Control & Coordination

Biology – X CBSE

Introduction

Movements or changes in position are an important characteristic of living beings. They may be due to growth or changes made in the internal body components with respect to one another. Growth movements are seen in a germinating seed. The seedling grows and pushes the soil to come out. Movements other than growth are seen in many animals and some plants, e.g., running of cat, children playing on swings, buffaloes chewing cud, folding and drooping of leaves in Sensitive Plant (Mimosa pudica). No growth movements and some growth movements occur in response to changes in environment. Cat may be running for a mouse or away from a dog. Plants grow towards sunshine. Children get fun and pleasure out of swinging. Chewing of cud by a buffalo is used to break tough food for better digestion. We close our eyes when bright light is focused on them. Hand is withdrawn immediately if one touches a hot object. In all cases movements are performed for providing advantage to the living organism.

Movements are not haphazard or secluded. They are highly controlled and coordinated. A movement is always appropriate and depends upon the event and environment triggering it. You will whisper to your friend in classroom but shout in the playing ground. This is possible only when one recognises the various events in the environment and allow the movement accordingly. For this the living organisms have systems of control and coordination. Control is the power of restrain and regulation by which something can be started, slowed down, expedited or stopped. Coordination (L. co-joint, ordinatos-regulated) is orderly or harmonious working of different but inter-related parts so as to perform one or more activities very smoothly. For example, during ingestion or taking in of food, eyes locate food, nose registers its smell, hands pick up the food and take it into the mouth, mouth opens to receive the food, teeth and jaw muscles take part in its mastication, saliva moistens it and starts the process of digestion while tongue perceives its taste and moves the food first below the teeth and later pushes it into pharynx in the form of bolus. Similarly during running, leg muscles work extra to provide

force that requires more energy. There is increased rate of breathing for supply of more oxygen. More blood is sent to provide more glucose to muscles. Therefore, multicultural organisms have specialised systems of tissues and organs that provide control and coordination of functions.

There are two modes of control and coordination, chemicals and nervous. Plants do not have a nervous system. They possess only chemical. Control and Coordination controls and coordination. Animals have both chemical and nervous controls and coordination. The two constitute neuroendocrine system.

ANIMALS: NERVOUS SYSTEM

It is the system of nervous organs, nerves and neurons that form a network throughout the body for conducting information via electrical impulses so as to coordinate and control activities of different parts as well as provide appropriate response to both internal and external stimuli. Stimulus is an agent, factor, chemical or change in external or internal environment which brings about a reaction in the organism. Response is the reaction of the organism to a stimulus. However, nervous system cannot operate alone in perceiving stimuli and providing response. It requires receptors and effectors for the same. Receptors are cells, tissues and organs which are capable of receiving particular stimuli and initiate impulses to be picked up by sensory nerves. Impulse is self propagated electrical current that runs along the surface of the nerve fibre for passage of information. Effectors are muscles, glands, tissues or cells which act in response to a stimulus received from the nervous system.

Sensory Receptors. (i) Photoreceptors. Detect light and form images. They occur inside eyes.

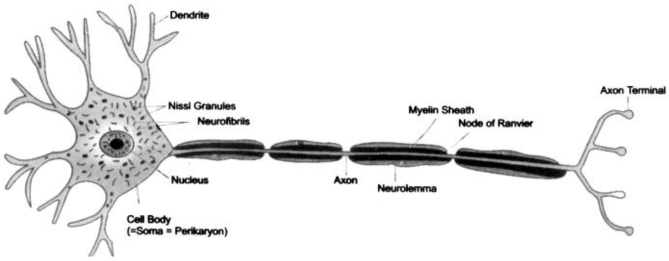
(ii) Gustatoreceptors. Detect taste. Located in taste buds on tongue and other parts of buccal cavity.

(iii) Thennoreceptors. Detect heat and cold. Located in skin.

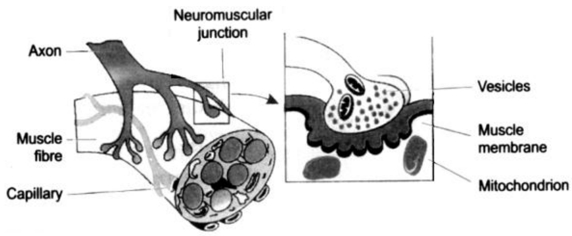
(iv) Olfactoreceptors. Detect smell. Located in olfactory epithelium in nasal cavities.
(v) Phonoreceptors. Detect sound. Located in inner ear.
(vi) Statoreceptorg. Detect changes in equilibrium. Located in inner ear.
(vii) Tangoreceptors. Tactile or touch receptors present in skin.
(viii) Pain and Pressure Receptors. Located in skin and deeper tissues.

STRUCTURE OF NEURON OR NERVE CELL

Neuron or nerve cell is a structural and functional unit of nervous system that is specialised to receive, conduct and transmit impulses. It is very long, sometimes reaching 90-100 cm. A neuron has three parts—



cell body, dendrites and axon. The term neuritis is used for both dendrites and axon.
(a) Cell Body or Cyton (= Soma, Perikaryon). It is broad, rounded, pyriform or stellate part of the neuron that contains a central nucleus, abundant cytoplasm and various cell organelles except centrioles. Because of the absence of centrioles, neurons cannot divide. Injured neurous are neither replaced nor repaired. Cytoplasm of cell body is also called nvuroplasm. Nucleus is large with a prominent nucleolus. Special structures present in cell body of a neuron are small ribosome containing Nissi granules and fine fibrils called neurofibrils. Cell body maintains the neuron through its metabolic activity and growth.
(b) Dendrites (Dendrons). They are fine short and branched protoplasmic processes of the cell body that pick up sensations (physical, mechanical, electrical, chemical) and transmit the same to the cell body. Dendrites contain Nissi granules and neurofibrils.
(c) Axon. It is a long fibre-like cytoplasmic process that carries impulses away from the cell body. Axon is branched terminally. The terminal branches are called terminal arborisations. Axon terminals may end in muscle fibres, glands, other structures or form synapses with dendrites of other neurons. Axon terminals are often knob-like.
Axon is covered by one or two sheaths. The sheathed axon is called nerve fibre. A number of nerve fibres are joined to form a nerve. The cell membrane covering the axon is called axolemma. Cytoplasm of axon is termed as axoplasm. It lacks Nissi granules. Neurofibrils are present. The single sheath present over the axon is made of Schwann cells. It is called neurolemma or neurilemma. If two, a layer of insulating myelin or fat occurs between neurolemma and axon. The two types of nerve fibres are respectively called nonmyelinated and myelinated. Myelinated nerve fibres are more efficient in transmission of impulses than nonmyelinated fibres. At intervals they bear unmyelinated areas called nodes of Ranvier.



Differences Between Dendrites And Axons

Dendrites	Axons
1. Size. They are short tapering processes.	They are long processes.
2. Number. A number of dendrites often develop from all around a cell body.	A single axon develops from a cell body.
3. Ends. The ends are tapering.	The ends bear knobbed branches called terminal arborisations.
4. Neurolemma. A covering of neurolemma absent.	Neurolemma is present.
5. Inclusions. They contain both Nissi granules and neurofibrils.	Nissi granules are absent. Neurofibrils are present.

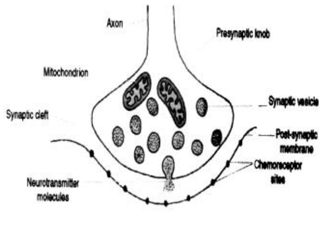
6. Impulse. They carry sensation or impulse the cell body.	They carry impulse away from the cell body.

A neuron can be sensory, motor or connector. A sensory or afferent neuron picks up sensation from the receptors and transmits the same to other parts like central nervous system. A motor or efferent neuron carries message to the muscle, gland or an organ to perform its function. Connector neuron or inter-neuron is special neuron which passes the message from a sensory neuron to motor neuron. Like neurons, nerves are also of three types— sensory, motor and mixed. Mixed nerve carries both sensory and motor nerve fibres.

Differences Between Sensory And Motor Neurons

Sensory/Afferent Neuron	**Motor/Efferent Neuron**
1. Conduction. It conducts impulses towards central nervous system.	It carries impulses away from central nervous system.
2. Information. It beings information from a receptor or sensory organ.	It takes information towards an effect organ.
3. Contact. It picks up information in the region of a dendrite terminal.	It hands over information by a axon terminal.

PASSAGE OF IMPULSE



Impulse transmission across a synapse.

A stimulus received by a neuron travels through it in the form of an electrochemical disturbance. During rest the outer surface of a neuron is positively charged while the interior has negative charge. Stimulus causes opening of ion channels which makes the outer surface negatively charged while the interior becomes positively charged. This creates the impulse which moves forward. The posterior region returns to the condition of rest. At the end of the neuron, the impulse is passed on to the next neuron, an organ, muscle or gland in the form of a neurotransmitter. Neurotraiismitter is a chemical secreted by axon terminal for transmission of impulse to the next neuron, muscle, gland or organ, e.g., acetylcholine, noradrenalin, glutamic acid.

SYNAPSE

It is a narrow gap containing junction between two neurons where an axon terminal comes in near contact with dendrite terminal of next neuron. Axon terminal is expanded to form a presynaptic knob. The dendrite terminal is slightly broadened and depressed to form post- synaptic depression. A narrow fluid filled space, called synaptic cleft, occurs between the two. As the impulse reaches the presynaptic knob, it stimulates release of
neurotransmitter into cleft. Neurotransmitter molecules come in contact with membrane of post-synaptic depression. It functions as stimulus and produces an impulse in the dendrite part of the second neuron. Because of the release of neurotransmitter on one side of the synapse, impulse travels through the neurons only in one direction-.

TYPES OF NERVOUS ACTIONS

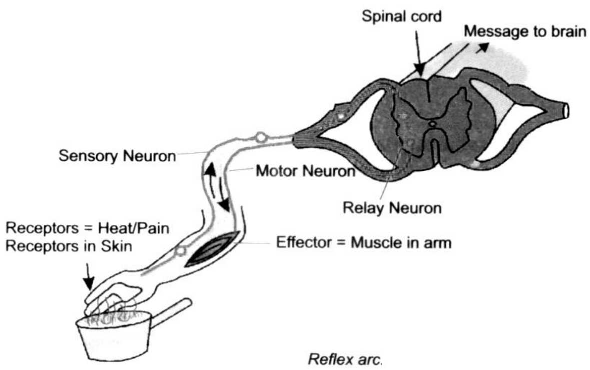
Nervous actions are of three types : reflex actions, voluntary actions and involuntary actions. Reflex actions and involuntary actions occur without consulting the will. Reflex action is an automatic, mechanical and immediate response to a harmful stimulus. Involuntary action is meant for controlling and coordinating the functioning of internal organs. Voluntary action of nervous system is performed under conscious directions of the brain, e.g., picking a pen for writing.

NEED FOR REFLEX ACTION

Central nervous system has several coordination centres where information received from various body parts is processed. The processing or thinking is based on information and experience already stored. The coordination centres decide about the response. The response is sent through motor neurons to the regions where reactions are to be produced. The whole process takes some time. However, there are certain situations where sensation requires immediate response. Delay caused during analysis and processing the information would be harmful. In such cases the body operates reflex action. Reflex actions seem to have evolved quite early in the physiology of animals when complex neuron network for processing had not been evolved. Even after evolution of processing centres, reflex actions have continued to persist because of their more efficiency for quick responses.

WHAT HAPPENS IN REFLEX ACTIONS

Reflex action (L. reflectors- to turn back) is a nerve mediated, automatic involuntary and spontaneous response to a stimulus acting on a specific receptor without consulting the will. It was discovered by Marshal Hall (1833). Reflex action is an accurate, unconscious, involuntary and instantaneous response to a stimulus where delay can be harmful. On being pricked or coming in contact with hot surface or flame, the hand is withdrawn even before pain is perceived by brain. Other examples of reflex action are wider opening of pupil in dim light, narrowing of pupil in strong light, salivation when food is eaten, secretion of digestive enzymes when food reaches a particular region of alimentary canal, closing of eyes when a flash of light is targeted, sweating during exercise and hot weather, jerking of knee when hit below knee cap (to extend leg for maintaining posture). By regular association, habit or practice, some actions can be converted into reflex actions, e.g., writing, reading, walking, driving, pedaling, knitting, salivation at sight or smell of a food. They are called/conditioned reflexes.



Reflex arc.

Reflex Arc. Reflex action requires a stimulus, a receptor organ, sensory neurons, a part of central nervous system, motor neurons and effector organ. The pathway taken by a stimulus to travel from receptor organ to effector organ is known as reflex arc. Its components are as follows (Fig. 2.4.).

(i) Receptor Organ. It is a tissue or organ which receives the stimulus for initiating nerve impulse, e.g., skin, eye, ear.

(ii) Sensory Neurons. They conduct impulses from receptor to central nervous system.

(iii) Part of Central Nervous System. It is spinal cord or brain. Accordingly, there are two types of reflexes, spinal reflexes and cerebral reflexes. Cerebral reflexes include closure of eyes exposed to flash of light, salivation at sight or smell of salivation at the time of crushing of food, peristalsis, inspiration and expiration. Examples of spinal reflexes are withdrawal of hands or feet on being pricked and knee jerk reaction. In central nervous system the impulse is transferred from sensory neuron to motor neuron either directly or through an inter-neuron.

(iv) Motor Neurons. They conduct motor impulse from central nervous system to the effector organ.

(v) Effector Organ. It is a muscle, gland or organ. The effector organ is activated by motor impulse to provide a suitable response to the stimulus.

Withdrawal of hand after coming in contact with hot surface, thorn or needle is an example of spinal reflex arc. Sensation is received by receptors present in skin. It is passed through sensory neurons reaching dorsal root of spinal nerve and then the spinal cord. In the spinal cord the impulse is transferred to motor neuron by a relay neuron or interneuron. Motor neurons come out through ventral root of spinal cord and reach the muscles of the arm, which are stimulated. The muscles move the hand away.

Closing of eyes when bright light is focused on them is a cerebral reflex. Sensation of bright light is picked up by sensory neurons that take them to superior quadrigemina of mid brain. Here the interneuron or relay neuron transfers the impulse to motor neurons. The latter take the impulse to pupil and eye lids. This activates the muscles to close the eyes.

In reflex action, the same stimulus always produces the same response.

IMPORTANCE OF REFLEX ACTION

1. Overloading. It checks overloading and overtaxing of brain.
2. Survival Value. Reflex actions have survival value.
3. Quick Response. There is an immediate response to otherwise harmful stimuli without the brain having analysed the same.

4. Conditioned Reflexes. With the help of conditioned reflexes we perform a number of our activities, e.g., reading, writing, typing, pedalling, playing a musical instrument.

Differences Between Reflex Action And Walt

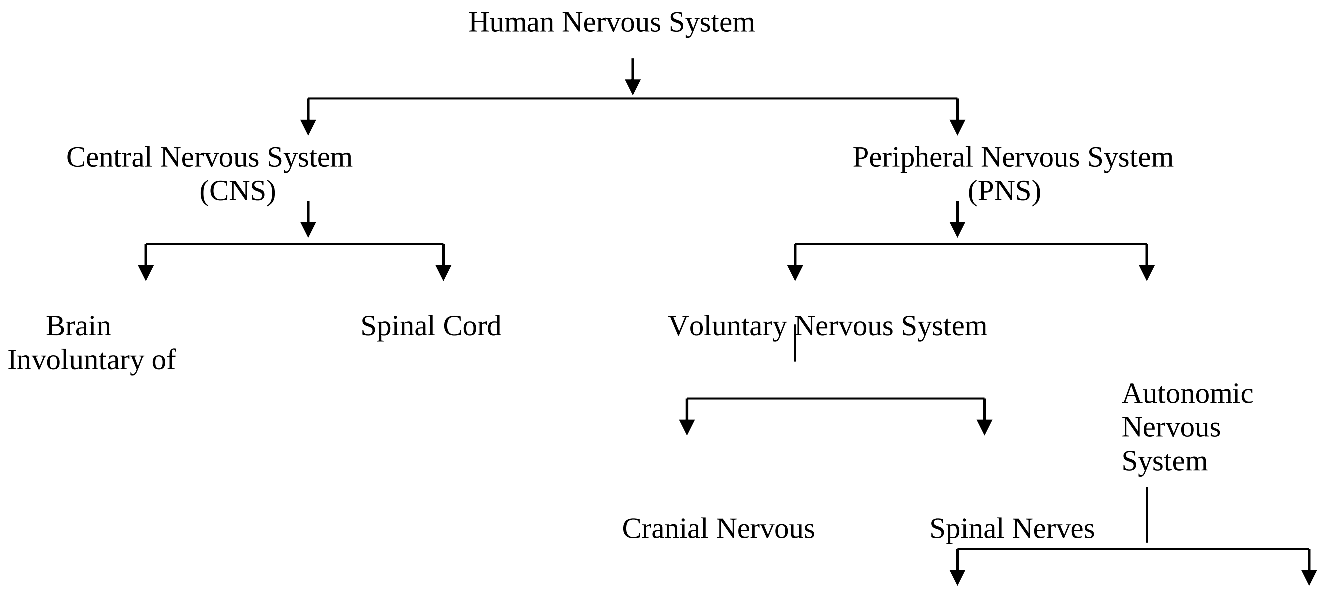
Reflex Action	**Walk**
1. Origin. Reflex action is inborn and present in an individual right from birth.	It is acquired through learning.
2. Inheritance. It is inherited.	It is not inherited.
3. Control. It is automatic. An individual cannot control it.	It is under control of the brain.
4. Intensity. It cannot be changed.	It can be changed.
5. Value. It has survival and protective value.	It has various functions, survival and protection.

FUNCTIONS OF NERVOUS SYSTEM

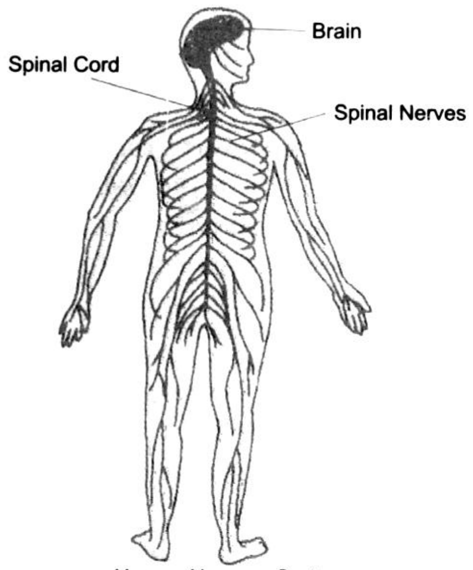
1. Control. Nervous system exerts control over the functioning of different tissues, organs and parts of the body.
2. Coordination. It coordinates the activity of different but inter-related organs so as to perform a particular function, e.g., swallowing.
3. Surrounding. It makes an animal aware of its surroundings with the help of sense organs.
4. Internal Environment. Nervous system gathers information about the internal environment of the body.
5. Higher Faculties. Intelligence, reasoning, memory, emotions, will, etc. are due to nervous system.
6. Involuntary Movements. They are movements of internal organs carried out by a section of nervous system without consulting the will of the individual, e.g., peristalsis.
7. Reflexes. They are immediate, automatic, protective response to harmful stimuli.

PARTS OF HUMAN NERVOUS SYSTEM

Human nervous system has two parts, central and peripheral. Central nervous system (CNS) is hollowed part of nervous system that lies along the mid dorsal part of the body inside axial skeleton. It has two parts, brain and spinal cord. Peripheral nervous system (PNS) is lateral part of nervous system that develops from central nervous system connecting different parts of the body with the same. It has two components, voluntary and involuntary. Voluntary peripheral nervous system is under the control of will. It consists of cranial nerves from brain and spinal nerves from spinal cord. Involuntary peripheral nervous system is also called autonomic nervous system. It has two parts, sympathetic nervous system and parasympathetic nervous system. They control the functioning of various internal body parts.



Sympathetic Nervous
Parasympathetic
System Nervous System



Human Nervous System.

HUMAN BRAIN (ENCEPHON)

It is the widest and the uppermost part of central nervous system which weight $1{\cdot}2-1{\cdot}4$ kg and constitutes 98% of the total nervous system. Human brain is the most advanced and wall developed of all animals. The brain is differentiated into three parts – fore brain, mid brain and hind brain.

Brain

Fore brain | Mid brain | Hind brain

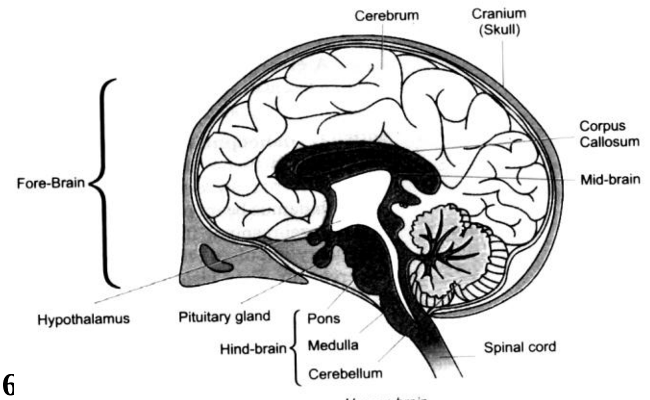
Olfactory Lobes (2) | Cerebrum (2 Cerebral hemispheres) | Diencephalon

Cerebral Peduncles | Corpora Quadrigemina

Pons | Cerebellum | Medulla Oblongata

1. Olfactory Lobes. They are a pair of widely separated club-shaped structures which occur on the inferior surface of cerebrum. Each olfactory lobe consists of an anterior olfactory bulb and a posterior narrow olfactory stalk. Olfactory lobes relay sense of smell received from olfactory epithelium to the temporal part of the cerebrum.

2. Cerebrum. It is the largest part of the brain which forms nearly 80% of the same. Cerebrum occupies the front, lateral and superior parts of the brain. It has

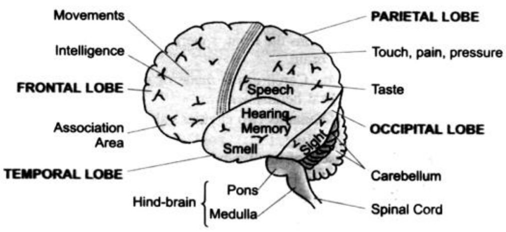


Human brain.

two closely placed cerebral hemispheres separated by a longitudinal cerebral fissure. The cerebral hemispheres are attached inferiorly by a thick nerve band called corpus callosum. Superior surface is convex while the inferior surface is concave. Internally, each cerebral hemisphere has a fluid filled cavity called lateral ventricle. There is a thick outer layer of grey matter called cerebral cortex. Inner to it is cerebral medulla of white matter. Grey matter is made of cell bodies while white matter is formed of myelinated nerve fibres. Cerebral cortex is thrown up into folds. The elevations are called gyri while the depressions are known as sulci. Cerebrum is main thinking part of brain. It has sensory, motor and association areas. In association areas the different types of sensory information's are integrated and interpreted on the basis of all inputs and information already stored in the brain. Right cerebral hemisphere controls the functioning of left parts of the body while the left cerebral hemisphere controls the right parts of the body. Each cerebral hemisphere is divided into four parts— frontal, parietal, temporal and occipital.

Frontal Lobes. They occur in front or anterior region. Frontal lobes are centres of intelligence. They control various types of movements (both voluntary and involuntary) including facial muscles. An association area provides association between sensations and movements.

Parietal Lobes. They are situated in the mid upper area. Parietal lobes have centres for taste, cutaneous senses (sensations of pain, touch, pressure, and temperature) and some components of speech.



Lateral view of brain showing functional areas of cerebrum.

Temporal Lobes. They lie on the lateral sides. Temporal lobes control hearing, smell and some components of speech.

Occipital Lobes. They occur in the hinder part. Occipital lobes have centres of perception of sight.
Area present at the junction of temporal, parietal and occipital lobes is the centre of intelligence (Wernicke's area). Memory, reasoning and emotions are also located in many places.

3. Diencephalon. It lies on the inferior side of the cerebrum. It has epithalamus on its roof, thalami on the sides and hypothalamus on floor. A narrow cavity called third ventricle occurs in diencephalon. Epithalamus bears pineal body and anterior choroids plexus (for filtering out cerebrospinal fluid from blood). Thalami (singular thalamus) relay sensory impulses (except that of smell) from medulla and other parts to cerebrum. They also regulate activity of smooth muscles. Hypothalamus has control centres for hunger, thirst, fatigue, sleep, sweating, body temperature and emotions. It also secretes a number of hormones. Ten of them control the functioning of anterior pituitary while two hormones pass into posterior pituitary to function as its hormones. Hypophysis or pituitary gland lies on the inferior side of hypothalamus.

4. Mid Brain. It is small area having two thick fibrous tracts and four swellings. Fibrous tracts are called cerebral peduncles or crura cerebri. They connect hind brain with fore brain. The four swellings are known as corpora quadrigemina or colliculi. They are connected with reflex movements of head, neck and trunk in response to light, sight and sound stimuli. The two superior colliculi or corpora quadrigemina have centres for sight reflexes while the two inferior corpora quadrigemina have centres of auditory reflexes.

5. Cerebellum. It is second largest part of the brain, constituting about 12.5% of the total. Cerebellum lies behind cerebrum and above medulla oblongata. It has two large furrowed lateral cerebella hemispheres and a central worm like vermis. Cerebellum coordinates muscular activity of the body. It also maintains equilibrium or posture of the body as during walking, jumping, lifting, catching, bending, etc.

Differences between Cerebrum and Cerebellum

Cerebrum	**Cerebellum**
1. Part. It is a part of fore brain.	It is part of hind brain.
2. Size. Cerebrum constitutes 80% of brain.	It constitutes 12-5% of brain.
3. Position. It forms the front, superior and lateral sides of the brain.	It lies in the posterior region of brain.
4. Components. Cerebrum is made of two parts called cerebral hemispheres.	Cerebellum has three parts, two lateral cerebellar hemispheres and one central vermis.
5. Cavities. It contains two cavities called lateral ventricles.	A cavity is nearly absent.

6. Scat. It is seat of intelligence and memory.	It coordinates muscular activity.
7. Control. Cerebrum controls intelligence, movements, speech, sight, smell, taste, hearing and other sensations.	Cerebellum maintains equilibrium of the body.

6. Pons (Pons Varolii). It is a cross-wise bundle of nervous nervous tissue that lies on the antero-ventral side of medulla oblongata. It connects the cerebellum, medulla oblongata and cerebrum. Pons functions as relay centre among different parts of brain. It also possesses pneumotaxic area of respiratory centre.
7. Medulla Oblongata. It is the hindermost part of the brain which lies below cerebellum. It continues behind into spinal cord. Medulla oblongata has a fluid filled cavity called fourth ventricle. Its roof bears posterior choroid plexus (for filtering cerebrospinal fluid from blood) and three pores for connecting external cerebrospinal fluid with internal cerebrospinal fluid. Medulla oblongata contains (i) Respiratory centre for regulating rate of breathing, (ii) Cardiac centre for regulating rate of heart beat. (iii) Regulation of blood pressure, (iv) Reflex centre for swallowing, vomiting, coughing, sneezing, salivation, peristalsis, etc.
Pons, medulla oblongata and mid brain are collectively called brain stem.

FUNCTIONS OF BRAIN

1. Sensory Information. Brain receives information from all the sensory receptors and sense organs of the body.
2. Processing. It processes the information obtained from various sources and chooses the most appropriate response.
3. Response. Brain sends instructions to effector organs all over the body to provide the appropriate response to received stimuli.
4. Control. It has controls for regulating the functioning of various body organs.
5. Coordination. Working of the different organs of a system is coordinated by brain.
6. Reflexes. It has centres for reflexes related to sound, sight and involuntary functioning of many body parts.
7. Faculties. It is the seat of intelligence, memory, reasoning, learning and emotions.

SPINAL CORD

It is a narrow cylindrical lower part of central nervous system which is 43-45 cm in length. It lies inside vertebral column that extends from base of brain upto early part of lumbar region. It is, however, connected to the end of vertebral column by fibrous connective called filum terminale. Spinal cord gives off a pair of spinal nerves from intervertebral spaces. Spinal never parallel to spinal cord for some distance before coming out from their respective intervertebral spaces. A number of spinal nerves run inside the vertebral column in the area of filum
terminale to form a grouping called cauda equina. Internally, the spinal cord possesses a narrow fluid filled central canal, ascending and descending nerve tracts and interneurons. Ascending tracts carry sensory impulses to brain while descending tracts pass motor impulses from brain.
Functions. (i) Spinal cord is centre of many reflex activities, (ii) It conducts sensory and motor impulses to and from brain.

VOLUNTARY PERIPHERAL NERVOUS SYSTEM

It consists of nerves that directly arise from central nervous system connecting different parts of the body for voluntary or conscious control of the brain. The peripheral nerves coming from brain are called cranial nerves. There are twelve pairs of cranial nerves. The peripheral nerves coming out of spinal cord are known as spinal nerves. There are 31 pairs of spinal nerves. Each spinal nerve has two roots, sensory feral root and motor ventral root. Dorsal root bears a ganglion called dorsal ganglion.

Differences Between Cranial And Spinal Nerves

Cranial Nerves	**Spinal Nerves**
1. Origin. They develop from brain.	They arise from spinal cord.
2. Number. The number of cranial nerves is 12 pairs.	The number of spinal nerves is 31 pairs.

3. Nature. They can be sensory, motor or mixed.	All spinal nerves are mixed in nature.
4. Root. A cranial nerve develops from a single root.	It develops from two roots.
5. Ganglion. It is not associated with all cranial nerves.	A ganglion occurs in the dorsal root of each spinal nerve.

INVOLUNTARY PERIPHERAL OR AUTONOMIC NERVOUS SYSTEM

It is a special system of ganglia and peripheral motor nerve fibres which innervates various organs and glands of the body for stimulating, slowing down and stopping their functions, without consulting the will. Autonomic nervous system develops from branches of some cranial and spinal nerves called visceral nerves. Autonomic nervous system has two opposing divisions, sympathetic and parasympathetic.

Sympathetic Nervous System. It is formed from branches of 12 thoracic and first three lumbar spinal nerves. The system forms 2 long chains of ganglia, a few isolated ganglia and long post-ganglionic fibres that innervate different organs, muscles and glands of the body. The sympathetic fibres secrete nor adrenaline into them for activation. Sympathetic system is also specialised to prepare the body for any emergency, like hormone adrenaline. It causes constriction of peripheral blood vessels, increased blood supply to heart, increased heart beat, higher breathing rate, dilation of pupil, etc.

Parasympathetic Nervous System. It is formed from branches of VI, VII, IX and X cranial nerves and sacral spinal nerves II, III and IV. The ganglia are located over the organs from where short postganglionic fibres develop to innervate the organs. The organs are influenced by secretion of neurotransmitter acetylcholine. Parasympathetic nervous system moderates or reduces heart beat, reduces blood pressure, dilates peripheral blood vessels, constricts pupil, stimulates excretion and Peristalsis.

Effect of Sympathetic and Parasympathetic Nervous System on Various Organs

Organ	**Sympathetic Nervous System**	**Parasympathetic Nervous System**
1. Pupil	Dilates	Constricts
2. Heart	Accelerates	Slows down
3. Gall Bladder	Relaxes	Contracts
4. Gastrointestinal Tract	Slows down movements	Speeds up movements
5. Blood Pressure	Increases	Decreases
6. Salivary Glands	Inhibited	Stimulated
7. Gastrointestinal Glands	Inhibited	Stimulated
8. Urinary Bladder	Relaxes	Constricts
9. Bronchi	Dilates	Constricts
10. Sweat Glands	Increased Secretion	Lesser secretion
11. Hair	Erect	Oblique.

HOW ARE NERVOUS ORGANS PROTECTED ?

Both brain and spinal cord are protected from mechanical injury and shock by bony cases around them. Brain is covered over by cranium or brain box of skull. Spinal cord is similarly covered by vertebral column. Additional protective coverings called meninges (singular meninx) occur between brain or spinal cord and the surrounding skeleton. They are three in number— duramater, arachnoid and piamater. (i) Duramater. It is thick Fibrous membrane which lies in contact with internal surface of bony case. (ii) Arachnoid. It is middle thin webby porous meninx. The space between it and diameter is fluid filled. It is known as subdural spare. (iii) Piamater. It is vascularised, pigmented and moderately thick meninx that lies over the brain and spinal cord. The space between it and arachnoid is called sub-arachnoid space. The same is filled with cerebrospinal fluid.

(i) Layers of fluid around brain and spinal cord protect them from shock, (ii) Duramater prevents slipping of brain and spinal cord from bony covering.

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 in the region of choroid plexus. It also passes back into blood. The fluid is rich in nutrients, minerals, hormones, urea and respiratory gases, (i) It supplies food and oxygen to different parts of the brain and spinal cord. (ii) It picks up carbon dioxide, urea and other waste products from CNS. (iii) It carries hormones to and from brain, (iv) It keeps CNS moist and protects it from shocks, (iv) By its buoyancy, it reduces the weight of brain.

HOW DOES NERVOUS TISSUE CAUSE ACTION ?

Nervous system generally operates through muscles. Axon terminal in contact with muscle fibre is broadened to function as motor end plate. The plasma lemma of the muscle fibre is folded and depressed in the region of neuromuscular junction (Fig. 2.2.). A narrow fluid filled gap occurs between the plasma lemma of muscle fibre and motor end plate of axon terminal. Whenever, an impulse reaches the motor end plate, it induces the release of neurotransmitter (acetylcholine or noradrenalin) into cleft area. The neurotransmitter sensitises the chemoreceptor sites of muscle fibre membrane. Sodium channels of the latter open. The positive potential developed due to the entry of sodium, esults in release of calcium ions from endoplasmic (or sarcoplasmic) reticulum of muscle fibre. Calcium ions open active sites of actin filaments and sensitise the lateral knobs of myosin filaments. Actin filaments slide past the myosin filaments producing new cross bridges and shortening the size of muscle fibre. The arrangement of actin and myosin filaments is different in striated and unstriated muscle fibres. This results in their differential contraction.

COORDINATION IN PLANTS

Plants do not have nerves and muscles. Even then they show movements which are well coordinated and controlled. Plants process only chemical coordination. Movements or change in position are of two types, movements of locomotion and movements of curvature. Curvature movements are changes in orientation of plants parts in relation to other like bending, twisting and elongation. Movements of curvature are more common plants because they are fixed. Movements curvature locomotion are changes in position of whole organism or cellular component. The agent or factor which causes movements is called stimulus. The region of plant which detects the stimulus is called perceptive region. The reaction of plants to stimulus is called response. The part of the plant which shown the response is called responsive region. Clearly there is conduction of stimulus from perceptive region to responsive region it seems to be electrochemical in nature.
It the response is favorable or towards the stimulus, it is called positive, e.g., positive phototpism. When the response is unfavorable or away form the stimulus, it is called negative, e.g., negative thermo taxis, negative geotropism.

MOVEMENTS OF LOCOMOTION

They are of two types, autonomic and paratonic.
1. Autonomic or Spontaneous Movements of Locomotion. They occur automatically due to intrinsic reasons, e.g., flagellar movements in unicellular algae like Chlamydomnas, cyclosis or streaming movement of cytoplasm.
2. Paratonic or Tactic Movements of Locomotion. They are locomotory movements of complete cells or cell organelles in response to external stimuli. (i) Chemo taxis. It is locomotory movement in response to chemicals, e.g., spermatozoids towards archegonia, (ii) Photo axis. Locomotory movement in response to light, e.g., chloroplasts in different intensities of light inside palisade cells.

MOVEMENTS OF CURVATURE

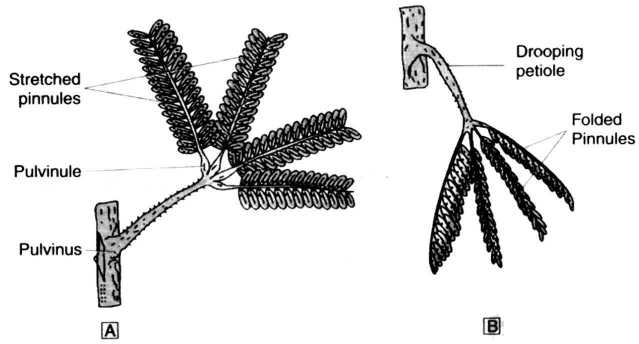
They are movements of plant parts in relation to others. Curvature movements are of two types, turgor movements and growth movements.

PLANT MOVEMENTS DUE TO TURGOR CHANGES

They occur in plant organs which have regions of bending where cells shrink or swell up due to loss or gain of turgidity. The movements are commonly reversible. Autonomic turgor movements occur in Telegraph Plant (Desmodium gyrans) where two lateral leaflets show jerky rising and falling because of rhythmic changes in cells present at the base of leaflet stalks. Sleep movements or nyctinasty occurs in response to turgor changes in the leaves of legumes and Oxalis. Here the leaves fold up at night and open up during the day. In many grasses leaves fold up in response to drought while they open up when sufficient water is available. The movement is called hydro nasty. The quickest response to a stimulus by any plant is shown by Sensitive Plant.

IMMEDIATE RESPONSE TO STIMULUS

A very quick response to stimulus is observed in the leaves of Sensitive Plant (Mimosa pudica, also called Touch-me-Not, Chhui-Mui). The stimulus is touch, injury, electric current and other shocks. Within $0 \cdot 1$ sec the response starts. It consists of upward folding of pinnules, coming together of pinnae and drooping down of petiole. The movement is called haptonasty (in response to touch) or seismonasty (in response to shock). The stimulus of touch or shock received by any part of the leaf is converted into either an electrochemical potential or a chemical called turgorin. The same travels at the rate of 20 cm/sec and reaches bases of pinnules, pinnae and petiole. Here large thin walled cells occur, on the upper side of pinnule bases and lower aides of pinna and petiole bases. As the impulse/chemical reaches here, the thin walled cells eject K^+ ions and then water. They shrink in size resulting in folding and drooping movements. The leaf recovers after 10 minutes.



PLANT MOVEMENTS DUE TO GROWTH

Unequal or differential growth in different parts of an organ results in its bending and other types of movements. They are both autonomic and paratonic.

(a) Autonomic Movements of Growth. They are shown by apical regions of stems and tendrils. The movements are called nutations (or circumnutations). While growing the apices of these organs bend in different directions resulting in their rotation. It helps the climbing stems and tendrils to find support for climbing or clinging.

(b) Paratonic Movements of Growth. They are growth movements in response to an external stimulus. Paratonic movements of growth are of two types, nastic and tropic.

NASTIC MOVEMENTS OF GROWTH

They are nondirectional movements of growth that are determined by the structure of the responding organ irrespective of the direction of stimulus which is generally diffuse. The responding organ is generally dorsiventral or asymmetric. Greater growth on one side causes the organ to bend to the opposite side. If greater growth occurs on the lower side, the phenomenon is called hyponasty. The flat organ bends upwards. If growth occurs more on the upper side, the flat organ will bend downwards. It is called epinasty. Flowers open at maturity due to epinasty. Calendula flowers show growth induced daily opening and closing of flowers. It can be called as growth photo nasty. Growth thermo nasty occurs in the flowers of Crocus and Tulipa.

TROPIC MOVEMENTS OF GROWTH

They are paratonic growth movements of curvature in which the direction of movement is determined by the direction of stimulus. Tropic movements generally occur in cylindrical organs like stems and roots. The important tropic movements are phototropism, geotropism, hydrotropism, thigmotropism and chemotropism.

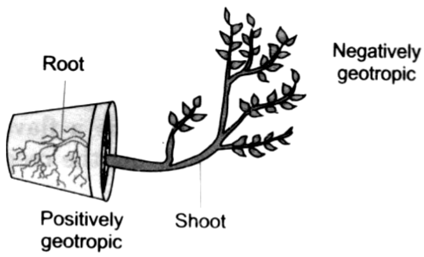
Differences between Nastic and Tropic Movements

Nastic Movements	**Tropic Movements**
1. Nature. They can be autonomic or paratonic, turgor or growth movements.	They are always paratonic growth movements.
2. Organs. The organs are Hat or asymmetric.	They are generally cylindrical.
3. Direction. Movements are nondirectional.	The direction of movement is related to direction of stimulus.
4. Stimulus. It is generally diffused.	It is generally unilateral.

Differences between Growth Movements and Turgor Movements

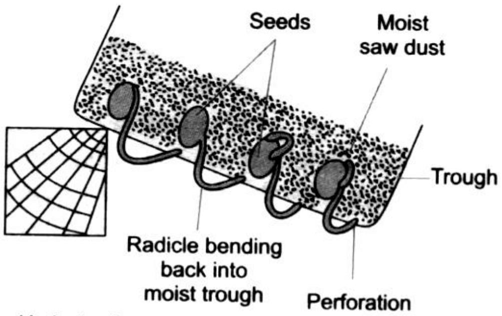
Growth Movements	**Movements of Variation/Turgor Movements (Nongrowth Movements)**
1. Nature. There is differential or asymmetric growth that results in movements.	There are turgor changes that produce movements.
2. Size. The size of the organs increases.	There is no change in size.
3. Reversibility. The movements are permanent or irreversible.	The movements are temporary or reversible.
4. Turgor Cells. They are absent.	They are present. Changes in their turgor bring about movements.
5. Cause. The movements are often caused by unequal distribution ot growth hormones.	The movements are caused by influx or efflux of K^+ ions along with passage of water.

Phototropism. It is directional growth movement of curvature which occurs in response to unidirectional exposure to light. The region of photoperception is shoot apex while the region of response is in the area of elongation. The light effective in phototropic response is blue light. The photoreceptor is a flavoprotein called phototropin. Leaves are essential for producing the response.
Stems generally bend towards the direction of light. They are positively phototropic. Leaves generally come to lie at right angles to light. They are diaphototropic. Roots are either neutral (nonphototropic) or negatively phototropic. Positively phototropic heads of Sunflower perform solar tracking as they move from east to west along the direction of sun.
Phototropic movement is generally caused by increased auxin on the dark side and lesser auxin on the illuminated side. It causes more growth on the dark side in stem causing it to bend towards the source of light. The opposite happens in root where less auxin stimulates growth while higher auxin inhibits growth.
2. Geotropism. It is directional growth movement of curvature which occurs in response to force of gravity. The region of graviperception is root cap in root, nodes and apex in shoots. The region of response or curvature is the zone of elongation in case of stem and root. For nodes the curvature producing region lies nearby.
Main root is positively geotropic while main stems or shoots are negatively geotropic. Negative geotropism is also seen in pneumatophores of mangrove plants. Runners are diageotropic. Root and stem branches lie at an angle and are called plagiogeotropic.
Tilt a well watered potted plant horizontally. Keep watering the plant on alternate days. Observe after a week that the apical part of the shoot has bent upwardly due to its negative geotropic nature. The apical part of the root has similarly bent downwardly due to its positive geotropic nature. Negative geotropic response of shoots is useful in standing up of lodged crop plants. Similarly, seedlings coming out of the seeds placed in different directions in the soil will pass their shoots upwardly out of soil (due to negative geotropic and positive phototropic response) while their roots will bend downwardly (due to positive geotropic response).



A potted plant showing geotropic response.

3. Hydrotropism. It is directional growth movement of curvature which occurs in response to unilateral stimulus. Hydrotropism in generally shown only by roots. Roots are positively hydrotropic. Positive hydrotropic response of roots is stronger than their geotropic response. This can be tested by placing germinating seeds in moist saw dust contained in a sieve. The radicles will pass down and come out of the sieve pores under the influence of gravity. However, after some growth, they bend back and enter the saw dust again showing that hydrotropic response is stronger than geotropic response.

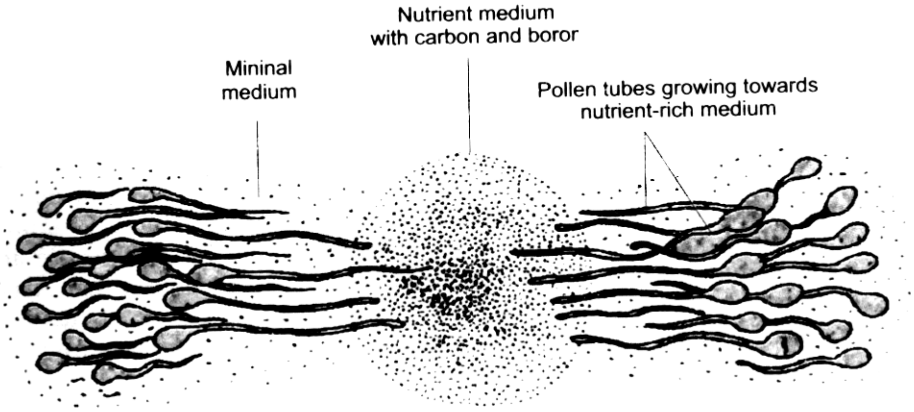


Hydrotropic response is stronger than geotropic response.

4. Thigmotropism (Haptotropism). It is directional growth movement of curvature which occurs in response to stimulus of contact. Thigmotropism is found in twiners and tendrils. After initial contact with support due to notation, the tendril or twiner shows less growth in the region of contact and more growth on the other side. As a result they bend over the support. Later on bending or coiling may occur in lower parts of the tendril as well.

Thigmotropism in tendril.

5. Chemotropism. Chemotropism is directional growth movement of curvature that occurs in response to a chemical stimulus. It is best seen in the growth of pollen tube inside style, ovary and ovule. Here every region produces its own nutrients and chemotactic chemicals for growth and passage of pollen tube. Chemotropism can be observed by germinating a number of pollen grains in a minimal medium. A drop of nutrient medium containing boron will result in bending of pollen tubes towards it from all directions.



Chemotropism in pollen tubes.

PLANT HORMONES—THE CHEMICAL COORDINATORS

Plant hormones or phytohonnones are chemical substances other than nutrients produced naturally in plants which regulate growth, development, differentiation and a number of physiological processes with or without translocation to other sites. They are commonly called plant growth regulators (PGRs) since most of them either stimulate or retard growth. Five major types of plant hormones are auxins, gibberellins, cytokinins, abscisic acid and ethylene. Three of them are growth promoters, viz. auxin, gibberellins and cytokinins. Abscisic acid is plant growth inhibitor. Ethylene is gaseous hormone which has dual function of inhibition and promotion of growth.

AUXINS

They are weakly acidic plant hormones which are capable of promoting cell elongation, especially of shoot segments at a concentration of less than 100 ppm that is inhibitory to roots. The most common natural auxin is indole 3-acetic acid or 1AA. It i? synthesized from amino acid tryptophan inside shoot apices, young developing leaves and seeds. 2 : 4-D, 2:4: 5-T and NAA are synthetic auxins. IBA (Indole butyric acid) is both natural and synthetic auxin. Major functions of auxins are as follows :

1. Cell Enlargement. They bring about growth of cells. In shoots auxin is effective above a concentration of 10 ppm while in roots the required concentration is 0-0001 ppm.

2. Root Formation. They are essential for root formation on stem cuttings. NAA and IBA are used in horticulture for inducing root formation on cuttings.
3. Respiration. Auxins stimulate respiration and provide energy for various active processes.
4. Movements. Several plant movements are mediated by differential distribution of auxin, e.g., geotropism, phototropism.
5. Apical Dominance. Apical bud does not allow sprouting of nearby buds due to high concentration of IAA in it.
6. Inhibition of Abscission. IAA prevents premature falling of leaves and fruits.
7. Fruit Growth. Auxins promote fruit growth.

GIBBERELLINS

They are weakly acidic tetra cyclic plant hormones which produce cell elongation of leaves and intact stems in general and increased internoodal length of genetically dwarf plants in particular. The hormones are named after fungus, Gibberella fujikuroi, which produces bakanae (foolish seedling) disease in rice. The diseased plants remain sterile and grow exceptionally tall due to excessive release of gibberellins. About 125 gibberellins are known. Gibberellic acid (GA_3) is the most common. Gibberellins are formed in leaves of buds, developing embryos and root tips. The major functions are as follows :
1. Growth. Gibberellins promote growth in stems and leaves. In Sugarcane, they increase yield due to greater growth of stem. Genetically dwarf plants grow to normal height. Bolting occurs in rosette plants as they induce growth of stem.
2. Fruit Yield. Gibberellins increase size and number of fruits.
3. Overcoming Dormancy. They break dormancy of buds and seeds.
4. Malt. There is increased production of malt, if gibberellins are supplied to germinating Barley seeds.
5. Flowering. They can replace requirement of cold and long day conditions for flowering of certain plants.

CYTOKININS

They are mildly alkaline plant hormones which promote cell division. Kinetin is a synthetic cytokinin. The first natural cytokinin was zeatin. Coconut milk and apple fruit extract are rich in cytokinins. Cytokinins are synthesized in root tips from where they reach shoots. Other areas of cytokinin synthesis are endosperm of developing seeds and to a minor extent all places where cell divisions are occurring. Major functions of cytokinins are as follows :
1. Cell Division. Cytokinins are essential for cell division.
2. Differentiation. They are required for differentiation of cells and tissues.
3. Prevention of Senescence. They delay ageing of plant organs including cut flowers, vegetables and fruits.
4. Phloem Transport. They are required for phloem transport.
5. Resistance. Cutokinins increase resistance to disease sand temperature extremes.
6. Apical Dominance. They overcome apical dominance and allow sprouting of lateral buds.

ETHYLENE (ETHENE)

It is a gaseous hormone which promotes transverse growth but inhibits longitudual growth and several functions. Ethylene is formed by all parts but maximum synthesis occur during ripening of some fruits called climacteric fruits, e.g, Apple, Banana, Major functions are as follows :
1. Growth. Ethylene promotes transverse growth but inhibits longtudnal growth.
2. Senescence and Abscission. Ethylene promotes senescence and abscission of leaves and flowers.
3. Dormancy. It breaks dormancy of different plant organs resulting in sprouting of rhizomes, bulbs, corms, etc.
4. Fruit. Ripening. The hormone is essential for ripening of fleshly fruits and dehiscence of dry fruits.

ABSCISIC ACID (ABA)

It is mildly acidic general growth inhibitor of plants that counteracts growth promoting hormones or reactions mediated by them. Abscisic acid is also called stress hormone or dormin as it induces dormancy for overcoming stress conditions. The major functions of abscisic acid are as follows :
1. controlling Growth. Abscisic acid keeps growth under check by counteracting the excessive activity of growth promoting hormones.

2. Transpiration. Is checks excessive transpiration by causing closure of stomata.
3. Dormancy. It induces dormancy of buds and seeds.
4. Senescence and Abscission. It promotes senescence of leaves and causes abscission of flowers and fruits.
5. Flowering. Abscisic acid promotes flowering in some short day plants.

FUNCTIONS OF PLANTS HORMONES

1. Induction of Dormancy. ABA induces dormancy of buds, seeds and storage organs.
2. Breaking of Dormancy. Gibberellins and cytokinins break dormancy of seeds, duds and storage organs.
3. Growth. It is mediated by auxin and gibberellins.
4. Cell Division. Auxins and cytokines control cell division.
5. Stomata. Cytokines bring about opening of stomata while abscisic avid (ABA) causes their closure.
6. Movements. Movements of growth are caused by differential distribution of auxin and other growth hormones.
7. Ripening of Fruits. It is controlled by gaseous hormone, ethylene.
8. Coordination. Plants coordinate their activities and response with the help of hormones.

PHOTOPERIODISM

The effect of daily duration of light hours or photoperiods on growth and development of plants, especially flowering is called photoperiodism. It was discovered by Garner and Allard (1920) in case of Maryland Mammoth variety of Tobacco. Leaves receive the photoperiodic stimulus with the help of receptor protein pigment called phytochrome. On the basis of photoperiodic response to flowering, plans are of three types SDP, LDP and DNP.
1. Short Day Plants or SDPs. They come to flower after they receive photoperiodic stimulus below a critical period, e.g., Xanthium, Aster, Dahlia, Rice, Soya Beam varieties.
2. Long Day Plants or LDPs. These plants come to flower after they receive photoperiodic stimulus above a critical period, e,g, Wheat, Oat, Spinach, Radish, Barley, Henbane.
3. Day Neutral Plants or DNPs (Indeterminate plants). They can flower throughout the year, e.g., tomato, Cucumber, Maize, Cotton, Sunflower.
Knowledge of photoperiodism is useful in growing plants throughout the year under green house conditions.

HORMONES IN ANIMAL

Hormones (Gk. Hormein – to excite) are chemical messengers on informational molecules produced by ductless glands which are translocated by circulatory system to other parts of for inducing a specific physiological response. First hormone secretion was discovered by Bayliss and Starling (1902). The term hormone was coined by Starling (1905).

CHARACTERISTIC

1. Glands. Hormones are produced by endocrine or ductless glands.
2. Secretion. They are poured into circulatory system for passage to different body parts.
3. Target Sites. Hormones act on specific cells, tissues and organs called target sites, generally away from the place of their synthesis.
4. Function. They function as chemical messengers or informational molecules that trigger specific chemical and physiological processes of target cells.
5. Slow Action. Since hormones reach the target sites through blood, their effect appears after a lag period. They are slow acting with the exception of adrenaline.
6. Chemical Nature. Hormones are small sized organic molecules which are of diverse origin— proteins, peptides, amino acids, amines and steroids.
7. Non-nutrient Nature. Hormones are nonnutrient in nature. They have no role in providing energy or body building materials. Hormones take part in stimulation or inhibition of physiological processes.
8. Concentration. The hormones are effective in very low concentration, e.g., adrenaline one in 300 million parts.
9. Effect. It is very specific. TSH acts only on thyroid while thyroxine affects all body parts.
10. Stimulus. Hormones are generally produced in response to specific stimuli.
11. Consumption. Hormones are ultimately broken down or consumed during their activity in target cells.

12. Deficiency or Excess. Both deficiency and excess of hormone are harmful, often leading to serious disorders.

GLANDS

A cell, tissue or organ that produces a secretion for performing a particular function is called gland. Glands are of four types— exocrine glands, endocrine glands, heterocrine glands and mixed organs.

1. Exocrine Glands (Gk. exn—outside, krinein—to secrete). They are glands which drain out their secretions through ducts. The secretion performs a metabolic activity, e.g., gastric glands, milk glands, sweat glands.

2. Endocrine Glands (Ductless Glands, Gk. endon—within, krinein— to secrete). They are isolated glands which do not have ducts for draining out secretion but instead pour the same into circulatory system for reaching target sites, e.g., thyroid, pituitary.

Differences between Endocrine and Exocrine Glands

Endocrine Glands	Exocrine Glands
1. Ducts. The glands are devoid of ducts.	The glands possess ducts.
2. Isolation. They usually occur in isolation.	They do not occur in isolation.
3. Drainage. The glands pour the secretion into system.	The glands pour their secretion over the target either directly or through ducts.
4. Site. The target site is far away from its endocrine gland.	The target site is adjacent to the gland.
5. Secretion. Secretion consists of hormones or informational molecules.	The secretions are various— enzymes, mucus, excretory substances, lubricants.

3. Heterocrine Glands (Mixed Glands, Gk. heteros—different, krinein—to secrete). They have both endocrine and exocrine regions. The endocrine part pours its secretion into circulatory system while exocrine part drains out its secretion through ducts, e.g., pancreas.

4. Mixed Organs. They are organs of metabolic or cytogenic (cell forming) importance which also possess endocrine activity, e.g., testes, ovaries.

ENDOCRINE SYSTEM

It is a system of isolated ductless glands that pour their secretion directly into circulatory system for passage to different targets in order to control their metabolism, permeability, growth, differentiation and activity. Endocrine system is also called hormonal system. Branch of science that is connected with the study of endocrine glands, hormones and their effects is known as endocrinology. Endocrine system often operates in coordination with nervous system. In many cases nervous system stimulates components of endocrine system. In other cases stimulation is provided by a specific metabolite or another hormone. Nervous system is very fast. It is connected to receptors as well as effectors. However, the effect cannot reach every cell of the body. Endocrine system is slower but influences all the cells of the target. A multiple effect can also be produced. Adrenaline reduces blood supply to skin and digestive system but increases the same to skeletal or voluntary muscles. There is increase in breathing rate and heart beat. The body becomes ready to deal with an emergency. Further, endocrine system controls and coordinates many processes of the body where nervous system has no role, e.g., cell permeability, cell division, cell growth, cell differentiation, development of sex organs, secondary sex characters and several other activities. Any discrepancy can lead to a disorder, e.g., dwarfism and gigantism, hypothyroidism (simple goitre, cretinism, myxedema), hyperthyroidism (exophthalmia).

Differences between Endocrine and Nervous Systems

Endocrine System	Nervous Systems
1. Passage of Information. It is through chemicals like hormones.	It is through electrochemical conduction.
2. Sensory Receptors. Absent.	Present.
3. Rapidity. The system is comparatively slower.	The system is rapid.
4. Connection. The system is not connected to target sites directly.	The system is directly connected to every under its control.

5. Response. The response is slow. of longer duration and produced by all the cells of target tissues.	The response is quick, of short duration and limited to those cells that are innervated.
6. Growth and Development. The system controls growth and development.	It has no role in growth and development.

COMPONENTS OF HUMAN ENDOCRINE SYSTEM

The major components of human endocrine system are hypothalamus, pituitary gland, pineal gland, thyroid, parathyroids, thymus, adrenals, gonads, pancreas, kidneys, heart and gastrointestinal tract.

1. Hypothalamus. It lies at the floor of diencephalon. Hypothalamus produces neurohormones (formed by secretory neurons) which are passed on to pituitary gland for controlling its activity. They are of two types, releasing hormones (RH) and inhibitory hormones (IH), viz. TSH-RH. ACTH-RH, FSH-RH, LH-RH, P-RH, P-IH, GH-RH (STH-RH), GH- IH (=somatostatin), MSH-RH, MSH-IH. Two hormones, elaborated by hypothalamus are directly passed to neurohypaphysis for secretion. They are oxytocin and vasopressin.

2. Pituitary Gland (Hypophysis). It is a small pea-shaped gland that is attached to the inferior surface of hypothalamus by a stalk. It has three parts— anterior, middle (= intermediate) and posterior. Posterior lobe of pituitary is also called neurohypophysis while anterior and middle pituitary lobes are collectively called adenohypophysis. Pituitary gland is known as master endocrine gland because a number of its secretions control the functioning of other endocrine glands.

ANTERIOR PITUITARY

(i) Growth Hormone or Somatotrophic Hormone (GH or STH). The hormone stimulates body growth by increased anabolic activity, retention of calcium, synthesis of more proteins, enlargement of long bones, muscles and visceral organs. Increased secretion produces gigantism (height above $2{\cdot}15$ m) while deficient secretion produces dwarfism (height $1{\cdot}0-1{\cdot}3$m). Excessive secretion of hormone in an adult causes acromegaly increase in size of bones of hands, feet and face),

(ii) Prolactin (Maternity Hormone). It stimulates growth of mammary glands during pregnancy and lactation afterwards.

(iii) Thyroid Stimulating Hormone (TSH). It stimulates thyroid to produce and release its hormones.

(iv) Adrenocorticotropic Hormone (ACTH). It activates adrenal cortex to produce its hormones.

(v) Follicle Stimulating Hormone (FSH). It stimulates sperm formation in males, growth of ovarian follicles and secretion of estrogen from them in females.

(vi) Luteinising Hormone (LH). In females the hormone stimulates ovulation and secretion of progesterone from corpus luteum. In males the hormone is also called interstitial cell stimulating hormone (ICSH). It induces Leydig cells of testes to secrete testosterone.

FSH and LH hormones are collectively called gonadotrophins or gonadotrophic hormones.

Middle Lobe of Pituitary

Melanocyte Stimulating Hormone (MSH). The hormone causes dispersal of melanin or pigment granules in chromatophores causing darkening of skin.

POSTERIOR LOBE OF PITUITARY

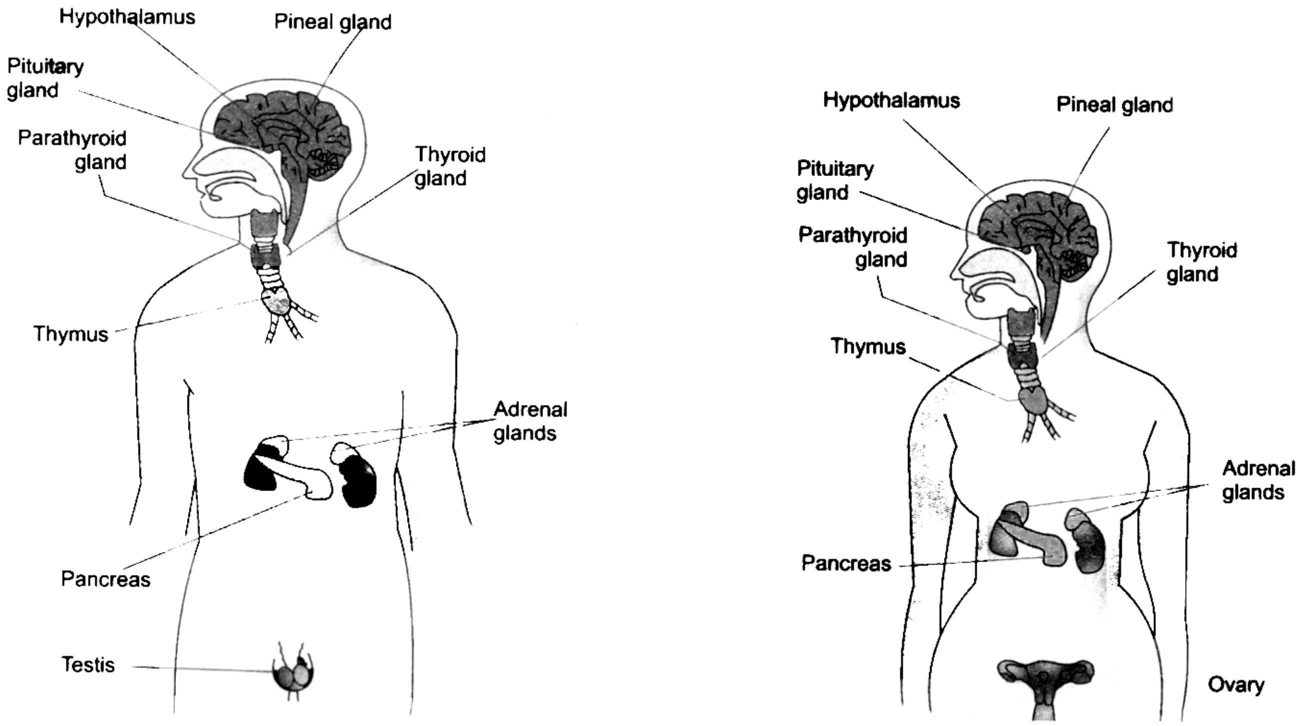
It produces two hormones which are actually neurosecretion products of hypothalamus.

(i) Oxytocin. The hormone stimulates uterine contractions during child birth and milk ejection during suckling of infant. Oxytocin is also called birth hormone and milk ejection hormone. Milk secretion is under control of prolactin.

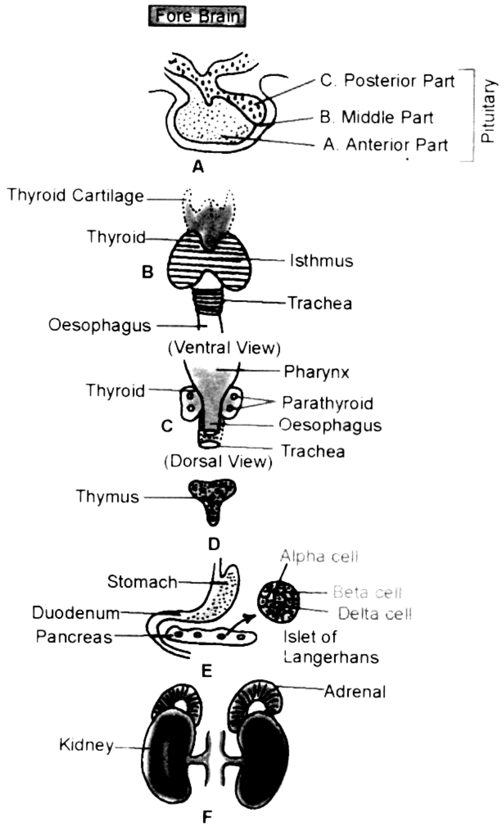
(ii) Vasopressin or Antidiuretic Hormone (ADH). It is essential for reabsorption of water from distal convoluted tubules, collecting tubules and collecting ducts for producing concentrated urine. Deficiency of hormone causes disorder known as diabetes insipidus. It produces a lot of dilute urine at short intervals resulting in excessive thirst and dehydration.

At high concentration the hormone raises blood pressure by causing constriction of arterioles.

3. Pineal Gland. It is small stalked body present over the epithalamus. The gland secretes hormone melatonin which controls mood, sleep and regulates sexual cycle. It also possesses antigonadotrophic characteristics.



Endocrine glands. A, Human male. B, Human female.



Some endocrine glands of human body.

4. Thyroid. It is the largest endocrine gland which is attached to trachea below larynx. It is bilobed or H-shaped.

The gland produces an iodine containing hormone called thyroxine. Thyroxine controls basal metabolic rate or BMR (at rest). It determines the consumption of energy, tendency of the body to gain weight, physical activity, body temperature, heart beat, etc. The hormone controls tissue differentiation, physical development, mental development, muscular activity, nervous activity and sexual development.

Deficiency of dietary iodine causes enlargement of thyroid which results in swelling of neck. The disorder is called simple or iodine deficiency goitre. It is quite common in northern hilly areas. Deficiency of thyroxine in children leads to physical and mental under-development called cretinism. In adults it causes nayxedema or pufTiness. Over secretion of thyroxine leads to protrusion of eyes or exophthalmia (Grave's disease), high metabolic rate and leaniness. Common salt is compulsorily iodised (with potassium iodide) in India to provide required iodine to thyroid.

5. Parathyroids. They are two pairs of small oval yellow glands which lie close to back of thyroid, two over each lobe. The glands secrete parathonnone (Collip's hormone). The hormone maintains optimum level of blood calcium and phosphorus by reducing their excretion and mobilization from bones when required. It is essential for proper functioning of nerves and muscles. Deficiency causes twitching, spasms and cramps. Excess causes softening of bones and deposition of calcium in urinary tract.

6. Thymus. It is a soft, pinkish bilobed gland which lies near the heart. Its size is maximum during puberty but begins to shrink thereafter, becoming microscopic in old age. The gland brings about maturation of T-lymphocytes. It secretes hormone thymosin required for formation of lymphocytes, resistance to infection and allergy.

7. Adrenal Glands (Suprarenal Glands). They are a pair of yellowish, flat, pyramid-like glands which lie over the upper end of kidneys. Each gland has an outer yellow adrenal cortex and inner reddish brown adrenal medulla. Adrenal cortex secretes three types of hormones called corticoids. The hormones are required for maintaining carbohydrate metabolism (glucocorticoids), mineral or $Na^+ - K^+$ balance (mineralocorticoids) and external sex characters (sex corticoids).

Adrenal medulla produces two hormones, adrenaline and noradrenaline. Adrenaline is also called emergency hormone or triple-F hormone (fight, fright and flight). It is produced in response to cold, joy, anger, fear and emotional stress. The hormone increases blood supply to heart and skeletal muscles. It constricts arterioles and blood supply to skin and gastrointestinal tract. The bronchioles dilate. There is increased rate of breathing, oxygenation and heart beat to meet any emergency.

8. Gonads. They are testes in males and ovaries in females.

(a) Testes. Under the influence of LH or ICSH the interstitial or Leydig cells of testes produce the male sex hormone called testosterone. Testosterone stimulates the development of external genitalia in foetus, growth of external genitalia and development of beard, moustache and low pitch voice at puberty, growth of bones and muscles.

(b) Ovaries. They produce mature ova under the influence of FSH. Maturing ova produce female sex hormone called estrogen. Estrogen is essential for development of secondary sex organs and external female sex characters like breasts, rounded contours, high pitch voice at puberty. The empty follicle after release of an ovum becomes corpus luteum which secretes female hormone progesterone. Progesterone is also produced by placenta during pregnancy. It helps in thickening of uterine wall, attachment of embryo to uterine wall, nonformation of new ova and maintenance of pregnancy.

Differences between Estrogen and Progesterone

Estrogen	Progesterone
1. Origin. It is produced by maturing ova.	It is formed by corpus luteum.
2. Function. It initiates and maintains sexual maturity.	It brings about growth and maintenance of uterine lining.
3. Pregnancy. It has no role in pregnancy.	Progesterone is essential for maintaining pregnancy.
4. Changes. Estrogen brings about changes in body contour, growth of breasts and pelvis.	The hormone helps in attachment of embryo to uterine wall, formation and maintenance of placenta, and growth of mammary glands.

9. Pancreas. It is heterocrine gland with exocrine part producing pancreatic juice. The endocrine part is represented by islets of

Langerhans. They produce a number of hormones. Two important pancreatic hormones are insulin and glucagons.

(i) Insulin. The hormone is produced by (3-cells of islet of Langerhans. Cells, tissues and organs recognise and absorb glucose only in the presence of insulin. In liver and muscles, insulin helps in conversion of absorbed glucose into glycogen. In deficiency of insulin, the cells fail to recognise and absorb glucose. As a result blood level of glucose rises with more and more glucose coming from digestive tract. Extra glucose is excreted through urine. The disorder is called diabetes mellitus or simple diabetes. It is corrected by administration of hypoglycemics and injection of insulin. Unattended diabetes results in wasting of body tissues, reduced healing power, ketone bodies, blurred vision and kidney problems. They may end up with gangrene and coma.

(ii) Glucagon. The hormone is secreted by a-cells of islets of Langerhans. Glucagon is required for mobilisation of glucose from glycogen and other sources.

Differences between Diabetes Mellitus and Diabetes Insipidus

Diabetes Mellitus	Diabetes Insipidus
1. Blood Sugar. Sugar level of blood is high.	Sugar level of blood is normal.
2. Gylcosuria. There is excretion of sugar in	Sugar is not excreted in urine.

urine.	
3. Cause. It is due to deficiency of insulin.	It is caused by deficiency of ADH or antidiuretic hormone.
4. Urine Concentration. Urine has normal concentration.	Urine is dilute.

10. Gastrointestinal Tract. A number of hormones regulate functioning of digestive tract, e.g., gastrin (activity of stomach), secretin (stoppage of activity of stomach), cholecystokinin (contraction of gall bladder, secretion of pancreatic juice), enterocrinin (secretion of intestinal juice).

11. Kidneys. They produce two hormones, erythropoietin (stimulates bone narrow to produce more RBCs) and renin. Renin acts on protein angiotensinogen to form angiotensin. Angiotensin raises blood pressure to increase ultra filtration.

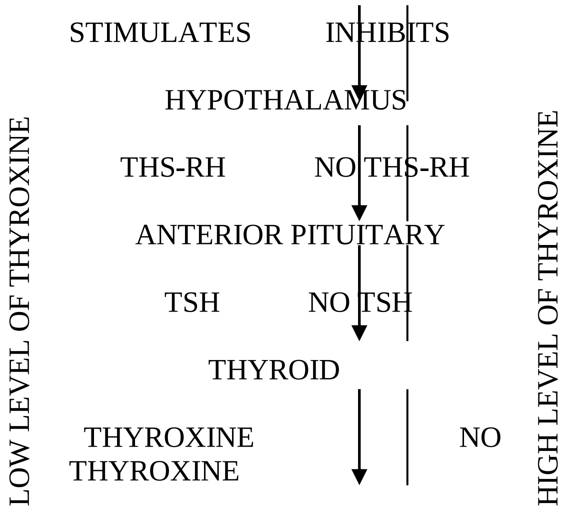
12. Heart. Atrial tissue of heart produces atrial natriuretic factor (ANF) to lower blood pressure.

HOMOEOSTASIS AND HORMONAL FEED BACK SYSTEM

Homoeostasis is maintenance of favorable internal environment. It is largely regulated by hormones. The concentration of hormones must be, therefore, kept at optimum level. This is done through feed back system. Feed back system is a regulatory mechanism in which presence of certain level of substance promotes or inhibits its further formation. Regulation of thyroxine production by its concentration in blood is an example of hormonal feed back system. Concentration of thyroxine in blood is detected by hypothalamus. If it is low, hypothalamus produces TSH-RH. The latter passes into anterior lobe of pituitary through hypophyseal portal vein. THS–RH stimulates pituitary gland to produce TSH or thyroid stimulating hormone. TSH passes into circulatory system and reaches thyroid.

Thyroid begins to secrete more thyroxine. If concentration of thyroxine rises above tits optimum level, hypothalamus stops producing TSH–RH. The unstimulated pituitary also stops producing THS (thyroid stimulating hormone). Non–availability of TSH results in failure of thyroid to produce thyroxine. Non–formation of new thyroxine will automatically result in reduction in level of blood thyroxine to suboptimum level when hypothalamus will be again stimulated.

Feedback by metabolites. Hormone secretion is also controlled by metabolites. Presence of excess glucose in blood, as after meals, stimulates $\beta-$cells of islets of Langerhans to secrete insulin. Insulin promotes glucose absorption by individual cells, absorption and formation of glycogen in liver and muscles. This reduces glucose level in blood. The secretion of insulin is also reduced.



Homoeostasis and hormonal feed back.

The End
