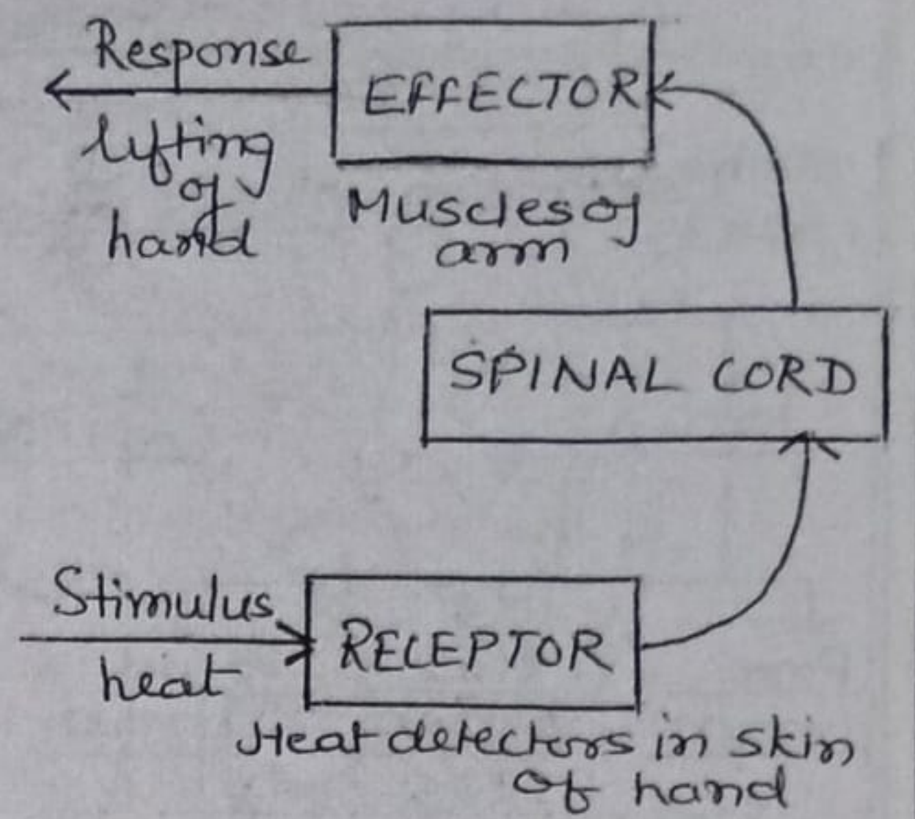


DIAGRAM SHOWING REFLEX ACTION AND ITS PATH.



FLOW DIAGRAM OF REFLEX ARC

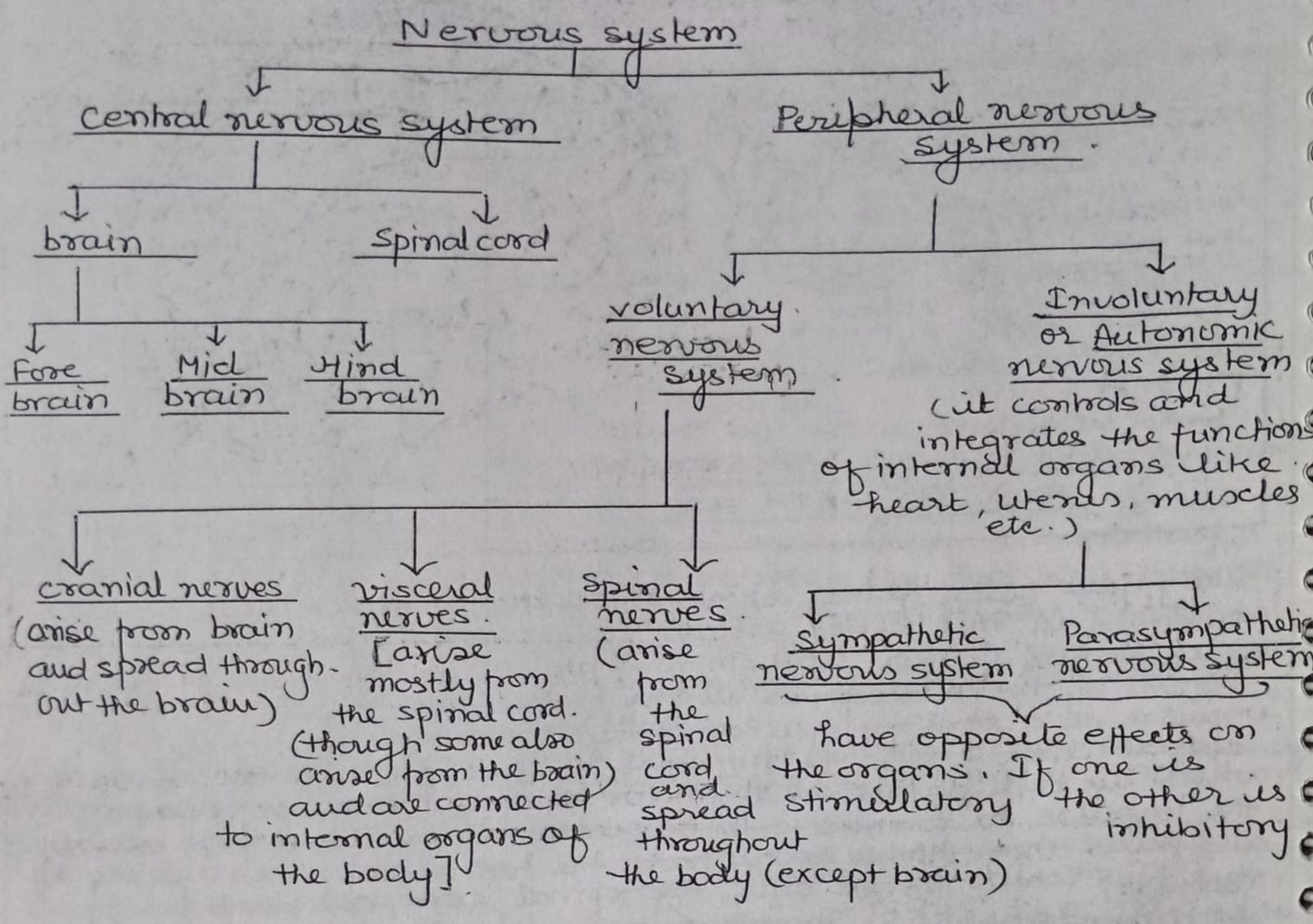
The figure given above shows the pathway taken by the nerve impulses in this reflex action. The stimulus here is the heat which we feel in our hand on touching a hot plate. The heat is sensed by thermoreceptors in our hand. The recepter triggers an impulse in a sensory neuron which passes the message to spinal cord. Here the impulse is passed to relay neuron which in turn passes it to motor neuron. The motor neuron passes the impulse to a muscle in our arm. The muscle then contracts and pulls our hand away from the hot object. The reflexes of this type which involve only the spinal cord are called SPINAL REFLEXES. Though spinal reflexes are produced in the spinal cord but message of reflex action taken also goes on to reach the brain. Thus after the reflex action has taken place, the brain sends messages to the the muscles or glands and all the voluntary actions that follow reflex action are brought about by the brain. The role of brain is to control and coordinate the voluntary actions which take place after the reflex action.

— Some reflex arcs involve the brain rather than the spinal cord only and are called CEREBRAL REFLEXES. The contraction of pupil of our eye automatically in the presence of bright light is an example of cerebral reflex.

HOW THE EFFECTORS CAUSE ACTION OR MOVEMENT—

When a motor nerve impulse sent by the spinal cord (or brain) reaches the effector organs (or muscles), then the muscle cause action or movement. Muscles are made up of muscle cell which contain special proteins. These proteins can change their arrangement when stimulated by nerve impulse causing the cells to change shape and contract. When the muscles contract, they pull on the bones of the body part and make it move.

CLASSIFICATION OF NERVOUS SYSTEM –



CENTRAL NERVOUS SYSTEM – It consists of brain and spinal cord. Brain is the highest coordinating centre in the body and is protected by the CRANIUM, a bony box in the skull. Brain is covered by three membranes called MENINGES and the space between the membranes is filled by CEREBROSPINAL FLUID that protects the brain from mechanical shocks.

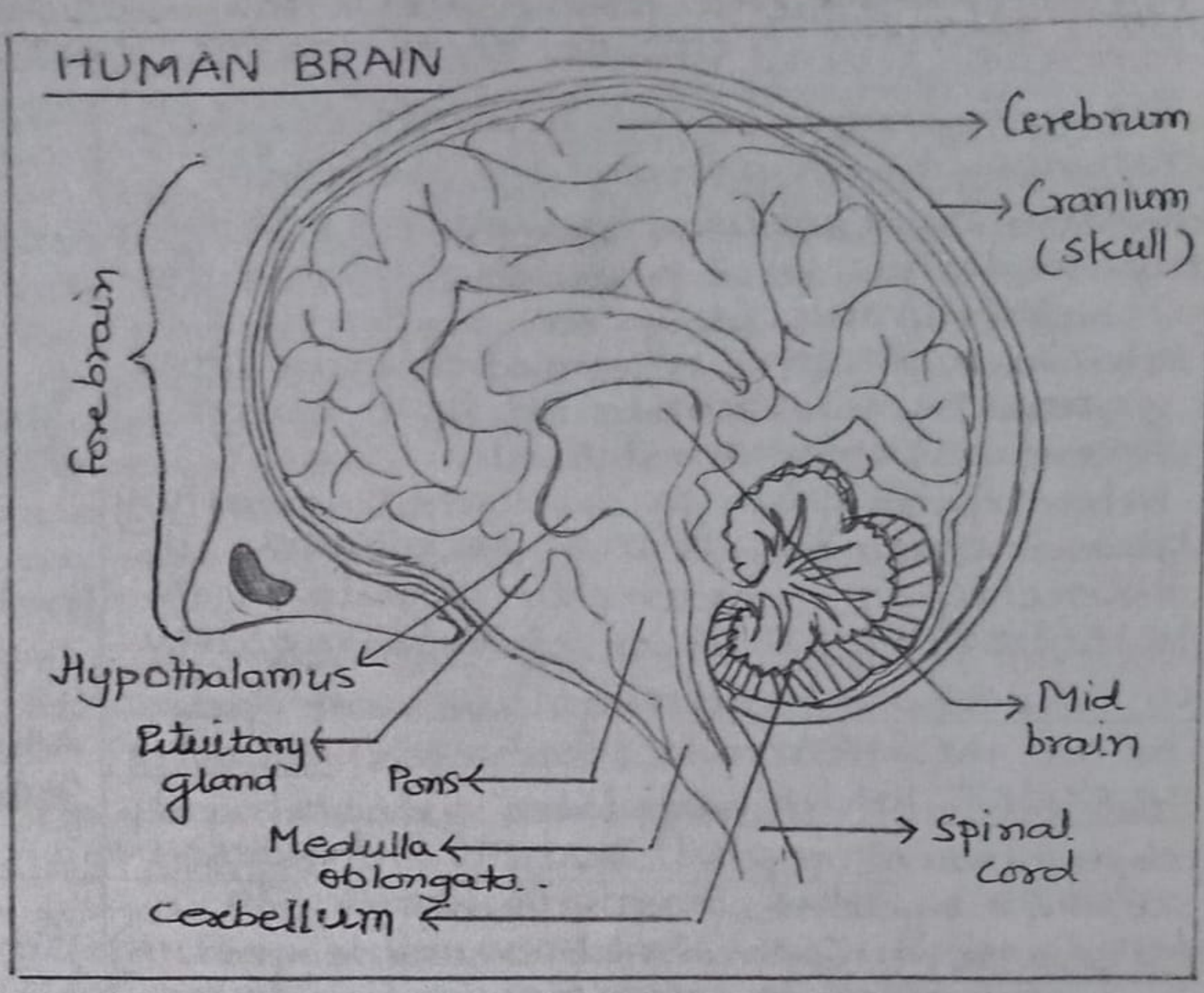
– It consists of three parts – fore brain, mid brain and hind brain.

(i) Fore brain – It forms the greater part of the brain and is further divisible into three regions – olfactory lobes, cerebrum and diencephalon.

(a) Olfactory lobes – receives impulses from olfactoreceptors and responsible for sensation of smell.

(b) Cerebrum – It is the most complex and specialized part of the brain. It consists of two cerebral hemispheres. The cerebrum has sensory areas where information is received from sense organs (receptors). Similarly, there is motor area from where impulses are sent to muscle or effector organs. In the cerebrum, specific regions for each kind of stimulus and its response are located. For example –

- occipital lobe (region for visual reception
- temporal lobe (region for auditory reception)
- parietal lobe (region for touch, taste, smell, temperature and conscious association.
- frontal lobe - for muscular activities.



(c) Diencephalon - This part has hypothalamus to which pituitary gland is attached.

(ii) Mid brain - It controls the reflex movements of head, neck and trunk in response to visual and auditory stimuli. It also controls the reflex movements of eye muscles, change in pupil size and shape of eye lens.

(iii) Hind brain - It consists of three parts -

(a) Cerebellum - helps in maintaining posture and balance of the body. It also enables us to make precise and accurate movements. It coordinates smooth body movements such as walking, riding a bicycle, picking up a pencil etc

(b) Pons - It regulates respiration.

(c) Medulla oblongata - It controls various involuntary actions such as heart beat, breathing, blood pressure, peristaltic movement of alimentary canal etc. It is also the controlling centre for reflexes such as swallowing, coughing, sneezing, vomitting etc

- SPINAL CORD is a cylindrical structure. It begins in continuation with the medulla oblongata and extends downwards, enclosed within vertebral column. It is also surrounded by meninges.

2. ENDOCRINE SYSTEM - The endocrine system helps in coordinating the activities of our body. It consists of many endocrine glands. These glands are ductless glands i.e. these directly pour their secretion into the blood. These glands secrete a chemical substance, called HORMONES. The various characteristics of hormones are given below -

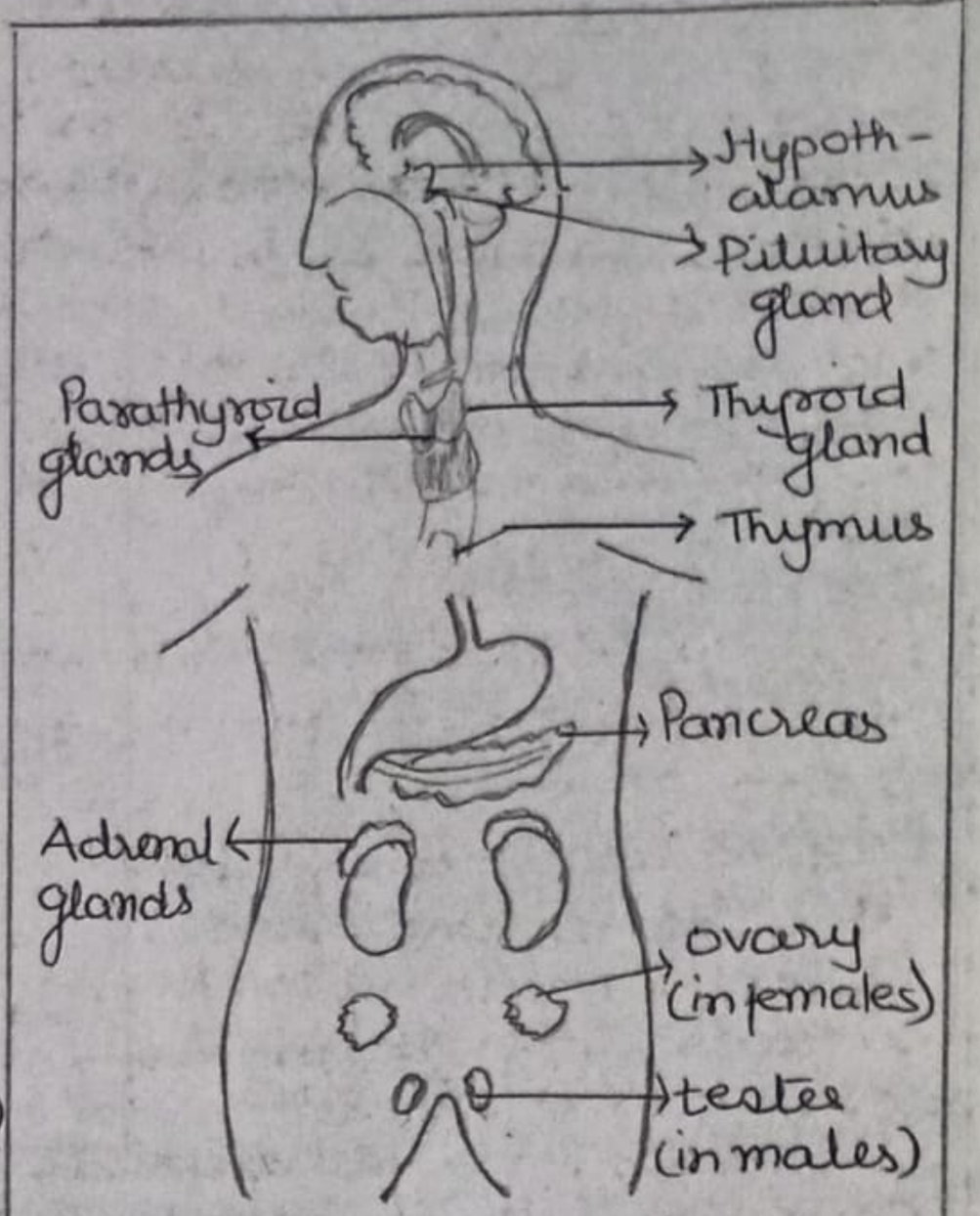
(i) The hormones are secreted ~~are secreted~~ in very small amount by endocrine glands.
(ii) They are poured directly into the blood and carried throughout the body by blood circulatory system.
(iii) The hormones have their effect at the site different from the sites where they are made. so they act as a chemical messenger
(iv) The hormones act on specific tissue or organs (called target organs).
(v) The hormones coordinates the activities of the body and also its growth.

- The endocrine glands are located in different parts of the body as shown in the figure. These glands are - Pineal

Pituitary, Pineal, Hypothalamus, Thyroid, Parathyroid, Thymus, Pancreas, Adrenal glands., Testes (in male) and ovaries (in females).

The main centre in the body for co-ordination of two systems (i.e. nervous system and endocrine system) are the hypothalamus and pituitary gland. The hypothalamus plays an important role in collecting information from other regions of the brain and from blood vessels passing through it. This information is passed on to pituitary gland which by its own secretions, directly or indirectly regulates the activities of all other endocrine glands.

(i) Pituitary gland - is present just below the brain. It secretes GROWTH HORMONE which regulates growth and development of the body. An excessive secretion of this hormone leads to GIGANTISM (abnormal excessive growth). On the other hand, insufficient secretion of growth hormone in childhood retards growth, leading to DWARFISM (abnormal stunted growth).



ENDOCRINE GLANDS IN HUMAN BEINGS.

(ii) Thyroid gland - is attached to windpipe in our body. It secretes a hormone, called THYROXINE (which contains iodine). The function of thyroxine hormone is to control the rate of metabolism of carbohydrate, fat and protein in our body. Iodine is required for making of thyroxine hormone, therefore, a deficiency of iodine in diet can cause a deficiency of thyroxine hormone in our body and cause a disease known as GOITRE. The main symptom of goitre is swollen neck. People are advised to use iodised salt for cooking food so as to prevent goitre disease.

(iii) Parathyroid gland - There are four small parathyroid glands which are embeded in thyroid gland: These glands secrete a hormone called PARATHORMONE which regulate calcium and phosphate level in body.

(iv) Pancreas - is present just below the stomach in the body. It secretes a hormone called INSULIN which regulates blood sugar level in body. Deficiency of insulin hormone in the body cause a disease known as DIABETES in which blood sugar level is increased. Diabetes can be controlled by taking proper diet, reducing weight, doing regular physical exercise and taking medicines. In some cases it is treated by giving injections of insulin.

(v) Thymus gland - is present in the lower part of neck and upper part of the chest. It secretes THYMUS HORMONE which plays a role in the development of immune system in our body. It is large in young children but shrinks after puberty or sexual maturity.

(vi) Adrenal gland – There are two adrenal glands which are located on the top of the two kidneys. These glands secrete a hormone called ADRENALINE. This hormone prepares our body to function at maximum efficiency during emergency situations like danger, excitement, anger etc. In an emergency situation, the nervous system stimulates the adrenal glands to secrete more adrenaline hormone which is carried by blood to different parts of the body. 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 diaphragm and the rib muscle. All these responses together enable us to deal with the emergency situation.

(vii) Testes – are present only in males and produce male sex hormone called TESTOSTERONE. It controls the development of male sex organs and male features (or secondary sexual characters).

(viii) Ovaries – are present only in females and produce two female sex hormones called OESTROGEN and PROGESTERONE. Oestrogen controls development of female sex organs and female features or secondary sexual character. Progesterone controls the uterus changes in menstrual cycle and also helps in maintenance of pregnancy.

CONTROL OF HORMONE SECRETION – The hormone secretion and balance in the body is maintained by FEEDBACK MECHANISM. This mechanism regulates the precise quantity and timing of hormone secretion. for example, when we take meal, our blood sugar level rises immediately. The increased blood sugar level is detected by the cells of pancreas which respond by producing more insulin. As a result, blood sugar level falls and insulin secretion is reduced.

COMPARISON OF NERVOUS SYSTEM AND ENDOCRINE SYSTEM –

NERVOUS SYSTEM	ENDOCRINE SYSTEM
Made up of neurons (nerve cells)	made of secretory cells (or endocrine glands)
Message transmitted in the form of electrical impulse.	Message transmitted in the form of chemicals called hormones.
Message transmitted along nerve fibres.	Message transmitted through blood stream.
Message travel very quickly.	Message travel more slowly.
Effect of message usually lasts for a very short while.	Effect of message usually lasts longer.

CONTROL AND COORDINATION IN PLANTS

Plants do not have any nervous system and sense organs like animals. The growth, control and coordination in plants is regulated by certain chemical substances known as PLANT HORMONES OR PHYTOHORMONES. They coordinate the activities of the plant by controlling one or the other aspect of the growth of a plant. There are four major types of plant

hormones involved in the control and coordination in plants. These are –

(i) Auxin – is synthesized in apical meristem of root tip and shoot tip. It stimulates the cell to grow longer.

(ii) Gibberlins – It stimulates stem elongation, seed germination and flowering.

(iii) Cytokinin – It promotes cell division, therefore, present in greater concentration in areas of rapid cell division such as fruits and seeds.

(iv) Abscisic acid (ABA) – inhibits the plant growth and reverse the growth promoting effects of auxins and gibberlins. Its effect include wilting of leaves.

- PLANT MOVEMENTS – The plants are fixed at a place with their roots in the ground, so they cannot move from one place to another. However, movement of the individual parts of a plant like shoot, roots, leaves etc is possible when they are subjected to some external stimuli like light, water, touch etc.
  – The plants show two types of movements – tropic and nastic movements.

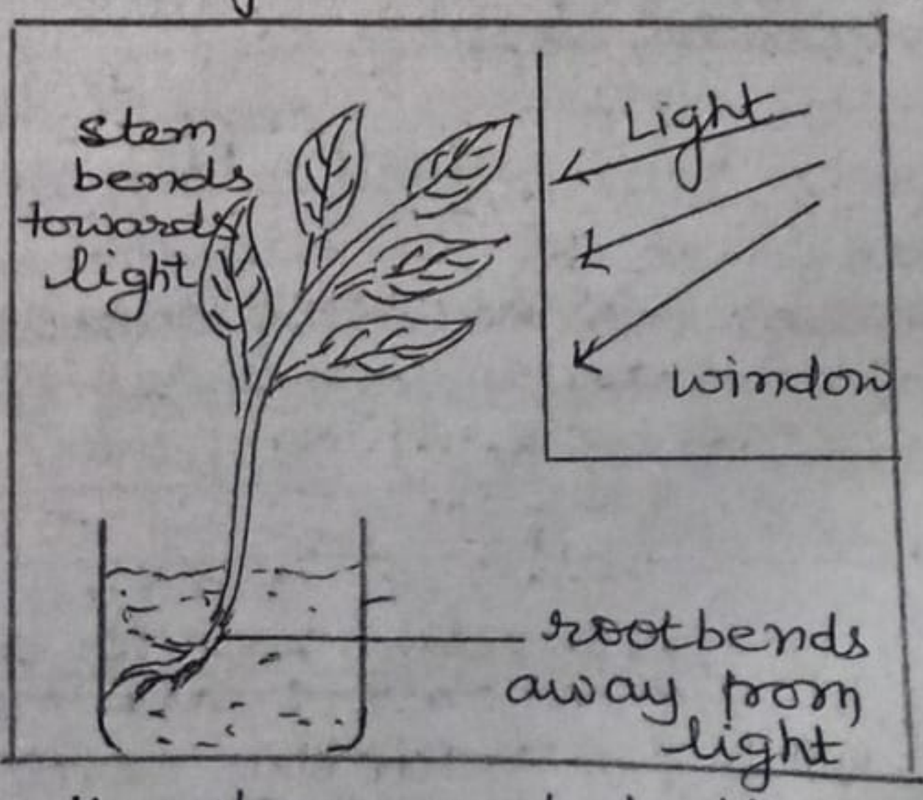
(1) Tropic movements. – A growth movement of a plant part in response to an external stimulus in which the direction of stimulus determines the direction of response is called TROPISM or TROPIC MOVEMENTS.

– If the growth of a plant is towards the stimulus, it is called POSITIVE TROPISM and if the growth or movement is away from the stimulus, it is called NEGATIVE TROPISM.

– There are five stimuli which give five types of tropism –

(i) Phototropism – is the response of a plant to light. Stem shows positive phototropism while root shows negative phototropism.

– When a plant is grown in the open ground with the sunlight coming from above, then the stem of the plant grows straight up. If however, the plant is grown with sunlight coming from one side, then the stem of the plant bends towards the direction from which the sun light comes. The roots of the plant however, bends away from the direction from which the sunlight comes. The response of plant towards light is due to action of auxin hormone, and can be explained as follows –.

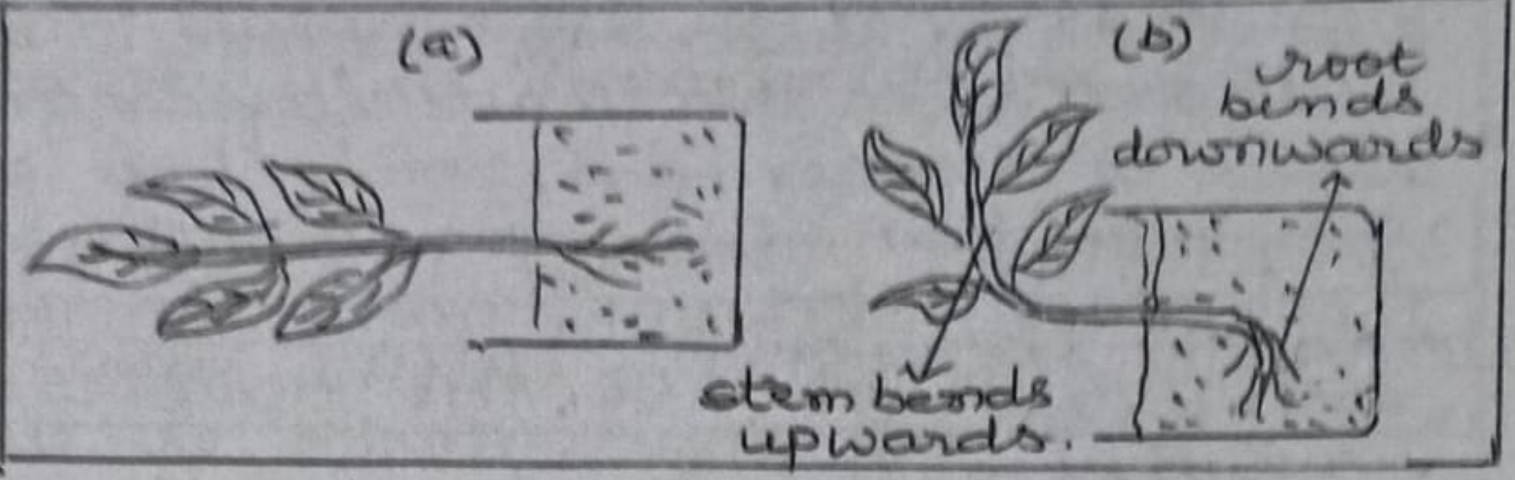


When sunlight comes from above, the auxin hormone present in the tip of stem spreads uniformly down the stem, and both the sides of the stem grow equally rapidly and the stem grows straight up. If sunlight falls from one side only, the auxin hormone diffuses to other side (or shady side) of the shoot This concentration of auxin stimulates the cells to grow longer on the side of the stem which is away from sunlight.

Thus the plant appears to bend towards light.
- the effet of auxin on the growth of root is exactly opposite to that on a stem. It decreases the rate of growth in a root the side of the root away from light have all the auxin concentrated in it. Due to this, the side of the root away from light will grow slower than the other side and make the root bend away from the light.

(ii) Geotropism - The response of plants to gravity is called geotropism. Root shows positive geotropism and stem shows negative geotropism.

- If we take potted plant and keep it horizontally as shown in fig: (a). i.e. both stem and root are parallel to the ground. After a few days, we will find that roots of the plant bend downwards towards the earth while the stem bends upwards, away from earth.



(iii) Hydrotropism - The movement of a plant in response to water is called hydrotropism. The root shows positive hydrotropism, even if it means going against the pull of gravity as shown in the figure.

(iv) Chemotropism - The growth or movement of a plant due to chemical stimulus is known as chemotropism. for example during fertilization pollen tube grow towards a chemical produced by ovule.

(v) Thigmotropism - is the response of plants to touch or contact with a solid surface. When the parts of the plant touches a support the side of the apical meristem comes in contact with the support grows slower than the other side e.g. tendrils coil around a support. This occurs as auxin gets concentrated on the side which is away from the support and it grows faster.

(2) Nastic movements - The movement of a plant part in response to an external stimulus in which the direction of response is not determined by direction of stimulus is called nastic movements. In such movements from whichever direction, the stimulus is applied, it affects all the parts of the organ of a plant equally and they also move in same direction.

- All tropic movements are growth movements but all nastic movements are not 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.

(i) Thigmonasty - is the non directional movement of a plant part in response to touch e.g. in touch-me-not plant (or Mimosa pudica). In this plant, the leaflets fold up

quickly on touching. This occus due to a sudden and rapid loss of water (turgor changes) from cells at the base of leaflets. Due to loss of water it lose its firmness and making the leaf to fold. After 15 to 30 minutes after the leaves have folded, water usually diffuses back into the cells at the base of leaflets and leaf returns to its original position.

(ii) Photonasty - is the nondirectional movement of a plant part (usually petals of flowers) in response to light. e.g. 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 and closing of flower in response to light is a growth movement. Petals open when their inner surfaces grow more than their outer surface. On the other hand, petals close when their outer surfaces grow more than their inner surfaces.

DIFFERENCE BETWEEN THE MOVEMENT OF LEAVES OF A SENSITIVE PLANT AND THE MOVEMENT OF SHOOT TOWARDS LIGHT —

Movement of leaves of a sensitive plant.	Movement of shoot towards light
(i) it is a nastic movement	it is is tropic movement.
(ii) the stimulus is touch	the stimulus is light.
(iii) it is caused due to sudden loss of water from base of the leaves.	it is caused by unequal growth on two sides of shoot.
(iv) it is not a growth movement	it is a growth movement.