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BIOLOGY

Standard 12

(Semester IV)

PLEDGE

India is my country.
All Indians are my brothers and sisters.
I love my country and I am proud of its rich and varied heritage.
I shall always strive to be worthy of it.
I shall respect my parents, teachers and all my elders and treat everyone with courtesy.
I pledge my devotion to my country and its people.
My happiness lies in their well-being and prosperity.

રાજ્ય સરકારની વિનામૂલ્યે યોજના હેઠળનું પુસ્તક

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PREFACE

In compliance with the new national syllabi designed by N.C.E.R.T. according to NCF-2005 and core-curriculum the Secondary and Higher Secondary Board of Education, Gujarat State, has prepared the new syllabi of various subjects with the approval of the State Government.

The State Textbook Board delightfully introduces the new edition of **Biology** for **Semester IV** for the students which has been prepared according to the new syllabus of Biology approved by the State Government for **Semester IV of XII standard.**

It has been reviewed and revised thoroughly by the subject experts.

The Textbook Board has taken all precautions to make it interesting, advantageous and inerroreous. However, the Board welcomes suggestions from the concerned intellectuals for the qualitative enrichment of this book.

Dr. Bharat Pandit
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FUNDAMENTAL DUTIES

It shall be the duty of every citizen of India :

(a) to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;

(b) to cherish and follow the noble ideals which inspired our national struggle for freedom;

(c) to uphold and protect the sovereignty, unity and integrity of India;

(d) to defend the country and render national service when called upon to do so;

(e) to promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;

(f) to value and preserve the rich heritage of our composite culture;

(g) to protect and improve the natural environment including forests, lakes, rivers and wide life, and to have compassion for living creatures;

(h) to develop the scientific temper, humanism and the spirit of inquiry and reform;

(i) to safeguard public property and to abjure violence;

(j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievement;

(k) to provide opportunities for education by the parent or the guardian, to his child, or a ward between the age of 6-14 years as the case may be.

* Constitution of India : Section 51-C

INDEX

1

Neural Control and Coordination in Animals

We have studied different physiological processes in animals. Each physiological process requires control and coordination. All functional components are necessary to be controlled are put together so that they work consistently. Thus, coordination is the process through which two or more organs interact and complement the functions of each other. For example, when we do physical exercise, we notice an increase in the rate of breathing, heart beat, flow of blood etc. When we stop physical exercise, we observe that breathing, heart beat, blood flow etc. gradually return to normal. Thus during physical exercise, the activity of various organs of body are coordinated, controlled and integrated jointly by two systems : the nervous system and the endocrine system. In humans all the physiological activities are controlled and coordinated by nervous and endocrine systems. The nervous system provides an organised network of nerves for fast coordination and the endocrine system provides chemical integration through hormones. In this chapter, you will learn about the nervous system of humans the nerve cell, which is the structural and functional unit of the nervous system; generation and conduction of nerve impulse, central nervous system and the physiology of reflex action.

Nervous System

The nervous system is composed of highly specialized cells called neurons (Nerve Cells). Neuron's function is to control various kinds of stimuli by sending nerve impulses which detect, receive and transmit stimuli. In higher organisms, the nervous system performs three basic functions. (1) Receiving sensory stimuli from external and internal environment by nerves to the brain. (2) Processing the stimuli information by brain. (3) Responding to stimuli transmitting impulses from brain to body parts or cells.

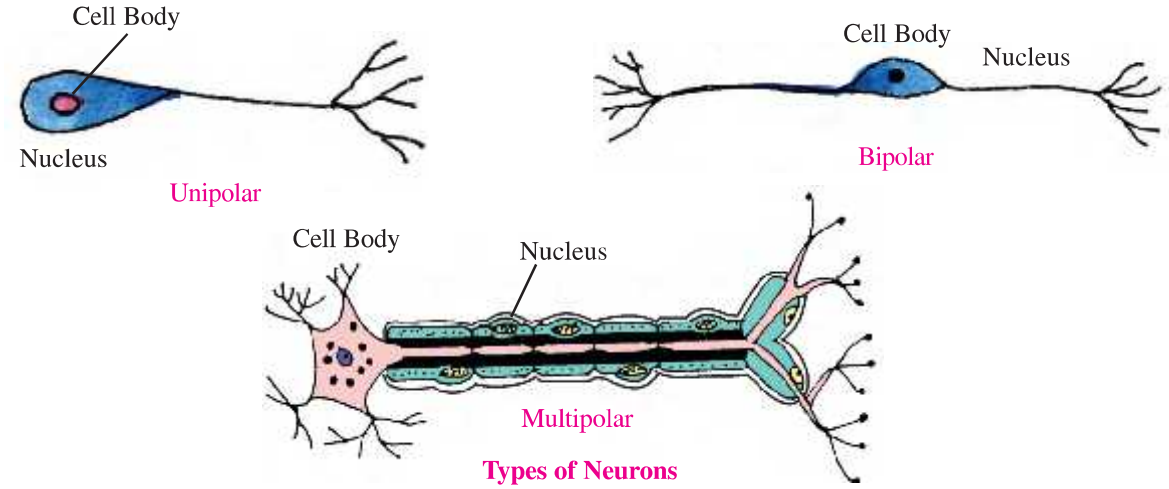
The nervous system of hydra is composed of network of nerve cells. The nervous system is well developed in insects, which consists of brain, ganglia and nervous system. Vertebrates have a highly developed nervous system.

Nerve Cells : Structural and Functional Unit of Nervous System

Structure of Nerve Cells : Nerve cells are the functional units of nervous system. Nerve cells differ in size and shape to a large extent. A microscopic structure of the nerve cell consists of three major parts, namely (1) cell body (2) dendrites and (3) axon. The cell body of nerve cell is called cyton. The cyton may be oval, rounded or star shaped. The cytoplasm of nerve cell is known as neuroplasm, and has a relatively large and spherical nucleus. The neuroplasm has mitochondria, golgibody and small variously shaped basophillic granules, which are known as Nissl's granules. The neurofibrils form a complicated network. Dendrites and axon are two types of processes of nerve cells; cyton contains neurofibrils which arise from peripheral region of neuroplasm and Nissl's granules which surround the nucleus.

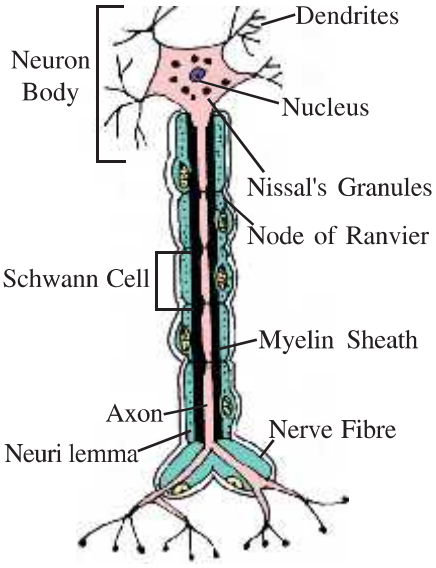
Dendrites are several short, branched and tapering processes. They carry nerve impulses towards the cyton. Axon is a single, cylindrical and very long process of uniform diameter, the distal end of which is branched. Each branch terminates in slight swelling structure called synaptic knob. There is no direct physical contact between terminal branches of an axon of a neuron and the dendrites of the following neuron. This physical gap is called 'synapse'. Synaptic knob which possesses synaptic vesicles produces chemical called neurotransmitters, such as acetylcholine.

On the basis of the number of axon and dendrites, the neurons are divided into three types. (1) Unipolar neurons a cell body with one axon only, e.g. found in embryonic stage. (2) Bipolar neurons a neuron with one axon and one dendrites e.g found in retina of eye. (3) Multipolar neurons a neuron with one axon and two or more dendrites, present in the cerebral cortex.



Types of Neurons

Axons are of two types, namely myelinated and non myelinated. The myelinated nerve fibres are surrounded by two sheaths, inner thick medullary sheath and outer neurilemma (sheath of Schwann cells). Medullary sheath is composed of a white, shining, fatty substance called myelin, which may serve as an insulating layer. But in the fibres of the peripheral nerve, myelin is absent at a certain points which are known as nodes of Ranvier. Non myelinated nerve fibers consist of an axis cylinder which has a single sheath, the neurilemma, while medullary sheath is absent. They do not show Ranvier nodes, found in autonomic nerve.



Structure of Nerve Cell

Initiation of the Impulse or Action Potential

Action potential is another name of a nerve impulse, that transmits along membrane. Nerve fibre can become excited in different ways. Touch, smell, chemical changes and pressure etc can induce this. A change in the polarity of nerve fibre is known as action potential. When the Nerve becomes excited, Na^+ channels open up and the electrical excitation generated in plasma membrane. Na^+ ions are actively transported inside through ion channels in plasma membrane. The lower concentration of Na^+ ion inside is responsible for this. Due to a sudden influx of a large amount of Na^+ towards inside, the plasma membrane becomes positively charged on its inner side; it is said to be depolarized. It lasts for a very short period only, of about 0.5 milli second. To be more definite, a nerve impluse is physico-chemical electrical change in the nerve fibre membrane produced by a stimulus at one end and transmitted along the nerve fibre to its termination without any change in abundance. Important features of action potential is that a stimulus must be of a certain minimum intensity, which can produce an action potential.

Conduction of Nerve Impulse throgh Nervefiber

Various sensations are conducted through nerve fibre. The conduction of nerve impulse is an electro-chemical process. Before understanding the process of generation of nerve impulse and its conduction, it is necessary to know the structure of the nerve fibre.

Structure of Nervefiber : As is the case in other cells of the body, the neuroplasm possesses a higher negative charge. Compared to it, there is a higher positive charge on the outer side of plasma membrane. The distribution of positive and negative ions is responsible for this difference in electrical charges. This difference in electrical charges between the inside and the outside of plasma membrane is called the 'membrane potential'. In an unexcited state of nerve fibre, it is called 'resting potential'. It can be measured using electrodes and voltmeter.

For maintenance of this electrical potential and induction of changes in it the structure of plasma membrane is responsible.

Like all plasma membranes, this plasma membrane is also made up of a lipid bilayer. Lipid is impermeable to ions. Special proteins occur in this layer at various places. These act as ion channels and ion pumps. Ion pumps and ion channels play an important role in maintenance and in changing of the electrical potential. Ion pumps are utilized in transport of ions against their concentration gradient. Energy of ATP is used in it. Main ion pump is sodium-potassium pump with this pump Na^+ are expelled out from the cytoplasm and K^+ are drawn into it. For every two Na^+ expelled three K^+ are drawn within. The concentration of K^+ remains high in cytoplasm. Concentration of Na^+ remains high on the outside of cytoplasm. Ion channels are aqueous and made up of protein. They carry out two-way transport of ions selectively. They are permeable to any one kind of ion only. Thus there are sodium channels, potassium channels, chlorine channels and calcium channels. Ion channels can be opened and closed. Chemical and electrical changes are responsible for this.

Resting Potential

When the nerve fibre is at rest, a negative electrical charge occurs on its inner side and a positive electrical charge occurs on its outerside. Such a nerve fibre is called polarized. For this, ions are responsible. Na^+ are concentrated on the outside of plasma membrane whereas K^+ are concentrated on its inside. Sodium-potassium pump is responsible for this. Moreover protien molecules having negative charges on them also occur. They cannot move out of plasma membrane.

This condition is called-resting potential.

Active Potential or Initiation of the Impulse

Nerve fibre can become excited in various ways. Touch, smell, pressure, chemical changes etc can induce this. A change in the polarity of nerve fibre is called active potential.

In the excited region Na^+ channels open up; the electrical excitation generated in plasma membrane in this region is responsible for this. Na^+ ions are poured inside through its ion channels in plasma membrane. The lower concentration of Na^+ on the inside is responsible for this. Moreover, negatively charged proteins are also responsible. Thus, due to a sudden influx of a large number of Na^+ towards the inside, the plasma membrane in this region becomes positively charged on its inner side. This phenomenon is called-depolarization. It is called active potential. It lasts for a very short period i.e. a millionth part of a second. The excited region immediately becomes repolarised.

For repolarization, the process of closure of Na^+ ion channels is responsible. Simultaneously, K^+ ion channels open up and K^+ ions go out of the plasma membrane.

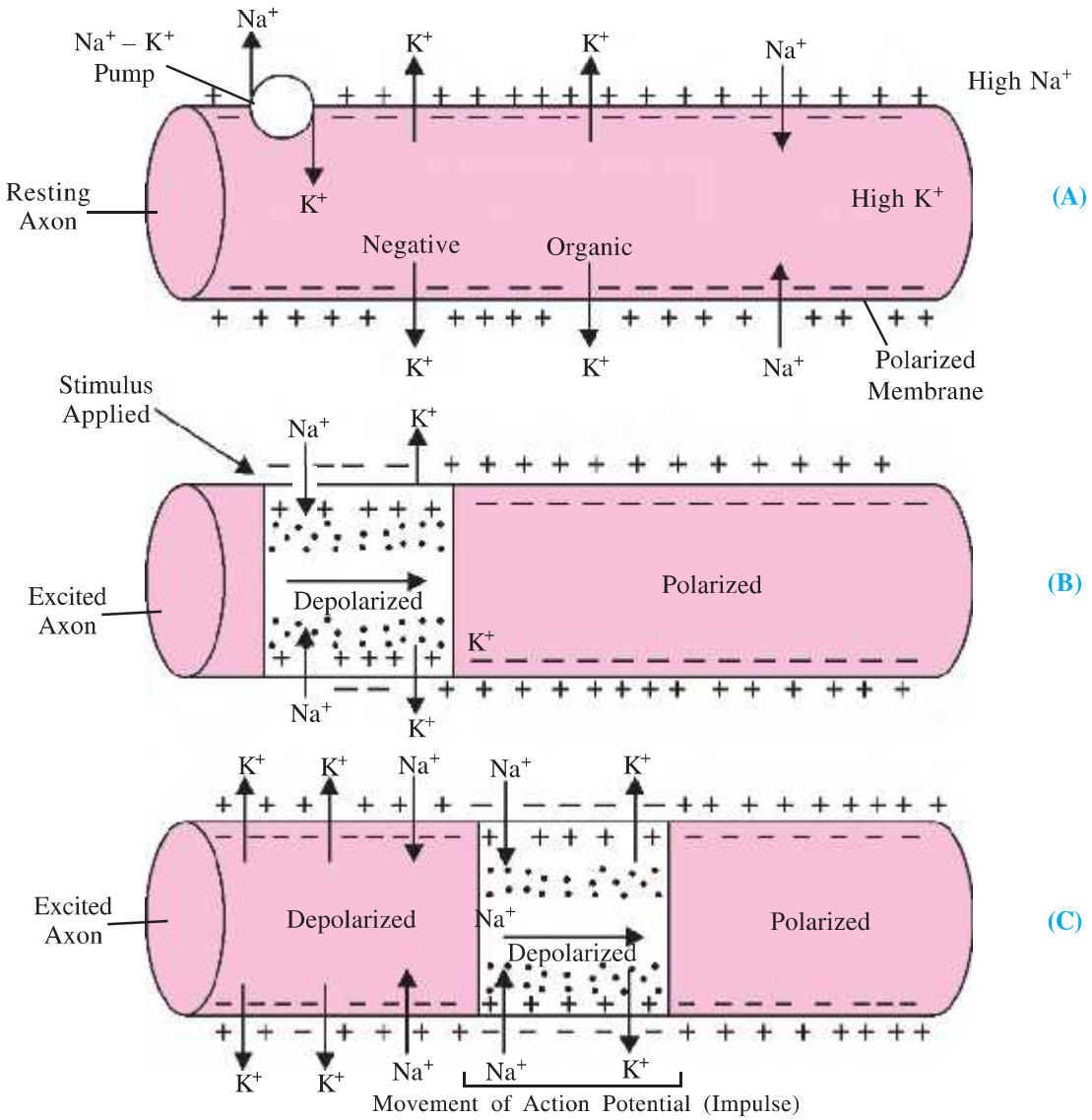
At the end of this phase, a difference in concentration of positive ions on two sides of plasma membrane is generated. Concentration of Na^+ increases on inside and that of K^+ increases on the outside. The activity of sodium-potassium pump removes this imbalance.

Conduction of Nerve Impulse

The nerve impulse generated as described above is now conducted along one direction. This process is self-induced because when the membrane electric potential is reduced in the nearby region, the ion-channels in the region automatically open up. Thus sequential depolarization and

repolarization progress and the nerve impulse moves along in that direction. To protect the impulse weakening through diffusion all around, nerve fibre is surrounded by a medullary layer. This conduction is very swift (100 meters per second).

In vertebrate animals, the medullary layer is discontinuous in the medullated nerve fibre. The regions with lesser medullary layer are known as node of Ranvier. In these nerve fibres, active potential, after it is generated, does not move in cyclic waves gradually. It moves directly from one Ranvier's node to the next node. Such a conduction in known as 'Saltatory Conduction'.

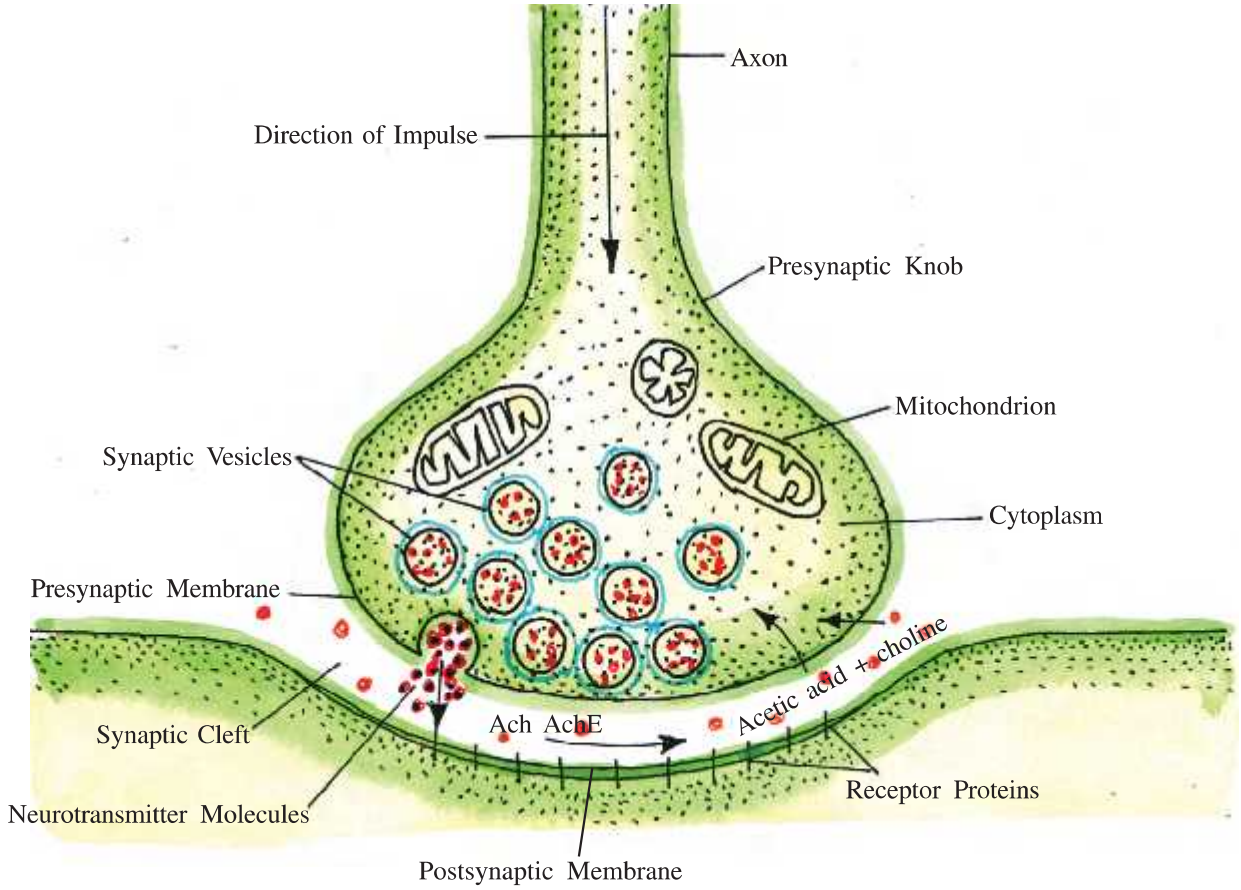


Conduction of Impulse through Nerve

Transmission of Impulse at a Synapse

Synapse is the close functional contact between axon of one neuron and cyton or dendrites of successive neuron with a cleft of about 200A° length. When a nerve impulse reaches the synapse, a chemical substance Acetylcholine (Ach) is liberated. This substance is responsible for the conduction of impulse through synpase. When impulse reaches the synaptic knob of the axon, it depolarises the presynaptic membrane, and thus calcium ions permeability increases. These calcium ions from the synaptic cleft enter into synaptic knob; this rise of calcium in cytoplasm releases a neurotransmitter, acetylcholine. This substance diffuses into the cleft and binds with protein receptor molecules which acts as the acetylcholine receptors, on the post synaptic membrane; now the post synaptic membrane allows sodium ions to enter the cell. This will cause the depolarization and generate new action potential in the post synaptic membrane. Now the nerve impulse passes to next neuron.

Acetylcholine is inactivated by acetycholine esterase (AchE) enzyme present in cleft and post synaptic membrane. Now, acetylcholine is hydrolysed in the presence of above mentioned enzyme into choline and acetic acid, which are reabsorbed into the synaptic knob where they are resynthesised into acetylcholine in presence of ATP. In synapse, transmission of impulse, arises in nerve direction, is not fixed because dendrite cannot secrete neurotransmitter.



Ach = Acetylcholine, AchE = Acetylcholine esterase
Transmission of Nerve Impulse at a Synapse

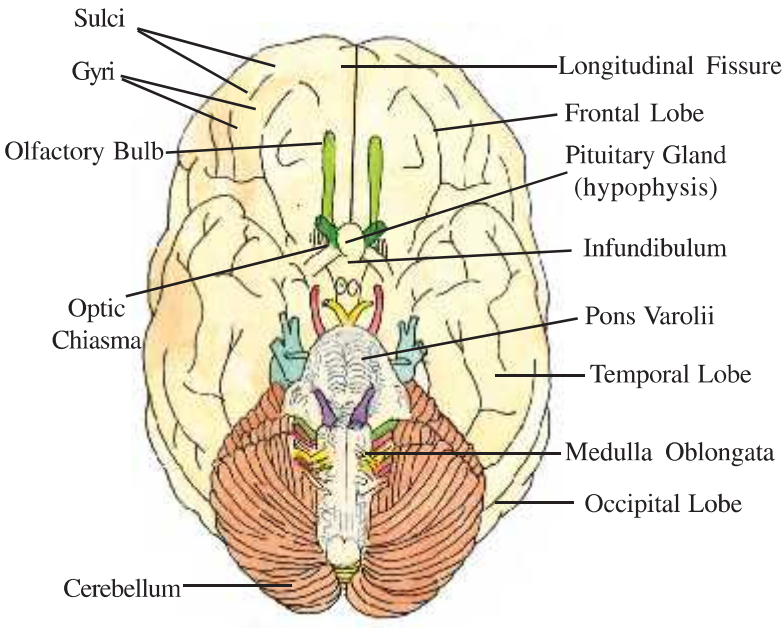
Human Nervous System : The human nervous system is divided into two parts (i) the central nervous system (CNS) (ii) the peripheral nervous system (PNS). Central nervous system consists of brain and spinal cord and it is the centre of information processing and control. The PNS comprises of cranial nerves which arise from brain and spinal nerves which arise from the spinal cord.

The nerve fibers of the PNS are of two types (1) afferent or sensory nerve fibres : These fibres transmit nerve impulse from the tissue/organs to central nervous system (CNS) (2) efferent or motor nerve fibres : These fibres conduct regulatory impulses from the CNS to the effector organs such as peripheral glands and muscles.

The PNS is divided into two divisions known as somatic nervous system and autonomic nervous system. The somatic nervous system transmits impulses from CNS to skeletal muscles. The autonomic nervous system relays impulses from the CNS to the involuntary organs and nonstriated muscles of the body. The autonomic nervous system is further divided into sympathetic nervous system and parasympathetic nervous system.

Central Nervous System (CNS)

The central nervous system consists of the brain and the spinal cord. These structures are covered by three membranes which are known as meninges. The inner membrane is pia matter which is a thin highly vascular membrane. The middle membrane, arachnoid matter, which is a thin transparent membrane, but non vascular. The outer membrane, dura matter is the thickest and toughest membrane, which covers the brain. It is also adherent to the inner surface of cranial bones by fibrous and vascular processes. The CNS has two distinct regions (1) white matter is white in colour and consists of myelinated fibres (2) gray matter consists of cyton bodies along with their dendrites and axon.



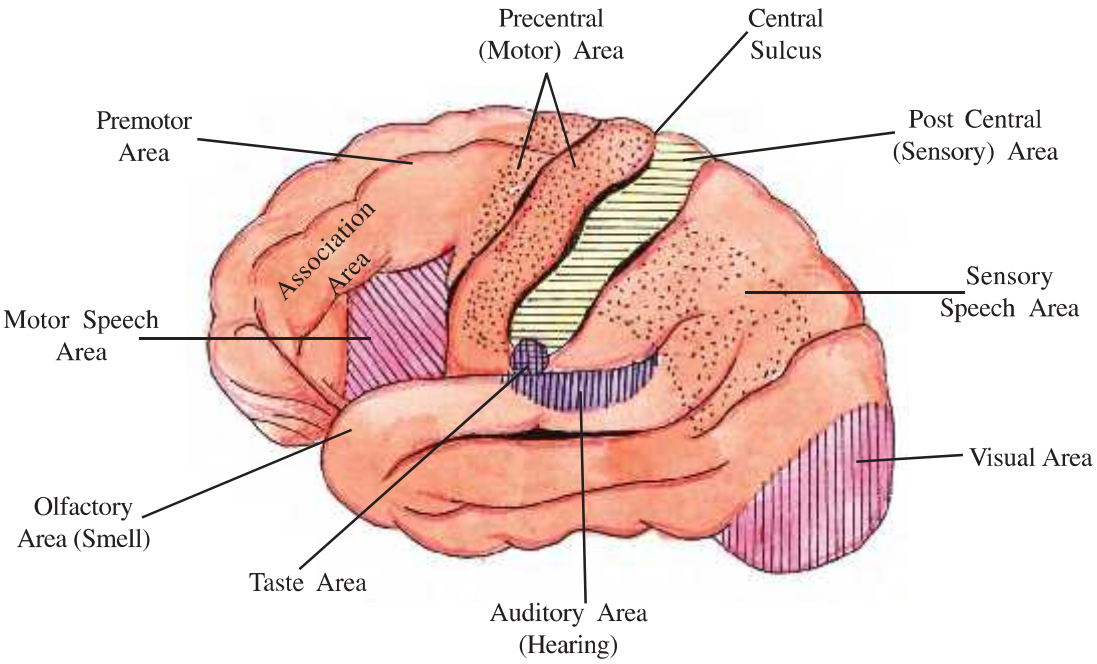
Ventral View of Human Brain

The brain is the central information analysing organ of body. It acts as the command and controlling system and functions as an integrated unit. It controls the voluntary movements and function of involuntary organs like heart, lungs, and kidneys as well as balance of the body, hunger and thirst and thermoregulation and activities of many endocrine glands. It is the site for processing of hearing, vision, memory, emotion, thoughts and finally intelligence. The brain can be divided into three major parts (1) fore brain (2) mid brain and (3) hind brain.

The weight of brain is about 1200 to 1400 grams, and number of neurons is about 100 billion. Fore brain forms greater part of the brain. It is formed of three regions, olfactory lobes, cerebral hemispheres or cerebrum and diencephalon.

Fore brain : The olfactory lobes present in a pair are small, club shaped, solid and separated from each other. They are visible only in the ventral view of the brain because they are fully covered by cerebral hemisphere. Cerebral hemispheres (cerebrum) are the largest parts of the brain and they are separated from each other by a longitudinal cerebral fissure. The hemispheres are connected by a large bundle of myelinated fibres, known as corpus callosum.

The outer surface of cerebrum is known as the cerebral cortex. The surface of the cortex is highly folded to increase the area for accommodating more nerve cells. The folds are called gyri and the depression between them are known as sulci. Three wide and deep sulci are termed as fissures, which divide each hemisphere into four lobes. Anterior frontal lobe controls voluntary movements The premotor area frontal lobe controls involuntary movements and autonomic nervous system. The associated area of the frontal lobe is concerned with memory, reasoning, learning and creative ability. Middle parietal lobe is associated touch, cold, temperature and pain. The posterior occipital lobe has visual and auditory areas which are centres for hearing and sight. The lateral temporal lobe is concerned with sound, smell, emotion and memory. Each cerebral hemisphere encloses a cavity called lateral ventricle, which is closed in front but open behind into third ventricle of diencephalon by a aperture known as foramen of monro.

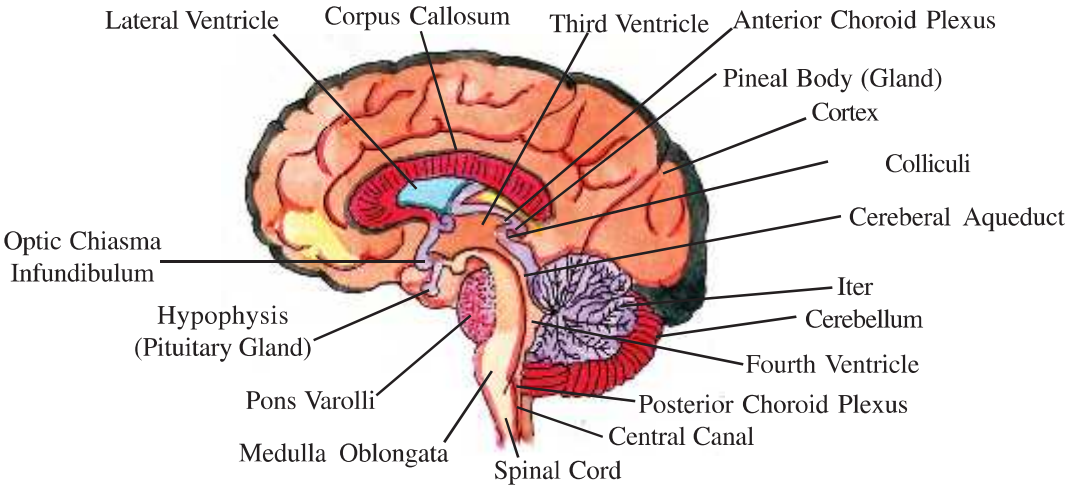


A Cerebral Hemisphere showing the Functional Areas

Diencephalon

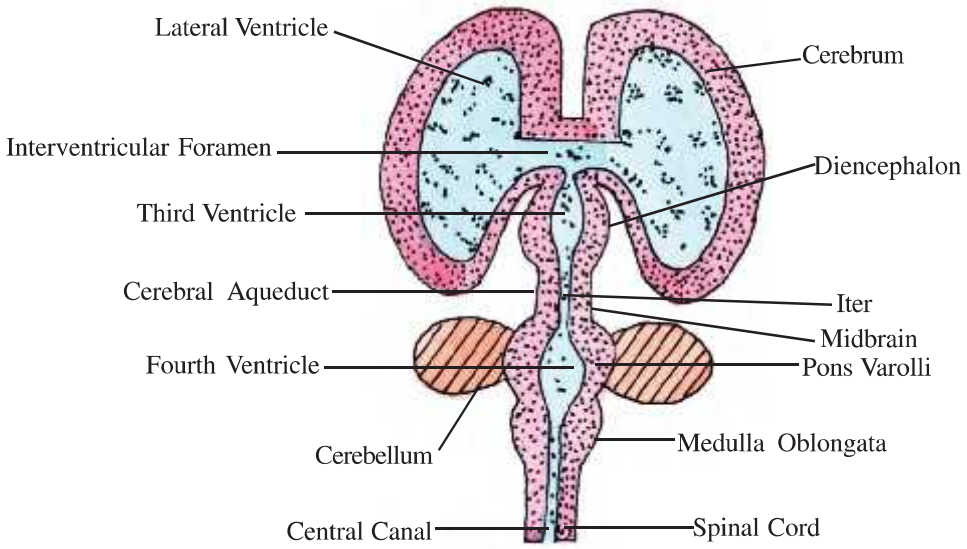
Diencephalon encloses a cavity of the third ventricle, the roof of the cavity is known as the epithalamus, the right and left sides are known as thalamus and floor as the hypothalamus. Epithalamus is not formed of nervous tissues, but it is mode up of blood vessels possessing folds. Which form anterior choroid plexus. Just behind this the epithalamus forms a short stalk, the pineal stalk, and at its tip is a rounded body, known as pineal body is present. Pineal body secretes hormone melatonin. The hypothalamus is visible in the ventral view of the brain. The optic nerve orginating from the eyes forms a crossing, the optic chiasma in front of the hypothalamus. The hypothalamus is small, possessing 4 grams weight. The pituitary is attached to the hypothalamus by a stalk called the infundibulum. The diencephalon encloses a cavity termed as third ventricle which communicates anteriorly with the lateral ventricle of cerebrum by the foramen of monro and posteriorly with the fourth ventricle of medulla oblongata by a narrow passage called the iter, which is present in mid brain.

Mid Brain : The mid brain is very small and it consists of four small lobes, the coropora quadrigemina. The superior pair is called superior colliculi which receives impulses from the eyes and muscles of head and controls visual reflexes. The inferior pair is termed as inferior colliculi, which receives impulses from the ears and the muscles of the head and controls the auditory reflexes.



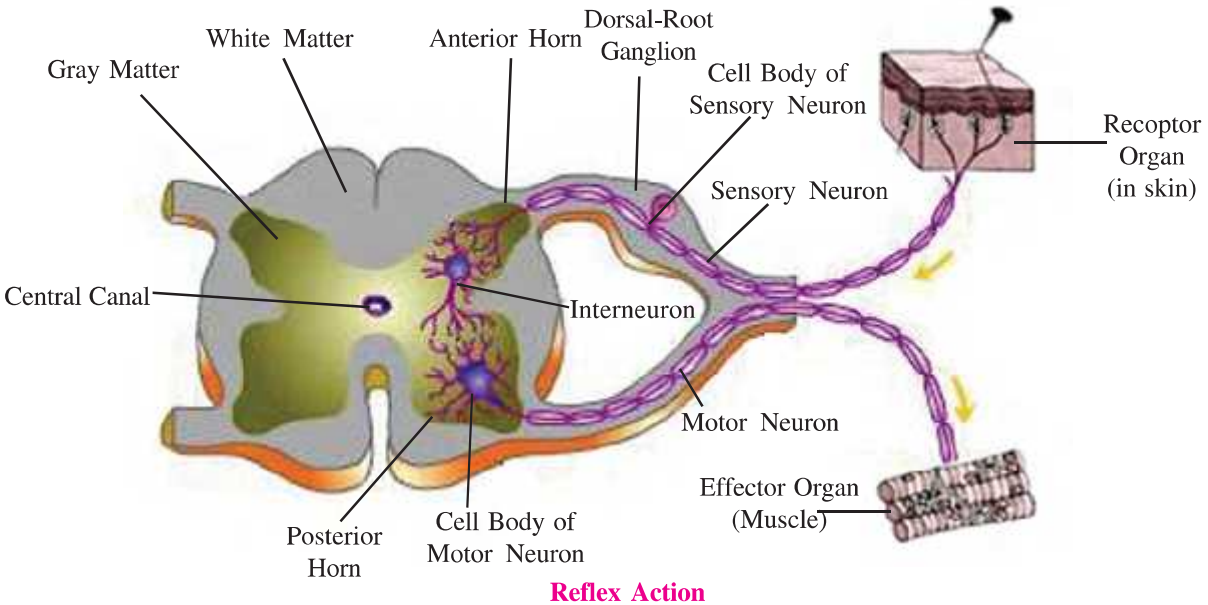
Vertical Section of Human Brain

Hind Brain : It consists of cerebellum, pons varolli and medulla oblongata. The cerebellum is very large and well developed. It consists of two large lateral parts, the cerebral hemispheres, and a small vermis. The cerebellum is solid, and has a branching tree like structure of white matter surrounded by a shealth of greatly folded grey matter. The cerebellum controls muscular activities like running, talking and typing. Pons varolii is an oval mass which consists of mainly nerve fibres, and bridges the cerebellar hemispheres and medulla oblongata; it relays impulses between medulla oblongata, cerebellar hemi-spheres and between the cerebrum and cerebellum. Medulla oblongata is pyramid shapedif is the posterior most part of the brain that connects the spinal cords. It encloses a cavity, the fourth ventricle. This ventricle has a very thin non nervous, epithelial, folded roof known as posterior choroid plexus. The medulla oblongata contains centres for cardiac activities, respiration and vasoconstrictor that control heart beat, breathing, blood pressure, salivation, swallowing, vomiting, sneezing and coughing and other involuntary functions



Schematic Representation of the Ventricles of Human Brain

Reflex Action : Reflex action is a monotonous or unchangeable response to a stimulus. An involuntry response to stimulus given by reflex center of brain/spinal cord without knowledge of the voluntary centers of brain is called reflex action. Animals show two types of actions, voluntary and involuntary. Voluntary action is performed by the animal according its will. In this action, the animal uses its own choice, for example, on seeing a leopard on the way, one may run away or call for help to save one self. An involuntary action is performed by the animal very quickly and the it takes place without any choice and willingness of animal. For example, the foot or hand is withdrawn when it suddenly touch a hot plate. These involuntary actions are known as reflex actions. The other common examples of reflex action in man are blinking of eyes, coughing, sneezing, yawning, knee-jerk, movement of diaphragm during respiration. In reflex, action the spinal cord is also involved for quick response to stimulus, such reflexes are known as spinal reflexes. Some reflexes which involve the brain, are termed as cerebral reflexes, for secretion excitement of the saliva after seeing palatable tasty food. These reflex actions are in our knowledge but there are some reflex as which go on without our knowledge, for example heart beating and paristalsis of the alimentary canal . These reflex actions are controlled by autonomic nervous system.



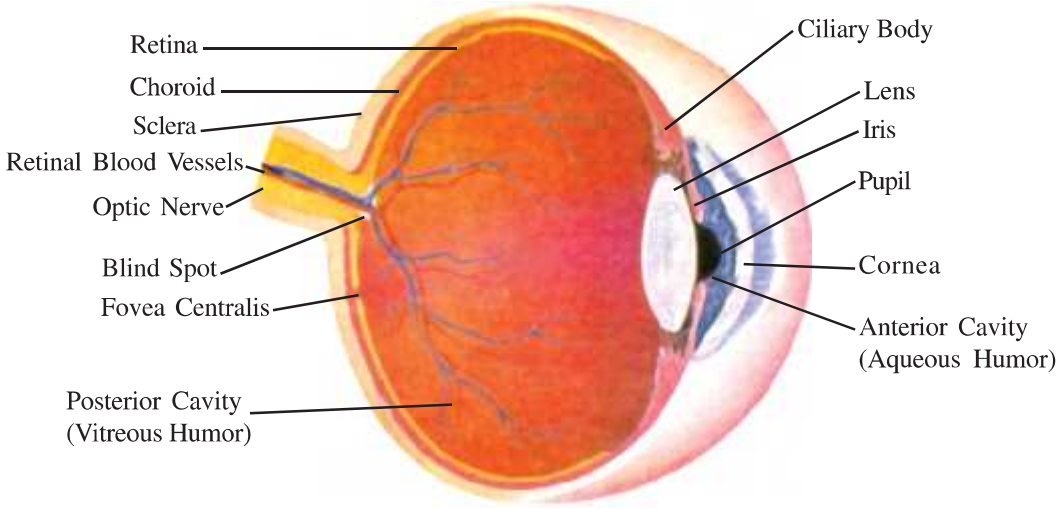
Reflex Action

Reflex Arc : The reflex arc is the nerve chain between a receptor and an effector organ a receptor of the neurons receives a stimulus. An afferent nerve brings the sensory impulse from the receptor to the CNS. The neuron of the spinal cord or brain analyses and interprets the sensory impulse and set up motor impulse. Spinal cord and brain act as modulators. The motor nerve carries the impulse from the brain or spinal cord to the effector organs. An effector organs may be a muscle or gland which responds to impulse instruction received from the modulator. In reflex arc, nerve impulse can travel only in a single direction. Importance of reflex action is that it enables the animal to respond quickly to harmful stimuli and saves the animal from harmful effect.

Conditioned Acquired Reflexes : The reflexes described above are unconditional reflexes and are inborn (inherited), while conditioned reflexes are acquired during life. They are behaviour of an animal gradually developed by training and experience. This reflexes are shown only by trained animals. The conditioned reflexes can be discontinued if the specific stimulus is lost it not transmitted through heredity. Thus conditioned reflexes play a significant role in learning. Examples of condition reflexes are habits, likes and dislikes, prejudices and interests, typing, riding a bicycle, knitting etc.

Sensory Reception and Processing : There are climatic changes in the environment. Have you ever thought how you feel ? How you see an object with its colour ? How you hear a sound ? The sensory organs detect changes in the environment and send impulses to the CNS, where all the impulses are processed and analysed. How can you understand the environment ? In this section, you will learn about the structure and functions of eye and ear.

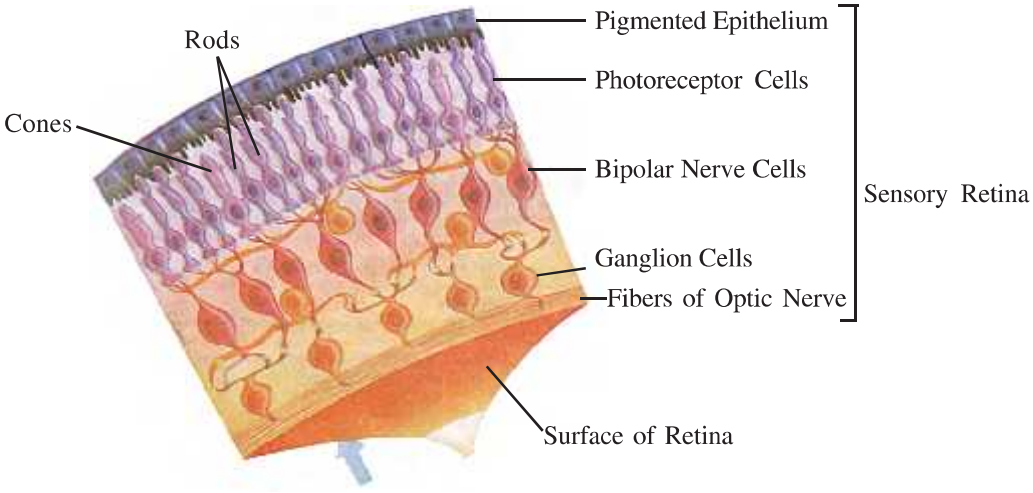
Eye Structure and Mechanism : The eyes are located in a deep protective bony cavities, known as orbits. The eye is hollow spherical in shape, about 2.5 cm in diameter and its weight is about 6 to 8 gms. The eye has two parts wall and contents. The wall of the eye is composed of three layers, outer fibrous sclera middle choroid and inner retina. The fibrous layer consists of sclera and cornea. Sclera forms the posterior 5/6th part of the collagen fibres while cornea forms, while 1/6th part made up of connective tissue and lacks blood vessels. Conjunctiva is thin, transparent and composed of stratified epithelium, which cornea externally covers and the exposed part of sclera. The choroid is made up of iris and ciliary body of two regions. Choroid is composed of connective tissue and blood vessels. Blood vessels of the choroid nourish the retina. Iris is a circular shelf like diaphragm and perforated in the centre by an aperture termed as pupil. The iris works like the diaphragm of a camera. Just behind the iris, the choroid is thickened to form ciliary body, which contains circular and radial muscle fibres. Retina is a delicate layer of optic part. It composed of four layers. (1) Pigmented epithelium. (2) Layer of photoreceptor cell. (3) Layer of dipolar nerve cells. (4) Layer of ganglion cells. Pigmented epithelium– It contain pigmented cells. Layer of photoreceptor cells, it contain rod cells and cone cells. Name given of these cell by their shape. Rod cells consist of purplish pigments termed as rhodopsin.



Structure of Eye

Rod cells function at night and in dimlight. In bright light rhodopsin splits in to scotopsin and retinal through a process called bleaching. Splitting of rhodopsin depolarizes the rod cells, and that releases a neurotransmitter which sends the nerve impulse to the optic nerve via bipolar and ganglion cells. In the dark, rhodopsin is resynthesized from retinal and scotopsin. Now rhodopsin becomes functional.

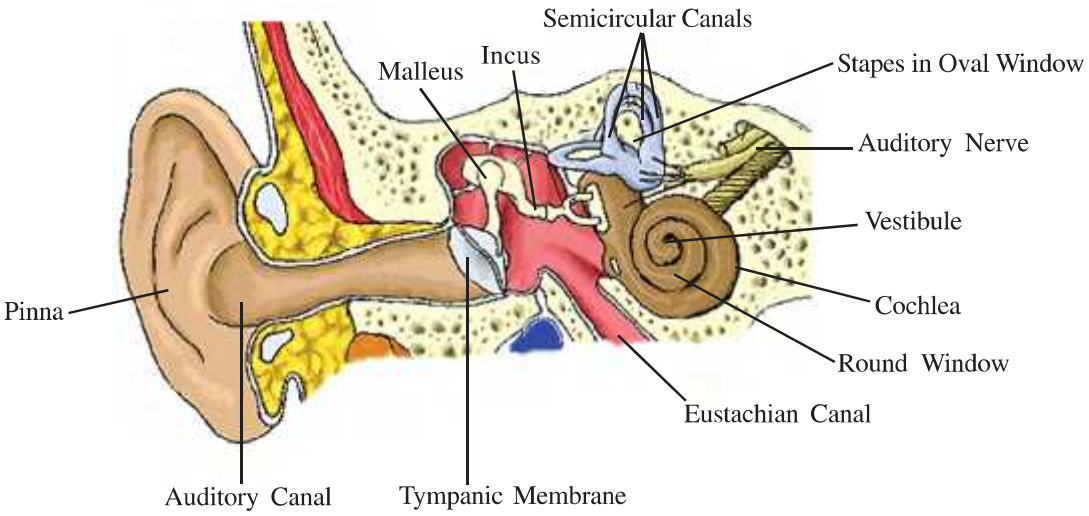
Cone cells contains iodopsin pigments. Cone cells function in day light and produce complete images and give colour vision. The cone cells are less sensitive as compared to rod cells. In the human eye, three types of cones are found which possess their own photopigment, each absorbing light rays of different wave-lengths. Erythrolabe pigment is sensitive to red light, chlorolabe pigment to green and cynolabe pigment to blue light. Lack of one or more types of cone cells causes colour blindness. Under the layer of rod cells and cone cells, a layer of bipolar nerve cells and a layer of ganglion cells are arranged. On the retina there is a small depression known as fovea, which has only cone cells. The retina from where optic nerves starts is known as blind spot. It lacks the receptor cells and is insensitive to light. The Lens is solid, elastic, transparent, biconvex, and consists of laminated fibrous tissue which is enclosed in thin elastic membrane known as lens capsule. The lens focuses light on retina. The lens divides eyeball cavity into two chambers. The anterior small aqueous chamber and the posterior large vitreous chamber. Aqueous chamber is filled with a watery clear fluid, the aqueous humor, which is secreted by ciliary processes of ciliary body. The vitreous chamber is full of transparent fluid thick the vitreous humour which is secreted by retina during development of the eye.



Ultra Structure of Retina

Mechanism of Vision : The light rays focused on the retina generate impulses on rods and cones. In the eyes scotopsin and retinal photopigments are present. Light influences dissociation of retinal and scotopsin, effecting changes in the structure of scotopsin. It produces membrane permeability changes. Due to this, potential differences are generated in the photoreceptor cells. This produces a signal that generates impulses in the ganglion cells through the bipolar cells. These impulses are carried by the optic nerve to visual area of the brain, where the impulses are analysed and the image formed on the retina is identified based on earlier memory and knowledge.

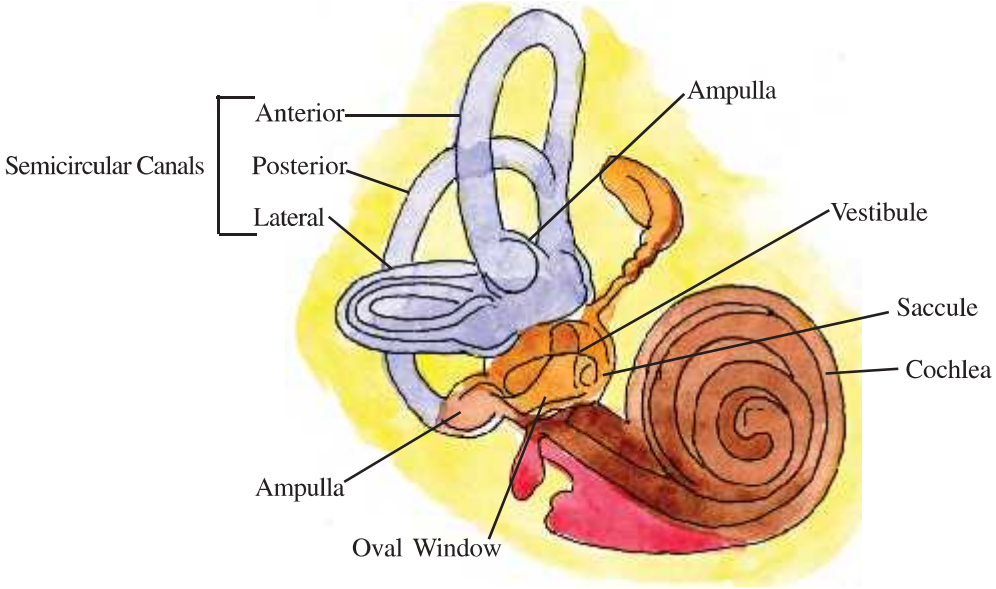
Structure of Ear : The human ear is made up of three major parts, external ear, middle ear and internal ear. The external ear consists of pinna and external auditory meatus (canal). Pinna is an oval, some what funnel-shaped, and the stiff outer ridge is known as helix, while its flexible lower lobe is known as lobule. The external auditory meatus is am S-shaped tube which spreads inwards up to the tympanic membrane. The upper part of meatus bears hairs which prevents entry of dust particles. Its inner parts have wax glands. It secretes a brownish fatty substance known as earwax. It protects and lubricates the lining of canal. Tympanic membrane is a thin, oval membrane made up of connective tissue with fibres, covered with skin outside and muscle membrane inside. Inner wall of the tympanic cavity has two apertures. The upper aperture is known as fenestra ovalis and the lower is called the fenestra rotunda. Both these apertures are covered by membrane. Middle ear contains three small, movable articulated bones, the ear ossicles. Hammer shaped ossicle is called the malleus, which is attached to tympanic membrane. Inner ossicle known as stapes, is stirrup-shaped. The middle anvil-shaped ossicle is known as incus, It is externally joined to the malleus and internally to the stapes. The function of ear ossicles is to transmit the vibration from the tympanic membrane to the internal ear and amplify vibration 20 times.



Structure of Ear

Internal ear is an irregular, delicate and complicated organ, he the know as membranous labyrinth which is enclosed in a bony labyrinth. The space between these two is filled with fluid called perilymph. The membranous labyrinth is also filled by another fluid, the endolymph. The membranous labyrinth consists of 3 parts (1) Vestibule, (2) semicircular ducts and (3) cochlear duct.

(1) Vestibule : is a sac like part and consists of 2 chambers, the larger utricle and smaller saccule, which leads into cochlear duct.

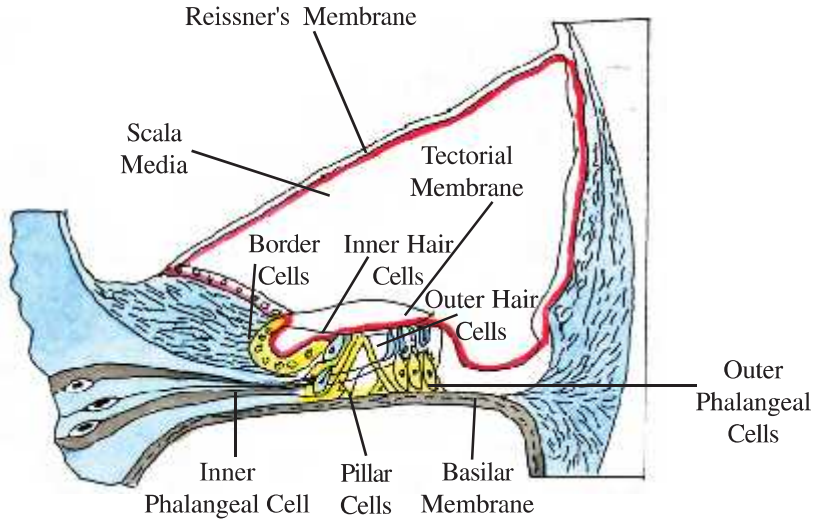


Inner Ear

Two sensory spots are present in macula of utricle and macula of saccule They are located in the wall of utricle and saccule. A macula consists of hair cells and supporting cells. The supporting cells contain many minute particles known as earstones or otoliths, composed of calcium carbonate and protein.

(2) Semicircular Ducts : Three semi circular ducts are aranged on outerior, posterior and lateral sides. Each duct opens in to the utricle on both ends. One end of each duct is swollen to form ampulla. Sensory spot is found on each ampulla and is known as crista its function is to maintain equilibrium.

(3) Cochlear Duct : It is a spirally coiled tube, resembling a shell of snail. It is a part of the bony labyrinth. Which encloses the cochlear duct together termed as the cochlea. Cochlea has three longitudinal chambers, known as scalae, which are separated from one another by a thin membrane. The middle chamber is termed as scala media, which consists of organ of corti. The roof of scala media is called as Reissner's membrane and floor is term as basilar membrane. Organ of corti is an organ of hearing which consists of receptor cells hair cells and supporting cells. The hair cells bear hair at their free surface and at the basal region synaps has contact with dendrites of nerve cells. The tips of hair are embedded in a tectorial membrane. supporting cells are of two types, longer pillar cells and shorter phalangeal cells.



T. S. Organ of Corti

Mechanism of Hearing

The sound waves reach to the tympanic membrane through the way of external ear. The vibrations of the tympanic membrane pass through ear ossicles to fenestra ovalis present in the bony labyrinth. From here the vibration pass to the basilar membrane of cochlear canal, and then travel on the other side of the canal to Reissner's membrane. These vibrations cause a movement of the endolymph. These movements are recognised by the sensory cells found in the organ of corti. These vibratory movements are converted into nerve impulses. These impulses are transmitted by nerve fibers via auditory nerves to the auditory area of cerebrum, where the impulses are analysed and sound is recognised.

Disorders of the Nervous System

Multiple sclerosis : A chronic disease of the nervous system that affects young and middle aged person. The mylin sheaths surrounding the nerves in the brain and spinal cord are damaged, which affects the function of the nerves. Symptoms include shaky movement of the limbs rapid involuntary movements of the eyes, defects in speech, paralysis in greater or less a degree, finally causing death.

Parkinson's disease : This disease is associated with deficiency of the neurotransmitter dopamine and aging. Symptoms include tremor, rigidity and lack of spontaneous movements.

Sciatica : Usually caused by degeneration of intervertebral disc. Main cause of sciatica is 'slipped' out of intervertebral disc. There is a continuous pain in back, thigh and leg.

SUMMARY

In human all the Physiological activities are controlled and coordinated by nervous and endocrine systems. The nerous system is composed of highly specialised nerve cells, which exercise body control by transmitting nervous impulses. The nervous system of Hydra is composed of a network of nerve cells. The nerve cell consists of cellbody, dendrites and axon. On the basis of the number of axon and dendrite, the neurons are divided into three types, multipolar, bipolar and unipolar. Axons are of two types, myelinated and non myelinated. Action potential is another name of nerve impluse. A change in the polarity of nerve fibers is known as action potential. Active transport of sodium ions from axoplasm into the interstitial fluid is known as sodium pump. When stimulus applied on membrane of nerve fibre. Then it becomes depolarised, the spread of electric current along membrane is known as depolarization wave or nerve impluse. When a nerve impluse reaches the synapse a chemical substace Ach is liberated which is responsible for the conduction of impulse. Human nervous system is divided into CNS and PNS.

The CNS consists of the brain and spinal cord. The brain is divided into fore brain, midbrain and hind brain. Forebrain consists of olfactory lobes, cerebral hemispheres and diencephalon The cerebral hemispheres are the largest parts of brain and are separated from each other by a longitudinal cerebral fissure and connected by the corpus callosum. Hypothalamus is a very important part of fore brain. The mid brain is a very small part, and consists of four small lobes, the corpora quadrigemina Hind brain consists of cerebellum, pons varoli and medulla oblongata.

Reflex action is a monotonous response to a stimulus. Reflex actions are of two types, voluntary and involuntary. Reflex arc is the nerve chain between a receptor and an effector organ. Reflexes are of two type conditional and unconditional.

The wall of the eye is composed of three layers. They are sclera, choroid and retina. Retina contains two types of photoreceptor cells, namely rods and cones. The light enters through cornea, the lens and images are formed on the retina. The ear is divided into external ear, the middle ear and internal ear. The middle ear contains three small ear ossicles are called malleus incus and stapes. Internal ear is a irregular, delicate and complicated organ. Membranous labyrinth is enclosed in bony labyrinth. Membranous labyrinth is filled with fluid, the endolymph. The membranous labyrinth is formed of 3 parts, vestibule, semicircular duct and cochlear duct. In the structure of organ of cortia group of hair cells is present which acts as auditory receptor and found on the basilar membrane. The vibratory movements are converted into nerve impulses, which are transmitted via auditory nerve to the auditory area of cerebrum, where the impulse are analysed and sound is recognised.

EXERCISE

1. Put a dark colour in a given circle for correct answer :

(1) From which the nerve impulses for hearing originate.

(a) Ear Ossicles ◯ (b) Cochlea ◯

(c) Auditory Nerve ◯ (d) Tympanic Membrane ◯

(2) In the resting stage of nerve, which is ture?

(a) Na^+ are pumped in and K^+ pumped out ◯

(b) Na^+ are pumped out and K^+ pumped in ◯

(c) There is no Na^+ or K^+ pump ◯

(d) None of these ◯

(3) Acetylcholine helps in

(a) Synaptic Transmission ◯ (b) Synaptic Delay ◯

(c) Membrane Permeability ◯ (d) None of these ◯

(4) Which ion produces action potential in a nerve fibre ?

(a) K^+ ◯ (b) Cl^- ◯ (c) Na^+ ◯ (d) Ca^{++} ◯

(5) Process of transmission of nerve impulse is

(a) Chemical ◯ (b) Physical ◯ (c) Biological ◯ (d) Mechanical ◯

(6) Which of the following pairs of elements/ions are required for conduction of nerve impulse?

(a) Na^+ and K^+ ◯ (b) Mg^{2+} and K^+ ◯

(c) Na^+ and Mg^{2+} ◯ (d) Ca^{2+} and Mg^{2+} ◯

(7) Organ of corti is found in

(a) Internal Ear ◯ (b) External Ear ◯

(c) Middle Ear ◯ (d) None these ◯

(8) Cerebellum is important in controlling

(a) Muscle Strength ◯ (b) Stretch Reflexes ◯

(c) Middle Ear ◯ (d) None of these ◯

(9) What is the location of structure which maintains the balance in human ?

(a) Outer Ear ◯ (b) Middle Ear ◯

(c) Inner Ear ◯ (d) Eustachian Tube ◯

(11) Node of Ranvier is seen in.....

(a) Cyton ◯ (b) Axon ◯ (c) Dendrite ◯ (d) Synape ◯

2. Answer the following questions in shorts :

(1) Name the fluid which is found in the space between pia mater and arachoid mater.

(2) Name the parts which constitute central nervous system (CNS).

(3) What is the origin of acetylcholine ?

(4) Where are the bipolar cells present in the human body ?

(5) Which is the principle mineral cation in the extracellular fluid ?

(6) Name the part of the brain which functions as endocrine gland.

(7) What is reflex action ?

3. Answer the following questions in detail :

(1) What is an impulse ? describe the physiology of impulse conduction.

(2) Describe the mechanism of hearing

(3) Describe the structure of internal ear.

(4) Describe the structure of forebrain of human.

(5) Write a brief note on synapse.

(6) How a nerve impulse is transmitted across a synaptic cleft ?

2

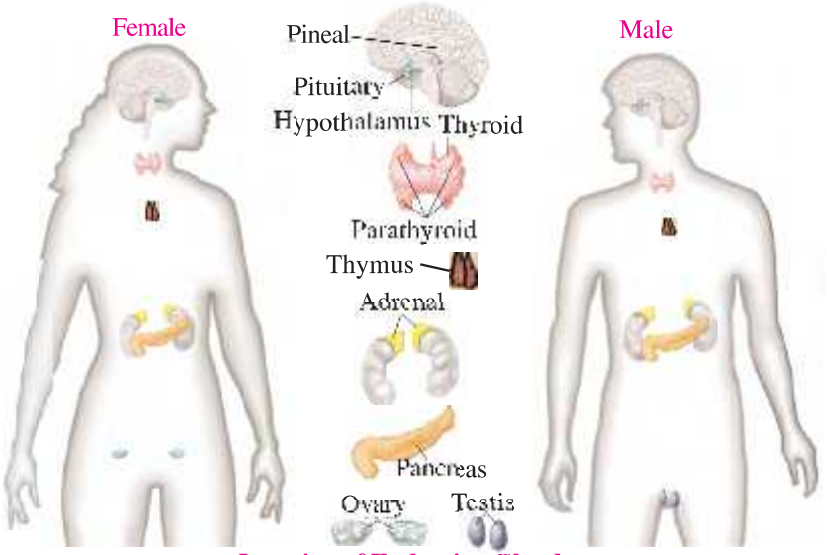
Chemical Coordination and Control

In the previous chapter, we have studied that the nervous system provides rapid coordination among organs. The nervous system controls speedily but its effects are very short lived. For example the nerve impulse transmits rapidly in milliseconds along the nerves to skeletal muscles, which respond immediately. But for the regulation of continuous cellular functions, control and coordination are done by endocrine system. Endocrine system is meant for internal regulation and communication of the human body. In this chapter we will study about human endocrine glands and their hormones and mechanism of hormones.

Endocrine Glands and Hormones

Endocrine glands are ductless and secrete the chemicals termed as hormones into the surrounding blood, which are then transported to the site of action, located away from the site of secretion. Hormones are special types of chemical messengers secreted by endocrine cells in one part of the body and influence the activity of various organs of another part of the body. They are effective in minute quantities to stimulate or inhibit specific physiological processes of the body. Hypothalamus, pituitary, pineal, thyroid, parathyroid, thymus, adrenal, pancreas, testis and ovary are the organised endocrine glands. In addition to these, hormones are secreted by some other organs, like heart, kidney and gastrointestinal tract.

Hypothalamus is the base of the diencephalon, a part of the forebrain. The hypothalamus is composed of nervous tissue and it regulates a wide range of body functions. Hypothalamus is connected with the anterior lobe of the pituitary gland by hypophysial portal vessels and with the posterior lobe of the gland by axon of its neurons. It contains several groups of neurosecretory cells which when stimulated, release hormones termed as neurohormones. These hormones regulate the synthesis and secretion of the pituitary hormones. Hypothalamus produces two types of hormones.

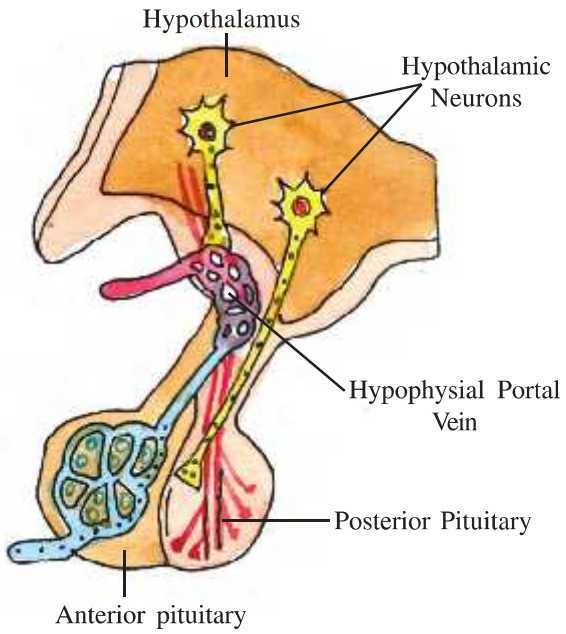


Location of Endocrine Glands

The releasing hormones (RH) stimulate secretion of pituitary hormones and the inhibiting hormones (IH) inhibit secretion of pituitary hormones. Growth hormones releasing hormone or somatotropic releasing hormone (GH.RH or STH.RH), stimulate the anterior pituitary to release growth hormone (GH) or somatotropin. Growth hormone releasing inhibiting hormone (GH-RIH), inhibits the secretion of growth hormone from the anterior pituitary.

Pituitary Gland

The pituitary gland is located just below the hypothalamus. It is situated in a depression of the sphenoid bone of the skull called sella turcica and attached to hypothalamus by stalk or infundibulum. Pituitary gland is divided anatomically into adenohypophysis and neurohypophysis (posterior lobe). Adenohypophysis consists of two parts, commonly known as anterior pituitary and pars intermedia. The anterior pituitary gland produces following hormones. (1) Growth Hormone (GH) or somatotropic hormone (STH) stimulates growth and development of all tissues by increasing cell division and protein synthesis. Dwarfism is caused by low secretion of GH. While Gigantism caused by over secretion of GH. It stimulates excess growth and abnormal height in childhood. In adult stage due of excess secretion of growth hormone, bones of lower jaw and libs becomes abnormally large which develops Acromegaly.



Pituitary and its Relationship with Hypothalamus

(2) Prolactin (PH) stimulates the growth of mammary gland and the secretion of milk after delivery. (3) Thyroid Stimulating Hormone (TSH) stimulates the thyroid and production of thyroid hormones. (4) Adrenocortico Trophic Hormone (ACTH) stimulates adrenal cortex to secrete glucocorticoid and mineralocorticoid hormones. (5) Leuteinising Hormone (LH) in male induces sex hormones-androgens (testosterone) which make the male reproductive system fully grown and functional. The (6) Follicle Stimulating Hormone (FSH) and androgen in male regulate spermatogenesis. In female LH causes ovulation of fully mature follicle (grafin follicles) and forms corpus luteum in the empty ovarian follicle.

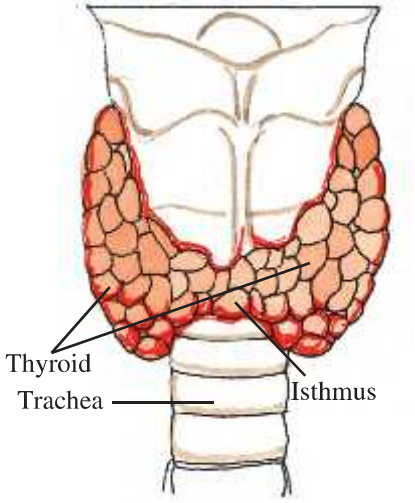
Follicle stimulating hormone (FSH) and Luteinising hormone are together termed as Gonadotrophic Hormones (GTHs). Intermediate lobe of pituitary secretes a hormones named Melanocyte Stimulating Hormone (MSH) which stimulates the melanocytes (black pigments in skin) and regulates pigmentation in skin. Posterior lobe of pituitary releases oxytocin and vasopressin. Oxytocin stimulates the contraction of smooth muscles of our body. In females, it stimulates a widening of uterus at the time of child birth and milk secretion from the mammary glands. Vasopressin stimulates the reabsorption of water and electrolytes by the distal tubules of kidney and reduces loss of water through urine (diuresis). It is also called anti-diuretic hormone (ADH). The deficiency of ADH reduces reabsorption of water and increases urine output. This disorder is known as diabetes incipidus.

Pineal Gland

The pineal gland is located under the corpus callosum between the two cerebral hemispheres of the brain. It is a very small, solid, vascular, reddish grey and conical body. Pineal secretes a hormone called melatonin, which plays a very important role in the regulation of a 24-hour rhythm of our body. Hence it functions as a biological clock. Pineal gland helps in maintaining the normal rhythm of body temperature, and sleep-wake cycle. The melatonin regulates metabolism, menstrual cycle, pigmentation and self defense capability.

Thyroid Gland

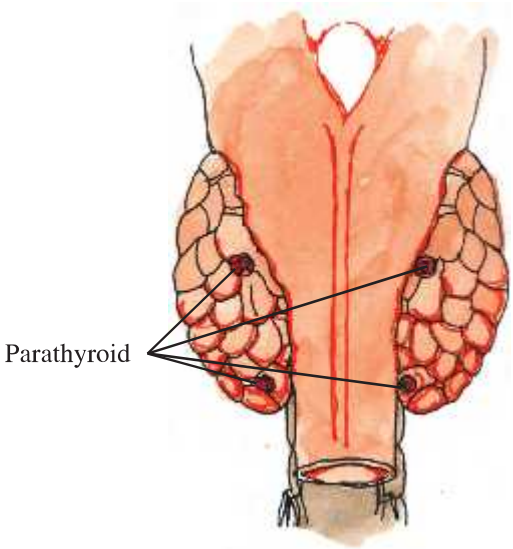
The Thyroid gland is bilobed, and located on either side of the upper part of the trachea. The two lobes are connected by a narrow connective tissue band called isthmus. The thyroid gland is composed of rounded follicles, which has a wall of cuboidal epithelium, and is filled with a gelatinous colloid secreted by epithelium. The thyroid gland secretes three hormones : Thyroxine (T4), Triiodothyronine (T3) and Thyrocalcitonin. Iodine is essential for the hormone of thyroid gland. Deficiency of iodine in our diet causes the enlargement of the thyroid gland, commonly known as Goiter. Hypothyroidism is caused by under secretion of thyroid gland. During pregnancy, it causes defective development and maturation of the infants leading to cretinism. A person with cretinism has stunted growth, mental retardation, abnormal skin and deaf-mutism. Hyperthyroidism in adult women may cause irregular menstrual cycle. In adult women the deficiency of hormone causes myxodema characterized by puffy appearance due to accumulation of fat in the subcutaneous tissue. Over secretion of Thyroxine hormone causes Exophthalmic Goitre, in which bulging of eyeballs, quick heart beat, rise in blood pressure and body temperature occur. Thyroid hormone plays an important role to control the general metabolism of carbohydrate by regulating the oxidation and ATP production. It maintains the basal metabolic rate (BMR) of the body. Thyroid hormone stimulates the process of RBC formation. Thyroid hormone also maintains water and electrolyte balance. Thyroid gland secretes hormone Thyrocalcitonin (TCT) which acts upon osteoblast of bones and decreases the calcium level in blood.



Thyroid Gland (Dorsal Side)

Parathyroid

The four lobes of parathyroid glands are located on the ventral surface of the thyroid gland. The parathyroid secretes only one hormone called Parathyroid hormone or Parethormone (PTH). PTH increasesthe Ca^{2+} level in blood. PTH acts on bone and activates the process of bone resorption. PTH increases Ca^{2+} absorption from the digested food and also activates reabsorption of Ca^{2+} by renal tubules. PTH along with TCT plays a significant role in maintenance of calcium balance in the body.



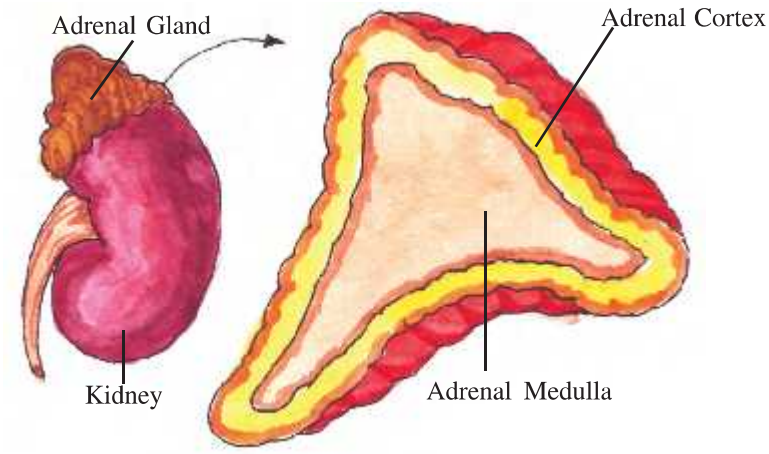
Diagrammatic View of the Position of Thyroid and Parathyroid Ventral Side

Thymus

It is located in upper dorsal side of the heart and aorta. The thymus is a soft, bilobed mass of lymphoid tissue. Thymus secretes hormone Thymosin. The thymus plays a major role in the development of the immune system. Thymosin stimulates the development and differentiation of T - lymphocytes which provide cell-mediated immunity. Beside this, thymosin stimulates the production of antibodies to provide humoral immunity. In children it is a prominent gland, but it gradually degenerates in the adult, resulting in a decreased secretion of thymosin. Due to this, the immune responses of old persons become weak.

Adrenal Gland

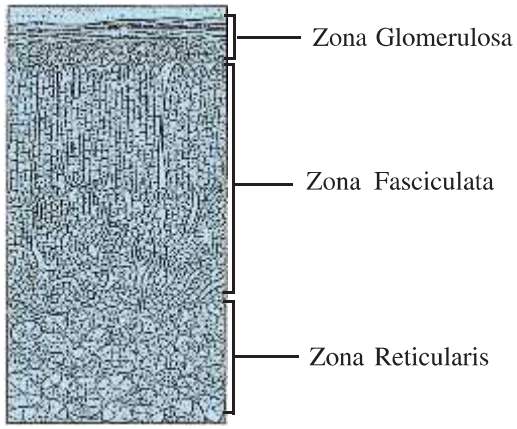
A pair of adrenal glands is present, one on the anterior part of each kidney. The adrenal gland is yellowish and conical in shape. Each gland has two distinct regions known as outer adrenal cortex and inner adrenal medulla. The adrenal medulla is a soft, dark reddish brown part. The adrenal medulla secretes two hormones known as adrenaline or epinephrine and noradrenaline or norepinephrine. They are placed in group called catecholamines. At the time of danger or stress or emergency, the CNS stimulates the medulla to secrete adrenaline and nor adrenaline. These hormones play an important role to over come 'flight or fight' situation hence they are called emergency hormones. Due to these hormones increase alertness and warm red face, pupilary dilation, raising of hairs, faster heart beats and sweating like symptoms are often noticeable. Catecholamine also activates the breakdown of glycogen resulting in an increased level of glucose in blood. They also stimulate the breakdown of protein and lipid.



Adrenal Gland and Kidney

Two Regions of Adrenal Gland

The adrenal cortex is divided into three layers : the inner layer Zona reticularis, middle layer, Zona fasciculata and the outer layer Zona glomerulosa. Each layer produces its own set of steroid hormones called corticoids. The adrenal cortex is important for life, because its destruction or removal causes death. Mineralocorticoids are secreted by outer layer. They regulate mineral metabolism and the balance of water and Na^+. Glucocorticoids hormones are secreted by middle region of adernal cortex. They regulate carbohydrate, protein and fat metabolism. They have antiallergic and anti-inflamatory effects and suppress the immune responses. The main glucocorticoid is cortisol. Sexcorticoids are hormones secreted by both, middle and inner parts of the cortex, which include male and female sex hormones. The male sex hormone, testosterone, stimulates the development of male secondary sexual characters such deepening of voice and distribution of hairs on body. The female sex hormones are estrogen and progesterone. The estrogen stimulates secondary sexual characters such as enlargement of breast and menstruation.



Adrenal L.S.

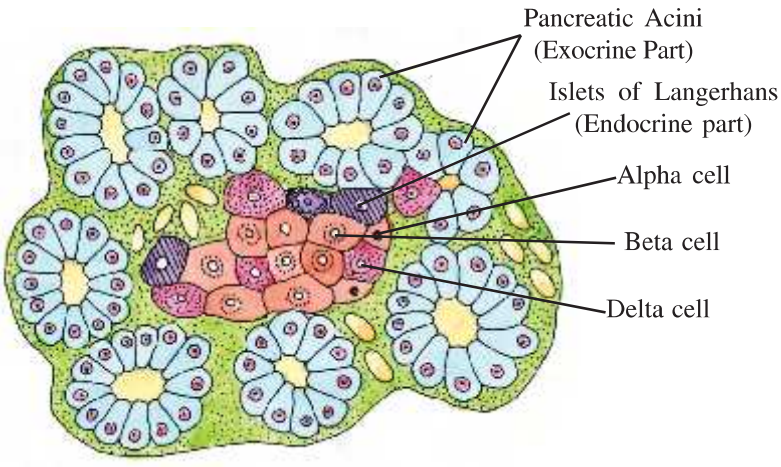
Disorders of Adrenal Gland

Addision Disease : It is caused by deficiency of mineralocorticoid, characterizid by ion imbalance. The symptoms include weakness, weight loss, vomitting, nausea and diarrhoea.

Cushing's syndrome is caused by excess secretion of cortisol. The symptoms include high blood sugar, obesity and rise in blood pressure and blood volume.

Pancreas

The pancreas is an elongated yellowish and lobulated gland. Pancreas acts as both exocrine as well as endocrine gland. The endocrine part of pancreas consists of about 1 to 2 million islets of Langerhans.



A Part of T.S. of Pancreas

The three main types of cells present in the islets of Langerhans are α-cells, -cells and delta cells. The β-cells secrete a hormone called glucagon which increases blood glucose level. Glucagon is a peptide hormone and is secreted in response to a fall in the blood glucose level. Glucagon acts mainly on liver cells and stimulates glycogenolysis resulting in an increased blood sugar (hyperglycemia). Glucagon also stimulates the process of gluconeogenesis which results in rise of blood glucose level. Thus Glucagon is a hyperglycemic hormone. Secretion of insulin from β-cells is stimulated by increased blood glucose level. Insulin acts mainly on liver cells and adipose tissue and increases cellular glucose uptake and utilisation. As a result there is a transfer of glucose from blood to liver cells and adipose tissue resulting in decreased blood glucose level(hypoglycemia). Insulin stimulates conversion of glucose to glycogen (glycogenesis). The glucose level is thus maintained by opposite effect of above both the hormones. Deficiency of insulin causes diabetes mellitus. Diabetes can cause damage to kidney, blood circulation and vision. The symptoms of diabetes are excessive urination, excessive thirst, greater hunger etc. This disease can be controlled by proper diet-control, physical excercise and external introduction of insulin. Delta cells are about 5% and secrete somatostatin, which inhibits growth hormone (GH).

Testis

Testis are situated in the scrotum (outside abdomen) of male. They secrete male sex hormones known as androgens, mainly testosterone is secreted from the group of Leydig's cells. Testosterone stimulates the development, maturation and functions of the male accessory sex organs like epididymis, vas deference, seminal vesicle, prostate gland and urethra. These hormones stimulate the development of male accessory sex characters like beard and moustaches, muscular growth, axillary hair, low pitch of voice, aggressiveness and broadening of shoulders. Androgens play a main stimulatory role in the process of maturation spermatogenesis. It also acts on the CNS and influences the male sexual behaviour and sex urge.

Ovary

A pair of ovary lie in the abdomen. Ovary secretes three steroid female sex hormones **:** estrogen, progesterone and relaxin. Ovary is composed of ovarian follicle and stromal tissues. Growing ovarian follicles secrete estrogen and after ovulation, the ruptured follicle is converted to corpus luteum which secretes progesterone.

Estrogen stimulates the female reproductive system to grow to full size and becomes functional. It also stimulates the secondary sex characters (e. g. enlargement of breast, broadening of pelvis, growing axillary hair). It also stimulates development of ovarian follicles in the ovary.

Progesterone supports embryo and foetal development and suspends ovulation, implantation of the foetus in the uterine wall, and helps in placental formation. Progesterone also acts on the mammary glands to stimulate milk secretion and storage of milk. Relaxin is secreted by corpus luteum at the end of the gestation period. It relax the cervix of the uterus for easy birth of the young one.

Hormones of Heart, Kidney and Gastrointestinal Tract

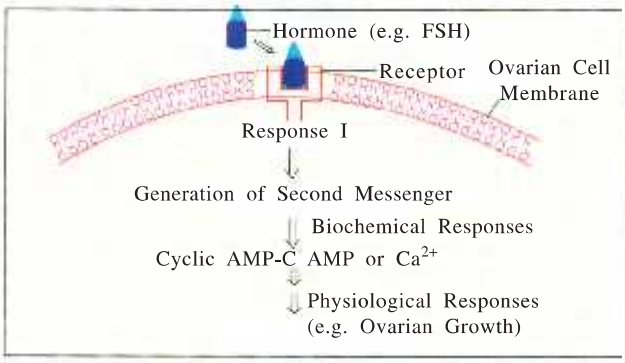
Hormones are also secreted by some tissues which are not endocrine glands. The atrial wall of heart secretes peptide hormone known as Atrial Natriuretic Factor (ANF) which decreases blood pressure, when blood pressure is increased. ANF causes dilation of the blood vessels, which reduces the blood pressure. The juxtaglomerular cells of kidney secrete erythropoietin which stimulates formation of RBCs (erythropoiesis). In different parts of gastro intestinal tract endocrine cells are present which secrete peptide hormones namely gastrin, secretin, cholecystokinin (CCK) and Gastric Inhibitory Peptide (GIP). Gastrin stimulates gastric glands to secrete pepsinogen and HCl. Secretin acts on the exocrine gland of pancreas and stimulates the secretion of bicarbonate ions and water. CCK acts on pancreas and gall bladder and stimulates them to secrete pancreatic enzyme and bile respectively. GIP inhibits gastric secretion. Many non endocrine tissues secrete hormones known as growth factors, which are important for normal growth of tissues and their repairing and regeneration.

Mechanism of Hormone Action

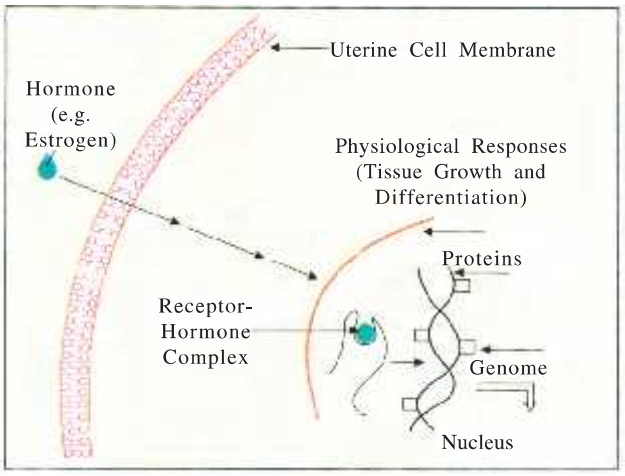
Hormones exhibit their effects on target cells by binding to specific proteins known as hormone receptors proteins, found only in the target cells. These hormone receptors, found on the cell membrane of the target cells, are known as membrane-bound receptors. Receptors found inside the target cells are known as intracellular receptors. Binding of a hormone to its receptors leads to formation of hormone receptors complex. Each receptor is specific to one specific hormone only and hence receptors are specific. Formation of hormone receptor complex creates certain biochemical changes in the target cells. Metabolic processes and physiological processes in target cells are regulated by hormones. On the basis of their chemical nature, hormones can be divided into following groups.

(i) peptide, polypeptide, protein hormones (e.g. insulin, gulcagon, pituitary hormones, hypothalamus hormones). (ii) steroid (eg. cortisol, testosterone and progesterone) (iii) iodothyronines (thyroid hormones) (iv) amino acid derivatives (epinephrine).

Hormones which interact with membrane-bound receptor generally do not enter the target cell and generate second messengers (eg. cyclic AMP, Ca^{2+} IP_3 (Inositol tri phosphate) which in turn regulate cellular metabolism. Hormones which bind with intracellular receptors such as steroid, mostly regulate gene expression by the interaction of hormone-receptor complex with the genome. As a result of many biochemical reactions, physiological reactions and development are affected.



Mechanism of Peptide Hormone



Mechanism of Steroid Hormone

SUMMARY

The nervous system controls speedily, but its effects are of very short period. Continuous regulation of cellular functions is necessary. This control and coordination is done by endocrine system. Endocrine is ductless gland and mainly secretes the chemicals termed hormones. Hormones are effective in minute quantity to stimulate or inhibit specific physiological processes of the body. The endocrine system consists of hypothalamus, pituitary, pineal, thyroid, adrenal, pancreas, parathyroid, thymus testis and ovary. In addition to these endocrine glands, some other organs. eg. gastrointestinal tract, heart and kidney also secrete hormones.

The hypothalamus contains several groups of neurosecretory cells, which produce releasing hormones (RH) and inhibiting hormones (IH). The pituitary gland is divided into three parts, anterior pituitary, intermediate lobe and posterior lobe. The anterior pituitary secretes six hormones, intermediate lobe secretes only one hormone and posterior lobe secretes two hormone. The pituitary hormones regulates the growth, and induce secretion of sex hormones. Pineal gland secretes melatonin which regulates 24 hour rhythm of body temperature.

The thyroid hormone plays an important role in the control of general metabolism and maintains BMR of the body. The parathyroid gland secretes parathyroid hormone (PTH) which increases the Ca^{+} level in blood. Thymus secretes hormone thymosins which stimulates development of T-lymphocytes and provide cell-mediated immunity. It also stimulates the production of antibodies to provide humoral immunity.

Adrenal gland have two regions known as adrenal cortex and adrenal medulla.The adrenal medulla secretes adrenaline and noradrenaline. The role of these hormones is often called flight or fight reaction. The hormones increase alertness, and cause warm red face, pupillary dilation and faster heart beat. The adrenal cortex secretes mineralocorticoids which regulate mineral metabolism, and the balance of water and Na^{+}. Glucocorticoids hormone regulates carbodydrate, protein and fat metabolism.

The main glucocorticoids is sex corticoids, which includes male and female sex hormones. Testosterone is a male sex hormone while oestrogen and progesterone are female sex hormones. The pancreas secretes hormones glucagon and insulin. Glucagon stimulates glycogenolysis and gluconeogenesis resulting in hyperglycemia. Insulin stimulates cellular glucose uptake and glycogenesis resulting in hypoglycemia. Insulin deficiency results in a disease called diabetes mellitus.

Testis secretes sex hormone mainly testosterone which stimulates development, maturation and functions of the male accessory sex organs. The ovary secretes estrogen which stimulates growth and development of female reproductive system and secondary sex characters. Progesterone plays an important role during delivery and prevents ovulation. Relaxin relaxes the cervix of the uterus for easy birth of the young one. The atrial wall of the heart secretes ANF which decreases blood pressure. The kidney produces erythropoietin which stimulates formation of RBC. The gastrointestinal tract secretes gastrin, secretin, cholecystokinin and gastric inhibitory peptide(GIP). These hormones regulate the digestive enzyme secretion and help in digestion.

EXERCISE

1. Put a dark colour in a given circle for correct answer :

(1) Which of the following does not secrete any hormone?

(a) Spleen ◯ (b) Ovary ◯ (c) Testes ◯ (d) Pancreas ◯

(2) The number of hormones secreted by anterior pituitary is

(a) 3 ◯ (b) 4 ◯ (c) 6 ◯ (d) 8 ◯

(3) The disease caused by hypo secretion of thyroxine is

(a) Goiter ◯ (b) Cretinism ◯

(c) Acromegaly ◯ (d) Addison's disease ◯

(4) Gigantism and acromegaly result from hypersceretion of

(a) ADH ◯ (b) GH ◯ (c) TSH ◯ (d) ACTH ◯

(5) Emergency gland of body is

(a) Thymus ◯ (b) Testis ◯ (c) Adrenal ◯ (d) Pituitary ◯

(6) Progesterone hormone is secreted by

(a) Corpus callosum ◯ (b) Corpus luteum ◯

(c) Corpus albicans ◯ (d) Thymus ◯

(7) To whom secretin stimulates ?

(a) Lungs ◯ (b) Gall bladder ◯

(c) Pancreas ◯ (d) Gastric glands ◯

(8) Which of the following is not a steroid hormone?

(a) Aldosterone ◯ (b) Androgen ◯

(c) Estrogen ◯ (d) Thyroxine ◯

2. Answer the following questions in short :

(1) Which are the two main types of glands in our body ?

(2) Define Hormone.

(3) What is the location of hypothalamus ?

(4) Name the gland which acts as an exocrine as well as an endocrine gland.

(5) Name the cells which secrete testosterone.

(6) Name the cells which secrete estrogen.

(7) Name the hormones secreted by thymus gland.

3. Do as directed :

(1) Differentiate between exocrine and endocrine glands.

(2) What is acromegaly ?

(3) Why is an injection of oxytocin hormone given at the time of childbirth ?

(4) State the differences between cretinism and myxoedema.

4. Answer the following questions in detail :

(1) What is hormone ? Describe thyroid gland in detail.

(2) Give an account of adrenal gland.

(3) Give an account of pancreas as a gland.

3

Reproduction in Organisms

All organisms reproduce. Reproduction is a biological process in which an organism gives birth to offspring similar to itself. The offspring grow, mature and in turn produce new offspring. Thus, there is a cycle of birth, growth and death. Reproduction enables the retention continuity of the species, from generation to generation. The genetic variation is created and inherited during reproduction.

There is a large diversity in the biological world and each organism has evolved its own mechanism to multiply and produce offspring. The organism's habitat, its internal physiology and several other factors are collectively responsible for how it reproduces. There are two types of reproduction in organisms, asexual and sexual. When offspring is produced by a single parent without the involvement of gamete formation, the reproduction is called asexual. When two parents (opposite sex) participate in the reproduction process and also involve fusion of male and female gametes, it is called sexual reproduction.

Asexual Reproduction

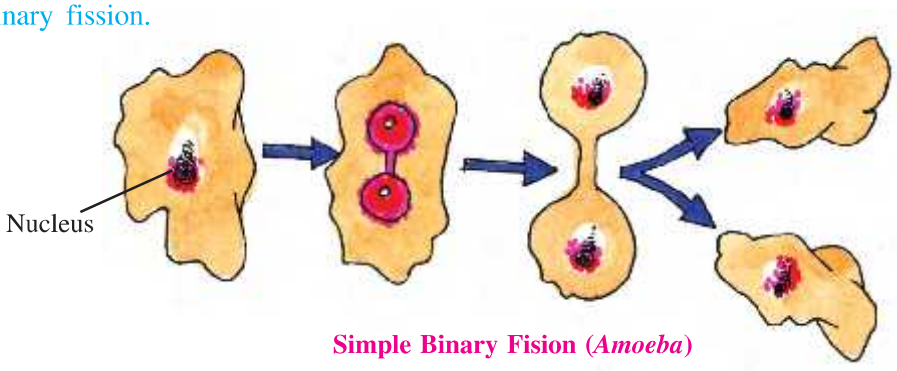
In asexual reproduction a single, parent is involved and is capable of producing offspring. As a result, the offsprings that are produced are not only identical to one another but are also exact copies of their parent. Asexual reproduction is common among single-celled organisms, and in plants and animals with relatively simple organizations. It is also seen in multicellular organisms.

Asexual Reproduction in Animals

In animals the common modes of asexual reproduction are as follows :

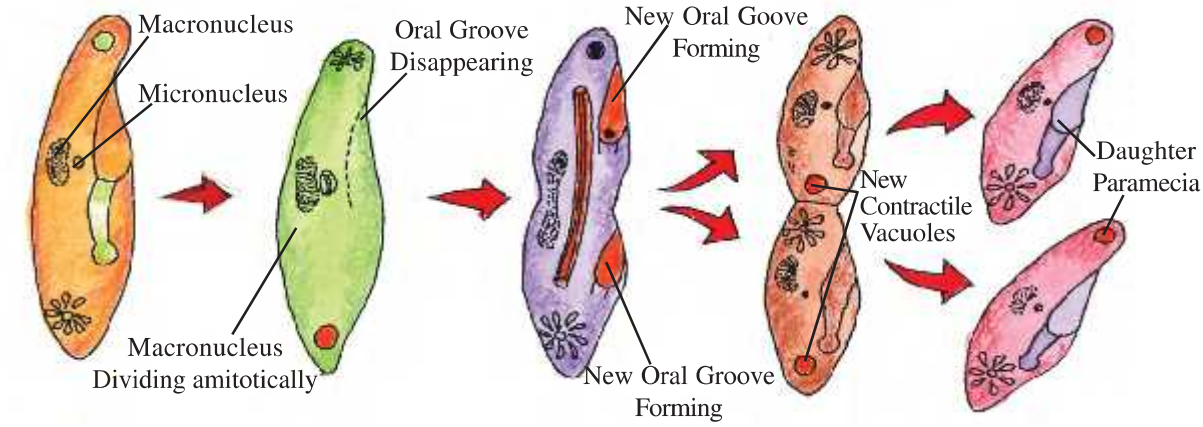
(1) Fission : This method is observed in Protists and Monerans. In fission, the nucleus divides first and the cytoplasm next. Subsequently, the mother cell splits into two equal sized daughter cells. This division is of cell division type.

When the cytoplasmic division passes through any direction (e.g. *Amoeba*) the fission is called simple binary fission.



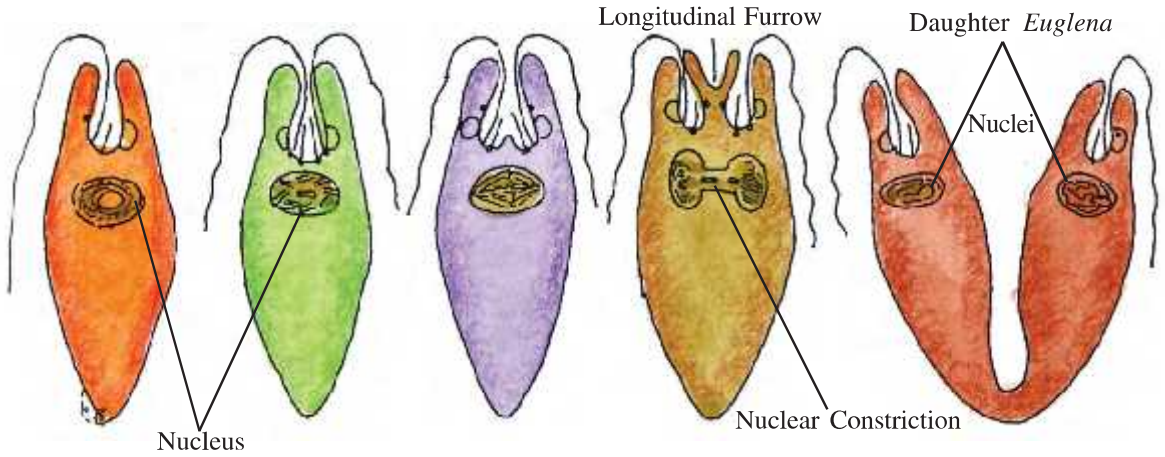
Simple Binary Fision (*Amoeba*)

If the plane of cytoplasmic division coincides with the transverse axis of the individual, the fission is termed transverse binary fission. Eg. *Paramoecium* and *Planaria*.



Transverse Binary Fission in *Paramoecium*

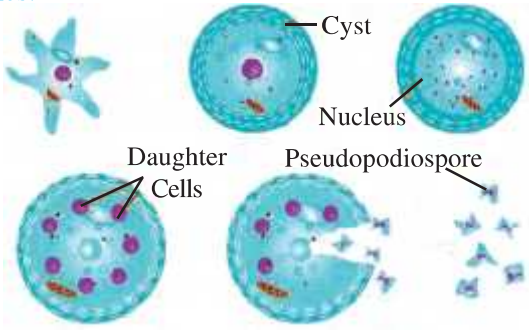
In *Euglena* and *Vorticella*, the plane of cytoplasmic division coincides with the longitudinal axis of the individual. This kind of fission is designated as longitudinal binary fission.



Longitudinal Binary Fission in *Euglena*

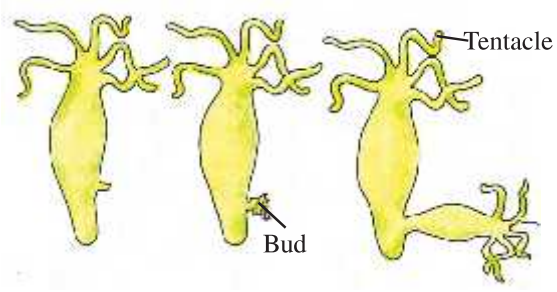
Binary fission involves mitosis only and consequently the resultant offsprings are genetically identical to the parent and to each other. It may be mentioned here that genetically identical offsprings resulting from a single parent are considered as clones.

Sometimes, the nucleus divides several times by amitotic nuclear division. Thus large numbers of nuclei are formed. Cytoplasm does not divide during this period. Then cytoplasm collects around each nucleus. Thus, within one maternal cell, innumerable unicellular and uninucleate offspring are formed. In course of time, they live as independent, unicellular organisms. This method of reproduction is called multiple fission. Multiple fission is observed in *Amoeba* and *Paramoecium*, *plasmodium*.



Sporulation in Amoeba

(2) Sporulation : Sporulation occurs during unfavorable conditions. Organisms like *Amoeba* withdraw their pseudopodia and become round in shape. They create a hard protective three layered cyst around themselves, this process is called encystations. When conditions become favorable, the nucleus of encysted *Amoeba* undergoes multiple divisions and a large number of *Amoeba* are formed. These are called pseudopodiospores. This process is called sporulation. When the cyst ruptures all new *Amoebae* are released. In *Plasmodium* this process occurs at a specific stage in its life cycle.

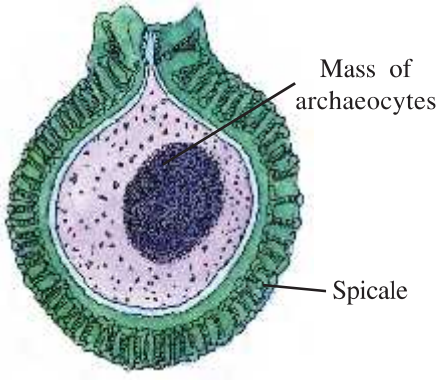


Exogenous Bud in Hydra

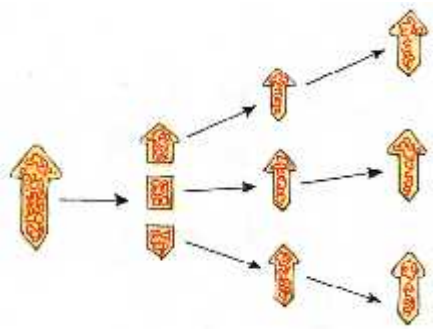
(3) Budding : In this method, first of all, cells of some part of the body of the animal repeatedly undergo mitotic cell divisions and the raised regions of cell masses, called bud, are formed. From such a bud a young animal develops. It separates from the parent body and lives as an independent animal.

If such a bud is produced on the outside of the body it is called exogenous budding. In *Hydra*, exogenous budding is observed.

In fresh water sponge (e.g. *Spongilla*) and marine sponge (e.g. Sycon) specialized cell masses are produced towards the inside of the body. An envelope surrounds this cell mass. Such structures are called internal buds or gemmules. Each gemmule gives rise to a new animal. This is called endogenous budding.



Internal Buds in Spongilla



Regeneration in *Planaria*

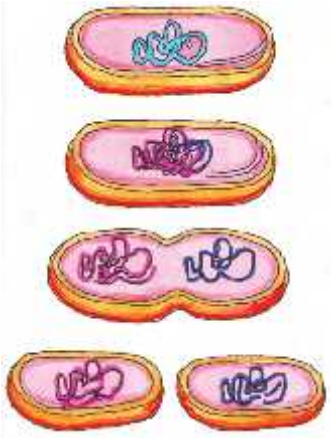
(4) Fragmentation : In this method of reproduction, the body becomes fragmented into several distinct parts. Each part develops the remaining body parts and becomes a complete animal. This capacity is known as regeneration. Fragmentation is observed in *Planaria*, *Hydra,* Starfish etc.

Asexual Reproduction in Plants

The common modes of asexual reproduction in plants is as following :

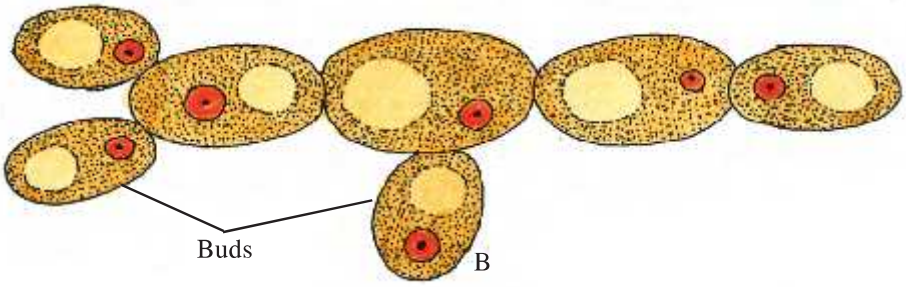
(1) Fission :

It is the simplest method, commonly found in algae, fungi and monerans (bacteria). In this process, the unicellular mother cell divides mitotically to form two daughter cells; each eventually grows into an independent organism.



Fission in Bacteria

(2) Buds : Some algae produce adventitious branches (e.g. *Dictyota, Fucus*) or buds (e.g. *Protosiphon*) where as fungus like yeast produces buds. These structures are formed due to unequal division and are attached to the parental cell which eventually gets separated and matured into a new organism.



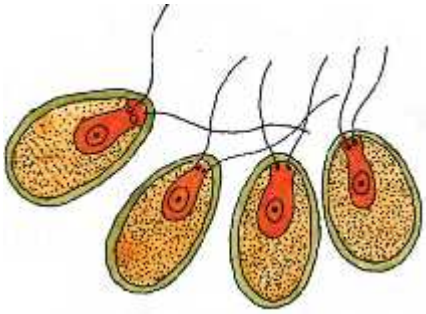
Buds in Yeast

(3) Fragmentation : In some algae (e.g. *Ulothrix, Oedogonium, Spirogyra and Zygnema*) and fungi (e.g. *Mucor, Rhizophus, Saprolegnia*), the vegetative thallus or hyphae break up into small segments due to mechanical pressure and each segment is capable of growing into a new mycelium

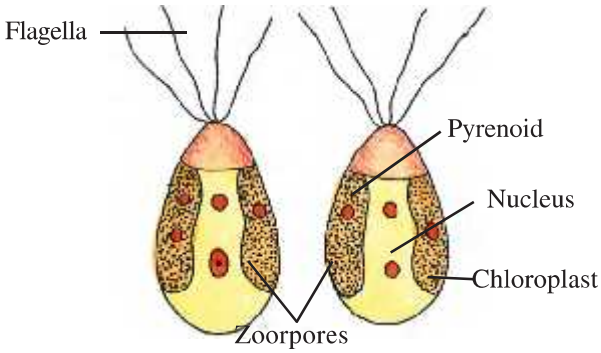
(4) Spore Formation : Asexual reproduction takes place by a variety of motile or non motile spores/conidia.

Ciliate motile spore, called zoospores are produced by algae and fungi, which swim in water for some time with the help of their flagella and then directly develop into new independent individuals, e.g. *Ulothrix, Chlamydomonas, Oedogonium*.

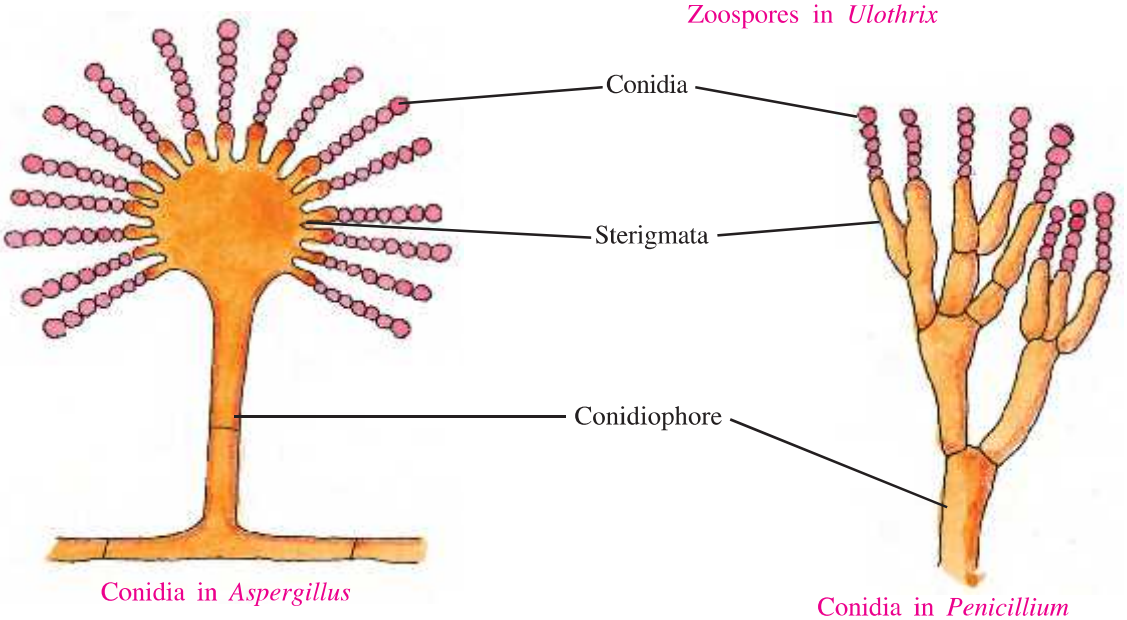
Non-flagellate and non-motile spore/conidia of various kinds are most common among terrestrial fungi. Such spores are light, dry and provided with a tough coat, and are well adapted for dispersal by wind e.g. *Penicillium, Aspergillus*.



Zoospores in *Chlamydomonas*



Zoospores in *Ulothrix*



Conidia in *Aspergillus*

Conidia in *Penicillium*

Spore Formation

True spores are always borne by a sporophyte. Thus, the sporophyte of mass reproduces asexually by spores. Similarly ferns (Nephrolepis) bear spores and reproduce asexually by them. These plants are homosporous (bear only one kind of spores). While in *Selaginella* (a pteridophyte) and gymnosperms they are heterosporous (bears two types of spores).

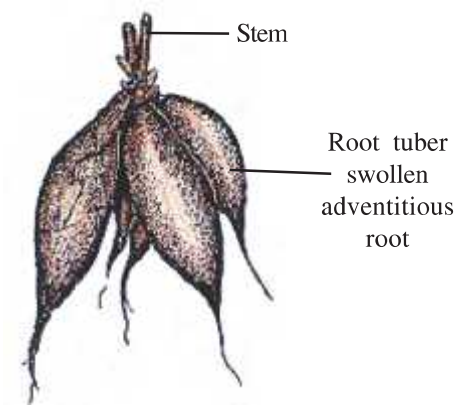
In animals and other simple organisms, the term asexual is used unambiguously while in plants, the term vegetative reproduction is frequently used.

In flowering plants the methods of vegetative propagation or reproduction are grouped into natural and artificial.

(i) Natural Methods

In natural methods of propagation, the development of a new plant from some organ of the mother plant under suitable environmental conditions is very common. Such special reproductive organs develop from stem, leaf, root or even flower.

Vegetative reproduction occurs through roots in Sweet potato, *Asparagus* and Dahlia.

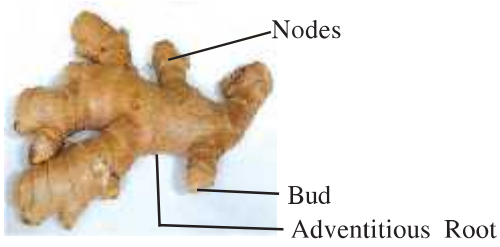


Roots of Dahlia

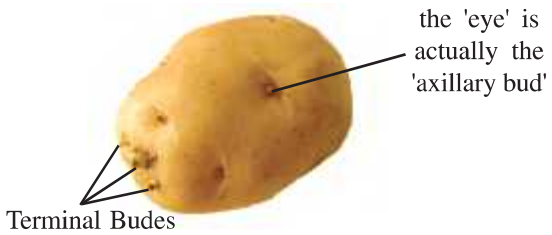
Sweet Potato

Vegetative Reproduction by Root

Ginger, Turmeric, *Amorphophalus*, potato and onion reproduce vegetatively through stem.



Ginger

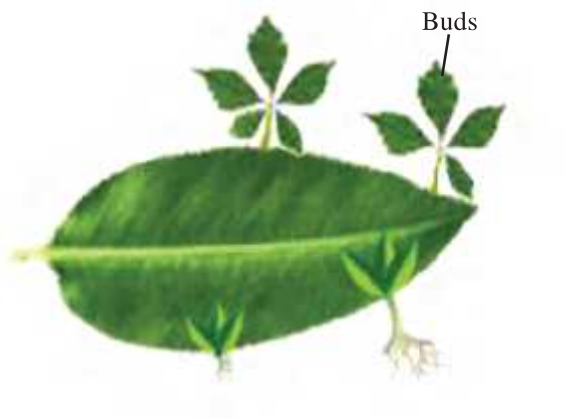


A Stem Tuber : Potato

Vegetative Reprodauction by Stem

In plant like *Bryophyllum,* buds develop in the margins of leaves. These buds produce new plants.

In plants like *Agave* and *Oxalis*, floral buds produce new plants and in *Dioscorea*, axillary buds do so.



Vegetative Reproduction by Leaf in *Bryophyllum*

Vegetative Reproduction by Floral Buds in *Agave*

Among the other natural methods of vegetative propagation, runners observed in lawn grass, offsets found in *Pistia*, stolons in *Nephrolepis* and suckers in mint plant are noteworthy.

(ii) Artificial Methods

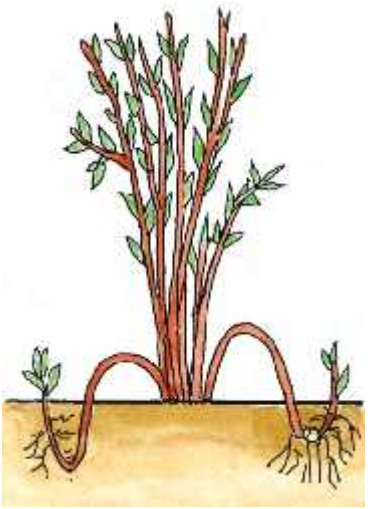
Methods are developed for artificial vegetative propagation in which some part of the plant organ is utilized for obtaining a new complete plant. Amongst them the most common methods are – cutting, layering and grafting.

(1) Cutting : Cut pieces of root are planted in moist soil and development of adventitious roots is artificially induced. New plants are developed in this way in lemon and tamarind.

In Rose, Sugarcane, *Croton*, China-rose and *Chrysanthemum* plants, proper sizes of stem pieces are obtained and are planted in moist soil to develop new plants. From the underground parts of stem, adventitious roots develop and buds on the aerial parts of stems sprout. The plant, so developed is called a "cutting". Later, these cuttings are transplanted in proper places.

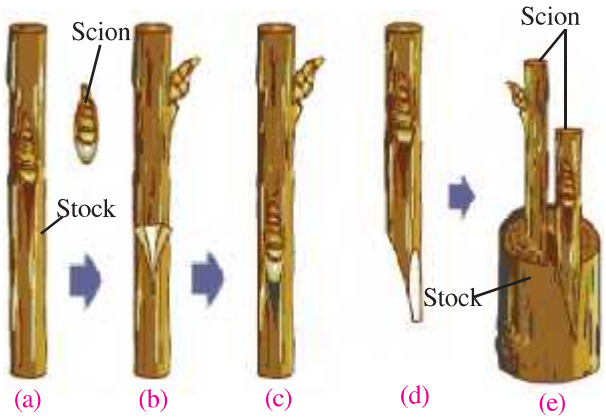
(2) Layering :

This method is employed in the cultivation of Rose, Lemon, Grape, *Hibiscus* and Jasmine. The lower branches of the plant are bent and pressed under the soil in such a way that the tip of the branch remains outside the soil and the middle portion is buried inside the soil. When adventitious roots develop from this buried region of plant stem, this branch is cut and separated from the parent plant. Thus, a new plant is obtained.



Layering

(3) Grafting : Grafting is practised in plants which do not root easily, or have a weak root system. In this method a union is established between two plants of the same or different kinds. Such a union is established between tissues of the two plants. This process can be induced more successfully amongst those plants which possess meristematic tissue.



Grafting

The main supporting plant is called stock plant. The plant which is being grafted on it is called scion. A plant possessing higher and desirable characters is selected as "scion". Various methods of grafting scion are practiced. Mango, Apple, Pear, *Citrus*, Guava, Litchi and many other fruit-yielding plants are thus obtained and maintained.

Grafting may be of different types, namely bud grafting, side grafting, tongue grafting, wedge grafting and crown grafting depending on the methods of uniting the two parts.

Significance of Vegetative Reproduction

(1) Vegetative reproduction is an ideal method of reproduction in plants in which it is desirable to maintain the same characteristics in the offspring which are present in the parents.

(2) Plants showing reduced power of sexual reproduction, long dormant period of seed or poor viability can also be multiplied easily through this method.

(3) Vegetative reproduction also helps in removing common infections from the parent plant.

(4) In the plants raised through grafting, it is even possible to bring together the desired characters from two plants.

Sexual Reproduction

Sexual reproduction involves formation of the male and female gametes, either by the same individual or by different individuals of the opposite sex. These gametes fuse to form the zygote which develops to form the new organism. It is a complex and slow process as compared to asexual reproduction. Because of the fusion of male and female gametes, sexual reproduction results in offspring that are not identical to the parents or amongst themselves.

Though the plants, animals or fungi differ in external morphology, anatomy and physiology, yet their sexual mode of reproduction is similar in pattern. All organisms reach a certain stage of growth and maturity in their life before they can reproduce sexually. This period is called the juvenile phase and in plants it is known as vegetative phase.

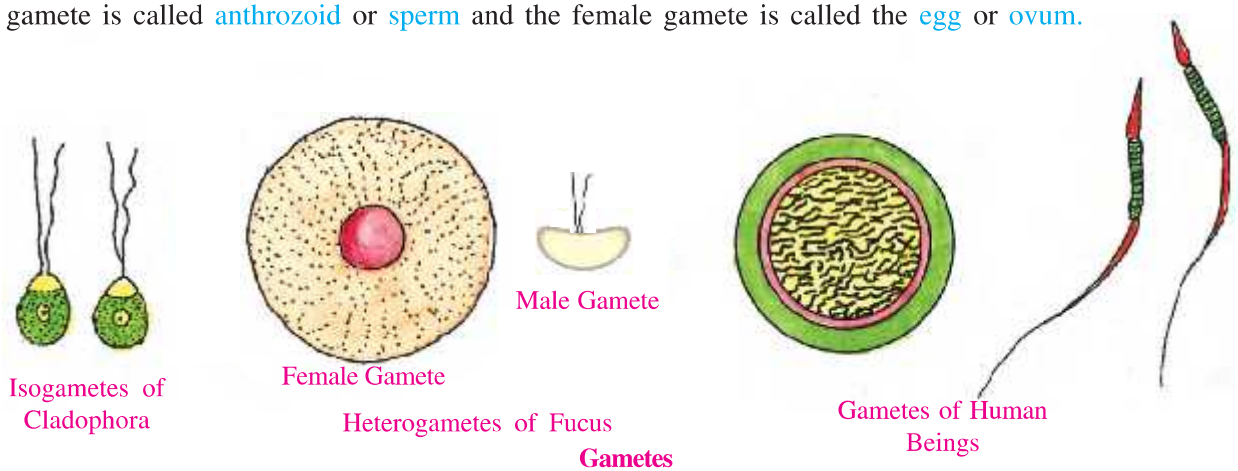
After attaining maturity, all sexually reproducing organisms show events and processes which have fundamental similarity, but the structures associated with sexual reproduction are quite different. In all cases, the sexual reproduction is characterized by the fusion of the male and female gametes of the species. For convenience these sequential events may be grouped into three distinct stages namely, the pre-fertilization, fertilization and the post-fertilization events.

Pre-Fertilization Events

The pre-fertilization events of sexual reproduction are found prior to the fusion of gametes. The two main pre-fertilization events are gametogenesis and gamete transfer.

(1) Gametogenesis : Gametogenesis is the process of formation of gametes. Generally gameter are of two types. i.e. male and female gametes. Gametes are haploid (n) cells. In some algae where two gametes are similar in appearance they are called isogametes or homogametes. It is morphologically and

physiologically similar and usually motile and has flagellates (e.g. *Cladophora, Ulothrix*). However in a majority of sexually reproducing organisms the gametes produced are of two morphologically and physiologically distinct types which are known as heterogametes or anisogametes. The male gametes are smaller and more active whereas the female gametes are larger and sluggish. In such cases the male gamete is called anthrozoid or sperm and the female gamete is called the egg or ovum.



Gametes

Gametes are always haploids, but the parent plant body from which they arise may be either haploid or diploid. A haploid parent produces gametes by mitotic division. Several organisms belonging to Monera, Fungi, Algae and Bryophyta have haploid plant body but in majority of organisms belonging to Pteridophyta, Gymnosperms, Angiosperms and most of the animals, the parental body is diploid. Here meiosis takes place to produce haploid gametes.

In diploid organisms the meiocytes (gamete mother cells) undergo meiosis. At the end of meiosis, only one set of chromosomes (n) gets incorporated in each gamete. Table showing diploid and haploid chromosome numbers of organisms.

Name of Organisms	Chromosome Number in Meiocyte ($2n$)	Chromosome Number in Gamete (n)
Apple	34	17
Maize	20	10
Onion	32	16
Potato	48	24
Rice	24	12
Cat	38	19
Dog	78	39
Human beings	46	23
House fly	12	06

(2) Gamete Transfer : After formation, the male and female gametes are brought together to facilitate fertilization. In a majority of organisms, male gamete is motile and the female gamete is stationary. There is a need for a medium through which the male gametes move. In Algae, Bryophytes and Pteridophytes, water is the medium through which this gamete transfer takes place. A large number of the male gametes, however, fail to reach the female gametes. To compensate this loss of male gametes during transport, the number of male gametes produced is several thousand times the number of female gametes produced.

In Angiosperms pollen grains are the carriers of male gametes and ovule has the egg cell. Pollen grains are produced in anthers and are transferred to stigma, a phenomenon which is known as

pollination. This phenomenon requires the involvement of external agents such as insects, animals, wind and water. Pollen grains germinate on the stigma and the pollen tubes carrying the male gametes reach the ovule and discharge two male gametes near the egg cell.

In bisexual animals, since male and female gametes are formed in different individuals, the organism must evolve a special mechanism for gamete transfer. It is essential for fertilization.

Fertilization

The fusion of two similar or dissimilar gametes is called syngamy and in its result diploid zygote is formed. This process is known as fertilization.

In majority of algae, fishes and amphibians, syngamy occurs in the external medium i.e. water (outside the body of the organism). This type of gametic fusion is called external fertilization. This happens in the bony fishes and frogs where a large number of offspring are produced. A major disadvantage is that the offspring are extremely vulnerable to predators threatening their survival upto adulthood.

In Plant groups (i.e. Fungi, Bryophytes, Pteridphytes), as well as Reptiles, Birds, and Mammals, syngamy occurs inside the body of the organism, hence the process is called internal fertilization. In this process, male gametes are motile and have to reach and fuse with egg. This takes place inside the female body.

In seed plants, the non-motile male gametes are carried to female gamete by pollen tubes.

Post-fertilization Events

The formation of zygote and the process of development of embryo (embryogenesis) are called post-fertilization events.

(1) Zygote : Formation of zygote (2n) is common in all sexually reproducing organisms. In organism with external fertilization, zygote is formed in the external medium (water), whereas in those exhibiting internal fertilization, zygote is formed inside the body of organism. Further development of zygote depends on the type of life cycle the organism possesses and the environment to which it is exposed. In organisms, such as Algae and Fungi, zygote develops a thick wall that is resistant to desiccation and damage. Commonly it undergoes a period of rest prior to germination.

Some unicellular protist animals (e.g. *Paramoecium*) exhibit sexual reproduction by forming male and female gamete nuclei, which they exchange through temporary cytoplasmic bridge, later the cytoplasmic bridge disappears and the gamete nucleus of one individual fuses with that of the other to form zygote nucleus. This mode of sexual reproduction is known as conjugation.

Zygote is the vital link that ensures continuity of species between organisms of one generation and the next.

(2) Embryogenesis : Embryogenesis is the process of development of embryo from the zygote. During embryogenesis, zygote undergoes cell division (mitosis) and cell differentiation.

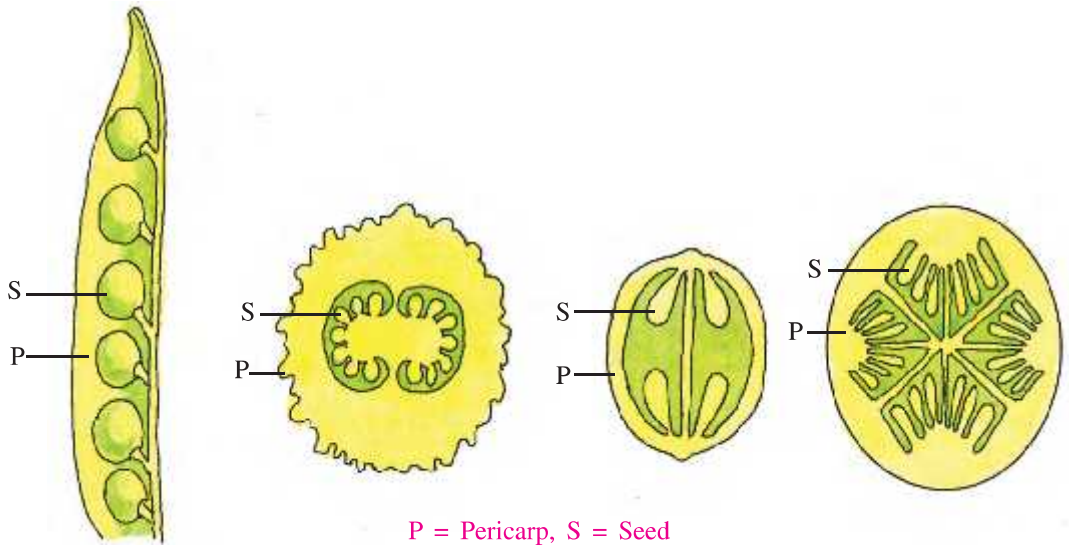
Cell divisions increase the number of cells in the developing embryo while cell differentiation helps groups of cells to undergo certain modifications to form specialized tissues and organs to form an organism.

In animals, when the development of zygote takes place outside the body of the female parent, it is called oviparous, while when it develops inside then it is called viviparous.

Oviparous

In oviparous animals like Reptile and Birds, the fertilized eggs covered by hard calcareous shell are laid in a safe place in the environment; after a period of incubation, young ones hatch out. On the other hand, in viviparous animals like Mammals including human beings the zygote develops into a young one inside the body of the female organism. After attaining a certain stage of growth, the young ones are delivered out of the body of the female parent. Because of proper embryonic care and protection, the chances of survival of young ones is greater in viviparous organisms.

In Angiosperms, the zygote is formed inside the ovule. After fertilization the sepals, petals, and stamens of the flower fall off. The pistil however, remains attached to the plant. The zygote develops into the embryo and the ovules develop into the seed. The ovary develops into the fruit which develops a thick wall called pericarp that is protective in function. After dispersal; seeds germinates under favourable condition to produce new plants.



P = Pericarp, S = Seed

L.S. / T.S. of Various Types of Fruits with Seeds

SUMMARY

Reproduction is a biological process in which an organism gives rise to offspring similar to itself. There are two types of reproduction in an organism, asexual and sexual. In asexual reproduction a single parent is involved and capable of producing offspring. Fission, sporulation, budding and fragmentation are the common modes of asexual reproduction seen in animals and plants. Zoospore, conidia, etc. are the most common asexual structures formed in several Algae and Fungi. In flowering plants vegetative reproductions is natural and artificial. In natural method, the development of a new plant take place under suitable environmental conditions from some organs like stem, leaf, root or even flower of the mother plant.

Runners, offsets, stolons and suckers are the common natural methods of reproduction seen in Angiosperms. The artificial methods of propagation are cutting, layering and grafting. In vegetative reproduction, the offspring are nurtured in the body of the parents.

Sexual reproduction involves formation and fusion of gametes. It is a complex and slow process as compared to asexual reproduction. Events of sexual reproduction may be categorized into the pre-fertilization, fertilization and post-fertilization events.

Pre-fertilization events of sexual reproduction are found prior to the fusion of gametes. The two main pre-fertilization events are gametogenesis and gamete transfer. Gametes are always haploid and homogametes or heterogametes. After formation, the male and female gametes are brought together to facilitate fertilization.

The fusion of two similar or dissimilar gametes is called syngamy which results into formation of diploid zygote; this process is known as fertilization. It is external or internal.

The formation of zygote and the process of development of embryo are called post fertilization events. Zygote is the vital link that ensures continuity of species between organisms of one generation and the next. Embryogenesis is the process of development of embryo from the zygote. During embryogenesis zygote undergoes cell division (mitosis) and cell differentiation. Cell divisions increase the number of Cells while differentiation helps group of cells to undergo certain modifications to form specialized tissues and organs to form an organism.

EXERCISES

1. Put a dark colour in a given circle for correct answer :

(1) Reproduction in *Amoeba* takes place by

(a) Binary fission ○ (b) Budding ○

(c) Zoospore formation ○ (d) Fragmentation ○

(2) What is flagellate motile spore called ?

(a) Conidia ○ (b) Zoospores ○

(c) Homospores ○ (d) Heterospores ○

(3) Non-flagellate spores known as conidia are found in

(a) *Penicillium* ○ (b) *Hydra* ○

(c) *Amoeba* ○ (d) *Chlamydomonas* ○

(4) Which animal reproduce by exogenous budding ?

(a) *Hydra* ○ (b) Spongilla ○

(c) *Plasmodium* ○ (d) *Amoeba* ○

(5) Which animal reproduce by multiple fission ?

(a) *Hydra* ○ (b) *Plasmodium* ○

(c) Spongilla ○ (d) *Amoeba* ○

(6) Which animals have a well developed capacity of regeneration ?

(a) *Hydra*, Starfish ○ (b) *Plasmodium* ○

(c) Earthworm ○ (d) *Spongilla* ○

(7) Sporulation occurs in

(a) *Plasmodium* ○ (b) *Hydra* ○

(c) Starfish ○ (d) Spongilla ○

(8) Which plant carries out vegetative reproduction with the help of root ?

(a) *Oxalis* ○ (b) *Bryophyllum* ○

(c) Onion ○ (d) Dahlia ○

(9) Which plant carries out vegetative reproduction with the help of floral buds ?

(a) *Oxalis* ◯ (b) *Bryophyllum* ◯

(c) Ginger ◯ (d) *Asperagus* ◯

(10) Which part in the plant *Bryophyllum* takes place in vegetative reproduction ?

(a) Stem ◯ (b) Floral buds ◯

(c) Underground roots ◯ (d) Buds in leaf margin ◯

(11) Which special method of vegetative reproduction occurs in Nephrolepis ?

(a) Offsets ◯ (b) Stolons ◯ (c) Runners ◯ (d) Suckers ◯

(12) Which one of the following is not the natural method of vegetative reproduction ?

(a) Suckers ◯ (b) Cutting ◯ (c) Runner ◯ (d) Offsets ◯

(13) Chromosome number in meiocyte of Apple is_____

(a) 17 ◯ (b) 34 ◯ (c) 20 ◯ (d) 10 ◯

(14) Conjugation as a sexual reproduction occurs in which animal ?

(a) *Birds* ◯ (b) *Hydra* ◯ (c) *Paramecium* ◯ (d) *Spirogyra* ◯

(15) Development of zygote which takes place outside the body is called.

(a) Viviparous ◯ (b) Oviparous ◯

(c) Oviviparous ◯ (d) None of these ◯

2. Answer the following questions in short :

(1) Define asexual reproduction

(2) Which animals are reproduced by binary fission ?

(3) Explain-clones

(4) Which animals reproduce by multiple fission ?

(5) What is fragmentation ?

(6) Define-reproduction

(7) What is Stock ?

(8) Explain-juvenile phase

(9) Define-Gametogenesis

(10) Gametes are always _____ (n/$2n$/$3n$) cells

(11) Give chromosome number in meiocytes of onion and house fly

(12) Explain-Fertilization

(13) Give the name of the main events of post fertilization

(14) Give the name of unicellular protist

(15) What is embryogenesis ?

3. Write short notes on :

(1) Sporulation in animal
(2) Spore formation in plants
(3) Fission in animals
(4) Fission in plants
(5) Fragmentation in animals
(6) Fragmentation in plants
(7) Cutting
(8) Layering
(9) Grafting
(10) Significance of vegetative reproduction
(11) Fertilization
(12) Zygote
(13) Embryogenesis
(14) Heterogametes and Homogemetes
(15) Pollination in Angiosperms

4. Answer the following questions in detail :

(1) What is asexual reproduction ? Describe common modes of asexual reproduction in animals.

(2) What is asexual reproduction ? Describe common modes of asexual reproduction in plants.

(3) Describe artificial methods of vegetative reproduction.

(4) Describe pre-fertilization events.

(5) Describe post-fertilization events.

4

Sexual Reproduction in Flowering Plants

Introduction

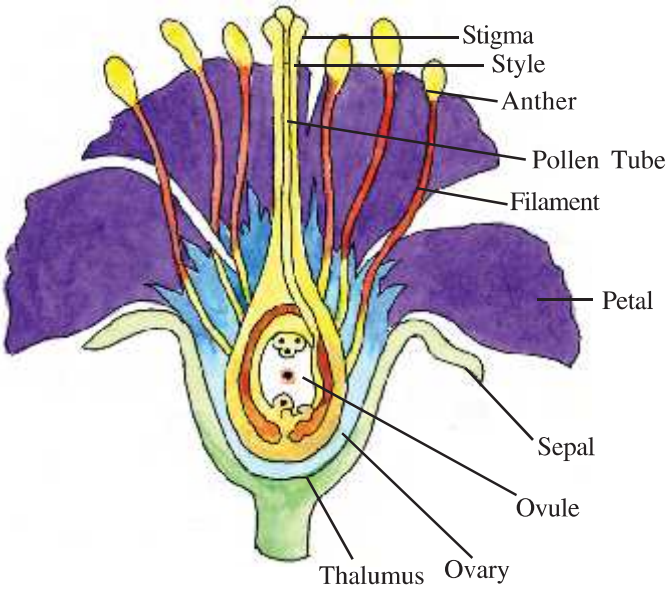
Reproduction is the most important characteristic of all living beings, plants and animals. It is a process of producing offspring and a means of self-perpetuation. The mode of reproduction varies according to individual species and available conditions. In lower angiosperms, it may be simply by division of cell or budding, whereas in higher organisms, it may be with the help of fully developed sex organs.

In higher plants reproduction may be asexual or sexual. In asexual reproduction, sex organs are not involved, and reproduction takes place by means of asexual methods, while in sexual reproduction, fusion of male and female gametes take place. Generally, in angiosperm plants the male and female sex organs are called stamen and pistil respectively. In some cases special modes of reproduction like apomixis and polyembryony are also reported. In this chapter, you will study various processes involved in the reproduction of flowering plants.

Flower : A Sexual Reproductive Part of Angiosperm Plants

Human beings have had an intimate relationship with flowers since time immemorial. Flowers are objects of aesthetic, social, ornamental, religious and cultural value. They have always been used as symbols for conveying important human feelings such as love, affection, happiness, grief, mourning and others.

Flower is the reproductive part of a plant. The flower is a compressed shoot, in which the sepals, petals, stamens and carpels are successive lateral organs. All these lateral organs are homologous to a leaf. The receptacle of the flower resembles structurally a vegetative tip. A typical flower has four sets of appendages, the outer two sets of sterile and the inner two sets of fertile appendages.



L.S. of Flower

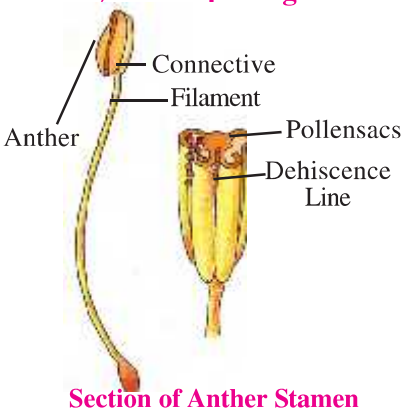
The two types of sterile appendages are sepals, which together form the calyx, and petals which make up the corolla. The two types of fertile appendages are stamens (microsporophylls) which make

up the androecium, and carpels (megasporophylls), which together produce the gynoecium. The stamen is typically a slender organ and includes two distinct parts, a proximal sterile part, the filament, and a distal fertile part, the anther, and the connecting structure between anther and filament is called connective. The carpel is generally divided in to a proximal ovule bearing part, the ovary, a distal pollen receptive part, the stigma, and a sterile region between ovary and stigma, the style.

Pre-Fertilization : Structures and Events

The differentiation and further development of the floral primordium to a flower is due to several hormonal and structural changes. In the flower, the androecium (representing the male reproductive organ) and the gynoecium (representing the female reproductive organ) differentiate and develop.

Stamen, Microsporangium and Pollen Grain



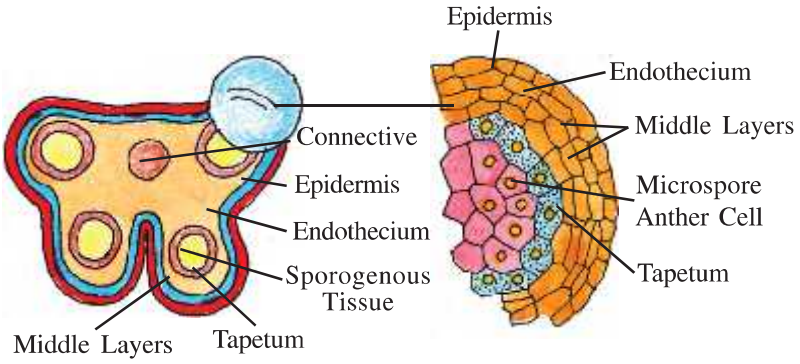
Section of Anther Stamen

Stamen : A stamen is known as microsporophyll. It is regarded as the male reproductive part of flower. A stamen consists of a filament, connective and an anther. The proximal end of the filament is attached to the thalamus of the flower. The number and length of stamens are variable in flowers of different species.

Internal Structure of Anther

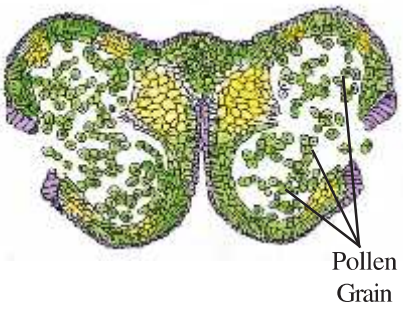
An anther is bilobed with each lobe having two theca, i.e. they are tetrathecous. Often a longitudinal groove runs lengthwise separating the theca. In transverse section, the anther is a tetragonal structure consisting of four microsporangia located at the corners. The microsporangia develop further and become pollen sacs. Pollen sacs are packed with pollen grains.

The typical microsporangium appears near circular in outline. It is generally surrounded by four wall layers – the epidermis, endothecium, middle layers and the tapetum. The epidermis is made of 3 to 5 layers. The cells of epidermis are greatly stretched and flattened. The endothecium is made of fibrous layers. These layers perform the function of protection and help in dehiscence of anther to release the pollen. The innermost layer of the wall develops into a single layered tapetum. It nourishes the developing pollen grains. The cells of tapetum have dense cytoplasm and conspicuous nuclei. The centre of each microsporangium process is made of compactly arranged homogenous cells called sporogenous tissue.



Anther T.S.

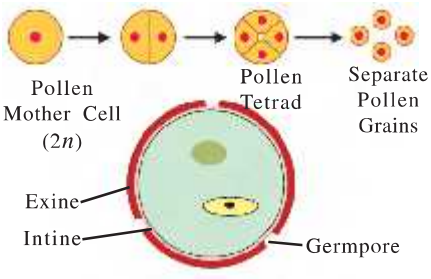
Enlarged View of Microsporangia



Mature Dehisced Anther

Microsporogenesis

As the anther develops, the cells of the sporogenous tissue undergo meiotic divisions to form microspore tetrads. Each one is a potential pollen. The process of formation of microspores from a pollen mother cell through meiosis is called microsporogenesis. The microspores, as they are formed, are arranged in a cluster of four cells- the microspore tetrad. As the anthers mature and dehydrate, the microspores dissociate from each other and develop into pollen grains. Inside each microsporangium several thousands of microspores are formed that are released with the dehiscence of anther.



Mature Microsporogenesis

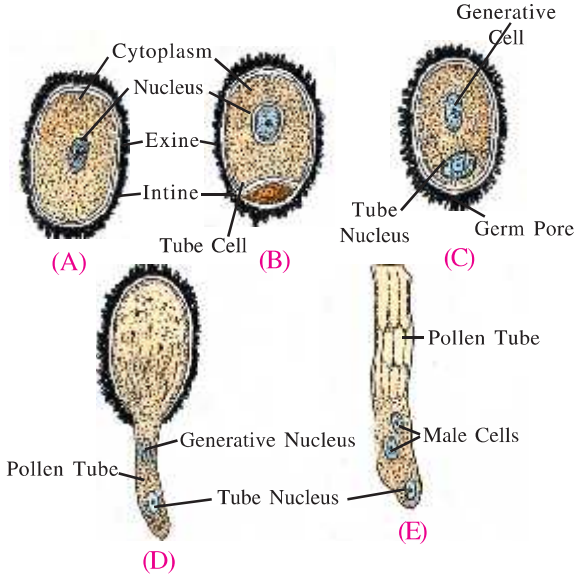
Pollen Grains

The pollen grain or microspore represent the male gametophytes and are possessed in the pollen sac or microsporangia. Pollen grain is a unicellular structure. They are very minute in size and are like particles of dust. Thus may be round, oblong, oval or rod like in shape. Pollen grains are generally spherical measuring about 25-50 micrometers in diameter. Thus may be smooth or spiny.

A pollen grain is uninucleate. The wall of pollen is two-layered. The hard outer layer is called exine. It is made of sporopollenin which is one of the most resistant organic materials known. It can withstand high temperatures and strong acids and alkali. No enzyme that degrades sporopollenin is so far known. Pollen grain exine has prominent aperatures called germpores where sporopollenin is absent. Pollen grains are well preserved as fossils because of the presence of sporopollenin. The inner layer of the pollen grain is called intine. It is thin and made up of cellulose and pectin. The cytoplasm of pollen grain is surrounded by a plasma membrane.

Development of Male Gametophyte

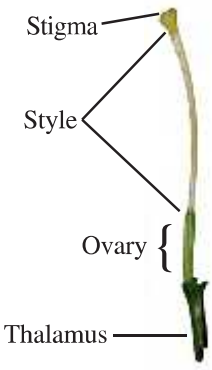
The development of male gametophyte from pollen begins when the pollen is still within the anther. The nucleus increases in size and then mitotically divides to produce two dissimilar cells. The large cell having abundant food reserve and large irregular shaped nucleus is called vegetative cell. The small cell is called generative cell.



Development of Male Gametophyte

When the pollen is at this stage of development, the anther dehisces in various ways and pollen is liberated. The intine of pollen develops as a pollen tube and comes out of a germ pore. It now extends through the style and grow towards the ovary. During this process, the tube cell remains in the terminal region of the pollen tube. It is gradually disintegrated. The generative cell divides mitotically and produces two male gametes.

The Pistil, Megasporangium and Embryo Sac



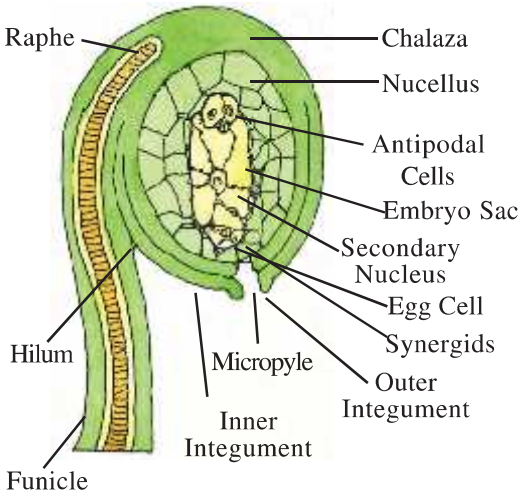
Pistil

Pistil : A gynoecium (pistil) is known as megasporophylls. It is a female reproductive part of the flower. When the pistil consists of only one carpel (e.g. in pea flower), it is called monocarpellary, and when it consists of two or more carpels, the pistil is said to be multicarpellary. The multicarpellary pistil can be apocarpus (free carpels) or syncarpous (united carpels).

Each carpel includes three parts-stigma, style and ovary. The stigma is the terminal end of the style upon which the pollen grain fall, and is generally knob-like and sticky. The style is the slender part beneath the stigma. The surface of the style can be smooth or covered with hairs. The swollen basal part of the pistil is the ovary. Inside the ovary is the ovarian cavity or locule. The placenta is located inside the ovarian cavity. Arising from the placenta is the megasporangia commonly called ovules. The number of ovules in the ovary may be one (wheat, mango) to many (papaya, orchids).

The Megasporangium (Ovule)

The ovule is small, oval structure attached to the placenta by a small stalk termed the funicle. The body of the ovule fuses with funicle in the region called hilum. Thus hilum represents the junction between ovule and funicle. Each ovule has one or two protective envelopes called integuments. A small opening is left at the apex of the integuments, this is termed the micropyle. Opposite the micropylar end, is the chalaza, representing the basal part of the ovule. The main body of the ovule has abundant reserve food materials. The nucellus is enclosed within the integuments. A large oval cell lying embedded in the nucellus toward the micropylar end is the embryo sac or female gametophyte. This makes a significant part of the mature ovule. It is an embryo sac, which bears the embryo later on.



L.S. of Ovule (Megasporangium)

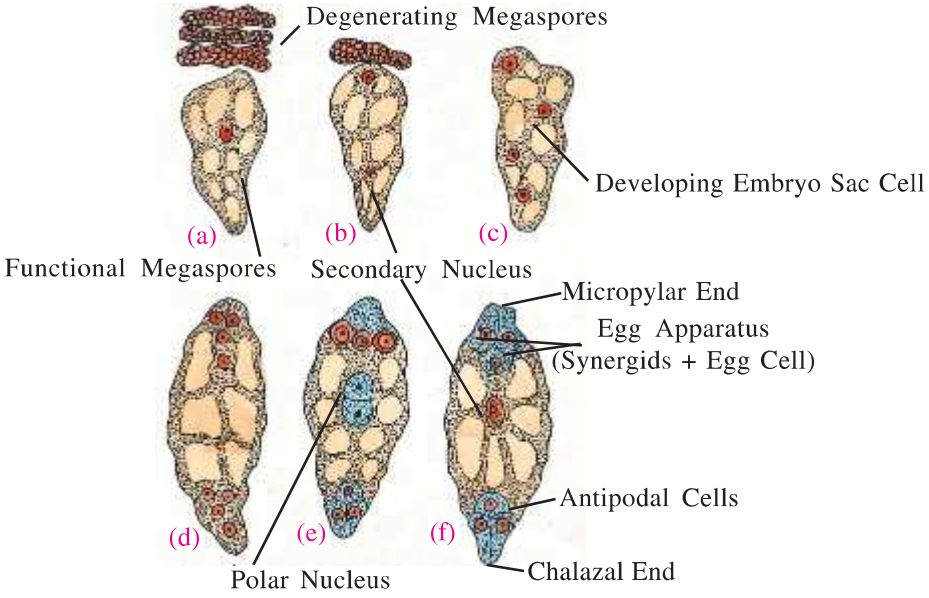
Megasporogensis

The process of formation of megaspores from the megaspore mother cell (MMC) is called megasporogenesis. Ovule differentiates a single megaspore mother cell, in the micropylar region of the nucellus. It is a large cell containing dense cytoplasm and a prominent nucleus. It divides meiotically and forms four haploid megaspores.

Embryo Sac (Female Gametophyte)

The megaspore (n) is the beginning of the female gametophyte generation. Generally of these four, only one becomes functional and produces the female gametophyte while the other three degenerate. This method of embryosac formation from a single megaspore is termed monosporic development.

The nucleus of the functional megaspore divides three times in succession and thus eight nuclei come into existence. A Female gametophyte develops through the organization of these eight nuclei. Three nuclei get organized into an egg-apparatus at the micropylar end. The egg-apparatus consists of one egg cell and two synergid cells. Towards the challazal end three nuclei get organized into three antipodal cells. Two nuclei jointly form a secondary nucleus (the large central cell) in the central region. Thus, a typical Angiosperm embryosac, at maturity, though 8-nucleate is 7-celled.



Development of Female Gametophyte

Pachanan Maheshwari in 1950 classified the female gametophyte into monosporic, bisporic and tetrasporic embryosac depending upon the number of megaspore nuclei taking part in the development.

Pollination

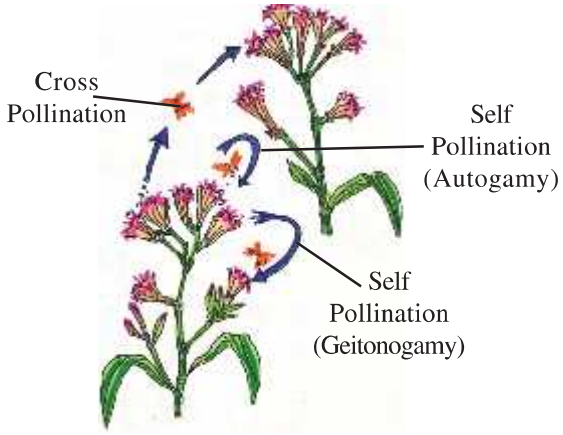
The process of transfer of pollen released from the anther to the stigma of a carpel is called pollination.

Kinds of pollination

Depending on the source of pollen, pollination can divided into two types.

(1) Self Pollination : Transfer of pollen from an anther to the stigma of the same flower of the same plant is called self-pollination. It can exist in bisexual flowers as well as unisexual flowers which exist on the same plant (monoecious condition). The process of self pollination can be of the following two types.

(a) Autogamy : In this type of self pollination, pollen grains of an anther are transferred to the stigma of the same flower. In other words, autogamy means pollination of a flower by its own pollens. Naturally autogamy is possible only in bisexual flowers.



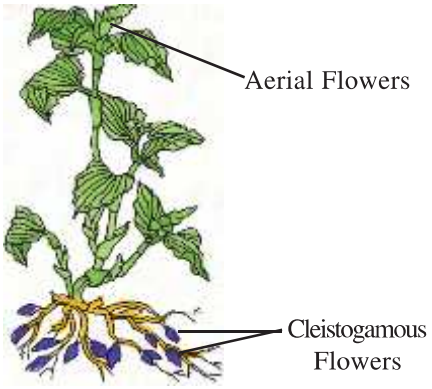
Self and Cross Pollination

In autogamous flowers, the stigma and anthers of a flower ripe almost simultaneously and this facilitates self-pollination. In several members of the Apiaceae, Lamiaceae and Cactaceae, there is a visible bending movement in the style which places the stigma closer to the anther.

(b) Geitonogamy : When the pollens of a flower pollinate any other flower present on the same plant, it is known as geitonogamy. Although geitonogamy is functionally cross-pollination involving a pollinating agent, genetically it is similar to autogamy since the pollen grain come from the same plant.

Adaptations Contrivances for Self Pollination

(i) Homogamy : It is the situation in which anther and stigma of a flower mature at the same time. Therefore the stigma is receptive at the time when anthers shed their pollens as in *Catharanthus roseus* (Barmasi). So there is a grater chance of self pollination although that is not obligatory.



Cleistogamy in *Commelina*

(ii) Cleistogamy : Production of flowers which never open is called cleistogamy and such flower are known as cleistogamous flowers. In such flowers, self pollination is carried out within closed buds. Therefore it is a remarkable way of avoiding cross-pollination e.g. *Viola*, *Oxalis* and *Commelina*.

Many plants which bears cleistogamous flowers also bear chasmogamosus flowers. There flowers open normally during anthesis. In *Commelina* cleistogamous flowers are produced on underground rhizomes or roots. They are small and inconspicuous, while chasmogamous flowers borne on aerial branches are generally bright coloured and attractive. Therefore cleistogamy may be called a facultative character.

(2) Cross Pollination : Transfer of pollen grains from the anther of the flower on one plant to the stigma of the flower on another plant, whether of the same kind or not, is called cross-pollination or allogamy. Cross pollination within a species is called xenogamy. Cross pollination involving different strains of plants yields hybrids. Cross-pollination is possible only in unisexual flowers. Cross-pollination leads to cross-fertilization; it has the advantage of genetic recombination.

The adaptations contrivances for cross pollination as follows :

(i) Dichogamy : In bisexual flowers, male and female sex organs mature at different time.

(ii) Self Sterility : Landing of pollen on stigma is no guarantee for seed set.

(iii) Heterostyly : In flowers which have styles of different lengths.

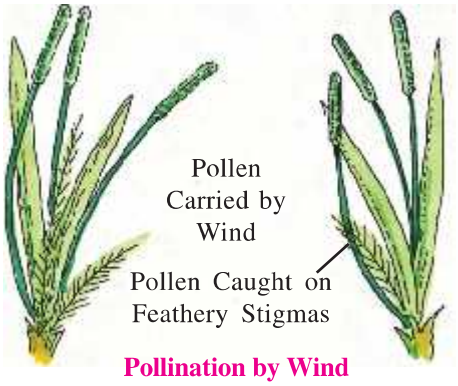
(iv) Herkogamy : In bisexual flower physical barrier between anther and stigma.

Agent of Pollination

Various transporting agents are required for carrying pollen from anther of one flower to stigma of a flower on another plant. Plants use abiotic (wind and water) and biotic (animals) agents to achieve pollination. Majority of plants use biotic agents for pollination. Only a small proportion of plants use abiotic agent. Each type of plants possesses some distinct characters related to their pollinating agent.

Anemophily (Pollination by Wind)

- Transfer of pollen grains through wind is called anemophily.
- Normally in such plants, the flower is unisexual.
- Pollen is produced in large amounts because the probability of their wastage is quite high.
- Pollen is small in size, light, dry and smooth.
- Male flowers are generally located higher on the plant and female flowers occur lower down.
- Stigma is branched, feathery, hairy and sticky.
- Flowers do not possess special shapes, colour, scent or nectar.
- Eg. Maize, Grasses, Coconut.



Pollination by Wind