PLANT PHYSIOLOGY

7th - Term I	Unit – 5	Reproduction & Modification in Plants
8th - Term I	Unit – 8	Organization of life
9TH BOOK	Unit – 18	Organization of Tissues
	Unit – 19	Plant Physiology
10TH BOOK	Unit – 16	Plant and Animal Hormones
	Unit – 17	Reproduction in Plants & Animals
12TH BOOK	Unit – 6	Reproduction in Plants & Animals

7th - Term I
Unit – 5 Reproduction & Modification in Plants

Reproduction

- The process by which plants and animals produce young ones and increase their number is known as 'reproduction'. Drumstick tree can be grown from both seeds and stem cuttings. When plants reproduced from seeds we call that process as sexual reproduction. All other ways of reproduction without seed are called as asexual reproduction.

Sexual reproduction

- Seed is produced from a flower by the process of pollination and fertilization. This is known as sexual reproduction. To understand how seeds are formed in a flower, first we need to understand parts of a flower.

Parts of flower

- Collect few buds and opened flowers of Hibiscus and Datura. With the help of your teacher, perform the following steps.

  - Observe and compare bud and opened flower of Hibiscus and Datura.
  - Tabulate the characteristics.

  - In a bud, we can see a green colour, leaf like structure which cover the whole bud or flower, Each of these green like structure present as an outermost layer is called as sepal. This outer most ring of sepals is known as calyx.

  - Petals are the largest part of flowers. They are oft en attractive, brightly coloured, sometimes sweet scented and attract the insects. This ring of petals together is called corolla.

  - Inner to this corolla, in Hibiscus, we can observe a long tube on which many stamens are arranged. But in Datura, we can see only five stalked structures, stamens. This ring or whorl of a flower is called androecium. Each stamens consists of two parts – a stalk called fi lament and a lobe called anther. If you touch these lobes in a mature flower, we can get a powdery substance called pollen grains, male reproductive part.

  - Inner to this androecium whorl, we can find a female reproductive part of the flower, called Gynoecium. You will find this part with a swollen bottom part. This is the ovary. Seeds are produced in this part. On top of the ovary there is a slender tube like structure called style. The top most sticky tip of the style is stigma. Pollen grains are receivedby the stigma. This is the fourth whorl of a flower.

Types of flowers

- Now we shall learn some important terms to understand flowers and their role in reproduction. .

  - If all the four whorls- calyx, corolla, stamens and pistil are present, then it is called as complete flower. .

- Complete flowers are bisexual flowers.

- If any of these four whorls is missing, then it is called as an incomplete flower.

- Incomplete flowers are unisexual flowers.

- There are two types of unisexual flowers, male flower and female flower

- The one with androecium and without gynoecium is called as male flowers and the one with gynoecium and without androecium is known as female flowers.

- These are called unisexual flowers.

The sunflower is not a single flower. It is a group of flowers clustered together. A group of flowers arranged together is called inflorescence. Tridax procumbens, looks like a single flower, but is an inflorescence. Leaf juice of this plant is used to cure wounds and cuts.

Flower to fruit

- To understand how a flower develops into fruit, let us perform an experiment on pumpkin plant. We know from our earlier explorations that flowers of pumpkin are unisexual- that is some of the flowers are male while many are female flowers.

Pollination

- In the above experiment we transferred the pollen grains from male flower to the female flower. This is called as an artificial pollination. However in nature there are many ways in which pollen grains reach the stigma of the flower and is called as natural pollination.flowers. Brush the collected pollen grains on the stigma with a soft paint brush. Take care not to damage the stigma. After few days we can see that flower in all bags that were not opened at all would wilt without forming a fruit, while most of the flowers to which pollens have been applied for fruits.

- The process by which pollen grains reach stigma is called as pollination. The flower that receives pollen grains is called pollinated flower while the one that did not receive pollen grains is called as unpollinated flower.

- In some plants like grasses, pollen grains are light. Stamens shed pollen grains, and are carried by wind to other flower. Insects, birds are also other agents of pollination. Bees, butterflies and variety of birds hover around flowers. They help to carry pollen from one flower to another. Pollen grains stick to their legs, wings or abdomen when they move from one flower to another. This is called as Cross pollination

- When you shake stamens, pollen grains fallout. Thus when a wind shake the flower or when a butterfly agitate the flower, pollen grainscould fall onto the stigma of same flower. Some plants that have both the male and female parts within a single flowers(bisexual) pollinate by this means. This is called as Self pollination.

- Beans (Fabaceae), tomatoes (Solanaceae) are commonly self-pollinate. Even though, for example tomato, self pollinate, they need the help of the insects to create vibrations within the flowers that will effectively loosen the pollen. Paddy is mostly self pollinating using just gentle wind as the pollinating agent. The agents that are helping in pollination are called pollinators.

Differences between Self / Cross Pollination.

Self Pollination	Cross Pollination
Pollen grains are transferred from the anther to the Stigma of the same flower or to another flower of the same plant.	Pollen grains are transferred from the anther to the Stigma of another flower of the same kind or different plant.
Plants do not need to produce pollen grains in a large quantity for self pollination.	Plants need to produce pollen grains in a large quantitiesto increase the chance of pollination
It does not produce changes in the characteristics of new plants.	Cross Pollination does introducs variations in characteristics of new plants.

- In many plants, pollens have to come from some other flowers. This is obvious in case of plants which have distinct male and female flowers like pumpkin. In some flowers the gynoecium matures first before the androecium shed pollens. Plants such as apples, plums, strawberries, pumpkins use insects for cross-pollination.

Fertilization

- Through pollination, pollen grains reach stigma. What happens to them after this? Substances produced on the stigma causes the pollen grain to germinate. During the germination a tube develops from the pollen grain that carries male gametes that ultimately reaches female gamete inside the ovary through the style. Male gamete fuses with the female gamete to form zygote. This process is knows as fertilization.

  - ❖ A green part above fruits of brinjal and lady's finger are sepals of a flower. In some, after fertilization, sepal will not fall from fruit and remain or persist with fruit.

  - ❖ **Custard apple :** It is made up of many fruits, aggregated together. Each fruit part is thin, membraneous with some granule like, which is edible.

  - ❖ **Mango :** Outer skin and middle pulpy are edible and sweet. Inner most is with single seed.

  - ❖ **Pea :** Fruit is not fleshy, but forms a covering pouch for many seeds.

- The world's largest and heaviest seed is the double coconut. The seed looks like two coconut fused together. It only grows in two islands of the Seychelles. A single seed may be 12 inches long, nearly 3 feet in circumference and weighs about 18 kg.

- Orchids have the smallest seeds in the plant kingdom. 35 million seeds may weight only about 25 gram

Asexual reproduction

- Earlier we saw that plants reproduce not only from seeds but by other processes as well. The production of new plants without the involvement of pollination and fertilization is knows as asexual reproduction. Let us know the types of asexual reproduction.

Vegetative Propagation

- In potato, shoot arise from eyes. Sugarcane, yam are also grown like this. Vegetative parts of the plants such as root, stem and leaves can help to propagate the plant.

Budding

- When we go to a bakery we see so many types of cakes and breads. These are very soft in nature. This is due to the presence of Yeast. Single yeast undergoes asymmetric division. It produces a small protuberance which gradually grows and detaches from the parent cell. This process is called budding.

Fragmentation

- In a pond we see so many algae. Spirogyra is a filamentous alga, when it matures, the filament divides into pieces. Each fragment or piece of a filament will grow into a new filament or individual. Likewise Spirogyra produces so many young ones and this process is known as fragmentation.

Spore Formation

- Scarcity of water, high temperature, nutrient deficiency in soil etc., are unfavourable conditions. During these conditions non-flowering plants like Algae, Fungi, Moss and Ferns produces spores. They germinate into a new plant when favourable conditions are returns.

Modifications of plant parts

- We can see that the tap root of the carrot is swollen. In the case of the carrot plant, the tap root has a different characteristics than the usual plants. Normally, each plant organ, originally evolved to meet certain needs of the plant. For example, roots evolved primarily to anchor the plant and also absorb water and mineral nutrients from soil. Leaves were adapted to optimize photosynthesis.

- Stems evolved to reach out to sunlight and also served to conduct water from roots to leaves. However in certain plant species, specific parts have evolved further in unusual and surprising ways to meet certain other specific needs, In some plants root, stem, and leaves change their shape and structure to perform special functions like storage of food, mechanical support, protection and other vital functions. This is known as modification.

- What appear as the 'leaf ' of a cacti are actually their stem and what appear as 'spine' on them are actually leaf. Its leaves are modified into spines, an adaptation to reduce transpiration. Photosynthesis is performed by the stem part of the plant

Modification of Root

Roots for storage

- A radish, turnip, beet root, and carrot. They all grow under the soil. As soon as you pluck it from the ground if you wash them gently, you will notice small roots dangling from their surface. All these vegetables are in fact roots of the plant. Instead of thin slender roots, in case of such plants, the roots have become a place to store the food produced by them.

- Hence they are thick and swollen. One can notice that the tap root of radish is in the shape of spindle, swollen in the middle and tapering at both ends. Such type of modified roots are called spindle shaped root. Example : Radish

- At times, like in the case of turnip, and beet root the tap root can acquire a shape of top, that is spherical at the base and tapering shortly towards the apex. They are called as Top shaped root.

- In case of carrot, the shape is conical, broad at the apex and tapering gradually towards the base and such modified roots are called Conical shaped root.

Mechanical Support

- It seems to have many trunk supporting it. However many of them are actually roots. As the banyan tree is large and huge, it needs support not to tilt and fall down. Many plants require such additional support. Such plants develop roots on their aerial parts to provide mechanical support. These roots grow downward and act as supportive organs. There are three types of modified roots for support.

❖ **Prop roots:** Roots are modified to provide mechanical support as seen in Banyan tree. These roots grow vertically from horizontal branches of a tree.

❖ **Stilt roots :** In sugar cane, and maize adventitious roots arise from the nodes in cluster at the base of the stem. These roots are called stilt roots which gives additional support.

❖ **Climbing roots:** In betel and black pepper, nodes or intermodes bear roots which help in climbing.

A root growing from a location other than the underground, such as from a stem or leaf is called as adventitious root

Gaseous Exchange:

- Avicennia is a tree which grows in mangroves or swamps. They have roots which are seen above the ground for the purpose of gaseous exchange. These roots are erect, peg like structures with numerous pores through which air circulates. These roots are called breathing roots, or pneumatophores.

Vanda is an epiphytic plant, which grows on trees. The velamen tissue present in the epiphytic root, absorbs moisture, to perform photosynthesis

Roots for other vital function

- Roots may also be perform special function. Haustoria or Sucking roots, are one such example. Cuscuta a parasite plant, climb the trees and other vegetation and use the haustorial roots to penetrate the tissue of the host plant and suck nutrients from them. They are usually found in parasitic plants that depend on the host plants for nutrients.

Modification of stems

- All three are stems. Some plants have their stems modified for storing food and for vegetative propagation. Modified stem may be aerial, subaerial or underground stems.

Aerial Modifications

Phylloclade: In dry climate, conserving water is a challenge. Water evaporates from the surface. If the surface area is larger, evaporation would be more; and if the surface area is smaller, the evaporation will be less. Plants with many leaves have more surface area. Cactus hence has a thick stem which does most of the food production through photosynthesis and leaves are reduced to small spines with less surface area.

Sub – aerial Modifications

- Stem of some plants remains sub – aerial which grow horizontally on the surface of the soil for the purpose of reproduction. There are four types.

❖ **Runner :** The stem grows laterally on the surface of the soil, breaks up to produce roots where it touches the ground to give rise to new plants. E.g: Centella (Vallarai)

❖ **Stolon :** Stolon is a slender branch of the stem that grows upwards to some distance and then bends towards the ground. Upon touching the ground, it gives rise to a new plant. E.g:Wild strawberry

❖ **Sucker :** Sucker is a short and weak lateral branch that grows diagonally upwards and directly gives rise to a new shoot. E.g : Chrysanthemum**.**

❖ **Offset :** An offset is a short and thick branch that arises from the axial part of a leaf. It has thick internodes. It produces a tuft of leaves and cluster of small roots below. E.g: Eichhornia

Underground modifications

- In aerial and sub aerial modifications, stem has indefinite growth. In underground modified stem, whole stem is burried under the ground and it has definite growth. Usually stem grows above the ground, but there are some stems that grow under the ground to store food. These underground stems swell and become thick.There are four types of underground stems:

1. Rhizome; 2. Corm; 3. Tuber; 4. Bulb

❖ **Rhizom:** It is an underground thick stem with nodes and internodes with scale leaves at the node. It grows horizontally and has an irregular shape. Rhizome have buds. If give rise to new stem and leaves. E.g: Ginger and Turmeric.

❖ **Corm:** This underground stem is round in shape and flat at the top and bottom. It is a condensed form of rhizome and bears one or more buds in the axils of scale leaves. Daughter plants arise from their buds. E.g: Colocasia.

❖ **Tuber:** It is an enlarged, spherical underground stem that stores food. It has many dormant buds on its surface known as "Eyes". If we plant a part of tuber with the bud, it grows into a new plant. E.g. Potato.

❖ **Bulb:** It is a condensed stem which is disc like and stores food in the fleshy leaves. The bulb has two types of leaves.

❖

1. **Fleshy Leaves**
2. **Scaly Leaves**

The upper part of the stem has a terminal bud and it is covered by many scaly leaves. The inner fleshy leaves store food as seen in Garlic and Onion.

Modifications of Leaf

- Plants have changed themselves to adapt to the environment they grow. One of them is the modification of leaves. Leaves of several plants get modified into different form based on the purpose and environment

❖ **Spines:** Leaves are reduced to spines, and the stem is modified into green succulent part to perform photosynthesis. Eg : Opuntia

❖ **Tendrils:** In climbers, the leaf of plant would be modified into elongated structure to help the plants climb efficiently.

  - Gloriosa superba – Leaf tips are modified into tendrils
  - Pisum sativum (pea) –Terminal leaflets are modified into tendrils.

❖ **Phyllode:** In Acacia auriculiformis, petioles expand to form leaf like structure. They carry out the function of leaf (Photosynthesis)

❖ **Traps:** Plants that grow in nitrogen deficient places adapt themselves well to get it. In Nepenthes, the leaves are modified into a flask like structure, which is used to attract insects and other tiny animals. The inner wall of the leaf secretes digestive enzymes that help to digest the insects and extract the nitrogen needed for the plant. Eg: Nepenthes**.**

8th Term I

Unit - 8 Organization of Life

- There are animals like amoeba which cannot be seen by our naked eye. There are animals like blue whale and elephants which are of huge size. The variations are not only seen size but also in the complexity of their, cells, tissues of the body structure.This is called organization of life.

- The biological organization are arranged from cellular level to organism level. It goes like tissue, organ, organ system and organisms. Each of this represents a level of organization and hierarchy. This organizations are of two levels, they are lower levels and higher levels of organism.

- Irrespective of the level, they exhibit and can perform all the life activities like growth, metabolism, reproduction etc., In this lesson, let us learn different levels of organizations of living organism with suitable example

Organisation of Cells and Tissues

- Cell is the smallest structural and functional unit of living organisms and it is capable of performing specific function. It is also called the building blocks of life. Single-celled organisms like Amoeba are able to carry out all the processes of life, like higher organisms. The body of Amoeba looks like a single cell, while higher animals are made up of billions of cells. Bacteria, yeasts and Amoeba have a single cell body and are called as unicellular organisms. Organisms such as human beings, cows and trees are made of a large number of cells and are called multicellular organisms. Thus the body has different levels of organisation. Cells make up tissues, tissues make up organs, and organs make up organ systems.

Prokaryotes and Eukaryotes

- Based on the structural organization, organism can be classified into prokaryotes and eukaryotes. In some of the organism like bacteria, cyanobacteria and mycoplasma, no true nucleus is seen. These organisms are called prokaryotes. However in the cells of amoeba, animals and plants, a well-defined nucleus, covered by membrane is seen. These organisms are called eukaryotes.

Biological levels of organization

- The biological organization shows the hierarchy in organization levels from simplest to more complex: atoms, to molecules, cells, tissues, organs, organ systems, organisms, populations, communities, ecosystem and finally biosphere. The pictorial representation of biological organization is given below. Though atoms and molecules make up the cells, they are considered as non living. Where as population, community, ecosystem and biosphere are of ecological importance. Hence we restrict our study from cells to organism.

CELL

- Cell is the structural and functional unit of life. Cells are often called as"building blocks of life". The study of cells is called cell biology. Cells consist of cytoplasm enclosed within a membrane, which contains many biomolecules such as proteins and nucleic acids. Cells vary widely in shape and size. There is a central spherical nucleus and a variety of cytoplasmic living cell organelles like the endoplasmic reticulum, mitochondria. golgibodies, centrioles, ribosomes, lysosomes, etc., present in an animal cell. Each cell organelle performs a specific function.

- The size of cells varies in different animals which are measured in units of micron (μm). (1cm =10 mm: 1 mm = 1000 microns.) The average cell size varies from 0.5 to 20 μm in diameter. The cells of bacteria are the smallest in size (1-2 μm). In human body, the smallest cell is RBC (7 μm in diameter), the longest one is the nerve cell which reaches a length of about 90 -100 cm and the human egg (ovum) is 100 μm in size . Among multicellular animals, the largest cell is, egg of an ostrich. It measures about 170 mm × 180mm in diameter. It is about 25,000 times bigger than a red blood cell. Mycoplasma with a diameter of 0.0001 mm is the smallest bacterium.

Stem cell

A stem cell is essentially a 'blank' cell, capable of becoming another more differentiated cell type in the body, such as a skin cell, a muscle cell, or a nerve cell. They are microscopic in size. Stem cells can be used to replace or even heal the damaged tissues in the body. They can serve as a built-in repair system for the human body, replenishing other cells as long as a person is still alive.

Shape

- Cells are of different shapes. Normally they are correlated with their functions. Some cells are oval or round, while certain others are elongated. Some cells are long and pointed at both ends. They exhibit a spindle shape. Cells are sometimes quite long. Some are branched like the nerve cell or a neuron. Some of our WBC cells are Amoeba like with irregular boundaries.

Our body is developed from a single cell called zygote. The zygote undergoes continuous mitotic division and forms the foetus consisting multitude of cells of different shape, size and content. Foetal cells gradually attain change in structure and function. This process is known as cell differentiation

Tissues

- Tissues are groups of cells that have a similar structure and act together to perform a specific function. They are of two type's simple and complex tissues. Simple tissues are made up of cells of same type or kind e.g. glandular tissue and complex tissues are made up of different kind of tissues e.g. tissues of dry skin. Hence, simple tissue is homogeneous and complex tissue is heterogeneous.

Types of Tissues

- Depending on the basis of their structure and function, tissues can be classified into four types – Epithelial (covering) tissue for protection, Muscular (contractile) tissue for movements and locomotion, Connective (supporting) tissue for binding different structures of body and Nervous tissue for conduction of nerve impulses. All the complex organisms consist of only four basic types of tissues.

Organ

- Organs are structures made up of two or more types of tissues, organized to carry out a particular function. Example: Brain, heart, lungs, kidney, liver etc., each of which has specific functions. Most organs are made of all four types of tissue. The intestine, for example, is made of epithelial tissue as the inner lining, which helps in enzyme secretion and nutrient absorption. Epithelial tissue is covered by layers of muscle tissue, which help in peristaltic movements to move the food. The intestine is also supplied by blood tissue (connective tissue) which helps in transporting nutrients absorbed by the intestine, and is connected to the brain through the nerve tissue, which conveys instructions from the brain.

The eyes - Photoreceptor

- The eye is one of the important sensory organs in the human body. It is composed of muscular tissue, connective tissue, neural tissue and mainly responsible for vision, differentiation of color (the human eye can differentiate approximately 10 – 12 million colors) and maintaining the biological clock of the human body. The human eye can be compared to a camera as both functions by gathering, focusing, and transmitting the light through the lens for creating an image of an object.

Structure and Functions of Human Eye

- The human eyes are the most complicated sense organ in the human body, with several parts fixed together form a spherical structure. Every part of the human eye is mainly responsible for a certain action. The structure of a human eye can be broadly classified into the external structure and internal structure.

The External Structure of an Eye

The parts of the eye that are visible externally comprise of the external structure of the eye-

- **Sclera:** It is a tough and thick white sheath that protects the inner parts of the eye. We know it as the 'White of the eye'.

- **Conjunctiva:** It is a thin transparent membrane that is spread across the sclera. It keeps the eyes moist and clear by secreting small amounts of mucus and tears.

- **Cornea:** It is the transparent layer of membrane that is spread over the pupil and the iris. The main role of the cornea is to refract the light that enters the eyes.

- **Iris:** It is a pigmented layer of tissues that make up the colored portion of the eye. Its primary function is to control the size of the pupil, depending on the amount of light entering it.

- **Pupil:** It is the small opening located at the middle of the Iris. It allows light to come in.
- **The Internal Structure of an Eye**

  - The internal structure of the eye includes the following parts:

- **Lens:** It is a transparent, biconvex, and an adjustable part of an eye, made up of protein The lens with the help of the cornea refracts light focused on the retina, therefore creating images on it.

- **Retina:** It is the layer present at the back of the eye where all the images are formed. It is the third and inner most coat of the eye which is very sensitive to light because of the presence of Photoreceptors (rods and cone cells). The retina functions by converting the light rays into impulses and sending the signals to the brain through the optic nerve.

- **Optic nerve:** It is located at the end of the eyes, behind the retina. The optic nerve is mainly responsible for carrying all the nerve impulses from the photoreceptors to the human brain, without which vision would not be possible.

- **Aqueous Humour:** It is a watery fluid that is present in the area between the lens and the cornea. It is responsible for the nourishment of both the lens and the cornea.

- **Vitreous Humour:** it is a semi-solid, transparent, jelly-like substance that covers the interior portion of the eyes. It plays an important role in maintaining the shape of the eye and also causes refraction of light before it reaches the retina.

Organ system

- A group of organs form the organ system, and together they perform a particular function. The heart and the blood vessels together make the cardiovascular system. Organs such as nose, pharynx, trachea, lungs and diaphragm work together as the respiratory system. The mouth, esophagus, stomach, duodenum, and the intestines together form the digestive system. Other examples of organ system include the endocrine system, integumentary system, muscular system, reproductive system, skeletal system, urinary system, immune system, etc.

The Respiratory System

- Our respiratory system consists of organs like trachea, bronchus and lungs which are responsible for exchange of air between the atmosphere and the blood. Together, these organ form what is called the respiratory tract. Let us see the organs of the respiratory tract in detail.

The nose

- We inhale air through the nostrils, which lead to the nasal cavity. The inner surface of this cavity is lined with cilia and mucus producing cells, which make it sticky and moist. The cilia and mucus trap dust and germs and prevent them from going deeper into the respiratory tract. The blood vessels in the nose help to warm the inhaled air.

The windpipe

- After passing through the nasal cavity, the air enters the pharynx. Then it goes into the trachea or the windpipe which is an elastic tube extending down the length of the neck and partly into the chest cavity. Between the pharynx and the trachea lies a small air passage called the larynx commonly known as the "voice box". The larynx has fold of tissue which vibrate with the passage of air to produce sound.

Bronchi

- The trachea divides into two branches called bronchi (singular: bronchus). Each bronchus leads to a lung, where it divides and redivides to finally form air passages called bronchioles.

Lungs

- The lungs are organs in the chest cavity that allow our body to take in oxygen from the air. They also help to remove carbondioxide from the body. The lungs lie on either side of the breast bone and fill the inside of the chest cavity. The left lung is slightly smaller than the right lung to allow room for the heart. Within the lungs, each bronchiole leads to a bunch of air sacs called alveoli (singular: alveolus).

- The lungs are two spongy elastic bags, on each side of the thoracic cavity. The thoracic cavity is bound dorsally by the vertebral column and ventrally by the sternum, laterally by the ribs and on the lower side by the dome shaped diaphragm.

Alveoli

- Alveoli are tiny air sacs in the lungs that take up the oxygen we breathe in and keep your body going. Although they are microscopic, alveoli are the workhorses of your respiratory system.You have about 480 million alveoli, located at the end of bronchial tubes. The total area of the airsacs in the lungs above 2000 square feet or more than one hundred times the body's surface area. Alveoli, is meant for the exchange of oxygen and carbondioxide.

On an average, an adult human being at rest breathes in and out 15 – 18 times in a minute. During heavy exercise, the breathing rate can increase upto 25 times per minute
Smoking damages lungs. Smoking is also linked to cancer. It must be avoided.
When you sneeze, you should cover your nose so that the foreign particles you expel are not inhaled by others.

Mechanism of Breathing

Inspiration (Inhalation)

- The process of taking air into the lungs is called inspiration or inhalation. During inspiration, the sternum is pushed up and outward and the diaphragm is pulled down. This increases the volume of the thoracic cavity and the pressure decreases. The air outside the body flows into the lungs. Here exchange of gases takes place between the air and the blood.

Expiration (Exhalation)

- The process of expelling air from the lungs is called expiration or exhalation. Upon exhalation, the lungs recoil to force the air out of the lungs. The intercostal muscles relax, returning the chest wall to its original position. During exhalation, the diaphragm also relaxes, moving higher into the thoracic cavity. This increases the pressure within the thoracic cavity relative to the environment. Air rushes out of the lungs due to the pressure gradient. This movement of air out of the lungs is a passive event.

Exchange of gases in the Alveoli:

- The content of oxygen in the inhaled air in alveoli is more than the blood flowing through the capillaries. So, the oxygen moves into the blood by simple diffusion. Haemoglobin in the blood combines with oxygen to form oxyhaemoglobin. The blood carrying oxygen reaches the heart through blood vessels. The heart pumps it to all the tissue in the body. The tissue releases carbon-dioxide which is carried back to alveoli by the blood. Carbon-dioxide diffuses from the blood to the air in the alveoli and is sent out of the body when the air is exhaled.

Differences between inhalation and exhalation

Inhalation	Exhalation
The Muscles of the diaphragm contract	The muscles of the diaphragm relax.
The diaphragm goes downward	The diaphragm goes upward
The ribs move upwards and Outwards	The ribs move downwards.
The Volume of thoracic (Chest) cavity increases	The Volume of thoracic (Chest) cavity decreases
Air enters the lungs through the nose	Air goes out of the lungs through the nose.

Homeostasis

- Homeostasis is a property of a human biological system where the self-regulating process tends to maintain the balance for the survival. The regulation takes place in a defined internal environment. Mammals are capable of maintaining a constant body temperature despite the changes in the external temperature. Behavioural and physiological responses are two important regulating mechanisms that maintain the stability of Homeostasis.

- In simple terms, it could be referred as a balance in a system to maintain a stable internal environment for the survival of the animal. If the homeostasis regulates successfully, life continues or if unsuccessful, death or disaster occurs.

- All the processes of integration and co-ordination of function are mediated by nervous and hormonal system. The liver, kidneys, and brain (hypothalamus), autonomic nervous system and the endocrine system help to maintain homeostasis.

- Maintenance of body fluid concentrations, body temperature are done by various bio-physical and bio-chemical methods. Human beings are warm blooded in nature i.e, they maintain their body temperature as constant. When the body temperature raises sweat is produced to bring the temperature down. When the body temperature lower heat is produced by the muscular work by shivering. This is an example for homeostasis.

- The control of blood glucose level is another example in which insulin hormone is secreted whenever the blood glucose level raises and glucagon hormone is secreted whenever the blood glucose level reduces.

Diffusion

- Diffusion is the movement of particles from an area of higher concentration to lower concentration. The overall effect is to equalize concentration throughout the medium.

- Examples for diffusion include, perfume filling a whole room and the movement of small molecules across a cell membrane. One of the simplest demonstrations of diffusion is adding a drop of ink to water.

Osmosis

- Osmosis is the movement of solvent particles across a semipermeable membrane from a dilute solution into a concentrated solution. The solvent moves to dilute the concentrated solution and equalize the concentration on both sides of the membrane.

- The movement of liquids in and out cells is dependent on the concentration of the solution surrounding it. There are 3 types of situations in which this could vary:

- **Isotonic:** Here the concentration of external and internal soultion of the organism are the same.

- **Hypotonic:** Here the external solution concentration is less compared to the concentration of the inner solution of an organism. In this case water will rush into the organism.

- **Hypertonic:** Here the external solution concentration is greater than the concentration of the inner solution of an organism. In this case the water will rush out of the organism.

Osmoregulation

- The term osmoregulation was coined by HOBER in 1902. Osmoregulation is the process by which an organism regulates the water balance in its body and maintains the homeostasis of the body. It includes controlling excess water loss or gain and maintaining the fluid balance and the osmotic concentration, that is, the concentration of electrolytes. It ensures that the fluids in the body do not get too diluted or concentrated

There are two major types of Osmoregulation:

- **Osmoconformers**These organisms try to maintain the osmolality of their body matching with their surroundings. Most of the invertebrates, marine organisms are osmoconformers.

- **Osmoregulators** These organisms maintain their internal osmolality, which can be extremely different from that of the surrounding environment, through physiological processes.

Cellular respiration

- Cellular respiration is the process by which organisms break down glucose into a form that the cell can use as energy. This energy is then made available to living cells in the form of ATP. Cellular respiration takes place in the cytoplasm and mitochondria of the cells.The Cellular respiration is classified into two types: aerobic respiration and anaerobic respiration.

Aerobic respiration

- In this type of respiration, the food substances are completely oxidized into H2O and CO2 with the release of energy. It requires atmospheric oxygen and all higher organisms respire aerobically. This reaction releases a large amount of energy.

It can be written as the following equation:
Glucose + Oxygen → Carbon dioxide + Water + Energy

Anaerobic respiration:

- In this type of respiration, partial oxidation of food takes place and the organisms release energy in the absence of oxygen. This type of respiration occurs in organisms like yeast. Ethyl alcohol and carbon dioxide are the by-products of this process. This reaction releases very little energy because glucose is not completely oxidized.

For example: yeast cells convert glucose into carbon dioxide and ethanol, with the release of energy, without using oxygen.
Glucose → Ethanol + Carbon dioxide + Energy

Differences between Aerobic and Anaerobic respiration

Aerobic	**Anaerobic**
Aerobic respiration takes place in the presence of oxygen	Anaerobic respiration takes place in the absence of oxygen
The end products of aerobic respiration and Carbon dioxide and water	The end Products of anaerobic respiration are CO_2 and ethanol or lactic acid
Common in all higher plants and animals	Common in certain microorganisms and human muscle cell

Metabolism

- Metabolism is the sum of chemical reactions by which living organisms sustain their life.

- Metabolism consists of anabolism (the buildup of substances) and catabolism (the breakdown of substances). The term metabolism is commonly used to refer specifically to the breakdown of food and its transformation into energy, cellular products and waste elimination.

Anabolism

- Anabolism or constructive metabolism, is all about building and storing: It supports the growth of new cells, the maintenance of body tissues, and the storage of energy for use in the future. During anabolism, small molecules are changed into larger, more complex molecules of carbohydrate, protein, and fat.

For example,

Glucose → Glycogen and other sugars
Amino acids → Enzymes, hormones, proteins
Fatty acids → Cholesterol and other steroids

Catabolism

- Catabolism or destructive metabolism, is the process that produces the energy required for all activity in the cells. In this process, cells break down large molecules (mostly carbohydrates and fats) to release energy. This energy release provides fuel for anabolism, heats the body, and enables the muscles to contract and the body to move. As complex chemical units are broken down into more simple substances, the waste products released in the process of catabolism are removed from the body through the skin, kidneys, lungs, and intestines.The following are examples for catabolism.

Carbohydrates → Glucose
Glucose → CO_2, Water and heat
Protein → Amino acid

- The repeated anabolism and catabolism reactions maintain the homeostatic condition in the organism. The metabolic process is the cause for maintaining ionic balance in the body. It is also responsible for movement, growth, development, maintenance and repair of the cells, tissues and the human body.These metabolic reactions occur in different organs of living species.

9th Book

Unit 18 – Organisation of Tissues

Introduction

- Unicellular organisms like bacteria and protozoans are made of single cells. On the other hand, multicellular organisms, like higher plants and animals, are composed of millions of different types of cells that are grouped into different levels of organization. Multicellular organisms have specialized cells, tissues, organs and organ systems that perform specific functions.

- Group of cells positioned and designed to perform a particular function is called a tissue. An organ is a structure made up of a collection of tissues that carry out specialized functions. For example, in plants the root, stem and leaves are organs, whereas xylem and phloem are tissues. Similarly in animals stomach, for example, is an organ that consists of tissues made of epithelial cells, gland cells and muscle cells. In this chapter, you will learn about different types of plant and animal tissues and how they are modified to coordinate life activities.

Plant Tissues

Plants are made up of vegetative and reproductive tissues. In general, plant tissues are classified into two types namely:

- Meristems or Meristematic tissues.
- Permanent tissues

Meristematic Tissues (Meristems)

- The term 'meristem' is derived from the greek word ' Meristos' which means divisible or having cell division activity. Meristematic tissues are group of immature cells that are capable of undergoing cell division. In plants, meristem is found in zones where growth can take place. Example: apex of stem, root, leaf primordia, vascular cambium, cork cambium, etc.,

Characteristic features:

- ❖ They are living cells.
- ❖ Cells are small, oval, polygonal or round in shape.
- ❖ They are thin walled with dense cytoplasm, large nuclei and small vacuoles.
- ❖ They undergo mitotic cell division.
- ❖ They do not store food materials.

Types of Meristems based on position

On the basis of their position in the plant, meristems are of three types: Apical meristem, Intercalary meristem and Lateral meristem.

- **Apical meristem:** These are found at the apices or growing points of root and shoot and bring about increase in length.

- **Intercalary meristem:** It lies between the region of permanent tissues and is part of primary meristem. It is found either at the base of leaf (e.g. pinus) or at the base of internodes (e.g. grasses).

- **Lateral Meristem:** These are arranged parallel and causes the thickness of the plant part.

Functions

- Meristems are actively dividing tissues of the plant, that are responsible for primary (elongation) and secondary (thickness) growth of the plant.

Permanent Tissues

- Permanent tissues are those in which, growth has stopped either completely or for the time being. At times, they become meristematic partially or wholly. Permanent tissues are of two types, namely: simple tissue and complex tissue.

Simple Tissues

- Simple tissues are homogeneous tissues composed of structurally and functionally similar cells. eg., Parenchyma, Collenchyma and Sclerenchyma.

Parenchyma: Parenchyma are simple permanent tissues composed of living cells. Parenchyma cells are thin walled, oval, rounded or polygonal in shape with well developed spaces among them. In aquatic plants, parenchyma possesses intercellular air spaces, and is named as Aerenchyma. When exposed to light, parenchyma cells may develop chloroplasts and are known as Chlorenchyma.

- Parenchyma may store water in many succulent and xerophytic plants. It also serves the functions of storage of food reserves, absorption, buoyancy, secretion etc.,

In potato, parenchyma vacuoles are filled with starch. In apple, parenchyma stores sugar

Collenchyma: Collenchyma is a living tissue found beneath the epidermis. Cells are elongated with unevenly thickened non-lignified walls.

- Cells have rectangular oblique or tapering ends and persistent protoplast. They possess thick primary non-lignified walls.They provide mechanical support for growing organs.

Sclerenchyma: Sclerenchyma consists of thick walled cells which are often lignified. Sclerenchyma cells are dead and do not possess living protoplasts at maturity. Sclerenchyma cells are grouped into fibres and sclereids.

- Fibres are elongated sclerenchymatous cells, usually with pointed ends. Their walls are lignified. Fibres are abundantly found in many plants. The average length of fibres is 1 to 3 mm, however in plants like Linumusitatissimum (flax), Cannabis sativa (hemp) and Corchorus capsularis (jute), fibres are extensively longer, ranging from 20 mm to 550 mm.

- Sclereids are widely distributed in plant body. They are usually broad, may occur in single or in groups. Sclereids are isodiametric, with liginified walls. Pits are prominent and seen along the walls.Lumen is filled with wall materials. Sclereids are also common in fruits and seeds.

Complex tissues

- Complex tissues are made of more than one type of cells that work together as a unit. Complex tissues consist of parenchyma and sclerenchyma cells. However, collenchymatous cells are not present in such tissues. Common examples are xylem and phloem.

Xylem

- Xylem is a conducting tissue which conducts water, mineral nutrients upward from root to leaves. Xylem gives mechanical support to the plant body. Xylem is composed of: (i) xylem tracheids (ii) xylem fibres (iii) xylem vessels and (iv) xylem parenchyma.

  - **Xylem tracheids:** These are elongated or tube-like dead cells with hard, thick andlignified walls. Their ends are tapering, blunt or chisel-like and devoid of protoplast. They have large lumen without any content. Their function is conduction of water and providing mechanical support to the plant.

  - **Xylem fibres:** These cells are elongated, lignified and pointed at both the ends. Xylem fibres provide mechanical support to the plant.

  - **Xylem vessels:** These are long cylindrical, tube like structures with lignified walls and wide central lumen. These cells are dead as these do not have protoplast. They are arranged in longitudinal series in which the partitioned walls (transverse walls) are perforated, and so the entire structure looks-like a water pipe. Their main function is to transport of water and also to provide mechanical strength.

- **Xylem parenchyma:** These are living and thin walled cells. The main function of xylem parenchyma is to store starch and fatty substances.

Phloem

- Phloem is a complex tissue and consists of the following elements: Sieve elements, Companion cells, Phloem fibres, and Phloem parenchyma.

Sieve elements: The conducting elements of phloem are collectively called as Sieve elements. Sieve tubes are elongated, tube-like slender cells placed end to end. The transverse walls at the ends are perforated and are known as sieve plates. The main function of sieve tubes is translocation of food, from leaves to the storage organs of the plants.

Companion cells: These are elongated cells attached to the lateral wall of the sieve tubes. A companion cell may be equal in length to the accompanying sieve tube element or the mother cell may be divided transversely forming a series of companion cells.

Phloem parenchyma: The phloem parenchyma are living cells which have cytoplasm and nucleus. Their function is to store food materials.

Differences between Xylem and Phloem

Xylem	**Phloem**
Conducts water and Minerals	Conducts organic solutes or food materials.
Conduction is mostly unidirectional i.e., from roots to apical parts of the plant.	Conduction may be bidirectional from leaves to storage organs and growing parts or from storage organs to growing parts of plants.
Conducting channels are tracheids and vessels	Conducting channels are sieve tubes.
Component of Xylem include tracheid Vessels, Xylem Parenchyma and Xylem fibres	Components are sieve elements, companion cells, phloem parenchyma and Phloem fibres.

Phloem fibers: Sclerenchymatous cells associated with primary and secondary phloem are commonly called phloem fibers. These cells are elongated, lignified and provide mechanical strength to the plant body.

Differences between Meristematic tissue and Permanent tissue

Meristematic Tissue	Permanent Tissue
Cytoplasm is dense, and Vacuoles are nearly absent	Usaually large central vacuole is present in living Permanent cells.
Intercellular Spaces absent	Intercellular Spaces Present
Component cells are small, spherical or polygonal and undifferentiated.	Componentcell are large, differentiated with different shapes.
Cell wall is thin and elastic	Cell wall is thick
Nucleus is large and prominent	Nucleus is less conspicuous
Cells grow and divide regularly	Cells do not normally divide.
Provides mechanical support and elasticity to the plant body	Provides only mechanical support.

Animal Tissues

- An assemblage of one or more types of specialized cells held together with extracellular material constitute the tissue. The study of tissues is known as Histology.

Simple tissue: A group of cells that are similar in origin, form, structure and work together to perform a specific function.

Compound tissue: A group of cells different in their structure and function but co-ordinate to perform a specific function

Animal tissues can be grouped into four basic types on the basis of their structure and functions.

❖ Epithelial tissue.
❖ Connective tissue
❖ Muscular tissue
❖ Nervous tissue

Epithelial Tissues

- It is the simplest tissue composed of one or more layers of cells covering the external surface of the body and internal organs. The cells are arranged very close to each other with less extracellular material. Epithelial cells lie on a non-cellular basement membrane. The epithelial tissue generally lacks blood vessels. The epithelium is separated by the underlying connective tissue which provides it with nutrients. There are two types of epithelial tissues. Simple epithelium is composed of single layer of cells resting on a basement membrane. Compound epithelium is composed of several layers of cells. Only the cells of the deepest layer rest on the basement membrane.

Functions of epithelial tissues

- ❖ The skin which forms the outer covering of the body protects the underlying cells from drying, injury and microbial infections.
- ❖ They help in absorption of water and nutrients.
- ❖ They are involved in elimination of waste products.
- ❖ Some epithelial tissues perform secretory function (Secretion of sweat, saliva, mucus and enzymes).

Simple Epithelium

- It is formed of single layer of cells. It forms a lining for the body cavities and ducts. Simple epithelium is further divided into following types.

Squamous Epithelium: It is made up of thin, flat cells with prominent nuclei. These cells have irregular boundaries and bind with neighbouring cells. The squamous epithelium is also known as pavement membrane, which form delicate lining of the buccal cavity, alveoli of lungs, proximal tubule of kidneys and covering of the skin and tongue. It protects the body from mechanical injury, drying and invasion of germs.

Cuboidal Epithelium: It is composed of single layer of cubical cells. The nucleus is round and lies in the centre. This tissue is present in the thyroid vesicles, salivary glands, sweat glands and exocrine pancreas. It is also found in the intestine and tubular part of the nephron (kidney tubules) as microvilli that increase the absorptive surface area. Their main function is secretion and absorption.

Columnar Epithelium: It is composed of a single layer of **slender**, **elongated** and **pillar** like cells. Their nuclei are located at the base. It is found lining the stomach, gall bladder, bile duct, small intestine, colon, oviducts and also forms the mucous membrane. They are mainly involved in secretion and absorption.

Ciliated Epithelium: Certain columnar cells bear numerous delicate hair like out growths called **cilia** and are called ciliated epithelium. Their function is to move particles or mucus in a specific direction over the epithelium. It is seen in the trachea of wind-pipe, bronchioles of respiratory tract, kidney tubules and fallopian tubes of oviducts.

Glandular Epithelium: Epithelial cells are often modified to form specialized gland cells which secrete chemical substances at the epithelial surface. This lines the gastric glands, pancreatic tubules and intestinal glands.

Compound Epithelium

It consists of more than one layer of cells and gives a stratified appearance. Hence, they are also known as stratified epithelial cells. The main function of this epithelium is to give protection to the underlying tissues against mechanical and chemical stress. They also cover the dry surface of the skin, the moist surface of the buccal cavity and pharynx.

Epithelial tissue in the skin functions as a water-proof membrane.

Connective Tissues

- It is one of the most abundant and widely distributed tissue. It provides structural frame work and gives support to different tissues forming organs. It prevents the organs from getting displaced by body movements.

- The components of the connective tissue are the intercellular substance is known as the matrix, connective tissue cells and fibres. Connective tissue is classified as follows:

- ❖ Connective tissue proper (Areolar and Adipose tissue)
- ❖ Supportive connective tissue (Cartilage and Bone)
- ❖ Dense connective tissue (Tendons and Ligaments)
- ❖ Fluid connective tissue (Blood and Lymph)

Connective tissue proper:

- Connective tissue proper consist of collagen fibres, elastin fibres and fibroblast cells.

Areolar tissue: It has cells and fibres loosely arranged in a semi-fluid ground substance called matrix. It takes the form of fine threads crossing each other in every direction leaving small spaces called areolae. It joins skin to muscles, fills space inside organs and is found around muscles, blood vessels and nerves. It helps in repair of tissues after injury and fixes skin to underlying muscles.

Adipose Tissue: Adipose tissue is the aggregation of fat cells or adipocytes, spherical or oval in shape. It serves as fat reservoir.

- They are found in subcutaneous tissue, between internal organs around the heart and kidneys. They act as shock absorbers around the kidneys and eye balls. They also regulate the body temperature by acting as insulator.

Supportive Connective Tissue:

- The supporting or skeletal connective tissues forms the endoskeleton of the vertebrate body which protect various organs and help in locomotion. The supportive tissues include cartilage and bone.

Cartilage: They are soft, semi-rigid, flexible and are less vascular in nature. The matrix is composed of large cartilage cells called chondrocytes. These cells are present in fluid filled spaces known as lacunae.

- Cartilage is present in the tip of the nose, external ear, end of long bones, trachea and larynx. It provides support and flexibility to the body parts.

Bone: It is solid, rigid and strong, non-flexible skeletal connective tissue. The matrix of the bone is rich in calcium salts and collagen fibres which gives the bone its strength. The matrix of the bone is in the form of concentric rings called lamellae. The bone cells present in lacunae are called osteocytes. They communicate with each other by a network of fine canals called canaliculi. The hollow cavities of spaces are called marrow cavities filled with bone marrow. They provide shape and structural framework to the body. Bones support and protect soft tissues and organs.

Dense Connective Tissue:

- It is a fibrous connective tissue densely packed with fibres and fibroblasts. It is the principal component of tendons and ligaments.

Tendons: They are cord like, strong, structures that join skeletal muscles to bones. Tendons have great strength and limited flexibility. They consist of parallel bundles of collagen fibres, between which are present rows of fibroblasts.

Ligaments: They are highly elastic structures and have great strength which connect bones to bones. They contain very little matrix. They strengthen the joints and allow normal movement.

Sprain is caused by excessive pulling (stretching) of ligaments

Fluid connective tissue:

- The blood and the lymph are the fluid connective tissues which link different parts of the body. The cells of the connective tissue are loosely spaced and are embedded in an intercellular matrix.

Blood

- Blood contains corpuscles which are red blood cells (erythrocytes), white blood cells (leucocytes) and platelets. In this fluid connective tissue, blood cells

move in a fluid matrix called plasma. The plasma contains inorganic salts and organic substances. It is a main circulating fluid that helps in the transport of nutrient substances.

Red blood corpuscles (Erythrocytes): The red blood corpuscles are oval shaped, circular, biconcave disc-like cells and lack nucleus when mature (mammalian RBC). They contain a respiratory pigment called haemoglobin which is involved in the transport of oxygen to tissues.

White blood corpuscles (Leucocytes): They are larger in size, contain distinct nucleus and are colourless. They are capable of amoeboid movement and play an important role in body's defense mechanism. They engulf or destroy foreign bodies. WBC's are of two types: Granulocytes and Agranulocytes. Granulocytes have irregular shaped nuclei and cytoplasmic granules. They include the neutrophils, basophils and eosinophils. Agranulocytes lack cytoplasmic granules and include the lymphocytes and monocytes.

Blood platelets: They are minute, anucleated, fragile fragments of giant bone marrow called mega karyocytes. They play an important role in blood clotting mechanism.

Lymph

- Lymph is a colourless fluid filtered out of the blood capillaries. It consists of plasma and white blood cells. It mainly helps in the exchange of materials between blood and tissue fluids.

Muscular Tissues

- Muscular tissues are made of muscle cells and form the major part of contractile tissue. They are composed of numerous myofibrils. Each muscle is made up of many long cylindrical fibres arranged parallel to one another.

- According to their structure, location and functions there are three main types of muscles: Skeletal muscle (or) striated muscle, Smooth muscle (or) non-striated muscle and Cardiac muscle.

Skeletal muscle: These muscles are attached to the bones and are responsible for the body movements and are called skeletal muscles. They work under our control and are also known as voluntary muscles. The muscle fibres are elongated, cylindrical, unbranched with alternating dark and light bands, giving them the striped or striated appearance. They possess many nuclei (multinucleate). They occur in the biceps and triceps of arms and undergo rapid contraction.

Smooth muscle: These muscles are spindle shaped with broad middle part and tapering ends. There is a single centrally located nucleus (uninucleate). These fibrils do not bear any stripes or striations and hence are called non-striated. They are not under the control of our will and so are called involuntary muscles. The walls of the internal organs such as the blood vessels, gastric glands, intestinal villi and urinary bladder contain this type of smooth muscle.

Cardiac muscle: It is a special contractile tissue present in the heart. The muscle fibres are cylindrical, branched and uninucleate. The branches join to form a network called as intercalated disc which are unique distinguishing features of the cardiac muscles. The contraction of cardiac muscle is involuntary and rhythmic.

Nervous Tissue

- Nervous tissue comprises of the nerve cells or neurons. They are the longest cells of the body. Neurons are the structural and functional units of the nervous tissue. The elongated and slender processes of the neurons are the nerve fibres. Each neuron consists of a cell body or cyton with nucleus and cytoplasm. The dendrons are short and highly branched protoplasmic processes of cyton. The axon is a single, long fibre like process that develops from the cyton and ends up with fine terminal branches.

Age of our body cells

- Cells of the eye lens, nerve cells of cerebral cortex and most muscle cells last a life time but once dead are not replaced.

- Epithelial cells lining the gut last only about 5 days.

Duration of cell replacement

- Skin cells- about every 2 weeks.
- Bone cells- about every 10 years.
- Liver cells- about every 300 – 500 days.
- Red blood cells last for about 120 days and are replaced.

- They have the ability to receive stimuli from within or outside the body and send signals to different parts of the body.

Nerve cells do not undergo cell division due to the absence of centrioles, but they are developed from glial cells by neurogenesis

Cell Division

- All cells reproduce by division and division of cells into daughter cells is called cell division.

Types of Cell Division

The three types of cell division that occur in animal cells are:

- Amitosis - Direct Division
- Mitosis - Indirect Division
- IMeiosis - Reduction Division

Amitosis

- It is the simplest mode of cell division and it occurs in unicellular animals, aging cells and in foetal membranes. During amitosis, nucleus elongates first, and a constriction appears in it which deepens and divides the nucleus into two. Followed by this cytoplasm divides resulting in the formation of two daughter cells.

Mitosis

- It was first discovered by Fleming in 1879. In this cell division one parent cell divides into two identical daughter cells, each with a nucleus having the same amount of DNA,same number of chromosomes and genes as the parent cells. It is also called as equational division. Mitosis consists of two events, they are: 1. Karyokinesis 2. Cytokinesis

Interphase: It is the resting phase of the nucleus. It is the interval between two successive cell divisions. The cell prepares itself for the next cell division.

Karyokinesis

- The division of the nucleus into two daughter nuclei is called Karyokinesis. It consists of four phases. They are: Prophase, Metaphase, Anaphase and Telophase.

Prophase (pro-first): During this stage chromosomes become short and thick and are clearly visible inside the nucleus. Centrosome splits into centrioles and occupy opposite poles of the cell. Each centriole is surrounded by aster rays. Spindle fibres appear between the two centrioles. Nuclear membrane and nucleolus disappear gradually.

Metaphase (meta – after): The duplicated chromosomes arrange on the equatorial plane and form the metaphase plate. Each chromosome gets attached to a spindle fibre by its centromere. The centromere of each chromosome divides into two each being associated with a chromatid.

Anaphase (ana – up, back): The centromeres attaching the two chromatids divide and the two daughter chromatids of each chromosome separate and migrate towards the two opposite poles.

Telophase (tele – end): Each chromatid (or) daughter chromosome lengthens, becomesthinner and turns into a network of chromatin threads. Spindle fibres breakdown and disappear. Nuclear membrane and nucleolus reappear in each daughter nucleus.

Cytokinesis

- The division of the cytoplasm into two daughter cells by constriction of the cell membrane is called cytokinesis.

Significance of Mitosis

- This equational division results in the production of diploid daughter cells (2n) with equal distribution of genetic material (DNA).
- In multicellular organisms growth, organ development and increase in body size are accomplished through the process of mitosis
- Mitosis helps in repair of damaged and wounded tissues by renewal of the lost cells.

Meiosis

- The term meiosis was coined by Farmer in 1905. It is the kind of cell division that produces the sex cells or the gametes. It is also called reduction division because the chromosome number is reduced to haploid (n) from diploid (2n). Meiosis produces fourdaughter cells from a parent cell. Meiosis consists of two divisions. They are:
- **Heterotypic Division** or First Meiotic Division
- **Homotypic Division** or Second Meiotic Division

Heterotypic division

- It divides the diploid cell into two haploid cells. The daughter cells resulting from this division are different from the parent cell in the chromosome number (Heterotypic). This consists of 5 stages:

  - Prophase I
  - Metaphase I
  - Anaphase I
  - Telophase I
  - Cytokinesis I

Prophase I

- Prophase I takes a longer duration and is sub divided into five stages. They are: Leptotene, Zygotene, Pachytene, Diplotene and Diakinesis.

Leptotene: The chromosomes become uncoiled and assume long thread like structures and take up a specific orientation inside the nucleus. They form a bouquet stage.

Zygotene (Zygon-adjoining): Two homologous chromosomes approach each other and begin to pair. Pairing of homologous chromosomes is called as synapsis.

Pachytene (Pachus-thick): The chromosomes are visible as long paired twisted threads. The pairs so formed are called bivalents. Each bivalent now contains four chromatids (tetrad stage). Homologous chromosomes of each pair begin to separate. They do not completely separate, but remain attached together at one or more points by X-shaped arrangements known as chiasmata. The chromatids break at these points and the broken segments may be interchanged (crossing over). As a result, the genetic recombination takes place.

Diplotene: Each individual chromosome of each bivalent begins to split longitudinally into two similar chromatids. The homologous chromosomes repel each other and separate. Chiasmata begin to move along the length of the chromosome from the centromere towards the end resulting in terminalization.

Diakinesis: The paired chromosomes are shortened and thickened. The nuclear membrane and nucleolus begin to disappear. Spindle fibres make their appearance.

Metaphase I

- The chromosomes move towards the equator and finally they orient themselves on the equator. The two chromatids of each chromosome do not separate. The centromere does not divide.

Anaphase I

- Each homologous chromosome with its two chromatids and undivided centromere move towards the opposite poles of the cell. This stage of the chromosome is called Diad.

Telophase I

- The haploid number of chromosomes after reaching their respective poles become uncoiledand elongated. The nuclear membrane and the nucleolus reappear and thus two daughter nuclei are formed.

Cytokinesis I: The cytoplasmic division occurs and two haploid cells are formed.

Homotypic Division

- In this division, the two haploid cells formed during first meiotic division divide into four haploid cells. The daughter cells are similar to parent cell in the chromosome number (Homotypic). It consists of five stages.

- Prophase – II
- Metaphase – II
- Anaphase – II
- Telophase – II
- Cytokinesis – II

Prophase II: The centriole divides into two, each one moves to opposite poles.
Asters and spindle fibres appear. Nuclear membrane and nucleolus disappear.

Metaphase II: The chromosomes get arranged on the equator. Two chromatids are separated.

Anaphase II: The separated chromatids become daughter chromosomes and move to opposite poles

Telophase II: The daughter chromosomes are centered. The nuclear membrane and the nucleolus appear.

Cytokinesis II: Two cells are formed from each haploid daughter cell, resulting in the formation of four cells with haploid number of chromosomes.

Significance of Meiosis

- The constant number of chromosomes in a given species is maintained by meiotic division.

Differences between Mitosis and Meiosis

Mitosis	**Meiosis**
Occurs in somatic cells	Occurs in reproductive cells.
Involved in growth and occurs continuously throughout life.	Involved in gamete formation only during the reproductively active age.
Consists of single division	Consists of two divisions.
Two diploid daughter cells are formed.	Four haploid daughter cells are formed.
The Chromosome number in the daughter cell is similar to the parent cell (2n).	The Chromosome number in the daughter cell is just half (n) of the parent cell.
Identical daughter cells are found	Daughter cells are not similar to the parent cell and are randomly assorted.

9th book
Unit 19 – Plant Physiology

Tropism in Plants

- Tropism is a unidirectional movement of a whole or part of a plant towards the direction of stimuli.

Types of Tropism

Based on the nature of stimuli, tropism can be classified as follows

- ❖ **Phototropism:** Movement of a plant part towards light. e.g. shoot of a plant.
- ❖ **Geotropism:** Movement of a plant in response to gravity. e.g. root of a plant.
- ❖ **Hydrotropism:** Movement of a plant or part of a plant towards water. e.g root of a plant.
- ❖ **Thigmotropism:** Movement of a plant part due to touch. e.g. climbing vines.
- ❖ **Chemotropism:** Movement of a part of plant in response to chemicals. e.g growth of a pollen tube in response to sugar present on the stigma.

- Tropism is generally termed positive if growth is towards the signal and negative if it is away from the signal. Shoot of a plant moves towards the light, the roots move away. Thus the shoots are positively phototropic.

- Usually shoot system of a plant is positively phototropic and negatively geotropic and root system is negatively phototropic and positively geotropic.

Some halophytes produce negatively geotropic roots (e.g. Rhizophora). These roots turn 180° upright for respiration.

Nastic Movements

- Nastic movements are non-directional response of a plant or part of a plant to stimulus. Based on the nature of stimuli, nastic movements are classified as follows.

Photonasty

- Movement of a part of a plant in response to light. e.g.Taraxacum officinale, blooms in morning and closes in the evening. Similarly, Ipomea alba (Moon flower), opens in the night and closes during the day.

Thigmonasty:

- Movement of a part of plant in response to touch. e.g. Mimosa pudica, folds leaves and droops when touched. It is also known as Seismonasty.

The Venus Flytrap (Dionaea muscipula) presents a spectacular example of thigmonasty. It exhibits one of the fastest known nastic movement.

Differences between Tropic and Nastic movements

Tropic Movements	**Nastic Movements**
Unidirectional response to the stimulus.	Non – directional response to the stimulus.
Growth dependent movements	Growth independent movements.
More or less permanent and irreversible	Temporary and reversible.
Found in all plants.	Found only in a few specialized plants.
Slow action.	Immediate action.

Thermonasty:

- Movement of part of a plant is associated with change in temperature. e.g. Tulip flowers bloom as the temperature increases.

Photosynthesis

- 'Photo' means 'light' and 'synthesis' means 'to build'. Thus photosynthesis literally means 'building up with the help of light'. During this process, the light energy is converted into chemical energy. Green plants are autotrophic in their mode of nutrition because they prepare their food materials through a process called photosynthesis. The overall equation of photosynthesis can be given as below:

$$\underset{\text{Carbon dioxide}}{6CO_2} + \underset{\text{Water}}{6H_2O} \xrightarrow[\text{Chlorophyll}]{\text{Photosynthesis}} \underset{\text{Gluose}}{C_6H_{12}O_6} + \underset{\text{Oxygen}}{6O_2\uparrow}$$

- The end product of photosynthesis is glucose which will be converted into starch and stored in the plant body. Plants take in carbon dioxide for photosynthesis; but for its living, plants also need oxygen to carry on cellular respiration.

- These activities show that certain things are necessary for photosynthesis. They are:
  - Chlorophyll - Green pigment in leaves
  - Water
  - Carbon dioxide (from air)
  - Sun light

Transpiration

- The loss of water in the form of water vapour from the aerial parts of the plant body is called as transpiration. The leaves have tiny, microscopic pores called stomata. Water evaporates through these stomata. Each stomata is surrounded by guard cells. These guard cells help in regulating the rate of transpiration by opening and closing of stomata.

Types of Transpiration

There are three types of transpiration:

- **Stomatal transpiration:** Loss of water from plants through stomata. It accounts for 90- 95% of the water transpired from leaves.

- **Cuticular transpiration:** Loss of water in plants through the cuticle.

- **Lenticular transpiration:** Loss of water from plants as vapour through the lenticels. The lenticels are tiny openings that protrude from the barks in woody stems and twigs as well as in other plant organs.

But transpiration is necessary for the following reasons.

- It creates a pull in leaf and stem.
- It creates an absorption force in roots.
- It is necessary for continuous supply of minerals.
- It regulates the temperature of the plant.

Exchange of Gases

- How does the plant get air? The leaves have minute pores called stomata through which the exchange of air takes place. These minute pores can be seen through a microscope. Air exchange takes place continuously through the stomata. Plants exchange gases (CO_2 to O_2) continuously through these stomata. You will study more about these physiological process in your higher classes.

10th Book
Unit 16 – Plant and Animal Hormones

Introduction

- The word hormone is derived from the Greek word "hormon" meaning " to excite". The function of control and coordination in plants is performed by chemical substances produced by the plants called plant hormones. In plants several cells are capable of producing hormones. These phytohormones are transported to different parts of the plants to perform various physiological functions.

- Endocrine glands in vertebrate animals possess a diversified communication system to co-ordinate physiological and metabolic functions by chemical integration. The endocrine system acts through chemical messengers known as hormones which are produced by specialized glands. Physiological processes such as digestion, metabolism, growth, development and reproduction are controlled by hormones.

Plant Hormones

- Plant hormones are organic molecules that are produced at extremely low concentration in plants. These molecules control morphological, physiological and biochemical responses.

Types of Plant Hormones

There are five major classes of plant hormones. They are:

- Auxins
- Cytokinins
- Gibberellins
- Abscisic Acid (ABA)
- Ethylene

- Among all these plant hormones auxins, cytokinins and gibberellins promote plant growth while abscisic acid and ethylene inhibit plant growth.

Auxins

- Auxins (Gk. auxein = to grow) were the first plant hormones discovered. The term auxin was introduced by Kogl and Haagen- Smith (1931). Auxins are produced at the tip of stems and roots from where they migrate to the zone of elongation. Charles Darwin (1880), observed unilateral growth and curvature of canary grass (Phalaris canariensis) coleoptiles. He came to the conclusion that some 'influence' was transmitted from the tip of the coleoptile to the basal region. This 'influence' was later identified as Auxin by Went.

Went's Experiment

- Frits Warmolt Went (1903– 1990), a Dutch biologist demonstrated the existence and effect of auxin in plants. He did a series of experiments in Avena coleoptiles.

- In his first experiment he removed the tips of Avena coleoptiles. The cut tips did not grow indicating that the tips produced something essential for growth.In his second experiment he placed the agar blocks on the decapitated coleoptile tips. The coleoptile tips did not show any response. In his next experiment he placed the detached coleoptile tips on agar blocks. After an hour, he discarded the tips and placed this agar block on the decapitated coleoptile. It grew straight up indicating that some chemical had diffused from the cut coleoptile tips into the agar block which stimulated the growth.

- From his experiments Went concluded that a chemical diffusing from the tip of coleoptiles was responsible for growth, and he named it as "Auxin" meaning 'to grow".

Types of Auxins: Auxins are classified into two types, namely natural auxins and synthetic auxins.
Natural Auxins: Auxins produced by the plants are called natural auxins. Example: IAA (Indole – 3 - Acetic Acid)

Synthetic Auxins: Artificially synthesized auxins that have properties like auxins are called as synthetic auxins. Example: 2, 4 D (2,4 Dichlorophenoxy Acetic Acid).

Physiological effects of auxins: Auxins bring about a variety of physiological effects in different parts of the plant body.

- ❖ Auxins promote the elongation of stems and coleoptiles which makes them to grow.
- ❖ Auxins induce root formation at low concentration and inhibit it at higher concentration.
- ❖ The auxins produced by the apical buds suppress growth of lateral buds. This is called apical dominance.
- ❖ Seedless fruits without fertilization are induced by the external application of auxins. (Parthenocarpy). Examples: Watermelon, Grapes, Lime etc.
- ❖ Auxins prevent the formation of abscission layer

Phenyl Acetic Acid (PAA) and Indole 3 Acetonitrile (IAN) are natural auxins. Indole 3 Butyric Acid (IBA), Indole-3- Propionic Acid, α-Naphthalene Acetic Acid (NAA), 2, 4, 5-T (2,4,5 Trichlorophenoxy Acetic Acid) are some of the synthetic auxins

Cytokinins

- Cytokinins (Cytos - cell; kinesis - division) are the plant hormones that promote cell division or cytokinesis in plant cells. It was first isolated from Herring fish sperm. Zeatin was the cytokinin isolated from Zea mays. Cytokinin is found abundantly in liquid endosperm of coconut.

Physiological effects of cytokinins

- ❖ Cytokinin induces cell division (cytokinesis) in the presence of auxins.
- ❖ Cytokinin also causes cell enlargement.
- ❖ Both auxins and cytokinins are essential for the formation of new organs from the callus in tissue culture (Morphogenesis).
- ❖ Cytokinins promote the growth of lateral buds even in the presence of apical bud.

- Application of cytokinin delays the process of ageing in plants. This is called Richmond Lang effect.

Gibberellins

- Gibberellins are the most abundantly found plant hormones. Kurosawa (1926) observed Bakanae disease or foolish seedling disease in rice crops. This internodal elongation in rice was caused by fungus Gibberellafujikuroi. The active substance was identified as Gibberellic acid.

Physiological effects of gibberellins

- Application of gibberellins on plants stimulate extraordinary elongation of internode. e.g. Corn andPea.
- Treatment of rosette plants with gibberellin induces sudden shoot elongation followed by flowering. This is called bolting.
- Gibberellins promote the production of male flowers in monoecious plants (Cucurbits).
- Gibberellins break dormancy of potato tubers.
- Gibberellins are efficient than auxins in inducing the formation of seedless fruit - Parthenocarpic fruits (Development of fruits without fertilization) e.g. Tomato

Abscisic Acid

- Abscisic acid (ABA) is a growth inhibitor which regulates abscission and dormancy. It increases tolerance of plants to various kinds of stress. So, it is also called as stress hormone. It is found in the chloroplast of plants.

Physiological effects of abscisic acid

- ABA promotes the process of abscission (separation of leaves, flowers and fruits from the branch).
- During water stress and drought conditions ABA causes stomatal closure.
- ABA promotes senescence in leaves by causing loss of chlorophyll.
- ABA induces bud dormancy towards the approach of winter in trees like birch.

❖ ABA is a powerful inhibitor of lateral bud growth in tomato.

Ethylene

- Ethylene is a gaseous plant hormone. It is a growth inhibitor. It is mainly concerned with maturation and ripening of fruits. Maximum synthesis of ethylene occurs during ripening of fruits like apples, bananas and melons.

Physiological effects of ethylene

❖ Ethylene promotes the ripening of fruits. e.g. Tomato, Apple, Mango, Banana, etc
❖ Ethylene inhibits the elongation of stem and root in dicots.
❖ Ethylene hastens the senescence of leaves and flowers.
❖ Ethylene stimulates formation of abscission zone in leaves, flowers and fruits. This leads to premature shedding.
❖ Ethylene breaks the dormancy of buds, seeds and storage organs.

Human Endocrine Glands

- Endocrine glands in animals possess a versatile communication system to coordinate biological functions. Exocrine glands and endocrine glands are two kinds of glands found in animals. Endocrine glands are found in different regions of the body of animals as well as human beings. These glands are called ductless glands. Their secretions are called hormones which are produced in minute quantities. The secretions diff use into the blood stream and are carried to the distant parts of the body. They act on specific organs which are referred as target organs.

The branch of biology which deals with the study of the endocrine glands and its physiology is known as 'Endocrinology'. Thomas Addison is known as Father of Endocrinology. English physiologists W. M. Bayliss and E. H. Starling introduced the term hormone in 1909. They first discovered the hormone secretin.

- Exocrine glands have specific ducts to carry their secretions e.g. salivary glands, mammary glands, sweat glands.

Endocrine glands present in human and other vertebrates are

- Pituitary gland
- Thyroid gland
- Parathyroid gland
- Pancreas (Islets of Langerhans)
- Adrenal gland (Adrenal cortex and Adrenal medulla)
- Gonads(Testes and Ovary)
- Thymus gland

Pituitary Gland

- The pituitary gland or hypophysis is a pea shaped compact mass of cells located at the base of the midbrain attached to the hypothalamus by a pituitary stalk. The pituitary gland is anatomically composed of two lobes and perform different functions. They are the anterior lobe (adenohypophysis) and the posterior lobe (neurohypophysis). The intermediate lobe is non-existent in humans.

- The pituitary gland forms the major endocrine gland in most vertebrates. It regulates and controls other endocrine glands and so is called as the "Master gland".

- Hormones secreted by the anterior lobe (Adenohypophysis) of pituitary

- The anterior pituitary is composed of different types of cells and secrete hormones which stimulates the production of hormones by other endocrine glands. The hormones secreted by anterior pituitary are

- Growth Hormone
- Thyroid stimulating Hormone
- Adrenocorticotropic Hormone
- Gonadotropic Hormone which comprises the Follicle Stimulating Hormone and Luteinizing Hormone
- Prolactin

Growth hormone (GH)

- GH promotes the development and enlargement of all tissues of the body. It stimulates the growth of muscles, cartilage and long bones. It controls the cell metabolism.

- The improper secretion of this hormone leads to the following conditions.

Dwarfism: It is caused by decreased secretion of growth hormone in children. The characteristic features are stunted growth, delayed skeletal formation and mental disability.

Gigantism: Oversecretion of growth hormone leads to gigantism in children. It is characterised by overgrowth of all body tissues and organs. Individuals attain abnormal increase in height.

Acromegaly: Excess secretion of growth hormone in adults may lead to abnormal enlargement of head, face, hands and feet.

Thyroid stimulating hormone (TSH)

TSH controls the growth of thyroid gland, coordinates its activities and hormone secretion.

Adrenocorticotropic hormone (ACTH)

ACTH stimulates adrenal cortex of the adrenal gland for the production of its hormones. It also influences protein synthesis in the adrenal cortex.

Gonadotropic hormones (GTH)

- The gonadotropic hormones are follicle stimulating hormone and luteinizing hormone which are essential for the normal development of gonads.

Follicle stimulating hormone (FSH)

- In male, it stimulates the germinal epithelium of testes for formation of sperms. In female it initiates the growth of ovarian follicles and its development in ovary.

Luteinizing hormone (LH)

- In male, it promotes the Leydig cells of the testes to secrete male sex hormone testosterone. In female, it causes ovulation (rupture of mature graafian follicle), responsible for the development of corpus luteum and production of female sex hormones estrogen and progesterone.

Prolactin (PRL)

- PRL is also called lactogenic hormone. This hormone initiates development of mammary glands during pregnancy and stimulates the production of milk after child birth.

Hormones secreted by the posterior lobe (Neurohypophysis) of pituitary

The hormones secreted by the posterior pituitary are

- Vasopressin or Antidiuretic hormone
- Oxytocin

Vasopressin or Antidiuretic hormone (ADH)

- In kidney tubules it increases reabsorption of water. It reduces loss of water through urine and hence the name antidiuretic hormone.

- Deficiency of ADH reduces reabsorption of water and causes an increase in urine output (polyuria). This deficiency disorder is called Diabetes insipidus.

Oxytocin

- It helps in the contraction of the smooth muscles of uterus at the time of child birth and milk ejection from the mammary gland after child birth.

Thyroid Gland

- The thyroid gland is composed of two distinct lobes lying one on either side of the trachea. The two lobes are connected by means of a narrow band of tissue known as the isthmus. This gland is composed of glandular follicles and

lined by cuboidal epithelium.The follicles are filled with colloid material called thyroglobulin.

An amino acid tyrosine and iodine are involved in the formation of thyroid hormone. The hormones secreted by the thyroid gland are

- Triiodothyronine (T3)
- Tetraiodothyronine or Thyroxine (T4)

Functions of thyroid hormones

The functions of thyroid hormones are

- Production of energy by maintaining the Basal Metabolic Rate (BMR) of the body.
- Helps to maintain normal body temperature.
- Influences the activity of central nervous system.
- Controls growth of the body and bone formation.
- Essential for normal physical, mental and personality development .
- It is also known as personality hormone.
- Regulates cell metabolism.

Thyroid Dysfunction

- When the thyroid gland fails to secrete the normal level of hormones, the condition is called thyroid dysfunction. It leads to the following conditions

Hypothyroidism

- It is caused due to the decreased secretion of the thyroid hormones. The abnormal conditions are simple goitre, cretinism and myxoedema.

Goitre

- It is caused due to the inadequate supply of iodine in our diet. This is commonly prevalent in Himalayan regions due to low level of iodine content in the soil. It leads to the enlargement of thyroid gland which protrudes as a marked swelling in the neck and is called as goitre.

Cretinism

- It is caused due to decreased secretion of the thyroid hormones in children. The conditions are stunted growth, mental defect, lack of skeletal development and deformed bones. They are called as cretins.

Myxoedema

- It is caused by deficiency of thyroid hormones in adults. They are mentally sluggish, increase in body weight, puffiness of the face and hand, oedematous appearance.

Hyperthyroidism

- It is caused due to the excess secretion of the thyroid hormones which leads to Grave's disease. The symptoms are protrusion of the eyeballs (Exopthalmia), increased metabolic rate, high body temperature, profuse sweating, loss of body weight and nervousness.

Parathyroid Gland

- The parathyroid glands are four small oval bodies that are situated on the posterior surface of the thyroid lobes. The chief cells of the gland are mainly concerned with secretion of parathormone.

Functions of Parathormone

- The parathormone regulates calcium and phosphorus metabolism in the body.They act on bone, kidney and intestine to maintain blood calcium levels.

Parthyroid Dysfunction

- The secretion of parathyroid hormone can be altered due to the following conditions.

- Removal of parathyroid glands during thyroidectomy (removal of thyroid) causes decreased secretion of parathormone. The conditions are Muscle spasm known as Tetany (sustained contraction of muscles in face, larynx, hands and feet).

  Painful cramps of the limb muscles

Pancreas (Islets of Langerhans)

- Pancreas is an elongated, yellowish gland situated in the loop of stomach and duodenum. It is exocrine and endocrine in nature. The exocrine pancreas secretes pancreatic juice which plays a role in digestion while, the endocrine portion is made up of Islets of Langerhans.

Human insulin was first discovered by Fredrick Banting, Charles Best and MacLeod in 1921. Insulin was first used in treatment of diabetes on 11th January 1922

- The Islets of Langerhans consists of two types of cells namely alpha cells and beta cells. The alpha cells secrete glucagon and beta cells secrete insulin.

Functions of Pancreatic hormones

- A balance between insulin and glucagon production is necessary to maintain blood glucose concentration.

Insulin

- ❖ Insulin helps in the conversion of glucose into glycogen which is stored in liver and skeletal muscles.
- ❖ It promotes the transport of glucose into the cells.
- ❖ It decreases the concentration of glucose in blood.

Glucagon

- Glucagon helps in the breakdown of glycogen to glucose in the liver.
- It increases blood glucose levels.

Diabetes mellitus

- The deficiency of insulin causes Diabetes mellitus. It is characterised by

  - Increase in blood sugar level (Hyperglycemia).
  - Excretion of excess glucose in the urine (Glycosuria).
  - Frequent urination (Polyuria).
  - Increased thirst (Polydipsia).
  - Increase in appetite (Polyphagia).

Adrenal Gland

- The adrenal glands are located above each kidney. They are also called supra renal glands.

- The outer part is the adrenal cortex and the inner part is the adrenal medulla. The two distinct parts are structurally and functionally different.

Adrenal Cortex

- The adrenal cortex consists of three layers of cells. They are zona glomerulosa, zona fasciculata and zona reticularis

Hormones of Adrenal Cortex

- The hormones secreted by the adrenal cortex are corticosteroids. They are classified into

  - Glucocorticoids
  - Mineralocorticoids

Functions of adrenocortical hormones

Glucocorticoids

- The glucocorticoids secreted by the zona fasciculata are cortisol and corticosterone

  - ❖ They regulate cell metabolism.
  - ❖ It stimulates the formation of glucose from glycogen in the liver.
  - ❖ It is an anti-inflammatory and anti-allergic agent.

Mineralocorticoids

- The mineralocorticoids secreted by zona glomerulosa is aldosterone

  - ❖ It helps to reabsorb sodium ions from the renal tubules.
  - ❖ It causes increased excretion of potassium ions.
  - ❖ It regulates electrolyte balance, body fluid volume, osmotic pressure and blood pressure.

Adrenal Medulla

- The adrenal medulla is composed of chromaffin cells.They are richly supplied with sympathetic and parasympathetic nerves.

Hormones of Adrenal Medulla
It secretes two hormones namely

  - ❖ Epinephrine (Adrenaline)
  - ❖ Norepinephrine (Noradrenaline)

- They are together called as "Emergency hormones". It is produced during conditions of stress and emotion. Hence it is also referred as "flight, fright and fight hormone".

Functions of adrenal medullary hormones
Epinephrine (Adrenaline)

- It promotes the conversion of glycogen to glucose in liver and muscles.
- It increases heart beat and blood pressure.
- It increases the rate of respiration by dilation of bronchi and trachea.
- It causes dilation of the pupil in eye.
- It decreases blood flow through the skin.

Norepinephrine (Noradrenalin)

- Most of its actions are similar to those of epinephrine.

Reproductive Glands (Gonads)

- The sex glands are of two types the testes and the ovaries. The testes are present in male, while the ovaries are present in female.

Testes

- Testes are the reproductive glands of the males. They are composed of seminiferous tubules, Leydig cells and Sertoli cells. Leydig cells form the endocrine part of the testes. They secrete the male sex hormone called testosterone.

Functions of testosterone

- It influences the process of spermatogenesis.
- It stimulates protein synthesis and controls muscular growth.
- It is responsible for the development of secondary sexual characters (distribution of hair on body and face, deep voice pattern, etc).

Ovary

- The ovaries are the female gonads located in the pelvic cavity of the abdomen. They secrete the female sex hormones

    - Estrogen
    - Progesterone

- Estrogen is produced by the Graafian follicles of the ovary and progesterone from the corpus luteum that is formed in the ovary from the ruptured follicle during ovulation.

Functions of estrogens

- It brings about the changes that occur during puberty.
- It initiates the process of oogenesis.
- It stimulates the maturation of ovarian follicles in the ovary.
- It promotes the development of secondary sexual characters (breast development, high pitched voice etc).

Functions of progesterone

- It is responsible for the premenstrual changes of the uterus.
- It prepares the uterus for the implantation of the embryo.
- It maintains pregnancy.
- It is essential for the formation of placenta.

Thymus Gland

- Thymus is partly an endocrine gland and partly a lymphoid gland. It is located in the upper part of the chest covering the lower end of trachea. Thymosin is the hormone secreted by thymus.

Functions of Thymosin

- It has a stimulatory effect on the immune function.
- It stimulates the production and differentiation of lymphocytes.

Unit 17 – Reproduction in Plants & Animals

Introduction

- "Living organisms cannot survive for an indefinite period on earth. All living organisms have the ability to produce more of its own kind by the process called reproduction. Reproduction is the unfolding of life forms where new individuals are formed. It ensures continuity and survival of the species. This process is to preserve individual species and it is called as self-perpetuation. The time required to reproduce also varies from organism to organism. You may find great variations in period of reproduction in yeast, bacteria, rat, cow, elephant and humans. In sexual reproduction offsprings are produced by the union of male and female gametes (sperm and egg). The male and female gametes contain the genetic material or genes present on the chromosomes which transmit the characteristic traits to the next generation. There are three types of reproduction in plants namely i) Vegetative ii) Asexual and iii)Sexual reproduction. In this unit you willknow more about the types and the processof asexual and sexual reproduction in plants,animals and human.

Vegetative Reproduction

- In this type, new plantlets are formed from vegetative (somatic) cells, buds or organsof plant. The vegetative part of plant (root, stem, leaf or bud) gets detached from the parent body and grows into an independent daughter plant. It has only mitotic division, no gametic fusion and daughter plants are genetically similar to the parent plant.

Vegetative reproduction may take place through

- **Leaves:** In Bryophyllum small plants grow at the leaf notches
- **Stems:** In strawberry aerial weak stems touch the ground and give off adventitious roots and buds. When the connections with the parent plant is broken, the offspring beomes independent.

- **Root:** Tuberous roots (Asparagus and Sweet potato) can be used for vegetative propagation.

- **Bulbils:** In some plants the flower bud modifies into globose bulb which are called as bulbils, when these falls on the ground they grow into new plants. e.g. Agave.

- **Fragmentation:** In filamentous algae, breaking of the filament into many fragments is calledfragmentation. Each fragment having atleast one cell, may give rise to a new filament of the algae by cell division e.g. Spirogyra.

- **Fission:** In this type the parent cell divides into two daughter cells and each cell develops into a new adult organism e.g. Amoeba.

- **Budding:** Formation of a daughter individual from a small projection, the bud, arising on the parent body is called budding. e.g. Yeast

- **Regeneration:** The ability of the lost body parts of an individual organism to give rise to an whole new organism is called regeneration. It takes place by specialized mass of cells e.g Hydra and Planaria.

Asexual Reproduction

- Production of an offspring by a single parent without the formation and fusion of gametes is called asexual reproduction. It involves only mitotic cell divisions and meiosis does not occur. Offspring produced by asexual reproduction are not only identical to parents but are also exact copies of their parent.

- Asexual reproduction occurs by spore formation. This is the most common method of asexual reproduction in fungi and bacteria.

- During spore formation a structure called sporangium develops from the fungal hypha. The nucleus divides several times within the sporangium and each nucleus with small amount of cytoplasm develops into a spore. The spores are liberated and they develop into new hypha after reaching the ground or substratum.

Sexual Reproduction in Plants

- Sexual reproduction is the process in which two gametes (male and female) are fused to produce offspring of their own kind. In such cases both sexes, male and female sex organs are needed to produce gametes. You have already learnt that the flower is a reproductive organ of a flowering plant. To

understand this further we need to study the structure of a flower.

Parts of a Typical Flower

- A flower is a modified shoot with limited growth to carry out sexual reproduction. A flower consists of four whorls borne on a thalamus. These whorls are from outside

  - Calyx – consisting of sepals
  - Corolla – consisting of petals
  - Androecium – consisting of stamens
  - Gynoecium or pistil – consisting of carpels

- The two outermost whorls calyx and corolla are non–essential or accessory whorls as they do not directly take part in the reproduction. The other two whorls androecium and gynoecium are known as the essential whorls, because both take part directly in reproduction.

- **Androecium:** Androecium, the male part of flower is composed of stamens. Each stamen consists of a stalk called the filament and a small bag like structure called anther at the tip. The pollen grains are produced in the anther within the pollen sac.

Pollen grain: Pollen grains are usually spherical in shape. It has two layered wall. The hard-outer layer is known as exine. It has prominent apertures called germpore. The inner thin layer is known as intine. It is a thin and continuous layer made up of cellulose and pectin. Mature pollen grains contain two cells, the vegetative and the generative cell. Vegetative cell contains a large nucleus. The generative cell divides mitotically to form two male gametes.

Gynoecium: Gynoecium is the female part of the flower and is made up of carpels. It has three parts:

- ❖ Ovary
- ❖ Style
- ❖ Stigma

The ovary contains the ovules.

Structure of the Ovule

- The main part of the ovule is the nucellus which is enclosed by two integuments leaving an opening called as micropyle. The ovule is attached to the ovary wall by a stalk known as funiculus. Chalaza is the basal part.

- The embryo sac contains seven cells and the eighth nuclei located within the nucellus. Three cells at the micropylar end form the egg apparatus and the three cells at the chalaza end are the antipodal cells. The remaining two nuclei are called polar nuclei found in the centre. In the egg apparatus one is the egg cell (female gamete) and the remaining two cells are the synergids.

Process of sexual reproduction in flowering plants. It involves:

- ❖ Pollination
- ❖ Fertilization

Pollination

- The transfer of pollen grains from anther to stigma of a flower is called as pollination

Importance of Pollination

- It results in fertilization which leads to the formation of fruits and seed.
- New varieties of plants are formed through new combination of genes in case of cross pollination.

Types of Pollination

- ❖ Self-pollination
- ❖ Cross pollination

Self-pollination (Autogamy)

- Self-pollination is also known as autogamy. The transfer of pollen grains from the anther to the stigma of same flower or another flower borne on the same plant is known as self-pollination. e.g. Hibiscus.

Advantages of self-pollination

- ❖ Self-pollination is possible in certain bisexual flowers.
- ❖ Flowers do not depend on agents for pollination.
- ❖ There is no wastage of pollen grains.

Disadvantages of self-pollination

- ❖ The seeds are less in numbers.
- ❖ The endosperm is minute. Therefore, the seeds produce weak plants.
- ❖ New varieties of plants cannot be produced.

Cross pollination

- Cross-pollination is the transfer of pollen from the anthers of a flower to the stigma of a flower on another plant of the same species e.g. apples, grapes, plum, etc.

Advantages of cross pollination

- The seeds produced as a result of cross pollination, develop and germinate properly and grow into better plants, i.e. cross pollination leads to the production of new varieties.
- More viable seeds are produced.

Disadvantages of cross-pollination

- Pollination may fail due to distance barrier.

- ❖ More wastage of pollen grains
- ❖ It may introduce some unwanted characters
- ❖ Flowers depend on the external agencies for pollination

Agents of Cross Pollination

- In order to bring about cross pollination, it is necessary that the pollen should be carried from one flower to another of a different plant.

- This takes place through the agency of animals, insects, wind and water.

Pollination by wind

- The pollination with the help of wind is called anemophily. The anemophilous flowers produce enormous amount of pollen grains. The pollen grains are small, smooth, dry and light in weight. Pollen of such plants are blown off at a distance of more than 1,000 km. The stigmas are comparatively large, protruding and sometimes hairy to trap the pollen grains. e.g. Grasses and some cacti.

Pollination by insects

- Pollination with the help of insects like honey bees, flies are called entomophily. To attract insects these flowers are brightly coloured, have smell and nectar. The pollen grains are larger in size, the exine is pitted, spiny etc., so they can be adhered firmly on the sticky stigma. Approximately, 80% of the pollination done by the insects is carried by honey bees.

Pollination by water

- The pollination with the help of water is called hydrophily.This takes place in aquatic plants.

  - ❖ Pollen grains are produced in large numbers.
  - ❖ Pollen grains float on surface of water till they land on the stigma of female flowers e.g. Hydrilla, Vallisneria.

Pollination by Animals

- When pollination takes place with the help of animals, it is called Zoophily. Flowers of such plants attract animals by their bright color, size, scent etc. e.g. sun bird pollinates flowers of Canna, Gladioli etc., Squirrels pollinate flowers of silk cotton tree.

Fertilization in Plants

- Pollen grains reach the right stigma and begin to germinate.
- Pollen grain forms a small tube-like structure called pollen tube which emerges through the germ pore. The contents of the pollen grain move into the tube.
- Pollen tube grows through the tissues of the stigma and style and finally reaches the ovule through the micropyle.
- Vegetative cell degenerates and the generative cell divides to form two sperms (or male gametes).
- Tip of pollen tube bursts and the two sperms enter the embryo sac.
- One sperm fuses with the egg (syngamy) and forms a diploid zygote. The other sperm fuses with the secondary nucleus (Triple fusion) to form the primary endosperm nucleus which is triploid in nature. Since two types of fusion syngamy and triple fusion take place in an embryo sac the process is termed as double fertilization.
- After triple fusion, primary endosperm nucleus develops into an endosperm.
- Endosperm provides food to the developing embryo.
- Later the synergids and antipodal cells degenerate.

Significance of Fertilization

- It stimulates the ovary to develop into fruit.
- It helps in development of new characters from two different individuals

Post fertilization changes:

- The ovule develops into a seed.

- ❖ The integuments of the ovule develop into the seed coat.
- ❖ The ovary enlarges and develops into a fruit.

- The seed contains the future plant or embryo which develops into a seedling under appropriate conditions.

Sexual Reproduction in Human

- In human beings the male and female reproductive organs differ anatomically and physiologically. New individuals develop by the fusion of gametes. Sexual reproduction involves the fusion of two haploid gametes (male and the female gametes) to form a diploid individual (zygote).

Organs of the reproductive system are divided into primary and secondary (accessory) sex organs.

- Primary reproductive organs include the gonads (Testes in male and Ovaries in female).
- Accessory sex organs

Male: Vas deferens, epididymis, seminal vesicle, prostate gland and penis.
Female: Fallopian tubes, uterus, cervix and vagina.

The secondary (accessory) sex organs include those structures which are involved in the

- ❖ Process of ovulation
- ❖ Fusion of the male and female gametes (fertilization)
- ❖ Division of the fertilized egg upto the formation of embryo
- ❖ Pregnancy
- ❖ Development of foetus
- ❖ Child birth.

Male Reproductive Organ - Structure of Testes

- Testes are the reproductive glands of the male that are oval shaped organs which lie outside the abdominal cavity of a man in a sac like structure called scrotum. Now we shall study the various cells which are present in the testes.

- Each testes is covered with a layer of fibrous tissue called tunica albuginea. Many septa from this layer divide the testes into pyramidal lobules, in which lie seminiferous tubules, cells of Sertoli, and the Leydig cells (interstitial cells).

- The process of spermatogenesis takes place in the seminiferous tubules. The Sertoli cells are the supporting cells and provide nutrients to the developing sperms. The Leydig cells are polyhedral in shape andlie between the seminiferous tubules and secrete testosterone. It initiates the process of spermatogenesis.

Female Reproductive Organ - Structure of Ovary

- The ovaries are located on either side of the lower abdomen composed of two almond shaped bodies, each lying near the lateral end of fallopian tube. Each ovary is a compact structure consisting of an outer cortex and an inner medulla. The cortex is composed of a network of connective tissue called as stroma and is lined by the germinal epithelium. The epithelial cells called the granulosa cells surround each ovum in the ovary together forming the primary follicle. As the egg grows larger, the follicle also enlarges and gets filled with the fluid and is called the Graafian follicle.

Gametogenesis

- The formation of the sperm in male and the ovum in female is called gametogenesis. It involves spermatogenesis (formation of spermatozoa) and oogenesis (the formation of ova). Gametes with haploid cells are produced through gametogenesis.

Structure of Human Sperm

- The spermatozoan consists of head, a middle piece and tail. The sperm head is elongated and formed by the condensation of nucleus.

The anterior portion has a caplike structure called acrosome. It contains hyaluronidase an enzyme that helps the sperm to enter the ovum during fertilization. A short neck connects the head and middle piece which comprises the centrioles.The middle piece contains the mitochondria which provides energy for the movement of tail. It brings about sperm motility which is essential for fertilization.

Structure of Ovum

- The mature ovum or egg is spherical in shape.The ovum is almost free of yolk. It contains abundant cytoplasm and the nucleus. The ovum is surrounded by three membranes. The plasma membrane is surrounded by inner thin zona pellucida and an outer thick corona radiata. The corona radiata is formed of follicle cells. The membrane forming the surface layer of the ovum is called vitelline membrane. The fluid-filled space between zona pellucida and the surface of the egg is called perivitelline space.

Puberty

- The reproductive system in both males and females becomes functional and an increase in sex hormone production resulting in puberty. This phenomenon tends to start earlier in females than in males. Generally boys attain puberty between the age of 13 to 14 years, while girls reach puberty between 11 to 13 years. In male, the onset of puberty is triggered by the secretion of the hormone testosterone in the testes, in female the secretion of estrogens and progesterone fromthe ovary. The secretion of both male and female hormones are under the control of the pituitary gonadotropins luteinizing hormone (LH) and follicle stimulating hormone (FSH).

Menstrual Cycle-Process of Ovulation

- The cyclic events that take place in a rhythmic fashion during the reproductive period of a woman's life is called menstrual cycle. In human females the menstrual cycle starts at the age of 11-13 years which marks the onset of puberty and is called menarche, and ceases around 48-50 years of age and this stage is termed menopause. The reproductive period is marked by characteristic events repeated almost every month in physiologically normal women (28 days with minor variation) in the form of a menstrual flow. The menstrual cycle consists of 4 phases

- ❖ Menstrual or Destructive Phase
- ❖ Follicular or Proliferative Phase
- ❖ Ovulatory Phase
- ❖ Luteal or Secretory Phase

- These phases show simultaneous synchrony of events in both ovary and uterus. Changes in the ovary and the uterus areinduced by the pituitary hormones (LH and FSH) and ovarian hormones (estrogen and progesterone).

Phase	Days	Changes in Ovary	Changes in Uterus	Hormonal Changes
Menstrual Phase	4-5 days	Development of Primary follicles	Breakdown of Uterine endometrial lining leads to bleeding	Decrease in Progesterone and Oestrogen
Follicular Phase	6th – 13th day	Primary follicles grow to become a fully mature Graafian follicle	Endometrium regenerates through proliferation	FSH and Oestrogen increase
Ovulatory Phase	14th day	The Graafian follicle ruptures, and releases the Ovum (egg)	Increase in endometrial thickness	LH Peak
Luteal Phase	15th – 28th day	Emptied Graafian follicle develops into Corpus luteum	Endometrium is prepared for implantation if fertilization of egg takes place, if fertilization	LH and FSH decrease, Corpus luteum produces progesterone and its level increases

			does not occur corpus luteum degenerates, uterine wall ruptures, bleeding starts and Unferetilized egg is expelled	followed bu a decline, if menstrual bleeding occurs.

Fertilization to Foetal Development

Fertilization

- Fertilization in human is internal and occurs in the oviduct of the female genital tract. It takes place usually in the ampulla of the fallopian tube. An oocyte is alive for about 24 hours after it is released from the follicle. Fertilisation must take place within 24 hours. The sperm enters into the ovum and fuses with it, resulting in the formation of a 'zygote'. This process is called fertilization. The zygote is a fertilized ovum.

Cleavage and Formation of Blastula

- The first cleavage takes place about 30 hours after fertilization. Cleavage is a series of rapid mitotic divisions of the zygote to form many celled blastula (Blastocyst) which comprises an outer layer of smaller cells and inner mass of larger cells.

Implantation

- The blastocyst (fertilized egg) reaches the uterus and gets implanted in the uterus. The process of attachment of the blastocyst to the uterine wall (endometrium) is called implantation. The fertilized egg becomes implanted in about 6 to 7 days after fertilization.

Gastrulation

- The transformation of blastula into gastrula and the formation of primary germlayers (ectoderm, mesoderm and endoderm) by rearrangement of the cells is called gastrulation. This takes place after the process of implantation.

Organogenesis

- The establishment of the germ layers namely ectoderm, mesoderm and endoderm initiates the final phase of embryonic development. During organogenesis the various organs of the foetus are established from the different germ layers attaining a functional state.

Formation of Placenta

- The placenta is a disc shaped structure attached to the uterine wall and is a temporary association between the developing embryo and maternal tissues. It allows the exchange of food materials, diffusion of oxygen, excretion of nitrogenous wastes and elimination of carbon dioxide. A cord containing blood vessels that connects the placenta with the foetus is called the umbilical cord.

Pregnancy (Gestation)

- It is the time period during which the embryo attains its development in the uterus. Normally gestation period of human last for about 280 days. During pregnancy the uterus expands upto 500 times of its normal size.

Parturition (Child Birth)

- Parturition is the expulsion of young one from the mother's uterus at the end of gestation. Oxytocin from the posterior pituitary stimulates the uterine contractions and provides force to expel the baby from the uterus, causing birth.

Sometimes ovaries releases two eggs and each is fertilised by a different sperm, resulting in Non-Identical Twins (Fraternal Twins). If single egg is fertilised and then divides into two foetus, Identical Twins develop

Lactation

- The process of milk production after child birth from mammary glands of the mother is called lactation. The first fluid which is released from the mammary gland after child birth is called as colostrum. Milk production from alveoli of mammary glands is stimulated by prolactin secreted from the anterior pituitary.

- The ejection of milk is stimulated by posterior pituitary hormone oxytocin.

Reproductive Health

- According to World Health Organization (WHO) reproductive health means a total well being in all aspects of reproduction, ability to reproduce and regulate fertility, women's ability to undergo pregnancy and safe child birth,maternal and infant survival and well being.

- Several measures were undertaken by the government to improve the reproductive health of the people by launching National Health Programmes such as the

❖ Family Welfare Programme
❖ Reproductive and Child Health Care (RCH) Programme

Family welfare programme: The National Family Welfare Programme is a comprehensive scheme which includes:
❖ Maternal and child health care (MCH)
❖ Immunization of mothers, infants and children.
❖ Nutritional supplement to pregnant women and children.
❖ Contraception with health education, to motivate couples to accept contraceptive methods and to have small family norms, which improve economic status, living status and the quality of life.

Reproductive and Child Health Care (RCH) Programme: It has integrated all services which include

❖ Pregnancy and child birth
❖ Postnatal care of the mother and child
❖ Importance of breast feeding
❖ Prevention of reproductive tract infections and sexually transmitted diseases.

Population Explosion and Family Planning

- Population explosion defined as the sudden and rapid rise in the size of population, especially human population. Realizing the dangers inherent in population growth, the Government of India has taken several measures to check population growth and introduced family planning. India has been one of the first country in the world to launch the nation wide family planning programme in 1952.

- Family planning is a way of living that is adopted voluntarily by couples on the basis of knowledge and responsible decisions to promote the health and welfare of the family group and society. The WHO (World Health Organisation) has also stressed the importance of family planning as global strategy health for all.

The inverted red triangle is a symbol of family planning in India for family welfare. It is displayed prominently at all hospitals, primary health clinics and family welfare centres where any help or advice about family planning is available free of cost. The symbol is displayed along with a slogan Small Family, Happy Family.

Contraception

- Contraception is one of the best birth control measures. A number of techniques or methods have been developed to prevent pregnancies in women. The devices used for contraception are called contraceptive devices.

❖ Barrier methods
❖ Hormonal methods
❖ Intra-Uterine Devices (IUDs)
❖ Surgical methods

Barrier Methods

- This method prevents sperms from meeting the ovum. Its entry into the female reproductive tract is prevented by barrier.

- **Condom:** Condom prevents deposition of sperms in the vagina. Condoms are made of thin rubber or latex sheath. Condom also protect against sexually transmitted diseases (STD) like syphilis, AIDS.

- **Diaphragm (Cervical cap):** Vaginal diaphragm fitting into the vagina or a cervical cap fitting over the cervix. This prevents the entry of sperms into the uterus.

Hormonal Methods

- Hormonal preparations are in the form of pills or tablets (contraceptive pills). These hormones stop (interfere with ovulation) the release of egg from the ovary.

Intra-Uterine Devices (IUDs)

- The intrauterine device (IUD) are contraceptive devices inserted into the uterus. There are two synthetic devices commonly used in India are Lippe's Loop and Copper-T made of copper and plastic (non irritant). This can remain for a period of 3 years. This reduces the sperm fertilizing capacity and prevents implantation. This also helps to give adequate time interval between pregnancies.

Surgical Methods

- Surgical contraception or sterilization techniques are terminal methods to prevent any pregnancy. This procedure in males is vasectomy (ligation of vas deferens) and in females it istubectomy (ligation of fallopian tube). These are methods of permanent birth control.

Urinary Tract Infection (UTI)

- Many diseases affect both women and men, but a few diseases occur at a higher frequency in woman. Woman are susceptible to UTI from the bacteria that are present on skin, rectum or vagina. This will enter the urethra, before moving upwards. The types of UTI are:

Cystitis or Bladder infection

- Bacteria lodged in the urinary bladder thrive and multiply leading to inflammation. It is most common in the age group of 20 to 50.

Kidney Infection

- The bacteria can travel from the urinary bladder and upward to ureter and affect one or both the kidneys. It also infects the blood stream and leads to serious life-threatening complications.

Asymptomatic Bacteriuria

- The bacteria present in the urinary bladder which may not show any symptoms

Personal Hygiene

- Hygiene is the practice of healthy living and personal cleanliness. Personal hygiene is caring of one's own body and health. Social hygiene is proper care of the surrounding environment. The main aspect of hygiene are body hygiene, food hygiene, sanitary hygiene and hygienic environment.

Body Hygiene

- Washing is vital to all age group of people which maintains our personal hygiene. A daily bath regularly keeps skin clean and free of germs. Hair should be kept clean by frequent washing. Mouth wash should be done after every meal. We should wash our hands many times during the day.

- Cloth towels used to dry our hands or body should be dried after each use and laundered regularly. Clothes, handkerchief, undergarments and socks should be washed daily. Washing prevents body odour, infections and skin irritation.

Toilet Hygiene

- The toilet has a lot to do with personal hygiene and general health as it is a place that cannot be avoided and used regularly. Parents should guide and practice their children on how to use the toilets at home, in schools and other public places so that it will protect the children from various contagious infections and diseases.The following measures can ensure toilet hygiene

❖ The floors of the toilet should be maintained clean and dry. This helps to reduce the bad odour and also infection.

❖ Toilet flush handles, door knobs, faucets, paper towel dispensers, light switches and walls should be cleaned with disinfectants to kill harmful germs and bacteria.

❖ Hands should be washed thoroughly with soap before and after toilet use.

Menstrual and Napkin Hygiene

- Women's health depends upon the level of cleanliness to keep them free from skin and genitourinary tract infection.

Menstrual hygiene

- Maintaining menstrual hygiene is important for the overall health of women. The basic menstrual hygiene ways are

❖ Sanitary pads should be changed regularly, to avoid infections due to microbes from vagina and sweat from genitals.

❖ Use of warm water to clean genitals helps to get rid of menstrual cramps

- Wearing loose clothing rather than tight fitting clothes will ensure the airflow around the genitals and prevent sweating.

Napkin hygiene

- The sanitary pad and tampons should be wrapped properly and discarded because they can spread infections.
- Sanitary pad or tampon should not be flushed down the toilet.
- Napkin incinerators are to be used properly for disposal of used napkins.

Unit -6 Asexual and Sexual Reproduction in Plants

- One of the essential features of all living things on the earth is reproduction. Reproduction is a vital process for the existence of a species and it also brings suitable changes through variation in the off springs for their survival on earth. Plant reproduction is important not only for its own survival but also for the continuation and existence of all other organisms since the latter directly or indirectly depend on plants. Reproduction also plays an important role in evolution. In this unit let us learn in detail about reproduction in plants.

Milestones in Plant Embryology

i. 1682 - Nehemiah Grew mentioned stamens as the male organ of a flower.

ii. 1694 - R.J.Camerarius described the structure of a flower, anther, pollen and ovule

iii. 1761 - J.G. Kolreuter gave a detailed account on the importance of insects in pollination

iv. 1824 - G.B.Amici discovered the pollen tube.

v. 1848 - Hofmeister described the structure of pollen tetrad

vi. 1870 - Hanstein described the development of embryo in Capsella and Alisma

vii. 1878 - E.Strasburger reported polyembryony

viii. 1884 - E.Strasburger discovered the process of Syngamy.

ix. 1898 - S.G.Nawaschin and L. Guignard

independently discovered Double
fertilization

x. 1904 – E.Hanning initiated embryo culture.

xi. 1950 - D.A. Johansen proposed classifi cation
for embryo development

- Basically reproduction occurring in organisms fall under two major categories

1. Asexual reproduction
2. Sexual reproduction

Asexual Reproduction

- The reproduction method which helps to perpetuate its own species without the involvement of gametes is referred to as asexual reproduction. From Unit I of Class XI we know that reproduction is one of the attributes of living things and the different types of reproduction have also been discussed. Lower plants, fungi and animals show different methods of asexual reproduction. Some of the methods include, formation of Conidia (Aspergillus and Penicillium); Budding (Yeast and Hydra); Fragmentation (Spirogyra); production of Gemma (Marchantia); Regeneration (Planaria) and Binary fission (Bacteria) (Refer chapter 1 of Unit I of class XI). The individuals formed by this method is morphologically and genetically identical and are called **clones**. Higher plants also reproduce asexually by different methods which are given below:

Vegetative reproduction Natural methods

- Natural vegetative reproduction is a form of asexual reproduction in which a bud grows and develops into a new plant. The buds may be formed in organs such as root, stem and leaf. At some stage, the new plant gets detached from the parent plant and starts to develop into a new plant. Some of the organs involved in the vegetative reproduction also serve as the organs of storage and perennation. Th e unit of reproductive structure used in propagation is called reproductive propagules or diaspores. Some of the organs that help in vegetative reproduction.

Vegetative reproduction in root

- The roots of some plants develop vegetative or adventitious buds on them. Example Murraya, Dalbergia and Millingtonia. Some tuberous adventitious roots apart from developing buds also store food. Example Ipomoea batatus and Dahlia. Roots possessing buds become detached from the parent plant and grow into independent plant under suitable condition.

Scourge of water bodies / Water hyacinth (Eichhornia crassipes) is an invasive weed on water bodies like ponds, lakes and reservoirs. It is popularly called "Terror of Bengal". It spreads rapidly through off set all over the water body and depletes the dissolved oxygen and causes death of other aquatic organisms.

- Vegetative reproduction in stemFrom the Unit 3 of class XI (Vegetative morphology) you are familiar with the structure of various underground stem and sub aerial stem modifications. These include rhizome (Musa paradisiaca, Zingiber officinale and Curcuma longa); corm (Amorphophallus and Colocasia); tuber (Solanum tuberosum); bulb(Allium cepa and Lillium) runner (Centella asiatica); stolon (Mentha, and Fragaria); offset (Pistia, and Eichhornia); sucker (Chrysanthemum) and bulbils (Dioscorea and Agave). The axillary buds from the nodes of rhizome and eyes of tuber give rise to new plants.

Vegetative reproduction in leaf

- In some plants adventitious buds are developed on their leaves. When they are detached from the parent plant they grow into new individual plants. Examples: Bryophyllum, Scilla, and Begonia. In Bryophyllum, the leaf is succulent and notched on its margin. Adventious buds develop at these notches and are called epiphyllous buds. They develop into new plants forming a root system and become independent plants when the leaf gets decayed. Scilla is a bulbous plant and grows in sandy soils. The foliage leaves are long and narrow and epiphyllous buds develop at their tips. These buds develop into new plants when they touch the soil.

Advantages of natural vegetative reproduction

- Only one parent is required for propagation.
- The new individual plants produced aregenetically identical.
- In some plants, this enables to spreadrapidly. Example: Spinifex
- Horticulturists and farmers utilize theseorgans of natural vegetative reproductionfor cultivation and to harvest plants inlarge scale.

Disadvantage of natural vegetative reproduction

- New plants produced have no geneticvariation.

Artificial Methods

- Apart from the above mentioned natural methods of vegetative reproduction, a number of methods are used in agriculture and horticulture to propagate plants from their parts. Such methods are said to be artificial propagation. Some of the artificial propagation methods have been used by man for a long time and are called conventional methods. Now-a-days, technology is being used for propagation to produce large number of plants in a short period of time. Such methods are said to be modern methods.

Conventional methods

- The common methods of conventional propagation are cutting, grafting and layering.

Cutting:

- It is the method of producing a newplant by cutting the plant parts such as root, stemand leaf from the parent plant. The cut part is placed in a suitable medium for growth. It produces rootand grows into a new plant. Depending upon thepart used it is called as root cutting (Malus), stemcutting (Hibiscus, Bougainvillea and Moringa) andleaf cutting (Begonia, Bryophyllum). Stem cuttingis widely used for propagation.

Grafting:

- In this, parts of two different plantsare joined so that they continue to grow as oneplant. Of the two plants, the plant which is incontact with the soil is called stock and theplant used for grafting is called scion. Examples are Citrus, Mango and Apple.There are different types of grafting based on themethod of uniting the scion and stock. They arebud grafting, approach grafting, tongue grafting,crown grafting and wedge grafting.

Bud grafting:

- A T- shaped incision is madein the stock and the bark is lifted. The scion budwith little wood is placed in the incision beneaththe bark and properly bandaged with a tape.

Approach grafting:

- In this method boththe scion and stock remain rooted. The stockis grown in a pot and it is brought close tothe scion. Both of them should have the samethickness. A small slice is cut from both and the cut surfaces are brought near and tied togetherand held by a tape. After 1-4 weeks the tip ofthe stock and base of the scion are cut off anddetached and grown in a separate pot.

Tongue grafting

- A scion and stock having the same thickness is cut obliquely and the scion is fit into the stock and bound with a tape.

Crown grafting.

- When the stock is large in size scions are cutinto wedge shape and are inserted on the slitsor clefts of the stock and fixed in positionusing graft wax.

Wedge grafting

In this method a slit is made in the stock or the bark is cut. A twig of scion is inserted and tightly bound so that the cambium of the two is joined.

Layering:

- In this method, the stem ofa parent plant is allowed to develop rootswhile still intact. When the root develops,the rooted part is cut and planted to grow asa new plant. Examples: Ixora and Jasminum.Mound layering and Air layering are few typesof layering.

Mound layering:

- This method is applied forthe plants having flexible branches. The lowerbranch with leaves is bent to the ground andpart of the stem is buried in the soil and tip ofthe branch is exposed above the soil. After theroots emerge from the part of the stem buriedin the soil, a cut is made in parent plant so thatthe buried part grow into a new plant.

Air layering:

- In this method the stem isgirdled at nodal region and hormones areapplied to this region which promotes rooting.This portion is covered with damp or moist soil using a polythene sheet. Roots emerge in thesebranches after 2-4 months. Such branches areremoved from the parent plant and grown in aseparate pot or ground.

Advantages of conventional methods

- ❖ The plants produced are genetically uniform.
- ❖ Many plants can be produced quickly bythis method.
- ❖ Some plants produce little or no seeds;in others, the seeds produced do notgerminate. In such cases, plants can beproduced in a short period by this method.
- ❖ Some plants can be propagated moreeconomically by vegetative propagation.Example: Solanum tuberosum.

- Two different plants with desirablecharacters such as disease resistant andhigh yield can be grafted and grown as a new plant with the same desirable characters.

Disadvantages of conventional methods

- Use of virus infected plants as parentsproduces viral infected new plants.
- Vegetative structures used for propagationare bulky and so they are difficult to handleand store.

Modern Method

- Professor F.C. Steward(1932) of Cornell University showed that the mature phloem parenchyma cells removed from the carrot were placed in a suitable medium under controlled conditions, could be stimulated to start dividing again to produce a new carrot plant. These cells were described as totipotent. The genetic ability of a plant cell to produce the entire plant under suitable conditions is said to be to tipotency. This characteristic feature of a cell is utilized in horticulture, forestry and industries to propagate plants. The growth of plant tissue in special culture medium under suitable controlled conditions is known as tissue culture.

Micropropagation

- The regeneration of a whole plant from single cell, tissue or small pieces of vegetative structures through tissue culture is called micropropagation. This is one of the modern methods used to propagate plants. The detailed steps involved in the micropropagation are given in Unit VIII.

Advantages of modern methods

- Plants with desired characteristics can bemultiplied rapidly in a short duration.
- Plants produced are genetically identical.
- Tissue culture can be carried out in anyseason to produce plants.
- Plants which do not produce viable seedsand seeds that are difficult to germinatecan be propagated by tissue culture.
- Rare and endangered plants can bepropagated.
- Disease free plants can be produced bymeristem culture.
- Cells can be genetically modified andtransformed using tissue culture.

Disadvantages of modern methods

- It is labour intensive and requires skilledworkers.
- Sterile condition must be maintainedwhich adds to the cost.
- Since the clones are genetically identical,the entire crop is susceptible to newdiseases or changes in environmentalconditions will wipe out the species.
- Sometimes, callus undergoes genetical changes which are undesirable forcommercial use.

Sexual Reproduction

- In previous classes reproduction in lower plants like algae and bryophytes was discussed in detail. Sexual reproduction involves the production and fusion of male and female gametes. The former is called gametogenesis and the latter is the process of fertilization. Let us recall the sexual reproduction in algae and bryophytes. They reproduce by the production of gametes which may be motile or non motile depending upon the species. The gametic fusion is of three types (Isogamy, Anisogamy and Oogamy). In algae external fertilization takes place whereas in higher plants internal fertilization occurs.

Flower

- A flower is viewed in multidimensional perspectives from time immemorial. It is an inspirational tool for the poets. It is a decorative material for all the celebrations. In Tamil literature the five lands are denoted by different flowers. The flags of some countries are embedded with flowers. Flowers are used in the preparation of perfumes. For a Morphologist, a flower is a highly condensed shoot meant for reproduction. As you have already learned about the parts of a flower in Unit II of Class XI, let us recall the parts of a flower. A Flower possesses four whorls- Calyx, Corolla, Androecium and Gynoecium. Androecium and Gynoecium are essential organs(Figure 1.3). The process or changes involved in sexual reproduction of higher plants include three stages .They are Pre-fertilization, Fertilization and Post fertilization changes. Let us discuss these events in detail.

Pre-fertilization structure and events

- The hormonal and structural changes in plant lead to the differentiation and development of floral primordium. Thestructures and events involved in pre-fertilization are given below.

Male Reproductive part - Androecium

- Androecium is made up of stamens. Each stamen possesses an anther and a filament. Anther bears pollen grains which represent the male gametophyte. In this chapter we shall discuss the structure and development of anther in detail.

Development of anther:

- A very young anther develops as a homogenous mass of cells surrounded by an epidermis. During its development, the anther assumes a four-lobed structure. In each lobe, a row or a few rows of hypodermal cells becomes enlarged with conspicuous nuclei. This functions as archesporium. The archesporial cells divide by periclinal divisions to form primary parietal cells towards the epidermis and primary sporogenous cells towards the inner side of the anther. The primary parietal cells undergo a series of periclinal and anticlinal division and form 2-5 layers of anther walls composed of endothecium, middle layers and tapetum, from periphery to centre.

Microsporogenesis:

- The stages involved in the formation of haploid microspores from diploid microspore mother cell through meiosis is called **Microsporogenesis**. The primary sporogeneous cells directly, or may undergo a few mitotic divisions to form **sporogenous tissue**. The lastgeneration of sporogenous tissue functions as microspore mother cells. Each microspore mother cell divides meiotically to form a tetrad of four haploid microspores (microspore tetrad). The microspore tetrad may be arranged in a tetrahedral, decussate, linear, T shaped or isobilateral manner. Microspores soon separate from one another and remain free in the anther locule and develop into pollen grains. The stages in the development of microsporangia is given in Figure 1.4. In some plants, all the microspores in a microsporangium remain held together called pollinium. Example: Calotropis. Compound pollen grains are found in Drosera and Drymis.

T.S. of Mature anther

- Transverse section of mature anther reveals the presence of anther cavity surrounded by an anther wall. It is bilobed, each lobe having 2 theca (dithecous). A typical anther is tetrasporangiate.

Another Wall

The mature anther wall consists of the following layers

- Epidermis
- Endothecium
- Middle layers
- Tapetum.

Epidermis:

- It is single layered and protective in function. The cells undergo repeatedanticlinal divisions to cope up with the rapidlyenlarging internal tissues.

Endothecium:

- It is generally a single layerof radially elongated cells found below theepidermis. The inner tangential wall develops and (sometimes radial walls also) of α cellulose(sometimes also slightly lignified). The cells are**hygroscopic**. In the anthers of aquatic plants,saprophytes, cleistogamous flowers and extremeparasites endothecial differentiation is absent.The cells along the junction of the two sporangiaof an anther lobe lack these thickenings. Thisregion is called **stomium**. This region along with the hygroscopic nature of endothecium helps inthe dehiscence of anther at maturity.

Middle layers:

- Two to three layers of cells next to endothecium constitute middle layers. They are generally ephemeral. They disintegrate or get crushed during maturity.

Tapetum:

- It is the innermost layer of anther wall and attains its maximum development at the tetrad stage of microsporogenesis. It is derived partly from the peripheral wall layer and partly from the connective tissue of the anther lining the anther locule. Thus, the tapetum is dual in origin. It nourishes the developing sporogenous tissue, microspore mother cells and microspores. The cells of the tapetum may remain uninucleate or may contain more than one nucleus or the nucleus may become polyploid. It also contributes to the wall materials, sporopollenin, pollenkitt, tryphine and number of proteins that control incompatibility reaction .Tapetum also controls the fertility or sterility of the microspores or pollen grains.

There are two types of tapetum based on its behaviour. They are:

- ❖ **Secretory tapetum** (parietal/glandular/ cellular): The tapetum retains the original position and cellular integrity and nourishes the developing microspores.

- **Invasive tapetum (**periplasmodial): The cells loose their inner tangential and radialwalls and the protoplast of all tapetal cells coalesces to form a periplasmodium.

Functions of Tapetum:

- It supplies nutrition to the developing microspores.
- It contributes sporopollenin through ubisch bodies thus plays an important role in pollen wall formation.
- The pollenkitt material is contributed by tapetal cells and is later transferred to the pollen surface.
- Exine proteins responsible for 'rejection reaction' of the stigma are present in the cavities of the exine. These proteins are derived from tapetal cells.

Many botanists speak of a third type of tapetum called amoeboid, where the cell wall is not lost. The cells protrude into the anther cavity through an amoeboid movement. This type is often associated with male sterility and should not be confused with periplasmodial type.

Anther Cavity :

- The anther cavity is filled with microspores in young stages or with pollen grains at maturity. The meiotic division of microspore mother cells gives rise to microspores which are haploid in nature.

Connective:

- It is the column of sterile tissue surrounded by the anther lobe. It possesses vascular tissues. It also contributes to the inner tapetum.

Microspores and pollen grains

- Microspores are the immediate product of meiosis of the microspore mother cell whereas the pollen grain is derived from the microspore. The microspores have protoplast surrounded by a wall which is yet to be fully developed. The pollen protoplast consists of dense cytoplasm with a centrally located nucleus. The wall is differentiated into two layers, namely, inner layer called **intine** and outer layer called **exine**. Intine is thin, uniform and is made up of pectin,hemicellulose, cellulose and callose together with proteins. Exine is thick and is made up of cellulose, sporopollenin and pollenkitt. The exine is not uniform and is thin at certain areas. When these thin areas are small and round it is called germ pores or when elongated it is called furrows. It is associated with germination of pollen grains. The sporopollenin is generally absent in germ pores.The surface of the exine is either smooth or sculptured in various patterns (rod like, grooved, warty, punctuate etc.) The sculpturing pattern is used in the plant identification and classification.

- Shape of a pollen grain varies from species to species. It may be globose, ellipsoid, fusiform, lobed, angular or crescent shaped. The size of the pollen varies from 10 micrometers in Myosotis to 200 micrometers in members of the family Cucurbitaceae and Nyctaginaceae

Palynology is the study of pollen grains.It helps to identify the distribution of coal and to locate oil fields. Pollen grains reflect the vegetation of an area.
Liquid nitrogen (-196^0C) is used to preserve pollen in viable condition for prolonged duration. This technique is called **cryopreservation** and is used to store pollen grains (pollen banks) of economically important crops for breeding programmes

- The wall material sporopollenin is contributed by both pollen cytoplasm and tapetum. It is derived from carotenoids. It is resistant to physical and biological decomposition. It helps to withstand high temperature and is resistant to strong acid, alkali and enzyme action. Hence, it preserves the pollen for long periods in fossil deposits, and it also protects pollen during its journey from anther to stigma.

- Pollenkitt is contributed by the tapetum and coloured yellow or orange and is chiefly made of carotenoids or flavonoids. It is an oily layer forming a thick viscous coating over pollensurface. It attracts insects and protects damage from UV radiation.

Bee pollen is a natural substance and contains high protein, carbohydrate, trace amount of minerals and vitamins. Therefore, it is used as dietary supplement and is sold as pollen tablets and syrups. Further , it increases the performance of athletes, race horses and also heals the wounds caused by burns . The study of honey pollen is called Mellitopalynology.

Pollen calendar shows the production of pollen by plants during different seasons. This benefits the allergic persons. Pollen grains cause allergic reactions like asthma, bronchitis, hay fever, allergic rhinitis etc., Parthenium hysterophorus L. (Family- Asteraceae) is commonly called Carrot grass is a native of tropical America and was introduced into India as a contaminant along with cereal wheat. The pollen of this plant cause Allergy.

Development of Male gametophyte:

- The microspore is the first cell of the male gametophyte and is haploid. The development of male gametophyte takes place while they are still in the microsporangium. The nucleus of the microspore divides to form a **vegetative** and a **generative** nucleus. A wall is laid around the generative nucleus resulting in the formation of two unequal cells, a large irregular nucleus bearing with abundant food reserve called vegetative cell and a small generative cell. At this 2 celled stage, the pollens are liberated from the anther. In some plants the generative cell again undergoes a division to form two male gametes. In these plants, the pollen is liberated at 3 celled stage. In 60% of the angiosperms pollen is liberated in 2 celled stage. Further, the growth of the male gametophyte occurs only if the pollen reaches the right stigma. The pollen on reaching the stigma absorbs moisture and swells. The intine grows as pollen tube through the germ pore. In case the pollen is liberated at 2 celled stage the generative cell divides in the pollen into 2 male cells (sperms) after reaching the stigma or in the pollen tube before reaching the embryo sac. The stages in the development of male gametophyte.

Female reproductive part - Gynoecium

The **gynoecium** represents the female reproductive part of the flower. The word gynoecium represents one or more pistils of a flower. The word pistil refers to the ovary, style and stigma. A pistil is derived from a carpel. The word ovary represents the part that contains the ovules. The stigma serves as a landing platform for pollen grains. The style is an elongated slender part beneath the stigma. The basal swollen part of the pistil is the ovary. The ovules are present inside the ovary cavity (locule)on the placenta .Gynoecium (carpel) arises as a small papillate outgrowth of meristematic tissue from the growing tip of the floral primordium. It grows actively and soon gets differentiated into ovary, style and stigma. The ovules or megasporangia arise from the placenta. The number of ovules in an ovary may be one (paddy, wheat and mango) or many (papaya, water melon and orchids).

Structure of ovule(Megasporangium):

- Ovule is also called megasporangium and is protected by one or two covering called **integuments**. A mature ovule consists of a stalk and a body. The stalk or the **funiculus** (also called funicle) is present at the base and it attaches the ovule to the placenta. The point of attachment of funicle to the body of the ovule is known as **hilum**. It represents the junction between ovule and funicle. In an inverted ovule, the funicle is adnate to the body of the ovule forming a ridge called **raphe**. The body of the ovule is made up of a central mass of parenchymatous tissue called **nucellus** which has large reserve food materials. The nucellus is enveloped by one or two protective coverings called **integuments**. Integument encloses the nucellus completely except at the top where it is free and forms a pore called micropyle. The ovule with one or two integuments are said to be **unitegmic** or **bitegmic** ovules respectively. The basal region of the body of the ovule where the nucellus, the integument and the funicle meet or merge is called as **chalaza**. There is a large,oval, sac-like structure in the nucellus toward the micropylar end called **embryo sac** or female gametophyte. It develops from the functional megaspore formed within the nucellus. In some species(unitegmic tenuinucellate) the inner layer of the integument may become specialized to perform the nutritive function for the embryo sac and is called as **endothelium** or **integumentary tapetum** (Example : Asteraceae). Th ere are two types of ovule based on the position of the sporogenous cell. If the sporogenous cell is hypodermal with a single layer of nucellar tissue around it is called **tenuinucellate** type. Normally tenuinucellate ovules have very small nucellus. Ovules with subhypodermalsporogenous cell is called **crassinucellate**type. Normally these ovules have fairly large nucellus.

Group of cells found at the base of the ovule between the chalaza andembryo sac is called **hypostase**and the thick -walled cells found above the micropylar end above the embryo sac is called **epistase**.

Types of Ovules

- The ovules are classified into six main types based on the orientation, form and position of the micropyle with respect to funicle and chalaza. Most important ovule types are orthotropous, anatropous, hemianatropous and campylotropous.

Orthotropous:

- In this type of ovule, the micropyle is at the distal end and the micropyle, the funicle and the chalaza lie in one straight vertical line. Examples: Piperaceae, Polygonaceae

Anatropous:

- The body of the ovule becomes completely inverted so that the micropyle and funiculus come to lie very close to each other. This is the common type of ovules found in dicots and monocots.

Hemianatropous:

- In this, the body of the ovule is placed transversely and at right angles to the funicle. Example: Primulaceae.

Campylotropous:

- The body of the ovule at the micropylar end is curved and more or less bean shaped. The embryo sac is slightly curved. All the three, hilum, micropyle and chalaza are adjacent to one another, with the micropyle oriented towards the placenta. Example: Leguminosae In addition to the above main types there are two more types of ovules they are,

Amphitropous:

- The distance between hilum and chalaza is less. The curvature of the ovule leads to horse-shoe shaped nucellus. Example: some Alismataceae.

Circinotropous:

- Funiculus is very long and surrounds the ovule. Example: Cactaceae

Megasporogenesis

- The process of development of a megaspore from a megaspore mother cell is called **megasporogenesis**.

- As the ovule develops, a single hypodermal cell in the nucellus becomes enlarged and functions as **archesporium**. In some plants, the archesporial cell may directly function as megaspore mother cell. In others, it may undergo a transverse division to form outer primary parietal cell and inner primary sporogenous cell. The parietal cell may remain undivided or divide by few periclinal and anticlinal divisions to embed the primary sporogenous cell deep into the nucellus. The primary sporogenous cell functions as a megaspore mother cell. The megaspore mother cell undergoes meiotic division to form four haploid megaspores. Based on the number of megaspores that develop into the Embryo sac, we have three basic types of development: **monosporic, bisporic**and **tetrasporic**. The megaspores are usually arranged in a linear tetrad. Of the four megaspores formed, usually the chalazal one is functional and otherthree megaspores degenerate. The functional megaspore forms the female gametophyte or embryo sac. This type of development is called monosporic development (Example: Polygonum). Of the four megaspores formed if two are involved in Embryo sac formation the development is called bisporic (Example: Allium). If all the four megaspores are involved in Embryo sac formation the development is called tetrasporic (Example: Peperomia). An ovule generally has a single embryo sac.

Development of Monosporic embryo sac.

- To describe the stages in embryo sac development and organization the simplest monosporic type of development is given below.

- The functional megaspore is the first cell of the embryo sac or female gametophyte. The megaspore elongates along micropylar-chalazal axis. The nucleus undergoes a mitotic division. Wall formation does not follow the nuclear division. A large central vacuole now appears between the two daughter nuclei. The vacuole expands and pushes the nuclei towards the opposite poles of the embryo sac. Both the nuclei divide twice mitotically, formingfour nuclei at each pole. At this stage all the eight nuclei are present in a common cytoplasm (free nuclear division). After the last nuclear division the cell undergoes appreciable elongation, assuming a sac-like appearance. This is followed by cellular organization of the embryo sac. Of the four nuclei at the micropylar end of the embryo sac, three organize into an **egg apparatus**, the fourth one is left free in the cytoplasm of the central cell as the upper polar nucleus. Three nuclei of the chalazal end form three **antipodal cells** whereas the fourth one functions as the lower polar nucleus. Depending on the plant the **2 polar nuclei** may remain free or may fuse to form a **secondary nucleus** (central cell). The egg apparatus is made up of a central egg cell and two synergids, one on each side of the egg cell. Synergids secrete chemotropic substances that help to attract the pollen tube. The special cellular thickening called filiform apparatus of synergids help in the absorption, conduction of nutrients from the nucellus to embryo sac. It also guides the pollen tube into the egg. Thus, a 7 celled with 8 nucleated embryo sac is formed.

Pollination

- Pollination is a wonderful mechanism which provides food, shelter etc., for the pollinating animals. Many plants are pollinated by a particularanimal species and the flowers are modified accordingly and thus there exists a co-evolution between plants and animals. Let us imagine if pollination fails. Do you think there will be any seed and fruit formation? If not what happens to pollinating organisms and those that depend on these pollinating organism for the food? Here lies the significance of the process of pollination.

- The pollen grains produced in the anther will germinate only when they reach the stigma of the pistil. The reproductive organs, stamens and pistil of the flower are spatially separated, a mechanism which is essential for pollen grains to reach the stigma is needed. This process of transfer of pollen grains from the anther to a stigma of a flower is called **pollination.**

- **Pollination** is a characteristic feature of spermatophyte (Gymnosperms and Angiosperms). Pollination in gymnosperms is said to be direct as the pollens are deposited directly on the exposed ovules, whereas in angiosperms it is said to be indirect, as the pollens are deposited on the stigma of the pistil. In majority of angiosperms, the flower opens and exposes its mature anthers and stigma for pollination. Such flowers are called **chasmogamous** and the phenomenon is **chasmogamy.** In other plants, pollination occurs without opening and exposing their sex organs. Such flowers are called **cleistogamous** and the phenomenon is **cleistogamy.**

- Based upon the flower on which the pollen of a flower reaches, the pollination is classified into two kinds, namely, **self-pollination (Autogamy) and cross-pollination(Allogamy).**

Self-pollination or Autogamy (GreekAuto = self, gamos = marriage):

- According to a majority of Botanists, the transfer of pollen on the stigma of the same flower is called self-pollination or Autogamy. Self-pollination is possible only in those plants which bear bisexual flowers. In order to promote self- pollination the flowers of the plants have several adaptations or mechanisms. They are:

Cleistogamy:

- In cleistogamy (Greek Kleisto= closed. Gamos = marriage) flowers never open and expose the reproductive organs and thus the pollination is carried out within the closed flower. *Commelina, Viola, Oxalis* are some examplesfor cleistogamous flowers. In Commelinabenghalensis, two types of flowers are produced- aerial and underground flowers. The aerialflowers are brightly coloured, chasmogamousand insect pollinated. The underground flowersare borne on the subterranean branches of therhizome that are dull, cleistogamous and selfpollinated and are not depended on pollinatorsfor pollination.

Homogamy:

- When the stamens andstigma of a flower mature at the same timeit is said to be homogamy. It favours self-pollination to occur. Example: Mirabilis jalapa,Catharanthus roseus

Incomplete dichogamy:

- In dichogamousflowers the stamen and stigma of a flowermature at different time. Sometimes , the time ofmaturation of these essential organs overlap sothat it becomes favourable for self-pollination.

Cross - pollination

- It refers to the transfer of pollens on the stigmaof another flower. The cross-pollination is oftwo types:

Geitonogamy:

- When the pollen deposits onanother flower of the same individual plant, itis said to be geitonogamy. It usually occurs inplants which show monoecious condition. It isfunctionally cross-pollination but is similar toautogamy because the pollen comes from sameplant.

Xenogamy:

- When the pollen (geneticallydifferent) deposits on another flower of adifferent plant of the same species , it is calledas xenogamy.

Contrivances of cross-pollination

The flowers of the plants have also several mechanisms that promote cross-pollination which are also called **contrivances of cross-pollination or outbreeding** devices. It includes the following.

Dicliny or Unisexuality

- When the flowers are unisexual only cross-pollination is possible. There are two types.

Monoecious:

- Male and female flowerson the same plant. Coconut, Bitter gourd.In plants like castor and maize, autogamy isprevented but geitonogamy takes place.

Monocliny or Bisexuality

- Flowers are bisexual and the special adaptation of the flowers prevents self-pollination.

Dichogamy:

- In bisexual flowers anthersand stigmas mature at different times, thuschecking self-pollination. It is of two types.

Protandry:

- The stamens mature earlierthan the stigmas of the flowers. Examples:Helianthus, Clerodendrum

Protogyny:

The stigmas mature earlier than the stamens of the flower. Examples: Scrophularia nodosa and Aristolochiabracteata

Monocliny or Bisexuality

- Flowers are bisexual and the special adaptation of the flowers prevents self-pollination.

Dichogamy:

- In bisexual flowers anthersand stigmas mature at different times, thuschecking self-pollination. It is of two types.

Protandry:

- The stamens mature earlierthan the stigmas of the flowers. Examples:Helianthus, Clerodendrum

Protogyny:

The stigmas mature earlier than the stamens of the flower. Examples: Scrophularia nodosa and Aristolochiabracteata

Herkogamy:

- In bisexual flowers the essential organs, the stamens and stigmas, are arranged in such a way that self-pollination becomes impossible. For example in Gloriosa superba, the style is reflexed away from the stamens and in Hibiscus the stigmas project far above the stamens

Heterostyly:

- Some plants produce two or three different forms of flowers that are different in their length of stamens and style. Pollination will take place only between organs of the same length.

Distyly:

- The plant produces two forms of flowers, Pin or long style, long stigmatic papillae, short stamens and small pollen grains;

Tristyly:

- The plant produces three kinds of flowers, with respect to the length of the style and stamens. Here, the pollen from flowers of one type can pollinate only the other two types but not their own type. Example : Lythrum

Self sterility/ Self- incompatibility:

- In some plants, when the pollen grain of a flower reaches the stigma of the same, it is unable to germinate or prevented to germinate on its own stigma. Examples: Abutilon, Passiflora.It is a genetic mechanism.

Agents of pollination

- Pollination is effected by many agents like wind, water, insects etc. On the basis of the agents that bring about pollination, the mode of pollination is divided into abiotic and biotic. The latter type is used by majority of plants.

Abiotic agents

- Anemophily - pollination by Wind
- Hydrophily - pollination by Water

Biotic agents

- Zoophily

Zoophily refers to pollination through animals and pollination through insects is calledEntomophily.

Anemophily:

- Pollination by wind. The wind pollinated flowers are called anemophilous.The wind pollinated plants are generallysituated in wind exposed regions. Anemophilyis a chance event. Therefore, the pollen maynot reach the target flower effectively and arewasted during the transit from one flowerto another. The common examples of windpollinated flowers are - grasses, sugarcane,bamboo, coconut, palm, maize etc.,

Anemophily:

- Pollination by wind. The wind pollinated flowers are called anemophilous.The wind pollinated plants are generallysituated in wind exposed regions. Anemophilyis a chance event. Therefore, the pollen maynot reach the target flower effectively and arewasted during the transit from one flowerto another. The common examples of

windpollinated flowers are - grasses, sugarcane,bamboo, coconut, palm, maize etc.,

Anemophilous plants have the following characteristic features:

- The flowers are produced in pendulous,catkin-like or spike inflorescence.
- The axis of inflorescence elongates so thatthe flowers are brought well above the leaves.
- The perianth is absent or highly reduced.
- The flowers are small, inconspicuous,colourless, not scented, do not secrete nectar.
- The stamens are numerous, filaments arelong, exerted and versatile.
- Anthers produce enormous quantities ofpollen grains compared to number of ovulesavailable for pollination. They are minute,light and dry so that they can be carried tolong distances by wind.
- In some plants anthers burst violently andrelease the pollen into the air. Example:Urtica.
- Stigmas are comparatively large, protruding, sometimes branched and feathery, adaptedto catch the pollen grains. Generally singleovule is present.
- Plant produces flowers before the new leavesappear, so the pollen can be carried withouthindrance of leaves.

Pollination in Maize (Zea mays):

- The maize is monoecious and unisexual. The male inflorescence (tassel) is borne terminally and female inflorescence (cob) laterally at lower levels. Maize pollens are large and heavy and cannot be carried by light breeze. However, the mild wind shakes the male inflorescence to release the pollen which falls vertically below. The female inflorescence has long stigma (silk) measuring upto 23 cm in length, which projects beyond leaves. The pollens drop from the tassel is caught by the stigma

Hydrophily:

- Pollination by water is calledhydrophily and the flowers pollinated bywater are said to be hydrophilous (Example:Vallisneria, Hydrilla). Though there are anumber of aquatic plants, only in few plantspollination takes place by water. The floralenvelop of hydrophilous plants are reduced orabsent. In water plants like Eichhornia and waterlilly pollination takes place through wind orby insects. There are two types of hydrophily,Epihydrophily and Hypohydrophily. In mostof the hydrophilous flowers, the pollen grainspossesses mucilage covering which protectsthem from wetting.

Epihydrophily:

- Pollination occurs at thewater level. Examples: Vallisneria spiralis,Elodea

Pollination in Vallisneria spiralis:

- It is a dioecious, submerged and rooted hydrophyte. The female plant bears solitary flowers which rise to the surface of water level using a long coiled stalk at the time of pollination. A small cup shaped depression is formed around the female flower on the surface of the water. The male plant produces male flowers which get detached and float on the surface of the water. As soon as a male flower comes in closer to a female flower, it gets settled in the depression and contacts with the stigma thus bringing out pollination. Later the stalk of the female flower coils and brings back the flower from surface to under water where fruits are produced.

Hypohydrophily:

Pollination occursinside the water. Examples: Zostera marina andCeratophyllum.

- Zostera marina is a submerged marine sea grass and pollination takes place under water. The pollen grains are long, needle like. They are shed under water. The specific gravity of the pollen is same as that of sea water, so that, the pollen floats freely at any depth. The stigma is very largeand long. The pollen comes in contact with the stigma and gets coiled around the stigma thus effecting pollination.

Zoophily:

- Pollination by the agency of animalsis called zoophily and flowers are said to bezoophilous. Animals that bring about pollinationmay be birds, bats, snails and insects. Of these,insects are well adapted to bring pollination.Larger animals like primates (lemurs), arborealrodents, reptiles (gecko lizard and garden lizard)have also been reported as pollinators.

Ornithophily:

- Pollination by birds is calledOrnithophily. Some common plants that arepollinated by birds are Erythrina, Bombax,Syzygium, Bignonia, Sterlitzia etc., Hummingbirds, sun birds, and honey eaters are someof the birds which regularly visit flowers andbring about pollination.

The ornithophilous flowers have the following characteristic features:

- The flowers are usually large in size.
- The flowers are tubular, cup shaped or urn- shaped.
- The flowers are brightly coloured, red,scarlet, pink, orange, blue and yellow whichattracts the birds.
- The flowers are scentless and produce nectarin large quantities. Pollen and nectar formthe floral rewards for the birds visiting theflowers.
- The floral parts are tough and leathery towithstand the powerful impact of the visitors.

Cheiropterophily:

- Pollination carried outby bats is called cheiropterophily. Some ofthe common cheiropterophilous plants areKigeliaafricana, Adansonia digitata, etc., Batsare nocturnal and are attracted by the odourof the flowers that open at or after dusk. Thecheiropterophilous plants have flowers bornesingly or in clusters quite away from the leavesand branches either on the long peduncle oron the trunk or branches. The flowers producelarge quantities of nectarPollination in Adansonia digitata: In this plant, the ball of stamens and the stigma project beyond the floral envelops. The bat holds the flower by clasping the stamen ball to its breast. While taking nectar its breast becomes laden with numerous pollen grains, some of which get deposited on the stigma of the flower when it visits next.

Malacophily:

- Pollination by slugs andsnails is called malacophily. Some plants ofAraceae are pollinated by snails. Water snailscrawling among Lemna pollinate them.

Entomophily:

- Pollination by insects iscalled Entomophily. Pollination by ant is called myrmecophily. Insects that are well adapted to bring pollination are bees, moths, butterflies, flies, wasps and beetles. Of the insects, bees are the main flower visitors and dominant pollinators. Insects are chief pollinating agents and majority of angiosperms are adapted for insect pollination. It is the most common type of pollination.

The characteristic features of entomophilous flowers are as follows:

- Flowers are generally large or if small theyare aggregated in dense inflorescenceExample: A steraceae flowers.

- Flowers are brightly coloured. The adjacent parts of the flowers may also be brightly coloured to attract insect. For example in Poinsettia and Bougainvillea the bracts become coloured.

- Flowers are scented and produce nectar.

- Flowers in which there is no secretion ofnectar, the pollen is either consumed asfood or used in building up of its hive by thehoneybees. Pollen and nectar are the floralrewards for the visitors.

- Flowers pollinated by flies and beetles produce foul odour to attract pollinators.

- In some flowers juicy cells are present which are pierced and the contents are sucked by the insects

Pollination in Salvia (Lever mechanism):

- The flower of Salvia is adapted for Beepollination. The flower is protandrous and the corolla is bilabiate with 2 stamens. A lever mechanism helps in pollination. Each anther has an upper fertile lobe and lower sterile lobe which is separated by a long connective which helps the anthers to swing freely. When a beevisits a flower, it sits on the lower lip which acts as a platform. It enters the flower to suck the nectar by pushing its head into the corolla. During the entry of the bee into the flower the body strikes against the sterile end of the connective. This makes the fertile part of the stamen to descend and strike at the back of the bee.

- The pollen gets deposited on the back of the bee. When it visits another flower, the pollen gets rubbed against the stigma and completes the act of pollination in Salvia (Figure 1.17a). Some of the other interesting pollination mechanisms found in plants are a) Trap mechanism (Aristolochia);Pit fall mechanism (Arum);Clip or translator mechanism (Asclepiadaceae) and Piston mechanism (Papilionaceae).

Pollination in Calotropis
(Translator mechanism)

- This mechanism is found in members of Asclepiadaceae(Apocynaceae as per APG system of classification). The flowers are bisexual with 5 stamens forming gynostegium(union of stigma with the androecium). The stigma is large and 5 – angled and is receptive on the underside. Each stamen at its back possesses a brightly coloured hood like outgrowth enclosing horn shaped nectar. The pollen in each anther lobe of a stamen unites into a mass, forming a pollinium. Pollinia are attached to a clamp or clip like sticky structure called corpusculum. The filamentous or thread like part arising from each pollinium is called retinaculum. The whole structure looks like inverted letter 'Y' and is called translator. When the insect visits the flower for nectar, the translator gets attached to the proboscis or leg of the visitor. During the visit to the next flower the pollinia come in contact with the receptive stigma carrying out pollination.

Pollination in Aristolochia (Trap mechanism)

- A special mechanism to accomplish pollination called trap mechanism is found in Aristolochia. The flowers are axillary and perianth is tubular with a hood at the top. The basal region is swollen and possesses gynostegium. The gynostegium has six anthers.

- The inner wall of tubular middle part of the perianth is slippery and lined with stiff hairs which are pointed downwards. The young flowers are erect. During this stage small fliesenter and could not escape because they are trapped by the hairs. As soon as the anthers of the flower ripe, the hairs wither and flower bents down. The flies escape with pollen and enter another flower where it dusts pollen on the stigma bringing out pollination.

Advantages of self-pollination:

- Pollination is almost certain in bisexualflowers.
- When the members of the species areuncommon and are separated by largedistances, the plant has to depend on self-pollination.
- If all the chances of cross-pollination fails,self-pollination will take place and preventthe extinction of the species.

Disadvantages of self-pollination:

- Continuous self-pollination, generationafter generation results in weaker progeny.
- Chances of producing new species andvarieties are meager.

Advantages of cross-pollination:

- It always results in bringing out muchhealthieroffsprings.
- Germination capacity is much better.
- New varieties may be produced.
- The adaptability of the plants to theirenvironment is better.

Disadvantages of cross-pollination:

- Depend on external agencies for the pollination and the process is uncertain.

- ❖ Various devices have to be adopted to attract pollinating agents.

Significance of Pollination

- ❖ Pollination is a pre-requisite for the processof fertilisation. Fertilisation helps in theformation of fruits and seeds.
- ❖ It brings the male and female gametescloser for the process of fertilisation.
- ❖ Cross-pollination introduces variations inplants due to the mixing up of different genes.These variations help the plants to adapt tothe environment and results in speciation.

Fertilization

- The fusion of male and female gamete is called fertilization. Fertilization in angiosperms is double fertilization type.

Events of fertilization

- The stages involved in double fertilization are:- germination of pollen to form pollen tube in the stigma; growth of pollen tube in the style; direction of pollen tube towards the micropyle of the ovule; entry of the pollen tube into one of the synergids of the embryo sac, discharge of male gametes; syngamy and triple fusion. The events from pollen deposition on the stigma to the entry of pollen tube in to the ovule is called pollen- pistil interaction. It is a dynamic process which involves recognition of pollen and to promote or inhibit its germination and growth.

Pollen on the stigma

- In nature, a variety of pollens fall on the receptive stigma, but all of them do not germinate and bring out fertilization. The receptive surface of the stigma receives the pollen. If the pollen is compatible with the stigma it germinates to form a tube. This is facilitated by the stigmatic fluid in wet stigma and pellicle in dry stigma. These two also decide the incompatibility and compatibility of the pollen through recognition-rejection protein reaction between the pollen and stigma surface. Sexual incompatibility may exist between different species (interspecific) or between members of the same species (intraspecific).The latter is called self-incompatibility. The first visible change in the pollen, soon after it lands on stigma is hydration. The pollen wall proteins are released from the surface. During the germination of pollen its entire content moves into the pollen tube. The growth is restricted to the tip of the tube and all the cytoplasmic contents move to the tip region. The remaining part of the pollen tube is occupied by a vacuole which is cut off from the tip by callose plug. The extreme tip of pollen tube appears hemispherical and transparent when viewed through the microscope. This is called cap block. As soon as the cap block disappear the growth of the pollen tube stops.

Pollen tube in the style

- After the germination the pollen tube enters into the style from the stigma. The growth of the pollen tube in the style depends on the type of style.

Types of style

- There are three types of style a) Hollow or open style b)solid style or closed style c) semi-solid or half closed style.

Hollow style (Open style):

- It is common among monocots. A hollow canal running from the stigma to the base of the style is present. The canal is lined by a single layer of glandular canal cells (Transmitting tissue).They secrete mucilaginous substances. The pollen tube grows on the surface of the cells lining the stylar canal. The canal is filled with secretions which serve as nutrition for growing pollen tubes and also controlling incompatibility reaction between the style and pollen tube. The secretions contain carbohydrates, lipids and some enzymes like esterases, acid phosphatases as well as compatibility controlling proteins.

Solid style (Closed type):

- It is common among dicots. It is characterized by the presence of central core of elongated, highly specialised cells called transmitting tissue.This is equivalent to the lining cells of hollow style and does the same function. Its contents are also similar to the content of those cells.

The pollen tube grows through the intercellular spaces of the transmitting tissue.

Semi-solid style (half closed type):

This is intermediate between solid and open type.

- There is a difference of opinion on the nature of transmitting tissue. Some authors consider that it is found only in solid styles while others consider the lining cells of hollow style also has transmitting tissue.

Entry of pollen tube into the ovule:

- There are three types of pollen tube entry into the ovule

Porogamy:

- when the pollen tube enters through the micropyle.

Chalazogamy:

when the pollen tube enters through the chalaza.

Mesogamy:

- when the pollen tube enters through the integument.

Entry of pollen tube into embryo sac:

- Irrespective of the place of entry of pollen tube into ovule, it enters the embryo sac at the micropylar end. The pollen enters into embryo sac directly into one of the synergids.

- The growth of pollen tube towards the ovary, ovule and embryo sac is due to the presence of chemotropic substances. The pollen tube after travelling the whole length of the style enters into the ovary locule where it is guided towards the micropyle of the ovule by a structure called **obturator** (See Do you know). After reaching the embryo sac, a pore is formed in pollen tube wall at its apex or just behind the apex. The content of the pollen tube (two male gametes, vegetative nucleus and cytoplasm) are discharged into the synergids into which pollen tube enters. The pollen tube does not grow beyond it, in the embryo sac. The tube nucleus disorganizes.

Double fertilization and triple fusion

- S.G. Nawaschin and L.Guignard in 1898 and 1899, observed in Lilium and Fritillaria that both the male gametes released from a male gametophyte are involved in the fertilization. They fertilize two different components of the embryo sac. Since both the male gametes are involved in fertilization, the phenomenon is called double fertilization and is unique to angiosperms. One of the male gametes fuses with the egg nucleus (syngamy) to form Zygote.

- The second gamete migrates to the central cell where it fuses with the **polar nuclei** or their fusion product, the secondary nucleus and forms the **primary endosperm nucleus (PEN)**.

- Since this involves the fusion of three nuclei, this phenomenon is called triple **fusion**. This act results in endosperm formation which forms the nutritive tissue for the embryo.

Post Fertilization structure and events

- After fertilization, several changes take place in the floral parts up to the formation of the seed.

- The events after fertilization (endosperm, embryo development, formation of seed, fruits) are called post fertilization changes.

Endosperm

- The primary endosperm nucleus (PEN) divides immediately after fertilization but before the zygote starts to divide, into an endosperm. The primary endosperm nucleus is the result of triple fusion (two polar nuclei and one sperm nucleus) and thus has 3n number of chromosomes. It is a nutritive tissue and regulatory structure that nourishes the developing embryo. Depending upon the mode of development three types of endosperm are recognized in angiosperms. They are nuclear endosperm, cellular endosperm and helobial endosperm

Nuclear endosperm:

- In the nuclear type, the Primary endosperm nucleus (PEN) divides into two without any wall formation. The subsequent division of these two nuclei are free nuclear so that the endosperm consists of only free nuclei and cytoplasm around them. The nuclei may either remain free or may become separate by walls in later stages. Examples: Coccinia, Capsella and Arachis.

Cellular endosperm:

- In this type the primary endosperm nucleus(PEN) divides into 2 nuclei which are immediately followed by a wall formation. Subsequent divisions are also followed by walls. Examples: Adoxa, Helianthus and Scoparia.

Helobial endosperm:

- In helobial type, the primary endosperm nucleus (PEN) moves towards the base of the embryo sac where it divides into two nuclei. These 2 nuclei are separated by a wall to form a large micropylar chamber and a small chalazal chamber. The nucleus of the micropylar chamber undergoes several free nuclear divisions whereas that of the chalazal chamber may or may not divide. Examples : Hydrilla and Vallisneria

- The endosperms may either be completely consumed by the developing embryo or it may persist in the mature seeds. Those seeds without endosperms are called non- endospermous or ex- albuminous seeds. Examples: Pea, Groundnut and Beans. Those seeds with endosperms are called endospermous or albuminous seeds. The endosperms in these seeds supply nutrition to the embryo during seed germination. Examples: Paddy, Coconut and Castor.

Ruminate endosperm:

- The endosperm with irregularity and unevenness in its surface forms ruminate endosperm (Example: Areca catechu). The activity of the seed coat or the endosperm itself results in this type of endosperm. The unequal radial elongation of the layer of seed coat results in the rumination of endosperm in Passiflora. In Annonaceae and Aristolochiaceae definite ingrowth or infolding of the seed coat produces ruminate endosperm. The irregular surface of the seed coat makes endosperm ruminate in Myristica.

Functions of endosperm:

- ❖ It is the nutritive tissue for the developing embryo.
- ❖ In majority of angiosperms, the zygote divides only after the development of endosperm.
- ❖ Endosperm regulates the precise mode of embryo development.

Endosperm haustoria

- Another interesting feature of the endosperm is the presence of haustoria. In the case of helobial endosperm the chalazal chamber itself acts as a haustorial structureIn cellular and nuclear endosperm special structures are produced towards the micropylar, chalazal, both micropylar and chalazal which may be in lateral direction depending on the species. These absorb nutrients from other outer tissue or from ovary tissue and supply them to the growing embryo.

Coconut milk is a basic nutrient medium which induces the differentiation of embryo (embryoids) and plantlets from various plant tissues. Coconut water from tender coconut is free-nuclear endosperm and white kernel part is cellular.

Embryogenesis
Development of Dicot embryo

The development of Dicot embryo (Capsella bursa-pastoris) is of Onagrad or crucifer type. The embryo develops at micropylar end of embryo sac.

- The Zygote divides by a transverse division forming **upper or terminal cell** and **lower or basal cell**. The basal cell divides transversely and the terminal cell divides vertically to form a four celled proembryo. A second vertical division right angle to the first one takes place in terminal cell forming a four celled stage called **quadrant.** A transverse division in the quadrant results in eight cells arranged in two tiers of four each called **octant stage.**

- The upper tier of four cells of the octant is called epibasal or anterior octant and the lower tier of four cells constitute hypobasal or posterior octants. A periclinal division in the octants results in the formation of 16 celled stage with eight cells in the outer and eight in the inner.

- The outer eight cells represent the dermatogen and undergoes anticlinal division to produce epidermis. The inner eight cells divide by vertical and transverse division to form outer layer of periblem which give rise to cortex and a central region of pleurome which forms stele

- During the development, the two cells of the basal cell undergoes several transverse division to form a six to ten celled suspensor. The embryo at this stage become globular and the suspensor helps to push the embryo deep into the endosperm. The uppermost cell of the suspensor enlarge to form a haustorium. The lowermost cell of the suspensor is called hypophysis. A transverse division and two vertical division right angle to each other of hypophysis results in the formation of eight cells. The eight cells are arranged in two tiers of four cells each The upper tier give rise to root cap and epidermis. At this stage embryo proper appears heart shaped, cell divisions in the hypocotyl and cotyledon regions of the embryo proper results in elongation. Further development results in curved horse shoe shaped embryo in the embryo sac. The mature embryo has a radicle, two cotyledons and a plumule.

Seed

- The fertilized ovule is called seed and possesses an embryo, endosperm and a protective coat. Seeds may be endospermous (wheat, maize, barley and sunflower) or non endospermous. (Bean, Mango, Orchids and cucurbits).

Fresh weight of an orchid seed may be 20.33 microgram and that of double coconut (Lodoiceamaldivica) is about 6 kg.

Structure of a Cicer seed as an example for Dicot seed

- The mature seeds are attached to the fruit wall by a stalk called funiculus. The funiculus disappears leaving a scar called hilum. Below the hilum a small pore called micropyle is present. It facilitates entry of oxygen and water into the seeds during germination. Each seed has a thick outer covering called seed coat. The seed coat is developed from integuments of the ovule. The outer coat is called testa and is hard whereas the inner coat is thin, membranous and is called tegmen. In Pea plant the tegmen and testa are fused. Two cotyledons laterally attached to the embryonic axis are present. It stores the food materials in pea whereas in other seeds like castor the endosperm contains reserve food and the cotyledons are thin. The portion of embryonalaxis projecting beyond the cotyledons is called radicle or embryonic root. The other end of the axis called embryonic shoot is the plumule. Embryonal axis above the level of cotyledon is called epicotyl whereas the cylindrical region between the level of cotyledon is called hypocotyl. The epicotyl terminates in plumule whereas the hypocotyl ends in radicle.

Structure of *Oryza* seed as an example for Monocot seed

- The seed of paddy is one seeded and is calledCaryopsis. Each seed remains enclosed by a brownish husk which consists of glumes arranged in two rows. The seed coat is a brownish, membranous layer closely adhered to the grain. Endosperm forms the bulk of the grain and is the storage tissue. It is separated from embryo by a definite layer called epithelium. The embryo is small and consists of one shield-shaped cotyledon known as scutellum present towards lateral side of embryonal axis. A short axis with plumule and radicle protected by the root cap is present. The plumule is surrounded by a protective sheath called coleoptile. The radicle including root cap is also covered by a protective sheath called coleorhiza. The scutellum supplies the growing embryo with food material absorbed from the endosperm with the help of the epithelium.

Apomixis

- Reproduction involving fertilization in flowering plants is called amphimixis and wherever reproduction does not involve union of male and female gametes is called apomixis.
- The term Apomixis was introduced by Winkler in the year 1908. It is defined as the substitution of the usual sexual system (Amphimixis) by a form of reproduction which does not involve meiosis and syngamy.
- Maheswari (1950) classified Apomixis into two types - Recurrent and Non recurrent

Recurrent apomixis:

It includes vegetative reproduction and agamospermy

Non recurrent apomixis:

- Haploid embryo sac developed after meiosis, develops into a embryo without fertilization.The outline classification of Recurrent apomixis is given below.

Vegetative reproduction:

- Plants propagate by any part other than seeds

Bulbils – Fritillariaimperialis; Bulbs – Allium; Runner – Mentha arvensis; Sucker – Chrysanthemum

Agamospermy:

- It refers to processes by which Embryos are formed by eliminating meiosis and syngamy

Adventive embryony

- An Embryo arises directly from the diploidsporophytic cells either from nucellus or integument. It is also called sporophytic budding because gametophytic phase is completely absent. Adventive embryos are found in Citrus and Mangifera

Diplospory (Generative apospory):

- A diploid embryo sac is formed from megaspore mother cell without a regular meiotic division Examples. Eupatorium and Aerva.

Apospory:

- Megaspore mother cell undergoes the normal meiosis and four megaspores formed gradually disappear. A nucellar cell becomes activated and develops into a diploid embryo sac. This type of apospory is also called somatic apospory. Examples Hieracium and Parthenium.

Polyembryony

- Occurrence of more than one embryo in a seed is called polyembryony. The first case of polyembryony was reported in certain oranges by Anton van Leeuwenhoek in the year 1719. Polyembryony is divided into four categories based on its origin.Cleavage polyembryony (Example: Orchids)

Formation of embryo by cells of the Embryosac other than egg (Synergids – Aristolochia;antipodals – Ulmus and endosperm – Balanophora).

- Development of more than one Embryo sacwithin the same ovule. (Derivatives of sameMMC, derivatives of two or more MMC – Casuarina)

- Activation of some sporophytic cells of theovule (Nucellus/ integuments-Citrus andSyzygium).

Practical applications

- The seedlings formed from the nucellar tissue in *Citrus* are found better clones for Orchards. Embryos derived through polyembryony are found virus free.

Parthenocarpy

- As mentioned earlier, the ovary becomes the fruit and the ovule becomes the seed after fertilization. However in a number of cases, fruit like structures may develop from the ovary without the act of fertilization. Such fruits are called parthenocarpic fruits. Invariably they will not have true seeds. Many commercial fruits are made seedless. Examples: Banana, Grapes and Papaya. Nitsch in 1963 classified the parthenocarpy into following types:

Genetic Parthenocarpy:

- Parthenocarpy arises due to hybridization or mutation Examples: Citrus,Cucurbita.

Environmental Parthenocarpy:

- Environmental conditions like frost, fog, low temperature, high temperature etc., induce Parthenocarpy. For example, low temperature for 3-19 hours induces parthenocarpy in Pear.

Chemically induced Parthenocarpy:

- Application of growth promoting substances like Auxins and Gibberellins induces parthenocarpy.

Significance

- The seedless fruits have great significancein horticulture.
- The seedless fruits have great commercialimportance.
- Seedless fruits are useful for the preparation of jams, jellies, sauces, fruit drinks etc.
- High proportion of edible part is availableinparthenocarpic fruits due to the absenceof seeds.