BOTANY

MATRICULATION - STANDARD X

Untouchability is a sin
Untouchability is a crime
Untouchability is inhuman

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PREFACE

"Education is not received, it is achieved"

Learning is a life long process for both the teacher and the pupil.

The crucial formative stage in the life of student is the Secondary Education Level. The subejcts taught to them need to be presented in a very precise and simple manner. Science Teachers have to play an important role of introducing students to a world which is being explored every day. The new facts emerging through research need to be incorporated into the academic curriculum. It should also be noted that all students do not choose a career related to science. It is therefore, essential to give an exposure to all students to the basic facts in all chapters of this text book.

The Biology syllabus is framed to bridge the Secondary and Higher Secondary level and to provide sufficient informations in Biology to the students. This text book aims to focus on these objectives, with updated knowledge and skills and also give an awareness to students to appreciate and to preserve our mother nature. In order to make learning more effective and interesting the revised syllabus is an attempt to reach the expectations of Education Department, Government of Tamil Nadu and at the same time aim at the students' thorough understanding of the subject.

At the end of every chapter in the self evaluation part, Questions have been framed in such a way to enable the students to review the entire syllabus quickly and critically. It is hoped that this book will serve the purpose in understanding the basic principles in Botany which will enable the students to secure maximum marks.

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UNIT 1

LEVELS OF ORGANIZATION

1.1 BACTERIA

A Dutch man **Anton Van Leeuwenhock** was the first to discover bacteria in 1675. The infective nature of these organisms was later proved by **Louis Pasteur** and **Koch**. **Ehrenberg** was the first to use the term Bacterium (1829). The study of bacteria forms a special branch of biology called **Bacteriology.** The plant kingdom is a diverse group ranging from the microscopic bacteria to the macroscopic flowering plants. The system of classification places bacteria under the kingdom prokaryota. It is necessary to draw a comparison between bacteria and viruses. The viruses are a bridge between the living and the non-living world. Though they reproduce like other living organisms they are different from bacteria. Viruses are considered to be animate and inanimate objects.

VIRUSES	BACTERIA
They possess living and non living characters.	They are living organisms.
They are very small and are measured in millimicron.	They are bigger than viruses and are measured in micron.
They are strictly obligate parasites.	They live as autotrophs and heterotrophs.
The viruses contain RNA or DNA as genetic material.	The bacterial cell has DNA as genetic material.
Viruses are harmful.	Bacteria are both useful and harmful.

Occurrence of Bacteria

They are a highly specialized group of organisms, cosmopolitan in distribution. They occur in air, water, soil or in bodies of plants and animals. Some of them occur as commensals e.g., *Escherichia coli* in human intestine. They also occur as symbionts. e.g. *Rhizobium* in root nodules of legumes.

Size

The size of a bacterial cell varies from 0.2 - 2 µm width and less than 2-10 µm in length. A single drop of liquid can contain about 50 million bacteria.

Classification

Bacteria can be classified based on several criteria such as shape, flagella, staining properties, nutrition, etc. Bacteria are classified based on their shape as follows:

Coccus: (pl-Cocci) These are spherical in shape and are non-motile. The spherical cells often occur as groups (Staphylococcus) and are named as Diplococcus (in pairs), Tetracoccus (in tetrads) or Streptococcus (in chains).

Bacillus: (pl-Bacilli) 'Bacillus' is a Latin word meaning little stick. These are rod shaped bacteria and may occur as Diplobacillus (in pairs) or Streptobacillus (in chains).

Spirillum: (p1-Spirilla) These are cork-screw shaped.

Vibrio: These are comma shaped or like a curved rod.

Some bacteria are able to change their shape and size with changes in the environmental conditions. Such bacteria are called **pleomorphic** . e.g., *Acetobactor*.

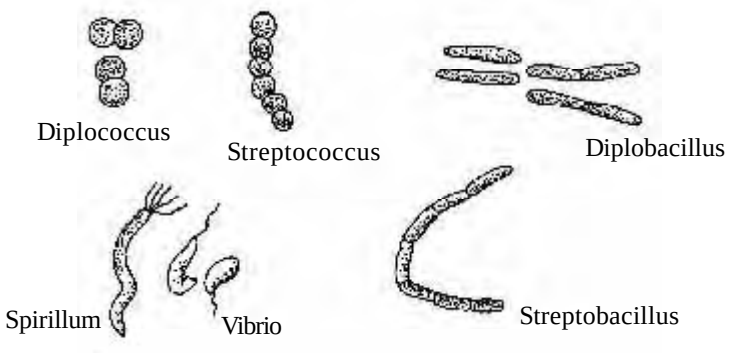


Fig 1.1 Shapes of bacteria

Flagellation in bacteria

Flagella are locomotory structures found in bacteria. Based on the presence or absence of flagella, their position and number, bacteria can be classified as follows:

Monotrichous: A single flagellum occurs at one end of the bacterial cell.

Amphitrichous: There is one flagellum at each pole of the bacterial cell.

Lophotrichous: There is a cluster of flagella at one end of the bacterial cell.

Peritrichous: The bacterial cell has a large number of flagella which are distributed all over the cell surface.

Atrichous: Bacteria which lack flagella are called atrichous.

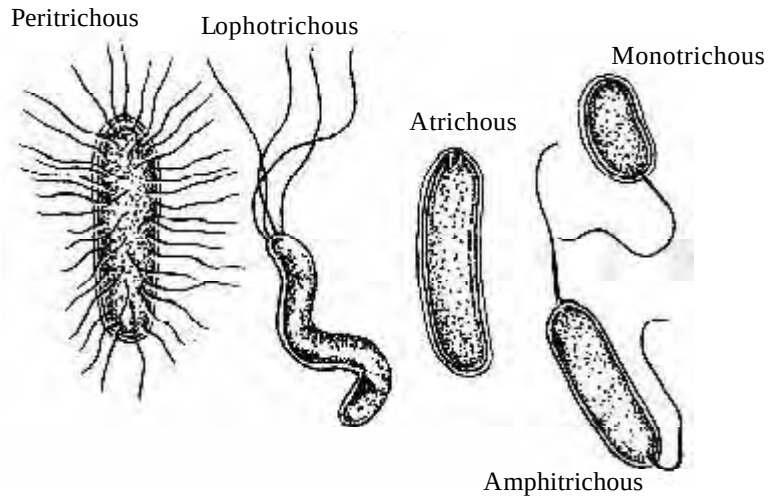


Fig 1.2 Types of flagellation in bacteria

Gram stain

It is a stain devised by the Danish bacteriologist Gram. The bacterial cells which retain the purple colour with gram stain are said to be gram positive. e.g., ***Bacillus subtilis***. Those which do not take up the stain are said to be gram negative. e.g., ***Escherichia coli.***

Ultra structure of a bacterial cell

The structure of bacteria can be studied in detail with the help of an electron microscope. Bacterial cell is a prokaryotic cell. Presence of **nucleoid** (i.e) nuclear material without a nuclear membrane and nucleolus is the characteristic feature of the prokaryotes.

The bacterial cell has a rigid cell wall protecting the cell and giving a definite shape to it. It is made of **peptidoglycan** (proteins and sugars). The living material inner to the cell wall is called protoplasm. It is differentiated into cell membrane, nuclear material and cytoplasm. The cell membrane produces infoldings called

mesosomes in some bacterial cells. It also contains enzymes for cellular respiration.The cytoplasm is a complex mixture of carbohydrates, proteins, fats, minerals and water. It contains non-living inclusions like lipid globules. Membrane bound organelles like golgi bodies, mitochondria, endoplasmic reticulum, lysosomes are absent. This is the typical character of prokaryotic cells. Ribosomes occur and are often seen as polysomes. They are the sites of protein synthesis. In cells of certain photosynthetic bacteria, membranous structures of various shapes called chromatophores are seen. They contain **bacteriochlorophyll** pigments. The nuclear material of a bacterial cell is made of a circular, DNA molecule. It is not bound by a nuclear membrane. Such a primitive nuclear organization is called **nucleiod** or **incipient nucleus** .There are extra rings of DNA seen in certain bacterial cells and are called **plasmids.** They carry important genes such as nitrogen

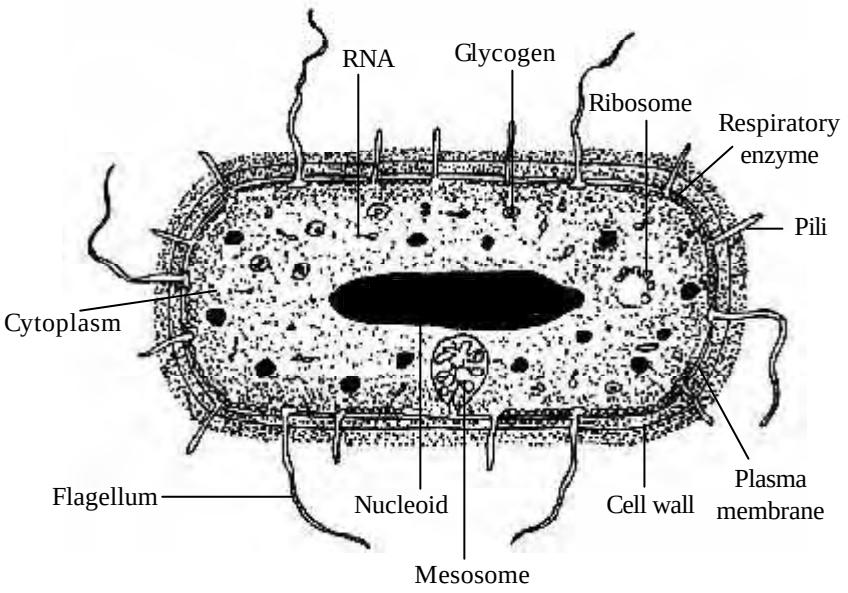


Fig 1.3 Ultra structure of Bacterial cell

fixing genes. There are thread like appendages which are called **flagella** found in bacterial cells. These are the organs of motility. **Pili** are minute, straight, hair like appendages found in the cell wall of many bacterial cells. These are considered to be organs of attachment.

Nutrition in bacteria

Bacteria show both autotrophic and heterotrophic modes of nutrition.

Autotrophic bacteria: The bacteria which are able to synthesize organic materials using raw materials from the environment are called **autotrophic bacteria**. Based on the energy source utilized by them, they are further classified into photosynthetic and chemosynthetic bacteria.

Photosynthetic bacteria: Bacteria like purple sulphur bacteria contain pigments called bacteriochlorophyll. With the help of these pigments they trap solar energy and manufacture carbohydrates. Atmospheric carbon di oxide is used as carbon source. In bacterial photosynthesis inorganic compounds like Hydrogen sulphide is used as hydrogen donor.

Chemosynthetic bacteria: They are non-photosynthetic autotrophs. They oxidize inorganic substances like nitrates, ammonia, etc. which are absorbed from the environment to obtain energy. This energy is used by the bacterial cell to combine carbon di oxide and water to form carbohydrates. This process of manufacturing food is called **chemosynthesis**.eg. Iron bacteria.

Heterotrophic bacteria: These bacteria depend on availability of food from outside sources. They are classified into saprophytic bacteria and parasitic bacteria.

Saprophytic bacteria: They grow on dead and decaying organic matter. They produce enzymes to digest the organic material and absorb them. The break down of carbohydrates is called **fermentation** and the break down of protein is called **putrefaction**. e.g., *Bacillus subtilis.*

Parasitic bacteria: They live on or within living plants and animals and obtain organic food from the host. e.g., *Xanthomonas citri* causes a disease called **citrus canker** in citrus plants. *Vibrio cholerae* causes **cholera** in human beings.

Symbiotic bacteria: These bacteria form mutually beneficial association with other organisms. Different species of the bacterium *Rhizobium* induce nodule formation in roots of suitable legume plants. The bacteria get shelter and food from the legume. In turn it fixes the atmospheric nitrogen into nitrogenous compounds for the legume plant.

Respiration in bacteria

Bacteria respire like other living organisms. They oxidise food materials present in the cytoplasm to obtain energy. The aerobic bacteria make use of free

atmospheric oxygen. e.g., ***Bacillus subtilis***. The anaerobic bacteria can live and multiply in the absence of free oxygen e.g., ***Clostridium botulinum***.

Reproduction in bacteria

Bacteria reproduce by three methods: binary fission, sporulation and sexual reproduction.

Binary fission

Under favourable conditions bacteria divide by this method. The cell elongates initially. This is followed by division of the nuclear material by formation of a septum. The plasma membrane invaginates followed by cell wall invagination. The mother cell is split into two identical daughter cells.

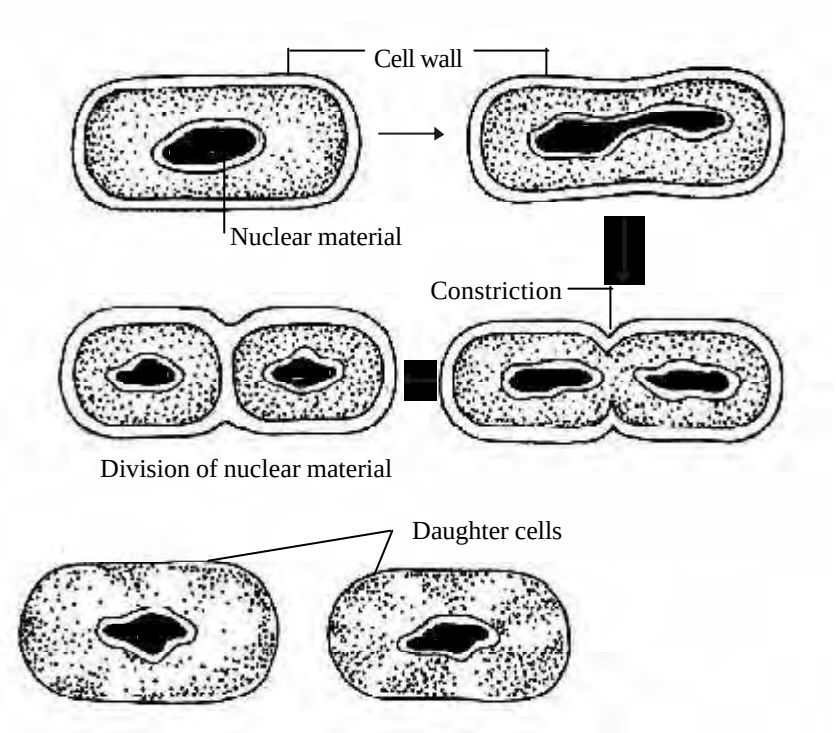


Fig 1.4 Binary fission in Bacteria

Sporulation

Several kinds of spores occur in bacteria. *Bacillus, Clostridium* are best examples of bacteria forming **endospores**. These are produced to resist adverse conditions. The contents of the bacterial cell undergo dehydration and form a

condensed mass. It secretes a thick wall around it called **exosporium.**

Sexual Reproduction

In bacteria fusion of gametes does not occur during sexual reproduction. Different types of sexual reproduction seen in bacteria are:

Conjugation

It is a method of sexual reproduction first observed in *Escherichia coli* by Lederberg and Tatum (1946). The bacterial cells involved in conjugation are classified as male (F+) or donor and female (F-) or recipient. F+ denotes the presence of fertility factor in the plasmid of the male and the female lacks the plasmid. The male or the donor bacterium has sex pili and gets attached to the

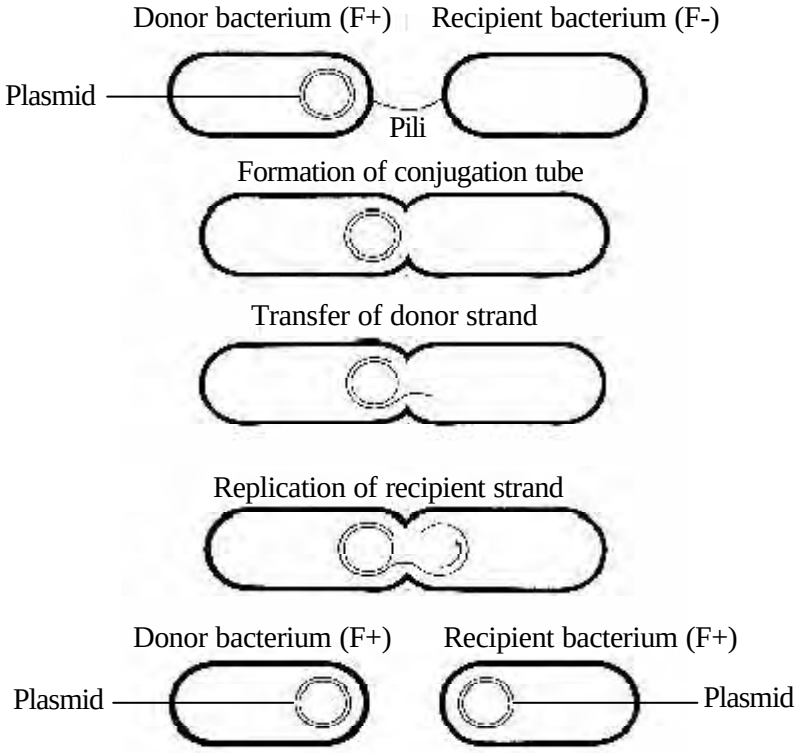


Fig 1.5 Conjugation in Bacteria

female or recipient bacterium. The sex pili forms the conjugation tube. The plasmid of the donor bacterium undergoes replication and a copy of it passes to the recipient through the conjugation tube. The female or recipient now becomes F+ bacterium.

Transformation

This was discovered by an English bacteriologist **Griffith** (1928). It is the process of acquiring of genes by a bacterium from dead decaying bodies of other bacteria. By this, non-pathogenic forms of bacteria can acquire disease causing genes.

Transduction

It is a method of gene recombination in which the bacteriophages (Bacterial viruses) transfer genes from one bacterial cell to another.

Economic importance of bacteria

Bacteria are of immense economic importance to mankind. They harm living organisms by causing diseases. At the same time their beneficial activities are a boon to us.

Beneficial activities

Decay and decomposition: Saprophytic bacteria cause decay and decomposition of dead bodies of plants and animals and release the nutrients to the soil. Hence they maintain soil fertility and also act as nature's scavengers.

Soil fertility: Bacteria play a prime role in maintaining soil fertility by enriching the soil nitrogen content. These bacteria are categorized as :

(a) Ammonifying bacteria: These saprophytes break down the nitrogenous remains in dead plant and animal bodies and convert them into ammonia. This is called **ammonification**. e.g., ***Bacillus ramosus***

(b) Nitrifying bacteria: Chemosynthetic autotrophs like ***Nitrosomonas*** *and* ***Nitrobacter***, covert the ammonium compounds in the soil into nitrate salts. This process of converting ammonium salts in to nitrates is called **nitrification**.

Role of bacteria in Industry

Dairy Industry: Lactic acid bacteria bring together droplets of casein, a milk protein and help in formation of curd.

Tobacco Industry: The leaves of tea, tobacco, and coffee fruits are fermented by the activity of certain bacteria to develop a characteristic flavour. e.g., ***Bacillus megatherium***.

Production of fibres: Stems of fibre plants like jute, hemp are kept under water for a few days. Bacteria act on the cell walls helping in the separation of fibres. The process of separation of fibres is called **retting**. e.g., ***Clostridium felsineum***.

Fermentation industry: Vinegar is manufactured from sugar solution employing ***Acetobacter aceti***. Butyl alcohol, methyl alcohol are manufactured using bacteria.

Leather Industry: Bacteria decompose fats found on the skin of animals. Hairs can be easily separated due to this and the leather is ready for use.

Medicine: Various antibiotics are extracted from bacteria. eg Streptomycin from ***Streptomyces griseus*** and Bacitracin from ***Bacillus subtilis***. Vitamin B_2 is manufactured by fermentative action of ***Clostridium acetobutylicum***.

Vaccine: Dead weakened disease producing bacteria are used to make vaccines to cure bacterial diseases like typhoid, cholera, etc.

Biotechnology: Bacteria are widely employed in genetic engineering experiments. It is used as a vector to carry genes. e.g., ***Agrobacterium tumifaciens***. Species of ***Pseudomonas*** are used to degrade organic compounds in seas and oceans due to oil spillage which will reduce the level of pollution in the ocean.

Harmful activities of bacteria

Bacteria can cause diseases in plants, animals and human beings.

Name of bacterium	Disease
Diseases in plants	
Xanthomonas citri	Citrus canker
Pseudomonas solanacearum	Wilt of potato
Diseases in human beings	
Diplococcus pneumoniae	Pneumonia
Mycobacterium tuberculosis	Tuberculosis
Diseases in Animals	
Bacillus anthraces	Anthrax

Soil fertility: Denitrifying bacteria like ***Thiobacillus denitrificans*** convert nitrates and ammonia into free nitrogen. This process is called **denitrification** and reduces soil fertility.

Food spoilage: Many saprophytic bacteria cause rotting of food stuffs like vegetables, butter, meat, fruits and spoilage of jellies, pickles, etc.

POINTS TO REMEMBER

- Bacteria were discovered by Anton Von Leeuwenhock.
- Bacteria are classified based on shapes into Cocci, Bacilli, Spirilli and Vibrio.
- Gram positive bacteria retain purple colour with gram stain.
- The nuclear material of bacteria is called nucleoid.
- Extra nuclear rings of DNA found in bacteria are called plasmids.
- Bacterial photosynthesis does not use water.
- Transformation, Conjugation and Transduction are the types of sexual reproduction seen in bacteria.
- Antibiotics like streptomycin, bacitracin are obtained from bacteria.

1.2 FUNGI

Fungi are a diverse group of the plant kingdom. They are non- chlorophyllous thallophytes which live as parasites or saprophytes. The study of fungi is called **Mycology**. Some fungi live in a symbiotic association with algae. They are called **Lichens**. Some fungi live in the roots of higher plants like Pinus. This type of symbiotic association is called **Mycorrhiza**.

Salient features of fungi

The plant body consists of a network of thread like filaments called **hyphae**. A mass of hyphae is called **mycelium.**

The cell wall of hyphae is made up of **chitin or fungal cellulose.**

They lack chlorophyll and are hence heterotrophic in their mode of nutrition.

They are **eukaryotic.** The cell consists of endoplasmic reticulum, golgi bodies, mitochondria, vacuoles and centrioles.

The reserve food materials are in the form of **glycogen and oil.**

Fungi reproduce vegetatively by fragmentation, fission, budding, formation of chlamydospores, etc.

Asexual reproduction is also seen by formation of zoospores, aplanospores, etc.

Sexual reproduction takes place by Isogamy, Anisogamy and Oogamy.

PENICILLIUM

Division	:	Mycota
Sub division	:	Eumycotina
Class	:	Ascomycetes
Sub class	:	Euascomycetidae
Order	:	Aspergillales
Family	:	Apergillaceae
Genus	:	*Penicillium*

Habit

Penicillium is one of the most cosmopolitan genera of fungi present in air. It is a saprophytic fungus found on decaying vegetables, fruits, textile, paper and wood. It is commonly known as the **green mould** or **blue mould**.

Vegetative structure

The plant body is called **mycelium** and consists of thin walled, profusely branched, septate **hyphae**. Some of the hyphae penetrate deep into the substractum. The cell wall of hypha is made up of chitin. Each cell contains organelles like mitochondria, ribosome, golgi apparatus and endoplasmic reticulum. The cells contain two to several nuclei in them. Storage products occur in the form of oil globules.

Reproduction

Penicillium reproduces by vegetative, asexual and sexual methods.

Vegetative reproduction

It takes place by **fragmentation.** The hyphae break into short segments. Each segment grows into a new mycelium.

Asexual Reproduction

Asexual reproduction in *Penicillium* takes place by production of conidia.

Production of Conidia

Conidia are uninucleate, non motile, asexual spores produced by species of ***Penicillium***. During production of conidia some of the hyphae from the mycelia grow vertically and are called **conidiophores**. These are produced as single separate structures or may be branched. The tip of the conidiophore is multinucleate.

It bears a terminal cluster of flask like structures called **sterigmata**. These are uninucleate and give rise to spores called **conidia**. Each conidium is smooth, uninucleate and coloured depending on the species. They are disseminated by wind and germinate into new mycelia on the onset of favourable conditions. The apical part of the conidiophore with branched sterigmata and chains of conidia look like a small artist's brush known as the **'penicillus'**. The conidia may be coloured (blue or green) and hence the fungus is called blue mould or green mould.

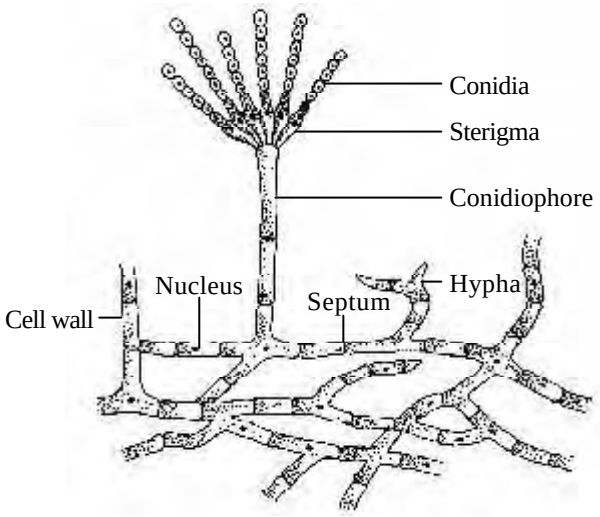


Fig 1.6 Asexual reproduction in *Penicillium* by conidia

Sexual reproduction

It occurs in some species of ***Penicillium*** by formation of sex organs and results in the formation of spores called ascospores. The ascospore germinates to form a new mycelium.

Economic importance of Fungi

Fungi are useful and harmful to man. Some of the beneficial activities of fungi are:

Brewing and Baking industry:

Yeast is a very valuable fungus in these industries. Yeast ferments sugar solution with the help of the enzyme zymase and produces alcohol and carbon di oxide. In the brewing industry, alcohol is the important product. In the baking industry carbon di oxide causes the dough to rise and makes the bread light. Carbon di oxide is also collected, solidified and sold as dry ice.

Production of organic acids: Various species of fungi particularly ***Penicillium*** and ***Aspergillus*** are used in production of organic acids. Oxalic acid is the fermentation product of ***Aspergillus niger***.

Processing of food: ***Penicillium camemberti*** is used in the cheese industry. It imparts a soft texture and a distinct flavour to cheese.

Vitamins: Yeast is the best source of vitamin B complex. The vitamin Riboflavin is obtained from a filamentous yeast.

Fungi as food: Several species of fungi are used as food. Many species of ***Agaricus*** and ***Morchella*** are edible and are cultivated on a commercial basis.

Decay and Decomposition: The saprophytic fungi in the soil decompose the dead plant and animal remains and return the mineral elements back to the soil. Thus they play a significant role in maintaining the mineral cycles in nature .

Antibiotics*:* ***Penicillium notatum*** and ***Penicillium chrysogenum*** are sources of the drug penicillin. It inactivates many pathogenic microbes.

Harmful activities of fungi

Damage to timber: Many species of ***Polyporus*** damage timber wood.

Damage of paper: Species of ***Aspergillus***, ***Fusarium*** damage paper which affects paper industries.

Spoilage of food: ***Penicillium digitatum*** damages citrus fruits in storage. ***Aspergillus*** and ***Mucor*** species spoil bread.

Diseases: Several parasitic fungi are pathogenic and cause diseases in plants, animals and human beings.

Diseases in plants

Tikka disease of groundnut: This is caused by **C*ercospora personata***. The disease is characterized by development of circular black spots on the leaf and the yield of groundnuts is affected.

Blast disease of rice: This is caused by ***Pyricularia oryzae***. Grey spots appear on the leaves and hence rice production is affected.

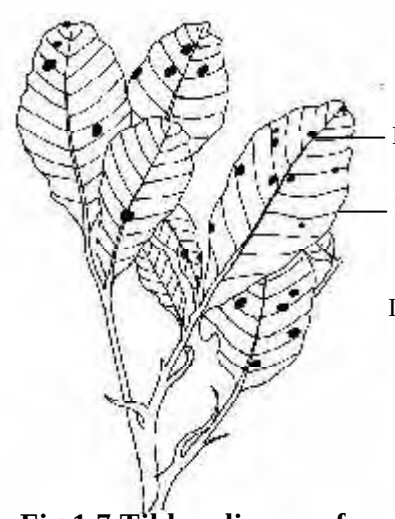


Fig 1.7 Tikka disease of groundnut

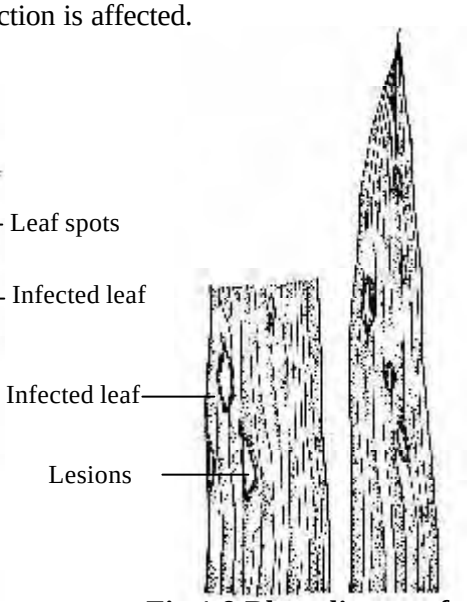


Fig 1.8 Blast disease of rice

Diseases in human beings

Candida albicans causes thrush in the mouth. The dermatophytes or ring – worm fungi include about 40 species belonging to the genera ***Trichophyton***, ***Microsporum*** and ***Epidermophyton***. They cause superficial infections of skin, hair, nails, etc in human beings.

1.3 ANTIBIOTICS

Antibiotics are antimicrobial agents. Chemotherapy of human ailments has been practiced for centuries but the discovery of antibiotics has indeed created a revolution in treating diseases caused by microbes. In 1929 **Alexander Flemming** made a discovery that the fungus ***penicillium*** **c**ould produce an antibacterial

substance which he called **penicillin.** Flemming was working on bacterial cultures of **staphylococci** and wanted to discover some anti bacterial substance which could control wound infections. He found that some of his cultures were contaminated with a mould called ***Penicillium notatum***. He found clear areas around the mould indicating that the bacterial cultures were destroyed. His keen sense of observation prompted him to culture this mould and later he was able to isolate the active principle penicillin. The mould was identified as ***Penicillium notatum***. This drug is a inhibitor of gram positive bacteria and helped to save the lives of many wounded soldiers in the second world war. There is a penicillin factory at Pimpri in India. Later streptomycin was discovered from ***Streptomyces griseus***, an actinomycete. It particularly destroys the gram negative bacteria. Other notable antibiotics are Vancomycin, Streptomycin, Bacitracin, etc.

The term antibiotic was coined by **Selman Waksman** in 1942. They are substances of microbial origin that in minute quantities have anti-microbial effects. They are obtained from bacteria and fungi. Antibiotics can affect microbes by inhibiting synthesis of enzymes or synthesis of cell wall. Most of the antibiotics are produced by microbial fermentation while some of them can be synthetically manufactured e.g. Chloramphenicol.

POINTS TO REMEMBER

- Fungi in association with algae form lichens.
- The plant body of fungi is called mycelium.
- Fungi consists of eukaryotic cells.
- *Penicillium* reproduces asexually by the formation of conidia.
- Penicillin was discovered by Alexander Flemming.

SELF EVALUATION

I. Choose and write the correct answer:

1. Vitamin B_2 is manufactured by the action of _____.
   a) Clostridium b) Bacillus c) Nitrobacter d) Pseudomonas
2. _____ is a symbiotic nitrogen fixing bacterium.
   a) Rhizobium b) Nitrosomonas c) Clostridium d) Anabaena
3. In *penicillium* sexual reproduction occurs by the formation of _____.
   a) Ascospore b) Conidia c) Aplanospore d) Endospore
4. _____ is an edible fungus.
   a) Aspergillus b) Puccinia c) Agaricus d) Microsporum

II. Fill in the blanks with suitable terms:

1. The nuclear material in bacteria is called _____.
2. _____ is a organelle found in prokaryotic and eukayotic cells.
3. The term bacterium was coined by _____.
4. Penicillin was discovered by _____.
5. Streptomycin is obtained from _____.

III. Answer the following questions in one or two sentences:

1. Mention two differences between viruses and bacteria.
2. Differentiate between pili and flagella.
3. What is retting?
4. Define transduction.
5. What is gram stain?
6. What is denitrification?
7. Define the term 'antibiotic'.
8. What is mycelium?
9. Name the causal agent of a) Tikka disease b) Anthrax

IV. Write short answers for each of the following questions in 100 words:
(Draw diagrams wherever necessary).

1. Explain autotrophic nutrition in bacteria.
2. Write a note on the harmful activities of bacteria.
3. Draw a neat labelled diagram of ultra structure of a bacterial cell.
4. Explain asexual reproduction in *Penicillium.*

V. Write detailed answers for each of the following questions in 200 words:
(Draw diagrams wherever necessary).

1. Describe the ultra structure of a bacterial cell.
2. Explain the types of reproduction in bacteria.
3. Write a note on economic importance of fungi.

UNIT 2

PLANT PHYSIOLOGY

Plant physiology is the branch of science, which deals with the functioning of the plants. Green plants are endowed with the unique capacity of trapping solar energy and converting it into chemical energy by the process called photosynthesis. Apart from manufacturing carbohydrates, they also carry out other processes like respiration, growth and development. The study of all these functions is called physiology. The plant cell is the basic physiological unit and the principle seat of all metabolic activities in a plant.

2.1 ABSORPTION OF WATER AND MINERALS

Presence of adequate amount of water in the soil is essential for the normal functioning of the plants. Soil water is in the form of a dilute solution containing minerals in a dissolved state.

Importance of water to plants

1. Water is an excellent solvent.
2. It serves as a medium for several chemical reactions.
3. Nearly 80% of the fresh weight of the plant tissues is composed of water.
4. It helps to maintain turgidity of the cells in the plant body.
5. It helps to maintain temperature in plants.
6. It serves as a medium for the movement of various dissolved substances.
7. Water plays a vital role in respiration and photosynthesis.

Sources of water

Source of water for the soil is rainfall, snowfall, dew, etc. Soil water exists in different forms as follows:

Gravitational water: This water percolates down through the spaces between the soil particles and reaches the water table. Roots cannot absorb this water. So this water is not available to the plants.

Hygroscopic water: These water molecules bind with the soil particles by the force of imbibition even under dry condition. Roots cannot separate the water molecules from the soil. So it is not available to the plant.

Capillary water: The water which is free to move by capillarity between the soil particles is called capillary water. This is the main source of available water to the plants.

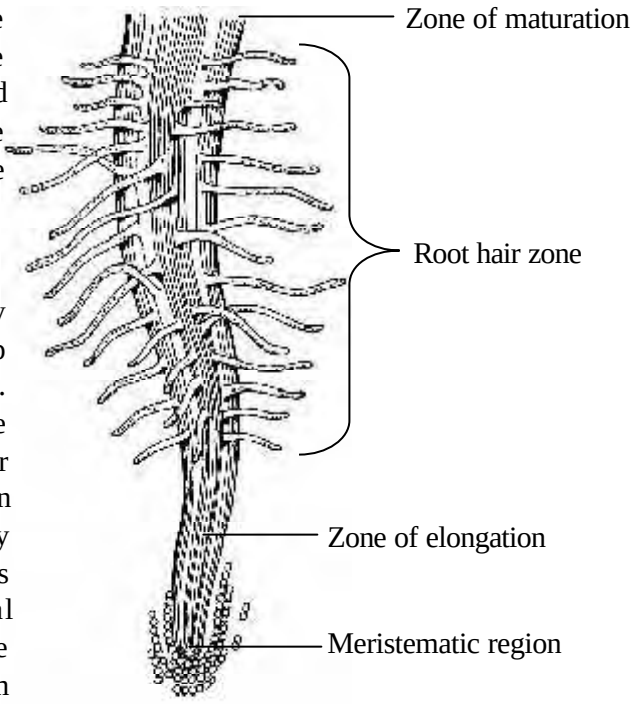


Fig 2.1 Tip of root showing root hair zone

Water absorbing organs

Plants generally absorb water with the help of root system from the soil. The **root hair zone** of the root is the area of water absorption in the root. In epiphytic plants, a spongy tissue called **velamen** is present in the aerial absorbing roots. This tissue absorbs water vapour from the atmosphere.

Forces responsible for water absorption are imbibition, diffusion and osmosis.

Imbibition

It is the uptake of water by substances that do not dissolve in water. It results in swelling up of the substances. e.g. dry grapes in water, gum, dry wood, starch, cellulose. The plant cell wall is made up of pectic substances. They are **hydrophilic** in nature. So they imbibe large amount of water.

Diffusion

It is the movement of molecules from a region of higher concentration to a region of lower concentration until the molecules are evenly distributed throughout the available space. This is applicable to solids, liquids and gases. e.g. Odour of perfume.

Osmosis

Osmosis is a special type of diffusion of liquids. Osmosis can also be defined as the movement of water molecules from a region of higher free energy to a region of lower free energy through a **semi permeable membrane** until they reach a state of dynamic equilibrium**.** The potential with which the water molecules diffuse through the membrane is called osmotic potential. The osmotic potential is otherwise called **water potential** (or) **chemical potential**. The water potential of pure water at 25°C is zero. When a solute (sugar or salt) is added to pure water, the water potential is decreased and it becomes negative as the free energy decreases. Always water moves from a region of higher water potential to a region of lower water potential. The symbol for water potential is ψ and the unit is pascal.

The process of osmosis can be demonstrated by a simple experiment employing a living system as follows.

Potato Osmoscope

A large sized tuber of potato is taken and peeled. Its base is cut to make it flat. A hollow cavity is made in the centre of the tuber and is filled with concentrated salt or sugar solution. The initial level of the solution is marked with

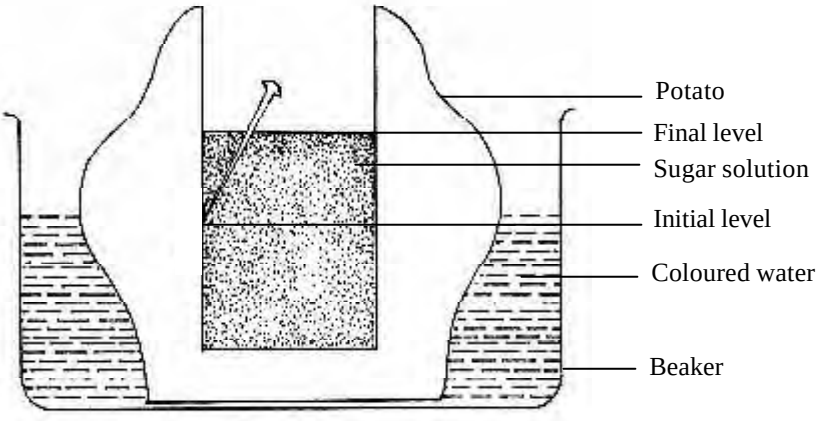


Fig 2.2 Potato osmoscope

the help of a pin inserted in the wall of the tuber. It is then placed in a beaker containing coloured water for some time. An increase in the level of the solution inside the tuber is observed. It is also found to be coloured. This is due to osmosis i.e. flowing of water from the beaker into the cavity of the potato through the living cells of potato, which act as the semipermeable membrane.

Absorption of water from the soil

The root hair zone of the root is the area of absorption of water from the soil. The root hairs are unicellular extensions of the rhizodermal cells of the root. The root hair cells have an outer cell wall, which is made of **hydrophilic colloids** – calcium and magnesium pectate which absorb water by **imbibition.** The imbibed water provides a channel for movement of water and inorganic salts into the root. The plasma membrane present inner to the cell wall is permeable to inorganic salts and not to organic substances. Hence it acts as a **semi permeable membrane**. Root hair contains a vacuole filled with cell sap. The sap is a solution of organic acids and sugars in water. The water potential of the cell sap is lesser than that of soil solution. Therefore water moves from the soil solution to the root hair by simple diffusion.

As a result of entry of water into the root hair cells, the cell sap increases in volume and exerts a pressure on the cytoplasmic layer and cell wall. This pressure is called **turgor pressure** and the cell is said to be turgid. Turgidity of a cell increases its water potential. The cortical cells adjacent to the root hair have a lower water potential. Water enters from the root hair to cortical cells by the process of osmosis aided by turgor pressure. This process continues till the endodermis and finally water reaches the xylem through the passage cells and pericycle. From the xylem the water is pushed to the aerial parts of the plant.

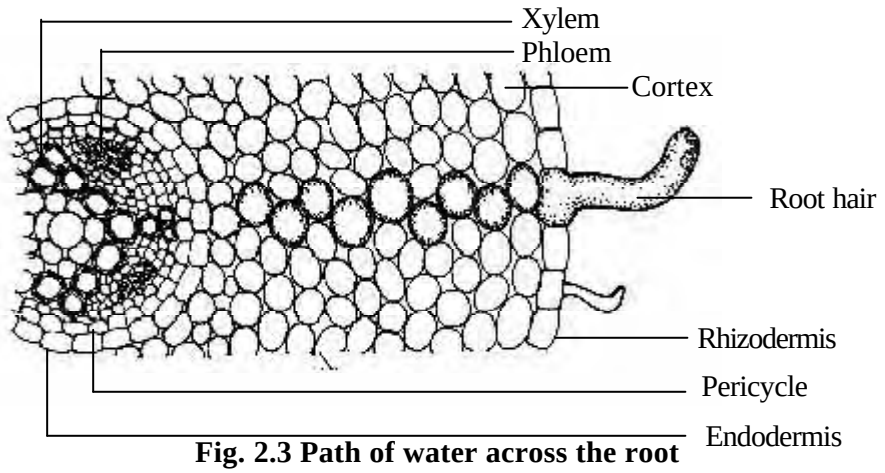


Fig. 2.3 Path of water across the root

Ascent of Sap

The water is absorbed mainly by the roots and is moved upward to all the parts of the plant through the stem. The upward movement of water and dissolved substances through the stem is called **Ascent of Sap.** Many theories have been

proposed to explain ascent of sap. They are (1) root pressure theory (2) vital theories (3) physical theories. The root pressure theory is discussed here.

Root Pressure Theory

This is based on the phenomenon of root pressure. Root pressure can be demonstrated in herbaceous plants like tomato. If the plant is cut near the base, the xylem sap is seen to flow out through the cut end with a pressure. This pressure is the hydrostatic pressure developed in the living parenchyma cells of the root system and is called root pressure. It has been measured to be about 2 atm.

Root Pressure Theory is not accepted because

a. The pressure developed in the root is very less. It cannot raise water in tall trees like the conifers, eucalyptus which grow upto 30 metres.
b. Ascent of sap is seen to take place even if roots are removed.

Absorption of Mineral Elements

Mineral elements are absorbed by roots. Unlike absorption of water, nutrient absorption occurs over the entire surface of the root. The initial uptake of mineral ions from the soil into to the intercellular spaces in root and the cell wall is by passive absorption. The absorption of mineral ions without the use of metabolic energy is called **passive absorption**. The entry of mineral ions into the cytoplasm and vacuoles of cells is by active absorption. The uptake of mineral ions against concentration gradient involving the use of metabolic energy is called **active absorption**. Several theories have been put forth to explain the process of active and passive absorption of mineral ions.

Mineral Nutrition

The soil plays an important role by supplying various nutrients necessary for the normal growth and development of plants. The term **"nutrient"** refers to mineral elements, which are absorbed by the plants from the soil. The uptake of inorganic elements in the form of mineral ions from the soil is called mineral nutrition. About 20 mineral elements have been found to be absolutely necessary for plant growth and reproduction. These are referred to as **essential elements.** They are further classified into **macronutrients** and **micronutrients** on the basis of the requirement by the plants. Plants show deficiency symptoms and show physiological disorders in the absence of one or more essential elements.

Macronutrients

They are essential elements, which are needed in large quantities for the plant. These include Carbon, Hydrogen, Oxygen, Nitrogen, Phosphorous, Sulphur, Potassium, Calcium, Magnesium and Iron.

Micronutrients

They are essential elements, which are needed for the plants in very small quantities. They include Manganese, Copper, Molybdenum, Zinc, Boron and Chlorine.

Sources of Minerals

Carbon enters into a plant as carbon di oxide from the atmosphere. Hydrogen is obtained from water and oxygen is obtained from air and water. Nitrogen is found in a gaseous form in the atmosphere. It cannot be directly absorbed by plants. It is converted into nitrate salts by microbes in the soil. Ammonia released by putrefaction in the soil is also converted into nitrate salts. The other elements are got from soil solution.

Physiological role of Mineral Elements (Macronutrients and Micronutrients)

- Carbon, Hydrogen and Oxygen are considered as framework elements. They constitute an essential part of Carbohydrates, Proteins and Fats, the basic macromolecules of all living systems.
- Nitrogen is a major constituent of proteins and nucleic acids.
- Phosphorous enters into the composition of nucleotides and ATP.
- Potassium plays a significant role in closing and opening of Stomata. It is also needed for translocation of food.
- Calcium is much needed for cell division. It is an integral part of the middle lamella found between plant cells.
- Magnesium is a structural component of the Chlorophyll molecule.
- Iron plays an important role in electron transport chain during respiration and photosynthesis.
- Chlorine plays a major role in photolysis of water during light reaction of photosynthesis.
- Manganese is an activator of enzymes particularly involved in Kreb’s cycle.

Symptoms of Mineral deficiency in plants

Deficiency symptoms are external manifestations of the deficiency of mineral elements in plants. The deficiency can be related to absence of a particular nutrient in the soil or non-availability of the nutrient to the plant due to various reasons. Some of the common deficiency symptoms observed in plants are :

Chlorosis – Loss of chlorophyll leading to yellowing of leaves.
Mottling – Appearance of patches of green and non-green areas on the leaves.
Wilting – Drooping of the leaves due to loss of conduction of water.
Necrosis – Death of tissues in certain parts.
Stunted growth – Plants with shortened internodes and smaller in size.

Fertilizers

Chemicals added to the soil to overcome mineral deficiency are called fertilizers. The NPK fertilizers contain the critical elements and are frequently used in fields. Ammonium Sulphate, Ammonium Nitrate, Urea, Super Phosphate are some of the commonly used fertilizers. They are synthetically manufactured in factories. The nutrient supplements, which are obtained from biological sources and used to maintain soil fertility, are called **biofertilizers.** They are easy to produce, economic to use and do not cause any damage to the plant or to the environment. Eg. The leaves of an aquatic fern *Azolla* contain a cyanobacterium called *Anabaena azollae*, which can fix atmospheric nitrogen in the soil.

ACTIVITY

1. Take a few dry raisins and soak in water. What do you observe?
2. Place some wet cotton in a petri dish. Cover it with filter paper. Place a few mustard seeds on it which have been soaked in water for few hours. You will notice the radicle emerging from the seeds. Examine the growing root tip and identify the various zones.

POINTS TO REMEMBER

- Capillary water is the main source of available water to plants.
- The root hair zone of the root is the area of water absorption.
- Osmosis is a special type of diffusion of liquids.
- The upward movement of water and dissolved substances through the stem is called ascent of sap.
- The essential elements required by a plant are classified into macronutrients and micronutrients.
- Nutrient supplements got from biological sources are called biofertilizers.

2.2 PHOTOSYNTHESIS

The term **"photosynthesis"** means synthesis of food with the help of light energy. It is defined as the conversion of light energy into chemical energy in the presence of carbon dioxide, water and photosynthetic pigments.

The overall equation of photosynthesis is

$$6\,Co_2 + 12\,H_2O \xrightarrow[\text{Photosynthetic pigments}]{\text{Sunlight}} C_6H_{12}O_6 + 6H_2O + 6O_2\uparrow$$

Green plants are said to be autotrophic in their mode of nutrition since they are capable of manufacturing their own food materials. Plants like fungi are described as heterotrophs since they directly or indirectly depend upon the autotrophs for their nutritional requirements. It must be noted that some of the bacteria also come under autotrophs. They are classified into photosynthetic and chemosynthetic autotrophs. You have already learnt about bacterial photosynthesis.

Types of photosynthesis

1. Oxygenic photosynthesis : The organisms release oxygen during photosynthesis. Water is the electron donor. e.g. higher plants.
2. Non-oxygenic photosynthesis : The organisms release compounds other than oxygen. Hydrogen sulphide is the electron donor. e.g. bacteria.

History of Photosynthesis

1845	Von Mayer recognized that green plants convert solar energy into Chemical energy.
1932	Emerson and Arnold discovered the light reactions of Photosynthesis.
1937	Hill demonstrated photolysis of water.
1954	Melvin Calvin explained the C_3 cycle of carbon fixation.
1965	Hatch and Slack explained the C_4 cycle of carbon fixation.

Raw materials for photosynthesis

Solar energy, photosynthetic pigments, carbon di oxide and water are the raw materials for photosynthesis. Solar energy is obtained from sun light. Less than one percent of solar energy is only used by plants for photosynthesis.

The photosynthetic pigments are present in the chloroplast. The green terrestrial plants obtain water from the soil through the roots and carbon di oxide from the air through the stomata. Aquatic plants obtain carbon dioxide as bicarbonates from the water.

Site of Photosynthesis

Leaves are the main photosynthetic organs of the plant and the **chloroplasts** is the photosynthetic apparatus. The Chloroplasts are disc shaped organelles of eukaryotic plant cells. Each chloroplast measures 4 – 10 microns in diameter and 2 – 3 microns in thickness. It has a double membranous envelope. The matrix enclosed by the membranes is called **stroma.** It is traversed by a number of flattened membranous sacs called **thylakoids.** A stack of thylakoids appears like a pile of coins and is called **granum.** The adjacent grana are connected by **fret membranes** or **stromal lamellae** . The pigment molecules are located in the grana. Light reaction of photosynthesis takes place in the grana. The stroma of the chloroplast contains enzymes and substrates necessary for the dark reaction of photosynthesis. The stroma also contains circular DNA, RNA and ribosomes.

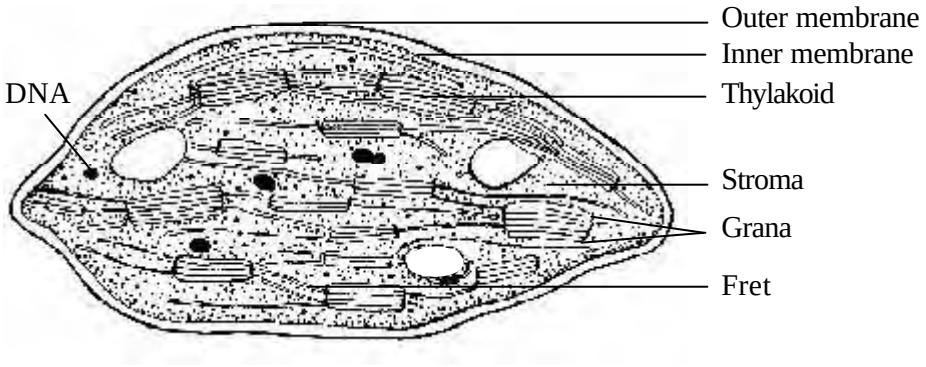


Fig. 2.4 Ultra structure of Chloroplast

Pigments involved in Photosynthesis

The chloroplasts contain two kinds of pigments, primary pigments and accessory pigments. Chlorophylls are the primary pigments. They occur in different types – chlorophyll a, b, c, d and e. Chlorophyll is an universal pigment found in all photosynthetic organisms except bacteria. Hence they are called primary photosynthetic pigments. The other pigments are called accessory pigments. e.g., Carotenoids (carotenes and xanthophylls). Carotenes are orange pigments and xanthophylls are yellow pigments. Primary pigments are directly involved in

photosynthesis whereas accessory pigments absorb the light energy and transfer it to the primary pigments for photo chemical reaction. They do not directly carry out the photo chemical reactions.

Mechanism of Photosynthesis

The process of photosynthesis occurs in two phases, the photochemical (light) reaction and carbon assimilation (dark) reaction. The light reaction or photochemical phase takes place in the grana of the chloroplast. The dark reaction takes place in the stroma of the chloroplast. This is also called photosynthetic carbon reduction pathway (PCR-pathway).

Light reaction

This is a light induced reaction. Photolysis and Photophosphorylation occur during this phase. Based on the involvement of primary and accessory pigments, **Emerson** (1957) proposed two pigment systems, which participate in the light reaction. They are PS I and PS II (Photosystem I and Photosystem II).

Photosystem I

It consists of more primary pigments - chlorophylls and less of accessory pigments. The reaction center is a special **chlorophyll a molecule** called **P700.** It is fed with energy harvested by the other molecules of the system.

Photosystem II

This is mainly composed of more accessory pigments and less primary pigments. The reaction center of PS II is **P680**, which consist of a special type of chlorophyll a molecule.

Photophosphorylation

Synthesis of ATP in the chloroplast utilizing light energy is called **Photophosphorylation.** The pigment molecules absorb photons when light energy is incident on them. They emit energized electrons. These electrons pass through a number of electron carriers. During this transport they lose energy and reach the ground state. This energy loss is channelised for the synthesis of ATP and reduction of NADP. Two types of photophosphorylation have been identified by Arnon (1954)

Cyclic Photophosphorylation

This involves only PS I. The pigment molecules of PS I (Photosystem I) absorb light energy and finally transfer it to the reaction center P700. It emits

energized electrons, which is accepted by Ferredoxin (FD). The electrons are cycled back to PS I through carriers called cytochromes. The energy loss during this process is linked to the production of ATP and is called **photophosphorylation**. It is described as cyclic photophosphorylation because the electron lost by PS I is cycled back to it. Two molecules of ATP are synthesized for transport of each pair of electrons during Cyclic Photophosphorylation. Cyclic photophosphorylation occurs during specific conditions only.

Non-Cyclic Photophosphorylation

PS I and PS II (Photosystem I & II) take part in non-cyclic photophosphorylation. The pigment molecules absorb light energy. The reaction centers P700 and P680 of PS I and PS II respectively emit energized electrons. The electron from PS I is accepted by Ferredoxin and used to reduce NADP to $NADPH_2$.

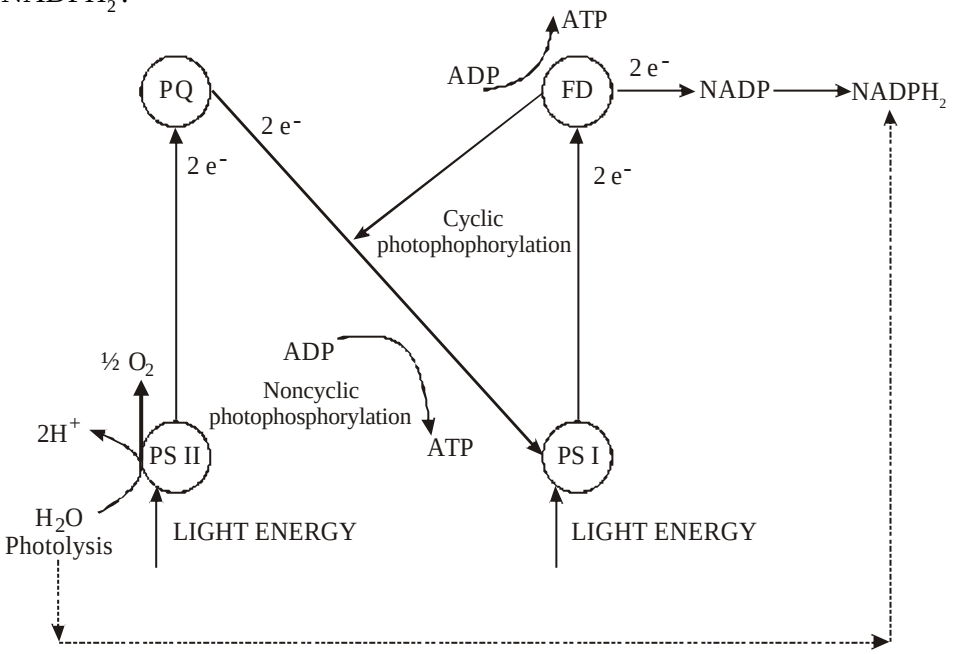


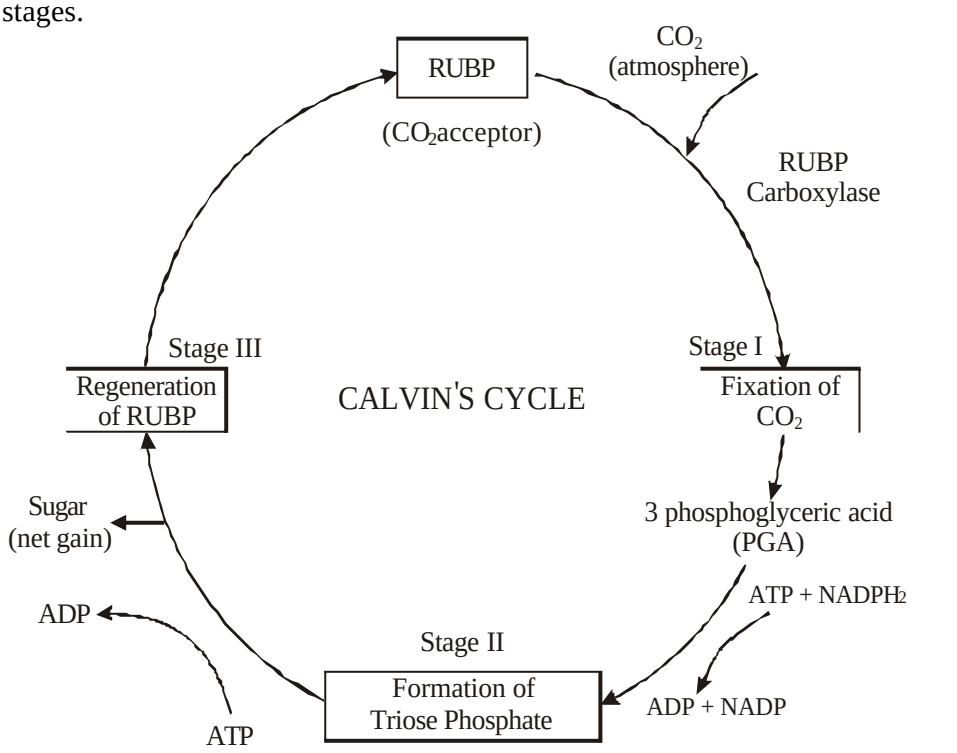
Fig. 2.5 Light Reaction of Photosynthesis-schematic representation

The electrons liberated from PS II and successively transported through the electron carriers, reaches PS I and compensates for the electron loss of PS I. During this transfer of electrons ATP molecules are synthesized (photophosphorylation). PS II gets back its lost electron by photolysis of water.

This is light dependent splitting of water molecules. Protons released during photolysis are used in $NADPH_2$ formation. Oxygen is evolved as a by-product. Since the electrons travel in a non-cyclic manner, the process is described as noncyclic photophosphorylation. For each pair of electrons transported during Non-cyclic photophosphorylation one ATP and one $NADPH_2$ molecule is formed. ATP and $NADPH_2$ are utilized in the dark reaction to reduce carbon di oxide to synthesize carbohydrates.

Photosynthetic Carbon Reduction - (PCR) pathway (Dark Reaction)

Light is not essential for this cycle of chemical reactions. It was discovered by **Blackmann** (1954). The reactions involve fixation of atmospheric carbon di oxide to form carbohydrates by using ATP and $NADPH_2$ generated in the light reaction. **Prof. Melvin Calvin** and his associates traced the path of carbon di oxide and hence it is also known as Calvin's cycle. The cycle occurs in three stages.



RUBP - Ribulose-1, 5-Biphosphate
ATP - Adenosine tri phosphate
ADP - Adenosine di phosphate
NADP - Nicotinamide Adenine Dinucleotide Phosphate

Fig. 2.6 Dark Reaction of Photosynthesis - Schematic representation.

Stage I – One molecule of carbon dioxide is accepted by a 5-carbon molecule, **Ribulose – 1, 5-Bisphosphate (RUBP)** to form an unstable six carbon compound**.** The enzyme catalyzing this reaction is **RUBP carboxylase (RUBISCO).** The six carbon compound splits into two molecules of a 3-carbon compound i.e. phospho glyceric acid. This the first stable product. Hence Calvin cycle is also known as C_3 cycle. The plants having this mode of PCR pathway are called C_3 plants. e.g., bean, potato, wheat.

Stage II – During this stage the ATP and $NADPH_2$ formed during the light reaction is utilised. Phosphoglyceric acid gets reduced to form Glyceraldehyde 3-phosphate. It takes place in two reactions. In the first reaction phosphoglyceric acid is converted into 1-3 Bisphosphoglyceric acid with the help of the enzyme PGA kinase. In the second step, 1-3 Bisphosphoglyceric acid is reduced to form 3 phosphoglyceraldehyde with the help of the enzyme 3 Phosphoglyceraldehyde dehydrogenase.

Stage III – The molecules of Glyceraldehyde – 3-phosphate are converted into RUBP (the initial carbon dioxide accepter molecule). A series of reactions occur which generate 4c, 6c and 7c phosphorylated compounds as intermediates. A three-carbon compound is used for sugar synthesis. A continuous supply of ATP, $NADPH_2$ and RUBP is required for continuation of calvin's cycle.

Significance of Photosynthesis

- Photosynthesis is the only process by which autotrophic organisms trap solar energy and convert it to food for heterotrophs. Only a few bacteria can synthesize food materials by chemosynthesis.
- Plant produce like timber, fibres, firewood, etc. are the products of photosynthesis in a plant.
- The process adds oxygen to the atmosphere, which compensates for the oxygen used in the respiration of living organisms.
- It provides energy in terms of fossil fuels like coal and petroleum. Thus all life on earth directly or indirectly depends on photosynthesis.

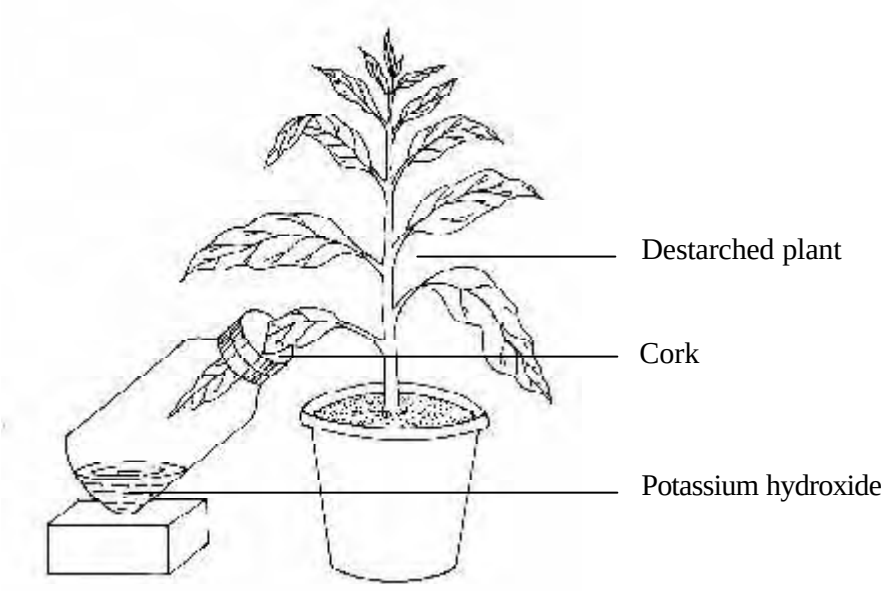
Mohl's half Leaf Experiment

Aim: To prove that carbon di oxide is essential for photosynthesis.

A destarched potted plant is taken. The plant is destarched by keeping it in darkness for few days. A wide mouthed bottle containing a small quantity of potassium hydroxide solution is taken. A split cork is fitted to the mouth of the bottle. One of the leaves of the potted plant is inserted through the split cork such that half of the leaf is inside the bottle. The whole apparatus is kept in sunlight. The leaf is tested for starch after few hours.

Test for Starch

The leaf to be tested for starch is dipped in boiling water for 5 minutes. It is then dipped in 90% alcohol to decolorize it. It is washed with water. Few drops of Iodine solution are added to it. The starch containing part of the leaf will turn



Leaf tested for starch

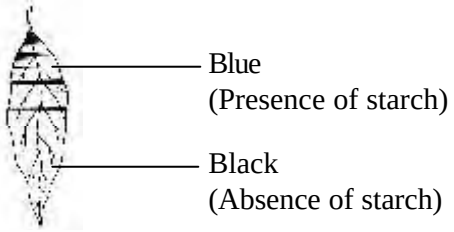


Fig. 2.7 Mohl's Half Leaf Experiment

blue in colour. It is observed that the part of the leaf inside the bottle does not answer the starch test. This is because the cabon di oxide inside the bottle was absorbed by potassium hydroxide and not available to the leaf for photosynthesis. The part of the leaf outside the bottle could make use of atmospheric carbon di oxide for photosynthesis. It turns blue in colour during the starch test. This proves that carbon di oxide is essential for photosynthesis.

Test Tube and Funnel Experiment

Aim: To prove that oxygen is evolved during photosynthesis.

A beaker is taken and filled with water. A few branches of Hydrilla (aquatic plant) are taken and inserted inside a glass funnel. The funnel is kept inverted inside the beaker. A test tube full of water is inverted over the stem of the funnel. The apparatus is kept in sunlight for few hours. Air bubbles are seen to collect in the test tube by the downward displacement of water. The test tube is slowly removed by closing the mouth with the thumb. The gas is tested for oxygen using a burning splinter. The splinter glows brightly proving that the gas is oxygen. Thus the gas evolved during photosynthesis is proved to be oxygen.

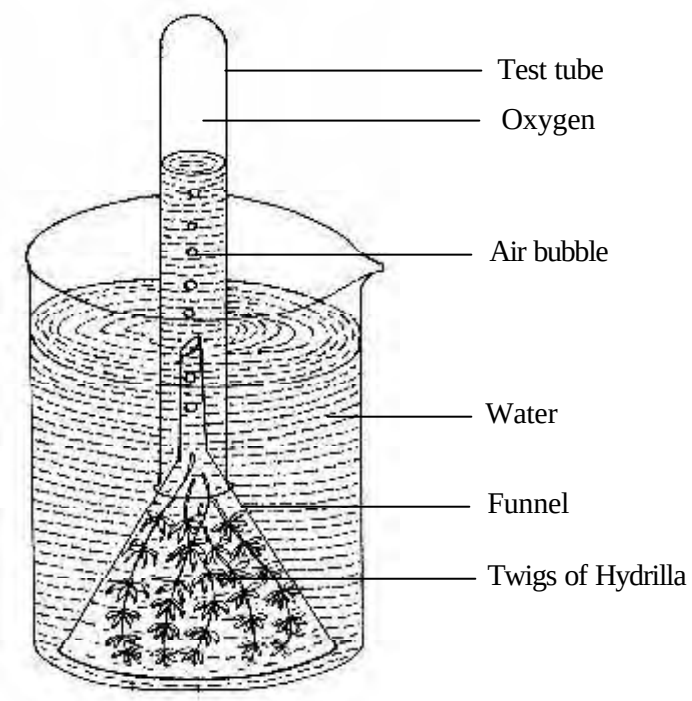


Fig. 2.8 Test Tube and Funnel Experiment

ACTIVITY

Crush some pieces of unripe apple with water. Filter it and treat the extract with Fehling's solution. Observe the change if any. Now repeat the experiment with ripe apple. Why does the colour change ? (Note : Fehling's test will give a yellow red precipitate if sugars are present in the extract).

POINTS TO REMEMBER

- Chloroplasts function as sites of photosynthetic activity.
- Light reaction takes place in the grana and dark reaction takes place in the Stroma of chloroplast. Synthesis of ATP in the chloroplast utilizing light energy is called Photophosphorylation.
- Cyclic Photophosphorylation involves only PS I.
- Non-cyclic Photophosphorylation involves PS I and PS II.
- Splitting of water molecules during light reaction is called photolysis.
- Dark reaction was discovered by Melvin Calvin.
- Ribulose – 1, 5 – Bisphosphate is the acceptor of atmospheric carbon di oxide.

2.3 TRANSPIRATION

Water is very essential for plant growth and development. A large quantity of water is absorbed by the plants from the soil for various metabolic activities. It is estimated that 98% of the water absorbed evaporates from the aerial parts of the plants and diffuses into the atmosphere.

Transpiration is defined as a process in which water is lost in the form of vapours through the aerial parts of a living plant body. Depending on the plant surface involved, transpiration is categorised into three types.

Cuticular transpiration – Transpiration taking place through the cuticle – outermost layer of stems, leaves is called cuticular transpiration. It accounts for 0.1% water loss.

Lenticular transpiration – Lenticels are small openings present in woody stems, twigs and fruits. Loss of water vapour through lenticels is called lenticular transpiration. It accounts for 1% water loss.

Stomatal transpiration – Stomata are minute pores present in the epidermis of leaves, young stems, etc. The loss of water vapour through stomata is called stomatal transpiration. About 93% of water loss takes place through the stomata only.

Adaptations of Xerophytes

Plants try to adapt themselves to the environment in which they live and conserve water. This is especially true of Xerophytes. These are plants found in dry habitats and adapt themselves to tolerate drought. For this they have many morphological and anatomical modifications.

Morphological Adaptations

- The root system is well branched in Xerophytes and roots penetrate to greater depths to absorb water for the plant.
- Plants like ***Casuarina*** have reduced leaves to decrease water loss by transpiration.
- In ***Opuntia*** the stem becomes flat and green to take up the function of the leaf and the leaves are reduced to spines. This modification is called **phylloclade**.

Anatomical Adaptations

- In ***Nerium*** the epidermis of stems and leaves is covered with a thick cuticle to reduce the rate of transpiration.
- Succulent xerophytes have well developed xylem tissues and also have fleshy parts to store water. e.g., ***Opuntia, Asparagus***.

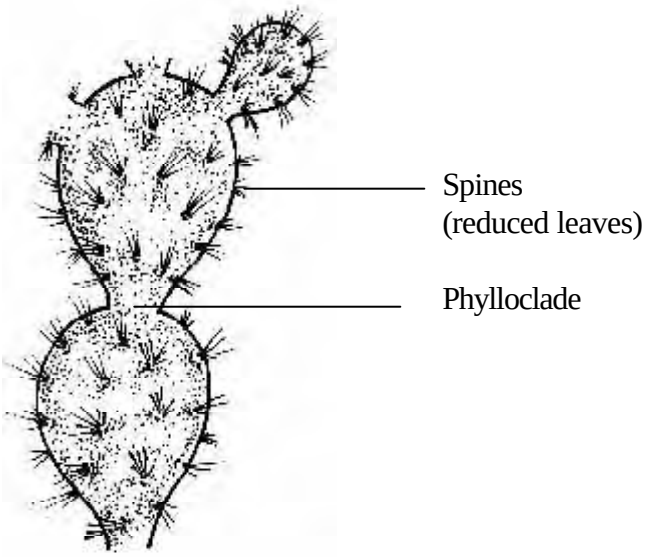


Fig. 2.9. Opuntia – succulent xerophyte

Mechanism of Stomatal Movement

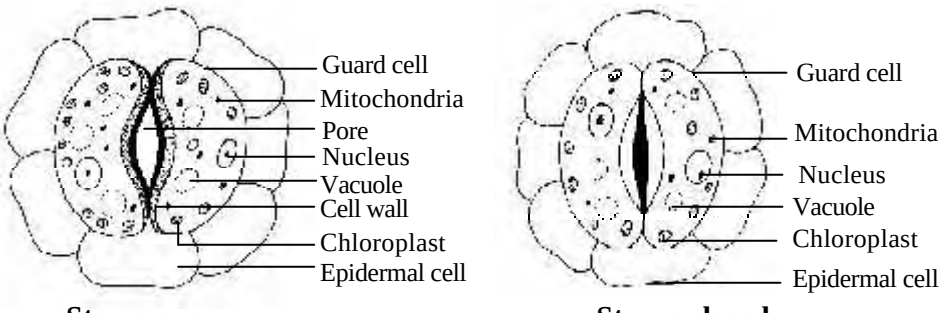
The stomata are tiny pores in the epidermis of leaves and other aerial parts of the plant. They are surrounded by two kidney shaped cells called guard cells. Each guard cell has an outer elastic wall and an inner thick wall. When the

guard cells are turgid (full of water), the outer walls are stretched and the stomata remains open. This happens during day time. At night the guard cells become flaccid by losing water to the surrounding cells. The inner walls come closer. This reduces the stomatal opening.

A number of theories have been put forth to explain mechanism of stomatal movement. The **Theory of active potassium transport by Levitt** is the most accepted one. This theory is explained as follows:

Opening of stomata during day time: In the presence of light the starch in the guard cells gets converted to organic acids like malic acid which dissociate into hydrogen and malate ions. The hydrogen ions leave the guard cells and enter the surrounding epidermal cells. In return the potassium ions from surrounding cells enter the guard cells by an active process. Potassium combines with malate to form potassium malate. This increases the osmotic concentration of guard cells and hence water enters into the guard cells. It becomes turgid and the stoma is kept open.

Closure of stomata during night time : The reverse process occurs at night. The starch formation does not occur at night. Hence potassium malate dissociates in the guard cells. Potassium ions move out to the neighbouring cells. The osmotic concentration of guard cells reduces and it loses water. Flaccid guard cells bring about closure of stomata.



Stoma open **Fig.2.10** **Stoma closed**

Distribution of Stomata: The number of stomata in a definite area varies among different species of plants. The number of stomata varies on the upper and lower side of the leaf. More number of stomata is distributed on the lower surface of leaf to reduce the rate of transpiration. In aquatic plants (submerged hydrophytes) stomata are vestigial or absent totally.

Significance of Transpiration:

Advantages

1. Transpiration pull is the main factor influencing the upward movement of water through xylem. Hence it contributes to ascent of sap.
2. The evaporation of water during transpiration is said to have a cooling effect on the leaves.

Disadvantages

1. Transpiration creates water deficit in the plant which results in wilting of plants. Persistent wilting can lead to death.
2. Higher rate of transpiration reduces the rate of growth. The metabolic activities of the plant are affected. Stunted growth is observed in plants if transpiration is very high.

Transpiration – A necessary evil

Water is of vital importance to the plant and yet large amounts of it are lost in transpiration. The leaf structure with mesophyll cells, intercellular spaces and the stomata facilitates exchange of gases for respiration and photosynthesis. This arrangement cannot hinder the evaporation of water from the mesophyll. Therefore transpiration is described as a necessary evil for the plant.

Anti-transpirants

In recent years efforts are focused on improving efficiency of water usage by plants. One of the methods to reduce transpiration is by the application of certain chemical substances. Anti-transpirants are those materials, which are applied to the plant for cutting down the rate of transpiration. It is also used for crop plants, which fetch good returns. Example of antitranspirants are phenyl mercuric acid, silicon oils, fungicides, absicic acid, etc. The antitranspirants bring about partial closure of stomata by forming a thin film over the transpiring surface.

ACTIVITY

Strip off thin peels from the upper and lower surface of a leaf (Ficus, Grass, Ocimum, Coccinia) using a forceps or nail polish. Mount the peel in water and examine under a microscope . Study the stomatal distribution on both the surfaces. You can also repeat this experiement with different leaves and compare the distribution.

POINTS TO REMEMBER

- Stomatal Transpiration accounts for maximum loss of water from the plant.
- The adaptation in Opuntia to reduce transpiration is called phyllociade.
- The Stomatal opening is controlled by guard cells.
- Transpiration is considered to be a necessary evil.
- Chemical substances used to reduce transpiration are called antitranspirants.

2.4 RESPIRATION

All living organisms require a continuous supply of energy for carrying out various functions of the body related to growth, development and movement. The energy requirement of the organism is fulfilled by respiration at the cellular level. Respiration is a process by which organic substances such as carbohydrates, proteins, fats (or) organic acids are degraded to release energy. It is a catabolic process.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + 2900 \text{ KJ energy}$$

It is essentially an energy releasing process.

Seat of respiration - Mitochondria

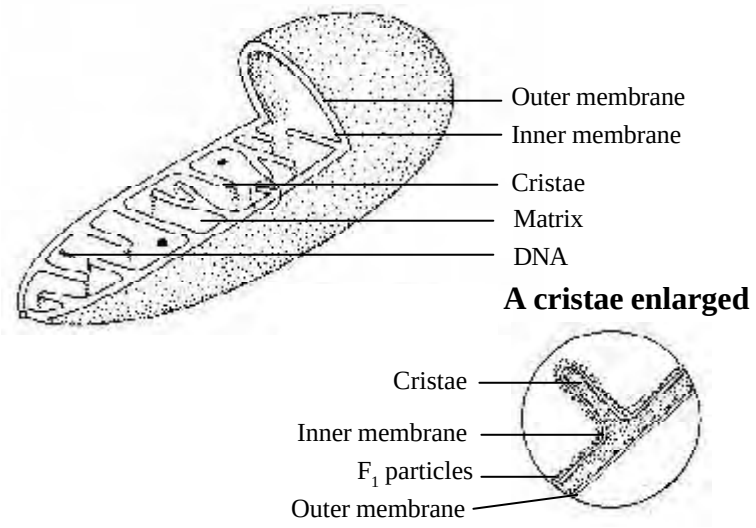


Fig.2.11 Ultra structure of a Mitochondrion

Mitochondria are small, spherical or rod shaped organelles present in the cytoplasm of eucaryotic cells. They are the sites of cellular respiration. Respiratory

substrate is oxidized and the energy is stored in mitochondria in the form of ATP. Hence they are also called as the powerhouse of the cell.

Each mitochondrion is 0.2 to 1.0 μm in diameter and 2 to 8 μm long. It consists of two membranes, outer and inner enclosing a matrix. The **outer membrane** is smooth but the **inner membrane** is subjected to finger like infolds called **cristae**. The cristae possesses knob like projections called **elementary particles** or F_1 or ETP (Electron Transport Particles). These are associated with ATP synthesis during oxidative phosphorylation. Mitochondria contain RNA and DNA also to carry on protein synthesis. Hence it is called **semi-genetic autonomous organelle**.

Adenosine Tri Phosphate(ATP)

The energy released during respiration is stored as ATP in the cells. ATP consists of a nitrogenous base Adenine, Ribose Sugar and three phosphate groups. Last two phosphate groups are attached by means of high-energy bonds. ATP is formed from ADP (Adenosine Di Phosphate) by an energy coupling mechanism called phosphorylation. ATP is hence called energy currency of the cell.

Types of Respiration

Based on the availability of oxygen, respiration is classified into two types.

Aerobic Respiration

The respiratory substrate is catabolised in the presence of oxygen with the liberation of carbon dioxide, water and a large amount of energy. This is the common type of respiration in higher organisms.

Anaerobic Respiration

Catabolism of the respiratory substrate in the absence of oxygen is termed anaerobic respiration. It is seen in lower organisms like bacteria and fungi.

Mechanism of Aerobic Respiration:

Aerobic breakdown of glucose involves 4 steps, Glycolysis, Oxidation of pyruvic acid, Krebs cycle and electron transport chain. The overall equation for aerobic respiration is written as follows.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + 2900 \text{ KJ cal energy}$$

Glycolysis

It involves several enzyme-mediated reactions by which a glucose molecule (6 carbon compound) is split into two molecules of pyruvic acid (3 carbon compound). Three German microbiologists **Embden, Meyerhof** and **parnas** discovered this pathway and hence it is called EMP pathway. It takes place in the cytoplasm of the cell and does not require oxygen. The net gain of energy rich molecules during this process is 2ATP and $2NADH_2$ molecules.

Oxidation of Pyruvic Acid

Pyruvic acid formed by glycolysis undergoes oxidative decarboxylation in the presence of an enzyme pyruvic dehydrogenase. Two molecules of pyruvic acid get reduced to two molecules of Acetyl CoA (2 carbon compound). Carbon dioxide is released as a by-product and 2 $NADH_2$ molecules are formed. This occurs in the mitochondrial matrix.

Kreb's Cycle or TCA Cycle (Tricarboxylic acid Cycle)

This cycle was elucidated by **Hans Krebs** (1935) for which he received a Noble Prize. This series of chemical reactions occur in the mitochondrial matrix. Acetyl CoA (2 carbon compound) combining with oxalo acetic acid (4 carbon compound) to form citric acid (6 carbon compound) triggers this reaction. This is followed by several enzyme catalyzed reactions. Complete breakdown of pyruvic acid takes place resulting in the production of carbon dioxide and water. Two molecules of Acetyl CoA entering Kreb's Cycle generate $6NADH_2$, 2ATP and $2FADH_2$ molecules.

Electron Transport Chain

Transfer of electrons and protons from $NADH_2$ and $FADH_2$ occur through the electron transport chain in the mitochondria. Molecular oxygen is the terminal acceptor of electrons and protons resulting in formation of water molecule. The energy loss during the transfer of electrons is coupled to the production of ATP. This is called **oxidative phosphorylation.** Three ATP molecules are formed when $NADH_2$ donates electrons to the electron transport chain and 2 ATP molecules are formed is $FADH_2$ is the electron donor.

Therefore in aerobic respiration, there is a stepwise breakdown of the substrate and also complete breakdown thereby ensuring higher proportion of energy being utilized in ATP synthesis.

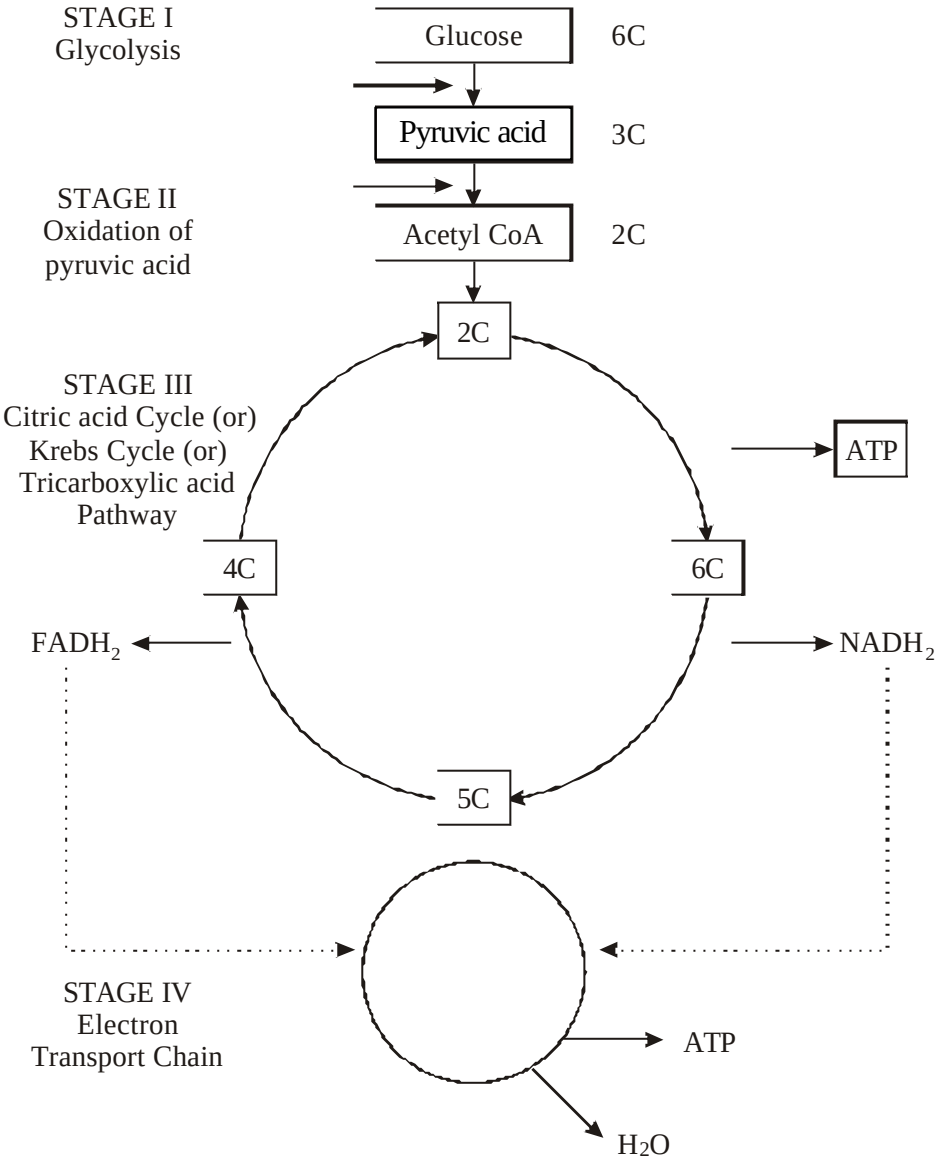


Fig. 2.12. Aerobic Respiration – schematic representation

Aerobic Breakdown of Glucose
Total gain of ATP

Stage	Source	No. Of ATP Molecules
Glycolysis	2 ATP	2
	$NADH_2$ (2 x 3 ATP)	6
Oxidation of Pyruvic Acid	2 $NADH_2$ (2 x 3 ATP)	6
Kreb's Cycle	6 $NADH_2$ (6 x 3 ATP)	18
	2 $FADH_2$ (2 x 2 ATP)	4
	2 ATP	2
		24

Thus one molecule of glucose yields energy equivalent to 38 ATP molecules by aerobic respiration.

Mechanism of Anaerobic Respiration

Pasteur (1860) discovered that *yeast* could respire in the absence of molecular oxygen. He was experimenting with *yeast* and explained alcoholic fermentation of glucose by the same. This process was called Anaerobic respiration. Anaerobic respiration can be defined as enzyme mediated partial breakdown of respiratory substrate without using oxygen. This results in the production of only a fraction of energy. It is commonly seen in bacteria, mould, roots of some waterlogged plants, etc. The term fermentation is applicable to anaerobic respiration since it takes place outside living cells by the extra-cellular enzymes produced by micro organisms.

Glycolysis is a common pathway for aerobic and anaerobic organisms. It involves breakdown of respiratory substrate into pyruvic acid. This is further anaerobically broken down to produce products like ethyl alcohol, lactic acid, acetic acid, etc. depending on the organism involved. The following equation represents the anaerobic breakdown of glucose by yeast.

$$C_6H_{12}O_6 \xrightarrow[\text{Zymase}]{\textit{Yeast}} 2C_2H_5OH + 2CO_2 + 50 \text{ K. Cal energy}$$

The enzyme **zymase** in yeast brings about fermentation resulting in production of ethyl alcohol and CO_2 from glucose. The net gain during anaerobic respiration is 2 molecules of ATP only. Anaerobic respiration yields much less energy than aerobic respiration because

1. There is incomplete breakdown of respiratory substrate.
2. Electron transport chain is not seen as in aerobic respiration. Hence $NADH_2$ cannot be reutilized for energy production.

Significance of Anaerobic Respiration :

1. Various types of wines can be prepared by alcoholic fermentation of sugar solution by yeast.
2. The fermentation activity of yeast finds application in baking & brewing Industry. (Refer economic importance of fungi)
3. Vinegar is obtained by fermentation activity of acetic acid bacteria.
4. It is used in clearing of hides in Tanning Industry.
5. Curing of tea and tobacco leaves is based on fermentation by bacterial species.

Fermentation is a basic principle in the field of Biotechnology with regard to manufacture of several products. On the other hand, it should be noted that fermentation by microbes could spoil food and cause food poisoning, stomach disorders, etc.

Differences between Aerobic and Anaerobic respiration

Aerobic Respiration	Anaerobic respiration
1. The organism makes use of oxygen for breaking the respiratory substrate	It breaks the substrate in the absence of oxygen.
2. Complete oxidation of substrate occurs.	There is incomplete breakdown of substrate.
3. It involves Glycolysis, Kreb's Cycle and Electron Transport chain	Glycolysis is followed by incomplete breakdown of pyruvic acid.
4. It takes place in cytoplasm and Mitochondria of the cell.	It occurs in the cytoplasm only.
5. It produces 2900 KJ (or) 686 K cal of energy per molecule of glucose	Only 50 K cal of energy is produced per molecule of glucose.
6. It takes place in higher organisms	It occurs in lower organisms like bacteria, yeast, etc.

Experiment to demonstrate Aerobic Respiration :

Some germinating seeds are taken in a conical flask. The flask is fitted with a cork. A delivery tube bent twice is fitted to the cork. The free end of the tube dips into a beaker of coloured water. A small test tube containing potassium hydroxide solution is suspended in the conical flask by means of a thread and the connections are made airtight.

It is observed that after sometime water rises in the tube. The germinating seeds respire aerobically utilizing the oxygen inside the conical flask. They liberate carbon dioxide, which is absorbed by the potassium hydroxide. This creates a partial vacuum in the flask. Therefore the level of water rises in the bent tube. This experiment proves that during aerobic respiration oxygen is taken in and carbon dioxide is liberated by living organisms.

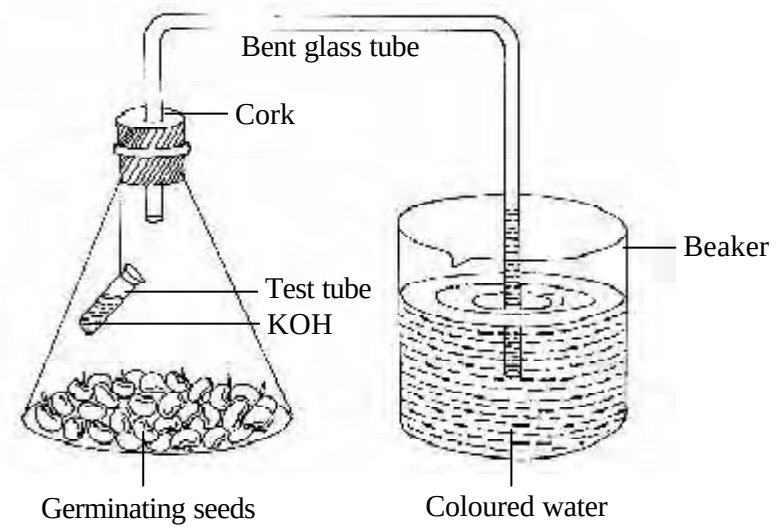


Fig. 2.13 Experiment to demonstrate Aerobic Respiration

Experiment to demonstrate Anaerobic Respiration(Fermentation)

A trough is filled with mercury. Some germinating seeds are taken and their seed coats are removed. They are taken in a small test tube which is then filled with mercury. The test tube is slowly inserted in the trough using the thumb. The experimental set up is kept undisturbed for a day. The level of mercury in the test tube comes down due to accumulation of a gas in the test tube. A few crystals of potassium hydroxide are introduced into the test tube. The gas is absorbed and the level of mercury in the test tube rises up. The seeds respired anaerobically since they could not absorb atmospheric oxygen due to presence of mercury.

Thus in anaerobic respiration, carbon dioxide is produced by living organisms / cells.

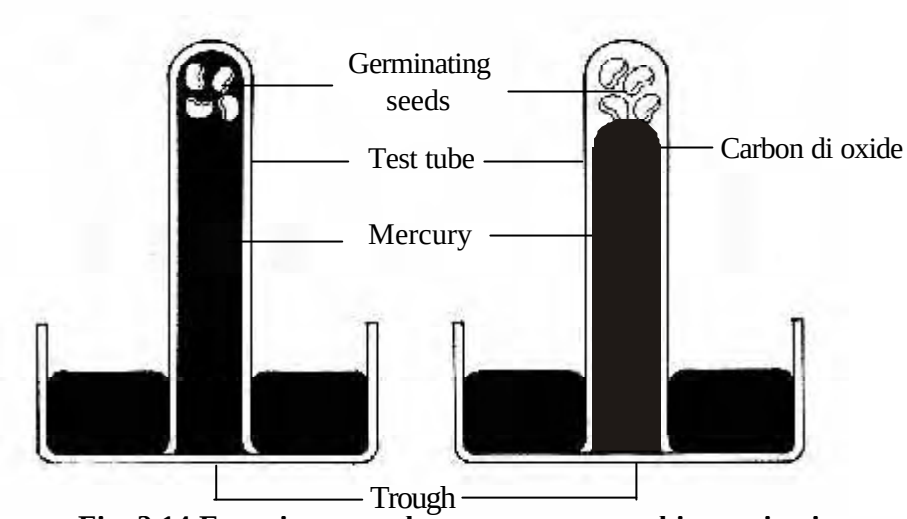


Fig. 2.14 Experiment to demonstrate anaerobic respiration

POINTS TO REMEMBER

- Mitochondria is the seat of cellular respiration.
- Energy is stored in the form of ATP in cells.
- Glycolysis is also called as EMP pathway.
- Formation of ATP during electron trasnsport chain is called oxidative phosphorylation.
- Anaerobic respiration is also called fermentation.

2.5 GROWTH AND PLANT HORMONES

Growth is a complex phenomenon. It is the result of many vital processes like cell division, cell elongation, cell differentiation and morphogenesis. Growth is defined as a permanent and irreversible increase in the size or volume of a living organism with an accompanied increase in dry weight. The growing tips of plant parts contain **meristematic tissues** where active growth occur. Meristematic cells are small, thin walled cells with dense cytoplasm. They are rich in food materials and are in an active state of cell division.

Meristematic tissues are classified into **apical meristems**, **intercalary meristems** and **lateral meristems**.The apical and intercalary meristems are responsible for increase in length of a plant body. Lateral meristems are responsible for the increase in the thickness of the plant in girth (width). Growth of a plant is

also influenced by environmental factors, biochemical and genetic factors, availability of water and minerals, etc. The most important are the biochemical factors which mediate through plant growth regulators.

Plant growth regulators

A German scientist **J. Sachs** (1882) was the first to suggest that some substances concerned with organ formation were synthesized in the leaves and translocated downwards. Later several substances influencing plant growth were discovered which are commonly called plant growth regulators. Plant growth regulators are defined as chemical substances synthesized in small quantity in one part of the plant and transported to the other sites where they produce specific physiological effects. Auxins, gibberellins, cytoxinins, ethylene and abscisic acid are the major plant growth substances.

Auxins

They are defined as organic compounds which at low concentrations induce elongation in shoot cells. It is found in abundance in meristematic regions like buds, growing tips of stem, leaves and roots.

Discovery of Auxins – Avena Curvature Test

Auxins were discovered by **Went** in 1928. He experimented with coleoptile tips of Avena (oats). Tips from the coleoptile were excised and placed on agar

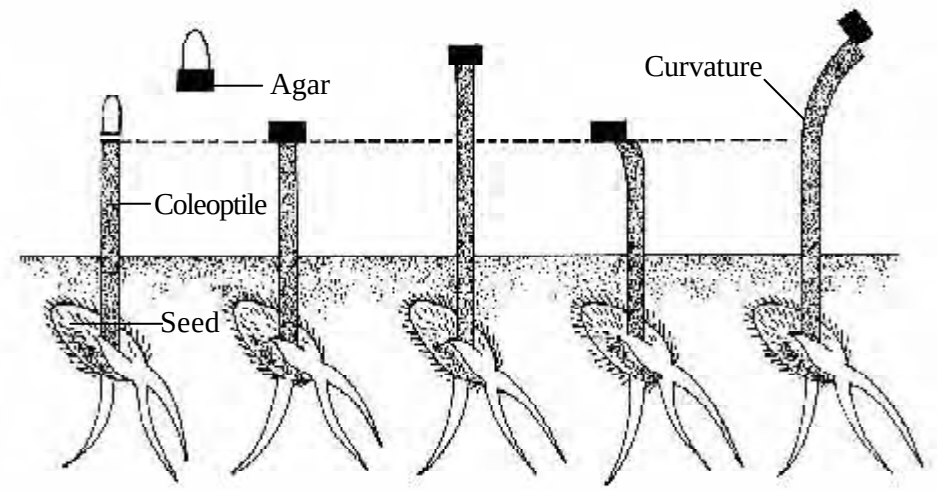


Fig. 2.15 Avena Curvature test

blocks. After four hours the agar blocks were placed on the decapitated coleoptiles. Normal elongation of the coleoptile was observed. He also found that placing the

agar block on one side of the coleoptile induced a corresponding curvature. This proved that the coeloptile tips were the source of some growth promoting substance which had diffused into the agar block. This substance was later analysed to be Indole – 3 – acetic acid (IAA). This is the natural auxin in higher plants. There are synthetic auxins like naphthalene acetic acid (NAA) which cause physiological responses similar to IAA.

Physiological role

1. Growth – Auxins play a major role in cell division and influences growth. It is therefore used in tissue culture experiments to produce a callus in combination with cytokinins.
2. Apical Dominance : Synthesis of Auxins in apical bud is responsible for apical dominance. The stunted growth of lateral buds when compared to apical buds is called apical dominance.
3. Inhibition of abscission : They prevent abscission of various organs of the plant. It is the process of separation of leaves, flowers and fruits from the plant. Auxins are used in horticulture to prevent fruit drop.
4. Parthenocarpy : The development of flowers into fruits without the act of fertilization is called parthenocarpy. Such fruits are called parthenocarpic fruits and are seedless. Auxins induce parthenocarpy in banana, grapes, etc.
5. Tropic movements : The bending response of shoots and roots to various stimuli are called tropic movements. Depending on the nature of stimuli tropic movements can be classified as phototropism (light induced) geotropism (induced by gravitational force), etc. Auxins are responsible for causing phototropic curvature in shoots.
6. Auxins are used in nurseries to induce adventitious roots from stem cuttings of rose, shoe flower, etc.

Gibberellins (GA)

The discovery of gibberellins was made by a Japanese plant pathologist **Kurusowa**. Some rice plants in the field were found to be abnormally tall. It was called '*foolish seedling disease,* or "bakane". Later it was found that these rice plants were infected with a fungus called *Gibberella fujikuroi.* It produced an active compound Gibberellin which caused the disease. Since then about 84 Gibberellins produced by different plants have been identified. They are known as GA_1, GA_2, GA_3 . . . . . GA_{84}. GA_3 is more common in all plants.

Physiological role

1. Elongation of dwarf plants : GA plays an important role in elongation of internodes in genetically dwarf plants. They are used to increase the length in plants like sugarcane.
2. Bolting : Sudden elongation of the stem followed by flowering is called Bolting. GA induces bolting in cabbage.
3. Parthenocarpy : They induce parthenocarpy resulting in the production of seedless fruits. E.g. pears and apples.
4. Break dormancy : GA helps the plants to overcome natural dormacy of buds, tubers etc. and stimulates them to grow.
5. Induce flowering : Certain biennials require low temperature for seed germination and flowering. Such plants can flower when treated with gibberellins. GA susbstitutes the low temperature requirement.

Cytokinins

The cytokinins are plant hormones which act primarily on cell division. They stimulate cytokinesis (division of cytoplasm during cell division). It was first isolated by **Miller** and his coworkers in USA. They are synthesized in meristematic regions of the plant. Liquid endosperm of coconut is a rich source of cytokinins.The chemical name of cytokinin is 6 furfuryl amino purine. They are different types of cytokinin. They are kinetin, benzyl adenine, zeatin, etc.

Physiological role

1. Cell division: It enhances cell division. It is used in tissue culture experiments to induce callus formation in combination with auxins.
2. Cell enlargement: Cytokinins stimulate enlargement of cells particularly in leaf discs and cotyledons.
3. Stimulation of lateral buds: Use of cytokinins helps to overcome apical dominance and induces growth of lateral buds.
4. Delay of Senescence: Senescence is a phenomenon in which mature leaves lose chloroplast, turn yellow and are ultimately shed from the plants. Cytokinins can delay senescence in plants.
5. It enhances chlorophyll synthesis and makes the leaf green.

Ethylene

Ethylene is a volatile plant growth regulator and was discovered in 1934. Scientists identified it to be a potential gas to promote ripening of fruits. It is synthesized in ripening fruits, flowers, leaves and acts as a natural plant growth hormone.

Physiological role

1. It has been established as the fruit ripening hormone. It stimulates all biochemical changes to promote fruit ripening.
2. Ethylene accelerates leaf abscission and senescence
3. Ethylene inhibts flowering.
4. It promotes apical dominance and inhibits growth of lateral buds.
5. Ethylene is responsible for breaking dormacy of buds and seeds.

Abscisic Acid (ABA)

It is a plant growth regulator produced by the mature leaves of plants. It functions as a general growth inhibitor.

Physiological Role

1. It causes closure of stomata by controlling movement of potassium ions in the guard cells.
2. It is responsible for dormancy of buds and inhibits seed germination.
3. It promotes senescence of leaves by causing loss of chlorophyll pigment and decreasing the rate of photosynthesis.
4. It controls geotropic responses of roots.
5. ABA is synthesized more during stress and adverse environmental conditions. It helps the plant to manage stress. Hence it is called stress hormone.

Measurement of Growth – Lever Auxanometer

The growth in length of plants can be measured by an instrument called Lever or Arc Auxanometer. The instrument consists of arc scale mounted on a vertical stand. A long pointer is attached to a pulley and moves on the arc scale. A silken thread is passed over the pulley with one end of the thread attached to the tip of the plant. The other end of the thread carries a weight, sufficient to keep the

thread stretched. As the plant grows the pulley moves and the pointer moves on the scale correspondingly. Readings are taken at definite intervals. The distance covered by the pointer is the measurement of increase in length of the point.

$$\text{Growth of the plant in length} = \frac{\text{Distance travelled by pointer x Radius of Pulley}}{\text{Length of pointer}}$$

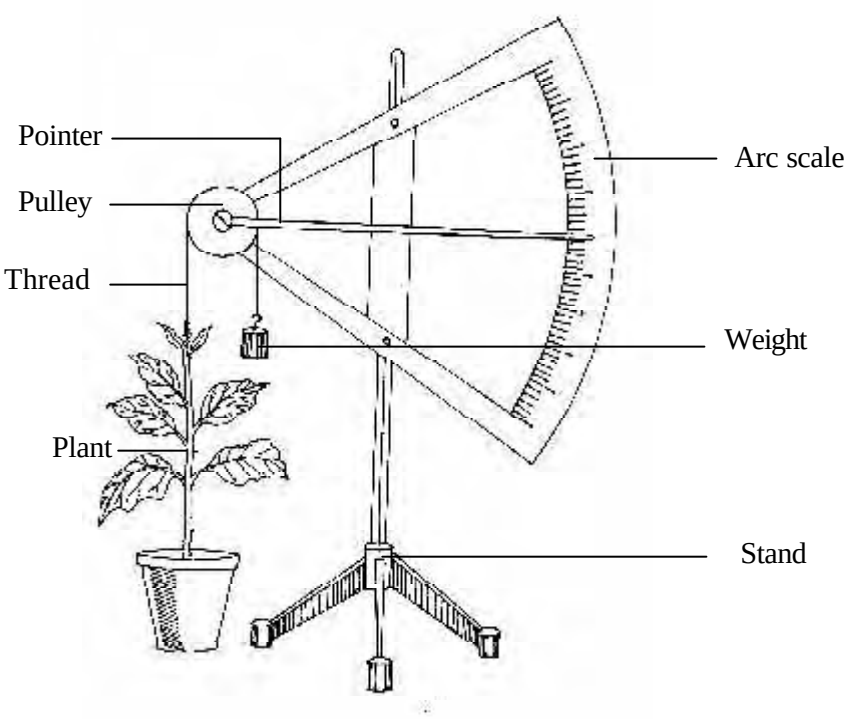


Fig. 2.16 Lever Auxanometer

POINTS TO REMEMBER

- The growing tips of plants contain meristematic tissues.
- Auxins were discovered by Went.
- Auxins are responsible for apical dominance.
- Gibberellins causes bolting in plants.
- Ethylene is a fruit ripening hormone.
- Abscicic acid functions as a general growth inhibitor.

SELF EVALUATION

I. Choose and write the correct answer:

1. Ascent of sap takes place through _____.
   a) Xylem fibres b) Cortical cells c) Root hairs d) Xylem vessels
2. Death of tissues is called _____.
   a) Mottling b) Chlorosis c) Necrosis d) Wilting
3. RUBP contains _____ carbon atoms.
   a) 4 b) 5 c) 6 d) 8
4. EMP pathway occurs in the _____ of the cell.
   a) Mitochondria b) Chloroplast c) Cytoplasm d) Ribosome
5. The concept of two pigment systems was proposed by _____.
   a) Arnon b) Hill c) Calvin d) Emerson.

II. Fill in the blanks with suitable terms:

1. _____ is the area of water absorption in a root.
2. _____ is a mineral which is an integral part of middle lamella.
3. Light reaction occurs in _____ of chloroplast.
4. Fixation of carbon is brought about by an enzyme called_____.
5. _____ is an example of an antitranspirant.
6. _____ is called fruit ripening hormone.

III. Answer the following questions in one or two sentences:

1. Define ascent of sap.
2. Explain the term ‘water potential’.
3. What is root pressure?
4. What are biofertilizers?
5. What is imbibition?
6. What is a nutrient?
7. What are lenticels?
8. Write the significance of photosynthesis.
9. Define photolysis of water.
10. Mention two differences between aerobic and anaerobic respiration.
11. What is ATP?
12. Mention the significance of anaerobic respiration.
13. What is ABA?
14. Define abscission.

IV. Write short answers for each of the following questions in 100 words:
(Draw diagrams wherever necessary).

1. Describe an experiment to prove osmosis.
2. Explain the physiological role of mineral elements.
3. Draw a neat labelled diagram of ultra structure of chloroplast.
4. What are the adaptations seen in xerophytes to minimize transpiration?
5. Describe the ultra structure of Mitochondria.
6. Draw a schematic representation of aerobic respiration.
7. Describe an experiment to measure the growth of a plant.
8. Describe an experiment to demonstrate anaerobic respiration.

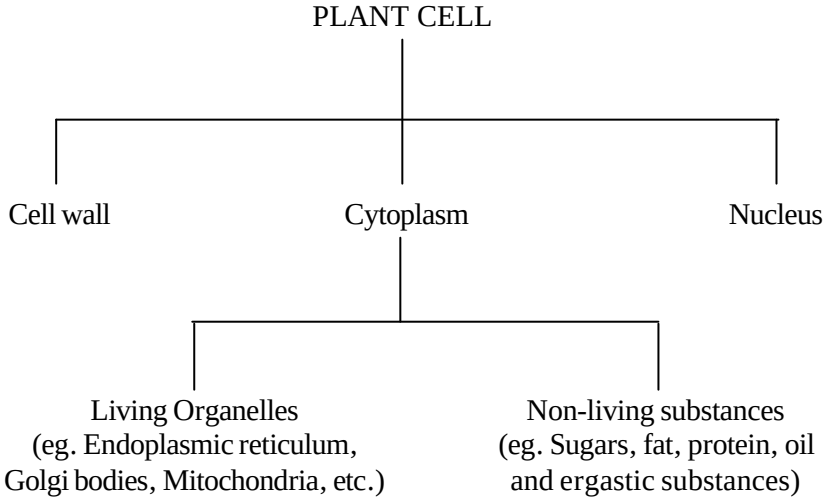
V. Write detailed answers for each of the following questions in 200words:
(Draw diagrams wherever necessary).

1. Write a note on photo phosphorylation.
2. Explain mechanism of aerobic respiration.
3. What are phytohormones? Write a note on Auxins.

UNIT 3

CELL BIOLOGY

The cell is the basic unit of structure, function and heredity. The term "CELL" was coined by **Robert Hooke** (1665) and he first observed it under his primitive microscope in the form of honey comb like structure from a piece of cork. **Schleiden** and **Theodor Schwann** propounded the cell theory in 1839. It states that all the living organisms are made up of cells, each cell is made up of cytoplasm and a nucleus with or without cell wall. A cell can originate from the pre-existing cells by the process of cell division. The science that deals with the structure and function of a cell is called as **Cell Biology** or **Cytology**. A typical plant cell consists of the following parts.



Due to the invention of electron microscope, the advanced study of cell has become possible. In prokaryotes true nucleus is absent but it contains nuclear material DNA or RNA e.g., Bacteria and Blue green algae. In eukaryotes, true nucleus controls all the metabolic activities and hereditary characters. Nucleus is an essential body of a cell and has the following parts, namely nuclear membrane, nucleoplasm, chromatin reticulum and nucleolus. e.g., all higher plants.

3.1 CHROMOSOMES AND GENES

The cells of higher plants have true nucleus. Hence they are called Eukaryotic cells. The nucleus is a spherical cellular component. The chromosomes are specialized filamentous nuclear material. They are the primary seat of genetic information of the cells. Inside the nucleoplasm are the filamentous thread like structures called chromatin reticulum or network.

> The rod like chromosomes in the nuclei of plant cell were first observed by **Karl Nagli** (1842). **W. Flemming** (1879) introduced the term "Chromatin". It is of two types namely heterochromatin and euchromatin. Heterochromatin contains small amount of DNA and large amount of RNA, whereas the euchromatin contains large amount of DNA. **Benden** and **Bovery** (1902) reported that the number of chromosomes for each species is constant. The present name chromosome (Greek: Chrom = colour, soma = body) was coined by **W.Waldeyer** (1888). In 1933, **Morgan** discovered hereditary functions of chromosomes.

STRUCTURE OF A TYPICAL CHROMOSOME

Size of Chromosome: The size of chromosome is ranging from 0.25 µm (fungi) – 30 µm (Trillium). The plant chromosomes are generally larger than animal chromosomes. The monocotyledon plants contain larger sized chromosomes than the dicotyledons. The largest chromosomes are lampbrush chromosomes (Oocytes of vertebrates) and Polytene chromosomes (salivary gland cells of dipteran insects).

Shape of Chromosome: During the time of cell division, the shapes of chromosomes change in their structure. In cell cycle, during the interphase chromosomes appear in the form of thin, coiled, filamentous, elastic, contractile stainable structures which are called chromonemata. The folded structures in the chromonemata are called chromomeres.

Structure of Chromosome: Each chromosome consists of two symmetrical structures called **chromatids**. The chromatids are joined at a particular point called **centromere** or **kinetochore**. It is visible during mitotic metaphase. The centromere divides the chromosomes into two parts. Each part is called chromosome arm. The centromere lies within a thinner region of the chromosome called the **primary constriction**. This region contains specific DNA sequences. It gives disc-like appearance. The chromosomal ends are known as **telomeres**. It is the terminal part of the chromosomes. Sometimes the chromosomes have a

round or knob like appendages called satellites. They are separated from the rest of the chromosomes by a **secondary constriction.** The chromosomes with the satellite are called **as Sat-chromosomes**. The size and shape of the satellite remain constant. The secondary constriction can be distinguished from primary constriction by the presence of chromosomal bends only at the position of centromere. It contains RNA for helping the attachment of genetic code.

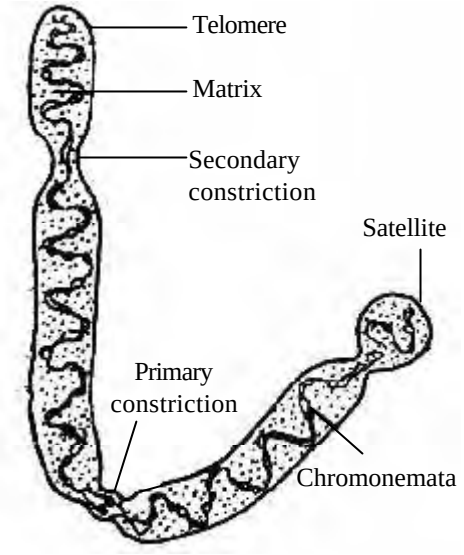


Fig. 3.1 Structure of chromosome

GENES

Genes are located on the chromosomes in a linear fashion. A gene is a segment of DNA that can code for a specific protein. Genes are made of nucleic acids. They are two types namely DNA and RNA. DNA is the genetic material of most of the plants and animals. RNA is the genetic material of some viruses.

3.2 TYPES OF CHROMOSOMES

In Eukaryotes, the chromosomes are classified on the basis of function into two types.

1. Autosomes: These are somatic chromosomes controlling body characters. Human beings have 22 pairs of autosomes.
2. Allosomes: These are sex chromosomes. They involve in sex determination. In human beings, male has XY and female XX chromosomes.

Based on the position of centromere the chromosomes are classified into four types.

1. Telocentric: The rod-like chromosomes are having centromere at one end.
2. Acrocentric: The centromere is placed near one end, thus forming a very short arm and a long arm.

3. Sub-metracentric: The centromere occurs near the center or at the medium portion of the chromosome. It has 'J' or 'L' shaped structure.
4. Metacentric: They are 'V' shaped. The centromere occurs in the center forming two equal arms.

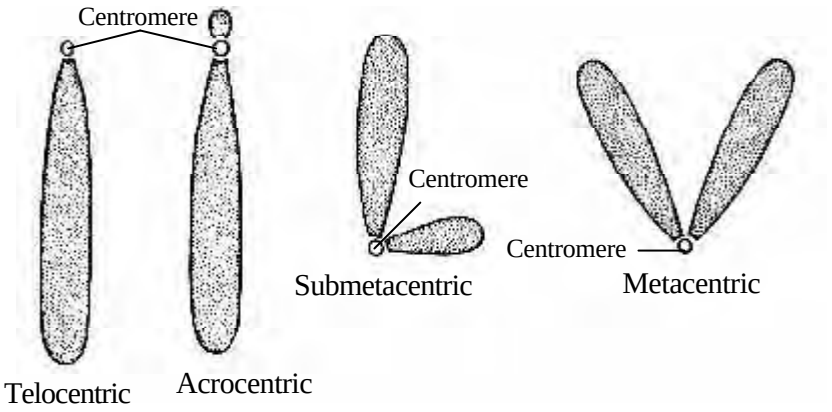


Fig 3.2 Four types of Chromosomes

Based the number of centromeres, chromosomes are classified into following types.

1. Monocentric: Most organisms contain only one centromere.
2. Dicentric: They have two centromeres.
3. Holocentric: Some species have diffuse centromeres, attached along the length of chromosome.
4. Acentric: These chromosomes are without centromere. Acentric and Dicentric are seen in chromosomal aberrations and are unstable.

The number of chromosome in a given species is constant. The number varies greatly from one species to another. The highest chromosome number exceeds 1000 as in some species of ***Ophioglossum*** (Pteridophyte).

Special types of chromosomes are of two types:

i. Polytene chromosomes ii. Lamp brush chromosomes

(i) Polytene Chromosome

It was first observed by **E.G. Balbiani** in 1881 in salivary gland cells of Dipteran larvae. They reveal a distinct pattern of transverse banding (dark and light).

The polytene chromosomes are visible during interphase and prophase of mitosis. Polytene chromosomes have Balbiani rings or chromosome puffs.

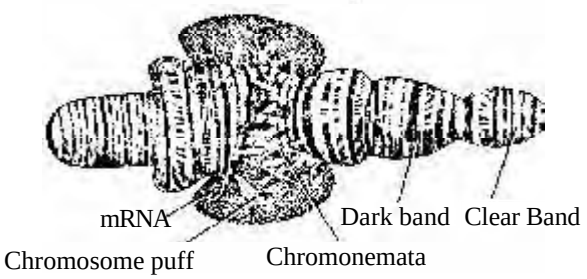


Fig 3.3 Polytene Chromosomes

(ii) Lamp Brush Chromosomes

It was first observed in animals Oocytes by **Flemming** 1882. This chromosome was described by **R. Ruckert** in 1892. It is also found in giant nucleus of an alga, ***Acetabularia***. They are characterized by enormous length and appearance of radiating hairs or side loops. It occurs as bivalents in diplotene stage of meiotic prophase in the primary Oocytes of all animal species (both vertebrates and invertebrates).

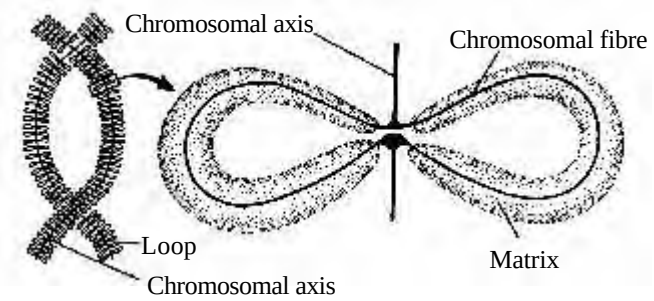


Fig 3.4 Lamb Brush Chromosomes

Karyotypes

All the members of a species are characterized by a set of chromosomes. Similar pairs of chromosomes are called as homologous chromosomes. If they are different pairs, they are called as heterologous chromosomes. The term Karyotype explains the different characteristics such as number, size, position of the centromere, length, secondary constrictions and satellites of the chromosomes. A diagrammatic representation of a karyotype (morphological characters of the chromosomes) of a species is called **idiogram**.

3.3 GENE AND GENOME

DNA is the most important genetic material which maintains the heredity characters. A segment of DNA in which genetic codes are encoded is called the gene. The term gene was coined by **W. Johannsen** in 1909. Genes are present on the chromosome at specific sites or loci (= locus).

The functional unit of a gene is called **Cistron**, the unit of recombination is called **Recon**, and the unit of mutation is called **Muton**. Usually a portion of DNA specifying a single polypeptide chain is termed as cistron. Each gene is responsible for the formation of Polypeptide chain (Protein).

GENE ACTION

DNA $\rightarrow$ m-RNA $\rightarrow$ Sequence of Amino Acids (Structure of Enzymes)

Since the structure of these enzymes is controlled by the genes, it shows that the genes determine the traits.

GENOME

A haploid set of chromosome is called genome (i.e) number of chromosomes in a gamete. The genome size of an individual is expressed in terms of number of base pairs found in its DNA. e.g., If pollen grains (microspore) of a pea plant has 7 chromosomes and the stem, leaf and root cells have 14 chromosomes its genome will be 7 for pea plant.

Eukaryotes have larger amounts of DNA than Prokaryotes. In *Escherichia coli* 3.4×10^6 base pairs are seen in its haploid genome. The presence of repetitive DNA sequences are seen in eukaryotic genome.

The diploid number of chromosomes for some of the most common plants is listed below.

Botanical Name of Plant	No. of Diploid Chromosome	Common Name
Allium cepa	16	Onion
Brassica juncea	36	Mustard
Cajanus cajan	22	Red gram
Capsicum annuum	24	Capsicum
Cocos nucifera	32	Coconut
Pisum sativum	14	Garden pea
Oryza sativa	24	Paddy

3.4 STRUCTURE OF DNA AND RNA

Deoxyribonucleic Acid (DNA) and Ribonucleic Acid (RNA) are the main genetic materials of living organisms. They are chemically called the nucleic acids. **Friedrich Miescher** discovered the DNA in 1869. The term nucleic acid was coined by **Richard Altmann** in 1889. Nucleic acids are responsible for the synthesis of proteins and transmission of hereditary characters.

Composition and structure of Nucleic acids:

The nucleic acids consist of nucleotides. Each nucleotide consists of a purine or pyrimidine base linked to pentose sugar which in turn is attached to phosphoric acid.

Thus, **Nucleotide = Nitrogenous base + sugar + phosphate**

WATSON AND CRICK MODEL OF DNA

In 1953, **S. James Watson** and **F.H.Crick** proposed a model of double helix structure of DNA molecule for which they were awarded noble prize. Though DNA is more concentrated in the chromosomes, they also occur in mitochondria and chloroplasts.

DNA is composed of double helical chains. The two strands are antiparallel i.e their 3'-5' phospho diester links are in opposite directions.

S = Sugar-Deoxyribose, A = Adenine,
T = Thymine, C = Cytosine,
G = Guanine, P = Phosphate

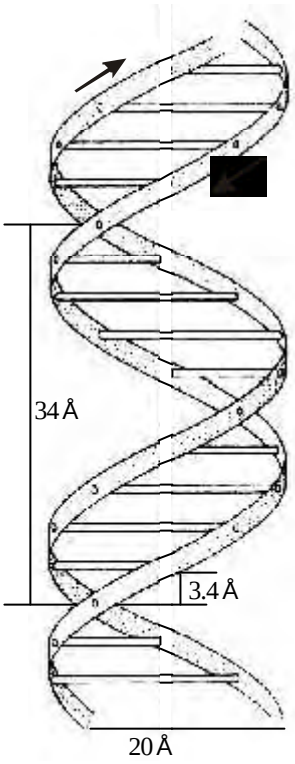


Fig 3.5
Double helix structure of DNA

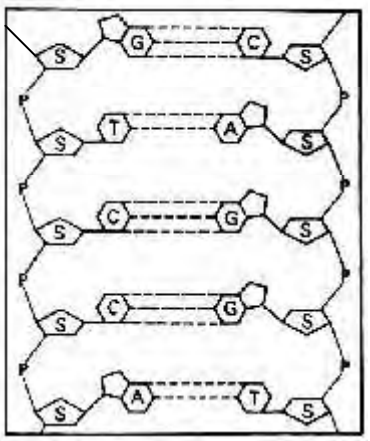


Fig 3.6 Chemical composition of DNA molecule

The two strands are held together by hydrogen bonds established between the pairs of bases. Two hydrogen bonds are formed between A and T (A = T), three hydrogen bonds are formed between G and C (G≡ C)

The distance between the nucleotides along one chain is 34Å. Further, one full turn of the double helix is completed in 3.4Å, i.e. 10 nucleotides are present in turn of one helix. The diameter of the helix is 20Å.

STRUCTURE OF RNA

Ribonucleic acid (RNA) is a single stranded polynucleotide. It contains ribose sugar. The purines and pyrimidines in the RNA are almost similar to that of DNA except that in the place of thymine, Uracil is found. RNA serves as a genetic material in some viruses.

Cells contain three major functional types of RNA. They are ribosomal RNA (r-RNA), messenger RNA (m-RNA) and transfer RNA (t-RNA) or Soluble RNA (S-RNA). They are found inside the nucleus and in the cytoplasm. All the three types of RNAs along with the DNA play an important role in protein synthesis.

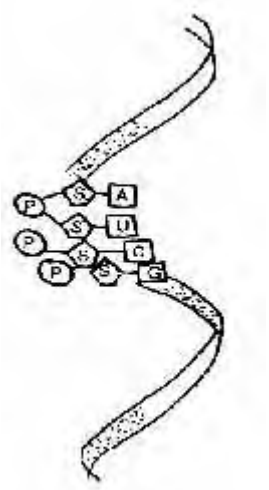


Fig 3.7
Structure of RNA

Difference between DNA and RNA

DNA	RNA
DNA is the genetic material for most of the organisms.	RNA is the genetic material of some viruses.
Usually DNA is double stranded (except in some viruses).	Usually RNA is single stranded.
It has 5 carbon-sugar-deoxyribose.	It has 5-carbon sugar-Ribose.
The common bases are Adenine, Guanine, Cytosine and Thymine.	The common bases are Adenine, Guanine, Cytosine and Uracil.
Pairing of bases occurs throughout the length of the molecule.	Pairing of bases is only in the helical region.
There is only one type of DNA.	There are three types of RNA (m-RNA, t-RNA and r-RNA)
DNA on replication forms DNA.	RNA usually does not replicate.
The main function is transfer of information from parent to offspring.	The main function is protein synthesis.

3.5 DNA – REPLICATION

DNA is capable of duplicating another strand of DNA. It is due to the synthesis of new strand. This process, by which new DNA is formed, is known as the replication or duplication. Duplication takes place during cell division. It occurs only after the synthesis of DNA. Synthesis of DNA usually takes place in the interphase of cell division.

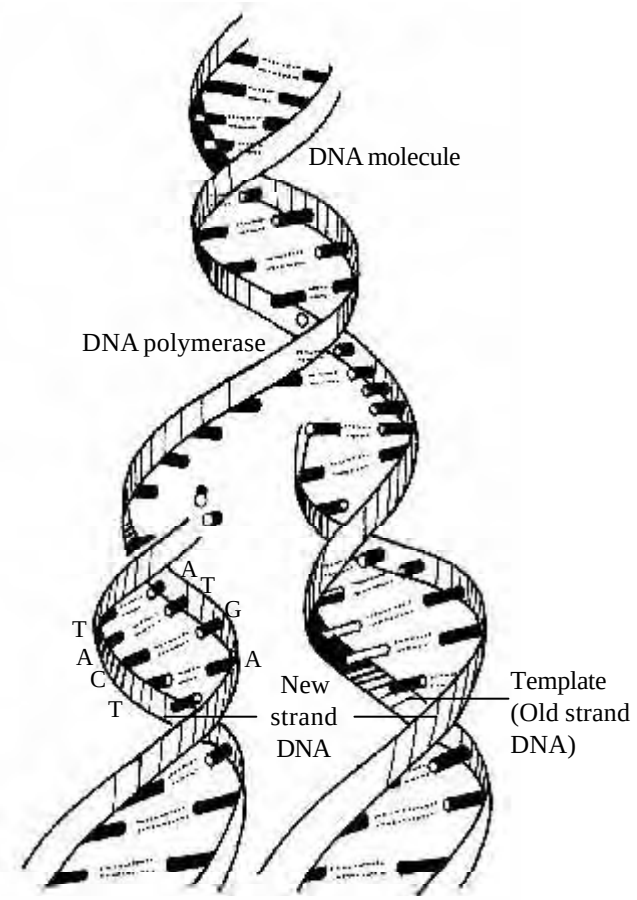


Fig 3.8 Semi-conservative method of replication of DNA molecule

MECHANISM OF DNA SYNTHESIS

The two strands of the double helix of DNA get separated or unwound gradually. Each polynucleotide strand acts as a template (or) mould for the new poly nucleotide chain. Each nucleotide of the old chain picks up its complementary nucleotide from the nucleoplasm. These nucleotides which form the new chain, are linked together by the enzyme called DNA polymerase. In this manner the new chain is exactly the complementary to the old chain, but similar to the other half of the original DNA strand. Thus at the end of replication two double helix strands of DNA are produced.

DNA plays a key role in the maintenance of the "living world". It acts as a carrier of genetic information from one generation to the next generation. **Watson & Crick** suggested this type of self-duplication of DNA molecules as **Semi-conservative type**.

> This semi conservative method was proved by **Matthew Meselson** and **Stahl** (1958) who used heavy isotope of nitrogen precursors in *Escherichia coli* cells to prove this method.

There are three kinds of nuclear enzymes that act on DNA, namely nucleases, polymerases and ligases. The nuclease enzymes act to break down a polynucleotide chain into its component nucleotides. A polymerase enzyme (replicase enzyme) helps in the formation of a polynucleotide chain i.e. copy of another. DNA ligases help in the joining of the new strands of DNA which are usually formed in discontinuous strands.

3.6 GENETIC CODE AND ITS SIGNIFICANCE

We know that DNA is the genetic material. It carries the genetic informations from cell to cell and from generation to generation. It has been discovered that the four bases (A,C,T,G) of DNA molecule keep the message for protein synthesis in a coded form which is called as **Genetic code**, but actually the genetic code is "a code for aminoacid".

There are twenty different aminoacids which are arranged in different sequences to form a polypeptide chain. A polypeptide chain contains a total number of about 100 to 300 aminoacids. **Three Nucleotides code for one aminoacid.**

If a relation is assumed to be a combination of two bases ($(4^2) = 16$) for each aminoacid sixteen combinations are possible. If there are three bases for a 'code' $(4^3) = 64$ combinations are possible. In 1954 **George Gomow** proposed the triplet code for the first time. Thus a **codon** may be described as hereditary unit that contains the information coding for one aminoacid, consisting of three nucleotides triplet code (a triplet). For example UUU – codes for Phenyl alanine.

The Genetic Code

1st Base	2nd Base								3rd Base
	U		C		A		G		
U	UUU	Phe	UCU	Ser	UAU	Tyr	UGU	Cys	U
	UUC	Phe	UCC	Ser	UAC	Tyr	UGC	Cys	C
	UUA	Leu	UCA	Ser	UAA	Term*	UGA	Term*	A
	UUG	Leu	UCG	Ser	UAG	Term*	UGG	Trp	G
C	CUU	Leu	CCU	Pro	CAU	His	CGU	Arg	U
	CUC	Leu	CCC	Pro	CAC	His	CGC	Arg	C
	CUA	Leu	CCA	Pro	CAA	Gln	CGA	Arg	A
	CUG	Leu	CCG	Pro	CAG	Gln	CGG	Arg	G
A	AUU	Ileu	ACU	Thr	AAU	Asn	AGU	Ser	U
	AUC	Ileu	ACC	Thr	AAC	Asn	AGC	Ser	C
	AUA	Ileu	ACA	Thr	AAA	Lys	AGA	Arg	A
	AUG	Met	ACG	Thr	AAG	Lys	ACG	Arg	G
G	GUU	Val	GCU	Ala	GAU	Asp	GGU	Gly	U
	GUC	Val	GCC	Ala	GAC	Asp	GGC	Gly	C
	GUA	Val	GCA	Ala	GAA	Glu	GGA	Gly	A
	GUG	Val	GCG	Ala	GAG	Glu	GGG	Gly	G

Fig 3.9 The genetic dictionary - Triplet code

Protein synthesis, the central dogma is shown below

DNA is the primary genetic material and that DNA controls the sequence of aminoacids in a protein but DNA itself is not the direct template that orders aminoacid sequences. Along with DNA, mRNA, rRNA and tRNA help in protein synthesis. Proteins which are produced are of two types. They are structural and functional proteins. Structual proteins help in the formation of organs and functional proteins are enzymes which help in the metabolic activities.

3.7 MUTATION

Sudden heritable changes in organisms are defined as mutations. The term mutation was first used by **Hugo de Vries** (1901) who observed it in *Oenothera lamarckiana*.

Hugo de Vries (1848-1935) of Netherlands was born in Haarlem in February 16, 1848 in Holland. He was a professor of Plant Physiology at the University of Amsterdam in 1881. He has observed mutation in *Oenothera lamarckiana* (Evening Primrose) and proposed the mutation theory. Hence he is called as the Father of Mutation.

T.G. Dobzhansky studied the (variation) mutation in **Population Genetics**. **T.H. Morgan** (1910) began his genetical work with the fruitfly *Drosophila melanogaster*. He was an American Zoologist, and he was awarded with Nobel Prize for his research work on mutations.

According to modern concept, the mutation is considered to be a sudden change in the genotype. Small mutations are called as **micromutations** and large mutations as **macromutations**.

Mutations may occur accidentally in nature or they may be induced by artificial methods. The results of mutations may be observed only in the phenotype or both phenotype and genotype. The mutation may be useful or harmful or neutral. Useful mutations may help the plant and animals in developing resistance to certain diseases. The induced mutations play a major role in plant breeding, where the attempts are being made to produce disease resistant varieties and varieties which can give better yield.

Geneticists have classified mutations in different ways based on different factors.

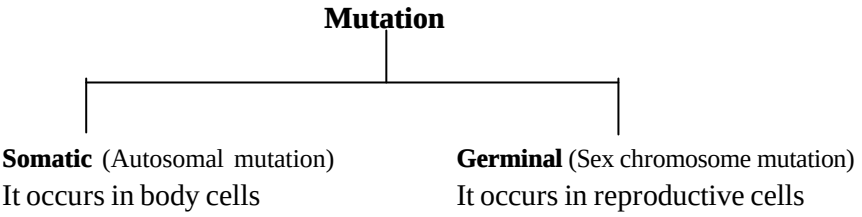
I Based on origin

Mutation

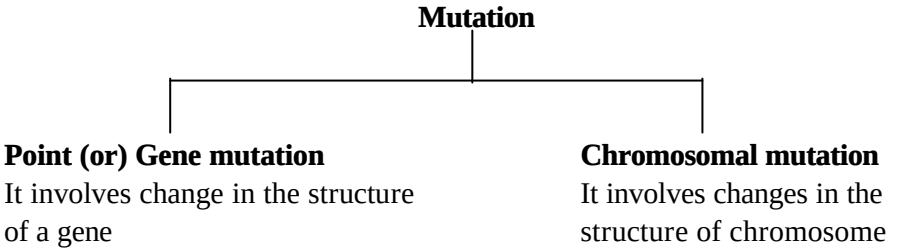
Spontaneous mutation
It occurs naturally
eg. expsoure to U-V rays
They are random and infrequent.

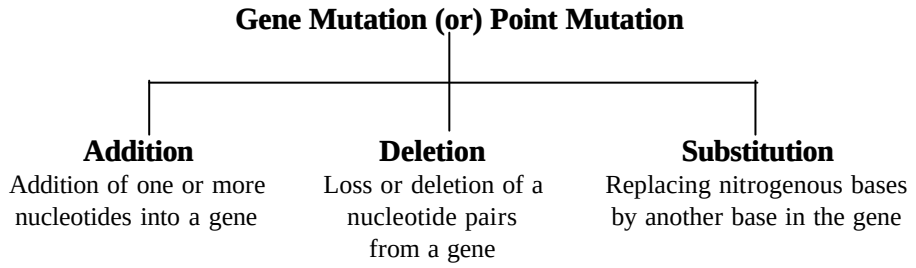
Induced mutation
It is induced by using mutagenic agents. e.g. Physical mutagens like U-V rays, high temperature
Chemical mutagens like phenol, caffine, mustard gas, nitrous acid.

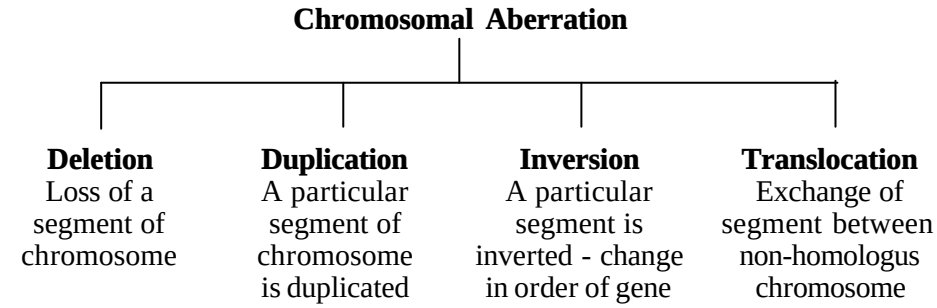
II. Based on the cells affected



III. Based on its effects







IV. Some other types of mutation

Mutation can be useful or harmful. Some of the harmful mutation may result in the death of the organisms. This type of mutation is called **Lethal Mutation**. If changes occur in the shape, colour and size of the organisms, it is known as **morphological mutation**.

Significance of Mutation

- Mutation may play an important role in the production of new species. They form the source of origin of new genes and thus, mutations act as a tool for evolution.
- The study of mutant strains of viruses helps us to know the fine structure of the genes.
- Beneficial mutations are used in modern agriculture (Polyploidy in many plants) and the industrial fermentation process.
- Through the mutation techniques, new varieties with desirable qualities have been developed. e.g. Sharbati sonora in wheat and Barley varieties, etc.
- In India, centres for inducing mutation breeding are established in the Gamma garden of Bose Research Institute, Kolkata and Indian Agricultural Research Institute (IARI), New Delhi to produce new varieties.
- Mutant strains a re produced from *Penicilliium* fungus to increase the yield of Penicillin.

3.8 GENETIC ENGINEERING, BIO-TECHNOLOGY & CLONING

Genetic Engineering is the modification of the genetic information of living organisms by manipulation of DNA. Adding, removing or repairing part of genetic material, (DNA) and changing the phenotype of an organism is called **Genetic Engineering.** It is also known as gene manipulation or recombinant DNA technology (r-DNA technology).

Recent advances made in genetics, molecular biology and bio-chemistry have resulted in the origin of new branch of science. The benefits derived through genetic engineering include:

a. To understand the gene structure and function through basic research.

b. Production of large quantities of insulin, interferon (antiviral protein produced by virus infected cells) human growth hormones, proteins (polypeptides) and vaccine for foot and mouth disease of cattle, etc.

c. This technique is also employed in the transfer of genes involved in nitrogen fixation (Nif-genes). This will help the cultivator to increase the productivity.

Basic techniques in Genetic Engineering

Genetic engineering has developed after the discovery of two enzymes. The enzymes which can cut DNA in to fragments, and enzymes which can join such fragments. Restriction Enzymes or Restriction endonucleases are molecular scissors which cut DNA at specific sites. DNA ligase is the paste enzyme which helps to join the broken DNA fragments.

Steps involved in genetic Engineering

The donor DNA coding for desirable character (insulin gene, nif gene) is selected, isolated and cut into fragments by using enzyme (restriction endonuclease).

The donor desirable DNA is integrated into plasmid DNA of bacterium, which acts as a vector.

The term vector DNA refers to carrier or cloning vehicles. The extra circular chrom-osomal DNA found in cytoplasm of E.coli is called **plasmid.**

Using DNA ligase, the donor DNA fragments joining with vector DNA fragment is called **splicing**. As a result, recombinant DNA or hybrid DNA is formed.

This is introduced into the bacterial host such as **E-coli, Bacillus subtilis** and **Streptomyces** sps.

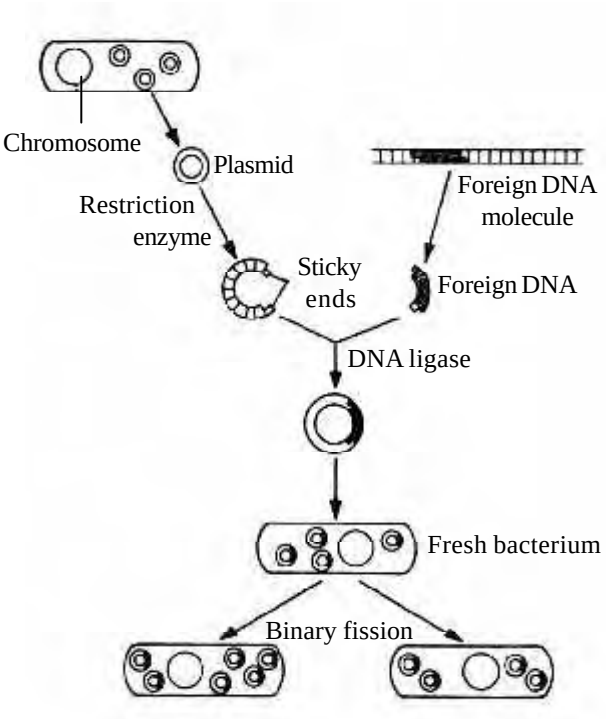


Fig. 3.10 Steps involved in Genetic Engineering

The r-DNA (recombinant DNA) dominates the host DNA in producing its own type of gene product such as protein, enzymes, etc. This will be multipled to produce genetically uniform population. This is called **molecular cloning** (or) **gene cloning.**

Application of Genetic Engineering

The foremost application of genetic engineering has been in understanding a structure of eukaryotic genes. Other modern applications are:

- Production of proteins, enzymes, hormones, antibiotics which are used in pharmaceutical industry.
- Altering the genotypes of plants through formation of insect resistant tomato plants, edible vaccines.
- Altering genotypes of animals to correct their genetic defects. e.g., production of human growth hormone.
- The ultimate identification test including the forensic application to determine the criminals in the case of murder or burglers, through DNA finger printing, restriction fragment length polymorphism.

BIO-TECHNOLOGY

Bio-technology has contributed towards the exploitation of biological organisms or biological processes through modern techniques, which could be profitably used in medicine, agriculture, animal husbandry and environmental cleaning. There are several applications of bio-technology such as brewing industry, enzyme technology, antibiotics, organic acids, vitamins, vaccines, steroids and monoclonal antibodies.

Brewing Industry : Fermentation in alcoholic beverages like beer, wine, etc.

Enzyme technology : Enzymes are bio catalysts that speed up reactions in cells. They can be used to catalyze industrially important chemical reactions and are more efficient than inorganic catalysts. Many enzymes are utilized in pharmaceutical industry.

Antibiotics : These are substances produced by some microbes that help in increasing the immunity to human beings which are toxic to other micro organisms.

Organic Acids : Acetic acid is used for the production of vinegar.

Vitamins: These are organic compounds present in variable minute quantities in natural food stuffs. They do not furnish energy but are very essential for energy transformation and regulation of metabolism.

Vaccines: Vaccines are substances that confer immunity against specific diseases. They act as antigens and stimulate the body to manufacture antigens. It was **Edward Jenner** in 1970 who coined the term **'Vaccine'** and the term 'Vaccination' for protective inoculation. Vaccines produced by biotechnology differ from others in that they do not contain weakened or killed agents. Instead they are so refined as to consist only of the reactive material, i.e. the antigen portion only. The first such vaccine was used against the hepatitis B virus (HBV).

Steroids: They are a type of derived lipids eg. cholesterol. Certain steroid drugs like prednisolone is produced from the fungus *Rhizopus*.

Monoclonal antibodies: These are the antibodies produced by cloned cells. Monoclonal antibodies are now used for the treatment of cancer.

CLONING

Cloning is an experimental technique wherein, a group of genetically identical organisms are produced. The "Clone" is an organism derived from a single parent by asexual method. A clone may be defined as exact carbon copy or copies of a single parent. The word clone only has its meaning to living species. The knowledge of cloning gained in the field of developmental biology and genetic control over differentiation of cells and the development of multi cellular organisms.

In March 1996, it was reported by a team of embryologists led by Lan Wilmut at the Roslin Institute, Edinburgh, Scotland. The cloned animal was a sheep and named as **Dolly**.

If the cloning technique is to be applied to veterinary science valuable animals could be cloned from desirable adult cells.

Plant Cloning

Cellular totipotency is the capacity of living cells to develop into the new individuals.

Steward and his co-workers, showed this phenomenon in the carrot cultures.

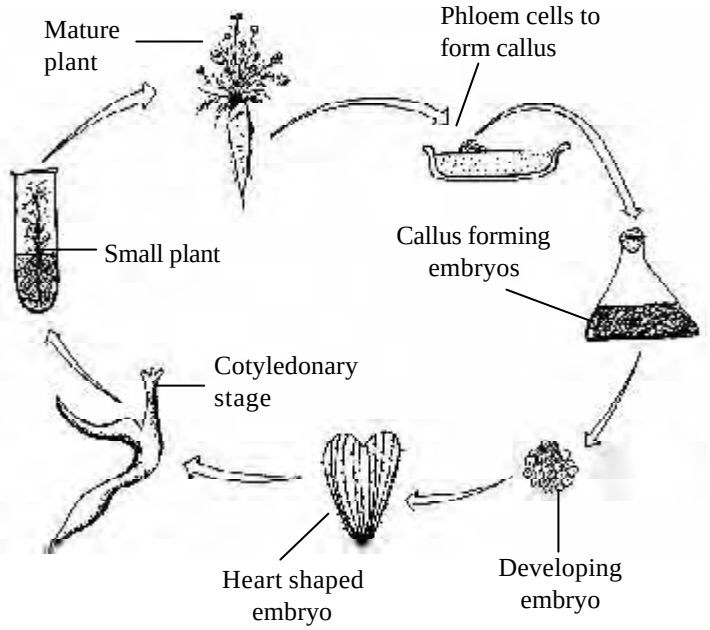


Fig. 3.11 Stages in the development of a mature carrot plant from isolated phloem cells

Procedure

1. Preparation of Medium: The medium is the subtratum on which the tissue grows. The most commonly used medium is the Murashige and Skoog medium which consists of essential micro and macro nutrients and the medium is soldified by adding agar. The pH is maintained at 5.8. The medium is taken in conical flask (or) culture tube (or) petri plates.
2. The Explant: A small segment of plant material removed from the plant body and used in vitro cultures is called explant.
3. Sterilization: Both medium and explant are sterilized to get rid of microbes such as bacteria and fungi.

4. Inoculation: The transfer of inoculum onto culture medium is called inoculation. This is done under aseptic condition by using inoculation chamber (or) laminar flow chamber.
5. Incubation: The culture is incubated at about 25°C. Under flourescent light with controlled photoperiods and to maintain in aspectic conditions.
6. The callus: It is an unorganised and undifferentiated mass of cells produced by division of the cells of explant.
7. Organogenesis: It is a process of development of primordial organs such as root, leaf, embryo in the callus in tissue culture.
8. Hardening: Exposing the plantlets to the natural environment in a stepwise manner is known as hardening.
9. Transfer into soil: After hardening plantlets are gradually transferred to the soil.

The modern cloning techniques involving nuclear transfer have been successfully performed on several species.

POINTS TO REMEMBER

- The chromosomes are filamentous thread like structures found in nucleoplasm.
- The terminal part of the chromosome is called Telomere.
- Genes are located on the chromosome in a specific loci.
- Chromosomes are classified on the basis of function, position of centromere and number of centromeres.
- The special type of chromosomes are polytene and lamp brush chromosome.
- A diagrammatic representation to karyotype of a species is called idiogram.
- A haploid set of chromosome is called genome.
- The new DNA strands are formed by the process of replication (or) duplication.
- Genetic code is a code for "aminoacids".
- Mutations are various types. e.g. Natural (spontaneous), Artificial (induced).
- Genetic Engineering as the modification of genetic information of living organisms by direct manipulation of their DNA.
- Restriction endonuclease and DNA ligase are the two basic tools used in DNA recombinant technology.
- The technology is involved in the industries to manipulate microbes for the production of improved quality products.
- Cloning is a technique, where a group of genetically identical organisms is produced.

SELF EVALUATION

I. Choose and write the correct answer.

1. The functional unit of gene is called …….
   a) Cistron b) Recon c) Muton d) Operon
2. The five carbon sugar found in the DNA is …….
   a) Ribose b) Xylulose c) Deoxy ribose d) Ribulose
3. Three nitrogenous bases code for one …….
   a) Protein b) Aminoacid c) DNA d) RNA
4. The type of mutation that causes death of the organisms is known as …….
   a) Lethal b) Induced c) Gene d) Chromosome
5. Who coined the term vaccine?
   a) Edward Jenne b) William Kuhne
   c) Alexander Flemming d) Wood ruff

II. Fill in the blanks with suitable terms:

1. The largest chromosomes are ……. and …….
2. The 'V' shaped structure of chromosome is called …….
3. In linear fashion ……. are located on the chromosomes .
4. The haploid set of chromosome is called …….
5. For the synthesis of proteins ……. are responsible .
6. The pyrimidine bases found in RNA are ……. and …….
7. The semi-conservative method of DNA replication was proved by ……. and …….
8. In plant breeding ……. mutation plays a major role.
9. Through mutation techniques ……. and ……. new varieties are obtained .

III. Answer the following questions in one or two sentences:

1. Define the term "centromere".
2. Define Karyotype.
3. What is Genome?
4. What is RNA?
5. Name the enzymes that involve for DNA replication.
6. Write the central dogma of protein synthesis.
7. Define Mutation.
8. What is Genetic Engineering?
9. Define Bio technology.

IV. Write short answers for each of the following questions in 100 words. (Draw diagrams wherever necessary).

1. Explain the structure of chromosome.
2. Distinguish between DNA and RNA.
3. Explain the account of DNA – Replication.
4. Write a brief note on applications of Bio-technology.

V. Write detailed answer for each of the following questions in 200 words. (Draw diagrams whenever necessary).

1. Describe the different types of chromosomes.
2. Describe the structure of DNA molecule.
3. Write an essay on Mutation.

UNIT – 4

REPRODUCTIION IN PLANTS

Reproduction in flowering plants is an unique biological phenomenon which is carried out by flowers. Flower is a modified or condensed part of the shoot. Most of the plants are bisexual i.e. both male and female reproductive organs are present in the same flower. Typically the flower consists of four parts namely calyx, corolla, androecium and gynoecium. The non essential parts of flower are calyx and corolla which may help in pollination. The essential parts of flower are androecium and gynoecium. These are the male and female reproductive parts of the flower.

4.1 FRUIT

A fruit is a matured or ripened ovary. It consists of two parts : pericarp (developed from the ovary wall) and seed (fertilized ovule). The pericarp consists of three layers : the outer portion called epicarp, middle portion called mesocarp and an inner portion called endocarp. The branch of science that deals with the characteristic features of fruit is called **Pomology**.

Parthenocarpic fruits

In some plants like Grapes, Banana, Oranges, etc the ovary may develop into a fruit without fertilization. Such fruits are seedless and are called **parthenocarpic** fruits.

Classification of fruits

The fruits are classified into two types based on the origin and development. They are **True fruit** or **Eucarp** - It develops from the ovary of a flower and **False fruit** or **Pseudocarp** – It develops from any other part of the flower other than ovary like thalamus or stalk of the flower.

Types of fruits

The fruits are classified into three main categories based on their origin.

Simple fruits

Fruit which develops from a single ovary of a single flower is called simple fruit. It is classified based on the nature of pericarp into fleshy fruits and dry fruits.

Simple fleshy fruits

In simple fleshy fruits the pericarp is succulent and juicy when they are fully ripe. The fleshy fruits are indehiscent in nature. The Pericarp is distinguished into three parts namely epicarp, mesocarp, and endocarp. There are mainly two types of fleshy fruits – **Baccate and Drupaceous**. Baccate is further classified into Berry, Hesperidium, Pome and Pepo.

Baccate

i. **Berry:** It is one or many seeded fruit. Here the epicarp is thin, the mesocarp is fleshy. They form a pulp which is edible and the seeds are embedded in it. e.g., Tomato, Brinjal, Dates, etc.

ii. **Hesperidium:** It develops from a multicarpellary, superior, ovary with axile placentation. The epicarp is thick leathery & contains oil glands. The white spongy layer lining the epicarp is called mesocarp. The endocarp forms distinct chambers. Juicy hairs produced from the endocarp is the edible part. e.g., Orange, Lemon, etc.

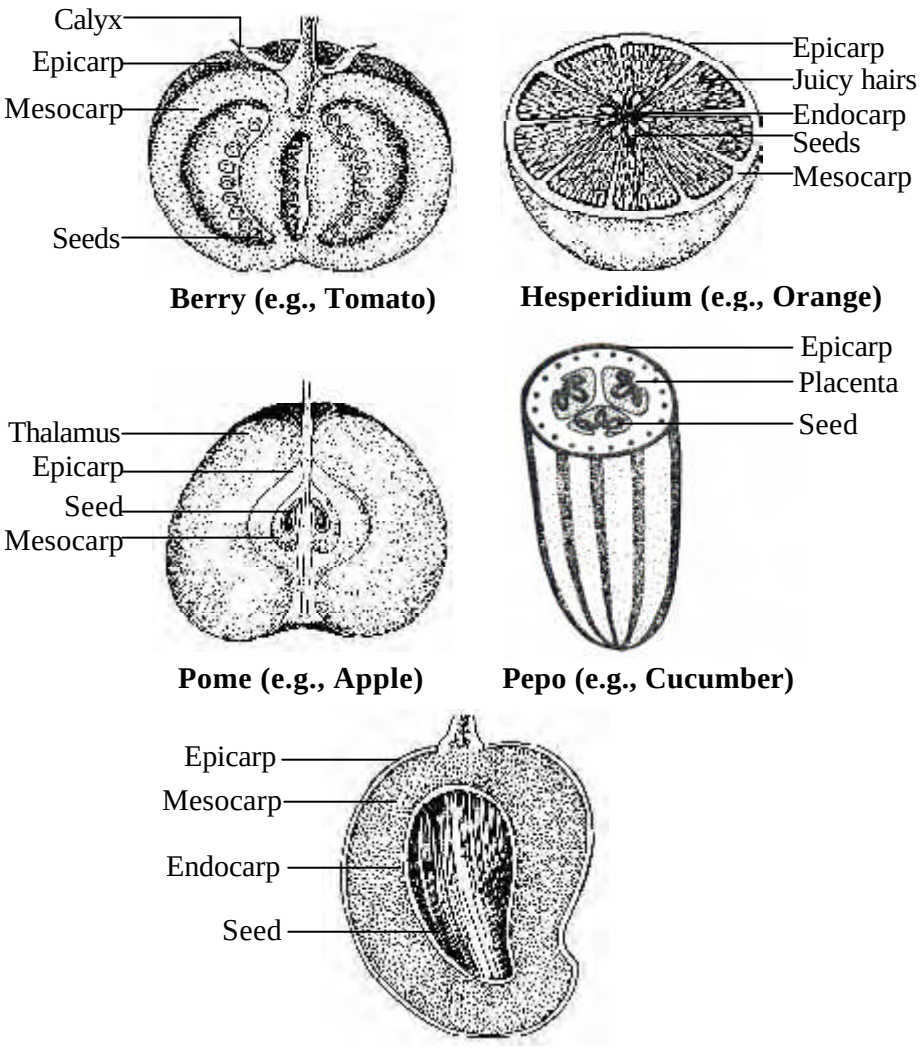
iii. **Pome:** This fruit develops from pentacarpellary, syncarpous, inferior ovary with many seeds. The thalamus becomes fleshy and develops into a fruit which is edible. The true fruit containing seeds remains inside. e.g., Apple, Pear, etc.

iv. **Pepo:** It develops from a tricarpellary , syncarpous, inferior ovary with parietal placentation. The pulp contains many seeds. e.g., Cucumber, Watermelon.

Drupe

It is usually one seeded fleshy fruit and develops from monocarpellary, syncarpous ovary. The pericarp is differentiated into outer skinny epicarp, middle fleshy mesocarp, and inner stony endocarp. Because of the presence of stony endocarp, the fruit is also known as stone fruit. e.g., Mango, Plum, etc.

SIMPLE FLESHY FRUITS



Berry (e.g., Tomato) **Hesperidium (e.g., Orange)**

Pome (e.g., Apple) **Pepo (e.g., Cucumber)**

Drupe (e.g., Mango)

Fig 4.1

Simple dry fruits

These fruits have a dry pericarp. They are classified based on their mode of dehiscence as Dry dehiscent, Dry indehiscent and Schizocarpic fruits.

Dry Dehiscent Fruits

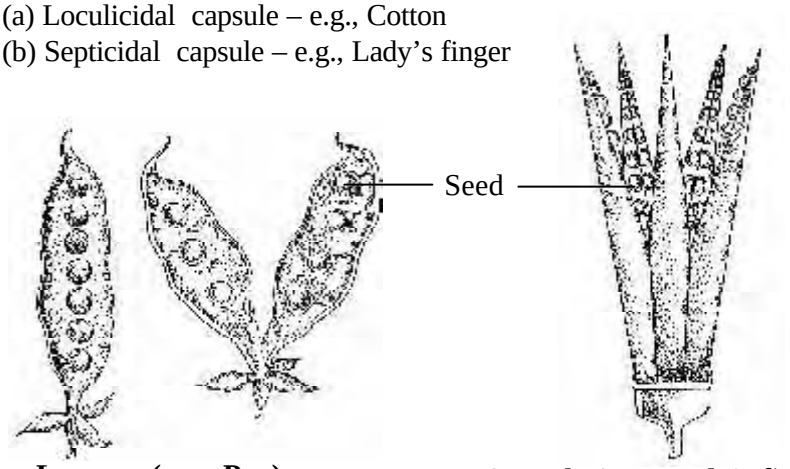
These fruits split open at maturity to liberate the seeds.

i. **Legume** : It develops from monocarpellary, unilocular, superior ovary with marginal placentation. Pericarp dehisces along both dorsal and ventral sutures. e.g. Pea, Bean, etc.

ii. Follicle: It is like a legume fruit, but the Pericarp dehisces along one suture only. e.g. **Calotropis**.

iii. Capsule: This is a many seeded fruit developing from superior or inferior, syncarpous, multicarpellary ovary. Capsules dehice by various methods.

(a) Loculicidal capsule – e.g., Cotton
(b) Septicidal capsule – e.g., Lady's finger



Legume (e.g., Pea) **Capsule (e.g., Lady's finger)**

Fig 4.2 Dry dehiscent fruit

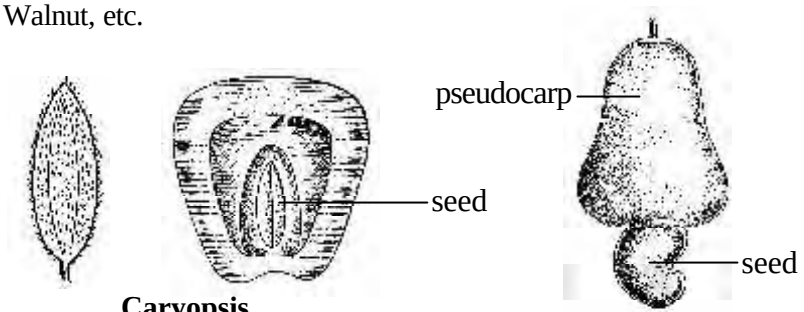
Dry indehiscent fruit : These fruits do not split open at maturity and the seeds are liberated by the decay of pericarp.

i. Achene: This is a single seeded fruit which develops from monocarpellary, unilocular ovary. Pericarp is hard and leathery remains free from the seed coat. e.g., **Clematis**, **Mirabilis**, etc.

ii. Caryopsis: It is a one-seeded fruit which develops from superior, monocarpellary ovary. Pericarp is fused with the seed coat. e.g., Maize, Wheat, Paddy, etc.

iii. **Cypsela :** This fruit develops from inferior, bicarpellary, syncarpous ovary. The Pericarp and the seed coat remain free. e.g. **Tridax.**

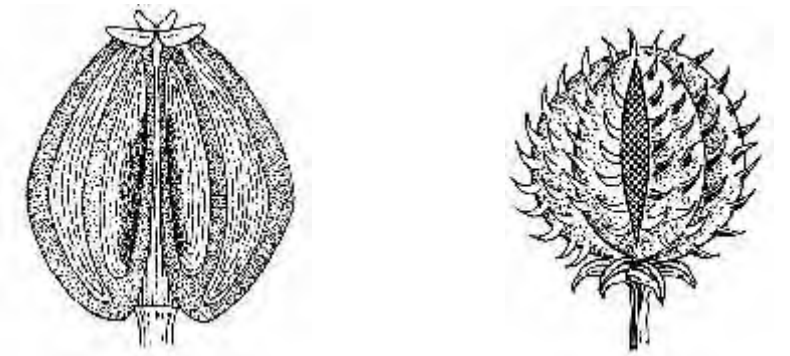
iv. **Nut :** It is a dry, indehiscent one seeded fruit with hard and woody pericarp. Nut is developed from superior, bi or multicarpellary ovary. e.g. Cashewnut, Walnut, etc.



Caryopsis (e.g., Paddy, Maize) **Nut (e.g., Cashewnut)**

Fig 4.3 Dry indehiscent fruits

Schizocarpic fruits: These fruits break into many one seeded parts called mericarps at maturity. The mericarps containing the seeds remain indehiscent. Thus the schizocarpic fruits show characters of dehiscent and indehiscent fruits.



Mericarp (e.g., Coriander) **Regma (e.g., Castor)**

Fig 4.4 Schizocarpic fruits

i. **Lomentum:** It resembles a legume and breaks transversely at constrictions between the seeds. e.g., **Acacia** (soap nut).

ii. **Cremocarp :** It is two seeded fruit which develops from bicarpellary, syncarpous, bilocular and inferior ovary. It dehisces longitudinally into two indehiscent mericarps. e.g., **Coriandrum**, etc.

iii. **Regma :** It develops from tricarpellary, syncarpous, superior ovary and breaks up into three one seeded cocci. e.g., Castor.

Aggregate fruit: It is developed from a single flower with multicarpellary, apocarpous, superior ovaries. Each free carpel develops into a fruitlet . Hence the aggregate fruit has a cluster of fruitlets attached to common stalk. e.g., **Polyalthia**. In ***Annona squamosa*** (custard apple) the margin of the carpels are united and appears like a single fruit.

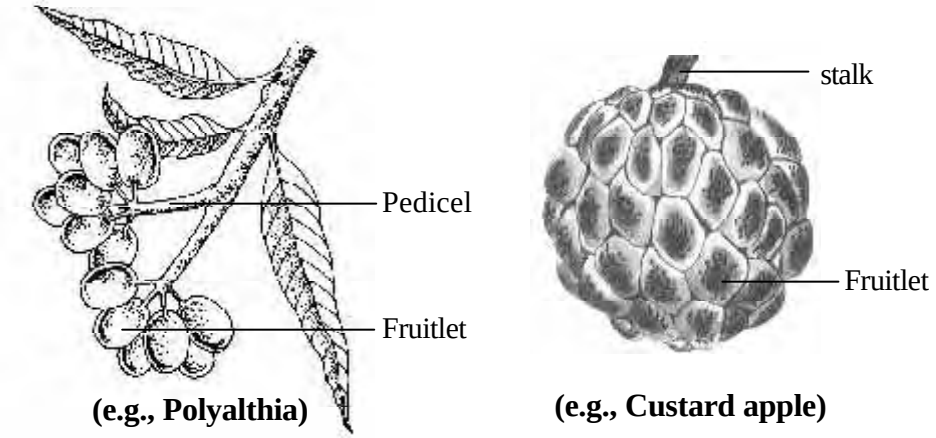


Fig 4.5 Aggregate fruit

Composite or multiple fruit

Multiple or composite fruit is formed by all the flowers of a whole infloresence give a single fruit.

There are two types of multiple fruits namely, **sorosis** and **syconus**.

Sorosis: In Jack fruit, the rachis (infloresence axis) and other floral parts of the female infloresence fuse together forming a composite fruit. It consists of a fleshy central axis. The edible part represents the perianth which is bag like and one seeded. There are numerous, elongated, whitish flat structures in between the edible flakes. They represent the sterile or unfertilised flowers. The spines on the tough rind represent the stigmas of the carpels.

In Pine apple the fruit develops from spike infloresence. The rachis and the flowers, along with bracts unite together into fleshy compound fruit. Flowers are usually sterile, and seeds are rarely formed.

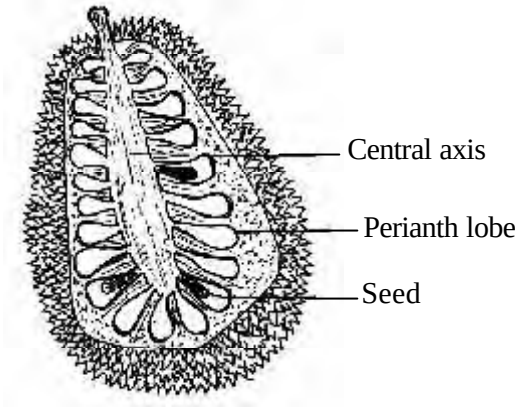


Fig 4.6 Multiple fruit (e.g., Jack fruit)

Syconus : It is derived from a special type of inflorescence known as hypanthodium, which has a fleshy receptacle. It has large number of minute unisexual flowers. On ripening, the receptacle becomes fleshy and juicy and forms the edible portion. e.g., Banyan, Peepal, Fig, etc.

4.2. SEED

Seed is a fertilized ovule. It possesses embryo, food material and protected by the seed coat. During the favourable condition, the seed germinates and gives rise to a new plant body.

Seeds have great variations in the size, shape, colour and surface. In orchids, there are many seeds which are tiny dust like particles. In coconut, there is a large sized seed. The seed grows into full plant.

On the basis of the number of cotyledons in the embryo (seed), the angiosperms have been divided into two groups.

1. **Dicotyledons :** Embryos with two cotyledons. e.g. Pea, Bean, Gram and Castor.
2. **Monocotyledons :** Embryo with one cotyledon, e.g., Maize, Rice, Wheat and Onion.

TYPES OF SEED

On the basis of endosperm content, there are two types of seed. **Endospermous or albuminous seeds:** In Castor, Maize and other cereal seeds, the cotyledons are thin and membranous. The food materials are stored in the endosperm. The cotyledons absorb the food from endosperm and supply it to the developing embryo. These seeds are known as endospermous or albuminous seeds.

Ex-endospermous or ex/non-albuminous seeds: However, in seeds like Pea, Bean the cotyledons are thick and fleshy. This part contains food material, It helps in development of embryo and germination. These kinds of seeds are known as ex-endospermous or ex-albuminous seeds.

DICOT SEED

A mature seed contains an embryonic plant and is provided with reserve food materials. It has an outer seed coat. e.g., Pea, Bean. The seeds are attached to the fruit wall by a stalk called the **funiculus**. At maturity, the seed is detached, and the funiculus makes a scar on the seed called **hilum**. Close to the hilum lies a minute pore called the **micropyle.** During germination water is absorbed through the micropyle and the **radicle** comes out through it. There is a ridge like structure in the seed coat called the **raphe**. The seed is covered by two distinct seed coats. The outer thick **testa** and inner thin, membranous covering called **tegmen**. The seed coat protects the seed from desiccation, mechanical injury, high temperature and the attack of bacteria, fungi and insects.

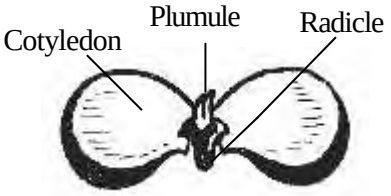


Fig 4.7 Structure of Gram seed

When the seed coat is removed, two fleshy **cotyledons** are seen. The cotyledons remain attached to a small embryonic axis. The part of the embryonic axis lying outside the cotyledons, directed towards the micropyle is the **radicle(**embryonic root). The other portion of the embryonic axis present between the two cotyledons is the **plumule**. It is the first apical bud of the future plant body and gives rise to the shoot system. The portion between the plumule and the cotyledons is the epicotyl and the portion between the radicle and the cotyledons axis is called hypocotyl. The axis along with the cotyledons is the embryo.

MONOCOT SEED

The maize grain is a single-seeded fruit and belongs to a type of simple dry indehiscent fruit called **caryopsis**. The thin layer of seed coat (testa) is fused with the fruit wall (pericarp). Morphologically the maize grain is yellow in colour and triangular in shape. On one side of the grain is a small, opaque, whitish area in which the embryo is present. e.g., Maize, Wheat, Rice, etc.

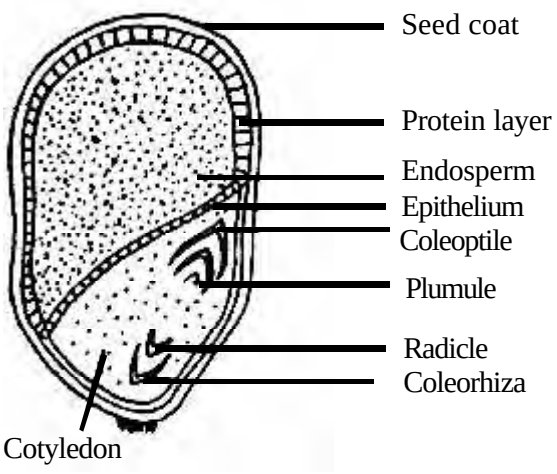


Fig 4.8 Structure of monocot seed (e.g., Maize)

The grain is divided into two unequal portions, by a definite layer known as **epithelium**. The bigger portion is the **endosperm** (food storage tissue) and the smaller portion is the **embryo**. The outermost layer contains only protein and it is called **aleurone layer**. The embryo consists of one shield shaped **cotyledon** also called the **scutellum** and an **axis**. The axis consists of a **plumule** at the upper portion and the **radicle** at the lower portion. Both radicle and plumule are surrounded by sheaths. **Leaf-sheath** or **coleoptile** is present on the plumule surface and the radicle is surrounded by a **root sheath** or **coleorrhiza**. The cone like coleptile has a pore at the apex through which the cotyledon emerges.

4.3 DISPERSAL OF FRUITS AND SEEDS

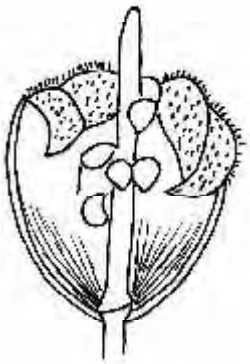
The reproductive capacity of plants is so tremendous that a very large number of seeds is produced by a single plant. If all these seeds fall directly below the parent plant, the seedlings would compete for space, water, oxygen, minerals and sunlight, leading to competition. When the seedlings are grouped together at one place they could easily be destroyed by grazing animals. Such a

situation would be detrimental to the species. The fruits and seeds of plants have evolved various devices by which they can be distributed far and wide through various agencies. This not only eliminates the unhealthy competitive struggle that would arise from over crowding, but also ensures the successful spreading and establishment of a species on the earth. Most fruits and seeds have evolved adaptations for dispersal.

AGENTS FOR THE DISPERSAL OF FRUITS AND SEEDS

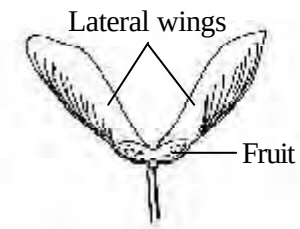
Based on the agent involved in dispersal there are various types of dispersal mechanisms of fruits and seeds in plants.

Autochory: Autochory is an active mechanism of self dispersal of fruits and seeds. Fruits like balsam burst with a sudden jerk and disperse the seeds by an explosive mechanism.

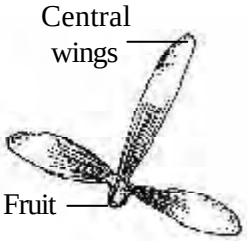


e.g. Balsam fruit
Fig 4.9 Autochory

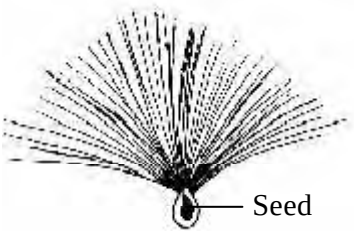
Anemochory: Anemochory is nothing but wind dispersal of fruits and seeds. Alternatively the wind may blow them away, for which they have to be light so that their buoyancy may enable them to float on air over long distances. Some of them are provided with hairs or membranous, wing – like structures which enable them to be carried away easily. e.g., seeds dispersed by the wind are Calotropis, Moringa (drum stick) etc. Fruits of Tridax carry a persistent calyx modified into a **pappus**. (a ring of fine, feathery hairs) which acts like a parachute and aids dispersal by wind.



e.g., Acer



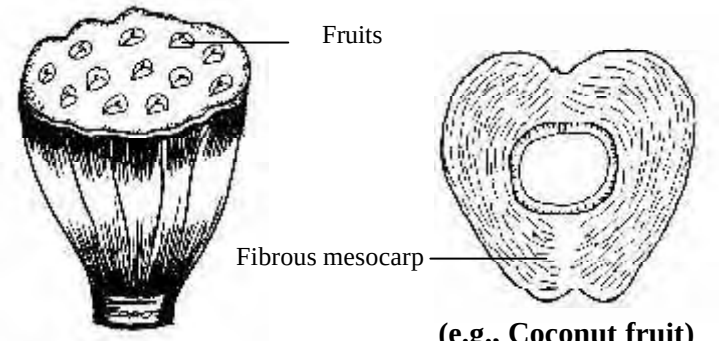
e.g., Hiptage



(e.g., Calotropis)
Fig 4.10 Anemochory

Fig 4.10 Anemochory

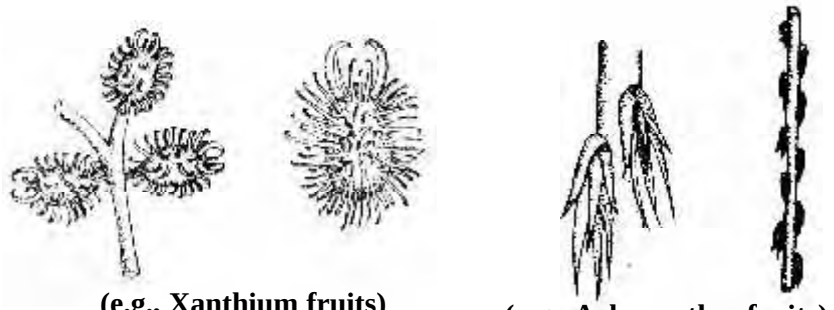
Hydrochory: Hydrochory is a mechanism in which dispersal of fruits and seeds is by water. Fruits which are dispersed by water have outer coats that are modified to enable them to float. The mesocarp of coconut is fibrous, which is easily carried away by water currents. The spongy thalamus with air chamber of lotus floats in water streams and after sometime the fruits get separated and the seeds germinate.



(e.g., Thalamus of Lotus) **(e.g., Coconut fruit)**

Fig 4.11 Hydrochory

Zoochory: Zoochory is a mechanism in which dispersal of fruits and seeds is by animals. Some fruits are provided with hooks, spines, bristles, stiff hairs, etc., on



(e.g., Xanthium fruits) **(e.g., Achyranthes fruits)**

Fig 4.12 Zoochory

their outer coat. With the aid of these outgrowths, these fruits stick to the furry coats or skins of some animals and get carried away from one place to another.

The fruits of **Xanthium** have sharp-pointed stiff hooks and in **Achyranthes** the perianth and bracts are pointed. Many fleshy fruits are eaten by animals and human beings and the seeds are thrown away. In fruits like **tomato** and **guava** the seeds are eaten along with the edible portion and later passed out by excreta. These types of seeds are protected from the digestive juices by their seed coat.

Man is responsible for the dispersal of many fruits and seeds in the pursuit of more economically useful plants. Plants like **Cinchona, Rubber** and **Eucalyptus** have been successfully introduced by man and they have acclamatised well to the new surroundings far away from their original mother land.

4.4 GERMINATION – TYPES OF GERMINATION

Germination is the commencement of growth from a seed, it starts with the absorption of water which leads to a rapid increase in weight and to a swelling of the tissues which ruptures the testa (seed coat) allowing the radicle and the plumule to emerge out.

Germination

It is a process, when all the necessary conditions of soil like pH, oxygen, water and temperature are provided, the first change noticed is swelling of the seed by rapid imbibition of water. This causes bursting of testa (seed coat). Absorption of water results in active physiological processes like respiration and enzyme secretion. Due to these processes the insoluble food stored in the cotyledon is made simple and soluble and is diluted by water. Later it is conducted towards the growing epicotyl, hypocotyl, radicle and plumule.

Types of germination

When the seed is placed in the soil, growth becomes vigorous, the radicle is the first organ to grow and comes out through the micropyle and fixes the seed to the soil. After this either the hypocotyl or the epicotyl begins to grow. Based upon these growths two types of germinations are observed. i.e. Epigeal germination (Epi - above) (geal – soil) and Hypogeal germination (Hypo – below) (geal – soil)

Epigeal germination

When the hypocotyl (the region between radicle and node is called the hypocotyl) grows first, it pushes the cotyledonary node and all other parts of the seed out of the soil. This mode of germination is called epigeal. e.g., Bean, Pea, Sunflower.

Hypogeal germination

When the epicotyl (the portion just above i.e. between node and plumule is called epicotyl) grows, first, only the plumule is pushed out of the soil while the cotyledonary node, cotyledons and all other parts remain under the soil. This type of germination is called hypogeal. e.g. Maize, Paddy etc.

Germination of bean seed

Bean is a dicotyledonous ex-endospermous or exalbuminous seed and has absorbed water, it swells and the testa becomes soft, the radicle grows through the micropyle of the seed coat and grows downward as primary root system, while the hypocotyl bends upward like an arch above the soil surface. After this the hypocotyl loop (arch) becomes erect and lifts the cotyledons upward. The cotyledons turn outward and expose the plumule, which grows upward to form first foliage leaves and shoot of the plant. The epigeal germination is the result of active growth and the elongation of the hypocotyl.

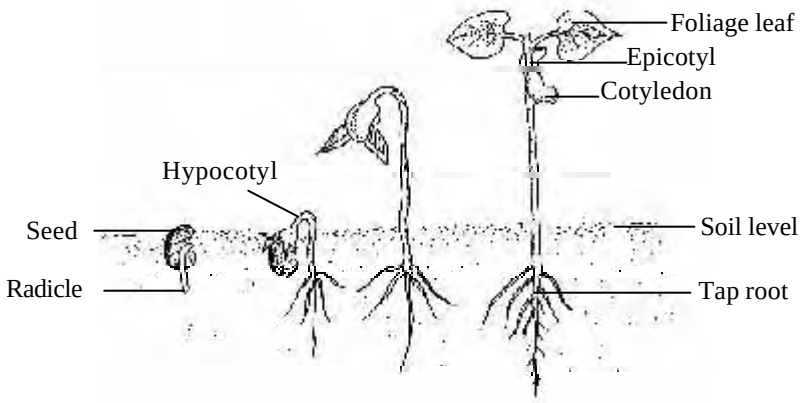


Fig 4.13 Epigeal germination (e.g., Bean seed)

Germination of maize

Maize is actually a fruit containing a single seed which is **monocotyledonous**. It shows **hypogeal** germination. As the seed germinates, the radicle pierces the fruit wall and the **coleorrhiza** and grows downwards to fix the developing seedling in the soil. This is followed by the growth of the coleoptile. The primary root developing from the radicle soon disintegrates and a cluster of fibrous adventitious roots take up the functions of the root. The formation of the fibrous root system is the typical characteristic of monocotyledons. In the meantime, the epicotyl of the plumule grows to split open the tip of the coleoptile.

The rapid growth and elongation of the epicotyl pushes the foliage leaves well above the ground leaving the seed buried in the soil.

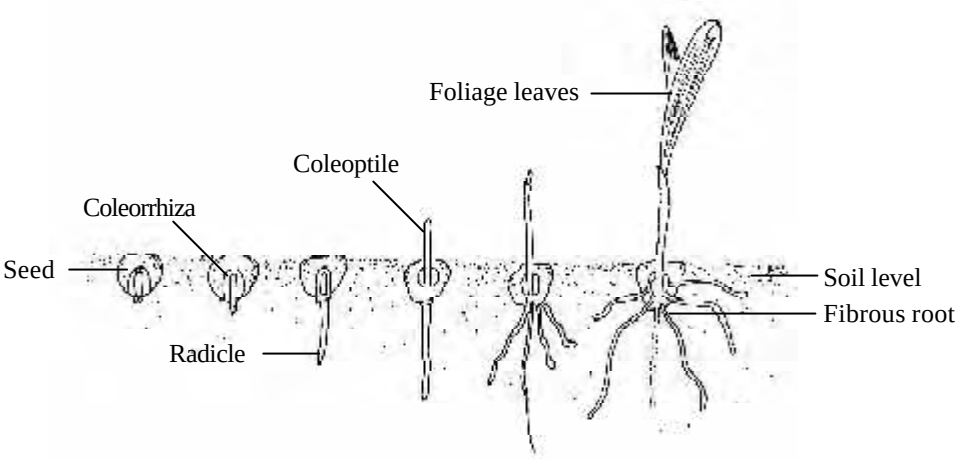


Fig 4.14 Hypogeal germination (e.g., Maize)

CONDITIONS NECESSARY FOR GERMINATION

External factors

1. **Moisture:** Sufficient quantity of water is essential for the seeds to germinate. Seeds absorb moisture and begin their vigorous physiological activities.
2. **Oxygen:** It is necessary to activate the seed to respire.
3. **Optimum temperature**: It is very much important to perform the physiological activities.
4. **Light:** It is required for healthy germination

Internal factors

The internal factors are the viability, dormancy period of the seed, the reserve food and hormones.

POINTS TO REMEMBER

- The essential whorls of flowers are androecium and gynoecium.
- Fruit is a fertilized ovary.

- ❖ Seeds are fertilised ovule.
- ❖ Pea, Beans are examples for dicot seeds.
- ❖ Maize, Wheat are examples for monocot seeds.
- ❖ Different agents like wind, water, animals and man help in the dispersal of fruits and seeds.
- ❖ Epigeal germination is seen in Bean seeds.
- ❖ Hypogeal germination is seen in maize seeds.

SELF EVALUATION

I. Choose and write the correct answer

1. A fruit is a fertilized _____.
   (a) Flower (b) Ovary (c) Ovule (d) Stamen
2. The stone fruit is _____.
   (a) Pome (b) Pepo (c) Drupe (d) Berry
3. Lady's finger and cotton are examples for _____.
   (a) Legume (b) Capsule (c) Follicle (d) Caryopsis
4. The portion between the plumule and cotyledon is _____.
   (a) Hypocotyl (b) Epicotyl (c) Embryo (d) Radicle
5. The fruits and seeds are dispersed by animals are called _____.
   (a) Anemochory (b) Hydrochory (c) Zoochory (d) Lithochory
6. The best example for hypogeal germination is _____.
   (a) Pea (b) Mustard (c) Maize (d) Sunflower

II. Fill in the blanks with suitable terms :

1. The seedless fruits are known as _____ .
2. The fruit develops from part other than the ovary is known as _____ .
3. _____ and _____ are the two types of simple fleshy fruits.
4. The one seeded fruit developing from monocarpellary superior ovary is _____ .
5. _____ and _____ are the examples for albuminous seeds.
6. Pappus hairy structure is found in _____ plant.
7. _____ and _____ are the two types of seed germination.

III. Answer the following questions in one or two sentences :

1. Define the term 'fruit'.
2. Define the term 'pomology'.
3. What are the types of dry fruits?

4. What is seed?
5. Define endosperm.
6. What is autochory?
7. Define epigeal germination.

IV. Write short answers for each of the following questions in 100 words :

1. Explain the types of baccate fruits with an example.
2. Write about aggregate fruits with an example.
3. Explain the structure of a dicot seed.
4. Explain the zoochory with examples.

V. Write detailed answer for each of the following questions in 200 words.

(Draw diagrams wherever necessary)

1. Describe the types of dry fruits and their types.
2. Give an account of hypogeal germination.

UNIT 5
ECONOMIC BIOLOGY

5.1 MEDICINAL PLANTS

Nature has bestowed on us a very rich botanical wealth. The herbal wealth of India and the knowledge of their medicinal properties have a long tradition, as referred to in Rig veda and other ancient literature. The topography of India in the tropical belt with its varied climatic zones make it a vast store house of medicinal plants. These contain substances known to modern and ancient civilizations for their healing properties. Until the development of Phytochemistry and, particularly, of the synthesis of organic compounds in the 19th century, medicinal plants and herbs were the sole source of active principles capable of curing many ailments. The active principles differ from plant to plant due to their biodiversity, i.e. to the plant's genetic coding ability to produce them.

Medicinal plants and medicinal herbs continue to be the source of proven medicaments of new and revolutionary drugs. If the active principles of synthetic drugs are so important and can be found in many plants and herbs, cheaply and easily bought at your home market or from Herbalist, why not use them? Medicinal Plants have been the source of many of mankind's most basic medicinal therapies, and form the foundation of the modern pharmaceutical industry.

The branch of Science that deals with the study of medicinal or drug plants, their history, botanical and anatomical identification, preservation, extraction and preparation of the drugs from the plants is called **Pharmacognosy**. The study of the action of the drugs is known as **Pharmacology**.

NEEM

Botanical name : ***Azadirachta Indica***

Family : ***Meliaceae***

Synonym : ***Melia azadirachta***

English name : ***Indian lilac, Margosa tree,***

Trade Names : Margosa, Neem

Morphology

The tree is large, evergreen and dense, growing 10-15 meters tall with a girth of 2 to 3 meters thick, bark dark grey compound leaves, alternate, imparipinnate, leaflets are acute with serrate margin. Flowers in axillary branches, small, white, aromatic, complete and actinomorphic. Fruits are green drupaceous berries with single seed and yellow when ripe.

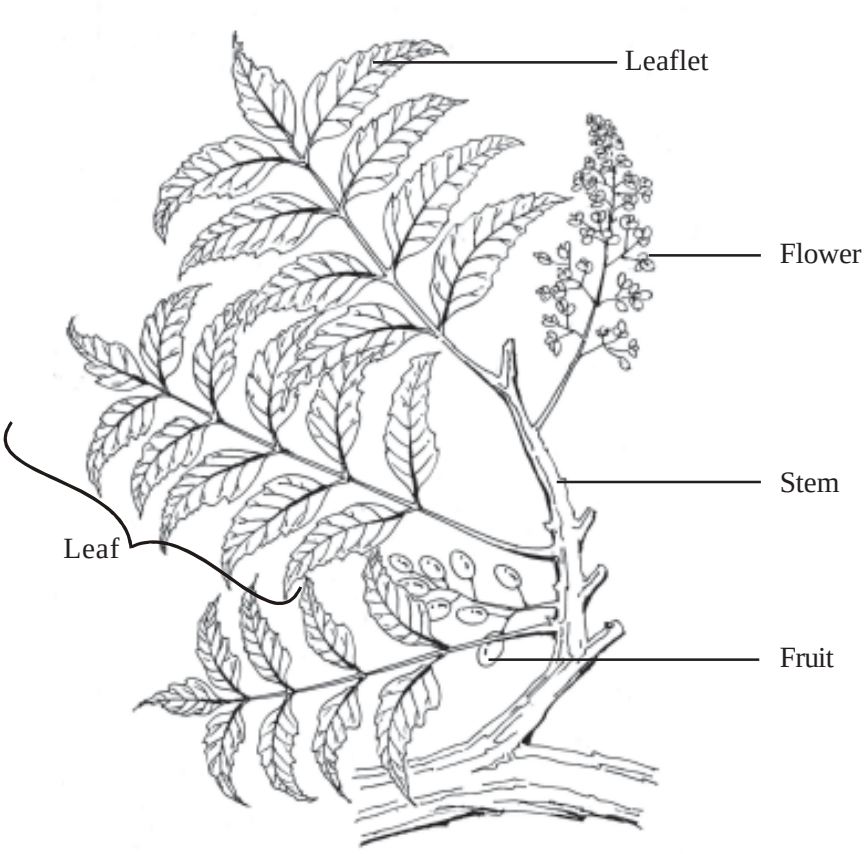


Fig 5.1 Neem

Distribution

It is a native of India and distributed in all parts of our country. It is considered as a good purifier of air and a good insect repellent. In India Neem is considered as a sacred tree. In Andhra Pradesh a special dish is prepared with neem flowers at “Ugadi”, Telugu New Year Day.

Chemical Content

The seed contains essential oil known as margosa or neem oil . The bitter constitutents separated from this oil are **nimbin** and **nimbidin. Nimbidin** contains Sulphur. Flowers yield a glucoside nimbosterin and a highly pungent essential oil and a few fatty acids. Leaves yield azadirachtin.

Traditional Use

Different parts of this plant are used in the following manner.

- Young twig used as tooth – brush.
- Gum used as stimulant
- Leaf used as antidote to small pox, dried leaves used as insecticide.
- Powdered flowers used as an anthelmintic.

Ayurveda

- Bark is used as bitter tonic, astringent, antiperiodic and used for liver pain .
- Leaves are used for excessive urination associated with itching, blood sugar, vomiting, acidity, jaundice, intestinal worms.
- Flower is used for stomach ache.
- Fruits are purgative and anthelmintic.
- Seed oil is used to eradicate ringworm , wounds in gums, rheumatism and skin diseases.

Unani

Uses similar to Ayurveda system of medicine.

Homeopathy

For control of mind, headache and other ailments of eyes, ears, nose, throat, mouth, stomach , abdomen, genito – urinary organs, chest, neck, fever, etc.

Modern Use

Anti bacterial, antihyperglycaemic and antihelmintic, antiviral, anti neoplastic, antifungal and used to treat white leprosy, eczema, ringworm, scabies, dandruff, diabetes, rheumatism and skin diseases.

VINCA ROSEA

Botanical Name	:	***Catharanthus roseus***
Synomyns	:	***Lochnera rosea, Vinca rosea***
Family	:	***Apocyanaceae***
English Name	:	***Madagascar periwinkle***
Trade Name	:	Nithyakalyani

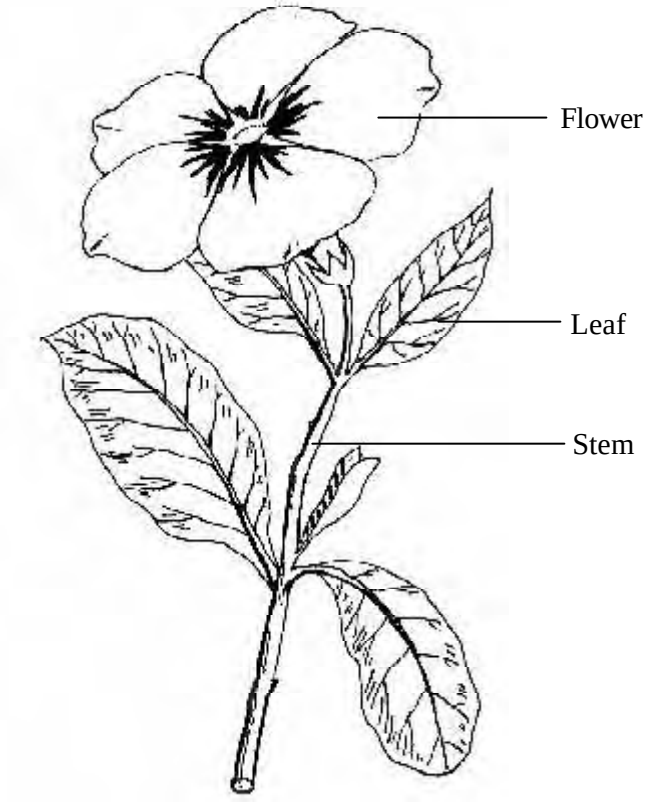


Fig. 5.2 Vinca rosea

Morphology

An erect, pubescent herb, with branched tap root. Leaves are simple, petiolate, ovate or oblong, unicostate, reticulate, entire, brittle with acute apex and glossy appearance. Flowers are bracteate, pedicellate, complete, normally 2 or 3 in cymose axillary clusters. Fruits are follicles with several black seeds.

Distribution

It is cultivated in South Africa, India, USA. Europe, Australia and West Indies as an ornamental plant and also for its medicinal properties.

Chemical Composition

A large number of Indole alkaloids are present in Catharanthus. Out of them **Vincristine** and **Vinblastine** are the most significant because they possess Oncolytic activity. **Vinblastine** contains indole alkaloid part called **Catharanthine** and dihydro indole alkaloid part called **Vindoline**.

Traditional Use

The whole plant is medicinally used for varied purposes and as a folk remedy for diabetics.

- Root bark: Contains alkaloids which have hypotensive and sedative properties.
- Root: Toxic, bitter tonic and good medicine for stomach ache.
- Leaves: The juice of the leaves is good for wasp – stings and menorrhagia. It is given intravenously in the treatment of acute leukaemia of children.

GINGER

Botanical name	:	***Zingiber officinale***
Family	:	***Zingiberaceae***
Trade name	:	Ginger

Morphology

Ginger is a slender perennial herb, 30 -100 cm tall with robust branched rhizome. Rhizome is the underground stem, tuberous, horizontally growing which is aromatic and of commercial value. The Rhizome is thick and laterally compressed often palmately branched about 1.5 – 2.5 cm in diameter, pale yellow within, covered with scale leaves and with fine fibrous roots. Leafy shoots annual, erect, formed of long leaf sheaths and bear 8-10 distichous leaves, simple, petiolate, entire linear lanceolate.

Distribution

Naturally occurs in Pacific Islands of South East Asia. Widely cultivated in Australia, India, China, etc. India produces the best quality ginger. Kerala produces about 70% of the total production in our country.

Chemical Composition

Ginger contains 1-3% volatile oil of which the chief constituents is a sesquiterpene, zingiberene and terpene. The pungent principle of ginger is **zingerone** . Dry ginger contains proteins, fat, fibre, carbohydrate, minerals, vitamins A, B & C. Steam distillation yields 1-3% aromatic oil.

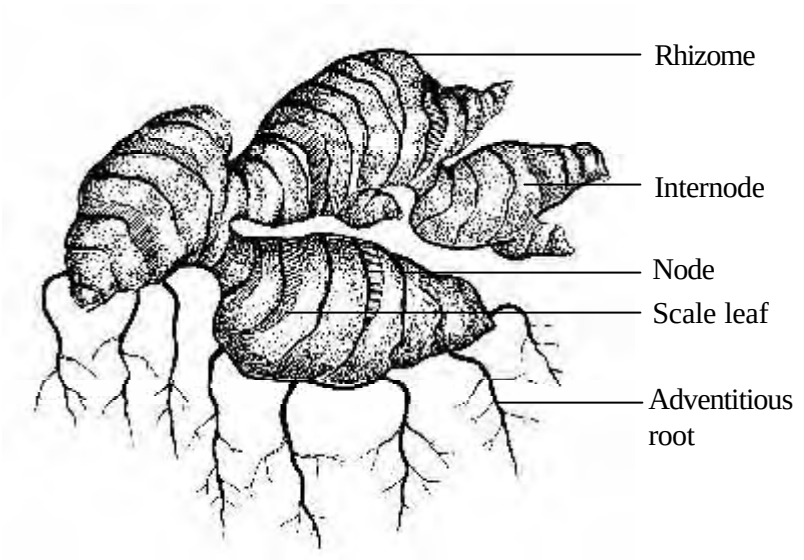


Fig 5.3 Ginger

Traditional Use

It has carminative and simulative properties hence used as medicine. Dried ginger paste is used as pain killer and applied on the forehead for severe headache and externally for sore throat, etc. The aroma of ginger is pleasant and spicy hence used in the manufacture of many food products. Used in bakery products, confectionary, pickles, sauces. etc.

The medical value of ginger lies in its stimulant and carminative properties. It is a valuable drug administered in dyspepsia, rheumatism, piles, neuralgia, pulmonary disorders and digestive problems. The fresh juice of ginger with honey is an excellent medicine and relief for coughs and asthma. Ginger juice is a good medicine for stomach disorders, mild diarrhoea and vomitting. It is also used for veterinary purposes.

TURMERIC

Botanical Name : ***Curcuma domestica***
Family : ***Zingiberaceae***
Trade Name : ***Turmeric***

Morphology

It is a perennial herb with large ovoid root stock, sessile thick tuber, bright yellow inside, petiole 60-90 cm long leaves green, peduncle long hidden by sheathing petiole. Inflorescence - raceme (spike).

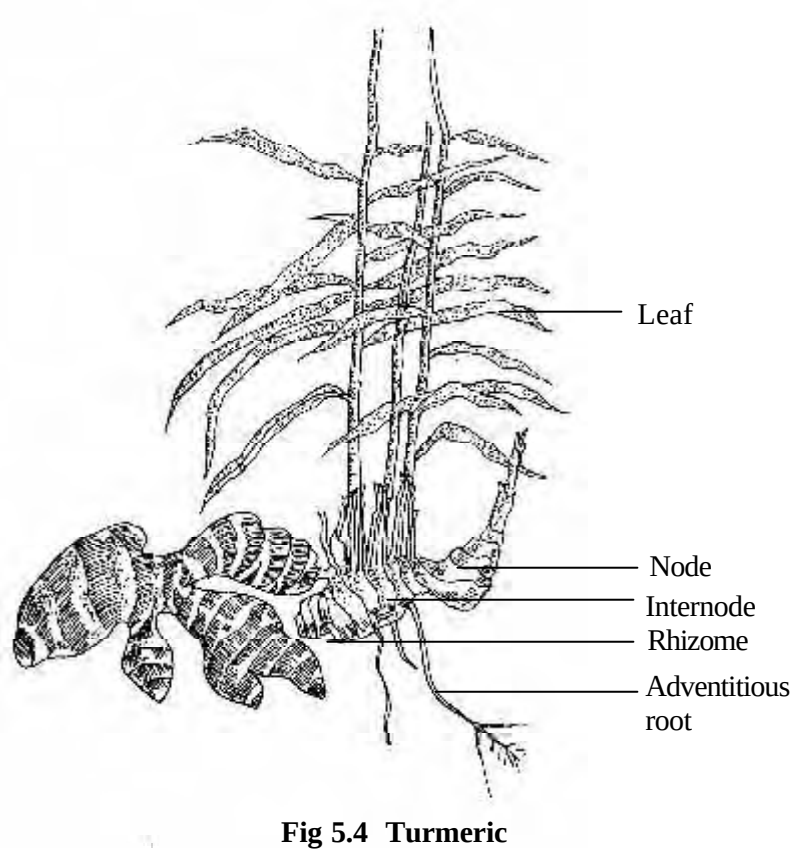


Fig 5.4 Turmeric

Distribution

The plant was domesticated in Southern or South Eastern Asia. Widely cultivated in West Bengal and other parts of India, Bangladesh, China and Sri Lanka.

Chemical Contents

Rhizome contains an essential oil – Curcumin (Colouring matter) and Zingiberine.

Traditional Use

Rhizome is used for whooping and other coughs. In Sri Lanka, Rhizome paste is used in skeletal fracture. Turmeric is an indispensable culinary ingredient. It imparts a musky flavour and yellow colour to curries. It is used as colouring matter in pharmacy, confectionery and food industries. It is also used as dye in certain cotton textiles, medicine and in cosmetics. Further it is also regarded by the Hindus as sacred for use in ceremonial and religious functions.

Rhizome used in mental cure, inflammation of eye, night blindness, indigestion, bronchitis, cough and cold, wounds, leprosy, body pain, headache improves body complexion effective against bacterial infection, skin diseases, intestinal worms, liver complaints, stammering, filaria, asthma, measles, boils, conjunctivitis, allergic reactions. Oil from rhizome is anti fungal, anti-inflammatory and antibacterial.

5.2 TYPES OF INDIAN MEDICINE

Medical practices

Human life and knowledge of preserving it as a growing concern, must have come into being almost simultaneously. All known cultures of the past-Egyptian, Babylonian, Jewish, Greek, Chinese, Indus-valley, etc. had their own glorious and useful systems of medicine and health care.According to the ancient books of knowledge, health is considered as a pre-requisite for achieving the supreme ends of life consisting of righteousness, wealth, artistic values and spiritual freedom. Preventive and curative aspects of diseases are considered as important components of the concept of positive health.

The systems of medicine, viz . Ayurveda, Unani, Siddha and Homeopathy (AYUSH) predominantly use plant based raw materials in most of their preparations and formulations. Modern medicines also contain at least 25% drugs derived from plants. Many drugs are synthetic analogues built on prototype compounds isolated from plants.

The World Health Organisation (WHO) estimated that 80% of the population of developing countries rely on traditional medicine mostly plant drugs, for their primary health care needs. Medicinal plants being natural having no

side-effects offer a range of safe, cost effective, preventive and curative therapies which could be useful in achieving the goal of **"Health for all"** in a cost effective manner. Demand for medicinal plants is increasing in both developing and developed countries but 90% material is harvested from wild sources without applying scientific management. Hence many species are under threat to become extinct.

Medicinal plants occupied an important position in the socio-cultural, spiritual and medicinal arena of rural people of India. Their sustainable management and harvesting conserve biodiversity, sustain human and environmental health , generate employment and enhance earnings. Therefore, a Task Force was set up by the planning commission for conservation and sustainable use of medicinal plants.

AYURVEDA SYSTEM OF MEDICINE

Ayurveda is the name which the ancient Indians gave to their Science of Medicine. Ayus means life and veda to know or attain. It is the only applied science which is still in practice having an unbroken continuity. Ayurveda is believed to be prevalent since 5000 years in India. It is one of the most noted systems of medicine in the world. Ayurveda is based on the hypothesis that everything in the universe is composed of five basic elements viz. space, air, energy, liquid and solid.

This system is based on two theories viz. the Hippocratic theory of four humours and the Pythagorian theory of four proximate qualities. The four humours are blood, phlegm, yellow bile and black bile while the four qualities are the states of living human body like hot, cold, moist and dry. Since life (AYUSH) is composed of body, senses, mind and soul, except the soul all the three become the subject of diseases. Preservation of health and its maintenance are the main aim of Ayurveda.

The ultimate goal of Ayurveda and philosophy is to attain happiness and to extinguish sorrow (dukha). Some important herbs from ayurveda are *Rauwolfia serpentina, Asparagus racemosus, Cassia angustifolia, Sesamum indicum, Withania somnifera, Piper longum* etc.

UNANI SYSTEM OF MEDICINE

The Unani Tibb (Unani System of Medicine) has grown out of the fusion of diverse thoughts and experiences of nations and countries, with an ancient cultural heritage, namely Egypt, Arabia, India, Iraq, Iran and China. It had its origin in the fifth and fourth centuries before Christ under the patronage of Hippocrates in Greece.

The unani Tibb is based on humoral theory. This theory supposes the presence in the body of four humours, Blood, phlegm, yellow bile and black bile.

Drugs are also assigned temperaments. Every person is supposed to have a unique humoural constitution which represents his healthy state. Any change in this brings about a change in his state of health. There is formulated also a power of self preservation or adjustment.

The Unani system of medicine aims to treat the cause of disease and not its symptoms. For this purpose, thorough history of the patient is recorded in addition to his pulse, urine, stool examination. The diseased condition is considered to be due to the imbalance between humours and accordingly treatment is given. The drugs are polyherbal formulations and their collective effect is considered.

SIDDHA SYSTEM OF MEDICINE

The Siddha system of medicine is the oldest among the traditional systems of India contributing much to the health care of human beings. The period of origin of Siddha medicine is evident from the extensive references available in the ancient Tamil Literature namely **'Thirukkural'** and **'Tholkappiam'.**

All existing things in the world and the Universe around it are made up of five basic elements, the earth, water, fire, air and space. The elements consisting the human body and other worldly substances are explained as Pancha bootha Panjeekaranam. Siddhas described 96 principles as the constituent of human beings. They include physical, physiological, moral and intellectual components of a person. They are nothing but the manifestation of the five basic elements.

The Sidha system of medicine evolved was perfected in the southern part of India. Plants had an extraordinary central role in ancient Tamil Culture. Besides their use in daily economy and trade, plants were an integral part of ancient Tamil life. Their faith in the Siddha system is partly due to the great reverence with which they hold the **Siddhars**. Siddha medicine is a storehouse of surprisingly powerful curative agents which is now demonstrated by treatments given at the Government Hospital of Thoracic Medicine, Chennai to patients with HIV infection. The Ministry of Health and Family Welfare, Government of India has funded for the Regional Centre for Siddha System of Medicine in Chennai to treat the patients for various diseases by using native medicine. Notable siddha drugs are ***Rasagandhi mezhugu, Amukkura churanam and Nellikai legiyam.***

The diagnostic methodology in siddha system is eight fold. The primary and the very unique in siddha system is pulse diagnosis. Apart from this, examination of tongue, complexion, speech, eyes, examination of urine are the tools used for the diagnosis.

HOMOEOPATHY SYSTEM OF MEDICINE

In comparison to other traditional system of medicine, Homeopathy is a newer one and has been developed in the eighteenth century by **Samuel Hahnemann** – German physician and chemist. He proposed that the cause of disease itself can be used for its treatment. He showed that *Cinchona* can be an effective cure for malaria. The collection of his findings is called **'The Organon of Medicine'.** Various medicinal plants used in homoeopathy are *Thuja occidentalis, Colchicum autumnale, Aconitum napellus* etc.

POINTS TO REMEMBER

- Neem is considered as a good purifier of air.
- The seeds of neem contain on essential oil called margosa.
- Vinca rosea contains a number of alkaloids and is used in treatment of cancer.
- The pungent principle of ginger is zingerone.
- The colouring matter in tumeric is curcumin.
- Ayurveda, Unani, Siddha and Homeopathi are different systems of medicine.

SELF EVALUATION

I. Choose and write the correct answer:

1. _____of Neem is used as insecticide.
   a) Leaf b) Flower c) Root d) Bark
2. The fruit of Neem is a _____.
   a) Drupe b) Follicle c) Capsule d) Nut
3. _____ is the major producer of Ginger.
   a) West Bengal b) Kerala c) TamilNadu d) Karnataka

II. Fill in the blanks with suitable terms:

1. Ginger contains an essential oil called _____.
2. _____ is a bitter constituent obtained from neem oil.
3. _____ is an alkaloid got from Vinca rosea.
4. The pungent principle of ginger is _____.

III. Answer the following questions in one or two sentences:

1. Mention any two uses of the rhizome of ginger.
2. What is the basis of Ayurveda?
3. What is pharmacognosy?
4. How is Neem used traditionally?

IV. Write short answers for each of the following questions in 100 Words :
(Draw diagrams wherever necessary).

1. Write a note on the chemical composition and traditional use of ginger.
2. How is Neem used in Ayurveda medicine?

UNIT 6

OUR ENVIRONMENT

The word "Environment" is derived from the French word "Environner" which means to encircle or surround. Thus, environment is the whole of all biotic (living) and abiotic (non living) factors that surround and potentially influence the organisms.

Environment provides a very close association and high degree of interdependence between the living and non living components of the biosphere. Among all the non living components water is an essential factor. It is a universal solvent. It plays a vital role in photosynthesis and in respiration. Nearly 80% of plant tissues are composed of water.

6.1 FRESH WATER CRISIS AND MANAGEMENT

The world is heading towards a water crisis due to natural and man-made hazards. According to a recent United Nations report, the supply of clean and fresh water is depleting in some regions, that within 30 years, about 2/3 of the population will suffer severe water stress. A special pattern of moist air movement is called monsoon. In India, if the monsoon fails, there will be water scarcity during summer seasons.

Resources of fresh water

Rain is the main resource of water for rivers, lakes, wells and springs. The ocean contains 93-97% of all the earth's water and it is the largest water habitat. The fresh water that can be utilised by man constitutes only 3%. Of this, only 1% is available for man's use. The rest is found in the ice caps and glaciers. Ground water forms 25% of our fresh water resources.

Causes of fresh water crisis

Natural forces : The natural forces such as poor rainfall or monsoon failure, hot winds, river changing directions are the causes for fresh water crisis.

Human causes : Human causes such as increase in population, rapid urbanization, over grazing by cattle, improper cultivation methods, irregular irrigation, poor sewage system and inadequate funds for providing required infrastructures.

Depleting ground water : Rural population depends on ground water for drinking and other domestic purposes. Over use of the supplies causes several kinds of problems, including drying of wells, natural springs and disappearance of surface water features such as wet lands, rivers and lakes. A heavily pumped well can lower the ground water table so that nearby shallower wells go dry.

Sea water intrusion : Many parts of the world are losing fresh water sources due to salt water intrusion. It disturbs the ground water table. Free flowing rivers are changed or converted into reservoir or linear sterile irrigation channels. Water is continuously evaporating from the fresh water lakes, ponds and dams. Leakage and siltation also happen in fresh water sites.

6.2 CONSERVATION OF WATER

Water is an essential natural resource for sustaining life and environment. It is a major component in all living systems. Plants use water as one of the components for photosynthesis. The root hairs absorb water from the soil in the form of solutions and is used as a mean of transport of nutrients inside the plant body. It is also essential for the maintenance of essential fluids through ionic balance and acid balance.

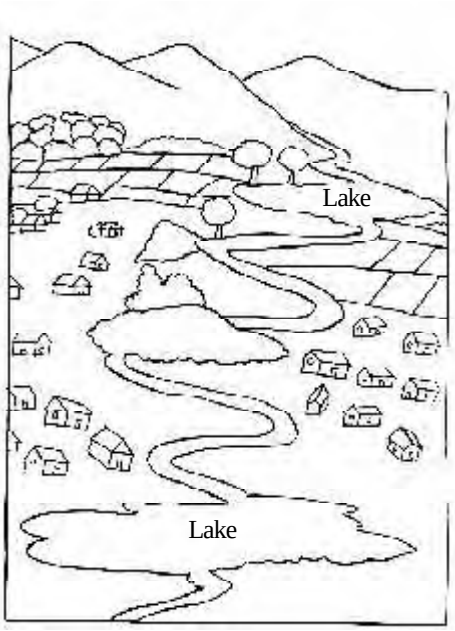


Fig 6.1 Conservation of water

The available water resources are under tremendous pressure due to increased demands. Water which is the free gift of nature, will soon become a scarce commodity. Therefore, conservation and preservation of water resources are urgently required to be done at priority basis. Water management has always been practiced in our communities since ancient times. But such practices have faded away during the past few decades mainly due to lack of awareness.

6.3 RAIN WATER HARVESTING

Rain water harvesting is a method adopted in the fresh water management. Urban centers in India are facing acute shortage of water on one hand and on the other, the streets are often flooded during the monsoons. This leads to serious problems with quality and quantity of ground water. This is despite the fact that all these cities receive good rainfall. However, this rainfall occurs during short spells of high intensity. Most of the rainfalls is just 100 hours out of 8,760 hours in a year. Because of such short duration of heavy rain, most of the rain falling on the surface tends to flow away rapidly leaving very little for recharge of ground water. Most of the traditional water harvesting systems in cities have been neglected, worsening the urban water crisis. Rain water harvesting facilitates capturing the run off water.

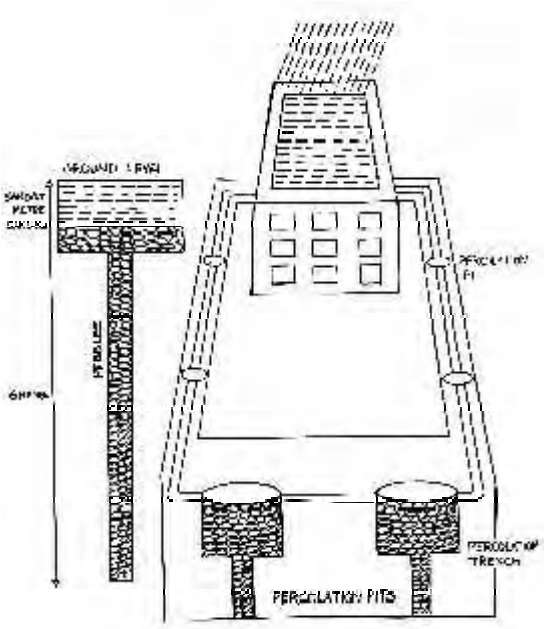


Fig 6.2 A method of rain water harvesting

Role of Government in rain water harvesting

In our country, the Ministry of Water Resources is endeavouring to make rain water harvesting a part of everyday life in our villages and cities as a people's movement. The Government of Tamil Nadu leads the Nation in implementing rain water harvesting programme. It has made it mandatory for all houses and buildings in the state to install rain water harvesting facility.

Methods of Rain Water harvesting

1. Seeding clouds

Seeding clouds method in which getting rain is made possible by spraying the dry ice or potassium iodide particles to initiate rain, if water laden clouds and conditions favour precipitation.

2. Rain water collection

Rain water harvesting essentially means collecting rain water on the roof of building or court yards and storing it underground for later use. The main idea in harvesting rain water is to check the run off water. The rain water that falls on the roofs of buildings or in court yards is collected through pipes and stored in underground tanks of the buildings fitted with motor for lifting water for use. The process of rain water harvesting is not only simple but economical also. It helps in meeting the increased demand for water, particularly in urban areas and prevent flooding of roads.

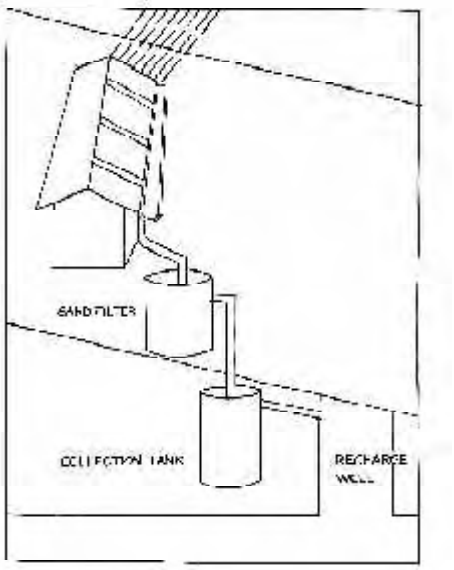


Fig 6.3 Fresh water management

The other methods of fresh water management

1. Water shed management

The management of rainfall and resultant run off is called water shed management. A water shed is an area characterized by water flow. Constructing of small dams can hold back water which will provide useful wild life habitat and stock watering facilities.

2. Dams, Reservoirs and Canals

It is to trap run of water from dams and storage reservoirs and transfer the water from areas of excess to areas of deficit using canals and under ground pipes.

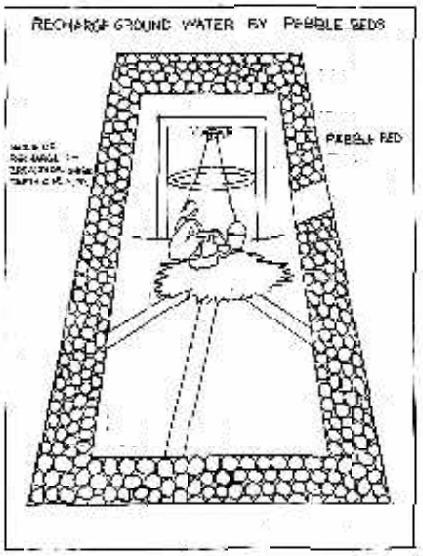


Fig 6.4 Domestic conservation method of water

3. Wetland conservation

It preserves natural water storage capacity and acts as aquifer recharge zones.

4. Domestic conservation

As an individual every one can conserve water and reduce the water loss by taking shorter shower, using low-flow taps, using recycled water for lawns, house plants and vehicle washing and using water conserving appliances.

5. Industrial conservation

Cooling water can be recharged and waste water can be treated and reused.

6. Desalination (Reverse osmosis)

Desalination of ocean water is a technology that have great potential for increasing fresh water. Desalination is more expensive than most other sources of fresh water. In desalination the common methods of evaporation and re-condensation are involved.

6.4 POLLUTION

Environment is the sum total of water, air and land, inter-relationships among themselves and also with human beings and other living organisms. The favourable unpolluted environment has a specific composition. When this composition gets changed by addition of harmful substances, the environment is called polluted environment. The substances polluting it are called pollutants. Environmental pollution can, therefore, be defined as "any undesirable change in the physical, chemical or biological characteristics of air, water and soil that may harmfully affect the various forms of life".

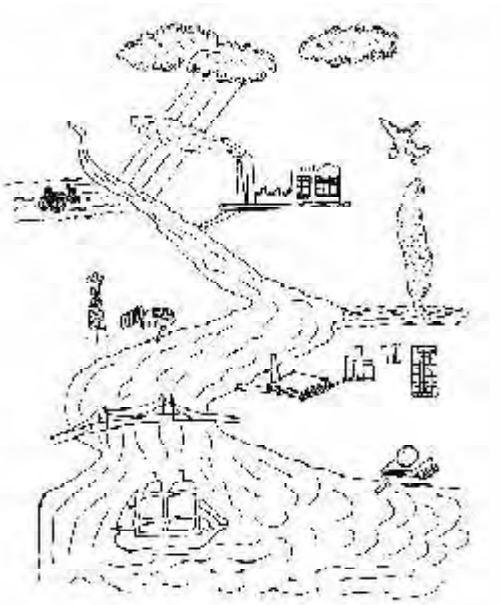


Fig 6.5 Types of pollutants

Wangart Maathai (2004) Nobel Prize Winner said that "The environment is very important in the aspects of Peace because when we destroy our resources, they become scarce and we fight over them."

Types of Pollution

Pollution is classified into three broad divisions as follows :

1. **On the basis of environment** pollution can be divided into three categories namely air pollution, land (soil) pollution and water pollution.
2. **On the basis of nature of pollutants** involved, this can be divided into two types. They are bio-degradable and non-degradable.
3. **Natural sources** like volcanic eruption, earth quakes, dust storms and man-made **(Anthropogenic)** sources. e.g. industrial and agricultural effluents.

6.5 INDUSTRIAL EFFLUENTS AND TREATMENT

The industrial activities produce waste water or effluents. These contain different kinds of organic and inorganic pollutants. Most of the substances present in these effluents are toxic to the ecosystem and are non biodegradable.

Chemical factories, petroleum refineries, leather and textile industries are the sources of several inorganic substances. These substances mostly include the heavy metals (eg. lead, mercury and copper) acids and salts. Agro-based industries and food processing centres produce effluents, rich in organic wastes. Treatment of waste water from industries is the prime concern today since they affect the aquatic ecosystem and also become a source for pathogenic microbes.

Eutrophication

The waste water with organic and inorganic elements reaches water bodies like ponds, lakes, etc. The nutrient content of water in these water bodies increase and cause profuse growth of algae. This is called algal bloom and covers the water surface thereby decreasing the oxygen content of water. This is followed by death of aquatic organisms. This process of enrichment of nutrients of water followed by loss of species diversity is known as **eutrophication**.

Effluent treatment plants

The industrial and municipal waste waters are treated in effluent treatment plant before they are discharged into water bodies. The following method is usually employed to treat waste water.

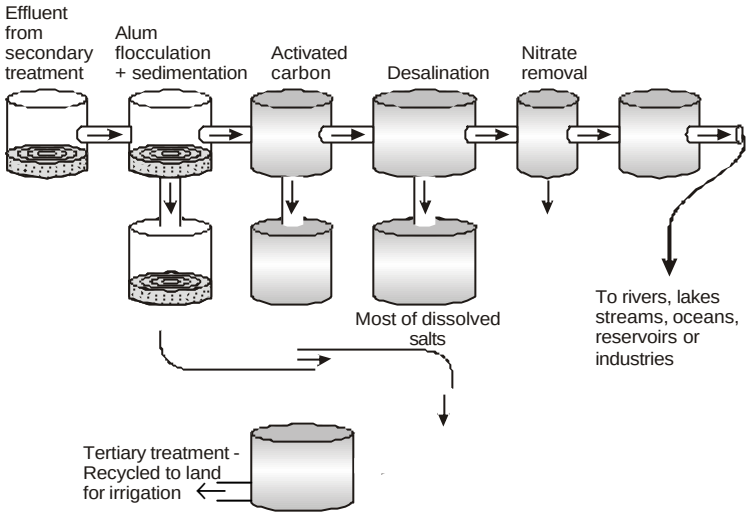


Fig 6.6 Method of effluent treatment plant

Primary treatment

This involves physical separation of large pollutants followed by sedimentation in large tanks. The suspended impurities are removed by sedimentation.

Secondary treatment

This is biological treatment of waste water and is effected by micro organisms. In this treatment, waste water is pumped into oxidation ponds. The micro organisms oxidise the organic matter and produce minerals and carbon di oxide. The remaining solid waste forms sludge. Active aeration is also brought about at this stage by growing algae in the upper surface of water. This supplies the necessary oxygen to the bacteria to bring about active decomposition of the organic pollutants.

Tertiary treatment

In this stage chemical substances present in water are removed. Strong oxidizing agents like chlorine are used to bring about chemical oxidation of water. UV radiation, Reverse Osmosis and other methods are employed in tertiary

treatment. After this, waste water can be discharged into natural waters or used for irrigation.

6.6 AIR POLLUTION

It is described as any change in the composition of air either by physical or chemical methods so as to cause harmful effects on health. These substances include gases, particulate matter, radio active substances, etc.

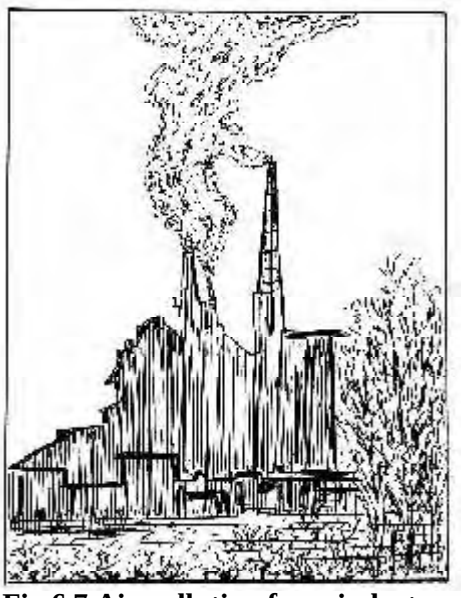


Fig 6.7 Air pollution from industry

Sources

There are mainly two sources

i. Natural sources
ii. Man-made (anthropogenic) sources

Natural sources

Volcanic eruptions, forest fire, sea salt sprays, biological decay, photochemical oxidation of terpenes, marshes, pollen grains, spores, etc. Radioactive minerals present in the earth's crust are the sources of radio activity in the atmosphere.

Man made sources

Industrial emissions, vehicles, aeroplanes, etc.

Air Pollutants

The following table shows a few air pollutants, their sources and effects on human beings.

Pollutants	Sources	Effect on human health
1. Carbon monoxide	(i) Incomplete combustion of fossil fuels (Petrol, Diesel, etc.) (ii) Burning of coal	(i) Decreases O_2 carrying capacity of blood (ii) Headaches, Nausea, Chest pain & vision problems.
2. Nitrogen oxides	(i) Automobile exhausts (ii) Coal industries, etc. (iii) Photochemical smog.	(i) Respiratory disorder (ii) Lung diseases may be caused.

Pollutants	Sources	Effect on human health
3. Sulphur di oxide	(i) Burning of sulphur containing fuel (aeroplanes) (ii) Chemical industries, Paper factory and fuel industries	(i) Chest troubles - Asthma irritation of eye, nose, throat
4. Hydrocarbons	(i) Fuel combustion	(i) Irritation of mucous membrane
5. Nitrophenol	(i) Chemical industries from unleaded petrol from burning of Polythene	(i) Responsible for Blood Cancer (ii) Bladder cancer (iii) Reproductive problems
6. Lead	(i) Metal industries	(i) Causes nervous & kidney problems

Other effects of Air Pollution are as follows :

Acid Rain

Oxides of nitrogen, sulphur, carbon produced by combustion of coal, petroleum, etc. dissolve in atmospheric water vapour. They form their corresponding acids like nitric acid, sulphuric acid, etc. and reach the earth surface as acid rain.

Effects of acid rain

- It changes the pH of the soil and destroys plants.
- It irritates eyes and skin of human beings.
- It decolourizes the leaf pigments and causes chlorosis and necrosis.
- Acid rain inhibits carbon di oxide fixation and photorespiration.
- Acid rain enters in lakes and rivers and destroy the aquatic life.
- It causes corrosion of many buildings, monuments, bridges, etc.
- In inhibits seed germination and growth of seedlings.

Global warming

Gases like carbon di oxide, methane are called green house gases. The increase in the concentration of these gases in the atmosphere allows radiations

of short wave length to escape into space. Solar radiations of long wave length are reflected back to the earth. The consequent increase in the global mean temperature due to green house gases is called **global warming.**

This has led to rise in sea level, has an effect on distribution of species and also brings about drastic changes in weather and climate.

Steps to reduce global warming

i. Reduction in emission of green house gases by reduced usage of fossil fuels.

ii. Increase the vegetation so that carbon di oxide is effectively used for photosynthesis.

iii. Develop alternative renewable sources of energy like solar energy, wind energy, etc.

Ozone depletion

Ozone is a colourless gas, found in the upper atmosphere (stratosphere) and is highly beneficial. Ozone absorbs the UV radiation from the sun, thereby protecting life on our planet. Ozone layer in the stratosphere is thinning due to the emission of pollutants like aerosol, chloro fluro carbon (CFC) into the atmosphere. Holes caused in the Ozone layer allow the harmful UV radiation to reach the earth surface. This causes skin cancer, affects the immune system, etc.

6.7 CONTROL OF AIR POLLUTION

Air pollution can be minimized by the following methods :

1. Use of crude oil should be avoided and use of high quality of fuels, unleaded petrol, bio-diesel and compressed natural gas (CNG) should be recommended. This will reduce sulphur and hydrocarbons content in the atmosphere.
2. Use of automobiles should be minimized and it can help the reduction of Nitrogen contents (NO) = Nitrogen oxides in the atmosphere.
3. Industrial smokes must be filtered before releasing into the atmosphere.
4. Vehicular pollution can be checked by regular tune-up of engines.
5. Use of renewable energy sources like solar energy, tidal energy, hydro energy may be adopted.
6. Bio-pesticides can be used instead of chemical pesticides in agriculture.

7. Radio-active explosions should be banned.
8. By planting more trees to get pure air (O_2) and reduce the CO_2 content of the environment.

6.8 NOISE POLLUTION

We hear various types of sounds everyday. A type of sound may be pleasant to someone and at the same time unpleasant to others. The unpleasant and unwanted sound is called "noise". The word "noise" is derived from the Latin word "nausea" meaning a feeling of sickness at the stomach with an urge to vomit. It is defined as "an unwanted or disagreeable sound that causes discomfort".

Sources of noise pollution

This can be classified into three categories :(1) Industrial noise (2) Transport noise (3) Neighbourhood noise.

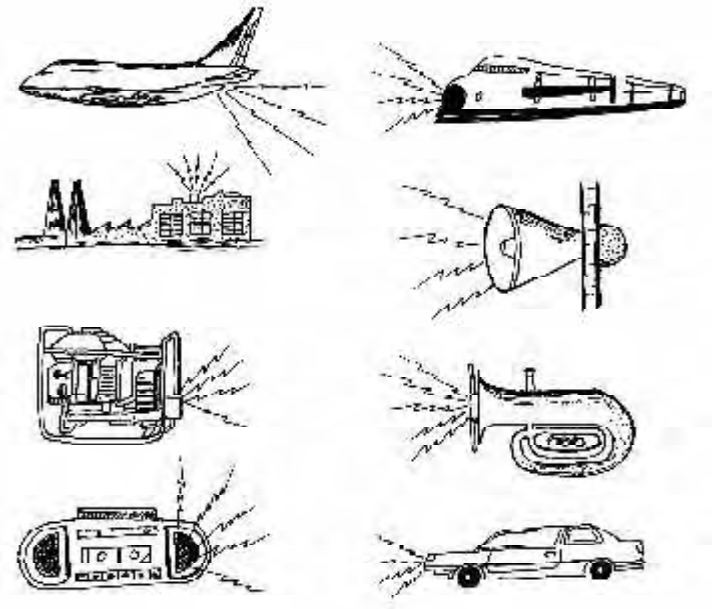


Fig 6.8 Sources of noise pollution

1. Industrial noise: It is caused by heavy machines.
2. Transport noise: It is caused by road traffic noise, rail, air craft noise, etc.

3. Neighbourhood noise: The common noise makers are musical instruments, TV, radio, transistors, telephones, washing machines, vacuum cleaners, fans, mixie, air conditioners and loud speakers. So noise is considered as potentially serious pollutant.

   Sound is measured in decibel **(dB)** unit. The human hearing capacity varies in intensity from 10 to greater than 120 dB. Any sound above 120 dB causes physical discomfort and pain in the ears.

Effects of noise pollution

- It affects human health, comfort and efficiency.
- It leads to excessive secretion of adrenalin into blood stream, which is responsible for high blood pressure.
- It increases the rate of heart beat, constriction of blood vessels, digestive spasms and dilation of pupil of the eye.
- It distracts attention and causes emotional disturbance.
- Excessive noise can lead to loss of hearing.
- Ultra sonic sound can affect the digestive, respiratory, cardio vascular system and the semicircular canals of the internal ear.
- Buildings are subjected to damage like cracks, broken windows, doors, etc. by sudden and explosive sound.

Prevention and control of noise pollution

- Lubrication and maintenance of machines can reduce noise.
- The workers in factories should be provided with ear protection aids.
- Planting trees like neem, coconut which are good absorbers of noises of high frequencies.
- Providing enclosures, shields, barriers are effective methods of reducing noise pollution.
- The intensity and time with regard to use of public address systems must be restricted.
- There should be silence zones around residential areas, educational institutions and hospitals.

The Government of India has drafted legislations which are meant for the protection of the environment. It is essential that all of us abide by the rules to save the environment and also mankind from the harmful effects of different kinds of pollution.

POINTS TO REMEMBER

- Environment is the sum total of all biotic and abiotic factors surrounding an organism.
- Rain is the main source of fresh water.
- Green plants use water for their photosynthesis.
- Rain water harvesting is a method adopted in the fresh water management. It improves the quality and quantity of ground water.
- Any undesirable change in the environment (air, water and soil) is called as pollution.
- The substance which causes pollution is known as pollutant.
- Any change in the composition of air either by physical or chemical methods to cause harmful effect on health is known as air pollution.
- The oxides of nitrogen, sulphur and carbon produce acid rain.
- The increased temperature of the earth due to accumulation of CO_2 is known as global warming.
- The unpleasant and unwanted sound is called noise.
- Sound is measured on decibal unit.

Self Evaluation

I. Choose and write the correct option for the following questions.

1. Which of the following is the main source of fresh water?
   a) Rain b) Ocean c) Sea d) Ground water
2. Photosynthesis occurs in
   a) All bacteria b) Fungi c) Virus d) Green plants
3. Reverse osmosis of ocean water is a technology, which is commonly known as
   a) Desalination b) Seeding clouds
   c) Evaporation d) Recondensation
4. The man made pollution is known as
   a) Hydrogenic b) Paleogenic c) Anthropogenic d) Phytogenic
5. The green house gas is _____ .
   a) SO_2 b) NO_2 c) CO_2 d) O_2
6. Excessive noise can lead to affect
   a) Lungs b) Ear c) Nose d) Muscles

II. Fill in the blanks with suitable terms.

1. The word environment is derived from _____.
2. Many parts of the world are losing fresh water sources due to _____.
3. The sources of inorganic substances that will cause pollution are _____ and _____ .
4. The man made pollutants are _____ and _____ .
5. Acid rain inhibits _____ and _____ in plant growth life.
6. CFC refers to _____.
7. Human hearing capacity is from _____ to _____.

III. Answering the following questions in one or two sentences.

1. Define the term 'Environment'.
2. Define algal bloom.
3. Define the term 'Desalination'.
4. What is meant by pollution?
5. What is meant by eutrophication?
6. What is acid rain?
7. Mention the sources of noise pollution.

IV. Write short answers for each of the following questions in 100 words.

1. What are the causes of fresh water crisis?
2. Mention the methods of fresh water management.
3. What are the effects of acid rain?
4. Write a note on ozone depletion.
5. What are the effects of noise pollution?

V. Write detailed answer for each of the following questions in 200 words.

1. Explain the different methods of rain water harvesting.
2. Describe the methods of industrial effluent treatments.
3. Explain the methods of control of air pollution.
4. Describe the prevention and control methods of noise pollution.

UNIT 7

APPLIED BIOLOGY

Agriculture contributes to the welfare of a nation. Agriculture may be defined as the science or practice of farming. It is derived from the Latin term "Ager Cultura" meaning "field cultivation". Agronomy is the science of soil management and crop production. A farmer uses "agricultural practices or farm operations" to get the maximum yield from his fields. The present agricultural land is polluted physically, chemically and biologically. As a result the productivity is gradually reduced. Over population, unplanned industrialization and migration towards cities and urban areas have created an unhealthy environment. Most of the agricultural lands have become barren.

We need crops with high yield and better nutritive value. The quantity and quality of crops can be improved by modern scientific methods. These have been undertaken by ICAR (Indian Council for Agricultural Research) and the National Seed Corporation (NSC) for production and marketing of selected seeds. State Agricultural Universities and non-government research organizations are also involved in the programmes. Wheat improvement was first started in Mexico in 1963-64 by **Norman Borlaug,** an American Agronomist.

7.1 GREEN REVOLUTION

In 1943 the British were ruling India. About four million people died due to hunger. The Bengal Famine is recorded as the world's worst food disaster. It was due to an acute shortage in food production. Four years after the British left India, when the Legistative Assembly met to discuss various issues, the measures for food security topped the agenda.

The architect of green revolution in India is Bharath Ratna **C.Subramaniam**. The Indian Council for Agricultural Research which was established by the British in 1923, was reorganized in 1965 and then again in 1973. **Dr. M.S.Swaminathan** and **Dr. M.P.Singh** are regarded as the pillars of India's Green Revolution.

Three Basic Elements: The Green Revolution was most successful in India because there were three basic elements to increase the productivity.

1. Continued expansion of farming areas: As a result, quantitative expansion of farm lands were covered.
2. Double – Cropping: Instead of one crop season per year, the decision was made to have two crop seasons per year.
3. Using seeds with improved varieties : The ICAR has developed new strains with high yield value (HYV) seeds mainly in wheat, rice, millet and corn etc.

There are many varieties of rice grown in India. The two main varieties are hill rice (upland variety) and swamp rice (low land variety). IR8, Jaya, Padma are some examples of hybrid varieties. Bela and N-22 are disease resistant varieties while IET - 1444 is a drought resistant one. There are two main varieties of wheat: bread wheat grown in spring and macaroni wheat grown in winter. The hybrid varieties are Sonalika, Kalyanasona, etc.

Statistical Results of the Green Revolution

The Green Revolution resulted in a record grain output of 131 million tonnes in 1978-79. This has established India as one of the world's biggest agricultural producers. The crop area under HYV varieties grew from 7% to 22% of the total cultivated lands during 10 years of the Green Revolution.

The percentage of total cultivated area for food crops has come down since 1950-51 but it is still predominant group with a coverage of 70%. The total food grain production of the country was 1900 Lakh tonnes in 1995-96.

Rice	794 Lakh tonnes	1995-96	1900 Kg per hectare
Wheat	626 Lakh tonnes	1995-96	2400 Kg per hectare
Millet	30 Lakh tonnes	1995-96	----
Pulses	13 Lakh Tonnes	1995-96	----
Tea	7.7 Lakh tonnes	1994-95	----
Coffee	1.8 Lakh tonnes	1994-95	----
Rubber	0.464 Lakh tonnes	1994	1265 Kg per hectare
Oil seed	226 Lakh tonnes	1995-96	----

Economic Results of the Green Revolution

Crop areas under high – yielding varieties need more water, fertilizers, pesticides, fungicides and certain other chemicals. This spurred the growth of local industrial growth, new jobs and contributed to the country's GNP (Gross National Product).

India repaid all the loans it had taken from the World Bank and its affiliates for the purpose of the Green Revolution. Canada asked the Indian Government to supply them with farmers experienced in the procedures of the Green Revolution. This helped India's foreign exchange earnings. The technologies were exported abroad. The Indian Agricultural Research Institute (IARI) is now working on a genetically modified 'Golden Rice' containing pro-vitamin A. India tops the world in the exports of spices.

Agricultural Techniques employed in Green Revolution

The techniques introduced to the developing world by the Green Revolution are use of high yielding hybrid variety of seeds and extensive use of chemical fertilizers, different types of irrigation, the use of heavy machinery for every possible agricultural process and extensive use of pesticides. Without the Green Revolution, agriculture would not have met the basic food requirements of the worlds' current population.

Agricultural Quality Control

The Green Revolution only focuses on hybrid, genetically modified and high yielding crops. They have had a deleterious effect on the quality of agricultural production resulting in loss of bio diversity and low health value food quality. Many people still believe that a second Green Revolution is likely to start and should focus on food crops grown with higher gross nutrition level and increased caloric value.

Agriculture is a major foreign exchange earner for our country through exports of goods like tea, spices, cotton, coffee and jute. Agriculture is the main support for our roadways and railways which move bulk of farm produce. Therefore, agriculture is rightly considered as the 'backbone of Indian Economy'.

7.2 PLANT BREEDING

Plant improvement is a method of combining desirable characters of a particular plant or a group of plants and then multiplying them. It is one of the most important applications of genetic principles.

Plant Breeding

The term 'plant breeding' is applied to techniques of improving plants. This is aimed at the following aspects.

1. Better yield varieties.
2. Improving resistance to insects, pests, fungal diseases, drought, frost and salinity.
3. More nutritive value.
4. Production of dwarf varieties.

There are seven different techniques that are used in plant improvement. They are:

1. Selection
2. Hybridization
3. Polyploid breeding
4. Mutation breeding
5. Protoplast fusion
6. Tissue Culture
7. Genetic engineering

1. **Selection:** It is the process of choosing a desirable crop, year after year for planting in the next season. It is the oldest method of crop improvement. Selection methods are of two types (i) mass-selection and (ii) pure line selection.
2. **Hybridization :** It is a process of crossing plants of two varieties, species or genera to bring together desirable characters (traits) in the progency called hybrids. The superiority of the hybrid over either parent, in one or more traits, is called Hybrid vigour or Heterosis. **Karpechenko** a Russian geneticist produced an intergeneric hybridization between radish and cabbage.

   Radish (Raphanus) x Cabbage (Brassica) $\rightarrow$ Raphanobrassica

3. Polyploid Breeding

A diploid plant has two sets (2n) of chromosomes, but any organism in which the number of sets of chromosomes is more is called a polyploid. Polyploidy can be induced by the use of a alkaloid called Colchicine (extracted from ***Colchicum autumnale)*** to double the chromosome number. Eg. Wheat. Polyploid plants contain more vitamins, than the normal diploid plants.

4. Mutation Breeding

Mutations are sudden changes in the genetic materials. Mutation can be artificially induced by treating seeds, seedlings or buds by the mutagens such as UV and X-rays. Radiation induces mutation to develop new variety of crops. Pest resistant ground nuts, with thick shells are produced by induced mutation breeding.

5. Protoplasmic fusion or Somatic hybridization

A hybrid produced from fusion of protoplasts along with nuclei of two different species is called somatic hybridization. Protoplast fusion is facilitated by using polyethylene glycol (PEG). An intergeneric hybrid, pomato, has been obtained by fusing protoplasts of potato and tomato.

Potato x Tomato $\rightarrow$ Pomato

6. Tissue Culture

It is a technique by which protoplasts, cells, tissues or an organ of a plant are grown in a static or liquid nutrient medium *in vitro* (culture tubes or flasks), under aseptic conditions and under controlled conditions of light and temperature. The technique is based on a concept that plant cells are 'totipotent', which is the ability of a single living cell to grow into a complete organism under appropriate conditions. **Haberlandt** (1902) a German Botanist made the first attempt on plant tissue culture. **Frank Steward** along with his colleagues, in 1953, successfully propagated carrot plants from the phloem of the roots. In India, it was **Prof. P. Maheswari** and **Dr. S.Narayanaswamy**, who initiated tissue culture at Delhi University.

7. Genetic Engineering

It is a tool used in plant improvement programmes. Its objective is to identify, isolate and introduce a desirable gene or genes into a crop plant that normally does not possess them. Transgenic plants such as tobacco, tomato, potato, apple, cotton and sunflower are produced. They are also called genetically modified plants (GM Plants).

The role of green manuring and bio-fertilizer

Various leguminous plants like ***Crotolaria juncea***, ***Cassia mimusoides*** accumulate more than 80 Kg of nitrogen per hectare in the soil when grown as green manures. ***Azolla*** an aquatic fern adds 30 Kgs of nitrogen per hectare where the yield is more or less similar to that of urea or ammonium phosphate. The mycorrhizal fungi and blue green algae ***(cyanobacteria)*** are also used as biofertilizers to increase the productivity of plants.

7.3 ECO-FRIENDLY AGRICULTURE

The goal of eco-friendly agriculture techniques is to reduce the input of chemical fertilizer and agricultural chemicals and to use organic fertilizer to achieve high yield. Bio-control agents like ***Trichoderma*** can be used instead of chemical pesticide to control plant diseases.

Eco-friendly agriculture includes all kinds of agriculture that foster high soil vitality and preserve agriculture environment. It means low input in agriculture, organic agriculture, or natural agriculture.

Purpose of Eco-friendly agriculture

It aims to prevent the ecosystems needed to maintain our lives from being destroyed or becoming impossible to restore. It is the agricultural system which maintains the reproductive process of nature and preserves the environment to secure productivity and profitability in the long run in harmony with the ecosystem.

Types of Agriculture

The two major types of agricultural practices followed in India at present are,

1. Intensive subsistence farming
2. Plantation agriculture

The intensive subsistence farming refers to cultivating the available land with high inputs of fertilizers and manures and using irrigational facilities wherever possible, with the aim of obtaining maximum yield.

Plantation agriculture: It refers to cultivation on an extensive area using efficient and scientific methods of farming. The crops grown in these plantations are tea, coffee and rubber.

Methods of cultivation

a. Broad casting: It involves throwing the seeds over the soil. This method is adopted when poor quality of seeds are used, labour is scarce and soil is infertile.
b. Dibbling: In this method seeds are dropped in furrows made by the ploughs at regular intervals.
c. Drilling: In which a bamboo shaft is attached to the plough and selected seeds are dropped through the bamboo shaft in a straight line.
d. Transplantation: It is a method in which the seeds are soaked in water before being sown in nurseries. Seedlings are raised about 15-20 cms. Later they are uprooted and planted again in fields.

Types of Crops

Rice and wheat are food crops, grown by the above methods. The crops are grouped under two major categories namely food and cash. The food crops are further grouped under cereals and pulses. Sugarcane, tobacco, cotton, rubber and jute are the cash crops. The coarse grains like jowar, bajra, and ragi are together called millets. These are hardy plants, resistant to heat and drought. They are also known as 'dry crops'. Dry crops thrive well in regions of inferior soil, low rainfall and high temperature.

Crop rotation

Pulses include different forms of dal. They are cultivated all over the country except in areas of heavy rainfall. They supply much required protein. They are leguminous and restore fertility to the soil by fixing atmospheric nitrogen. They are usually rainfed crops grown off season of rice or wheat. Therefore, these are valuable "crops of rotation", or cover crops (crops grown at the ground level to prevent soil erosion). They enrich the soil fertility.

Role of Green manuring

Various leguminous plants like *Crotalaria juncea, Cassia mimusoides, Glycine max, Indigofera linifolia, Acacia nilotica, Lathyrus* and *Mucuna* are used as green manures. They provide more than 80 Kg of nitrogen per hectare in the soil when added as green manures. In biological nitrogen fixation, nitrogen is converted into a form usable by plants for producing aminoacids and for further synthesis of proteins by certain bacteria and cyanobacteria.

Advantages of bio-fertilizers

1. Symbiotic nitrogen fixing *Rhizobium* is a bio fertilizer. It adds 50 to 150 Kg of nitrogen to soil. *Azotobacter* and *Azospirillum* secrete antibiotics which act as biopesticides.
2. Bio fertilizers are easy to produce in abundance and are available at low cost to the marginal farmers.
3. Ectotrophic mycorrhizae, which act as a bio-fertilizer, increases the surface area of the roots of host plants, so that more absorption of nutrients by the roots is made possible.
4. Application of bio fertilizers increases yield up to 45% and the left over bio fertilizers in the soil increases yield as long as the bio fertilizers remain in the soil up to 3 to 4 years.
5. Soil fertility is preserved, without causing any damage to the soil.

Need for Eco-friendly agriculture

1. To maintain and preserve a healthy agricultural environment by allowing the soil, water and ecosystem to thrive.
2. To meet customer's demands for safe farm products.
3. To provide a pleasant rural scene with crystal clear water and nature as a local tourist resource.

Our country faces serious land degradation problems which have been aggravated by the pressure of unprecedented exploitation of human and animal populations on the land. More and more lands have become infertile and unproductive due to the lack of sufficient nitrogen.

Planting of leguminous plants provide multifarious advantages. So cultivating effective microbial strains, can easily fix atmospheric nitrogen and enrich the soil fertility.

POINTS TO REMEMBER

- The quantity and quality of crops can be improved by modern scientific methods.
- Green revolution only focusses on hybrid, genetically modified and high yielding crops.
- Plant improvement is a method of combining desirable characters of particular plants or a group of plants.

- The goal of eco-friendly agriculture techniques is to reduce the input of chemical fertilizer and agricultural chemicals.
- Soil fertility is preserved, without causing any damage to the soil.

SELF – EVALUATION

I. Choose and write the correct answer.

1. Ectotrophic mycorrhizae, which act as a
   a) Chemical fertilizer b) Bio-fertilizer
   c) Farm manure d) Soil fertility
2. An example of food crops.
   a) Wheat b) Jute c) Cotton d) Rubber
3. An example of cash crop.
   a) Cotton b) Rice c) Pulses d) Mucuna
4. Seeds are dropped in a furrow in this method of cultivation.
   a) Drilling b) Dibbling c) Broad casting d) Soaking

II. Fill in the blanks with suitable terms.

1. The cultivation of cash crops on an extensive scale using modern technique is known as _____ agriculture.
2. Crops cultivated for other than food are called _____ crops.
3. _____ are valuable rotation crops.
4. _____ are known as dry crops.
5. Food disaster was due to an acute short fall in _____.

III. Answer the following questions in one or two sentences.

1. Define Eco-friendly agriculture.
2. What are the three basic elements of green revolution?

IV. Write short answers for each of the following questions in 100 words.

1. What are the different types of crops?
2. Explain the rotation of crops.

V. Write detailed answer for each of the following questions in 200 words.

1. Give an account of Green Revolution in India.
2. Give an account of Plant Breeding in detail.
3. Give an account of Eco friendly agriculture.

BOTANY PRACTICALS

I. Identification of slides

a) Penicillium - Structure

Identification - The given slide is identified as Penicillium – a fungus, Vegetative structure.

Reasons for identification:

1. The plant body of penicillium is called mycelium.
2. Mycelium consists of thread like structures called hypha.
3. Each hypha is septate and has a cell wall.
4. The cytoplasm consists of a nucleus, organelles like mitochondria, golgi body, ribosomes, etc.
5. It is commonly known as green or blue mould.

Refer **Fig 1.6** (Only Thallus)

b) Penicillium – Asexual reproduction

Identification - The given slide is identified as Penicillium - Asexual reproduction

Reasons for identification :

1. Penicillium reproduces asexually by production of spores called conidia.
2. Some of the hyphae grow vertically and are called conidiophore.
3. The conidiophore bears a terminal cluster of flask like structures called sterigmata.
4. It produces uninucleate spores called conidia
5. Each conidium germinates to form a new mycelium.

Refer **Fig 1.6**

II. Specimens (preserved or fresh specimen)

Fruits: Simple Fleshy Fruits (Refer **Fig 4.1** for diagrams)

Identification: The given specimen is identified as Tomato (V.S.) – Simple fleshy fruit-Berry.

Reasons for identification :

1. Tomato is a simple, fleshy many seeded berry fruit.
2. It is developed from a bicarpellary, syncarpous, superior ovary.

3. The pericarp is differentiated into an outer epicarp (skin), middle mesocarp and inner endocarp.
4. Mesocarp and endocarp are fused to form a fleshy pulp in which the seeds are embedded.

2. Identification : The given specimen is identified as Mango (V.S.) - Simple fleshy fruit – Drupe.

Reasons for identification

1. Mango is a simple, fleshy, one seeded fruit.
2. It is developed from monocarpellary, superior ovary.
3. The pericarp is differentiated into an outer epicarp, middle fleshy mesocarp and inner hard endocarp.
4. The endocarp is stony and encloses the seed.

3. **Identification** - The given specimen is identified as Cucumber (C.S.) - Simple fleshy fruit – Pepo.

Reasons for identification:

1. Cucumber is a simple, fleshy many seeded fruit.
2. It develops from an inferior, syncarpous ovary with parietal placentation.
3. The pericarp is distinguished into epicarp, mesocarp and endocarp.
4. The epicarp is thick and leathery.
5. Mesocarp is fleshy. The placenta with ovules and mesocarp is the edible portion of the fruit.

4. **Identification** - The given specimen is identified as Apple (V.S.) - Simple fleshy fruit-Pome.

Reasons for identification

1. Apple is a simple, fleshy many seeded fruit.
2. It develops from Pentacarpellary, syncarpous,inferior ovary.
3. The thalamus becomes fleshy and forms the edible portion. Hence apple is a false fruit.
4. The pericarp of the true fruit is cartilaginous and encloses the seeds.

5. **Identification:** The given specimen is identified as Orange (C.S.) – Simple fleshy fruit- Hesperidium.

Reasons for identification:

1. Orange is a simple, fleshy many seeded fruit.
2. This fruit is derived from multi carpellary, syncarpous, superior ovary with axile placentation.
3. The pericarp is distinguished into the following layers.
   a. Outer epicarp is thick and leathery. It contains oil glands.
   b. Middle mesocarp is white and spongy.
   c. Inner endocarp forms distinct chambers and produces numerous juicy outgrowths which forms the edible portion.

6. **Identification**: The given specimen is identified as Polyalthia – Aggregate fruit.

Reasons for identification:

1. It develops from a single flower having multicarpellary gynoecium.
2. Each free carpel develops into a fruitlet.
3. A cluster of fruitlets develop from a single flower.

Refer **Fig 4.5**

7. **Identification:** The given specimen is identified as Custard Apple – Aggregate fruit.

Reasons for identification:

1. It develops from multicarpellary, apocarpous ovary.
2. Each free carpel develops into a fruitlet.
3. The margin of the carpels are fused and forms a large fruit.

Refer **Fig 4.5**

8. **Identification** - The given specimen is identified as Jack fruit (V.S) - Multiple fruit.

Reasons for identification:

1. Jack fruit develops from the entire female infloresence.
2. The Perianth of the flower develops into the edible part which is bag like and one seeded.
3. The whitish, elongated, flat structures in between the edible flakes represent the sterile or unfertilized flowers.
4. The spines on the tough rind represent the stigma of the carpels.

Refer **Fig 4.6**

DRY FRUITS

1. **Identification:** The given specimen is identified as Bean fruit – Dry dehiscent fruit-legume.

   Reasons for identification:

   1. The fruit develops from monocarpellary, unilocular, superior ovary with marginal placentation.
   2. The pericarp is dry and dehisces along the dorsal and ventral sutures.
   3. The seeds are liberated at maturity by dehiscence of the pericarp.

Refer **Fig 4.2**

2. **Identification:** The given specimen is identified as Lady's finger: - Dry dehiscent fruit - Capsule.

   Reasons for identification:

   1. The fruit develops from a superior, syncarpous, multicarpellary ovary with axile placentation.
   2. The fruit dehisces at maturity to liberate the seeds.
   3. The dehiscence occurs along the partition wall or septa. Hence it is called septicidal capsule.

Refer **Fig 4.2**

Dispersal of fruit and seeds

Dispersal by wind – Hiptage

Identification - The given specimen is identified as Hiptage.

Reasons for identification :

1. Hiptage is an example for dispersal by wind – anemochory.
2. There are three wing like structures developed on the seed.
3. Two wings are short and are on the lateral sides and the wing at the center is long.
4. The wings help in the dispersal of the seed by wind.

Refer **Fig 4.10**

Dispersal by wind – Acer

Identification: The given specimen is identified as Acer.

Reasons for identification:

1. Acer is an example for dispersal by wind – anemochory.
2. There are two wing like membranous structures developed on the seed on the lateral side.
3. The wings help in dispersal of the seeds by wind.

Refer **Fig 4.10**

Lotus - Dispersal by Water

Identification: The given specimen is identified as Thalamus of Lotus.

Reasons for identification:

1. Lotus is an example for dispersal by water - Hydrochory.
2. The spongy thalamus contain many air chambers.
3. Air chambers help the fruits to float in water.
4. The seeds are liberated by the decay of the thalamus.

Refer **Fig 4.11**

Dispersal by water – Coconut

Identification: The given specimen is identified as Coconut.

Reasons for identification:

1. Coconut is an example for dispersal by water - Hydrochory.
2. In coconut, the mesocarp is fibrous in nature enclosing numerous air spaces.
3. These air spaces help the fruit to float in water.

Refer **Fig 4.11**

III. Bean – Epigeal Germination

Identification: The given specimen is identified as Bean-Epigeal Germination.

Reasons for identification:

1. The seed absorbs water, swells up and ruptures.
2. The hypocotyl grows through the micropyle and the lower part of the hypocotyl is the radicle. It grows downwards to form the primary root system.
3. The upper part of hypocotyl is arched becomes erect and lifts the cotyledon above the soil. Since the cotyledons are brought above the ground it is called epigeal germination.
4. The cotyledons turn outward and release the plumule.
5. The plumule grows upward to form the first foliage which are simple leaves.
6. The cotyledon shrivels, falls and the leaves that develop subsequently are compound leaves.

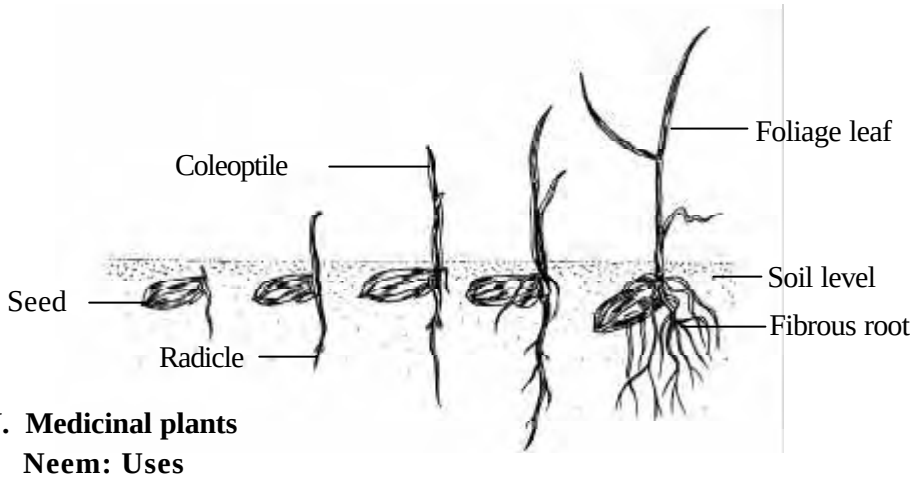
Refer **Fig 4.13**

Paddy – Hypogeal Germination

Identification: The given specimen is identified as Paddy - Hypogeal Germination.

Reasons for identification:

1. The Paddy seed imbibes water from the soil.
2. The radicle elongates, pierces through the coleorhiza. It forms the fibrous root system.
3. The coleoptile emerges out grows rapidly and pushes the tip of the plumule to spilt open.
4. The epicotyl pushes the foliage leaves well above the soil, leaving the seed undisturbed in the soil.
5. The leaves are simple, ribbon shaped with parallel venation.



IV. Medicinal plants

Neem: Uses

1. Neem tree is considered to be a purifier of air.
2. The seeds of neem contain an essential oil called margosa oil.
3. The dried leaves are used as an insecticide.
4. Fruits are used for their anti helminthic properties.
5. Products obtained from different parts of the tree are used to cure diseases like diabetes, leprosy and skin diseases.

Refer **Fig. 5.1**

Ginger: Uses

1. Ginger is used for its carminative properties in medicine.
2. Fresh juice of ginger with honey can cure cough.
3. Ginger is used as a spice due to its aroma.
4. Dry ginger contains proteins , fats , carbohydrates , vitamins and minerals.
5. Ginger is used to treat diseases like rheumatism and pulmonary disorders.

Refer **Fig 5.3**

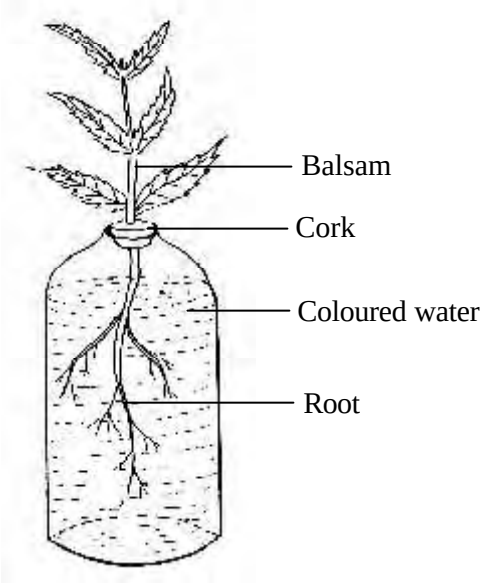
Turmeric: Uses

1. The rhizome contains an essential oil called curcumin which gives colour.
2. The rhizome paste is used to treat skeletal fracture.
3. It is an essential ingredient for cooking.
4. It is used as a dye for cotton textiles.
5. Oil from the rhizome has antibacterial and anti inflammatory properties.

Refer **Fig 5.4**

V. Plant physiology.

1. Ascent of sap



Aim: To prove that ascent of sap takes place through the xylem of the plant.

Apparatus Required: Leafy shoot of Balsam, Bottle with one holed rubber cork, Water, Eosin.

Procedure: A leafy shoot of Balsam plant is cut under water. It is fitted into a bottle containing water using a one holed rubber cork. Few drops of Eosin is added to colour the water. The set up is left for few hours.

Observation: After some time the plant is removed from the bottle. The veins of the leaves will be found to be coloured and red streaks can be observed along the whole length of the semi transparent stem. A section of the stem is observed under a microscope. Red streaks are observed in the xylem of the stem.

Inference: Red streaks are observed due to the usage of coloured water eosin dye in the xylem only. Therefore ascent of sap takes place only through the xylem of the plant.

Result: Thus ascent of sap takes place through the xylem of a plant

2. Mohl's Half Leaf Experiment

Aim: To prove that carbon di oxide is essential for photosynthesis.

Apparatus Required: Potted plant (destarched), Wide mouthed bottle, Split cork, Potassium hydroxide, Materials for testing starch.

Procedure: A destarched potted plant is taken. The plant is destarched by keeping it in darkness for few days. A small quantity of potassium hydroxide solution is taken in a wide mouthed bottle. A split cork is fitted to the mouth of the bottle. One of the leaves of the potted plant is inserted through the split cork such that half of the leaf is inside the bottle. The whole apparatus is kept in sunlight. The leaf is tested for starch after few hours.

Test for Starch: The leaf to be tested for starch is dipped in boiling water for 5 minutes. It is then dipped in 90% alcohol to decolorize it. It is washed with water. Few drops of Iodine solution is added to it. The starch containing part of the leaf will turn blue in colour. The other part of the leaf remains colourless.

Observation and Inference: It is observed that the part of the leaf inside the bottle does not answer the starch test, hence colourless. This is because the carbon di oxide inside the bottle was absorbed by potassium hydroxide and not available to the leaf for photosynthesis. The part of the leaf outside the bottle could make use of atmospheric carbon di oxide for photosynthesis. It turns blue in colour during the starch test.

Result: This proves that carbon di oxide is essential for photosynthesis.

Refer **Fig. 2.7**

3. Test Tube and Funnel Experiment

Aim: To prove that oxygen is evolved during photosynthesis.

Apparatus Required: Beaker, Funnel, Test tube, Water, Twigs of Hydrilla, splinter.

Procedure: A beaker is taken and filled with water. A few branches of Hydrilla (aquatic plant) are taken and inserted in the glass funnel. The funnel is kept inverted inside the beaker. A test tube full of water is inverted over the stem of the funnel. The apparatus is kept in sunlight for few hours. Air bubbles are seen collecting in the test tube by the downward displacement of water. The test tube is slowly removed by closing the mouth with the thumb. The gas is tested for oxygen using a burning splinter.

Observation and Inference: The splinter glows brightly proving that the gas is oxygen. The gas evolved during photosynthesis is proved to be oxygen, since it favours combustion.

Result: Thus it is proved that oxygen is evolved during photosynthesis.

Refer **Fig. 2.8**

4. Lever Auxanometer

Aim: To measure the growth in length of a plant using Lever Auxanometer.

Apparatus Required: Potted plant, Lever Auxanometer.

Procedure: Lever Auxanometer consists of arc scale mounted on a vertical stand. A long pointer is attached to a pulley and moves on the arc scale. A thread is passed over the pulley with one end of the thread attached to the tip of the plant. The other end of the thread carries a weight, sufficient to keep the thread stretched.

Observation: As the plant grows the pulley moves and correspondingly the pointer moves on the scale. Readings are taken at definite intervals. The distance covered by the pointer is the measurement of increase in length of the plant.

Result: Growth of the plant in length =

$$\frac{\text{Distance travelled by the pointer x Radius of Pulley}}{\text{Length of the pointer.}}$$

Refer **Fig 2.16**

VI. Models

1. **Chromosomes**

1. The chromosomes are specialized, filamentous, nuclear components.
2. Each chromosome consists of two symmetrical structures called chromatids.
3. The chromatids are joined at a particular point called centromere.
4. Genes are located on the chromosomes in a linear fashion.
5. The chromosomes appear in the form of a reticulum and can be seen as individual structures only at the time of cell division.

Refer **Fig. 3.1**

2. DNA (Deoxyribo Nucleic Acid)

The displayed model is identified as DNA – Watson and Crick Model.

Reasons for identification:

1. DNA is made up of a double helical chain.
2. The two strands consist of deoxyribose sugar and phosphate arranged in an alternate manner.
3. The nitrogenous bases found in DNA are purines (Adenine, Guanine) and Pyrimidines (Thymine, Cytosine).
4. The two strands are held together by hydrogen bonds between the nitrogenous bases.

5. Two hydrogen bonds are formed between Adenine and Thymine. Three hydrogen bonds are formed between Guanine and Cytosine.
6. DNA is the genetic material for all living organisms except some viruses.

Refer **Fig. 3.5**

3. RNA (Ribo Nucleic Acid)

The displayed model is identified as RNA.

Reasons for identification :

1. RNA is a single stranded polynucleotide.
2. It consists of Ribose sugar and phosphate arranged in an alternate manner forming the backbone of the strand.
3. The nitrogenous bases found in RNA are purines (Adenine, Guanine) and Pyrimidines (Uracil, Cytosine).
4. RNA is a genetic material in many viruses.

Refer **Fig. 3.7**

VII. Project

1. Prepare a model of DNA (or)
2. Collect any three medicinal plants and describe their usefulness.

STANDARD X - MATRICULATION
QUESTION PAPER DESIGN AND BLUE PRINT
BIOLOGY - BOTANY

Time: $1^{1}/_{4}$ Hrs. **Marks: 50**

I. Weightage to learning outcome.

S. No.	Categories	Percentage (%)
1.	Knowledge	32
2.	Understanding	31
3.	Application	27
4.	Skill	10
	Total	100

Note:

1. Total Mark is inclusive of choice.
2. While preparing question paper, there may be variation in weightage of categories upto 5%.

II. Weightage of various types of questions.

Sl. No.	Types of Questions	Marks for each Question	Total No. of Questions	No. of Questions to be answered	Total Marks
1.	Section - A (MCQ)	1	5	5	5 x 1 = 5
2.	Section - B (FIB)	1	5	5	5 x 1 = 5
3.	Section - C (VSA)	2	7	5	5 x 2 = 10
4.	Section - D (SA)	5	6	4	4 x 5 = 20
5.	Section - E (LA)	10	2	1	1 x 10 = 10
	Total		25	20	50

III. Expansions:

MCQ	:	Multiple Choice Questions
FIB	:	Fill in the Blank
VSA	:	Very Short Answer
SA	:	Short Answer
LA	:	Long Answer

NOTE:

1. While preparing multiple choice questions, the question paper setter should not give options like **"none of the above" and "all the above".**

2. Options to be given are selected only from the text contents. Unfamiliar, irrelevant and non textual matter should be avoided.

3. There should not be any ambiguous options and there must be only one appropriate answer among the four alternatives.

4. Questions are to be framed in such a manner that the candidates should write the VSA in two minutes, SA in five or six minutes and LA in fifteen or sixteen minutes each.

III.

UNITS	MCQ	FIB	VSA	SA	ESSAY	TOTAL
Levels of Organisation	1	1	1	1	--	9
Plant Physiology	1	--	2	1 (Diagram compulsory)	1	20
Cell Biology	1	1	--	1	--	7
Reproduction in plants	1	--	1	1	1	18
Economic Botany	--	1	1	--	--	3
Our Environment	1	1	1	1	--	9
Applied Biology	--	1	1	1	--	8
Total No. of Questions	5	5	7	6	2	74

IV. Level of questions

S. No.	Level of questions	Percent
1.	Easy Type	50%
2.	Average Level	40%
3.	Difficult Level	10%

Note:

The level of difficulty varies from individual to individual. The question paper should be a balanced one on the basis of general expectations from the group as a whole. The question paper setter is strictly instructed to follow the blue print of the question paper and there should not be any deviation.

Standard X Matriculation - Question Paper Design and Blue Print
Biology - Botany
2006 - 2007

UNITS	KNOWLEDGE (24 Marks)					UNDERSTANDING (23 Marks)					APPLICATION (20 Marks)					SKILL (7 Marks)					TOTAL
	MCQ	FIB	VSA	SA	LA	MCQ	FIB	VSA	SA	LA	MCQ	FIB	VSA	SA	LA	MCQ	FIB	VSA	SA	LA	
1. Levels of Organisation	1(1)	-	1(2)	-	-	-	-	-	1(5)	-	-	1(1)	-	-	-	-	-	-	-	-	4
2. Plant Physiology	1(1)	-	-	-	1(10)	-	-	1(2)	-	-	-	-	1(2)	-	-	-	-	-	1*(5)	-	5
3. Cell Biology	1(1)	-	-	-	-	-	1(1)	-	-	-	-	-	-	1(5)	-	-	-	-	-	-	3
4. Reproduction in Plants	1(1)	-	-	1(5)	-	-	-	-	-	1(10)	-	-	-	-	-	-	-	1(2)	-	-	4
5. Economic Botany	-	1(1)	-	-	-	-	-	-	-	-	-	-	1(2)	-	-	-	-	-	-	-	2
6. Our Environment	1(1)	-	-	-	-	-	1(1)	1(2)	-	-	-	-	-	1(5)	-	-	-	-	-	-	4
7. Applied Biology	-	1(1)	-	-	-	-	-	1(2)	-	-	-	-	-	1(5)	-	-	-	-	-	-	3
Total Marks	5	2	2	5	10	-	2	6	5	10	-	1	4	15	-	-	-	2	5	-	74

Note: *Skill (Diagram) - Compulsory Question

Std. X - Matriculation Examination

Model Question Paper (Theory)

Science - II

Biology - Botany

Time: $1\frac{1}{4}$ Hrs. **Marks: 50**

Section - A

I. Choose the correct answer. **5 X 1 = 5**

1. In Penicillium sexual reporduction occurs by the formation of _____ .
   a. ascospore b. conidia c. aplanospore d. endospore
2. RUBP contains _____ carbon atoms.
   a. 4 b. 5 c. 6 d. 8
3. The functional unit of gene is called _____ .
   a. Cistron b. Recon c. Muton d. Operon
4. A fruit is a fertilized _____ .
   a. flower b. ovary c. ovule d. stamen
5. Which of the following is the main source of fresh water?
   a. rain b. ocean c. ice d. groundwater

II. Fill in the blanks with suitable terms. **5 X 1 = 5**

6. A synthetically manufactured antibiotic is _____ .
7. The 'V' shaped structure of chromosomes is called _____ .
8. Ginger contains an essential oil called _____ .
9. CFC refers to _____ .
10. Food disaster was due to an acute shortfall in _____ .

III. Answer any five of the following questions in one or two sentences. **5 x 2 = 10**

11. What is retting?
12. Explain the term “water potential”.
13. What is imbibition?
14. Define the term ‘pomology’.
15. How is neem used traditionally?
16. What is acid rain?
17. Define eco-friendly agriculture?

IV. Write short answers for any four of the following questions in 100 words. Draw diagrams wherever necessary.
(Question No.20 is a compulsory question.) **4 X 5 = 20**

18. Explain autotrophic nutrition in bacteria.
19. Explain the types of baccate fruits with an example.
20. Give the schematic representation of dark reaction of photosynthesis.
21. Distinguish between DNA and RNA.
22. What are the effects of noise pollution?
23. Explain rotation of crops.

V. Write detailed answer for any one of the following in 200 words. Draw diagrams wherever necessary. **(1 x 1 0 = 10)**

24. Write a note on photophosphorylation.
25. Give an account of hypogeal germination.

Standard X - Matriculation Examination
Model Question Paper
Botany Practicals

Time: $1^1/_2$ Hours Max. Marks: 25

I. Identify the given slide A and write any two reasons for identification. Draw a labelled sketch. 3

II. Identify the given specimens B and C and classify them. Write any two salient features. Drawn labelled diagrams. 2 x 3 = 6

III. Identify the type of germination in the displayed specimen D and give two reasons. 3

IV. Identify the given medicinal plant E and write any two uses. 2

V. Identify the given experimental setup F. Write the aim, procedure and inference. 3

VI. Identify the given model G and write its significance. 3

VII. Project 2

VIII. Record 3

External (20 marks)

Question	I	3
Question	II	6
Question	III	3
Question	IV	2
Question	V	3
Question	VI	3

Internal (5 marks)

Project	2
Record	3
Total	25

Botany Practicals - Guidelines for evaluation

I.	Identification	1	
	Any Two Reasons	1	
	Diagram	1	3
II.	Identification & Classification	1	
	Any Two Salient Features	1	
	Diagram	1	3 x 2 = 6
III.	Identification	1	
	Any Two Reasons	2	3
IV.	Identification	1	
	Two Uses	1	2
V.	Aim	1	
	Procedure	1	
	Inference	1	3
VI.	Identification	1	
	Any Four Points of Significance	2	3
VII.	Project		2

Any one of the Projects can be selected by the student and the same should be submitted during the practical examination.

1. Model of DNA must be prepared by the student.

or

2. The student must collect any three medicinally important plants or their products and write the uses.

VIII.	Record	3