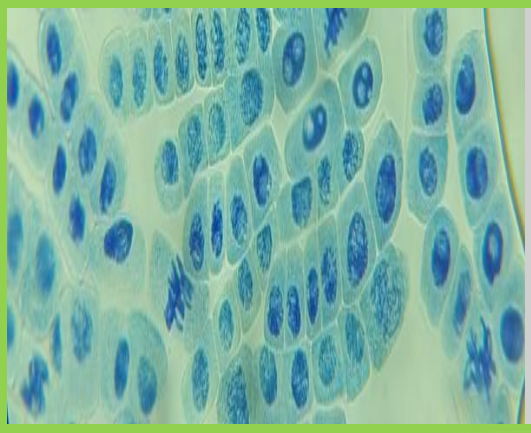
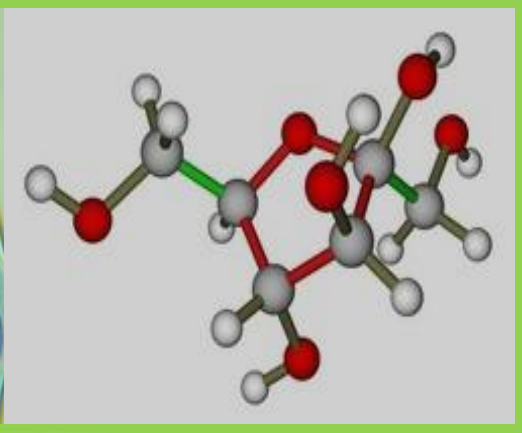
BSCBO- 304

B.Sc. III YEAR

LABORATORY PRACTICAL-III





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SCHOOL OF SCIENCES
UTTARAKHAND OPEN UNIVERSITY

BSCBO-304

LABORATORY COURSE-III

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CONTENTS

BLOCK-1 CELL BIOLOGY, MOLECULAR BIOLOGY AND BIOTECHNOLOGY

PAGE NO.

BLOCK-2 ECONOMIC BOTANY, GENETICS AND PLANT BREEDING

PAGE NO.

BLOCK-3 PLANT PHYSIOLOGY AND BIOCHEMISTRY PAGE NO.

BLOCK-1: CELL BIOLOGY, MOLECULAR BIOLOGY AND BIOTECHNOLOGY

UNIT-1: STUDY CELL STRUCTURE FROM ONION/ *TRADESCANTIA* LEAF PEELS; DEMONSTRATION OF STAINING AND MOUNTING METHODS

1.1 OBJECTIVES

After reading this unit students will be able-

- To study cell structure from onion peel

1.2 INTRODUCTION

All living organisms are made up of cell. Plant cell is an eukaryotic cell with distinctive features. It has a rigid cell wall outside the cell membrane which is composed of cellulose, hemicellulose, and pectin. Cell wall maintains the shape of the cell, provides rigidity and protection to the cell against osmotic shock and physical damages and pathogens and also play an important role in intercellular communication. The pores in the cell wall allow the movement of nutrients and water into and out of the cell. Some plants also have a secondary cell wall which contains lignin.

Beneath the cell wall, cytoplasmic membrane (or plasma membrane or cell membrane) is present which a lipid bilayer with inserted proteins. Cell membrane is semi permeable which regulates the movement of molecules and ions across it. It encloses cytoplasm which is composed of proteins, lipids, carbohydrates, mineral salts and 70-90% water. The cytoplasm contains a number of membrane-bound organelles. A large central vacuole is present in the cytoplasm which occupies more than 30% of cell volume. It is surrounded by a membrane called tonoplast. It maintains turgor pressure against the cell wall, acts as store house of pigments, play role in osmoregulation.

Plastids are membrane-bound organelles which carry out many functions *viz*., photosynthesis, serve as store house for products like starch. They have their own DNA and some ribosomes. The main types of plastids are: (a) **Chloroplast-** They contains photosynthetic pigments which capture light energy from sun. The light energy is transduced into chemical energy via formation of carbohydrate using carbon dioxide and water. The process is called as photosynthesis. A matrix called stroma lies within the inner membrane of chloroplast. Stroma contains DNA, 70S ribosomes, lipid droplets, starch granules and complex internal membrane systems whose prominent components are thylakoids which are flattened disc shaped arranged in stacks called grana. A complex of proteins and light harvesting pigments like chlorophyll and carotenoids are present within thylakoid membrane. Photosynthesis occurs in thylakoid membrane. (b) **Chromoplasts-** These are involved in the synthesis as well as storage of pigments which impart colour to their petals and fruits. (c) **Leucoplasts-** They are located in roots and do not contain pigments. They either may serve as store house of starch, lipid and proteins or are involved in synthesis of fatty acids and many amino acids.

Nucleus is surrounded by nuclear membrane and is filled with nuclear sap or nucleoplasm. It contains chromatin which is composed of DNA and histone proteins. Endoplasmic reticulums (E.R.) exist in rough or granular form (called Rough endoplasmic

reticulum, R.E.R.) or smooth or a granular form (called Smooth endoplasmic reticulum, S.E.R.). Rough endoplasmic reticulum is the site of protein synthesis. Endoplasmic reticulum is the site of a large number of functions like carbohydrate, lipid and protein metabolism, synthesis of cell membrane, storage site for synthesised molecules. E.R. serves as a major transport route by which proteins, lipids, steroids etc. move out of cell.

Ribosome is 80S type which is a dimer of 60S (large subunit) and 40S (small subunit). 40S subunit is composed of 18S rRNA and 33 proteins while 60S is composed of 5S, 5.8S and 28S rRNA and 49 proteins. It exists in free form as well as bound with R.E.R. Both free and bound forms synthesise proteins. Proteins synthesised on bound form are either secreted out or integrated into the E.R. membrane while free ribosomes are site of synthesis of non-secretory and non-membranous proteins. Mitochondrion is the power house of cell. Its outer membrane is 60 to 75 A^0 thick while inner membrane which has numerous invaginations is 50 to 70 A^0 thick. It is the site of ATP synthesis. Mitochondrion also has its own DNA, 70S ribosomes and RNA like chloroplast.

Golgi apparatus (or Golgi complex or Dictyosomes) is composed of flattened, saclike cisternae that are stacked on each other. A complex network of tubules and vesicles is located on the edges of cisternae. Golgi bodies are sites of various synthetic activities which are essential for the synthesis of various cell constituents. Proteins and lipids carried from endoplasmic reticulum are carried to golgi apparatus where they are repackaged into secretory vesicles which are then move to cytoplasmic membrane where they release their contents by exocytosis. It also package hydrolytic enzymes into lysosome. Lysosomes are called as suicidal bags. They contain hydrolytic enzymes like proteases, nucleases, glycosidases, sulfatase, lipase and phosphatase. Microbodies are smaller than lysosome and contain catalase and peroxidase. Peroxisome is a type of microbody where some amino acids are oxidized with the production of hydrogen peroxide. Centrioles are a pair of cylindrical structures near the nucleus which are involved in cell division. They serve as organizing centre for mitotic apparatus.

1.3 STUDY CELL STRUCTURE FROM ONION/ TRADESCANTIA LEAF PEELS

Onion contains both a modified stem in the centre with scale leaves. Stem of onion is disc shaped (discoid) whose lower side bears adventitious roots. Scale leaves are of two types: Inner fleshy scale leaves form the edible part while the outer thin scale leaves form the protective covering. The cell of an onion consists of a cell wall, cell membrane, cytoplasm, nucleus and a large vacuole besides other typical cell organelle.

1.4 PROCEDURE OF STAINING AND MOUNTING

Requirements to study cell structure from onion peel

Onion, Glass slides, Coverslip, Watch glass, Forceps, Needle, Brush, Blade/razor, Filter

paper, Safranin/Methylene blue, Glycerine, Dropper, Water, Compound microscope.

Method

(i) Remove the outermost peel of an onion.
(ii) Cut a small part from an inner scale leaf with the help of blade.
(iii) Pull out the thin transparent membranous peel adhered to the inner surface of leaf using forceps.
(iv) Place the peel in a watch glass containing water. Cut it into small rectangular pieces.
(v) Add 1-2 drops of safranin/methylene blue to water in a watch glass. Mix the two properly. Transfer the peel into the watch glass. Leave it for 2-3 minute.
(vi) Dip the peel in water to remove excess stain.
(vii) Put a drop of glycerine in the centre of a clean glass slide. Transfer the peel onto the slide with the help of brush and needle.
(viii) Place the coverslip over it carefully avoiding any air bubbles.
(ix) Remove any excessive glycerine from the edge of coverslip with a filter paper.
(x) Observe the slide under microscope first under low power and than under high power.

Observations

Draw a well labelled diagram of what is observed under microscope.

Record the observations as given below:

(a) Shape of cell
(b) Cell arrangement
(c) Intercellular space present/absent
(d) Nucleus (present/absent)
(e) Cell wall (Present/absent)
(f) Vacuole (Present/absent)
(g) Any other feature present in cytoplasm

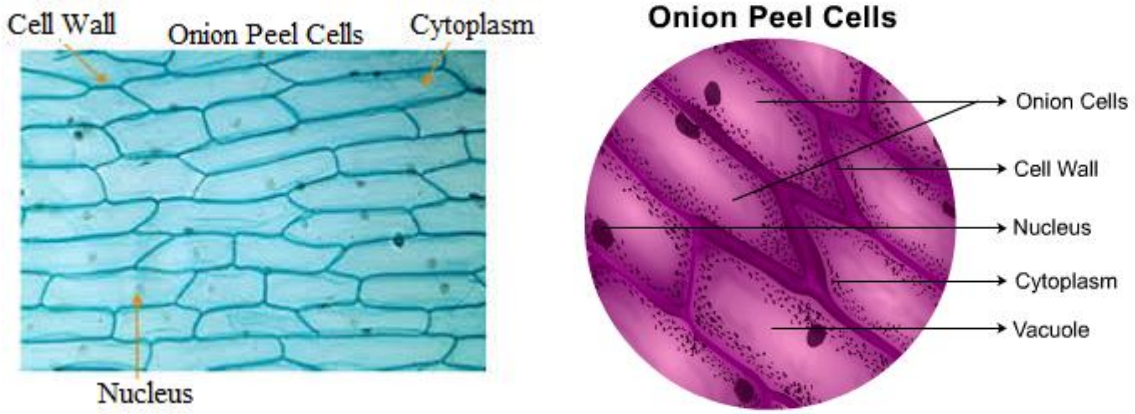

Fig.1.1Cell structure of onion peel

(Source: http://amrita.olabs.edu.in/userfiles/1/image/Onion&cheek_cells.gif)

Precautions

1. Glass slide and cover-slip should always be clean and dry.
2. The folding of peel shall always be avoided.

3. Over staining and under staining should be avoided.
4. Always use brush to transfer peel onto slide.
5. Mounting should always be done in the centre of the slide.
6. Cover-slip should always be placed gently to avoid air bubbles.

1.5 SUMMARY

Plant cell is an eukaryotic cell containing membrane bound organelles. Cell has an abundant membrane system because of their large volume and also due to the need for adequate regulation, metabolic activity and transport. Cell wall is primarily composed of cellulose. Cytoplasmic membrane acts as a selectively permeable barrier which regulates the movement of solute and ions into and out of the cell. Cytoplasm contains nucleus, mitochondrion, golgi apparatus, endoplasmic reticulum, plastids, vacuoles, ribosome, microbodies and centriole. These organelles carry out specialized functions. Nucleus contains chromatins which are composed of histone proteins and DNA.

Endoplasmic reticulum is involved in glycogen, steroid, lipid and protein synthesis. Ribosome is 80S type. Mitochondria are the site of ATP synthesis. Chloroplast contains chlorophyll and enzymes for photosynthesis. Both mitochondria and chloroplast contains DNA, 70S ribosome and RNA. Golgi apparatus functions in secretion, carbohydrate synthesis and glycoprotein formation. Lysosomes contain a number of digestive enzymes. Microbodies contain catalase and peroxidases. Vacuoles maintain turgor pressure against the cell wall, acts as store house of pigments and play role in osmoregulation. Centrioles serve as organizing centers for mitotic apparatus.

1.6 GLOSSARY

Eukaryote- An organism having a true nucleus (nucleus bounded by nuclear membrane) and membrane-bound organelles.
Cell wall- Its a protective covering outside cell which provides rigidity to cell.
Cell membrane- It is a protein-lipid bilayer structure beneath cell wall which surrounds cytoplasm.
Cytoplasm- It lies beneath cell membrane which contains membrane bound organelles.
Mitochondria- It is the powerhouse of cell which is site of ATP synthesis.
Endoplasmic reticulum- It is a site of protein, lipid and glycogen synthesis.
Plastids- These are membrane-bound organelles which carry out many functions viz., photosynthesis, serve as store house for products like starch.
Lysosome- These are called suicidal bags which contain many digestive enzymes.
Vacuole- These are the organelles which maintain turgor pressure against the cell wall.
Nucleus- It contains chromatin which are composed of histone proteins and DNA.
Centrioles- It serve as organizing centres for mitotic apparatus.
Golgi body- It is composed of flattened, saclike cisternae that are stacked on each other.

1.7 SELF ASSESSMENT QUESTIONS

1.7.1 Fill in the following blanks:

(i) ATP synthesis takes place in.....
(ii) Lysosomes are also called as.....
(iii) Osmoregulation is carried out by.....
(iv) Chromatin is composed of histone proteins and.....
(v) Chloroplasts contain ..... pigments.
(vi) Centriole serves as organization centre for..... apparatus.
(vii) Rough endoplasmic reticulum synthesize.....
(viii) Catalase is present in.....
(ix)Plant cell wall is primarily composed of.....
(x) Cell membrane is composed of lipids and.....

1.7.2 Write True or False:

(i) Chloroplast contains DNA.
(ii) Eukaryotes have 70s ribosome.
(iii) Photosynthesis takes place in mitochondria.
(iv) A monolayer of lipid is present in cell membrane.
(v) DNA is present only in nucleus.
(vi) Chitin is present in plant cell wall.
(vii) Mitochondria have 80S ribosome.
(viii) Chromatin is composed of DNA only.
(ix) 40S subunit of ribosome is composed of 23S rRNA.
(x) Vacuole is surrounded by membrane called tonoplast.

Answers Key:

1.7.1 Fill in the blanks-

(i) Mitochondria (ii) Suicidal bags (iii) Vacuoles (iv) DNA (v) Photosynthetic (vi) Mitotic (vii) Protein (viii) Micro bodies (ix) Cellulose (x) Protein

1.7.2 True/False

(i) True, (ii) False, (iii)False, (iv)False, (v) False, (vi)False, (vii)False, (viii)False, (ix) False (x) True

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1.10 TERMINAL QUESTIONS

Q1. Write a short note on plastid.

Q2. What is the difference between R.E.R. and S.E.R.?

Q3. What is the function of Golgi apparatus?

Q.4.Write the method of Staining and Mounting of onion peel.

UNIT-2 ESTIMATION AND RELATIONSHIP BETWEEN NUCLEUS AND CELL VOLUME AT SHOOT/ ROOT APICES BY CAMERA LUCIDA/MICROMETER METHOD

2.1 OBJECTIVES

After reading this unit students will be able-

- Know to estimate the cell volume and relationship between nucleus and cell volume in the apical meristem of shoot by camera lucida.

2.2 INTRODUCTION

The primary meristem is essentially the functional embryo of a plant. It remains undifferentiated, continually gives rise to new cells and is the ultimate source of all the organs of the plant. The volume of the apical meristem is defined as that region at the stem tip in which the cells are meristematic, non-vacuolate and essentially isodiametric. The volume can be determined using camera lucida. A camera lucida is an optical device used as a drawing aid. The camera lucida performs an optical superimposition of the subject being viewed upon the surface upon which the observer is drawing. The observer sees both scene and drawing surface simultaneously, as in a photographic double exposure. This allows the observer to duplicate key points of the scene on the drawing surface, thus aiding in the accurate rendering of perspective.

2.3 ESTIMATION AND RELATIONSHIP BETWEEN NUCLEUS AND CELL VOLUME AT SHOOT/ ROOT APICES

The size of the nucleus would at first-approximation be related to the amount of DNA in the cell, and its volume would therefore be the relevant size parameter to determine capacity. The nuclei of the apical meristem cells behave in much the same manner as the cells during development. As growth proceeds there is a progressive decrease in nuclear volume, a constant minimal volume being reached, as with the cells, at the time of flattening-off of the growth curve. The nuclei, however, decrease at a much less rapid pace than do the cells, and as a result the small cells characteristic of the later growth stages have relatively larger nuclei and less cytoplasm than the large cells found in the plumular and young seedling meristems. Thus the changes in cell/nucleus ratio may be concerned in bringing about the cessation of growth. Cell volume is frequently proportional to the DNA content of the cell nucleus.

2.3.1-Estimation and relationship between nucleus and cell volume at shoot/ root apices by Camera lucida

1. Collect the shoot tips from the shoots of 5 plants at weekly intervals so that the shoot tips of different growth stages can be collected.
2. Fix them in Carnoy's fixative (Absolute alcohol: Glacial acetic acid: Chloroform; 6:3:1). Dehydrate them using a series of tertiary butyl alcohol, embedded in paraffin.
3. Cut 10 micrometer thin sections and stained them with mercuric bromophenol blue and examine them under light microscope.
4. Take the height of shoot apex as the vertical distance from the adaxial point of the nearest

foliar buttress to the midpoint of the apical dome.

5. Make the camera lucida drawings of median longisections on graph paper.
6. Compute the area by counting the number of enclosed squares on the graph paper and converting them into square micrometer by applying appropriate factors. Calculate the average area of cells from the total areas of median longisection by dividing the total number of cells.

Since shoot apex constitutes a segment of regular sphere therefore volume can be calculated as:

$$V= 1/6\ h\ (h^2 + 3r^2)$$

Where h is height in micrometer;
r = 1/2 base of the segment in micrometer

The cell population of apical meristem zone can be calculated by dividing the volume of shoot apex by the average volume of the cell. The nucleus of the cell is a spherical shaped located centrally.

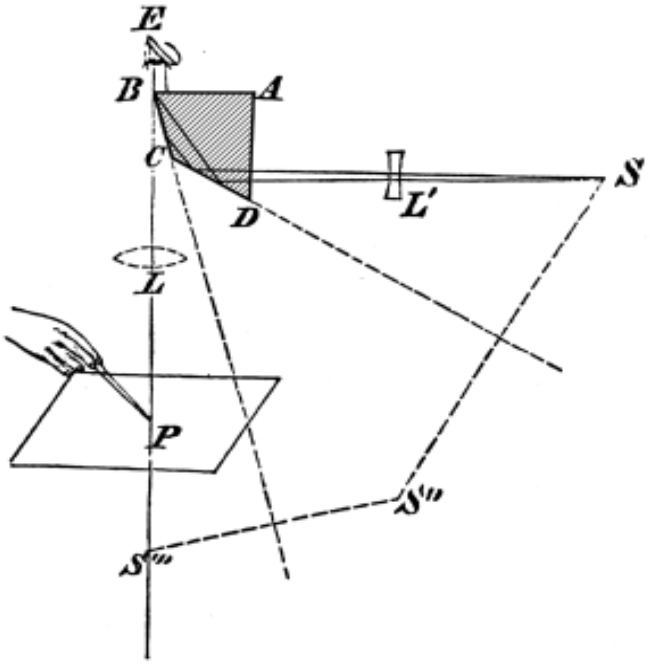

Fig.2.1 Principle of Camera lucida
(Source: https://en.wikipedia.org/wiki/Camera lucida)

2.3.2- Procedure for the cell volume and relationship between nucleus and cell volume in the apical meristem of shoot by micrometry

Introduction

The measurement of cell size is done under microscope with the help of two scales called micrometers. An ocular micrometer is a small circular glass disk on which uniformly spaced lines of unknown distance ranging from 0 to 100 are etched. It is inserted into the eye piece of the microscope and then calibrated against a stage micrometer. The stage micrometer is a

special glass slide having uniformly spaced lines of known distance etched on it. The stage micrometer is usually divided into 0.01 millimetre and 0.1 millimetre graduations and is clipped to the stage of the microscope.

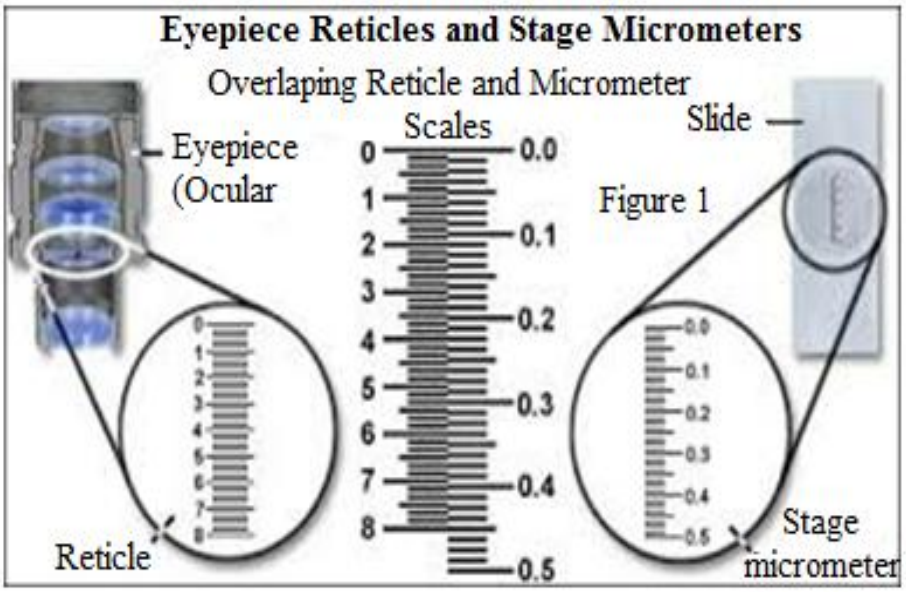

Fig.2.2 Ocular and stage micrometer

(Source:http://www.microscopemaster.com/microscope-stage-micrometer)

Method

1. Remove the eyepiece from the microscope and remove its top lid.
2. Remove the eye lens and carefully place the ocular micrometer into the eyepiece.
3. Place the eye lens back and screw the top lid of eyepiece.
4. Place the eyepiece back into the microscope.
5. Clip the stage micrometer to the stage and centred the etchings by moving the mechanical stage.
6. Position the low power objective.
7. Rotate the eyepiece till the etchings on both the micrometers superimpose.
8. Position 100X objective now.
9. Move the mechanical stage so that a line on the stage micrometer coincides with a line on the ocular micrometer. Then search for another line on the ocular micrometer, which coincides with another line on the stage micrometer.
10. Count the number of divisions between the coinciding lines for both the micrometers.
11. Calculate the calibration factor for the objective used.
12. Calculate the calibration factor for other objectives in a similar way.
13. Remove the stage micrometer.
14. Prepare the slide of shoot tip as described in camera lucida method.
15. Place the slide on the stage and focus it.
16. Count the number of ocular divisions covered by the apical cell by viewing through the eyepiece.
17. Determine the size of the apical cell.

Observations

Record the number of ocular divisions between the lines of coincidence. Record the number of stage micrometer divisions between the lines of coincidence. Also record the number of ocular divisions covered by the apical cell.

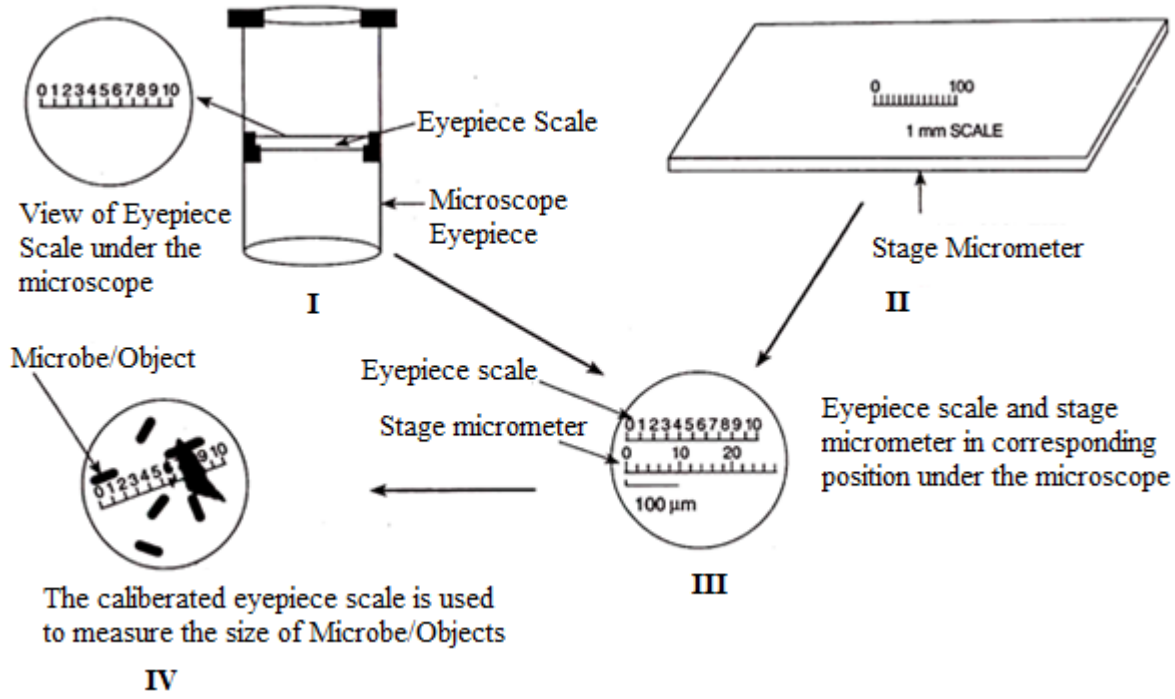

Fig.2.3 Principle of Micrometry

(Source: http://www.biologydiscussion.com/microscope/compound-microscope)

Calculations

If Y divisions of ocular micrometer = Z divisions of stage micrometer

1 division of ocular micrometer = Z/Y divisions of stage micrometer

Since, 1 division of stage micrometer= 0.01 mm or 10micrometer

Calibration factor= 10^{*} Z/Y

Size of cell = Number of ocular divisions covered by cell X Calibration factor

2.4 SUMMARY

The ontogenetic changes in the apical meristem can be studied by determining the cell size or volume by micrometry or camera lucida method. Meristem volume tends to increase during development. Apical cells and their nuclei show a progressive diminution in size, a constant minimal size being attained with the onset of maturity. This change is evidently related to the annual growth cycle of the plants.

2.5 GLOSSARY

Meristem- It is a tissue in plants made of dividing cells. They are in parts of the plant where growth can take place.

Camera lucida- It is an optical device used as a drawing aid. The camera lucida performs an optical superimposition of the subject being viewed upon the surface upon which the observer is drawing.

Micrometer- It is a scale used for measurement of cell size under microscope. It is of two types: Stage micrometer and ocular micrometer.

Nucleus- Nucleus is surrounded by nuclear membrane and is filled with nuclear sap or nucleoplasm. It contains chromatin which is composed of DNA and histone proteins.

Eyepiece- It is also called as ocular lens. It is a type of lens used in microscope and is named so because it is usually the lens that is closest to the eye when someone looks through the device.

2.6 SELF ASSESSMENT QUESTION

2.6.1 Fill in the blanks:

(i) …… can be used to measure cell volume.
(ii) A camera lucida is a …… device.
(iii) ……... micrometer is clipped to the stage of the microscope.
(iv) Carnoy fixative is made up of absolute alcohol, glacial acetic acid and ……
(v) The size of nucleus would approximately related to the amount of ……in the cell.

2.6.2 Write true/false:

(i) Primary meristem remains undifferentiated.
(ii) Stage micrometer is inserted into the eyepiece of microscope.
(iii) Ocular micrometer must be calibrated with the stage micrometer.
(iv) Cell volume is usually not proportional to the DNA content of cell.
(v) One division of stage micrometer is equal to 1 millimetre.

Answers Key:

2.6.1 Fill in the blanks-

(i) Camera lucida/Micrometry, (ii) Optical, (iii) Stage, (iv) Chloroform, (v) DNA

2.6.2 True/False-

(i) True, (ii) False, (iii) True, (iv) False, (v) False

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2.9 TERMINAL QUESTIONS

Q1. How is size of apical cell determined by camera lucida method?
Q2. What is micrometry? Describe its principle.
Q3. How micrometer is used to measure the cell size?

UNIT-3 CHROMOSOME STUDY DURING CELL DIVISION

3.1 OBJECTIVES

After reading this unit students will be able-

- To study the changes in chromosome during mitosis.
- To study the changes in chromosome during meiosis.

3.2 INTRODUCTION

Cell division is a process by which the cell duplicates itself either for growth and repair or for reproduction of organism. Chromosome plays an important role during cell division as chromosomes are the mean by which hereditary characters are transferred from parents to next generation in sexual reproduction or from parent cell to daughter cells. The cell division are of two types: Mitosis and Meiosis.

3.3 STUDY OF CHROMOSOME DURING CELL DIVISION

The cell division are of two types: Mitosis and Meiosis.

1-Mitosis

Mitosis is the process of cell division by which the chromosome content of a somatic cell (haploid or diploid) is kept constant through successive cell divisions. The division of the cell is initiated by division of the nucleus i.e. Karyokinesis followed by division of cytoplasm i.e. Cytokinesis. The stages of karyokinesis are: Prophase, Metaphase, Anaphase and Telophase. Mitosis begins at prophase with the thickening and condensation of the chromosomes. The chromatids coil around each other spirally. The nuclear membrane and nucleolus shrinks and disappears. The end of prophase is marked by the beginning of the organization of a group of fibres to form a spindle. In metaphase the chromosome become thick and two chromatids of each chromosome become clear. The chromosomes move towards the equatorial plate and get arranged at the equatorial plane. Centromeres divide and each chromatid moves to align itself on the equatorial plate.

During anaphase each chromatid pair separates from the centromere and move towards the opposite ends of the cell by spindle fibers. The cell membrane begins to pinch at the centre. At the termination of anaphase, chromosomes form densely packed group at the two poles. In telophase the chromatids arrive at opposite poles of cell. The spindle disappears and the daughter chromosome uncoils to form chromatin fibers. The nuclear membranes and nucleolus re-form and two daughter nuclei appear at opposite poles. The newly formed nucleus contains the same numbers of chromosomes, as that in the parent nucleus. After nuclear division the division of cytoplasm takes place. The cytokinesis takes place in two ways either by the formation of cell plate in the centre extending towards the cell wall or by the formation of cytoplasmic cleavage or furrow in equatorial region that deepens to form a wall separating the two daughter nuclei.

2-Meiosis

Meiosis is the process by which haploid gametes or spores are produced by two successive divisions of diploid nucleus. During meiosis, homologous chromosomes pair, replicate once and undergo assortment so that each of the four meiotic products receives one representative of each chromosome. The two nuclear divisions are: Meiosis I and Meiosis II.

Meiosis I

In meiosis I, the chromosome number is reduced from diploid to haploid. The mechanism consists of four important phases – Prophase I, Metaphase I, Anaphase I and Telophase I. Prophase I is the most complex phase of meiosis I and is of longer duration. It consists of five sub stages: Leptotene, Zygotene, Pachytene, Diplotene and Diakinesis. Leptotene is marked by the appearance of the chromosomes as long threads. In zygotene homologous chromosomes pair side by side and gene by gene with each other. This process of lateral association of homologues is called synapsis. When the two homologous chromosomes consisting of four chromatids are paired, this structure is called a bivalent.

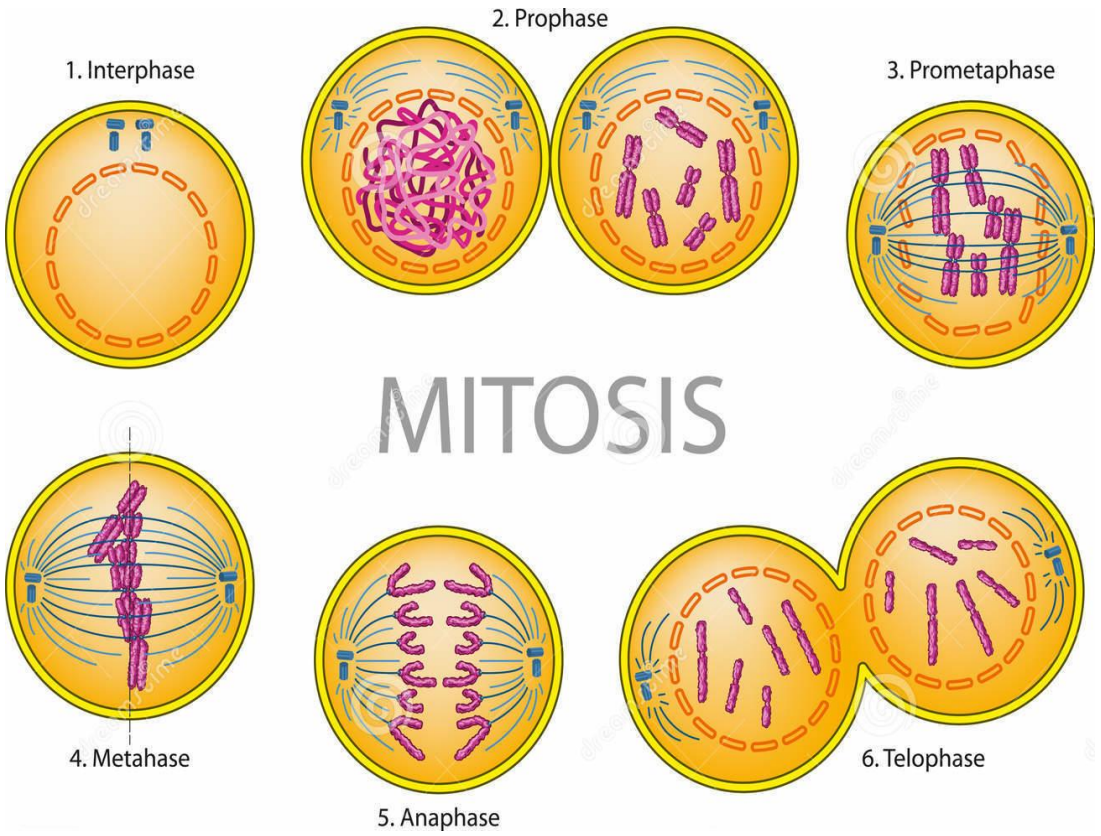

Fig.3.1 Different stages of Mitosis (Source: www.dreamstime.com)

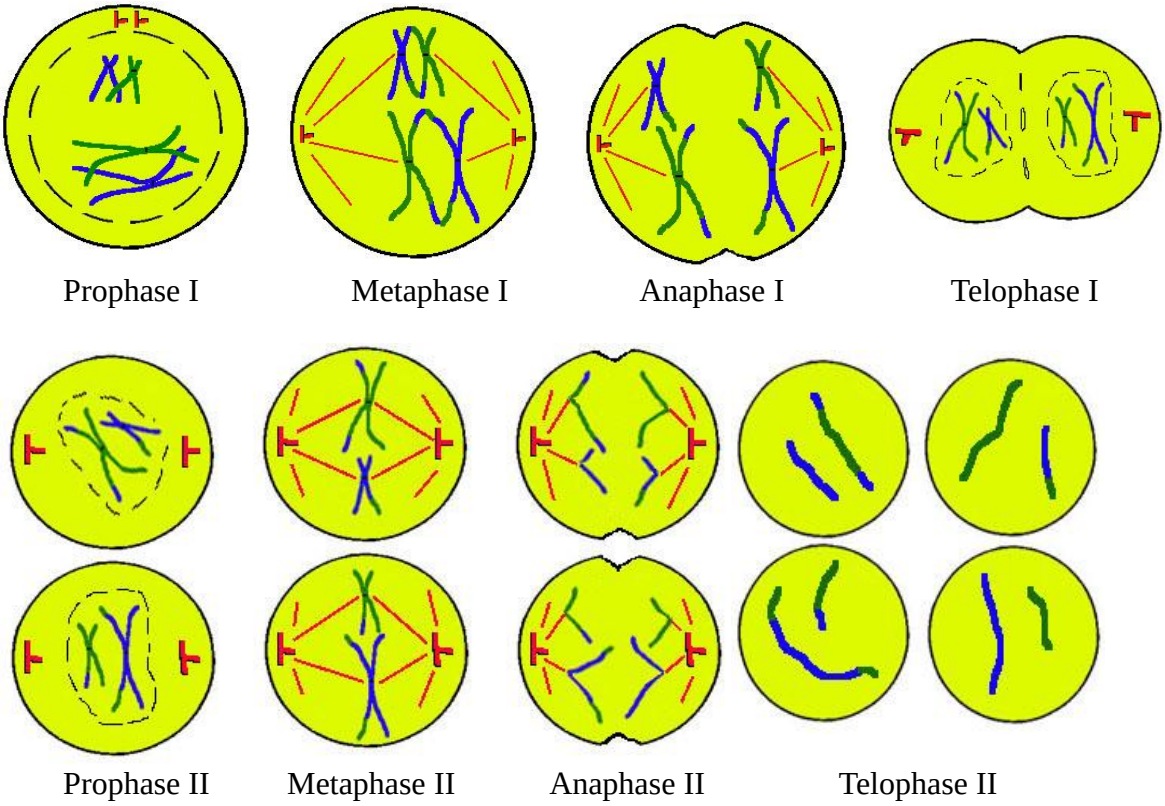

Fig.3.2 Different stages of Meiosis (Source: http://www.actforlibraries.org/meiosis)

In pachytene stage, shortening and thickening of chromosomes takes place. During this stage crossing over takes place resulting into exchange of portions of homologous chromosomes. In diplotene, homologous chromosomes begin to separate, particularly in the region surrounding the centromere. The sister chromatids remain attached at the centromeric region, at some points homologous chromosomes remain in close contact, these points are known as chiasmata. The last stage of Prophase I is diakinesis which is characterized by shortened chromosomes and the terminalization of chiasmata. In metaphase I, the homologous chromosomes which are joined through the chiasmata become oriented on the spindle, with the centromeres of each chromosomes lying towards poles but the ends of chromosomes towards the equatorial plate. During anaphase I the chromosomes in each bivalent separate at this stage so that homologous pairs disjoin and migrate towards the opposite poles. As a result, the maternally and paternally derived homologues are segregated. Telophase I is a reorganization phase. Nuclear membrane and nucleolus reappear and thus at each pole a haploid nucleus is formed.

Meiosis II

It is similar to mitotic division with the sub stages: Prophase II, Metaphase II, Anaphase II and Telophase II. In prophase II, the chromosomes condense, and the centromeres divide. In metaphase II, a spindle apparatus is organized and the chromosomes become aligned at the equatorial plate. In anaphase II the centromeres migrate to the opposite pole of the spindle, pulling the chromatids with them. Each of the two cells produced by the first division divides in telophase II, resulting into formation of four haploid cells. The chromosomes become less condensed and a nuclear membrane forms.

3.3.1- Procedure for study of mitosis in onion root tip

The meristamatic cells located in the root tips provide the most suitable material for the study of mitosis. The chromosome of monocotyledonous plants is large and more visible, therefore, onion root tips are used to study mitosis by squash method.

Requirements

Carnoy fixative (Absolute alcohol: Glacial acetic acid: Chloroform; 6:3:1), Acetocarmine stain, 1 N HCl, 45% Acetic acid, 90% alcohol, 70% alcohol, Couplin jar, Glass slide, Cover slip, Blotting paper, Watch glass, Spirit lamp, Filter paper, Microscope.

Method

1. Take a large sized mature onion a week before the experiment. Cut all the dried roots from the stem at the base of the bulb. Now place these onions on the mouth of couplin jars filled with water in such a way that the stem portion must be dipped continuously in water. In about a week the new roots would develop and would start growing downward in the water.
2. Take the onions and cut the milky white portion of root tips viz., up to 5 mm length. Cut each piece into smaller pieces and fix them in Carnoy fixative for half an hour.
3. Transfer the material to 90% alcohol and then to 70% alcohol keeping the material for 10 minutes in each. Now preserve the material in 70% alcohol.
4. Take few pieces from 70% alcohol in a watch glass in few drops of 1N HCI and leave for 5 minutes. This will make the material soft.
5. Drain off the HCI and wash the pieces with a little distilled water at least twice or thrice.
6. Put the root tips on a clear slide on right hand side and pour a few drops of 2% acetocarmine stain. Warm the slide gently on sprit lamp for few minutes at least 3-4 times but never let it boil. Cool and leave it for 10 minutes in the stain. Now drain the excess of stain with the help of filter paper and put few drops of 45% acetic acid.
7. Place a cover slip over the material and put above the coverslip a piece of blotting paper or filter paper folded two to three times. Press the coverslip gently with the thumb to break the cell membranes.
8. Observe the slide under the microscope first in low power and then in high power.

Observations

Draw the various stages seen under microscope and comment upon them.

3.3.2-Procedure for study of mitosis in buds of *Tradescantia* or male spikelet's of Bajra

The meiosis can be studied by squash method.

Requirements

Carnoy fixative (Absolute alcohol: Glacial acetic acid: Chloroform; 6:3:1), Acetocarmine

stain, 45% Acetic acid, Normal saline, 90% alcohol, 70% alcohol, Needle, Slide, Watch glass, Coverslip, Filter paper or blotting paper, Spirit lamp, Microscope.

Method

1. Take young buds of *Tradescantia* or immature male spikelet's of Bajra (Millet) and fix them in freshly prepared Carnoy fixative for 10 hrs. After rehydrating in 90% and 70% alcohol store the material in 70% alcohol.
2. Take a bud of *Tradescantia* or few smaller anthers from the male spikelet of Bajra in 70% alcohol in a watch glass.
3. Dissect out the bud or dissect each anther taken from the spikelet with needles & keep them in 45% acetic acid.
4. Put few anthers on the slide and few drops of Acetocarmine stain over them. Warm the slide gently a few times, but never let it boil.
5. Drain off excess stain and put few drops of 45% acetic acid.
6. Now put cover slip over the material and cover it with filter paper or blotting paper. Press the cover slip with thumb so as to rupture the anthers.
7. Observe the slide under the microscope first in low power and then in high power.

Observations

Draw the various stages seen under microscope and comment upon them.

Precautions

1. Carnoy fixative should be prepared fresh.
2. Always preserve the material in 70% alcohol if study is to be conducted later.
3. Always take a mature onion one week before the experiment for mitosis so that fresh roots can appear. For meiosis take young buds of *Tradescantia* or immature male spikelet's of Bajra.
4. Coverslip should be pressed very gently.

3.4 SUMMARY

Cell division is a process by which the cell duplicates itself either for growth and repair or for reproduction of organism. Mitosis is the process of cell division by which the chromosome content of a somatic cell (haploid or diploid) is kept constant through successive cell divisions. The division of the cell is initiated by division of the nucleus (Karyokinesis) followed by division of cytoplasm (Cytokinesis). Meiosis is the process by which haploid gametes or spores are produced by two successive divisions of diploid nucleus. During meiosis, homologous chromosomes pair, replicate once and undergo assortment so that each of the four meiotic products receives one representative of each chromosome. The two nuclear divisions are: Meiosis I and Meiosis II. In Meiosis I, the chromosome number is reduced from diploid to haploid. Meiosis II, it is similar to mitotic division.

3.5 GLOSSARY

Cell division- It is a process by which the cell duplicates itself either for growth and repair or for reproduction of organism.
Karyokinesis- It is the division of nucleus.
Cytokinesis- It is the division of cytoplasm.
Chromatid- It is one copy of a newly copied chromosome which is still joined to the original copy by a single centromere.
Centromere- It is the part of a chromosome that links sister chromatids.

3.6 SELF ASSESSMENT QUESTIONS

3.6.1 Fill in the blanks-

(i) The division of nucleus is called as.....
(ii) The process of cell division by which the chromosome content of a cell is kept constant is called.....
(iii) ..... method is used to study mitosis and meiosis.
(iv) Carnoy fixative is made up of absolute alcohol, glacial acetic acid and.....
(v) The longest duration phase of Meiosis-I is.....

3.6.2 Write true or false-

(i) Cytokinesis is followed by karyokinesis.
(ii) Meiosis I is similar to mitosis.
(iii) Zygotene stage occurs in prophase II.
(iv) In zygotene homologous chromosomes pair side by side with each other.
(v) Safranin stain is used for staining chromosome.

Answer Keys-

3.6.1 Fill in the blanks:

(i) Karyokinesis, (ii) Mitosis, (iii) Squash, (iv) Chloroform, (v) Prophase-I

3.6.2 True or False:

(i) False, (ii) False, (iii) False, (iv) True, (v) False

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3.9 TERMINAL QUESTIONS

1. Describe the different stages of mitosis.
2. Describe the different stages and significance of meiosis.
3. Discuss the procedure for study of mitosis in buds of *Tradescantia* or male spikelet's of Bajra.
4. Write the procedure to study mitosis by squash method.

UNIT-4 BIOTECHNOLOGY EXERCISE

4.1 OBJECTIVES

After reading this unit students will be able to-

- Know the Checking of purity of DNA by spectrophotometric method.
- Know Quantification of DNA by spectrophotometric method

4.2 INTRODUCTION

DNA (Deoxyribonucleic acid) is the genetic material present in the cell. It is a polynucleotide which is made of up of nucleotides. A nucleotide is made up of nitrogenous bases, deoxyribose sugar and phosphate. There are 4 nitrogenous bases present in DNA: Adenine (A), Thymine (T), Cytosine (C) and Guanine (G). It has a double helical structure which was given by J.D. Watson and Francis Crick in 1953. The two helical chains are coiled around the same axis to form a right handed double helix (B form of DNA). These two chains are anti-parallel to each other i.e. they have 5' to 3' and 3' to 5' polarity. The diameter of DNA is 20Å. The distance between each turn is 3.6nm. There are 10 nucleotides per turn. It has a hydrophilic backbone made up of alternating deoxyribose and negatively charged phosphate groups. The hydrophobic bases are stacked inside double helix which stabilizes the double helix structure. The double helix structure is also stabilized by inter-chain hydrogen bonding between a purine (A and G) and pyrimidine base (C and T). A base pair with T by two hydrogen bond while G base pair with C by three hydrogen bonds. The bases within the same strand are joined to each other by phosphor diester bond between the $5^{'}$ phosphate groups of previous base with $3^{'}$ OH group of next base.

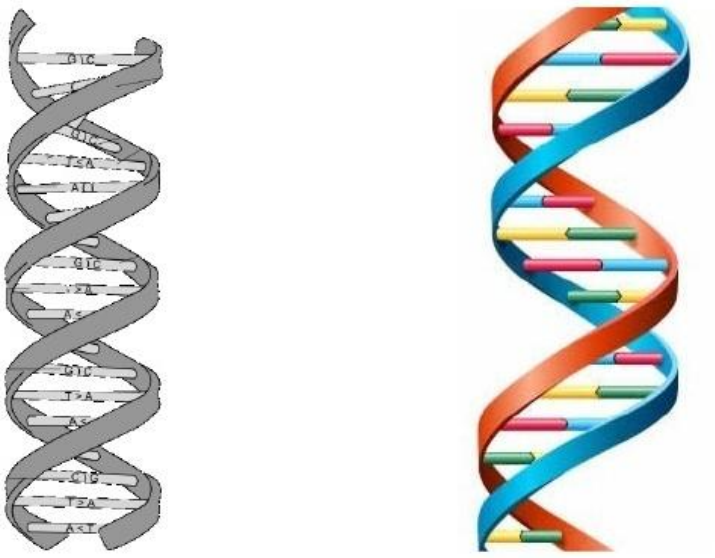

Fig. 4.1 - Double helical structure of DNA

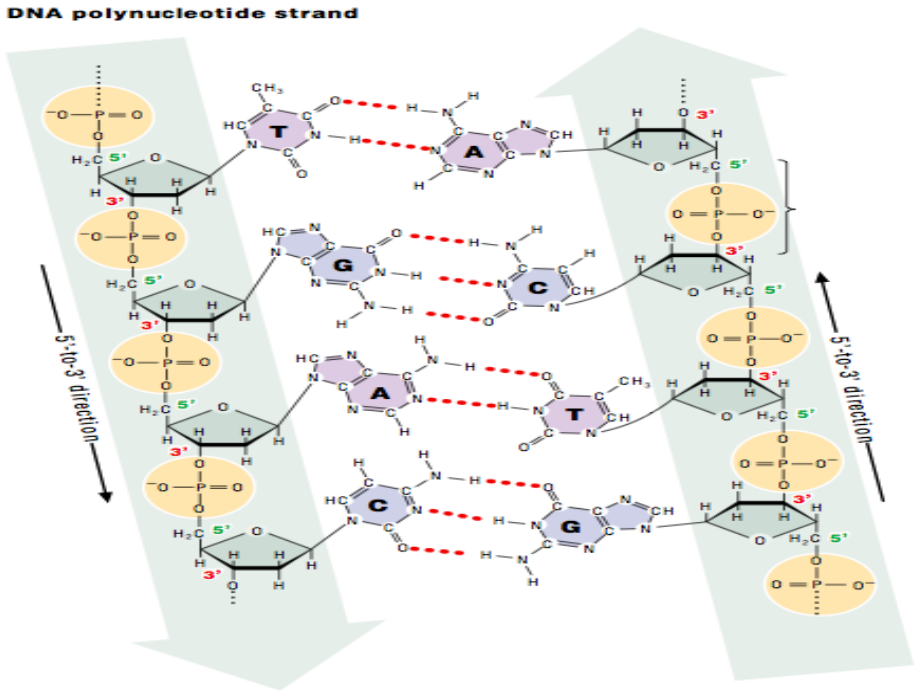

Fig.4.2- Molecular structure of DNA
(Source: Pierce, B.A., 2007)

4.3 BIOTECHNOLOGY EXERCISE

DNA is extracted from plant cell by breaking the cell using physical and chemical methods. The cell is frozen using liquid nitrogen and is broken down using pestle and mortar. The powdered tissue is resuspended in a suitable buffer containing CTAB (Cetyl Trimethyl Ammonium Bromide) which is a detergent used for lysis and also for precipitation of nucleic acid. The protein contaminants are removed from DNA is purified using Phenol: Chloroform: Isoamyl alcohol mixture (25:24:1). RNA contamination is removed from DNA using RNase which degrades RNA into its monomeric subunits. DNA is concentrated using ethanol which precipitates polynucleotides. However, sometimes DNA remains contaminated with protein or RNA and therefore it is very important to check its purity.

The purity of DNA and quantity of DNA is determined either by spectrophotometric method or agarose gel electrophoresis. Nucleic acid exhibits strong absorption of UV light due to the presence of conjugated double bonds in the purine and pyrimidine bases. It has characteristic absorption maxima at 260 nm. Protein exhibit absorption of UV light at 280 nm due to the presence of aromatic amino acids (phenylalanine, tyrosine, and tryptophan). The ratio of absorbance at 260 nm and 280 nm in between 1.7 and 1.9 is indicative of purity of DNA sample. A highly pure DNA has the ratio value 1.8. If ratio is less than 1.7 then it is contaminated with protein and if it is higher than 1.9 it is contaminated with RNA.

Requirements- DNA sample, TE buffer, Quartz cuvette, Eppendorffs, U.V.

spectrophotometer, Tissue paper, Wash bottle, Distilled water, Auto pipette, Sterilized micro tips.

Procedure:

1. Switch on the spectrophotometer. Switch on the UV lamp and set the absorbance at 260 nm. Allow it to warm for about 10-15 minutes.
2. Dilute the given DNA sample appropriately in TE buffer.
3. Clean the cuvette.
4. Set the blank zero with TE buffer
5. Put 1ml DNA sample in the cuvette and place it in sample holder of spectrophotometer.
6. Read the absorbance at 260 nm.
7. Repeat the procedure at 280 nm.
8. Calculate the ratio of absorbance.

Fig.4.3 Spectrophotometer

(Source: Biowave-II-UV-Vis-spectrophotometers-for-low-volume-DNA-measurements)

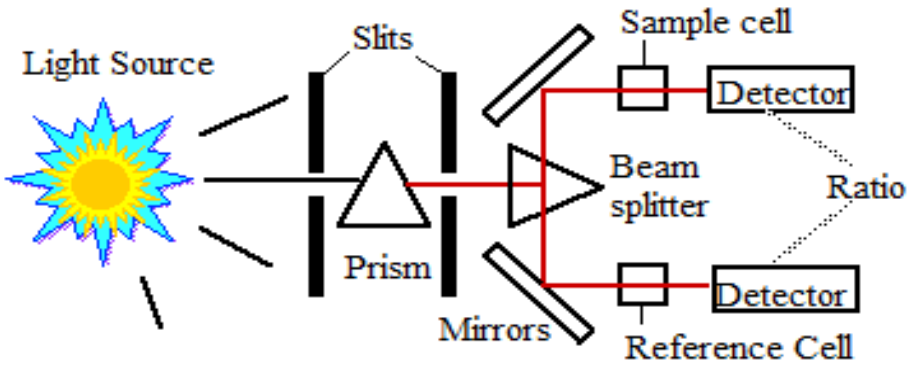

Fig.4.4 Principle of Spectrophotometer

(Source: www.boomer.org/c/p1/Ch02/Ch0207.html)

Observations

Absorbance at 260 nm = ……..……

Absorbance at 280 nm = ……..

Calculations

$$\text{Ratio of absorbance} = \frac{\text{Absorbance at 260 nm}}{\text{Absorbance at 280 nm}}$$

Interpretation- If ratio is 1.8 or in between 1.7 and 1.9 then the given DNA sample is pure. If ratio is less than 1.8 or 1.7 then it is contaminated with protein and if it is higher than 1.9 it is contaminated with RNA.

For determining the concentration of DNA

1 O.D. = 50 microgram/ml of ds DNA or 33 microgram/ml of ss DNA

Record the absorbance of unknown DNA at 280 nm

If absorbance of ds DNA at 280 nm =Z

Then concentration of ds DNA = 50 Z microgram/ml

Precautions

1. Cuvette should be properly cleaned and dry.
2. Record the reading when a constant value is observed.
3. No voltage fluctuation should be there.
4. Always set zero with the blank or subtract the reading of blank from that of the sample.

4.4 SUMMARY

DNA is the carrier of hereditary information from one generation to another. It has a double helical structure which is made up of bases (purine and pyrimidine), deoxyribose sugar and phosphate groups. It is usually contaminated with RNA and protein. The purity and concentration of DNA is determined either by spectrophotometer or agarose gel electrophoresis.

4.5 GLOSSARY

DNA- It is deoxyribonucleic acid. It is a double helical structure which carried the hereditary information from one generation to other. It is made up of bases (adenine, guanine, thymine and cytosine), deoxyribose sugar and phosphate groups.

RNA- It is ribonucleic acid which is single stranded made up of bases (adenine, guanine, cytosine and uracil), ribose sugar and phosphate groups.

Polynucleotide- It is a polymer made up of nucleotide which in turn is made up of nitrogenous base, sugar and phosphate. It can be either DNA or RNA.

Double helix- DNA is made up of two chains which are coiled around a common axis.

Phosphodiester bond- It is formed between the 5' phosphate group of previous base with 3' OH group of next base.
SDS- It is sodium dodecyl sulphate which is a detergent that remove lipid and therefore used for disintegration of cell membrane during DNA extraction.
CTAB- It is Cetyl Trimethyl Ammonium Bromide which is a detergent used for cell lysis and for precipitation of nucleic acid.

4.6 SELF ASSESSMENT QUESTIONS

4.6.1 Fill in the blanks:

(i) DNA is made up of base, sugar and.....
(ii) The purine bases in DNA are..... and.....
(iii) The hydrophilic backbone of DNA is made up of deoxyribose sugar and.....
(iv) Adenine base pair with.....
(v) There are ..... hydrogen bonds between guanine and cytosine.
(vi) The bond between the 5' phosphate group of previous base with 3' OH group of next base is called.....
(vii) DNA gives maximum absorption at ..... nm.
(viii) Nucleic acid exhibits strong absorption of UV light due to the presence of..... bonds in the purine and pyrimidine bases.
(ix) The highly pure DNA has ratio of absorbance at 260 and 280 nm is.....
(x) The contamination of RNA is removed from DNA using.....

4.6.2 Write true or false:

(i) DNA is single stranded structure.
(ii) Thymine is a pyrimidine.
(iii) Adenine always base pair with Cytosine.
(iv) Protein gives maximum absorption at 260 nm.
(v) Phenol is used for removal of protein.
(vi) Nucleic acid gives maximum absorption in visible region.
(vii) CTAB is a detergent used in isolation of plant DNA.
(viii) Ethanol precipitates mononucleotides.
(ix) A nucleotide is made up of base and sugar only.
(x) DNA is positively charged.

Answers Key:

4.6.1 Fill in the blanks-

(i) Phosphate, (ii) Adenine, Guanine, (iii) Phosphate, (iv) Thymine, (v) 3, (vi) Phosphodiester (vii) 260, (viii) Conjugated double bonds, (ix) 1.8, (x) RNase

4.6.2 True/False

(i) False, (ii) True, (iii) False, (iv) False, (v) True, (vi) False, (vii) True, (viii) False, (ix) False (x) False

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4.9 TERMINAL QUESTIONS

1. Describe the properties of DNA.
2. How is the purity of DNA checked?
3. How will you determine the concentration of DNA?

BLOCK-2: ECONOMIC BOTANY, GENETICS AND PLANT BREEDING

UNIT-5 ECONOMICALLY IMPORTANT PLANTS AND PLANT PRODUCT; THEIR COLLECTION, IDENTIFICATION AND MAINTENANCE

5.1 OBJECTIVES

After reading this unit student will be able-

- To describe the economical importance of various plants and plant products.
- To understand the identification, collection and maintenance of given plants

5.2 INTRODUCTION

The economic botany deals with application of botanical knowledge to the well being of mankind. Plants fulfill three major needs of human life viz., food, clothing and shelter. Most of the useful articles are also plant conversion products. Plants yield fibers, wood, drugs, beverages, oils, cellulose, fats, latex, fumitories, masticatories, spices, tannins, dyes, latex, gums, etc.. The food primarily comes from plants in the forms of cereals, millets, pulses, vegetables and fruits. For clothing, again plants are indispensable. The plants that yield fibers are second only to food plants. Man needed some form of clothing, and this need was fulfilled only by fiber yielding plants. In this respect, cotton occupies an important position, supplemented by jute and some other fiber for coarse clothing. The most familiar and important plant product is wood, which is used in all types of construction work. It becomes quite evident that knowledge of botany and its proper application led to the well-being of humanity in several ways. It becomes quite evident that knowledge of botany and its proper application led to the well-being of humanity in several ways. Some of the important plants and their uses are described in this chapter.

Practical Work

The plants of economic importance are kept in the laboratory as specimen, a student is expected to study their characters, identify the plant and the useful plant parts. The student should also be informed about different uses of the plant, cultivation, production and marketing statistics, etc. Therefore, comments written in practical record should include the following sequence.

1. Botanical name of the plant
2. Common English or Hindi name / vernacular name
3. Family
4. Part/parts of the plant used
5. Characters of the plant/ plant part
6. Cultivation, harvesting and processing
7. Uses of the plant part/ parts
8. World production/ Production in India

Practical record should also include diagrams of typical plant or plant part which is economically useful.

5.3 ECONOMICALLY IMPORTANT PLANTS AND PLANT PRODUCTS

1. Cereals

The cereals are the most important source of plant food for man. They constitute the most important group in the food plants of India. The cereals are the members of Gramineae family, and possess the characteristic fruit, the caryopsis. In this fruit the wall of the seed becomes fused with the ovary wall to form the husk. The term grain is applied to this type of fruit. There are six true cereals of which rice, wheat and maize, are most important cereals and they played a crucial part in the development of human civilization. Sometimes millets and sorghums are referred to as cereals. Cereals contain a high percentage of carbohydrates, together with a considerable amount of proteins and some fats, even vitamins are present.

WHEAT

Botanical name: *Triticum aestivum*
Hindi name: Gehoon or Gehu, Kanak
Family: Gramineae (Poaceae)
Part used: Edible part is caryopsis which is a fruit or grain.

Fig. 5.1 - *Triticum aestivum* (Wheat)

1. The grains are produced in an inflorescence which is a spike of spikelets. A mature grain consists of embryo, starchy endosperm, proteinaceous aleurone layer and husk.
2. Wheat flour is used for breads, cakes, biscuits and other confectionary products. Starch is employed in the preparation of beer, industrial alcohol and other a1coholic beverages, for sizing textiles, etc. Wheat straw is used for weaving chairs, mattresses, stuffing, baskets, packing, cattle feed, etc.
3. Largest producer of wheat is U. S. A., other wheat producing countries are Russia, China, Canada, Australia, India, etc.
4. In India it is a major cereal and covers 12% of the total area under cereals and 76% of that under winter cereals. It is mainly cultivated in U.P., Haryana, Punjab and M.P.
5. Various species used include *T. aestivum, T. durum, T. dicoccum, T. sphaerococum,* etc.

RICE

Botanical name: *Oryza sativa*
Hindi name: Chawal, Dhan
Family: Gramineae (Poaceae)
Part used: Edible part is caryopsis.

Fig. 5.2 - *Oryza sativa* (Rice)

1. Half the world's population, mostly the densely populated regions of the world, use this cereal as a staple food.
2. Plant is a large annual grass. The inflorescence

is a panicle, its branches ending into a grain, covered by a husk.
3. The plant grows in hot, moist tropics. The area should be flooded with water during early stages.
4. The grains are used after removal of the husk and are very nutritious. Grain contains considerable amount of proteins, fat and starch. It also forms a raw material for alcoholic beverages. The stems are used as hat fibers and straw for mushroom cultivation.
5. China produces about 32% of the World's rice, India following with 21%. The highest yield in India comes from West Bengal and Bihar.

MAIZE (Corn)
Botanical name: *Zea mays*
Hindi name: Makka, Bhutta
Family: Gramineae (Poaceae)
Part used: Edible part is caryopsis.

Fig. 5.3 - *Zea mays* (Maize)

1. The plant is annual grass. It possesses both male and female flowers on the same plant. Grains are fruits (caryopsis) which contain proteins besides starchy endosperm.
2. Maize is used as a food for livestock; flour is used in the preparation of corn bread. Other uses include corn flakes, corn starch, syrup, corn oil, dextrin's, industrial alcohol. Fibers are also obtained from the main plant for making paper, yarn and as pith. Zein the maize protein is useful in the manufacture of artificial fibers.
3. U. S. A. produces half the world's output. Other corn producing countries include China, Argentina, Brazil, India, Mexico, etc.
4. In India, maize was introduced by East India company in 12th century. It is now chiefly cultivated in U. P., Bihar, Rajasthan, M. P., Punjab, A. P., etc.

PEARL MILLET
Botanical name: *Pennisetum glaucum*
Hindi name: Bajra
Family: Poaceae / Gramineae – (Grass family)
Part used: seed and leaves.

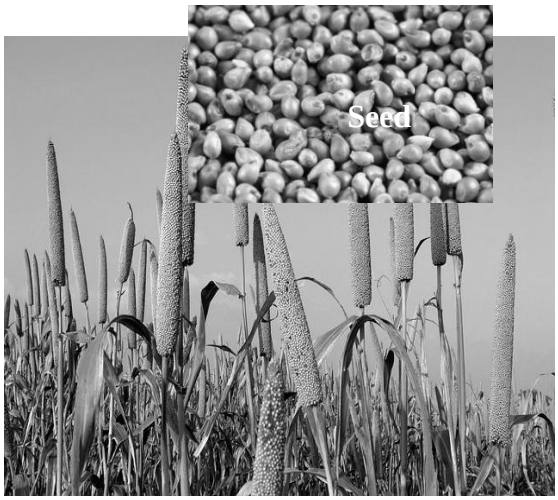

Fig. 5.4 - *Pennisetum glaucum* (Pearl millet)

1. With ovoid grains of 3 – 4 mm length pearl millet has the largest kernels of all varieties of millet (not including sorghum) which can be nearly white, pale yellow, brown, grey, slate blue or purple. The height of the plant ranges from 0.5 – 4 m.
2. Pearl millet is one of the most extensively

cultivated cereals in the world, after rice, wheat, and sorghum, and particularly in arid to semi-arid regions.

3. Pearl Millet is a principal food cereal cultivated in drought prone semi-arid regions of Africa and Indian subcontinent. In the U.S.A., Australia, Southern Africa, and South America, pearl millet is grown most extensively as a forage crop. India is the largest producer of pearl millet. Rajasthan is the highest-producing state in India.

4. In addition to grain and forage uses, pearl millet crop residues and green plants also provide sources of animal feed, building material, and fuel for cooking, particularly in dry land areas.

5. Pearl millet is considered more efficient in utilization of soil moisture and has a higher level of heat tolerance than even sorghum and maize. The crop grows easily in that region due to its ability to withstand harsh weather conditions like drought and flood.

2. SUGAR AND STARCH

Sugars- The glucose manufactured by the green plant in photosynthesis, is almost universally present in plant cells, and the basic material of metabolism, glucose. The most important complex sugar is sucrose or cane sugar. The sugar is accumulated in abundant in sugarcane and sugar beets.

Starch- It occurs in all green plants, as complex carbohydrate. They are derived also from glucose and constitute the first visible product of photosynthesis. Commercial sources of starch are wheat, barley, Maize, Potatoes.

SUGARCANE

Botanical name: *Saccharum officinarum*

Hindi name: Ganna

Family: Gramineae (Poaceae)

Part used: Part of the plant used is stem for sugar extraction.

Fig. 5.5 - *Saccharum officinarum*

1. This perennial grass grows 8 to 12 feet tall and is supported by stilt roots.

2. It grows best in warm humid weather.

3. The sugarcane is propagated by cutting of various sizes made from upper joints of old canes. These cutting are known as seed, are placed in trenches and nearly covered with soil.

4 The juice extracted from stem by expression is crystallized to manufacture sugar. The bagasse, molasses and filter mud which are by-products of sugar extraction are also used variously.

5. Chief cane sugar producing countries include Brazil, Cuba, India, China, Australia, etc.

6. Eighty percent sugar cane in is grown in north India with U .P. leading the list including Punjab, Bihar, Coimbatore and Haryana.

POTATO

Botanical name: *Solanum tuberosum*
Hindi name: Alu or Aaloo
Family: Solanaceae
Part used: Part of the plant used is underground stem tuber.

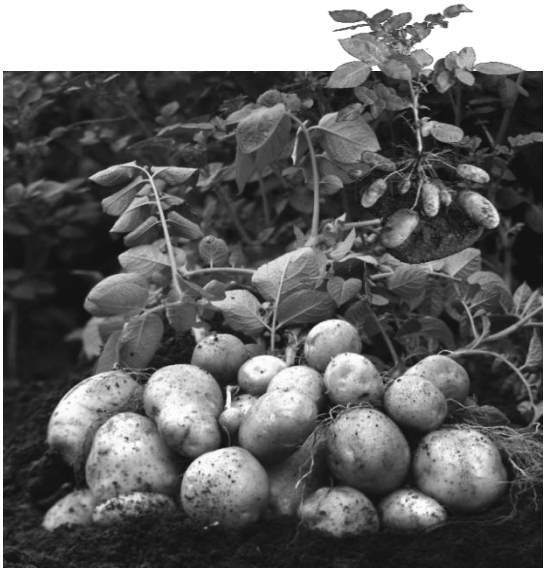

Fig. 5.6 - *Solanum tuberosum*

1. It is rich in starch and forms one of the most commonly used vegetable
2. Plant, a native of South America, is about foot tall, spreading annual. The underground branches swell at the tip to form tubers.
3. It grows over a wide range of soil and climatic conditions.
4. It is a universal staple food and is also used for sizing cotton and paper, production of dextrin's, alcohol, adhesives, etc.
5. About 90% production comes from Europe. In India it is largely cultivated in U.P., H.P., Punjab, M.P., etc.

3. PULSES OR LEGUMES

The legumes or pulses belong to the family Leguminosae. The Legumes are next in importance to cereals as source of human food. They contains more proteins than any other vegetable product. Carbohydrates and fats are also present in legumes. The protein occur as aleurone grains in the same cells with the starch grain. The high content of protein is related with the presence nodules on the roots of legumes, containing nitrogen fixing bacteria. The pulses are also important from the point of view of animals nutrition, to which they contributes by their seeds, hulls and the green parts. The legumes have been cultivated and used as a food for centuries all over the world. About one-seventh of cultivated area in India is under pulses.

CAJAN PEA (Pigeon Pea)

Botanical name: *Cajanus cajan*
Hindi name: Arhar
Family: Papilionaceae (Leguminosae)
Part used: Edible part is the seed produced in pod or legume (fruit).

Fig. 5.7 - *Cajanus cajan* (Cajan Pea)

1. This annual plant is 6-7 feet tall. The leaves are trifoliate and flowers are borne in an axillary raceme.
2. It is grown as a mixed crop with jowar, bajra, ragi, cotton, maize, ground nut, etc.
3. Cajan pea is extensively used as *dal;* the green leaves and tops as animal feed and also as a green manure.

4. It is chiefly grown in U.P., Rajasthan, Orissa, Maharashtra,
Bihar, M.P., etc. India also export small quantities to U. K., France, Sri Lanka, Burma, etc.

SOYBEAN

Botanical name: *Glycine max*
Hindi name: Bhatwar or bhat, Soyabean
Family: Papilionaceae (Leguminosae)
Part used: Edible part is the seed produced in pod or legume.

Fig. 5.8-*Glycine max* (Soyabean)

1. It is a small, bushy, erect or prostrate annual that grows from 1-6 feet. Each pod contains 3-4 seeds.
2. It is grown alone or mixed with maize or sorghum; in fertile loam or sandy loam soils.
3. Soybean contains 32-42% proteins and has the highest lysine content (3.8%).
4. Besides being used variously as a food article, soybean flour, oil and milk are also extensively used.
5. Manchuria leads the production followed by Korea, Japan, China and Indonesia. India also grows a small amount of this crop.

BLACK GRAM

Botanical name: *Vigna mungo (Phaseolus mungo)*
Hindi name: Urd
Family: Papilionaceae (Leguminosae)
Part used: Edible part is the seed produced in pod or legume.

Fig. 5.9-*Vigna mungo* (Black Gram)

1. It is a herbaceous annual with procumbent branches, wooly in appearance. The leaves are trifoliate and the flowers are borne in clusters of five to six.
2. It is grown as a mixed crop in loamy or heavy soils in worm climate with good amount of rain.
3. It is highly prized for its high phosphoric contents. It is preferred in the preparation of *papars*, *kachoris*, etc. The seeds are eaten raw, germinated, salted or boiled. They are also used as *dal.* Straw is fed to the cattle.
4. The major areas of production in India include M.P., U.P., Punjab, Maharashtra, West Bengal, A.P. and Karnataka.

GREEN GRAM

Botanical name: *Vigna radiata* (*Phaseolus radiatus)*
Hindi name: Moong
Family: Papilionaceae (Leguminosae)
Part used: Edible part is a seed produced in pod or legume.

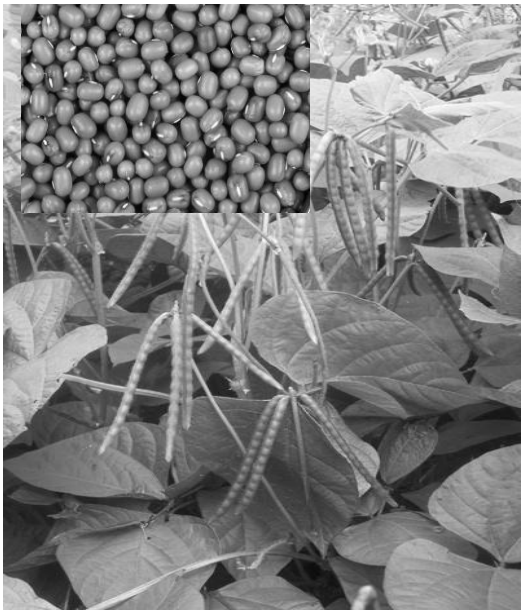

Fig. 5.10 - *Vigna radiata* (Green Gram)

1. This small herbaceous annual grows to a height of 1-3 feet. The leaves are trifoliate and the yellow flowers are produced in clusters.
2. It grows on loams as well as on red and black soils as a kharif crop. It requires rainfall between 25-35 inches distributed throughout the year.
3. The green pods are used as vegetable, seeds as a pulse and straw and husk as fodder for cattle. Seeds are eaten as whole, as *dal*, parched, salted, germinated or boiled.
4. It is widely cultivated in India. The major states are M.P.,U.P., Punjab, Maharashtra, Rajasthan, Karnataka, Tamil Nadu, Bihar and A.P.

GRAM PEAS (Chick Peas or Bengal Gram)

Botanical name: *Cicer arietinum*
Hindi name: Chana
Family: Papilionaceae (Leguminosae)
Part used: Edible part is a seed produced in pod or legume.

Fig. 5.11 - *Cicer arietinum* (Gram Pea)

1. The plant is branched, about 2 feet tall, leaves are pinnately compound and the fruit contains 1-3 seeds.
2. It is a dry crop grown in rabi season. It is best suited to areas of moderate rainfall with mild cold weather in water retentive clay loams and black cotton soils.
3. Gram is eaten raw, boiled or cooked. Green foliage is also used as a vegetable. It is used as a *dal* and gram flour or *besan* is used in various preparations.
4. It is rich in proteins, carbohydrates and contains varied amounts of vitamin A, B, and C. It also contains useful quantities of minerals.
5. In India it is mainly cultivated in U.P., Punjab, Rajasthan, M.P., Bihar, Maharashtra, A.P., West Bengal, Tamil Nadu and Karnataka.

4. VEGETABLES

The term vegetable is usually applied to edible plants which store up reserve food in roots, stem, leaves and fruits, which are eaten raw, cooked and as salad. The vegetables rank next to cereals as sources of carbohydrate food. The nutritive value of vegetables is incredible, due to the presence of indispensable mineral salts and vitamins. India grows a large variety of vegetables belonging to the tropical, sub-tropical and temperate zones.

UNDERGROUND VEGETABLES

In these vegetables the food is stored in underground parts. The storage organs may be true roots or modified stems, such as rootstock, tubers, corms and bulbs.

A. ROOT VEGETABLES

SWEET POTATO (Camote)

Botanical name: *Ipomoea batatas*
Hindi name: Shakarkand
Family: Convolvulaceae
Part used: Edible part is root (tuber) whereas leaf is used as folk medicine.

Fig. 5.12-*Ipomoea batatas* (Sweet Potato)

1. Tuberous-rooted perennial, usually grown as an annual; top herbaceous, drying back to ground each year. Stems forming a running vine up to 4 m long, usually prostrate and slender, with milky juice, lateral stem-branches arising from the short stem and usually not branched. Leaves ovate, borne on long petioles, palmately veined, angular or lobed, depending on variety, green or purplish.
Flowers rare, seeds 1–4 per pod, flattened, hard-coated, angular.
2. The sweet potato is a native of tropical America. Now it is widespread in all tropics and some parts of the temperate zone, and found abundantly in South Seas, China, Japan, Indonesia, and India. It is cultivated throughout India.
3. Cultivated mainly for the tuber, used as vegetable, eaten raw, boiled and roasted, baked fried, or dried and ground into flour to make biscuits, bread, and other pastries.
4. Tubers also dehydrated in chips, canned, cooked and frozen, creamed and used as pie fillings. Leafy tops eaten as vegetable and sold in markets in Malaysia.
5. Folk Medicine- The leaf decoction is used in folk remedies for tumors of the mouth and throat. Sweet potato is a folk remedy for asthma, bug bites, burns, catarrh, ciguatera, convalescence, diarrhea, fever, nausea, stomach distress, and tumors.

BEETROOT (Garden beets, Sugar beets)
Botanical name: *Beta vulgaris*
Hindi name: Chukandar
Family: Amaranthaceae (Formally Chenopodiaceae)
Part used: Edible part is root and leaves whereas seed are used in folk medicine.

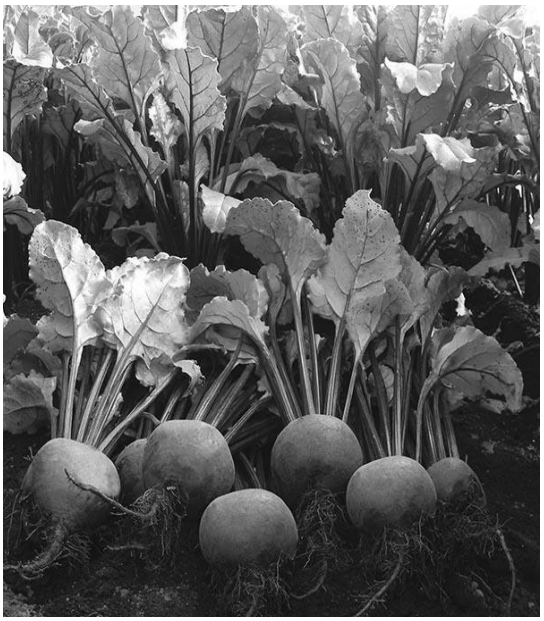

Fig. 5.13-*Beta vulgaris* (Beetroot)

1. Annual or biennial herb, leaves glabrous, ovate to cordate, dark green or reddish, frequently forming a rosette from the underground stem, roots conspicuously swollen at junction with stem; flowering stalk 1.2–1.8 m tall, flowers small, numerous in a tall open panicle, fruit an aggregate of 2 or more fruits forming an irregular dry body; in garden beets, roots are usually a deep red color and may be globular or cylindrical. Beet crops are propagated from seed, sown in early spring when the ground is suitable for tilling.
2. Generally used in vegetables salad. Garden beets are grown for the roots which are eaten cooked, as a vegetable, in salads or pickled, used as a important cattle food.
3. Refreshing juice is extracted from it. Sugar is manufactured from juice in European countries, it is the second most important source of sugar. Chard and spinach beet are grown for the leaves which are used as a potherb.
4. Many studies indicate that eating more plant foods, like beetroot, decrease the risk of obesity, overall mortality, diabetes, and heart disease and promote a healthy complexion and hair, increased energy, and overall lower weight.
5. Folk Medicine- The decoction prepared from the seed is a folk remedy for tumors of the intestines. Seed, boiled in water, is said to cure genital tumors. The juice or other parts of the plant is said to help tumors, leukemia and other forms of cancer.

RADISH
Botanical name: *Raphanus sativus*
Hindi name: Muli
Family: Cruciferae (Brassicaceae)
Part used: Edible part is root and leaves.
Also root and seed are used in medicine.

Fig.5.14-*Raphanus sativus* (Radish)

1. They are annual or biennial plants with a fleshy tap root. They are grown all over the World, many varieties are cultivated differing in the shape and color of the roots. In India, they are chiefly cultivated in Uttar Pradesh, Punjab, Maharashtra and Baroda.
2. The roots, young leaves and the fruits are used as vegetable. Usually they are eaten raw,

but may be cooked like other vegetables.
3. The roots are used as diuretic in urinary troubles, piles and gastrodynia. Juice of fresh leaves are diuretic and laxative.
4. The seeds are expectorant, diuretic and carminative. Seeds yield a non drying fatty oil suitable for soap making; also for edible purposes and as an illuminant. Hydrogenated oil is used in Japan in manufacture of crayon. Seed cake is rich in protein and appears to be suitable for use as manure and after removal of isothiocyanates use as a feed stuff.

CARROT
Botanical name: *Daucus carota*
Hindi name: Gajar
Family: Apiaceae
Part used: Edible part is root whereas seed are used in folk medicine.


Fig.5.15-*Daucus carota* (Carrot)

1. An annual or biennial herb, that grows between 30 and 60 cm tall, and is roughly hairy, with a stiff, solid stem. The leaves are tri-pinnate, finely divided and lacy. The fruits are oval and flattened, with short styles.
2. It is native to temperate regions of Europe and southwest Asia, and naturalized to North America and Australia. In India they may be chiefly grown in the Punjab, Uttar Pradesh and Madhya Pradesh.
3. Cultivated for the enlarged fleshy taproot, eaten as a raw vegetable, as salad or cooked in many dishes.
4. They are sold in bunches, or canned, frozen, or dehydrated. They may be baked, sautéed, pickled, and glazed, or served in combination with meats, in stews, roasts, soups, meat loaf or curries.
5. Carrot juice is beneficial for health. Essential oil is used to flavor liqueurs and perfumes.
6. Folk Medicine: Seeds are aromatic, carminative, diuretic, and stimulant, and are used for dropsy, chronic dysentery, kidney ailments, and worms, Diuretic, and eliminating uric acid. Local stimulant for indolent ulcers; other ingredients of carrot lower blood sugar; hence carrot might be increased to good advantage in the prevention of cancer, diabetes, dyspepsia, and gout, possibly heart disease.

B. STEM VEGETABLES

POTATO
Botanical name: *Solanum tuberosum*
Hindi name: Alu or Aaloo
Family: Solanaceae
Part used: Edible part is modified stem (globose berry).

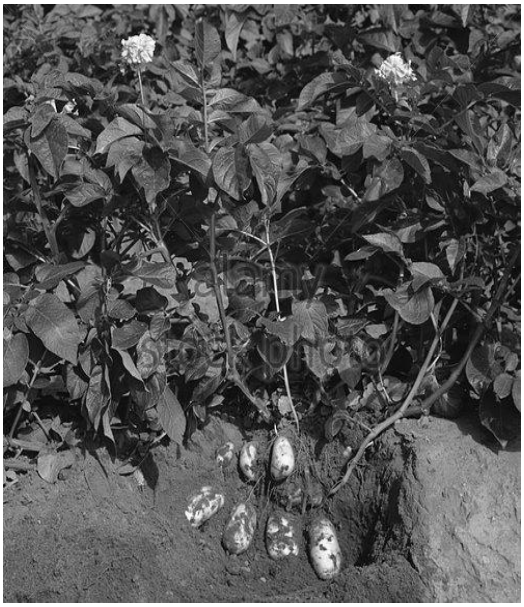

Fig.5.16- *Solanum tuberosu* (Potato)

1. Potato plants are herbaceous perennials that grow about 60 cm high, depending on variety, with the leaves dying back after flowering, fruiting and tuber formation. Leaves alternate, imparipinnate, short-stalked, Flowers white or blue, pedunculate in lateral, many flowered cymes, Fruit is a globose 2-celled berry, many-seeded, yellowish green.
2. Potato is an important cash crop which gives ready cash to farmers. It is said to be 'complete food' as it contains carbohydrates, proteins, vitamin B and C and minerals like P, Ca and Fe required for body growth.
3. It is one of the major vegetable crop of the world, richest source of starch, calorific value is high.
4. It produces more food per unit area than any cereal crop within short period. In India it is used as vegetable alone or mixed with other vegetables. Various products prepared form potato are chips, finger chips, cubes, flour etc.

ONION

Botanical name: *Allium cepa*
Hindi name: Kanda, Pyaz
Family: Liliaceae/ Amaryllidaceae
Part used: Edible parts are underground stems (bulbs) and leaves.

Fig.5.17-*Allium cepa* (Onion)

1. The onion is most frequently a biennial or a perennial plant, but is usually treated as an annual and harvested in its first growing season. The onion plant has a fan of hollow, bluish-green leaves and its bulb at the base of the plant begins to swell when a certain day-length is reached. The bulbs are composed of shortened, compressed, underground stems surrounded by fleshy modified scale (leaves) that envelop a central bud at the tip of the stem.
2. Onions are best cultivated in fertile soils that are well-drained. Sandy loams are good as they are low in sulphur, require a high level of nutrients in the soil.
3. Onion is the most important commercial spice crop grown in India and exported. Leaves and immature bulbs are consumed as vegetable, used for raw consumption, used in making sauce, ketch-up, pickles, and chutney. Dried onion chips and powder have great demand for export.
4. The bulbs obtained during seed production are feed to cattle or poultry. It is mixed in other vegetables and soups as spice and flavoring agent. It contains vitamins B and C and minerals Ca and Fe. It has medicinal properties and used against ear-ache, colic pain etc.

GARLIC

Botanical name: *Allium sativum*
Hindi name: Lasan, Lahsun
Family: Liliaceae/ Amaryllidaceae
Part used: Edible parts are leaves and bulb (cloves), it is also used in medicine.

Fig.5.18 *Allium sativum* (Garlic)

1. This is a perennial plant with narrow flat leaves and several small bulb, known as cloves, enclosed in a white skin. It is a bulbous plant, grows up to 1.2 m (4 ft) in height. Garlic is native to the plains of western Asia.
2. Its use in cooking is as old as humanity. The bulb are used as a condiment and flavoring substance.
3. Garlic powder is extensively used as condiment and also serves as carminative and gastric stimulant. Juice is applied in skin troubles and used as ear drop.
4. It possesses anti-inflammatory, anti-arthritic, anticoagulant, hypo-proteinemic, hypocholesteremic, antibacterial, antifungal, antihypertensive and hypoglycemic action. It increases prothrombin time and fibrinolytic action. It is used in dermatophytosis, cough, febrifuge, in intermittent fever, dyspepsia. It is also used as a rubefacient, hepatoprotective and anti-androgenic.

C. FRUIT VEGETABLES

TOMATO

Botanical name: *Solanum Lycopersicum*
Hindi name: Tamatar
Family: Solanaceae
Part used: Edible part is fruit.

Fig.5.19 *Solanum Lycopersicum* (Tomato)

1. The species originated in Central and South America. The plant is short lived, Perennial & annual plant, erect, aerial, woody below and herbaceous above, cylindrical with distinct ribs, solid, branched, green, Flower are small and yellow Fruit are many seeded berry.
2. Fresh ripe fruits are refreshing and appetizing and are consumed raw in salads or after cooking.
3. Unripe fruits are cooked and eaten, they are considered culinary vegetables, being ingredients of savory meals. Large quantities of fruits are canned, consumed also in the form of juice, paste, ketchup, sauce, soup and powder.

BRINJAL (Egg plant)

Botanical name: *Solanum melongena*
Hindi name: Baingan or Baigun
Family: Solanaceae
Part used: Edible part is fruit, whereas roots are used in medicine.

Fig.5.20 *Solanum melongena* (Brinjal)

1. It is an annual herbaceous plant, under shrub, erect, aerial, woody below and herbaceous above, cylindrical with distinct ribs, solid, branched, green, flower white or pinkish in colour, Fruit are large, ovoid, whitish or purple many seeded berry.
2. The fruits are given as culinary vegetable, usually cut into slices and fried or boiled. Besides being consumed as a vegetable, it is also pickled; sliced fruits are dried and stored.
3. It is rich in iodine contents, they are given in liver complaints; they stimulate interhepatic metabolism of cholesterol. Aqueous extract of fruits inhibit choline esterase activity of human plasma.
4. It contains higher percentage of vitamin B2 than other vegetables. The roots are antiasthmatic and general stimulant; juice use in ulcer of nose. Seeds yield fatty oil.

LADY'S FINGER (Okra)

Botanical name: *Abelmoschus esculentus*
Hindi name: Bhindi
Family: Malvaceae
Part used: Edible part is flower, fruit, young pod and stalk, whereas seeds are used in medicine.

Fig.5.21 *Abelmoschus esculentus* (Okra)

1. It is a native of tropical Africa, now cultivated throughout India. The plant is a stout annual. The young pods are mucilaginous.
2. The fruit are used as vegetable. It can also be dried and canned. The stalk are sometimes used for making fibers. Tender pods are also used for thickening soups and gravies whereas flowers are eaten in soups.
3. Ripe seeds roasted for use as coffee substitute, also used in curries and chutneys. Seed are rich in protein; they are powdered and mixed with maize flour. Seed yield a fatty edible oil.
4. A vegetable gum, called okra gum is obtained from the plants, and used as combined flavoring and bodying agent in vegetable soups and gravies.
5. Immature capsule are emollient, demulcent and diuretic, seeds are stimulant, cordial and antispasmodic. The leaves yield essential oil, seed cake rich in protein.

5. TIMBERS

Prior to a tree being harvested (logged), timber is the term most often used. Other industries generally refer to timber as the product ready for making something. For example, wood that is suitable for carpentry and building houses is called timber. Timber is a type of wood that has been processed into beams and planks, a stage in the process of wood production. It is commercially used in many purposes such as in making furniture's, construction work, frames, doors, windows, boats, railway sleepers etc.

SISSOO

Botanical name: *Dalbergia sissoo*
Hindi name: Shisham
Family: Papilionaceae
Part used: Part of the plant used is heartwood which is a valuable timber.

1. It is a large tree reaching a height of 30 m and a girth of 2.4 m.
2. The heartwood is brownish in colour with darker streaks. It is hard and moderately heavy to very heavy.
3. It is diffuse porous. Growth rings are indistinct and ripple marks are present.
4. The wood can be seasoned without much difficulty. It can last for about 288 months.
5. The tree occurs throughout the sub-Himalayan tract from Indus to Assam. It has also been extensively cultivated in many parts of the country especially Punjab, U.P., West Bengal and Assam.
6. Shisham is very commonly used for building purposes, furniture, carriages, carving, etc.

Fig. 5.22 - *Dalbergia sissoo* (Sissoo)

SAL

Botanical name: *Shorea robusta*
Hindi name: Sal, Sakhu
Family: Dipterocarpaceae
Part used: Part of the plant used is heartwood which is a valuable timber.

1. It is a large deciduous tree reaching a height of about 37 m (up to 46 m) and a girth of about 3.7 m.
2. The sapwood and heart wood are distinct. The sapwood is white with brownish tinge and heart wood is brown to reddish brown. The wood is dull hard to very hard and usually heavy to very heavy.
3. It is diffuse porous to ring porous. The annual rings are indistinct to absent. Ripple marks are normally absent.

Fig. 5.23 - *Shorea robusta* (Sal)

4. The wood is difficult to season. It develops cracks during seasoning. It remains in good condition even after 20 years of contact with the ground.
5. This most popular wood is used as a structural timber used for doors, windows, beams, planks, etc. It is also useful as railway sleepers.

TEAK
Botanical name: *Tectona grandis*
Hindi name: Sagaun
Family: Verbenaceae
Part used: Part of the plant used is heartwood as timber.

1. It is a large deciduous tree with outer bark peeling off in long thin flakes.
2. The wood is moderately hard, strongly and characteristically scented. It contains an oil which is easily perceptible to touch. The oil acts as preservative against white ants.
3. Heart wood is dark brown and turns almost black with age. Annual rings are distinct, marked with regularly arranged pores.
4. Teak wood is used for construction purposes, furniture and cabinet work.
5. The tree grows in Western Ghats, Tamil Nadu, M.P., Orissa, Mysore and Bihar.

Fig. 5.24 - *Tectona grandis* (Teak)

PINE WOOD

Botanical name: *Pinus roxburghii*

Hindi name: Chir

Family: Pinaceae

Part used: Part of the plant used is heartwood as timber.

Description:

1. It is native to the Himalayas, and was named after William Roxburgh.
2. It is a large tree reaching 30–50 m, bark is red-brown, leaves are needle-like, in fascicles of three, very slender, distinctly yellowish green, cones are ovoid conic 12–24 cm long and 5–8 cm broad at the base when closed, seeds are 8–9 mm long, with a 40 mm wing, and are wind-dispersed.

Economic Importance:

1. Source of an oleoresin which yields turpentine oil, chiefly used as a solvent for paints and varnishes; also used in perfumery industry, in the manufacture of synthetic pine oil, disinfectants, insecticides, and denaturants.
2. It is expectorant, useful in chronic bronchitis and especially recommended for gangrene of lungs. Given as a carminative in flatulent colic and also used to arrest minor hemorrhages in tooth-sockets and nose.
3. Also employed in paper and rubber industries, furniture polishes, floor waxes, shoe creams, metal polishes, and printing inks.
4. Wood used for constructional purposes, cheap joinery and furniture, packing cases, truck and bus bodies, and electric transmission poles. Also used for railway sleepers and for wagons and railway carriages.

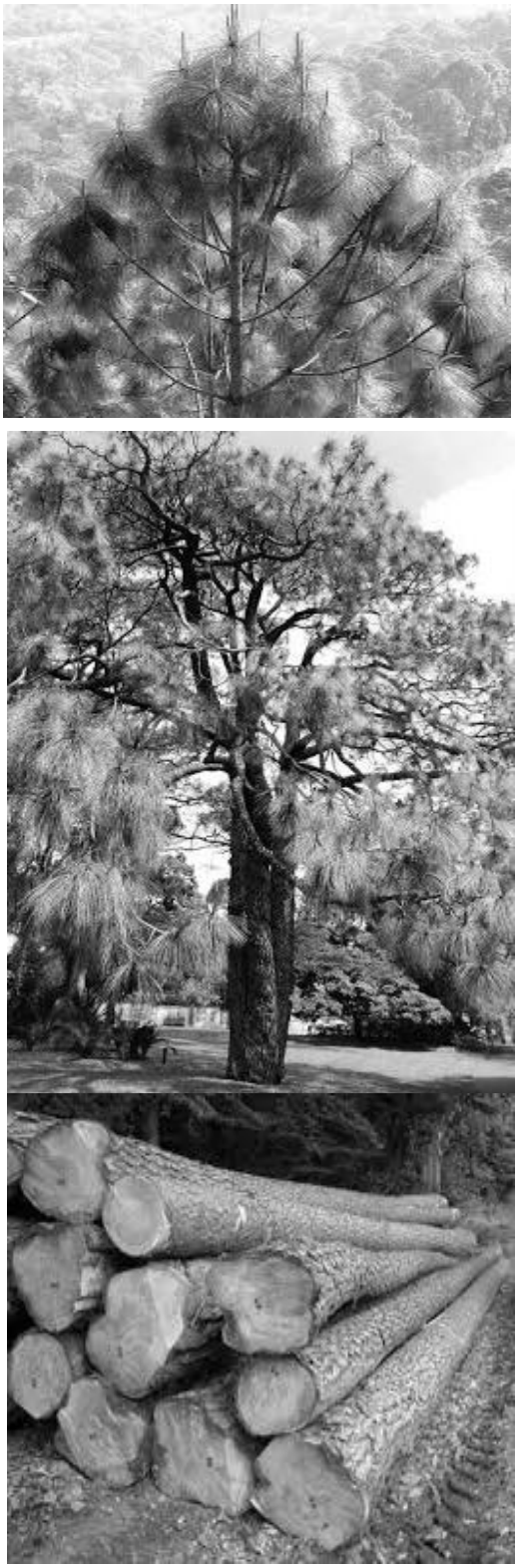

Fig. 5.25 - *Pinus roxburghii* (Pine Wood)

DEODAR

Botanical name: *Cedrus deodara*

Hindi name: Devadar, Diar

Family: Pinaceae

Part used: Part of the plant used is heartwood as timber.

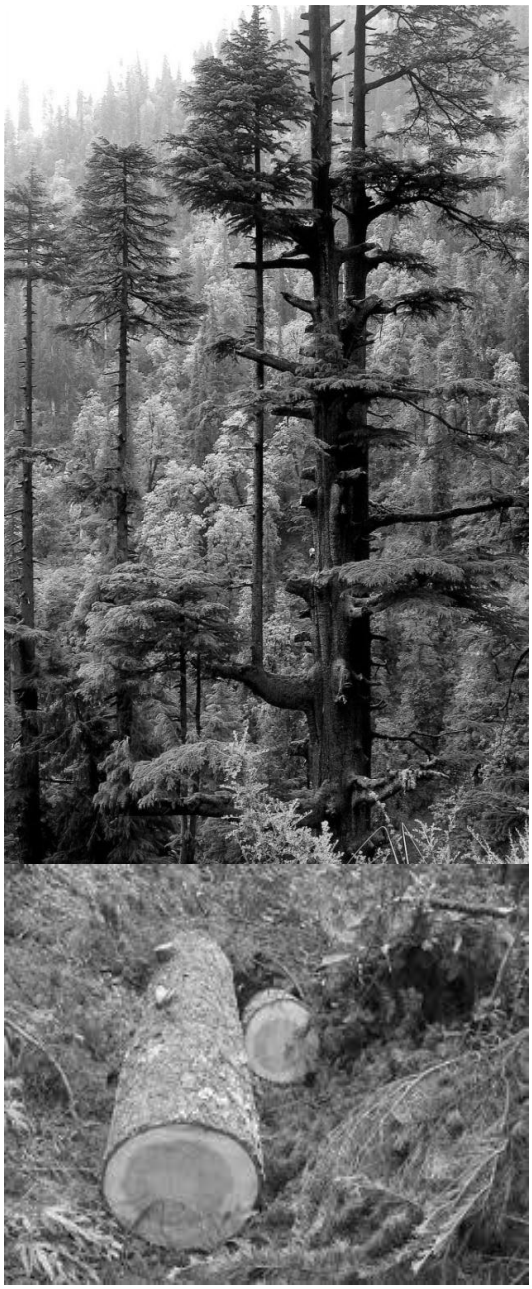

Fig.5.26-*Cedrus deodara* (Deodar)

Description:

1. A tall evergreen tree found in the North-Western Himalayas from Kashmir to Garhwal.
2. It is a large evergreen coniferous tree reaching 40–50 m tall, with a trunk up to 3 m in diameter, forming a typical conical crown. Branches two types, long shoots bear spirally arranged leaves, dwarf shoots bear cluster of leaves in pseudo-whorls. Flowers monoecious, male and female cones occurring on separate branches.

Economic Importance:

1. It is used in Ayurvedic medicines is well recorded. The inner wood is aromatic and used to make incense. As insects avoid this tree, the essential oil is used as insect repellent.
2. It also has antifungal properties and has some potential for control of fungal deterioration of spices during storage.
3. This is strongest of Indian coniferous wood. Seasoned heartwood of deodar is very durable. The durability of deodar may be due to the presence of terpene/resin acids present in the heartwood.
4. The timber is used for construction work and for railway sleepers. It is also suitable for beams, floor boards, ports, window frames, light furniture and shingles.

6. BEVERAGES

The beverages containing caffeine are used all over the world for their stimulating and refreshing qualities. Caffeine is an alkaloid, which has definite medicinal value and acts as a diuretic and nerve stimulant. The important non-alcoholic beverages are - Tea, Coffee and Cocoa.

TEA

Botanical name: *Camellia sinensis*
Hindi name: Chai or cha
family: Theaceae
Part used: Parts of plant used are leaves which give a popular beverage called tea.

Fig.5.27- *Camellia sinensis* (Tea)

1. It is a species of evergreen shrub or small tree whose leaves and leaf buds are used to produce tea. It is usually trimmed to below 2 m when cultivated for its leaves, has a strong taproot, flowers are yellow-white, 2.5–4 cm in diameter, with 7 to 8 petals.
2. It is mainly cultivated in tropical and subtropical climates, in areas with at least 127 cm of rainfall a year. Many high quality teas are grown at high elevations, up to 1,500 meters, as the plants grow more slowly and acquire more flavor.
3. Tea contains 2.5% theine, 13-18% tannin, volatile oils and a small amount of caffeine.
4. The leaves are plucked and cured and an infusion in boiled water yields most popular of the beverages.
5. India is one of the leading producers and exporters of tea. About 73% of the total output comes from south-east region, especially Assam and West Bengal.

COFFEE

Botanical name: *Coffea arabica*
Hindi name: Kafi
Family: Rubiaceae
Part used: Parts of the plant used are seeds which are used for the preparation of a beverage called coffee.

1. Wild plants grow between 9 and 12 m tall, leaves are opposite, simple elliptic-ovate to oblong, glossy dark green. The flowers are white, and grow in axillary clusters, seeds are contained in a drupe (cherry), maturing bright red to purple and typically contains two seeds (the coffee beans). The plant grows in hot, moist climate. These are raised from seeds or seedlings and come into bearing in the third year.
2. The fruits are berries and the skin is removed. The seeds are then roasted to develop aroma, flavor and colour. Seeds contain 0.75 to 1.5% caffeine, a volatile oil caffeol, glucose, dextrin, proteins and fatty oils.
3. It is a source of 90% of the world supply. Brazil tops the world production. U.S.A. leads in per capita consumption.
4. In India, coffee is cultivated in Karnataka, Tamil Nadu and Kerala.

(A) (B)

Fig.5.28 (A) *Coffea arabica* (Coffee), (B) Coffee Beans

COCOA

Botanical name: *Theobroma cacao*
Common name: Cocoa
Family: Malvaceae
Part used: Plant part used are fruit seeds (cocoa beans)

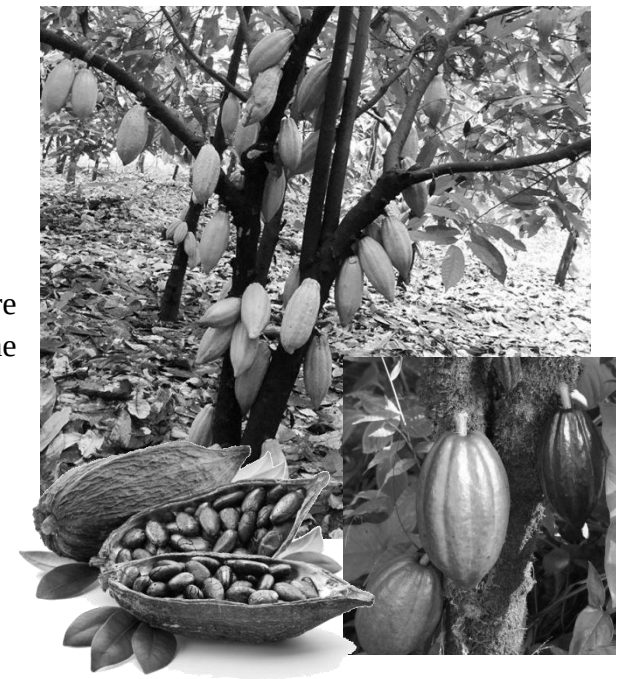

Fig.5.29-*Theobroma cacao* (Cocoa)

1. A small tree, grows to 50 ft., it require constant warmth and rainfall to thrive. The cocoa tree is native to the America, but now cultivated along the Malabar Coast and in the Nilgiris and Pulney hills. It is grown throughout tropical South and Central America, West Indies, and many other parts of the world.
2. Its seeds, cocoa beans, are used to make cocoa mass, cocoa powder, confectionery, ganache and chocolate (which is obtained by roasting and grinding the seeds).
3. The seed contain less than 1 percent of an alkaloid, theobromine, with a few traces of caffeine, is responsible for the stimulating properties.
4. Chocolate is also said to contain the chemical Phenyl ethylamine, a natural amphetamine found in the human brain, which induces a feeling of euphoria.

7. OILS

The term "plant oils", we refer to oils that are derived from one or more parts of a plant, shrub or tree. Hence the oil could be from the root, stem/bark, leaves, flowers, seeds, fruits and whatever else could be a part of the plant. Oils, oleoresins & extracts from plants are

used in a wide variety of ways – in food, as medicine, in cosmetics & toiletry, as ingredients for industrial products, as fuel, and more. Essential oils are volatile, and are usually derived from the non-seed parts of the plants. Most fixed oils are the so-called "fatty oils", and a majority of the fatty oils are derived from the seeds, hence the term oilseeds, meaning oil-bearing seeds. Some of the fixed oils are derived from vegetables & nuts.

GROUNDNUT
Botanical name: *Arachis hypogaea*
Hindi name: Moongphali
Family: Fabaceae/Leguminosae
Part used: Part of the plant used are seeds from which oil is extracted.

Fig.5.30- *Arachis hypogaea* (Groundnut)

1. Peanut is an annual herbaceous plant growing 30 to 50 cm, leaves are opposite and pinnate with four leaflets
2. It is widely grown in the tropics and subtropics, grow best in light, sandy loam soil with a pH of 5.9–7 being important to both small and large commercial producers.
3. It is classified as both a grain legume and, because of its high oil content, an oil crop. Peanuts harbor symbiotic nitrogen-fixing bacteria in root nodules. Seeds are an important source of vegetable non-drying oil.
4. Peanuts have a variety of industrial end uses. Paint, varnish, lubricating oil, leather dressings, furniture polish, insecticides, and nitroglycerin are made from peanut oil. Soap is made from saponified oil, and many cosmetics contain peanut oil and its derivatives.
5. The protein portion is used in the manufacture of some textile fibers. Peanut shells are used in the manufacture of plastic, wallboard, abrasives, fuel, cellulose (used in rayon and paper), and mucilage (glue).
6. The major ground nut producing countries are India, China, West Africa, U.S.A, etc.

CASTOR
Botanical name: *Ricinus communis*
Hindi name: Arandi
Family: Euphorbiaceae
Part used: Seeds of the plant used for oil extraction.

1. It yields one of the most important non-drying oils. The oil contents of seeds vary from 35 to 58%. It is green in colour. Oil is collected from the seeds by solvent extraction or expression.

2. Castor oil is used as purgative. Being water resistant, it is used for making fabrics, for protective covering of air-planes, insulations, etc. It is also used in soap manufacture, inks, plastics, paints, varnishes, leather preservation, etc.
Oil cake is poisonous and cannot be used as cattle feed. However, it is an excellent fertilizer.
3. In India AP., Tamil Nadu, Maharashtra and Karnataka are chief castor seed growing states.

Fig.5.31- *Ricinus communis* (Castor)

MUSTARD
Botanical name: *Brassica campestris*
Hindi name: Sarson
Family: Cruciferae
Part used: Part of the plant used are seeds for extraction of oil.

1. It yields one of the most important edible oils. The oil content varies between 30-48%. Oil contains glycerides and erucic acid.
2. It is mostly grown along with rabi crops.
3. The seed and oil are used as condiments in the preparation of pickles and for flavoring curries and vegetables. Oil is also used in lamps, in tempering steel, in oiling wooden goods, in making soaps, etc. The oil cake is used as a cattle feed. The leaves of young plants are used as green vegetable.

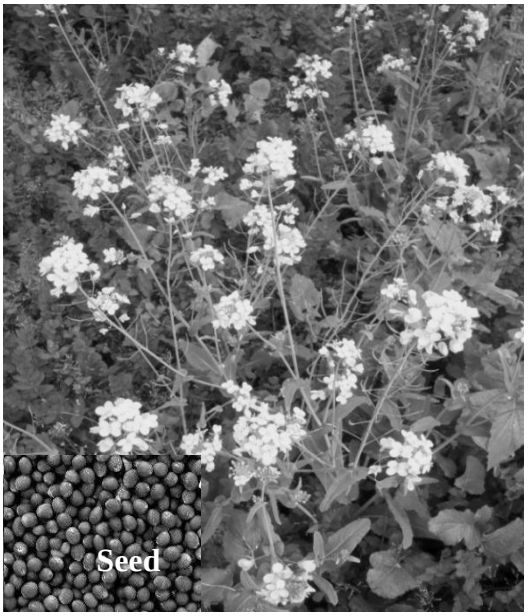

Fig.5.32-*Brassica compestris* (Mustard)

4. India is the first both with regard to acreage and production in the world. It is chiefly grown in Bihar, M.P., West Bengal, Orissa and U.P.

LINSEED
Botanical name: *Linum usitatissimum*
Hindi name: Alsi
Family: Linaceae
Part used: Parts of the plant used are (a) seeds for oil extraction and (b) stem for extraction of fibers.

1. Oil. The seeds contain about 32 to 40% of drying oil which is expressed mechanically. It is chiefly used in the preparation of paints and varnishes because it dries into thin elastic film when exposed due to absorption of oxygen from the atmosphere. It is also used in the preparation of soaps, manufacture of printing ink and linoleum, oil cloth, water proof fabrics, and as edible oil in some areas. The residue oilcake is a valuable cattle feed and manure.
2. Fibers. The pericyclic fibers are separated from the stem. These are very tough, wiry strands of long and thick (cellulose) cells. Fibers possess great tensile strength, fineness and durability. It is used in the manufacture of linen cloth, thread, canvas, writing and cigarette papers and insulating materials.
3. The major linseed growing countries are U.S.A, Canada, Argentina, Russia and India.
4. In India *Linum* is chiefly grown for its oil and fibers in M.P., U. P. and Maharashtra as rabi crop.

Fig.5.33-*Linum usitatissimum* (Linseed)

8. FIBERS

Fiber yielding plants rank second only to food plants in their usefulness to human kind. The utilization of fibers is directly related to the advancement of civilization. They have enormous value in our daily life. The chief fibers of commercial importance have been classified in six groups- textile fibers (e.g., cotton, flax), brush fibers, filing fibers, rough weaving fibers, natural fabrics and paper-making fibers.

COCONUT (Coir)
Botanical name: *Cocos nucifera*
Hindi name: Nariyal
Family: Arecaceae (Palm family)
Part used: Parts of the plant used are (a) mesocarp of the fruit for fibers and (b) endosperm of the seed for extraction of oil.

1. This tall palm tree bears fruits in bunches on the tree. The fruit is a three sided drupe consisting of a smooth rind or exocarp, a reddish brown fibrous mesocarp and a hard stony endocarp or shell enclosing the seed. The well known coconut

Fig.5.34- *Cocos nucifera* (Coconut)

meat and milk are actually the endosperm of the seed.
2. The fibrous husk is used for the manufacture of coir which is used for the cordage, mats, foot rugs, brushes, stuffing, etc.
3. The shells are used as containers and as fuel. The milk (watery endosperm) is a refreshing drink. The cellular endosperm is eaten raw or dried to form copra from which oil is extracted.
4. Coconut oil is used in the manufacture of margarine, vegetable ghee and hard soaps.
5. Unopened inflorescence yields palm sugar and Leaves are used for thatching.
6. Indonesia leads the production followed by Philippines, India and Sri Lanka.

JUTE
Botanical name: *Corchorus capsularis*
Hindi name: Pat, Titapat.
Family: Tiliaceae (Linden family)
Part used: Parts of plant used are fibers from phloem (bast fibers) of stem.

1. The plant is an annual shrub and is grown from seeds. It is best grown in humid regions with moderate rains, on light, sandy, deltaic loams.
2. The fibers are obtained from the secondary phloem by retting the stem. The stems are beaten and fibers separated.

(A) **(B)**

Fig.5.35 (A) - *Corchorus capsularis* (Jute), (B) - Jute

3. The fiber is used for manufacturing packing cloth, hessian, bags for transport and storage, rugs, curtains, upholstery, linings, ropes, twines, etc.
4. This is the most important cash crop of north-east India, especially valleys of Ganges and Brahmaputra in Assam,West Bengal, Bihar and Orissa. About 67% of the products are consumed at home while the rest are exported to U.S.A., U.K., Australia, Canada, Argentina, etc. Other major jute producing country is Bangladesh.

COTTON
Botanical names: *Gossypium arboreum*
Hindi name: Kapas
Family: Malvaceae
Part used: Parts of the plant used are (a) seeds for oil extraction and (b) seed hair as cotton

fibers.

1. This plant is an important fiber and oil seed crop. Both oil and fibers are obtained from the seeds. The fibers are epidermal hair, while oil is expressed from the seeds.
2. Plant is a perennial shrub or a small tree which grows on sandy damp soil of humid regions. Black alluvial soil of the In India, Deccan plateau is considered the best.
3. Oil obtained from the seeds is used as salad and cooking oil, preparation of oleomargarine, oil residue as raw material for soap, washing powders. Oil cake is used as food for cattle.
4. The fibers are collected from seed hairs and after processing bales are made into varied products. It is an important constituent of cotton fabrics, rubber tire fabrics, carpets, blankets, cordage, etc. Raw cotton is used for stuffing.
5. Cotton is cultivated in U.S.A., India, Pakistan, Egypt and Brazil.
6. In India, it is grown in Maharashtra, Karnataka, Punjab, Assam, Gujarat, Madhya Pradesh and Uttar Pradesh.

Fig.5.36 *Gossypium arboreum* (Cotton)

9. FRUITS

Morphologically a fruit is the seed-bearing portion of the plant, and consists of the ripened ovary and its contents. Simple fruits are derived from a single ovary, and compound fruits from more than one. The aggregate fruits are derived from numerous carpels of the same flower, while composite fruits develop from ovaries of different flowers. In economic botany only those fruits are considered which are usually eaten without cooking. For convenience the fruits have been divided into two groups, tropical fruits (e.g. mango, citrus fruits, litchi, banana, plum, peach, guava, sugar apple, fig, papaya, pine-apple etc.) and temperate fruits (e.g. apple, pear, plum, peach, strawberries, grape, etc.).

MANGO

Botanical name: *Mangifera indica*
Hindi name: Aam
Family: Anacardiaceae
Part used: Edible part is fruit whereas leaves used in medicine.

1. It is the most popular and important fruit crop of India and occupying about 60% of the

total area under fruits. It is one of the most highly prized dessert fruit of the tropics.

2. Mangoes thrive in all parts of India where temperature as high as 115-120°F prevail during summer. It thrive in a wide variety of soils. It grows in rich clayey loams, as well as in poor sandy and gravelly soil, provided it is fairly deep and well drained.

3. Young and unripe fruit usually acidic and used in pickles, chutney, *amchur* and culinary preparations. Ripe fruits are preserved by canning or used in the manufacturing of juice and squash, jam and jellies, preserve as *murabba* and *ampapur*.

4. It has a rich, luscious, aromatic flavor and a delicious taste in which sweetness and acidity are blend delightfully. Sucrose, glucose, fructose and maltose are present in ripe mango. Unripe fully developed mangoes of pickling varieties contain citric, malic, oxalic, succinic and two unidentified acids. Ripe fruits constitute a rich source of vitamin A.

5. Mango leaves are very useful for managing diabetes. The tender leaves of the mango tree contain tannins called anthocyanidins that may help in treating early diabetes.

Fig. 5.37 *Mangifera indica* (Mango)

APPLE

Botanical name: *Malus pumila*
Hindi name: Seb
Family: Rosaceae
Part used: Edible part is fruit.

1. Apple occupies the most important position among the fruits of temperate regions and is widely cultivated in many parts of the world. In India apple is a commercial crop in the hilly areas of Kashmir, Kulu, and Kumaon.

2. The apple plant is essentially suited to regions which have a low winter temperature, attended by snowfall. It thrives best in well drained medium loam, but it has been successfully grown on a

Fig.5.38-*Malus pumila* (Apple)

variety of soils ranging from the deep fertile loams of Kashmir to the light loams of Kulu valley and the brown or reddish brown sandy loams of Kumaon.
3. Apple is valued mainly as dessert fruits. Fruits may be preserved for later use after slicing and drying; they are also canned and jams and jellies are made from them.
4. The juice extracted from the fruits is used fresh or after fermentation into cider wine and vinegar; apple brandy is obtained by distilling cider.
5. Apple is rich in pectin and is useful in diarrhea. Apple murabba, a preserve popular in India, is regarded as a stimulant for the heart; it is reported to relieve physical heaviness and mental strain.
6. Apple is considered a good source of potassium also it contains Ca, Mg, K, Na, P, Cl, S and Fe. The mineral constituent of apple are considered valuable for human nutrition.

BANANA
Botanical name: *Musa paradisiaca*
Hindi name: Kela
Family: Musaceae
Part used: Edible part is fruit.

Fig.5.39 - *Musa paradisiaca* (Banana)

1. The banana is one of the tallest herbs. The tree-like stem is composed of the sheathing spiral leaf bases. At the top of stem there is a crown produced of large oval deep-green leaves. The leaves are up to 12 feet in length and 2 feet in width, with a prominent midrib.
2. It is very ancient plant and a native of India and Malaya. It is grown in the place where the climate is warm, humid and rainy. Kerala, Tamil Nadu, Andhra Pradesh, Karnataka, Gujarat, West Bengal, Bihar, Assam, Maharashtra and coastal areas are ideal for growing banana.
3. The fruits when ripped are edible. They have a high content of carbohydrates with some fats and proteins. Their food value is three times that of wheat. Green bananas may be cooked and eaten as vegetable.
4. Fruit pulp is dried and made into flour, used also for jams and jellies, sugar coated chips and several Indian confections.
5. It makes a fair source of minerals and vitamins particularly of B group. Peels are also used as cattle feed. Banana fruit is laxative and used in intestinal disorders, uremia, nephritis, hypertension and other vascular diseases.

LITCHI
Botanical name: *Litchi chinensis*
Hindi name: Lichi
Family: Sapindaceae
Part used: Edible part is fruit.

1. It is a medium-sized evergreen tree, with alternate pinnate leaves, with 2-8 lateral leaflets; the terminal leaflet is absent, flowers are small, greenish-white or yellowish-white, produced in panicles, and fruit is a drupe.

2. The edible flesh consists of a highly developed aril enveloping the seed. The centre contains a single glossy brown nut-like seed. Fleshy, sweet arils covering the seeds are delicious; they are eaten as such or canned.

3. Ingested in moderate amounts, the litchi is said to relieve coughing and to have a beneficial effect on tumors and enlargements of the glands.

4. Litchi contains important phyto-chemical named Oligonol, which seems to be having features like anti-oxidants and anti-influenza. A tea of the fruit peel is taken to overcome smallpox eruptions and diarrhoea.

Fig.5.40- *Litchi chinensis* (Litchi)

5. For successful cultivation the following requirement are considered essential- humid atmosphere, freedom from injurious frosts, abundance of soil moisture and deep loamy soil. The soils of litchi growing areas in Bihar and U.P. are rich in lime.

CITRUS FRUITS

ORANGE (Mandarin)
Botanical name: *Citrus reticulata*
Family: Rutaceae
Hindi name: Santra
Part used: Edible part is fruit.

1. Mandarin is a small, evergreen tree with axillary thorns, growing 3 - 8 meters tall. A very popular fruit, widely available in countries around the world.

2. Three main climates are suitable for commercial citrus production - tropical climates, subtropical with winter rain. This species grows better in the subtropics than in the tropics.

Fig.5.41- *Citrus reticulata* (Orange)

3. In India it is cultivated in Khasi hills, Darjeeling, Garhwal, Dehradun, Sikkim, Tripura, Himachal Pradesh, Punjab, Tamil Nadu and Maharashtra.

4. The fruit is eaten as raw or cooked in puddings, cakes, confectionery etc, it is delicious, rich in vitamin C. The essential oil is distilled mainly used in confectionery, Pharmaceuticals and toilet preparations.

5. The fresh fruit is also used in salads, desserts and main dishes. The peel is used fresh, whole or zested, or dried. It can be used as a spice for cooking, baking, drinks, or candy.
6. Mandarins have also been used in Ayurveda. In traditional Chinese medicine, the dried peel of the fruit is used to treat abdominal distension, to enhance digestion, and to reduce phlegm.
7. They are rich in vitamin C, flavonoids, acids and volatile oils. The fruit is antiemetic, aphrodisiac, astringent, laxative and tonic. The seed is analgesic and carminative. It is used in the treatment of hernia, lumbago, mastitis and pain or swellings of the testes.

PUMMELO (Pomelo)
Botanical name: *Citrus grandis* (*C. maxima*)
Hindi name: Chakotra
Family: Rutaceae
Part used: Edible part is fruit. Leaves and peel are also used in culinary.

Fig.5.42- *Citrus grandis* (Pomelo)

1. Fruit is usually a pale green to yellow when ripe (but also pink or red), with sweet flesh and thick spongy rind. It is the largest citrus fruit.
2. The peel is sometimes used to make marmalade, or candied then dipped in chocolate. Also used in Chinese cooking or candied. In general, citrus peel is often used in southern Chinese cuisine for flavoring, especially in sweet soup desserts.
3. Fruits are esteemed for deserts, made into jams and considered nutritive and refrigerant.
4. Leaves used in epilepsy, chorea, and convulsive coughs.

LEMON
Botanical name: *Citrus limon*
Hindi name: Nimbu
Family: Rutaceae
Part used: Fruit and lemon zest.

Fig.5.43-*Citrus limon* (Lemon)

1. It is a species of small evergreen tree in the flowering plant family Rutaceae, native to Asia.
2. Lemons are a rich source of vitamin C, and contain numerous phytochemicals, including polyphenols, terpenes, and tannins. As with other citrus fruits, they have significant concentrations of citric acid.
3. Fruit is used for culinary and non-culinary purposes throughout the world, primarily for its juice, which has both culinary and cleaning uses.
4. The pulp and zest are also used in cooking and baking.
5. The juice of the lemon is about 5 to 6% citric acid, which gives a sour taste. The distinctive sour taste of lemon juice makes it a key ingredient in drinks and foods such as lemonade and

lemon meringue pie.
6. The antibacterial and immune stimulant properties of lemon have led to many medicinal uses, treating scurvy, preventing colds and flu, relieving stress and fatigue.

10. MEDICINAL PLANTS

The branch of medical science, which deals with the drugs plants, is known as Pharmacognosy. Most of the drugs are obtained from wild plants growing in all parts of the world, especially in tropical regions. The medicinal value of drug plants is due to the presence in the plant tissue of some chemical substances that produce a definite physiological action on human body. The most important of these substances are alkaloids. Some of these chemicals are powerful poisons and therefore the drugs should be prepared and prescribed only by expert physicians.

RAUWOLFIA (Snakeroot)
Botanical name: *Rauwolfia serpentina*
Hindi name: Sarpagandha, Chandrabagha
Family: Apocynaceae (oleander family)
Part used: It is the roots of the plant that are mainly used for medicinal purposes.

1. Sarpagandha is an erect, evergreen shrub, leaves are large, in whorls of three - dark green above and pale green below. The flowers are white, pinkish or red, occurring in whorls. Fruit are tiny, oval, fleshy which turn a shiny purple-black when ripe.
2. The drug consists of the dried roots with their bark intact, preferably collected in autumn from three or four year old plants.
3. It particularly belongs to India in the Sub-Himalayan tracts as well as, in the lower ranges of the Eastern and Western Ghats and in the Andaman.

Fig.5.44 -*Rauwolfia serpentina* (Snakeroot)

4. This herb is considered to be effective in lowering blood pressure and fever. It also helps in stimulating uterine contractions at the time of delivery. It has been used for millennia as an antidote against bites of venomous reptiles.
5. It has a potent anti-arrhythmic effect which used to treat high blood pressure

(hypertension). It is used in insomnia and irritative conditions of the central nervous system. It causes depletion of catecholamine at the central and peripheral level and depletion of Serotonin at the central level.

6. Root is a valuable remedy for dysentery and painful affections of bowel. Decoction of root is applied to increase uterine contractions and promote expulsion of fetus. Juice of leaves is instilled in eyes as a remedy for the opacities of cornea.

EPHEDRA

Botanical name: *Ephedra gerardiana*
Hindi name: Asmania or Somlata
Family: Ephedraceae
Part used: Fruit is edible. Young branchlets and stems of the plant are used as a medicine.

Fig.5.45 - *Ephedra gerardiana* (Ephedra)

1. It is a perennial small shrub composed primarily of fibrous stalks, generally about 8 inches, yellow flowers followed by round, red, edible fruits.
2. It is endemic to the mountains of Afghanistan, Bhutan, northern India, Nepal, Pakistan, Sikkim, Tajikistan, and Tibet.
3. It is sometimes used as a stimulant, and in Ayurvedic medicine, its tea is used as medicine for colds, coughs, bronchitis, asthma, and arthritis.
4. Its tincture is effective as a cardiac and circulatory stimulant whereas its rhizome is used as fuel by the people of Tibet. Some species are grown as ornamental plants.

CINCHONA

Botanical name: *Cinchona officinalis*
Common name: Quinine, Peruvian bark
Family: Rubiaceae
Part used: It is the bark of the tree that is used in herbal medicine and is sourced for drugs.

Fig.5.46 *Cinchona officinalis* (Cinchona)

1. Species of cinchona are all evergreen, with waxy, dark green leaves resembling other species of the Rubiaceae family (such as coffee). They may be shrubs or trees, up to 15 m in height. The flowers are produced in panicles and may be white, red, or pink depending on the species.
2. The native range of cinchona species are the lower to mid-elevations of the Andes in South America. Cinchona is the national tree of both Peru and Ecuador. In India the habitat is mainly found to be Nilgiri Hills.

3. Its bark is an important constituent in herbal medicines and is used as a tonic and a digestive stimulant for the cure of conditions like indigestion, gastro-intestinal disorders and also as an appetite stimulant. Quinine is an anti-fever agent and is used for the prevention and cure of malaria.
4. In general, the herb can classified as an excellent analgesic, anesthetic, anti-arrhythmic, antibacterial, anti-malarial, antimicrobial, anti-parasitic, antipyretic, antiseptic, antispasmodic, antiviral, astringent, bactericide, cytotoxic, febrifuge, fungicide, insecticide, nervine, stomachic and a tonic.

ACONITUM
Botanical name: *Aconitum heterophyllum* wall.
Hindi name: Ativisha, Atis
Common name: Aconite, Wolfsbane, Monkshood
Family: Ranunculaceae
Part used: Dried tuberous roots.

Fig.5.47- *Aconitum heterophyllum*

1. Biennial herb, up to 1 m tall. Lower leaves orbicular and broadly ovate, more or less 5-lobed, teeth obtuse, upper leaves clasping, lanceolate, not lobed, sharply toothed. Flowers 2-5 cm long, dull green blue with purple veins. Follicles downy; seeds many. Sparsely distributed on meadows and slopes between 2500-3500 m.
2. It is used in curing kapha and pitta. Tuberous and roots are bitter tonic, astringent, antiperiodic, aphrodisiac, useful in diarrhoea and dysentery, acute inflammation, dyspepsia, loss of memory, piles and throat disease.
3. Roots powder is useful in splenic fever and gastric troubles of children suffering from cough and vomiting.
4. Folklore- The powdered root is considered as an antidote to poison, in gastroentiric fever of the infants and children.

ATROPA (Deadly Nightshade)
Botanical name: *Atropa belladonna*
Hindi name: Angur Shefa, Luckmunee, Suchi
Family: Solanaceae
Part used: The roots & the leaves are the most commonly used parts for its medicinal purposes.
1. Atropa is a perennial branching herb growing to 5 feet tall, leaves are dull, darkish green in colour and of unequal size, 3-10 inches long, The flowers, borne in leaf axils, are of a dark and purplish colour, tinged with green, about 2.5 cm long, pendent,
bell-shaped, furrowed. The fruit is smooth berry (intensely sweet but most of their alkaloids

are in the seed), which ripens to acquire a shining black or purple color.
2. It is native to temperate southern and central Europe but has been cultivated and introduced outside its native range. The species grows well in soils that have a chalky composition, it thrive in woods, on waste ground and near old ruins.

Fig.5.48- *Atropa belladonna* (Atropa)

3. The plant is believed to be narcotic, diuretic, sedative, antispasmodic, mydriatic. Belladonna is the most valuable plant in the treatment of eye diseases for atropine, obtained during extraction is an important constituent on account of its power of dilating the pupil.
4. It is used as a lotion, plaster or liniment in case of neuralgia, gout, rheumatism and sciatica. It also helps in relieving acute sore throat, local inflammation and congestion. It is powerful antispasmodic in intestinal colic and spasmodic asthma.
5. In children, it is used to treat whooping cough and false croup and also used in treating pneumonia, typhoid fever and other acute diseases.
6. It helps in dealing with peptic ulcers. It is used in treating the physical symptoms seen in people affected by Parkinson's disease.
7. As a drug it is good for its action on the brain and the urinary bladder in disorders connected to these organs.
8. It is also used in homeopathic treatment and to relieve headaches caused by tension.

5.3.1- Identification

Plant identification is the process of matching a specimen plant to a known taxon. It uses various methods, most commonly dichotomous keys or multi-access keys. Plant identification has evolved over hundreds of years and depends to a large extent on what criteria and whose system is used. Plant identification implies comparisons of certain characteristics and then assigning a particular plant to a known taxonomic group, ultimately arriving at a species or infra-specific name. Taxonomy is the branch of botany which deals with plant identification, nomenclature and classification. You have to observe the qualities of the unknown, but to do that accurately, you need a identification key and when you are using a key-you need to know some plant basics- the difference between perennial and annual plants, for example, and some general information about plant parts- flowers, leaves, roots, seeds, and fruit.

A typical dichotomous key for plant identification, which presents a series of choices to narrow down the search. If it is woody, is it a tree, a shrub, or a woody vine. If it is a tree,

is the leaf arrangement opposite or alternate, are the leaves compound or simple, do the leaves have entire margins, or are they serrated, and so on. A plant detective can make a lot of progress with this line of questioning up to a point, "but a botanist's life starts getting difficult at the species level, because you have to use flowers and fruit to distinguish between species. The vegetative features (leaves, needles) of plants are not very characteristic at higher levels of classification. There will always be difficult specimens, especially if they are sterile," that is, without flowers and fruits.

The ability to identify a plant is important for several reasons. From a vegetation management perspective, it is important to know a plant's identity to determine if it is a weed and the level of risk it poses to desired vegetation. Identification is especially important for early detection of new weeds that have never been documented in an area before and can be targeted for eradication. Plant identification is also important for people who raise livestock and are concerned about their animals eating toxic plants. In addition, many people are interested in harvesting edible plants from the wild or their garden and yard. Knowing what plant you are about to eat could become a matter of life or death.

Plant identification can be challenging and even intimidating for the inexperienced. Many people are not comfortable using a dichotomous key and grow weary thumbing through a guidebook page by page until they happen to find a picture that looks similar to the plant they want to identify. However, looking at just a few morphological features of a plant can help you narrow down the options or even identify the plant to genus and species.

5.3.2- Collection

Field work is one of the most essential part in the Botanical study. It permits to come across many types of plants, otherwise not seen and available in the laboratory. It is, therefore, advisable to go round many localities and explore their vegetation. Organized excursions or outings, led by experienced persons, add to the knowledge of common plants in nature. While on a collection trip, local or outstation, following things are to be carried along.

1. Containers: For packing the collected material, preferably carry plastic unbreakable containers or polythene bags.

2. Preservatives: Formalin-Acetic-Alcohol (FAA) or Alcohol 70% or Alcohol 90%, and/or Formalin 6%-10%.

3. Other requirements: Scalpel knife, blade, forceps, pencil, paper, a hand lens, a bag or vasculum for keeping plants or plant press with many newspapers or blotting papers.

After collecting the plant, it should be immediately killed and preserved or pressed to avoid its rotting and dehydration. Plants -are either sprinkled or immersed with a little of the killing agent at the spot. On return to the laboratory collected material should be transferred to new and suitable containers with fresh preservative. The plants should be completely immersed in the preservative. A few plants e.g., different parts of gymnosperms and angiosperms if collected in large quantities, are preserved in containers. But if materials are collected in lesser quantities a herbarium sheet is prepared. Even if large quantity of such plants is available, one plant with fertile parts is preserved in the form of a herbarium sheet, while others should be packed in Cl container. Every tube should be labeled. It is desired to write the name of the specimen, place and date of collection. The place of collection and date

should also be written on a small piece of white card with a pencil, on the spot and inserted in the container. On return to laboratory, material is identified with the help of standard books. A label bearing mime of the division and class to which the material belongs, the name of the material, date and place of collection and also the name of student is pasted on the container.

5.3.3- Maintenance

Herbarium is the collection of dried plant specimen, mounted on sheets. Freshly-picked specimen are dried and pasted on mounting paper of regulation-sized herbarium sheets. The purpose of such a collection is to study the vegetation of a locality and maintain its record. Collected plants are placed in the collecting sheets. The most practical size is 16.5 x 23 inches; when folded 16.5 x 11.5 inches. Old newspapers serve this purpose to an appreciable extent and a large supply should always be included in the kit.

A specimen collected should represent root, stem, leaves' and flowers. The plants are placed between the sheets or newspapers in such a way that relation between different organs is maintained. Herbaceous plants, 2 feet or less higher, may be collected entire. These can be bent to V or N shape whenever necessary. The most desirable is to collect a branch, about one foot high, containing leaves and flowers. In cases, where entire plant or branch cannot be folded to the size of herbarium sheet, only reproductive and fruiting parts and a stem with a few leaves are collected. Delicate reproductive parts collapse even if pressed fresh. These can be pressed perfectly by applying bits of moist paper to the fresh reproductive structures and spreading them when plants are placed in the press. If parts of the herbaceous plant are thick and difficult to dry, split them before placing on the collecting sheet.

Water plants collapse if dried by usual method. These should be rolled up in wet paper when in the field and brought to the laboratory. On return to the laboratory, these plants are placed in water and floated out on sheets of white paper. The sheets are taken out of water carefully, so that the various parts do not cohere. The white sheets are placed in the blotting paper and then dried as usual. After specimen has been collected and placed in collecting sheet, it is kept in plant press. This collecting sheet be placed in between blotting papers, one on either side. While on collection it is important to note date, locality, habitat, height, method of branching, colour of reproductive parts, common name, etc. This should be noted separately in a field-book.

5.4 SUMMARY

Economic botany is the study of the relationship between people (individuals and cultures) and plants. Economic botany intersects many fields including established disciplines such as - Agronomy, Anthropology, Archaeology, Chemistry, Economics, Ethno Botany, Ethnology, Forestry, Genetic Resources, Geography, Geology, Horticulture, Medicine, Microbiology, Nutrition, Pharmacognosy, and Pharmacology. This link between botany and Anthropology explores the ways humans use plants for food, shelter, medicines, textiles, and more. Plants are extremely important in the lives of people throughout the world. People depend upon plants to satisfy such basic human needs as food, clothing, shelter, and health care. These needs are growing rapidly because of a growing world population, increasing incomes,

and urbanization.

The cereals are the members of Gramineae family, and possess the characteristic fruit, the caryopsis. There are six true cereals of which rice, wheat and maize, are most important cereals and they played a crucial part in the development of human civilization. Cereals contain a high percentage of carbohydrates, together with a considerable amount of proteins and some fats. The Legumes are next in importance to cereals as source of human food. They contain more proteins than any other vegetable product. The legumes have been cultivated and used as a food for centuries all over the world. The vegetables rank next to cereals as sources of carbohydrate food. The nutritive value of vegetables is incredible, due to the presence of indispensable mineral salts and vitamins. Vegetables store up reserve food in roots, stem, leaves and fruits, which are eaten raw, cooked and as salad. The storage organs may be true roots or modified stems, such as rootstock, tubers, corms and bulbs.

Timber is a type of wood that has been processed into beams and planks, a stage in the process of wood production. It is commercially used in many purposes such as in making furniture's, construction work, frames, doors, windows, boats, railway sleepers etc. The beverages containing caffeine are used all over the world for their stimulating and refreshing qualities. Caffeine is an alkaloid, which has definite medicinal value and acts as a diuretic and nerve stimulant. Oils, oleoresins & extracts from plants are used in a wide variety of ways – in food, as medicine, in cosmetics & toiletry, as ingredients for industrial products, as fuel, and more. Essential oils are volatile, and are usually derived from the non-seed parts of the plants. Fiber yielding plants rank second only to food plants in their usefulness to human kind. The utilization of fibers is directly related to the advancement of civilization. They have enormous value in our daily life. A fruit is the seed-bearing portion of the plant, and consists of the ripened ovary and its contents. In economic botany only those fruits are considered which are usually eaten without cooking. The branch of medical science, which deals with the drugs plants, is known as Pharmacognosy. Most of the drugs are obtained from wild plants growing in all parts of the world, especially in tropical regions.

5.5 GLOSSARY

Aleurone: protein granules (aleurone grains) found in a single layer of cells (aleurone layer) in the outermost portion of the endosperm.

Ailments: an illness, typically a minor one.

Amphetamine: a racemic drug, that stimulates the central nervous system: used chiefly to lift the mood in depressive states and to control the appetite in cases of obesity.

Anti-androgenic: are a class of drugs which prevent androgens like testosterone and dihydrotestosterone (DHT) from mediating their biological effects in the body.

Antifungal: Antifungal medicines are used to treat fungal infections.

Antihypertensive: Anti-hypertensive are a class of drugs that are used to treat hypertension (high blood pressure).

Anti-inflammatory: Anti-inflammatory or anti-inflammatory refers to the property of a substance or treatment that reduces inflammation or swelling

Antispasmodic: (chiefly of a drug) used to relieve spasm of involuntary muscle.

Aphrodisiac: a food, drink, or other thing that stimulates sexual desire.

Arid: (of land or a climate) having little or no rain; too dry or barren to support vegetation.
Arthritis: acute or chronic inflammation of a joint, often accompanied by pain and structural changes and having diverse causes, as infection, crystal deposition, or injury.
Asthma: a paroxysmal, often allergic disorder of respiration, characterized by bronchospasm, wheezing, and difficulty in expiration
Astringent: causing the contraction of skin cells and other body tissues.
Bagasse: is the fibrous matter that remains after sugarcane or sorghum stalks are crushed to extract their juice.
Beverages: any potable liquid, especially one other than water, as tea, coffee, beer, or milk.
Bronchitis: acute or chronic inflammation of the membrane lining of the bronchial tubes, caused by respiratory infection or exposure to bronchial irritants, as cigarette smoke.
Bulbs: any round, enlarged part, especially at the end of a cylindrical object.
Caffeine: a white, crystalline, bitter alkaloid, usually derived from coffee or tea: used in medicine chiefly as a nervous system stimulant.
Calorific: relating to the amount of energy contained in food or fuel.
Canned: preserved in a can or jar.
Carminative: a drug causing expulsion of gas from the stomach or bowel.
Caryopsis: a small, one-celled, one-seeded, dry indehiscent fruit with the pericarp adherent to the seed coat, the typical fruit of grasses and grains.
Catecholamine: any of a group of chemically related neurotransmitters, as epinephrine and dopamine, that have similar effects on the sympathetic nervous system.
Chard: a variety of beet, Beta vulgaris cicla, having leaves and leafstalks that are used as a vegetable.
Ciguatera: a tropical disease caused by ingesting a poison found in certain marine fishes.
Confectionary: a place where confections are kept or made; a candy; sweetmeat.
Convalescence: the gradual recovery of health and strength after illness.
Convulsion: contortion of the body caused by violent, involuntary muscular contractions of the extremities, trunk, and head.
Cordage: fiber and wire ropes, lines, hawsers, etc., taken as a whole, especially with reference to the rigging and other equipment of a vessel.
Cordate: (of leaves) heart-shaped, with the attachment at the notched end.
Cordial: a strong, sweetened, aromatic alcoholic liquor; liqueur.
Culinary: of, relating to, or used in cooking or the kitchen.
Cymes: an inflorescence in which the primary axis bears a single central or terminal flower that blooms first.
Decoction: is a method of extraction by boiling herbal or plant material to dissolve the chemicals of the material, which may include stems, roots, bark and rhizomes.
Dermatophytosis: also known as ringworm, is a fungal infection of the skin.
Dextrin: are a group of low-molecular-weight carbohydrates produced by the hydrolysis of starch or glycogen.
Diabetes: is a group of metabolic disorders in which there are high blood sugar levels over a prolonged period.
Diuretic: increasing the volume of the urine excreted, as by a medicinal substance.
Dropsy: an old term for the swelling of soft tissues due to the accumulation of excess water.

Drupe: any fruit, as a peach, cherry, plum, etc., consisting of an outer skin, a usually pulpy and succulent middle layer, and a hard and woody inner shell usually enclosing a single seed.
Dysentery: is a type of gastroenteritis that results in diarrhea with blood.
Dyspepsia: is a pain or an uncomfortable feeling in the upper middle part of your stomach.
Embryo: the rudimentary plant usually contained in the seed.
Endosperm: nutritive matter in seed plant ovules, derived from the embryo sac.
Epilepsy: a disorder of the nervous system, characterized either by mild, episodic loss of attention or sleepiness or by severe convulsions with loss of consciousness.
Euphoria: a state of intense happiness and self-confidence.
Expectorant: promoting the discharge of phlegm or other fluid from the respiratory tract.
Febrifuge: serving to dispel or reduce fever, as a medicine.
Flatulent colic: Severe abdominal pain caused by spasm, obstruction, or distension of any of the hollow viscera, such as the intestines.
Foliage: the leaves of a plant, collectively; leafage.
Folk Medicine: health practices arising from superstition, cultural traditions, or empirical use of native remedies, especially food substances.
Gastrodynia: pain in the stomach; a stomach ache. Also called gastralgia .
Glabrous: having a surface devoid of hair or pubescence.
Glazed: having a surface covered with a glaze; lustrous; smooth; glassy.
Globose: having the shape of a globe; globelike.
Gout: an acute, recurrent disease characterized by painful inflammation of the joints, chiefly those in the feet and hands, and especially in the great toe, and by an excess of uric acid in the blood.
Heartwood: the hard central wood of the trunk of an exogenous tree; duramen.
Hepatoprotective: or antihepatotoxicity is the ability to prevent damage to the liver. This damage is known as hepatotoxicity.
Hernia: the protrusion of an organ or tissue through an opening in its surrounding walls, especially in the abdominal region.
Hulls: the husk, shell, or outer covering of a seed or fruit.
Husk: the dry external covering of certain fruits or seeds, especially of an ear of corn.
Hypertension: elevation of the blood pressure, especially the diastolic pressure.
Hypoglycemic: an abnormally low level of glucose in the blood.
Illuminant: an illuminating agent or material.
Imparipinnate: pinnately compound leaves in which there is a lone terminal leaflet rather than a terminal pair of leaflets; also called "odd-pinnate".
Indispensable: absolutely necessary, essential
Inflorescence: the arrangement of flowers on the axis.
Intermittent fever: any fever characterized by intervals of normal temperature.
Kernels: the softer, usually edible part contained in the shell of a nut or the stone of a fruit, or the body of a seed within its husk or integuments.
Kharif: (in India) a crop sown in early summer for harvesting in the autumn.
Laxative: a medicine or agent for relieving constipation.
Leukemia: is cancer of the blood or bone marrow.
Linoleum: a material consisting of a canvas backing thickly coated with a preparation of

linseed oil and powdered cork, used especially as a floor covering.
Livestock: the horses, cattle, sheep, and other useful animals kept or raised on a farm or ranch.
Loamy: a rich, friable soil containing a relatively equal mixture of sand and silt and a somewhat smaller proportion of clay.
Lumbago: pain in the lower, or lumbar, region of the back or loins, especially chronic or recurring pain.
Mastitis: painful inflammation of the breast.
Molasses: a thick syrup produced during the refining of sugar or from sorghum, varying from light to dark brown in color.
Monoecious: having the stamens and the pistils in separate flowers on the same plant.
Mydriatic: is an agent that induces dilation of the pupil.
Nausea: sickness at the stomach, especially when accompanied by a loathing for food and an involuntary impulse to vomit.
Nephritis: inflammation of the kidneys.
Nodules: a tubercle, a small, rounded mass or lump.
Obesity: the condition of being very fat or overweight; corpulence.
Panicle: a compound raceme, or any loose, diversely branching flower cluster.
Peduncle: a flower stalk, supporting either a cluster or a solitary flower.
Perceptible: capable of being perceived; recognizable; appreciable.
Phlegm: the thick mucus secreted in the respiratory passages and discharged through the mouth, especially that occurring in the lungs and throat passages, as during a cold.
Piles: are swollen blood vessels in or around the anus and rectum. Piles are hemorrhoids that become inflamed.
Pinnate: (of a leaf) having leaflets or primary divisions arranged on each side of a common stalk.
Potherb: any herb prepared as food by cooking in a pot, as spinach, or added as seasoning in cookery, as thyme.
Procumbent: (of a plant or stem) lying along the ground, but not putting forth roots.
Prothrombin: a plasma protein involved in blood coagulation that on activation by factors in the plasma is converted to thrombin.
Rabi: the grain crop sown in September and reaped in the spring.
Ripen: to bring or come to maturity, the proper condition, etc.; mature.
Rosette: a circular cluster of leaves or other organs. Any arrangement, part, object, or formation more or less resembling a rose.
Rubefacient: causing redness of the skin, as a medicinal application.
Saponified: turn (fat or oil) into soap by reaction with an alkali.
Sapwood: the softer part of the wood between the inner bark and the heartwood.
Sautéed: cooked or browned in a pan containing a small quantity of butter, oil, or other fat.
Scurvy: a disease marked by swollen and bleeding gums, livid spots on the skin, prostration, etc., due to a diet lacking in vitamin C.
Spikelet: the basic unit of a grass flower, consisting of two glumes or outer bracts at the base and one or more florets above.
Staple food: is a food that is eaten routinely.

Spasm: a sudden involuntary muscular contraction or convulsive movement.
Stimulant: something that temporarily quickens some vital process or the functional activity of some organ or part.
Temperate: relating to or denoting a region or climate characterized by mild temperatures.
Trifoliate: (of a compound leaf) having three leaflets.
Tumor: a tumor is an abnormal growth of cells that serves no purpose.
Uremia: a condition resulting from the retention in the blood of constituents normally excreted in the urine.
Varnishes: resin dissolved in a liquid for applying on wood, metal, or other materials to form a hard, clear, shiny surface when dry.
Zest: is a food ingredient that is prepared by scraping or cutting from the outer, colorful skin of unwaxed citrus fruits such as lemon, orange. Zest is used to add flavor to foods.

5.6 SELF ASSESSMENT QUESTION

5.6.1 Short answer type question:

1. What type of fruit is present in wheat?
Ans. Caryopsis.

2. The medicinally most important part of *Rauwolfia serpentina* is a
Ans. Root

3. Castor oil is obtained from
Ans. *Ricinus communis*

4. What are the botanical names of soya bean, ground nut and coconut?
Ans. Soya bean-*Glycine max*, Groundnut-*Arachis hypogaea*, Coconut-*Cocos nucifera*.

5. Name the fiber obtained from the husk of coconut
Ans. Coir.

6. Epidermal seed fibers are obtained from
Ans. Cotton

7. Reserpine, is a drug is extracted from
Ans. *Rauwolfia serpentina*

8. Which part of mango fruit is edible?
Ans. Mesocarp

9. Orange fruits are rich sources of-
Ans. Citric and malic acid

10. Which part of coconut produces coir?

Ans. Mesocarp

11. The edible part of potato is
Ans. Modified stem

12. The alkaloid present in the tea leaves are
Ans. Caffeine and Theophylline, and Theobromine

5.6.2 Multiple choice questions:

1. Major food crops of the world belongs to the family
(a) Leguminosae (b) Solanaceae
(c) Cruciferae (d) Gramineae

2. Which one of the following is a plant of great medicinal value?
(a) *Brassica oleraceae* (b) *Rauwolfia serpentine*
(c) *Coffea robusta* (d) *Cryptostegia grandiflora*

3. Fiber of great commercial importance derived from epidermis is:
(a) Flax (b) Hemp
(c) Coir (d) Cotton

4. Which one of the following plants is a rich variety of timber?
(a) *Cassia fistula* (b) *Dalbergia sissoo*
(c) *Acacia Arabica* (d) *Morus alba*

5. Pulses are important source of
(a) Proteins (b) carbohydrate
(c) fats (d) sugar

6. Soyabean oil is
(a) Drying oil (b) semi -drying oil
(c) Essential oil (d) None of all

7. Mustard oil is rich in
(a) Eurucic acid (b) Linoleic acid
(c) Palmatic acid (d) Stearic acid

8. Cotton fiber is
(a) Surface fiber (b) Hard fiber
(c) Bast fiber (d) Coir

9. Mango is a fruit of
(a) Temperate (b) Sub- tropical

(c) Tropical (d) None of the above

10. Banana is propagated by
(a) Suckers (b) Rhizome
(c) Seed (d) Stem cutting

11. Tea and coffee is a
(a) Distilled beverage (b) Alcohol beverage
(c) Non -alcohol beverage (d) Fermented beverage

12. Coffee is mainly grown in
(a) Karnataka (b) Andhra Pradesh
(c) Kerala (d) Orissa

13. Potato is a modified
(a) Stem (b) Root
(c) Leaves (d) Fruit

14. Onion crop is
(a) Annual (b) Biennial
(c) Perennial (d) None of the above

15. Which of the following is cultivated for carbohydrates, protein and fats?
(a) *Arachis hypogaea* (b) *Cajanus cajan*
(c) *Ricinus communis* (d) *Cicer arietinum*

16. Which one of the following is the hardest wood?
(a) *Shorea robusta* (b) *Tectona grandis*
(c) *Cedrus deodara* (d) *Dalbergia sissoo*

17. Which one yield resin, timber and pulp?
(a) *Dalbergia* (b) *Pinus*
(c) *Eucalyptus* (d) *Quercus*

18. Jute is obtained from
(a) Primary xylem (b) Primary phloem
(c) Secondary xylem (d) Secondary phloem

19. Which one of the following is the pseudo cereal?
(a) *Zea mays* (b) *Oryza sativa*
(c) *Triticum aestivum* (d) *Fagopyrum esculantum*

20. Which one of the following is surface fiber?
(a) Coir (b) Sun hemp

(c) Cotton (d) All of these

5.6.3-Fill in the blanks

1. The scientific name of brinjal_____
2. A drug which reduces high blood pressure is obtained from_____
3. Food grains which provide the most important staple food for mankind are_____
4. The botanical name of bajra is_____
5. Banana fruit is a rich source of_____
6. The botanical name of orange is_____
7. *Aconitum heterophyllum* belongs to the family_____
8. Gram pea is dry crop grown is _____season.
9. _____ are the edible part of beetroot.
10. In maize then food stored in_____
11. A drug for the treatment of hypertension is obtained from_____
12. _____is the botanical name of Garlic.
13. Tea is a rich source of_____
14. Pulses belongs to the family_____
15. Flax fiber are obtained from_____

5.6.2 Answers Key: 1-(d), 2-(b), 3-(d), 4-(b), 5-(a), 6-(b), 7-(a), 8-(a), 9-(c), 10-(b), 11-(c), 12-(a), 13-(a), 14-(b), 15-(a), 16-(a), 17-(b), 18-(d), 19-(d), 20-(c)

5.6.3 Answers Key: 1-*Solanum melongena*, 2-*Rauwolfia serpentina*, 3-cereals, 4-*Pennisetum glaucum*, 5-Vitamin A and C, 6-*Citrus reticulata*, 7-Ranunculaceae, 8-Rabi season, 9-Roots, 10-Endosperm, 11-*Rauwolfia*, 12-*Allium sativum*, 13-Alkaloids, 14-Fabaceae, 15-*Linum usitatissimum*

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5.9 TERMINAL QUESTIONS

1. Describe the morphological features of Sweet Potato and Beetroot. Discuss their economical role.
2. Write a short note on cereals. Give an account on wheat and rice cereals crops.
3. Give a detailed account on economic importance of pearl millet.
4. Write a short note on Sugar and Starch. Describe their role as an important crop in India.
5. Describe the commercial and economical importance of Legumes. Discuss the any two legume crops.
6. What are underground vegetables? Write about the characteristics of Radish and Carrot.
7. Write about the economical importance of fruit vegetables. Discuss detailed features of Tomato and Brinjal.
8. What are the main characteristics of *Cedrus deodara.* Write about its role in Ayurvedic medicines.
9. What are the chief sources of Caffeine? Give an account on Beverages.
10. Write a short note on Oils. Discuss the role of Mustard and Groundnut in culinary cooking as well as in medicine.
11. Give an account on any two of the following:

a. Cotton b. Coir c. Jute

12. Write a short note on the economic importance of the following:

a. Mango b. Lemon c. Banana

13. Give detailed account on Medicinal plants. Write about the medicinal role of *Rauwolfia serpentina*.
14. Write a essay note on, medicinal uses of the plant *Atropa belladonna*.
15. What is the chief constituent of *Cinchona* plant. Describe the economical importance of it.

UNIT-6 EXERCISE ON GENETIC PROBLEMS RELATED TO MENDEL'S LAWS OF INHERITANCE, INCOMPLETE DOMINANCE AND OTHER TYPES OF INHERITANCE

6.1 OBJECTIVES

After reading this section you will understand and able to -

- Explain the basic concepts of genetics.
- Describe understandable explanations of various laws of Mendelism.
- Provide multiple approaches of genetics problem.
- Solve different problems of genetics.

6.2 INTRODUCTION

Genetics is defined as the branch of biology concerned with the study of heredity and variation. The word genetics (from the Greek word *genno* = give birth) was first suggested by British scientist **William Bateson**. Genetics is a centre of every organism life. It influences an organism's physical characteristics, internal organization, metabolism and behaviour. The era of genetics began in the 1860s, when **Gregor Mendel** conducted a decade long series of experiments using pea plants in central Europe. He revealed that traits are transferred from parents to offspring in predictable ways.

Mendel was born in the Czech Republic, he did his graduation from Augustinian monastery in Brno in 1843 and monastery recommended him for further study at the University of Vienna. After 2 years of study in Vienna, Mendel returned to Brno, and started teaching at the school and also began his experimental work with pea plants. He conducted breeding experiments from 1856 to 1863 and presented his results publicly at the meetings of Brno Natural Science Society in 1865. Mendel's paper from these lectures was published in 1866. At the time, no one seemed to have noticed that Mendel had discovered the basic principles of inheritance. He died at the age of 61 on January 6, 1884, unrecognized for his contribution to genetics. The significance of Mendel's discovery was recognized in 1900, when three botanists- **Hugo de Vries**, **Erich von Tschermak** and **Carl Correns**; began independently conducting similar experiments with plants and arrived at conclusions similar to those of Mendel.

Throughout this unit, a number of concepts are interconnected; Mendel's principles of dominance, segregation and independent assortment, incomplete dominance and the interaction of genes. These concepts might at first appear to be unrelated, but they are actually different views of the same phenomenon, because the genes that undergo segregation and independent assortment are located on chromosomes. The principal aim of this unit is to examine these different concepts and to solve their relations in the form of genetic problems.

6.3 GENETIC PROBLEMS

Mendel's approach to the study of heredity was successful because of several reasons. One of the choice of experimental plants, *Pisum sativum* (garden pea), which offered clear

advantages for genetic investigation and his interpretation of the result by using mathematics. Mendel obtained many different true-breeding (homozygous) varieties of pea, each distinguished by a peculiar characteristic (Table-6.1).

Table – 6.1: Seven pairs of contrasting characters of pea plant

S. No.	Character	Contrasting Traits	F_1 Result	
			Phenotype	Genotype
1	Seed shape	Round/Wrinkled	Round	*Ww*
2	Seed colour	Yellow/Green	Yellow	*Gg*
3	Pod shape	Full/Constricted	Full	*Cc*
4	Pod colour	Green/Yellow	Green	*Yy*
5	Flower colour	Red/White	Red	*Ww*
6	Flower position	Axial/Terminal	Axial	*Tt*
7	Stem height	Tall/Dwarf	Tall	*Dd*

To understand Mendel's postulates, we must first introduce several new terms as well as a symbol convention for the unit factors (genes). Traits such as tall or dwarf are physical expressions of the information contained in unit factors. The physical expression or observable features of a trait is the **phenotype** of the individual. Mendel's unit factors represent units of inheritance called **genes** by modern geneticists. For any given character, such as plant height, the phenotype is determined by alternative forms of a single gene, called **alleles**. All alleles for any particular gene will be found at a specific place on a chromosome called the **locus** for that gene. For example, the unit factors representing tall and dwarf are alleles determining the height of the pea plant. Geneticists have several different systems for using symbols to represent genes. According to this convention, the first letter of the recessive trait symbolizes the character in question; in lowercase italic, it designates the allele for the recessive trait and in uppercase italic, it designates the allele for the dominant trait. Thus for Mendel's pea plants, we use *w* for the white flower allele and *W* for the red flower allele. When alleles are written in pairs to represent the two unit factors present in any individual (*WW, Ww* or *ww*), the resulting symbol is called the **genotype**. The genotype represents the genetic makeup of an organism for the trait or traits, it describes whether the individual is haploid or diploid. By reading the genotype, we know the phenotype of the individual; *WW* and *Ww* are red flowered and *ww* is white flowered. When both alleles are the same (*WW* or *ww*) the individual is **homozygous** for the trait; when the alleles are different (*Ww*) we use the terms **heterozygous**.

6.3.1 - Mendel's laws of inheritance

Mendel's simplest cross is a monohybrid cross, which involved only one pair of contrasting traits. A monohybrid cross is made by mating true-breeding (homozygous) individuals from two parent strains, each exhibiting one of the two contrasting forms of the character under study. Initially, we examine the first generation of offspring of such a cross, and then we consider the offspring of **selfing**, that is, of self-fertilization of individuals from this first generation. The original parents constitute the **parental generation** (P), their offspring are the **first filial generation** (F_1) and the individuals resulting from the selfed F_1 generation are the **second filial generation** (F_2).

Step -1: Each parental homozygote produces one kind of gamete

P Red *WW* × White *ww*

↓ *W* ↓ *w*

Step -2: The F_1 heterozygotes produce two kinds of gametes in equal proportions

F_1 Red *Ww*

Gametes- *W* *w*

Self-fertilization

Step -3: Self-fertilization of the F_1 heterozygotes yields red and white offspring in a 3:1 ratio

F_2

	W	*w*
W	*WW* (Red)	*Ww* (Red)
w	*Ww* (Red)	*Ww* (White)

F_2 Results -

Phenotypes	Genotypes	Genotypic ratio	Phenotypic ratio
Red	*WW*	1	3
	Ww	2	
White	*ww*	1	1

After a decade of careful work documenting the consistent patterns of inheritance, Mendel derived several principles which are known as **Mendel's laws of inheritance**.

1. **The Law of Dominance –** In a heterozygote, one allele may hide the presence of another allele. Mendel's observed that, in monohybrid cross, a phenotypic character which appears only in homozygous individuals is called a recessive character and the pair of alleles which specifies a recessive phenotypic character is called recessive pairs of alleles. Another phenotypic character which appear in homozygous as well as in heterozygous individuals of both F_1 and F_2 generation. Such a trait is called dominant character and such alleles which phenotypically expressed itself in the heterozygous as well as in the homozygous is called a dominant allele.

2. **The Law of Segregation -** In a heterozygote, two alleles of a gene are different entities that segregate from each other during the formation of gametes. According to this principle, hereditary characteristics are determined by genes that appear in pairs, one of each pair being inherited from each parent. During meiosis, the pairs of factors are separated or segregated. Hence, each gamete produced by an offspring at maturity

contains only one member of the pair. This concept of a gene explained how a characteristic could persist from generation to generation without blending with other characteristics, as well as how it could seemingly disappear and then reappear in a later generation.

3. **The Law of Independent Assortment** – The alleles of two different genes segregate independently of each other. According to this law, when the gametes are formed the members of the different pairs of genes segregate quite independently of each other and that all possible combinations of the genes concerned will be found among the progeny. Thus, besides obtaining the phenotypic ratio of 3:1 of a monohybrid cross, we got the different ratio of 9:3:3:1. This type of diversion in the ratio of F_2 progeny of a dihybrid cross was due to **independence assortment**.

Step -1: Each parental homozygote produces one kind of gamete

P Yellow, Round × Green, Wrinkled

GGWW *ggww*

↓ ↓

GW *gw*

Step -2: The F_1 heterozygotes produce four kinds of gametes in equal proportions

F_1 Yellow, Round

GgWw

Gametes- *GW* *Gw* *gW* *gw*

Step -3: Self-fertilization of the F_1 heterozygotes yields four phenotypes in a 9:3:3:1 ratio

F_2 Self-fertilization

	GW	*Gw*	*gW*	*gw*
GW	*GGWW*	*GGWw*	*GgWW*	*GgWw*
Gw	*GGWw*	*GGww*	*GgWw*	*Ggww*
gW	*GgWW*	*GgWw*	*ggWW*	*ggWw*
gw	*GgWw*	*Ggww*	*ggWw*	*ggww*

F_2 Results –

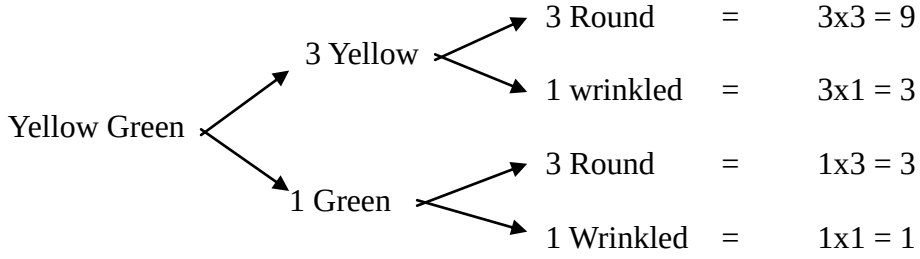
Phenotypes	Genotypes	Genotypic ratio	Phenotypic ratio
Yellow, Round	*GGWW* *GGWw* *GgWW* *GgWw*	1 2 2 4	9
Yellow, Wrinkled	*GGww* *Ggww*	1 2	3
Green, Round	*ggWW* *ggWw*	1 2	3
Green, Wrinkled	*ggww*	1	1

6.3.2 – Methods of analysis

1. Punnett square Method – In above monohybrid and dihybrid cross, different combination of gametes are symbolized and put in a square box. This visual diagram of square is called the **Punnett square**. The genotype and phenotype which produces due to result of the different combination of gametes are easily determined by the help of Punnett square. This was discovered by R.C. Punnett, in which, each of the possible gamete is placed in an individual column or a row.

2. Forked line Method - A method for bringing the combinations of a cross together may be dihybrid illustrated as follows; first predict the dihybrid cross as two monohybrid crosses- that is, *Gg* x *Gg* and *Ww* x *Ww* – drawing together. If one member of each pair is dominant, a 3 : 1 phenotypic ratio would be predicted from each monohybrid cross. Since, the two pairs are independent, the ratio 3 : 1 from *Gg* x *Gg* may be combined with the ratio 3: 1 from *Ww* x *Ww*.

GgWw x *GgWw*



So, dihybrid phenotypic ratio is 9: 3: 3: 1

3. Test and Back cross - The genotype of an F_1 organism, produced by the breeding of homozygous dominant and homozygous recessive parents is heterozygous but shows the dominant phenotype. An organism displaying the recessive phenotype must have a genotype which is homozygous for recessive allele. When F_1 organism are back crossed with one of the

two parents (homozygous dominant or homozygous recessive) from which they were derived, then such a cross is called **back cross**. In such back crosses, when F_1 individual is back crossed with the homozygous dominant parent, no recessive progeny are obtained. But when F_1 individual is back crossed with its homozygous recessive parents, both the phenotype (dominant and recessive) obtained the progeny. While both of these crosses are back cross, but only the cross with the recessive parent is called **Test cross**. A monohybrid test cross gives a 1: 1 phenotypic ratio, while in dihybrid cross the phenotypic ratio is 1: 1: 1: 1.

P	Tall	×	Dwarf
	DD		*dd*
	↓		↓
	D		*d*
F_1	Tall		
	Dd		

A. Back cross: F_1 Tall x P_1 Tall

Dd *DD*

Back cross result: 50% *DD* and 50% *Dd* = 100% Tall

B. Test cross: F_1 Tall x P_1 Dwarf

Dd *dd*

Test cross result: 50% *Dd* and 50% *dd*
= test cross ratio is 1: 1

6.3.3 – Extension of Mendelism

Mendel's experiments established that genes can exist in alternate forms. This discovery suggested a simple functional dichotomy between alleles, as if one allele did nothing and other did everything to determine the phenotype. However, genes can exist in more than two allelic states and each allele can have a different effect on the phenotype. In the absence of Mendel's allelic inter relationship and number of existing allelic state, the phenotypic ratio has been found to be modified.

1. Incomplete dominance - When a dominant allele does not mask completely the phenotypic expression of the recessive allele in a heterozygote, then a mixing of both dominant and recessive characters takes place in the F_1 and F_2 progeny. This phenomenon is known as **incomplete dominance**, **partial dominance** and **semi-dominance**. In such cases, the mixing occurs only in the phenotype of the F_1 heterozygotes and the alleles maintain their individual identities and segregate from each other during gamete formation. The F_1 gametes produce F_2 progeny having the same phenotypic and genotypic ratios of 1:2:1. For example-

Four O'clock plant or *Antirrhinum majus* with red flowers (*WW*) are crossed with white flowered (*ww*) plants; the offspring have pink flowers (*Ww*).

Phenotype	Genotype	Amount of gene product
1. Red	*WW*	2X
2. White	*ww*	0
3. Pink	*Ww*	X

2. Co dominance – In the co dominance, both dominant and recessive alleles lack their dominant and recessive relationships and both have capability to express them phenotypically in the heterozygous condition. In co dominance, the dominant and recessive characters occur together side by side. Hence, heterozygote genotype gives rise to a phenotype which different from either of the homozygous genotypes. The F_1 heterozygotes produce a F_2 progeny in the phenotypic and genotypic ratio of 1:2:1 like the incomplete dominance. For example- MN blood group, Karl Landsteiner and Philip Levin discovered a glycoprotein molecule found on the surface of red blood surface that act as native antigen, two forms (M & N) of this glycoprotein exist. An individual may exhibit either one or both of them.

3. Multiple Alleles – In the Mendelism each characteristic has been controlled by a gene which may have appeared in one of two forms or alleles and an allele is a specific form of a given gene. When more than two alleles for the same gene are found within members of population for a single characteristic and occupy the same gene loci on homologous chromosomes. This is known as the multiple allele. For example- Human Blood Group, contain three different forms of alleles (I^A, I^B and I^o) for ABO blood group.

Possible Genotype	Phenotype
$I^A I^A$ or $I^A I^o$	A blood group (with A antigen)
$I^B I^B$ or $I^B I^o$	B blood group (with B antigen)
$I^A I^B$	AB blood group (with A&B antigen)
$I^o I^o$	O blood group (with no antigen)

6.4 SUMMARY

Mendelian genetics is based on the transmission of traits (genes) from parents to progeny and thus from generation to generation. Mendel studied the inheritance of seven different characters in pea, each characters being controlled by different gene. Mendel proposed three postulates on the basis of their research findings – (i) the alleles of a gene are either dominant or recessive, (ii) different alleles of a gene segregate from each other during the formation of gametes and (iii) the alleles of different genes assort independently. The result of genetic crosses can be predicted by Punnett squares, which use the principles of mathematical probability to follow the union of gametes. Mendel's revealed the phenotypic and genotypic ratios, which are 3 : 1 and 1 : 2 : 1 for monohybrid crosses. A cross between F_1 individual and a recessive parent is called test cross. A test cross can distinguish the pure dominant individual from the hybrid dominant individual. In some cases, F_1 heterozygotes have

intermediate phenotype are incomplete dominance and some genes have more than two alleles in a population are multiple allele.

6.5 GLOSSARY

Allele: One of two or more alternate forms of a gene.
Back cross: A cross between an individual offspring and one of its parents.
Character: An attribute or feature.
Co dominance: The condition in heterozygous where both members of an allelic pair contribute to phenotype.
Dihybrid cross: A cross in which inheritance of two pairs of contrasting characters is studied simultaneously.
Diploid: An organism or cell with two set (2*n*) of chromosome or two genomes.
Gene: A genetic factor (region of DNA) that helps determines a characteristic.
Genotype: Set of alleles possessed by an individual organism.
Haploid: An organism or cell having only one complete set (*n*) of chromosome or one genome.
Heterozygote: An individual organism possessing two different alleles at a locus.
Homozygote: An individual organism possessing two of the same alleles at a locus.
Locus: Specific place on a chromosome occupied by an allele.
Monohybrid cross: A cross between two parents in which inheritance of only one pair of contrasting characters is studied.
Multiple allele: More than two allelic forms exist for certain gene.
Phenotype: The appearance of a character.
Test cross: A cross between F_1 individual types with recessive parental type.

6.6 SELF ASSESSMENT QUESTIONS

6.6.1 – Very short answer questions

1- What is genetics?
2- Who is the father of genetics?
3- How many different contrasting characters did Mendel notice in garden pea?
4- What the term is used for a class of individuals which are morphologically similar?
5- What is Mendel's monohybrid phenotypic ratio?
6- What is Mendel's dihybrid phenotypic ratio?
7- What is Mendel's monohybrid genotypic ratio?
8- What is allele?
9- What is locus?
10-What is Punnett square?

6.6.2 – Multiple choice questions

1. Number of characters observed in garden pea by Mendel for his experiment is-

(a) Three (b) Five
(c) Seven (d) Nine

2. The various forms of a given gene are called-
(a) Genotype (b) Phenotype
(c) Gametes (d) Alleles

3. An individual with a pair of identical factor (allele) is-
(a) Hybrid. (b) Homozygous.
(c) Heterozygous. (d) None of the above.

4. Mendel's do not propose-
(a) Dominance. (b) Gamete segregation.
(c) Independent assortment of gene. (d) Incomplete dominance.

5. Recessive gene can be expressed in-
(a) Homozygous condition. (b) Heterozygous condition.
(c) Both of the above. (d) None of the above.

6. In monohybrid cross a typical genotypic ratio is-
(a) 3 : 1 (b) 9 : 7
(c) 1: 2: 1 (d) 9 : 3 : 3 : 1

7. In dihybrid cross a typical phenotypic ratio is -
(a) 1: 2: 1 (b) 1 : 1 : 1 : 1
(c) 9 : 3 : 3 : 1 (d) 9 : 3 : 4

8. The gene which exhibits multiple effects is known to be-
(a) Complementary (b) Multiple Allele
(c) Co dominance (d) Supplementary

9. Independent assortment of Mendel was proved by-
(a)Test cross (b) Back cross
(c) Monohybrid cross (d) Dihybrid cross

10. The Mendel's law was rediscovered by-
(a) Hugo de Vries (b) Erich von Tscermark
(c) Carl Correns (d) All the above

11. A gamete contains-
(a) Only one allele of gene (b) Two allele of gene
(c) All allele of gene (d) None of the above

12. A breeding experiment dealing with a single trait is called-

(a) Monohybrid cross (b) Dihybrid cross
(c) Trihybrid cross (d) All of the above

13. What will be the test cross ratio in the monohybrid cross-
(a) 1 : 1 (b) 1 : 2 : 1
(c) 9 : 3 : 3: 1 (d) All of the above

14. In which cross both phenotypic and genotypic ratio will be similar-
(a) Monohybrid cross (b) Dihybrid cross
(c) Incomplete dominance (d) Multiple allele

15. How many gametes are produced by *AaBb* genotype-
(a) 02 (b) 04
(c) 08 (d) None of the above

6.6.3 – Fill up the following blanks –

1-The term Genetics is coined by ……
2- Mendel was born in the …….
3- Mendel's choose …….. plant for his genetic experiments.
4- F1 progeny crossed with homozygous recessive parent is known as …… cross.
5- ABO blood group is example of …….. allele.
6- MN blood group is example of ……..
7- Offspring with intermediate phenotype is due to ……
8-…….. introduced the Punnett square method.
9-The test cross ratio in the dihybrid cross is …….
10-Law of segregation is also known as ……..

6.6.1 Answer Key – **1**. The study of various traits and genes and how they are inherited from one generation to next, **2**. G.J. Mendel, **3**. Seven, 4. Phenotype, **5**. 3:1, **6**. 9: 3: 3: 1, **7**. 1:2:1, **8**. Alternative forms of a gene, **9**. A point where an allele is located on the chromosomes, **10**. The representation of monohybrid or dihybrid crosses by making squares.

6.6.2 Answer Key – 1. (**c)**, 2. (d), 3. (b), 4. (d), 5. (a), 6. (c), 7. (c), 8. (b), 9. (d), 10. (d), 11. (a), 12. (a), 13.(a), 14. (c), 15. (b)

6.6.3 Answer Key – 1. William Bateson, 2. Czech Republic, 3. Pea, 4. Test, 5. Multiple Allele, 6. Co dominance, 7. Incomplete dominance, 8. R.C. Punnett, 9. 1: 1: 1 : 1, 10. Purity of gametes.

6.7 REFERENCES

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6.9 TERMINAL QUESTIONS

6.9.1 - Long answer type questions-

1 – Explain the law of independent assortment with the help of an example?

2 – What are multiple allele? Explain the Human blood group as an example of multiple allele?

3 – Why did Mendel's choose the pea plant for genetic experiment? How did he make sure that plants were pure?

4 – What kind of plants will be produced in F_2 generation by crossing between pure tall (*DD*) and pure dwarf (*dd*)?

5 – A man with type 'A' blood has a wife with type 'B' blood. They have a child with type 'O' blood. What will be the possible genotype of husband and wife?

6 – How many different kinds of F_1 gametes, F_2 genotype and F_2 phenotype would be expected from AABB x aabb?

7 – What phenotypic ratio would be expected from a test cross of F_1 and a pure recessive (AaBb x aabb), if the F_2 resulting from F_1 x F_1 (selfing) was 9 : 3 : 3 : 1?

8 –In a case, woman of blood group O presented a baby of blood group O and suit against a man of blood group AB for father. What bearing might the blood type information have on the case?

6.9.2 - Short answer type questions-

1 – Describe the brief history of genetics.

2 – Why did Mendel select pea plant for his experiments?

3 – Point out the main findings of Mendel's experiments.

4 – Define the Law of inheritance.

5 – What do you understand by heterozygous and homozygous?

6 – What is the difference between the genotype and phenotype?

7 – Describe the test and back cross.

8 – Define the incomplete dominance.

9 – How you find out the phenotypic and genotypic ratio?

10 – Describe the dihybrid cross with example.

UNIT-7 STUDY OF THE FLORAL BIOLOGY OF SOME OF THE LOCALLY AVAILABLE CROP PLANTS

7.1 OBJECTIVES

After reading this unit students will be able -

- To Elucidate the Systematic position of Wheat, Pea, Mustard, Brinjal, Tomato
- To Describe Flower morphology and floral characters of Wheat, Pea, Mustard, Brinjal, Tomato

7.2 INTRODUCTION

Floral biology means the study of flowering part of the plant which includes inflorescence, flower structure, flower parts, arrangement, pollination & fertilization.Floral biology is an area of ecological research that studies the evolutionary factors that have moulded the structures, behaviour and physiological aspects involved in the flowering of plants.

7.3 FLORAL BIOLOGY OF WHEAT

WHEAT-Triticum aestivum (Verna.-Gehun): Wheat is a grass widely cultivated for its seed, a cereal grain which is a worldwide staple food, giving about one third of the total production. In temperate regions it is the major source of food. There are many species of wheat which together make up the genus *Triticum*; the most widely grown is common wheat (*T. aestivum*).

Systematic position

Kingdom - Plantae (Plants)
Subkingdom -Tracheobionta (Vascular plants)
Super division -Spermatophyta (Seed plants)
Division -Magnoliophyta - (Flowering plants)
Class -Liliopsida - (Monocotyledons)
Subclass - Commelinidae
Order - Cyperales
Family -Poaceae (Grass family)
Genus - Triticum L. (wheat)
Species- Triticum aestivum L.

Habitat: Wheat is a grass that is cultivated worldwide. It is an annual grass that usually planted at the end of the summer, grown in dry and mild climate.

Root: Adventitious, fibrous root system.
Stem: The stem is 3 to 4 feet in height or more, herbaceous, erect, cylindrical sometimes

furrowed, and either glabrous or scabrous, with distinct nodes (each node is swollen and solid) and internodes (generally hollow), unbranched, with a number of tillers.

Leaves: The normal leaf of wheat is divisible into two parts, the leaf-sheath and the leaf blade (lamina). The leaf also having accessory organs, the ligule and the auricle.
The sheath is inserted on the node and envelops the stem. The blade is long, narrow, lanceolate and acuminate with parallel venation. Two claw-like appendages near the ligule region are prominent, these are known as auricles (usually hairy and pale green)

Inflorescence: Spike of spikelets. This is a compound spike bearing two rows of lateral spikelets on its axis and a single terminal spikelets. There are many short internodes on the main axis. Each internode is narrow at the base and broader at the apex.
The spikelets are sessile and arranged alternately, the spikelet is inserted on the apex of internode.

Spikeletes: The solitary and sessile flowers (florets) are arranged on a short, joined axis, the rachilla. The flowers are alternately placed on the spikelet. At the base of each spikelet, two glumes occur, appear to be opposite of each other (actually one glume overlaps the other).
The normal glume is somewhat boat shaped, with a thick main nerve, dividing it into two unequal halves. In each spikelet the number of flowers varies. Usually two grains, sometimes three and very rarely four mature in a single spikelet.

Flower: Sessile, bracteate, two bracts- lemma (inferior palea) and palea (superior palea). They are situated opposite to each other. The **lemma** is somewhat boat-shaped with many nerves. The colour of lemma is greenish white, sometimes pink.
The **palea** is a thin membranous bract just opposite the lemma. It is slipper shaped with two prominent nerves. The flower is small, zygomorphic, hermaphrodite, hypogynous, incomplete, irregular and not showy.

Perianth: It is represented by two thin membranous structures, the **lodicules**. They are colourless, narrow and scale-like, and sometimes hairy.

Androecium: Stamens 3, polyandrous, filaments are long, slender and free; the anthers dorsifixed when young and versatile when mature.

Gynoecium: Single median carpel (monocarpellary), theoretically tricarpellary. The ovary is superior, unilocular, hairy and triangular. From the tip of the ovary two style arise, single ovule, basal placentation, style short; stigma 2, feathery.

Fruit: A caryopsis (achene with pericarp completely united or adherent with the seed coat), the seed coat firmly united to the ovary wall.

Seed: Albuminous, Endospermic and containing a single cotyledon called scutellum, which is shield shaped and pressed against the endosperm.

Floral formula: Br, ·|·, ♀, P_2 (lodicules), A_3, $G_{(1)}$.

Floral Diagram:

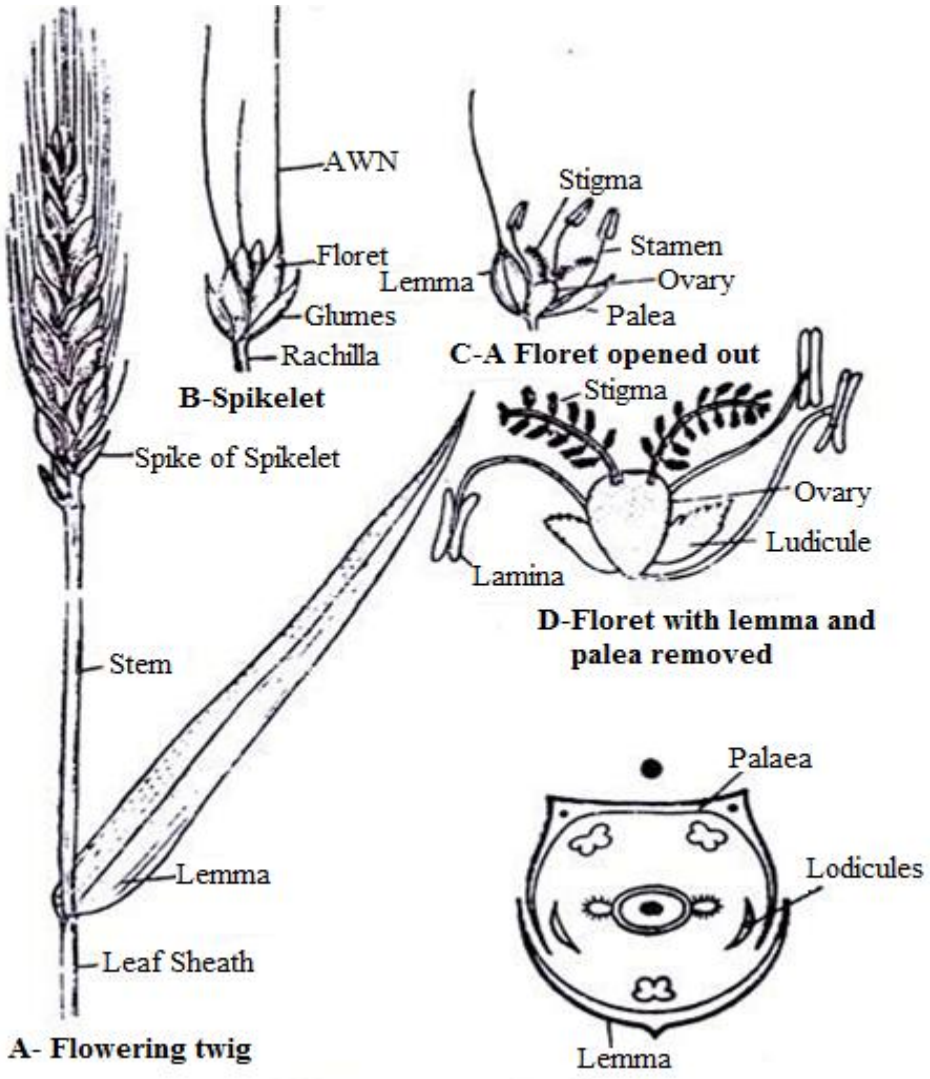

Fig. 7.3- *Triticum aestivum* L. (Verna.-Gehun)

7.4 FLORAL BIOLOGY OF PEA

PEA (Pisum satvium)- (Verna.- Matar)**:** The **pea** is most commonly the small spherical seed or the seed-pod of the pod fruit ***Pisum sativum***. Each pod contains several peas. Pea pods are botanically fruit, since they contain seeds and developed from the ovary of a (pea) flower. *P. sativum* is an annual plant, with a life cycle of one year. It is a cool-season crop grown in many parts of the world; planting can take place from winter to early summer depending on location.

Systematic position

Kingdom - Plantae – Plants

Subkingdom -Tracheobionta – (Vascular plants)

Super division -Spermatophyta – (Seed plants)

Division -Magnoliophyta – (Flowering plants)

Class -Magnoliopsida – (Dicotyledons)

Subclass - Rosidae

Order - Fabales

Family -Fabaceae / Leguminosae –(Pea family)

Genus - Pisum L. – (pea)

Species-Pisum sativum L. – (garden pea)

Habit: Annual herb; cultivated.

Root: Tap, branched, with nodules containing nitrogen fixing bacteria *(Rhizobium radicicola).*

Stem: Herbaceous, weak, climbing with the help of leaf tendrils, cylindrical, branched, smooth, Glaucous.

Leaves: Alternate, compound, imparipinnate, stipulate (stipules large Foliaceous, ovate, semicordate, irregularly toothed at the base), leaflets 4 or 6, the common rachis ends in a branched tendril; the leaflets entire, smooth, net veined, oval to oblong, mucronate tips, green and Glaucous, the terminal leaflet is always a tendril.

Inflorescence: Racemose, flowers arranged in axillary racemes or solitary.

Flower: Pedicellate, zygomorphic, irregular, hermaphrodite, papilionaceous, white or pink, complete, hypogynous to perigynous, bracteate or Ebracteate.

Calyx: 5 sepals, gamosepalous, campanulate calyx tube, teeth long or the upper short; Sepaloid, ascending imbricate aestivation.

Corolla: 5 petals, 1 standard, 2 wings, 2 keels united, keels shorter than wings and enclose the pistil and stamens; corolla papilionaceous, white or pink in colour; descending imbricate (vexillary) aestivation; inferior.

Androecium: 10 stamens in two bundles (diadelphous) of 9 + 1, nine stamens unite at the base and form a tube around ovary tenth is posterior and free; anthers bi-lobed, basifixed, Introrse, dehiscence by longitudinal splitting.

Gynoecium: Carpel one (monocarpellary); ovary superior, unilocular; marginal placentation;

ovules many; style bent and long, stigma simple; terminal and hairy; ovary also hairy.

Fruit: A legume (pod), broad.

Seeds: Rounded, uniform, white.

Floral formula: Br, ·|· , ♀ ,$K_{(5)}$,$C_{1+2+(2)}$, $A_{(9)+1}\underline{G}_1$

Floral Diagram:

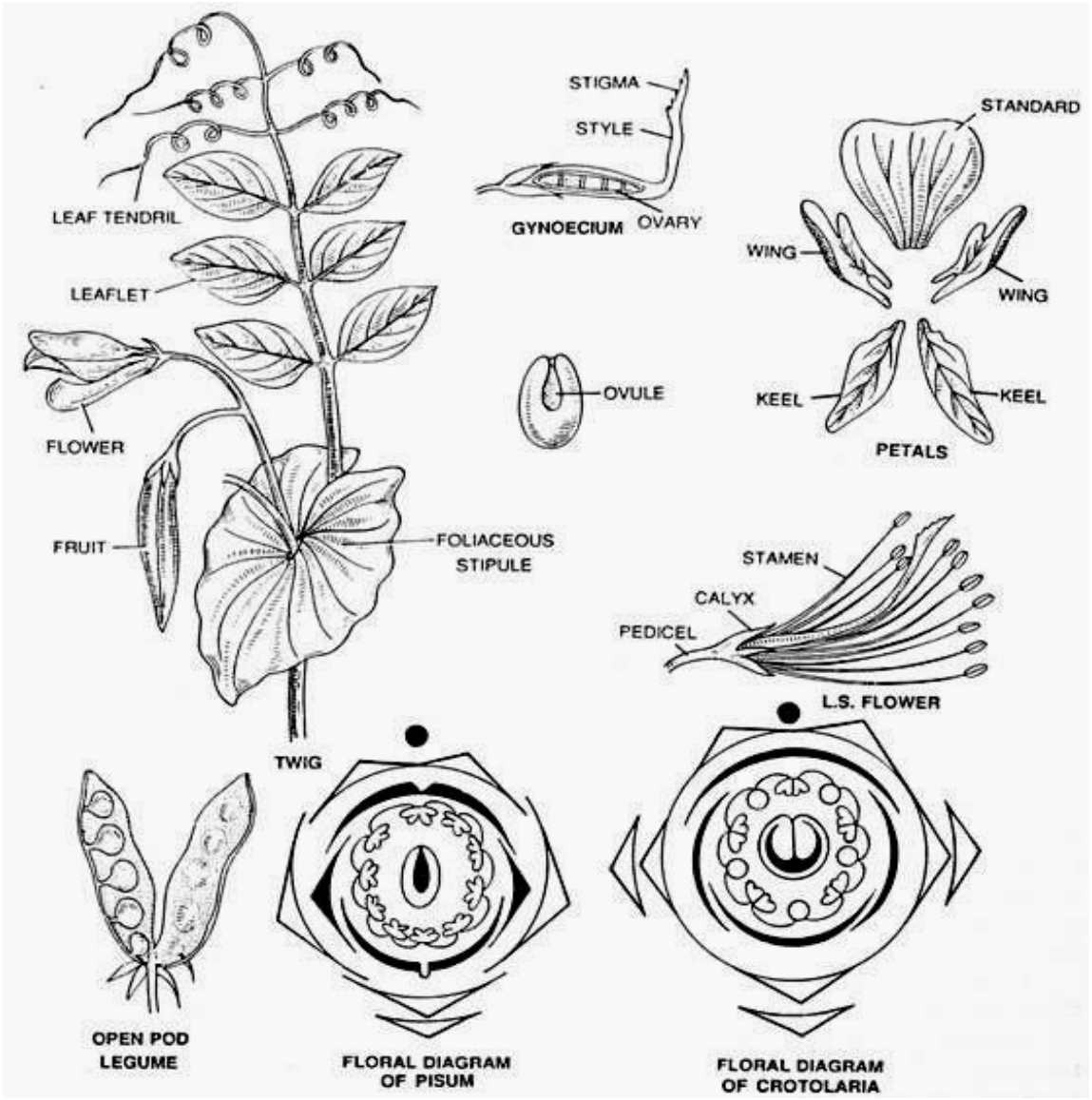

Fig. 7.4- *Pisum satvium L.* (Verna.- Matar)

7.5 FLORAL BIOLOGY OF MUSTARD

MUSTARD (Brassica campestris)- (Verna.- Sarson): Flowers contain flavonol glycoside brassicoside. Seeds contain epi-progoitrin (major thioglucoside). Seeds used in

exacerbations, cancer and tumours. Roots emollient and diuretic, juice used in chronic cough and bronchial catarrh.

Systematic position

Kingdom - Plantae – (Plants)

Subkingdom -Tracheobionta – (Vascular plants)

Super division -Spermatophyta – (Seed plants)

Division -Magnoliophyta – (Flowering plants)

Class -Magnoliopsida – (Dicotyledons)

Subclass - Dilleniidae

Order - Capparales

Family -Brassicaceae / Cruciferae – (Mustard family)

Habit and habitat: An annual herb, cultivated for seeds which yield oil.

Root: Tap and branched.

Stem: Herbaceous erect, cylindrical, solid, glabrous or hairy.

Leaf: Simple, alternate, Exstipulate, lower ones lyrate and upper oblong or lanceolate, unicostate reticulate venation, hairy, sessile.

Inflorescence: A Corymbose-raceme.

Flower: Ebracteate, Pedicellate, complete, Actinomorphic, hermaphrodite, cruciform, tetramerous, hypogynous, and yellow.

Calyx: Sepals 4 (2 + 2) in two whorls, outer whorl antero-posterior, the two lateral one saccate, green, polysepalous, inferior.

Corolla: Petals four, polypetalous, cruciform, Valvate, inferior, yellow.

Androecium: Stamens six, Tetradynamous, in two whorls, the outer with two short lateral stamens and inner with four long stamens arranged in two median pairs. Basifixed, polyandrous, Introrse. Four green nectarines are present, on the inner side of each short stamen and a similar one at the base but outside each pair of long median stamens, inferior.

Gynoecium: Bicarpellary, syncarpous, superior, unilocular becoming bilocular by the development of false septum called – replum; parietal placentation, style short, stigma bilobed.

Fruit: Siliqua.

Seed: Non-endospermic, Numerous, minute, Ex-Albuminous.

Floral formula: Ebr, ⊕ , ♂ , K_{2+2}, C_4, A_{2+4}, $G_{(2)}$

Floral Diagram:

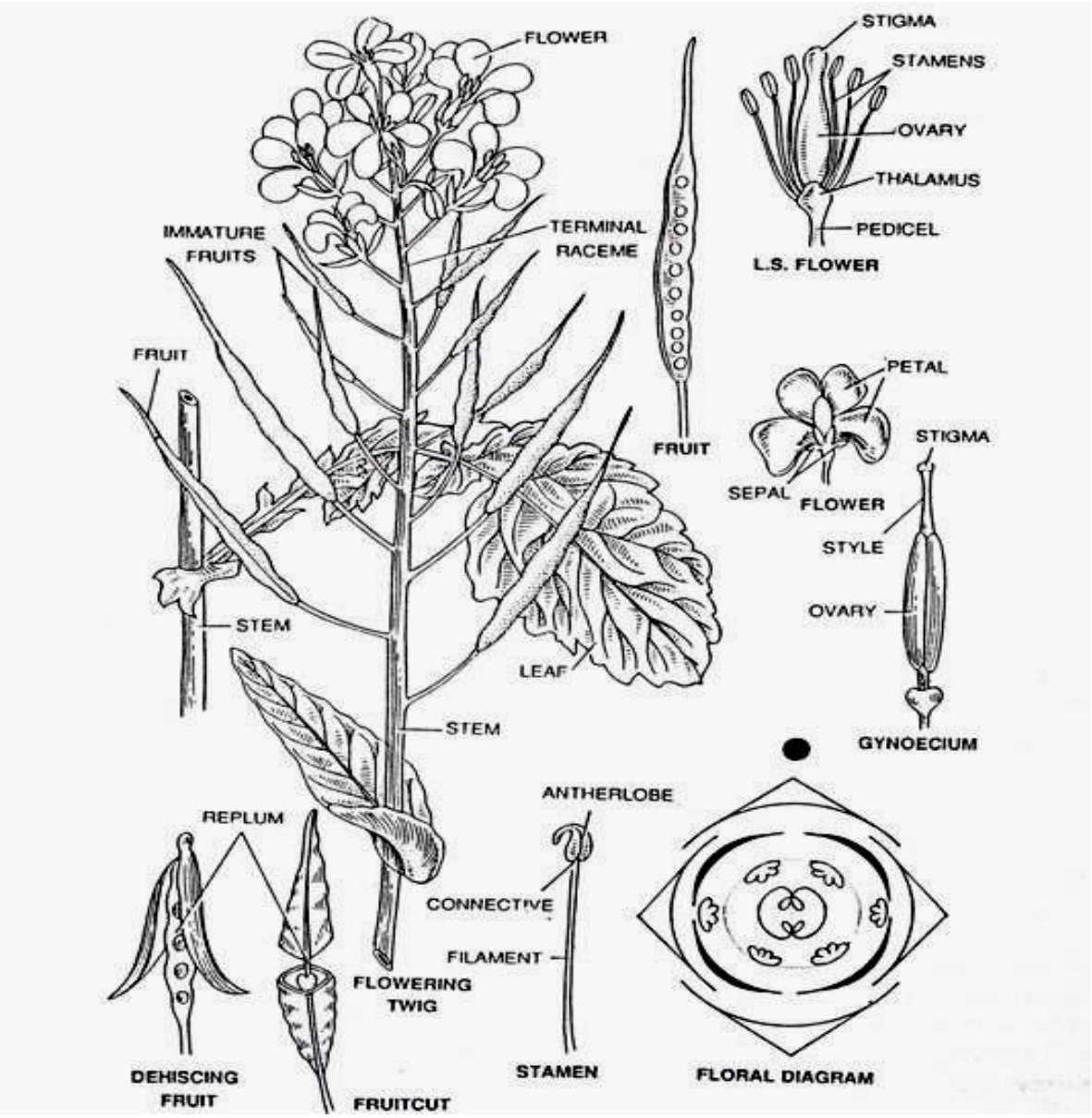

Fig. 7.5- *Brassica campestris L.* (Verna. - Sarson)

7.6 FLORAL BIOLOGY OF BRINJAL

BRINJAL (Solanum melongena L.)- (Verna.- Baingan): Eggplant (*Solanum melongena*), or aubergine, is a species of nightshade, grown for its edible fruit. It is known

in South Asia and South Africa as *brinjal*.

The fruit is widely used in cooking. As a member of the genus *Solanum*, it is related to the tomato and the potato. The eggplant is a delicate, tropical perennial often cultivated as a tender or half-hardy annual in temperate climates. The stem is often spiny.

Systematic position:

Kingdom - Plantae – (Plants)

Subkingdom -Tracheobionta – (Vascular plants)

Super division -Spermatophyta – (Seed plants)

Division -Magnoliophyta – (Flowering plants)

Class -Magnoliopsida – (Dicotyledons)

Subclass - Asteridae

Order - Solanales

Family -Solanaceae – (Potato family)

Genus - Solanum L. – (Nightshade)

Species- Solanum melongena L. – (eggplant)

Habit: Brinjal is an annual herbaceous plant, under shrub.

Root: Branched tap root system.

Stem: Erect, aerial, woody below and herbaceous above, cylindrical with distinct ribs, solid, branched, green.

Leaves: Alternate, simple, Exstipulate, Petiolate, ovate, repand, acute, glabrous, unicostate reticulate venation.

Inflorescence: Cymose. Often solitary Cyme or clusters of 2-5 flowers.

Flower: Ebracteate, Actinomorphic, hermaphrodite with pistil surrounded by stamens, Pedicellate, Heteroclamydeous, hypogynous, white or pinkish in colour.

Calyx: Sepals 5, gamosepalous, pentafid, Valvate, persistent, light green colour, hairy, inferior.

Corolla: 5 petals, Gamopetalous, Valvate, rotate, white to light purple colour.

Androecium: Stamens 5, free, epipetalous, polyandrous alternate to petals, small filament inserted deep in the corolla tube, large anthers dithecous, usually basifixed or dorsifixed, Introrse.

Gynoecium: Bicarpellary, syncarpous, hypogynous, ovary superior, carpels placed obliquely in diagonal plane, bilocular, placentation axile, ovules many in each locules, placentae swollen, a nectariferous disc or lobes may be present, stigma Capitate or lobed.

Fruit: A many seeded berry

Seed: Endospermic.

Floral formula: Ebr, ⊕ , ♂ , $K_{(5)}$,$C_{(5)}$, $A_{(5)}$, $\underline{G}_{(2)}$

Floral Diagram:

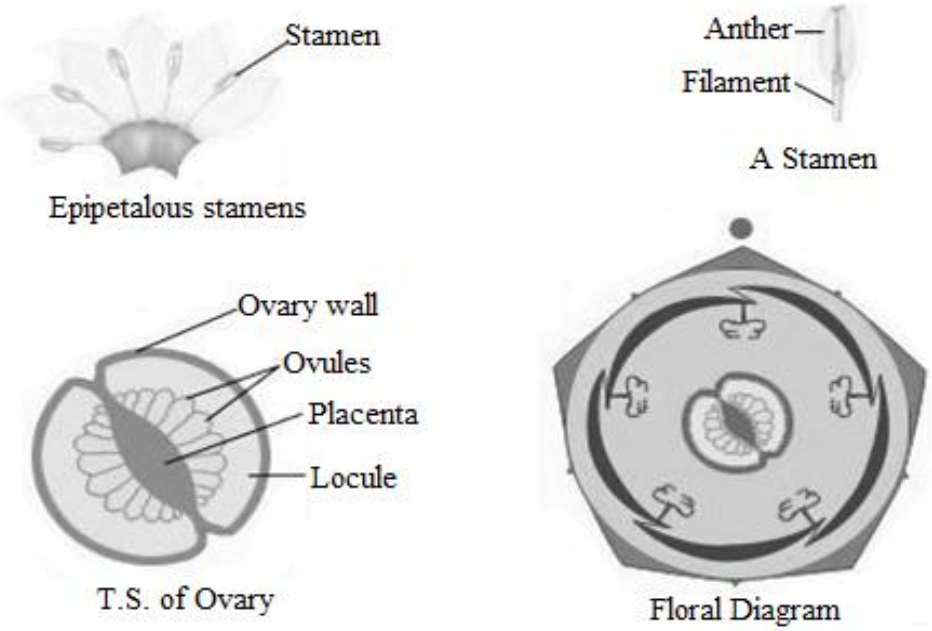

Fig. 7.6- *Solanum melongena L.* (Verna.- Baingan)

7.5 FLORAL BIOLOGY OF TOMATO

TOMATO (Solanum lycopersicum L.)- (Verna.-Tamatar): The tomato is the edible fruit of *Solanum lycopersicum*, commonly known as a tomato plant, which belongs to the nightshade family, Solanaceae. The species originated in Central and South America. Tomato is consumed in diverse ways, including raw, as an ingredient in many dishes, sauces, salads, and drinks. While tomatoes are botanically berry-type fruits, they are considered culinary vegetables, being ingredients of savory meals.

Systematic position:

Kingdom - Plantae – (Plants

Subkingdom -Tracheobionta –(Vascular plants)

Super division -Spermatophyta –(Seed plants)

Division -Magnoliophyta – (Flowering plants)

Class - Magnoliopsida – (Dicotyledons)

Subclass - Asteridae

Order - Solanales

Family - Solanaceae – (Potato family)

Habit: A short lived, Perennial & annual plant.

Root: Branched tap root system.

Stem: Erect, aerial, woody below and herbaceous above, cylindrical with distinct ribs, solid, branched, green.

Leaves: Alternate, simple, Exstipulate, Petiolate, ovate, repand, acute, glabrous, unicostate reticulate venation.

Inflorescence: Extra-axillary helicoids cymes. Extra-axillary position is due to fusion.

Flower: Ebracteate, Pedicellate, complete, hermaphrodite, Actinomorphic, Pentamerous, hypogynous, small and yellow.

Calyx: Sepals 5, gamosepalous, pentafid, Valvate, persistent, green, hairy, inferior.

Corolla: Petals 5, Gamopetalous, rotate, Valvate, five lobed, bright yellow, inferior.

Androecium: Stamens 5, polyandrous epipetalous, alternipetalous, filaments shorts, equal in length, anthers long and conniving, basifixed, dithecous, and dehiscence by apical pores.

Gynoecium: Bicarpellary, syncarpous, ovary superior, bilocular, axile placentation, placentae swollen, ovules many in each loculus, ovary obliquely placed; style single, hairy; stigma bilobed.

Fruit: Many seeded berry.

Seed: Endospermic.

Floral formula: Ebr, $\oplus$, ♂ , $K_{(5)}$,$C_{(5)}$, $\overset{\frown}{A_5}$, $\underline{G}_{(2)}$

Floral Diagram:

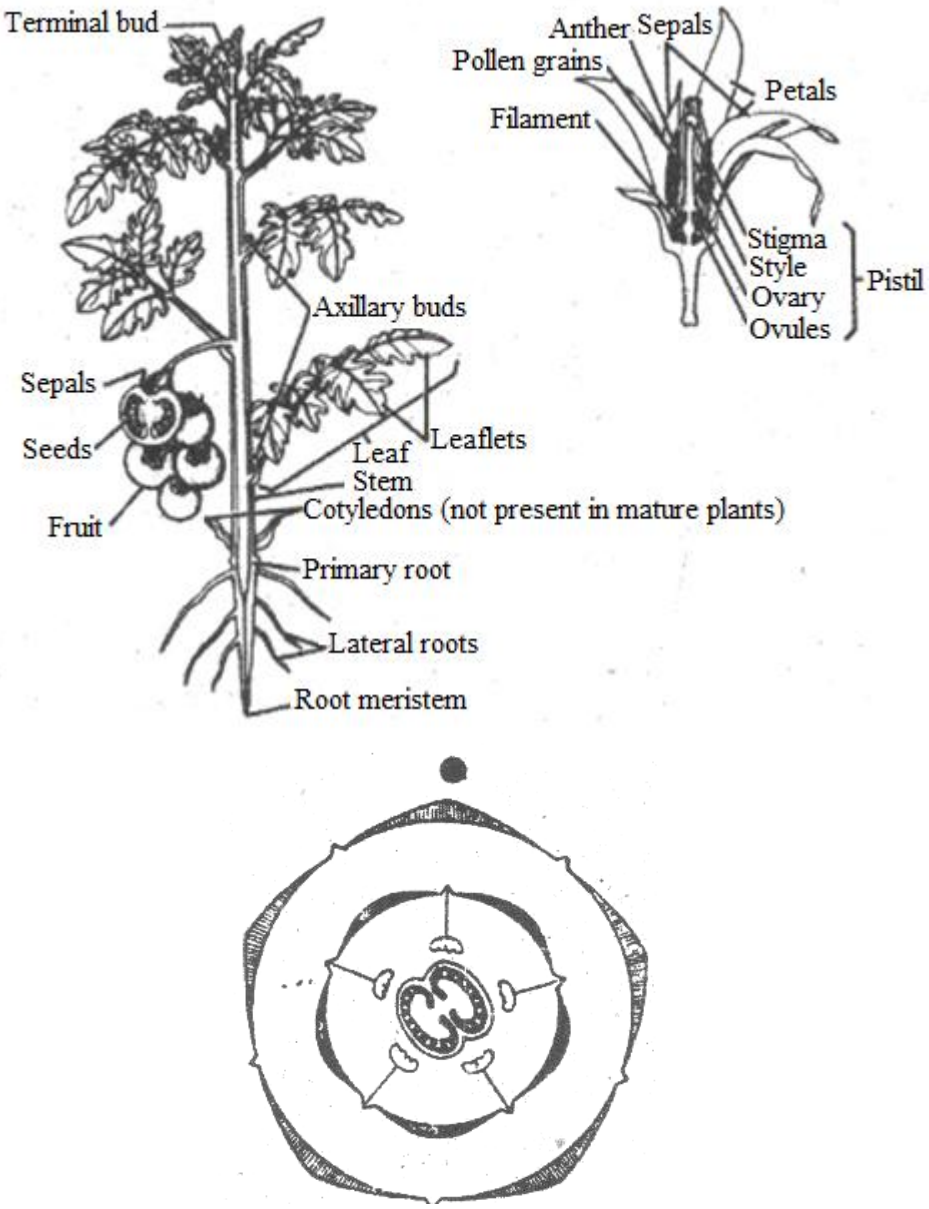

Fig. 7.7- *Solanum lycopersicum L.*- (Verna - Tamatar)

7.6 SUMMARY

Flowers are the reproductive structures of angiosperms. The flower is composed of four whorls of modified leaves, the calyx, corolla, androecium, and gynoecium. Each of these whorls contains one of the flower organs, the sepals, petals, stamens, or pistils, respectively. Sepals and petals are not directly involved in reproduction, while the stamens and pistils are the male and female reproductive organs.

In addition, each flower possesses an ovary is formed from modified leaves called carpel. This ovary, an exclusive feature of angiosperms, encloses the ovules and develops into a fruit after fertilization. The calyx is made up of sepals, green leaf-like structures that enclose the unopened bud. They serve a protective role for the flower before it opens, and afterward extend from the base of the flower.

The corolla is made up of the petals of the flower, which are usually brightly colour in

order to attract insects. Together, the corolla and calyx make up the Perianth, the non-reproductive portion of the flower. The Androecium is composed of the male reproductive organs, the stamens. Each stamen consists of a long, slender filament topped by a pollen-producing anther. The anther contains numerous sporangia, which give rise to microspores. These microspores develop, and turn, into pollen grains, which carry sperm cells to the female reproductive organs.

The Gynoecium, composed of a pistil, lies in the very middle of the flower. The top of the pistil, where pollen grains land, is called the stigma and the shaft leading down into the ovary is called the style. The ovary, containing ovules and egg cells, makes up the very bottom of the pistil.

The floral formula is a way to represent the structure of a flower using specific letters, numbers and symbols, presenting substantial information about the flower in a compact form. It can represent a taxon, usually giving ranges of the numbers of different organs, or particular species. The structure of a flower can also be expressed by the means of *floral diagrams*. The use of schematic diagrams can replace long descriptions or complicated drawings as a tool for understanding both floral structure and evolution. Such diagrams may show important features of flowers, including the relative positions of the various organs, including the presence of fusion and symmetry, as well as structural details.

7.5 GLOSSARY

Actinomorphic: having radial symmetrical, regular.
Acuminate: ending in a pointed tapering apex.
Acute: tapering more broadly than acuminate.
Adnate: With unlike parts integrally fused, not easily separable.
Adventitious: appearing in an abnormal or unusual position or place, as a root.
Aestivation: Referring to position, arrangement, and overlapping of floral parts.
Albuminous: containing albumen.
Androecium: The male parts of a flower, collectively.
Angiosperm: a plant having its seeds enclosed in an ovary; a flowering plant.
Anther: The structure in a flower bearing the pollen.
Apetalous: Having no petals or corolla
Apocarpous: With carpels distinct, the pistil or ovary simple
Auricle: a claw-like appendage.
Axile: the angle formed by an axis and lateral members (e.g., stem and leaf).
Axillary: pertaining to or growing from the axil.
Basifixed: fixed to the filament (stalk) at the base.
Bilobed: consisting of or divided into two lobes.
Bilocular: divided into two chambers or containing two compartments internally (two celled).
Bract: A leaf-like element below a flower or on an inflorescence. They are usually green, but occasionally are brightly coloured and petal-like.
Bracteate: having bracts.

Bracteolate: possessing bracteoles.
Calyx: The whorl of sepals of a flower collectively forming the outer floral envelope or layer of the perianth enclosing the bud
Campanulate: bell-shaped, as a corolla.
Capitate: forming or shaped like a head or dense cluster or knob like (swollen).
Carpel: Female structure in the fourth or outermost whorl in flowers of angiosperms compound ovary
Caryopsis: the grain (fruit) of cereals and grasses one-seeded, indehiscent.
Chronic: continuing a long time or recurring frequently.
Compound: composed of several similar parts that combine to form a whole.
Connivent: the bending towards each other of two or more similar organs.
Corolla: The whorl of petals of a flower that collectively form an inner layer of the perianth.
Corymbose: A form of inflorescence in which the flowers form a flat topped or convex cluster, the outermost flowers being the first to open (corymb like arrangement)
Cyme: the main axis terminates in a flower.
Dehiscence: In pollen, the opening of the anther to release the pollen or to expose the ripe pollen to pollinators.
Diadelphous: united into two sets by their filaments.
Diandrous: flowers having two stamens.
Dithecous: arranged alternately in two opposite rows.
Dorsifixed: attached to the dorsal side.
Ebracteate: without bracts.
Endosperm: nutritive matter in seed-plant ovules, derived from the embryo sac.
Epigynous: having all floral parts conjoint and generally divergent from the ovary at or near its summit
Epipetalous: having the stamens attached to the petals.
Exalbuminous: without stipules.
Exstipulate: without stipules.
Extra-axillary: situated away from the axil of the leaf.
Extrorse: Facing outward; e.g., describing the anther-sac opening facing away from the ovary
Extrorse: turned or facing outward, as anthers that open toward the perianth.
Filament: The usually narrow and often threadlike part of the stamen which supports the pollen-bearing anther
Flower: The organ in an angiosperm that comprises the group of structures used for sexual reproduction. The parts of a flower are arranged in whorls.
Foliaceous: consisting of leaf-like plates or laminae; foliated.
Fruit: The structure that develops after fertilization. In angiosperms, it develops from a carpel or aggregation of carpel's
Gamopetalous: united petals (corolla).
Gamosepalous: united sepals (calyx).
Glabrous: not hairy, smooth.
Glaucous: covered with a whitish bloom, as a plum.
Glume: the bracts and bracteoles of the spikelets of Gramineae.

Gynoecium: the pistil or pistils of a flower; the female parts.
Hermaphrodite: bisexual, flower having both Androecium and Gynoecium.
Heteroclamydeous: having a perianth consisting of distinct sepals and petals
Hypogynous: situated on the receptacle beneath the pistil and free of the ovary, as stamens, petals, or sepals.
Imbricate: overlapping like tiles, as scales or leaves. A mode of aestivation in which one member of the whorl is outside all the others (i.e., its margin are free) and one inside all the others (i.e., both the margins are overlapped), the others overlap by one margin only.
Inferior: epigynous condition
Inflorescence: A reproductive shoot on a flowering plant, bearing one or more partial or complete flowers.
Introrse: Facing inwards usually referred for anthers.
Lamina: leaf blade.
Lanceolate: lance-head shaped, a leaf broad below the middle and tapering towards apex.
Leaflet: one of the blades of compound leaf.
Legume: the pod of pea family, dehiscing along both sutures.
Ligule: a membranous outgrowth at the junction of leaf blade and leaf sheath in grasses.
Lobed: having lobes or divisions extending less than halfway to the middle of the base.
Locule: The cavity or chamber in an ovary.
Lodicules: rudimentary membranous perianth at the base of the ovary in grass family.
Monocarpellary: Having only one carpel
Nectary: a nectar secreting gland.
Nectaferous: producing nectar.
Node: the place of insertion of a leaf on the stem.
Nodule: a small node or tubercle.
Ovary: The female reproductive structure that contains the ovules and becomes the fruit, it is derived from the carpels.
Ovule: The haploid female reproductive cell, located in the ovary, which receives a haploid nucleus from the germinating pollen grain to form the diploid zygote.
Palea: The scale like, membranous organ in the flowers of grasses that is situated upon a secondary axis in the axil of the flowering glume and envelops the stamens and pistil.
Parietal: borne or peripheral region reference for placenta.
Pedicel: The short stem growing from the top of the peduncle and carrying the flower bud at its top
Pedicellate: Having the flower carried above the peduncle on a stem called a pedicel
Pendent: Hanging downward from the vertical axis of the pedicel or plant
Pentamerous: with five members in each whorl.
Perennial: can live for more than two years.
Perianth: The structures surrounding the sexual parts of a flower, that is, the petals and sepals or the calyx plus the corolla
Pericarp: The structure developing from the wall of the ovary that protects or encloses the seed or seeds in an angiosperm
Perigynous: situated around the pistil on the edge of a cuplike receptacle, as stamens or petals.

Persistent: not falling off.
Petal: Leaf-like structures that enclose the rest of the structures in a flower. The second lowest whorl in a floral structure; petals collectively, the corolla
Petiolate: the leaf with petiole.
Pistil: Female sexual organ of a flower, comprised of the ovary, style, and stigma
Placentation: the disposition or arrangement of a placenta or placentas.
Pollen: Male sexual structure that transmits the male gamete to the female stigma
Polyandrous: having an indefinite number of stamens.
Polypetalous: with free petals.
Polysepalous: with free sepals.
Raceme: a flower cluster with the separate flowers attached by short equal stalks at equal distances along a central stem. The flowers at the base of the central stem develop first.
Racemose: an inflorescence in which the main axis continues to grow and remain stronger than the laterals which arise from it, the youngest lateral comes out from nearest apex.
Rachilla: the axis of the spikelet of the grasses.
Rachis: the axis of an inflorescence or of a compound leaf.
Repand: having a wavy margin, as a leaf.
Reticulate venation: veins are interconnected and form a web like network
Sepal: a segment of calyx. Leaf-like structures that enclose the rest of the structures in a flower. The first or lowest whorl in a floral structure; sepals collectively, the calyx
Sepaloid: resembling or functioning as a sepal.
Sessile: without a stalk. Having a flower or leaf born directly on the stem or peduncle rather than on an elongated stalk.
Spike: a racemose elongated inflorescence bearing sessile flowers.
Spikelets: the laterals of the inflorescence of grasses, the small spikes.
Stamen: The male sexual organ in a flower comprised of a filament and an anther.
Stigma: The female structure at the tip of the pistil. This is the receptive organ for pollen germination
Stipulate: having stipule.
Stipule: a leaf-like outgrowth at the base of petiole, usually in parts.
Style: The structure in the pistil that extends from the ovary and bears the stigma at its distal end.
Superior: situated above another member. A superior ovary has its base above the insertion of calyx; a superior calyx or corolla is inserted above the ovary.
Syncarpous: united carpels, compound ovary.
Tendrils: they are either modified branches or leaves. They are filament like usually coiling round the support.
Tepal: The petals and the sepals collectively.
Tetradynamous: with four long and two short stamens.
Umbel: an inflorescence having aerial branches of equal length from a common point.
Unilocular: one chambered ovary.
Valvate: an aestivation with the segments of calyx or corolla are so placed that their edges touch each other not overlap.
Whorl: a pattern of spirals or concentric circles.

Zygomorphic: having only one plane of symmetry, as in a pea or snapdragon; bilaterally symmetrical.

7.6 SELF ASSESSMENT QUESTION

7.6.1 Short answer type questions:

1. Why is flower called as modified shoot?
2. The structures surrounding the sexual parts of a flower, i.e., the petals and sepals is called?
3. When Gynoecium matures earlier than the androecium in bisexual flower it is called?
4. A membranous outgrowth at the junction of leaf blade and leaf sheath in grasses?
5. A flower with essential & non- essential whorls is termed as?
6. The leaf-like outgrowth at the base of petiole, usually in parts is called?
7. *Raphanus sativus*, belongs to which family?
8. What is the botanical name of Garden Tomato and Eggplant?
9. A flower is said to be incomplete when it has:
10. A flower is brightly coloured, scented and secrete nectar. It is most probably pollinated by:

7.6.2 Fill in the blanks:

1. If male and female flowers are borne on different plants, the plant is called _____
2. Placentation in Tomato is _____
3. A characteristic of angiosperms is _____
4. A flower is said to be complete when it has all the _____
5. Botanical name of Mustard is _____
6. Tomato belongs to _____family.
7. A leaf like outgrowth at the base of the petiole, called _____
8. Third whorl in flower is of _____

7.6.3 Multiple choice questions:

1. Sessile flowers have
(a) No scent (b) Irregular shape
(c) No pedicles (d) No petals

2. Bicarpellary ovary with parietal placentation is found in
(a) Solanaceae (b) Poaceae
(c) Brassicaceae/ Cruciferae (d) Leguminosae

3. Corolla refers to the
(a) Collection of sepals (b) Collection of petals
(c) Collection of carpels (d) Collection of stamens

4. A landing platform is provided to insects through

(a) Calyx (b) Epicalyx
(c) pedicel (d) petals

5. Pollen grains are produced inside the
(a) Stamen (b) Pistil
(c) Anther (d) Pollen sacs

6. In order to attract insects for pollination,
(a) Petals are brightly coloured (b) Petals are protected by calyx
(c) Epicalyx is essential (d) Petals have large surface area

7. Tetradynamous condition of Androecium is one of the striking features of
(a) Solanaceae (b) Poaceae
(c) Brassicaceae/ Cruciferae (d) Leguminosae

8. 'Families of Flowering Plant' book was written by-
(a) Bentham and Hooker (b) John Hutchinson
(c) Engler Prantl (d) None of the above

9. Inflorescence of wheat is
(a) Spike (b) Catkin
(c) Panicle (d) Verticillaster

10. Aubergine is another name of
(a) Pea (b) Tomato
(c) Mustard (d) Brinjal

11. A flower with essential and non-essential whorls
(a) Incomplete (b) Irregular
(c) Sessile (d) Complete

12. A bisexual flower which never open in its life span is called
(a) Homogamous (b) Cleistogamous
(c) Heterogamous (d) Polygamous

13. Third whorl in a flower is of
(a) Petal (b) Sepal
(c) Stamen (d) Pistil

14. Parallel venation are found in
(a) Monocot (b) Dicot stem
(c) Dicot root (d) None of these

15. Arrangement of leaves on branches

(a) Phyllotaxy (b) Vernation
(c) Venation (d) Phytotaxy

7.6.1 Answer Key: 1. Because in some flowers thalamus become elongated & show distinct node, internodes, 2. Perianth, 3. Protogyny, 4. Ligule, 5. Complete flower, 6. Stipule, 7. Brassicaceae, 8. *Solanum lycopersicum* (Tomato), and *Solanum melongena* (Eggplant), 9. Only two whorls, 10. Insects.

7.6.2 Answers Key: 1-unisexual, 2-axile, 3-flower, 4-four whorls, 5-*Brassica campestris*, 6-Solanaceae, 7-Stipule, 8-stamen.

7.6.3 Answers Key: 1-(c), 2-(c), 3-(b), 4-(d), 5-(d), 6-(a), 7-(c), 8-(b), 9-(a), 10-(d), 11-(d), 12-(b), 13-(c), 14-(a), 15-(a)

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7.8 SUGGESTED READINGS

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7.9 TERMINAL QUESTIONS

7.9.1 Long Answer Type Question:

1. Describe the floral biology of Wheat?

2. Give five important floral characters of Fabaceae. Mention the two economically important plants belonging to the family?

3. Give floral formula and floral diagram with examples to distinguish between following pair of family: Poaceae and Solanaceae.

4. Give the comparative account of Solanaceae and Brassicaceae with reference to their floral characteristics.

5. Given only the androecium and gynoecium, how would you distinguish any one pair of the following families from each other:

(a) Poaceae and Brassicaceae

(b) Fabaceae and Solanaceae.

6. Write a short assay on Floral biology, what is the role of it in taxonomy.

7. Write the systematic position of Mustard and Garden Pea. Also describe their Floral formula and Floral diagram.

8. Mention the significance features of the following genera and assign it to its respective family: (a) *Triticum* and *Pisum*

9. Describe the general characteristics and Floral diagram of the any two:

(a) Wheat (b) Brinjal (c) Pea

10. Write an account on complete Floral Biology and systematic position of *Brassica compestris*.

11. Define the following terms (any five):

(a) Aestivation

(b) Placentation

(c) Actinomorphic

(d) Zygomorphic

(e) Superior ovary

(f) Perigynous flower

(g) Epipetalous stamen

UNIT- 8 EMASCULATION TECHNIQUES IN THE FIELD ALONG WITH BAGGING AND LABELLING

8.1 OBJECTIVES

After reading this unit students will be able-

- To describe the emasculation technique in the field
- To know bagging and labeling technique

8.2 INTRODUCTION

Plant breeding is the genetic improvement of the crop in order to create desired plant types that are better suited for cultivation, give better yields and are disease resistant. Conventional plant breeding is in practice from 9,000-11,000 years ago. Most of our major food crops are derived from the domesticated varieties. But now due to advancements in genetics, molecular biology and tissue culture, plant breeding is being carried out by using molecular genetics tools. Classical plant breeding includes hybridization of pure lines, artificial selection to produce plants with desirable characters of higher yield, nutrition and resistance to diseases.

When the breeders wish to incorporate desired characters (traits) into the crop plants, they should increase yield and improve the quality. Increased tolerance to salinity, extreme temperatures, drought, resistance to viruses, fungi, bacteria and increased tolerance to insect pests should also be the desired traits in these crop plants. The main objective of plant breeding is to produce the new crop varieties superior in all aspects as compared to the existing types. This objective is achieved by different methods of crop improvement:

(1) Selection
(2) Plant Introduction and acclimatization
(3) Mutational breeding
(4) Hybridization

1. Selection Method for Crop Improvement

It is the simplest and oldest breeding method. It is also called as German method or German method of broad breeding because once it was used nicely in Germany for improving the sugar beets and small grains such as rye and wheat.

It can be defined as preservation of certain individual plants of desirable characters. In simplest form selection means choosing plants of one's choice. It is the basis of all crop improvement. Even today it is most common method of crop improvement among the cultivators.

Types of Selection Method

(a) Natural Selection: This is a natural process. It operates in the nature without human interference. According to the Darwin's principle "**Survival of the fittest**" plants which survive through the adversities of nature are preferred and the weaker ones are wiped out. Thus, nature itself selects the fittest organisms.

So, natural selection favors these characters which are essential for survival of a species. The selection pressure ultimately resulted in the appearance of many differences between species and subspecies. Natural selection has given the cultivated crops and

'**ecotypes**' in plants.

(b) Artificial Selection: It can be defined as to choose certain individual plants for the purpose of having better crop from a mixed population where the individuals differ in characters. Here the selecting agent is man. Man exploits the variations existing among the species. He picks of a few plants of better qualities from mixed populations and tries to propagate them.

2. Plant Introduction & Acclimatization

Plant introduction usually means the introduction of the plants from places outside the county, may be of same or another continent. It can be defined as the "**process of introducing plants from their growing locality to a new locality**". The introduction of the genotypes from the place where it is grown to an entirely new area. It is the easiest or most common method of crop improvement.

Acclimatization follows the introduction and both processes go side by side. Acclimatization is the adaptation or adjustment of an individual plant or a population of plants under the changed climate for a number of generations: Thus, it is a sort of natural selection operating into the introduced plant material.

3. Mutation Breeding

A sudden heritable change in a characteristic of an organism is called mutation; function of mutations with the aid of mutagens is called mutagenesis. Breeding method utilizing variation created through mutagenesis is called mutation breeding. In this method, gamma rays and X-rays are the most commonly used physical mutagens, while EMS (ethyl methane sulphonate), EI (ethylene imines) and sodium azide are the most commonly used chemical mutagens.

4. Hybridization

Hybridization is the most common method of creating genetic variation. Hybridization is crossing of two or more types of plants for bringing their traits together in the progeny. It brings about useful genetic/ heritable variations of two or more lines together. Line is a group of individuals related to descent and have similar genotype. The individuals or lines used in hybridization are called parents. Hybridization takes a lot of time.

Objectives of Hybridization:

1. To artificially create a variable population for the selection of types with desired combination of characters.
2. To combine the desired characters into a single individual, and
3. To exploit and utilize the hybrid varieties.

Hybridization may be of following types**:**

(i) Intra-varietal hybridization: The crosses are made between the plants of the same variety.

(ii) Inter-varietal or Intraspecific hybridization: The crosses are made between the plants belonging to two different varieties.
(iii) Interspecific hybridization or intrageneric hybridization: The crosses are made between two different species of the same genus.
(iv) Introgressive hybridization: Transfer of some genes from one species into the genome of the other species is known as introgressive hybridization. The crosses between different species of the same genus or different genera of the same family are also known as distant hybridization or wide crossing. Such crosses are called distant crosses.

The above procedure of hybridization are described as follows-
(a) Selection of Parents with Desired Characters.
(b) Selfing or self-fertilization.
(c) Emasculation.
(d) Bagging.
(e) Tagging.
(f) Artificial Pollination (Crossing).

(a) Selection of Parents: The selection of parents depends upon the aims and objectives of breeding. Parental plants must be selected from the local areas and are supposed to be the best suited to the existing conditions.

(b) Selfing of Parents or Artificial Self-Pollination: It is essential for inducing homozygosity for eliminating the undesirable characters and obtaining inbreeds.

(c) Emasculation: Emasculation is a method of '**Artificial Hybridization**' generally used to promote cross pollination in plants and avoid self pollination. This is done to achieve the beneficial variations which are not established due to inbreeding by self pollination. Cross Pollination is a necessary requirement for bisexual and monoecious plants only because unisexual plants are in no way capable to self pollinate. Dioecious plants have to undergo cross pollination as pollen and stigma are present on the flowers of two different plants. Out breeding devices are the artificial ways to promote cross pollination in bisexual or monoecious plants. This can be achieved by the means of "**Emasculation and Bagging**" techniques.

Emasculation, the process in which the anther/stamen of the bisexual flowers are being removed by means of forceps or by hand, taking care that other floral parts do not get damaged. This process is to be done before the Maturity or stage of release of pollens from Anthers. Bagging, after the anthers are being plucked out, the flower is being bagged by means of a butter paper to avoid the entry of any undesired pollen. Once the stigma becomes receptive the bagging is removed, stigma is dusted with the desired pollen and the flower is being bagged again. When the fertilization has taken place and flowering is initiated the bagging is removed and hence the "**Employment of Cross pollination in a Bisexual flower has been achieved**"

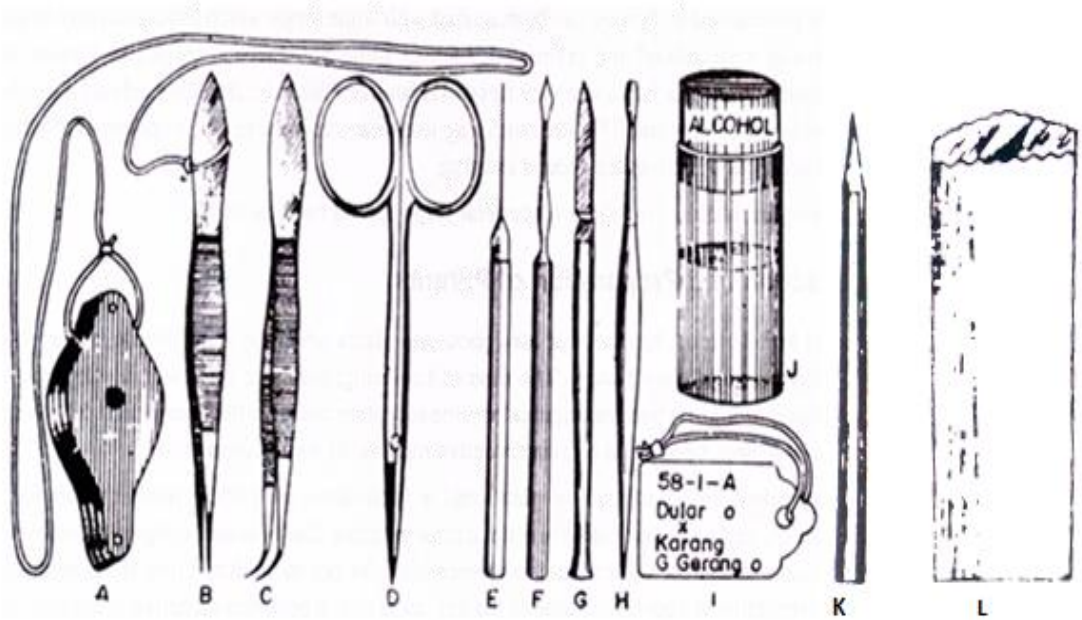

Fig. 8.1-Plant breeding kit: (A) Magnifying glass, (B & C) Forceps, (D) Scissors, (E & F) Needles, (G) Scalpel, (H) Brush (I) Label (J) Alcohol tube (K) Pencil and (L) Bag.

(d) Bagging: Bagging involves covering flowers on male as well as female parents separately by using suitable bags made up of polythene, muslin or paper. It is necessary for female flowers to protect them from cross pollination by unwanted pollen grains. Bagging is also carried out for the male parent flowers to protect the pollen from contamination and also to collect the pollen in the bag. For artificial cross pollination, these flowers are uncovered and after pollination once again they are bagged till they develop seeds.

(e) Tagging: The emasculated flowers are tagged just after bagging. Generally circular tags of about 3 cm or rectangular tags of about 3 x 2 cm are used. The tags are attached to the base of flower or inflorescence with the help of thread.

(f) Crossing: It can be defined as the artificial cross-pollination between the genetically unlike plants. In this method mature, fertile and viable pollens from the male parent are placed on the receptive stigma of emasculated flowers to bring about fertilization. Pollen grains are collected in Petridish (e.g., Wheat, cotton etc.) or in paper bags {e.g., maize) and applied to the receptive stigmas with the help of a camel hair brush, piece of paper, tooth pick or forceps. In some crops (e.g., Jowar, Bajra) the inflorescences of both the parents are enclosed in the same bag.

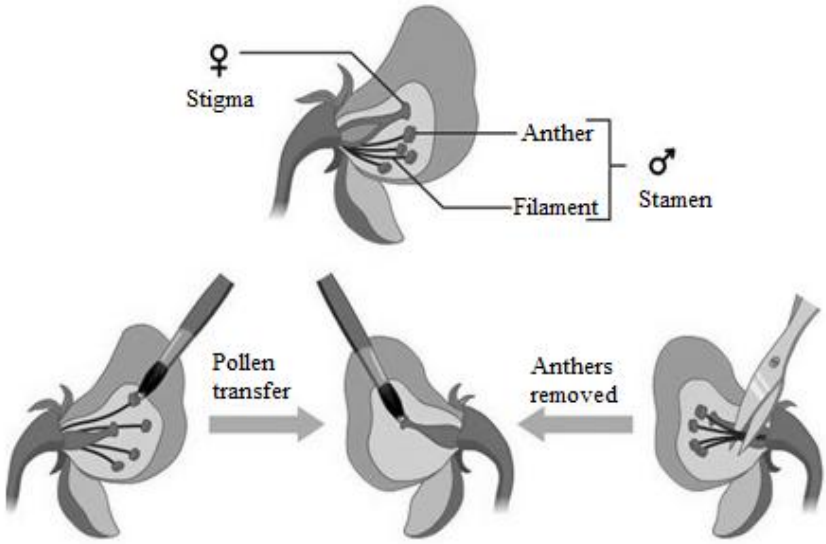

Fig.8.2 Cross-pollination, transfer of pollen from one flower to the stigma of another flower

Pollination

Pollination is the process by which pollen is transferred to the female reproductive organs of a plant, thereby enabling fertilization to take place. The two most important operations that determine the amount of seed set in hybridization are emasculation and pollination. In case of pollination, mature, fertile and viable pollen should be placed on a receptive stigma to bring about fertilization. The duration of pollen viability after anther dehiscence varies greatly from one species to another e.g., a few minutes in that fresh pollen from mature anthers should be used for pollination. The time of anther dehiscence falls within the duration of stigma receptivity and both generally coincide with the opening of flowers.

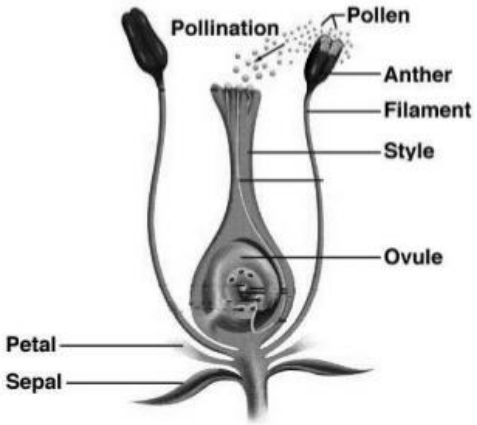

Fig.8.3 Pollination in a flower

Pollen grains are collected in a bag, and are used for dusting stigmata of female inflorescence or of emasculated flowers, the e.g., in maize, bajra etc.

Mature anthers are collected from the flowers of male parent. The pollen is liberated and applied to the stigma with the help of a camel hair brush, pieces of paper, tooth pick or forceps. Anthers are collected and allowed to burst directly over the stigma.

In rice, oats, wheat and barley, one anther is generally inserted in each floret where it

dehisces and covers the stigma with pollen grains. The spike of male inflorescence is shaken over the emasculated inflorescence just when the anthers are about to dehisce. The lemma and palea of the spike of male parent are also clipped of to expose the anthers, which are used as the source of pollen.

In species like maize, the male inflorescence may be detached and enclosed in the bag covering the female inflorescence. In case of bajra and jawar, panicles from the male parent may be enclosed in the same bags that enclose the panicles of female parent.

8.3 EMASCULATION TECHNIQUE IN THE FIELD

The removal of stamens or anthers or the killing of pollen grains of a flower without affecting in any way the female reproductive organs is known as emasculation. The purpose of emasculation is to prevent self-fertilization in the flowers of female parent. In dioecious plants, male plants are removed, while in monoecious species the male flowers, e.g., in castor, or the male inflorescence, e.g., in maize, are removed to prevent self-pollination. But emasculation is essential in bisexual flowers. In species with relatively large flowers, hand emasculation may be adequate in most hybridization programmes. The efficiency of an emasculation technique may be tested by bagging the emasculated flowers without pollination. The amount of seed thus set would indicate the frequency of chance self-fertilization during emasculation. If the seeds are to be used in genetic studies, there should be no self-pollination during emasculation.

Emasculation is done before the anthers are mature and the stigma has become receptive to minimize accidental self-pollination. Emasculation is generally done in the evening, between 4 and 6 p.m., one day before the anthers are expected to dehisce or mature and the stigma is likely to become fully receptive. Therefore, the flowers selected for emasculation are likely to open the next morning. Generally, it is desirable to remove the older and the younger flowers located close to the flower to be emasculated in order to avoid confusion in identification of crossed pods etc.

Hand emasculation

This method is generally used in those plants which have large flowers. In this method the corolla of the selected flowers is opened and the anthers carefully removed with the help of fine-tip forceps.

Following are the important precautions while performing this method:
i. Flowers should be selected at proper stage.
ii. Stigma should be receptive and anthers should not have dehisced.
iii. All the anthers should be removed from the flowers without breaking
iv. Stigma and ovary of the flower should not be damaged.

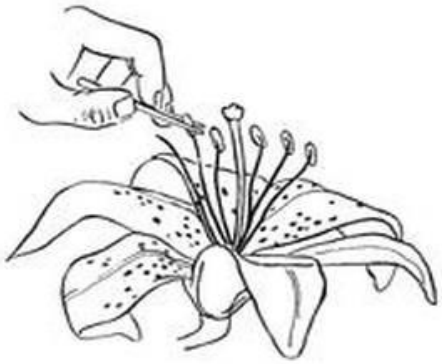

Fig.8.4-Hand emasculation

Suction method

This method is useful in species with small flowers. Emasculation is done in the morning just before or immediately after the flowers open. The petals are generally removed with forceps exposing the anthers and the stigma. A thin rubber or glass tube attached to a suction hose is used to suck the anthers from the flowers. The tube is also passed over the stigmas to suck any pollen grains present on their surface. The suction may be produced by an aspirator attached to water tap or by a small suction pump. The suction should be enough to suck the stamens and pollen grains, but not the flowers or the gynoecium. Washing the stigma with a jet of water may help in reducing self-pollination.

Hot water emasculation

Pollen grains are more sensitive than the female reproductive organs to both genetic and environmental factors. This property is utilized to kill the pollen grains with hot water or other agents like alcohol treatment or cold water treatment without damaging the female reproductive organs. In the case of hot water emasculation, the temperature of water and the duration of treatment vary from crop to crop. For jowar-42-48°C for 10 minutes. Rice-40-44°C for 10 minutes. The hot water is generally carried in thermos flasks and the whole spike is immersed in the water.

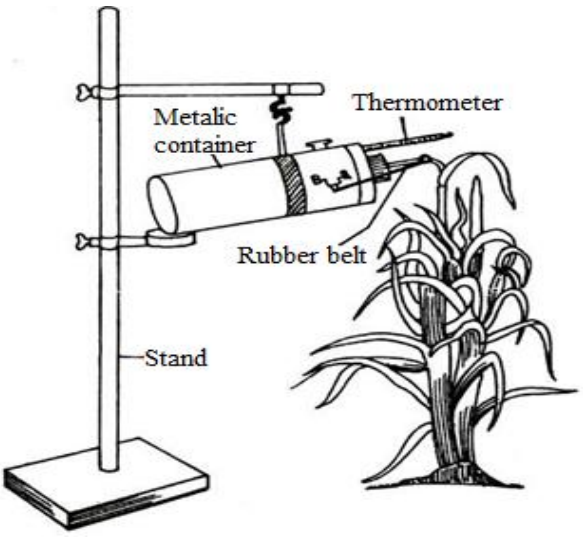

Fig.8.5- Hot water treatment method

Alcohol treatment

It is not a commonly used method of emasculation. The method consists of immersing the flower or the inflorescence. Immersing the flower or the inflorescence in alcohol of a suitable concentration for a brief period, followed by rinsing with water. However, the duration of treatment is of utmost importance. Even a slightly, prolonged period of treatment, a few seconds more than the recommended, would greatly reduce seed set. This is because the female reproductive organs would also be killed by a longer treatment.

Cold treatment

Cold treatment, like hot water treatment, kills pollen grains without damaging gynoecium. In case of rice, treatment with cold water at 0-6° C kills pollen grains without affecting gynoecium. Keeping wheat plants at 0-2°C for 15-24 hours kills the pollen grains. The amount of self-pollination is generally greater in cold treatment than in the case of hot water treatment.

Genetic emasculation

Genetic or cytoplasmic male sterility may be used to eliminate the necessity of emasculation. Many species are self-incompatible. In such cases, emasculation is not necessary because self-fertilization will not take place. For commercial hybrid seed production, male sterility is the most feasible method of emasculation. Protogyny facilitates crossing the anthers mature, hand pollination ensures seed set from cross pollination and prevent self-fertilization, i.e., in bajra (*Pennisetum americanum*).

Use of Chemical Gametocide

Certain chemical agents are capable of causing male sterility, when sprayed before flowering. These chemicals are also known as chemical hybridizing agents (CHA), the chemicals which selectively kills the male gamete without affecting the female gamete. e.g. FW450 in cotton, Ethrel, Sodium methyl arsenate, Zinc ethyl arsenate in rice, Maleic hydrazide for cotton and wheat.

8.3.1-Bagging

Immediately after emasculation, the flowers or the inflorescences are enclosed in suitable bags of appropriate size to prevent random cross-pollination. Usually these bags are kept till seed-setting is complete. In cross-pollinated crops, like maize, the male flowers are also bagged to maintain the purity of pollen used for pollination. The pollens are also collected only from already bagged males for crossing purpose.

Fig.8.6- Bagging method

The bagging is usually done in the evening of previous day of crossing, since most of the crops become receptive in the morning. These bags are kept on the females as such till seed setting is complete while in males they are removed as soon as the crossing is over.

The bags may be made of paper, butter paper, glassine or fine cloth. Butter paper or vegetable parchment bags are the most commonly used. The size of bags is according to the size of flowers of a crop in which they are to be used. In many cases ordinary muslin cloth and paper bags are satisfactory. The thin paper bags immersed in oil or paraffin are best for withstanding the insect attacks as well as for the plants having very delicate flowers.

In some cases, it is essential to puncture the bags with numerous minute holes to provide ventilation and prevent moulds development inside the envelope. Many special devices such as cylindrical muslin cloth bags, glass or celluloid cylinders plugged with cotton and with firm support, are used occasionally.

Fig.8.7- Different methods of bagging

The bags are tied to the base of inflorescence or to the stalk of flower with the help of thread, wire or pins designed for the purpose. Fungus development on the fruit or the spike may be prevented by removing the bags after the danger of cross-pollination is over usually

2-3 days after pollination.

8.3.2-Labelling

The emasculated flowers are tagged just after bagging. The tags are attached to the flower or the inflorescence with the help of thread. The information is recorded on the tags with a carbon pencil. The crossed flowers are properly tagged and labeled.

The labelling is done either on the bag itself or on the labels specially designed for this purpose. They are of different sizes and shapes, and either may be purchased from the market or made in the laboratory from the ordinary, but somewhat hard, paper. They are tagged to bags with the help of threads. The labelling on them must be as brief as possible but complete, bearing the following information;

1. Number referring to the field record.
2. Date of emasculation.

Fig.8.8-Tagging method

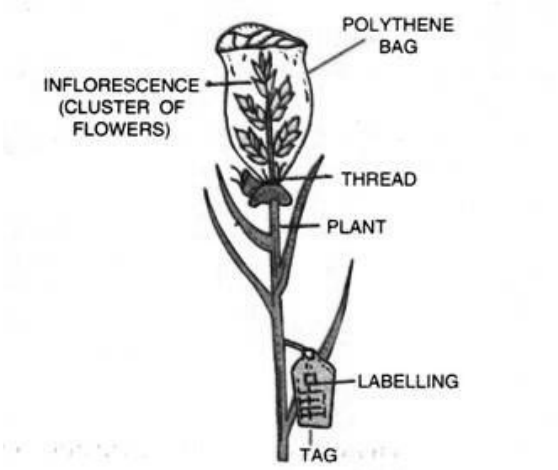

Fig 8.9- Bagging and tagging at the time of hybridization

3. Date of crossing or pollination.
4. Details of parents, names of the female and the male parents. The name of the female parent is written first, and that of the male parent is written later.
5. No. of flowers emasculate.

The first and second information are entered with the emasculation, while the third and fourth steps are entered after crossing. All other necessary particulars must be entered in a handy field- record book in which the observations are also recorded from time to time.

8.4 PROCEDURE OF EMASCULATION

Objective: To emasculate flowers of given crop in field for hybridization.

Requirements: Needle, forceps, scalpel, scissors, pocket lens, absolute alcohol or rectified spirit.

Principle: Emasculation is the process of removal of anthers from bisexual flowers to prevent self-pollination before anthesis.

Procedure:

1. Sterilize all equipments in absolute alcohol or rectified spirit.
2. Sterilize finger and hand before emasculation by rinsing in alcohol.
3. Remove calyx and corolla with the help of forceps and scalpel etc.
4. Carefully remove stamens with the help of forceps etc.
5. Gynoecium should not be touched and it must remain as such.

Precautions:

1. Unwanted flowers must be removed before emasculation.
2. Only those floral buds are emasculated in which anthesis has not occurred.
3. Emasculated flowers must be covered with bag soon after the process is completed.

Procedure of Bagging & Labelling

Objective: Bagging and labelling of emasculated flowers.

Requirements: Butter paper bag of suitable size, U-pin, hard paper, tag, etc.

Principle: Bags cover the emasculated flowers. These bags protect the emasculated flowers from insects, pollen grains, dust, drew, rain etc. This process is called as bagging. Labelling is tagging of label containing desirable information for future reference.

Procedure:

1. Prepare a small bag of butter paper of suitable size.
2. Cover the emasculated flower carefully with this paper bag.
3. U-pin or thread is used to tie the bag to the floral axis of the plant.
4. A label of hard paper is made containing following information and this is tagged with a thread to the emasculated flower.

Information that has to be written on the tag is:

i. Specific reference no._____

ii. Date of emasculation_____

iii. Date & time of pollination_____

iv. Name of plant _____

v. Date of harvesting_____

vi. Name of plant breeder_____

8.5 SUMMARY

Emasculation is a method of artificial hybridization generally used to promote cross pollination in plants and avoid self pollination. It is the process of removing anthers from bisexual flowers without affecting the female reproductive part i.e. pistil, which is used in various plant hybridization techniques. This is done to achieve the beneficial variations which are not established due to inbreeding by self pollination. Cross Pollination is a necessary requirement for bisexual and monoecious plants only because unisexual plants are in no way capable to self pollinate. Dioecious plants have to undergo cross pollination as pollen and

stigma are present on the flowers of two different plants. Outbreeding devices are the artificial way to promote cross pollination in bisexual or monoecious plants. This can be achieved by the means of **'Emasculation and Bagging"** techniques.

Emasculation is necessarily followed by controlled pollination. Emasculation is done during early morning between 6 and 8 am in spikelets, due to open on the same day. Emasculation should be over well ahead of the time of anthesis. It is performed by plant breeders in bisexual flowers to obtain the desired variety of a plant by crossing a particular plant with the desired pollen grain. To remove the anthers, the flowers are covered with a bag before they open. This ensures that the flower is pollinated by pollen grains obtained from desirable varieties only. Later, the mature, viable, and stored pollen grains are dusted on the bagged stigma by breeders to allow artificial pollination to take place and obtain the desired plant variety.

Various artificial hybridization techniques (under various crop improvement programmes) involve the removal of the anther from bisexual flowers without affecting the female reproductive part through the process of emasculation. Then, these emasculated flowers are wrapped in bags to prevent pollination by unwanted pollen grains. This process is called bagging. The bagging is usually done in the evening of previous day of crossing, since most of the crops become receptive in the morning. The emasculated flowers are tagged just after bagging. The tags are attached to the flower or the inflorescence with the help of thread. The information is recorded on the tags with a carbon pencil. The crossed flowers are properly tagged and labeled. This technique is an important part of the plant breeding programme as it ensures that pollen grains of only desirable plants are used for fertilization of the stigma to develop the desired plant variety.

8.6 GLOSSARY

Acclimatization: The physiological adaptation of an organism to changes in climate or environment, such as light, temperature, or altitude.

Anther: The pollen-bearing part of a stamen.

Artificial pollination: Occurs when humans intervene with the natural pollination process. They carry pollen, or plant sperm, from one flower to another, allowing the pollen to fertilize the ovaries and create seeds that will develop into fruits and new plants.

Aspirator: An apparatus or device employing suction.

Bagging: Put (something) in a bag.

Bisexual flower: A flower that has both male (androecium or stamens) and female (gynoecium or carpels) functional reproductive parts in the same flower.

Calyx: The sepals of a flower, typically forming a whorl that encloses the petals and forms a protective layer around a flower in bud.

Corolla: The petals of a flower, typically forming a whorl within the sepals and enclosing the reproductive organs.

Cross-pollination: Pollination of a flower or plant with pollen from another flower or plant.

Cytoplasm: The cell substance between the cell membrane and the nucleus, containing the cytosol, organelles, cytoskeleton, and various particles.

Dehiscence: The release of materials by the splitting open of an organ or tissue.
Dioecious: Having the male and female organs in separate and distinct individuals; having separate sexes.
Emasculation: The removal of the anthers of a flower in order to prevent self-pollination or the undesirable pollination of neighboring plants.
Feasible: Capable of being done, effected, or accomplished.
Genotype: The genetic makeup, as distinguished from the physical appearance, of an organism or a group of organisms.
Gynoecium: The pistil or pistils of a flower; the female parts.
Heritable: Capable of being inherited.
Hybrid seed: In agriculture and gardening, hybrid seed is seed produced by cross-pollinated plants.
Hybridization: The process of an animal or plant breeding with an individual of another species or variety.
Inbreeding: The production of offspring from the mating or breeding of individuals or organisms that are closely related genetically.
Inflorescence: The arrangement of flowers on the axis.
Inherited: To receive (a characteristic) from a parent or ancestor by genetic transmission.
Labelling: Is describing someone or something in a word or short phrase.
Lemma: A phyto-morphological term used in botany referring to a part of the spikelet of grasses.
Male sterility: An absence or non-function of pollen grain in plant or incapability of plants to produce or release functional pollen grains.
Monoecious: Having both male and female organs in the same individual; hermaphroditic.
Muslin cloth: A cotton fabric of plain weave.
Mutational breeding: Or "**Variation breeding**", is the process of exposing seeds to chemicals or radiation in order to generate mutants with desirable traits (or lacking undesirable ones) to be bred with other cultivars.
Outbreeding: Breed from parents not closely related.
Palea: The palea is the uppermost of the two chaff-like bracts that enclose the grass floret (the other being the lemma).
Panicle: A loose branching cluster of flowers, as in oats.
Paraffin: A waxy white or colorless solid hydrocarbon mixture used to make candles, wax paper, lubricants, and sealing materials. Also called paraffin wax.
Vegetable parchment: A paper-like material made from a base of cotton rags or alpha cellulose called waterleaf, and containing no sizing or filling materials; used for documents and food packaging.
Pistil: The ovule-bearing or seed-bearing female organ of a flower, consisting when complete of ovary, style, and stigma.
Pollen: The fertilizing element of flowering plants, consisting of fine, powdery, yellowish grains or spores, sometimes in masses.
Pollination: The transfer of pollen from the anther to the stigma.
Protogyny: The condition of flowers whose female parts mature before the male ones.
Pure-line: An inbred line of genetic descent or a uniform strain of organisms that is relatively

pure genetically because of continued inbreeding and artificial selection.
Receptive: Having the quality of receiving, taking in, or admitting.
Rectified spirit: Or "**Rectified alcohol**", is highly concentrated ethanol which has been purified by means of repeated distillation, a process that is called rectification.
Rinsing: To wash lightly with water.
Scalpel: A small, light, usually straight knife used in surgical and anatomical operations and dissections.
Self-fertilization: Fusion of male and female gametes (sex cells) produced by the same individual.
Self-incompatible: A widespread mechanism in flowering plants that prevents inbreeding and promotes out-crossing.
Self-pollination: The pollination of a flower by pollen from the same flower or from another flower on the same plant.
Spike: A kind of inflorescence in which sessile flowers are arranged on an unbranched elongated axis.
Stigma: The apex of the pistil of a flower, on which pollen grains are deposited and germinate.
Tag: A strip of leather, paper, metal, or plastic attached to something or hung from a wearer's neck to identify, classify, or label.
Tagging: To label, identify, or recognize with a tag or other identifier.
Viable pollen: Pollen which perform its function of delivering the sperm cells to the embryo sac following compatible pollination

8.7 SELF ASSESSMENT QUESTION

8.7.1 Short answer type questions:

1. Give name of two chemical Gametocide used for emasculation of flowers for hybridization?
2. What temperature are generally used in hot water & cold water treatments for emasculation?
3. In crops having small flowers, which emasculation method is generally avoided?
4. Pollination of a flower or plant with pollen from another flower or plant?
5. Mechanism in flowering plants that prevents inbreeding and promotes out-crossing?
6. The condition of flowers whose female parts mature before the male ones?
7. The phyto-morphological term used in botany referring to a part of the spikelet of grasses?
8. The production of offspring from the mating or breeding of individuals or organisms that are closely related genetically?
9. The pollination of a flower by pollen from the same flower or from another flower on the same plant?
10. Pollen which perform its function of delivering the sperm cells to the embryo sac following compatible pollination?
11. Genetic emasculation also known as?
12. The bag used in bagging method is made up of other than paper and butter paper?

13. The information is recorded on the tags with help of?
14. The bag are kept on the female as such till seed setting is complete, while in males they are removed as soon as the ?
15. The crops in which the inflorescence of both the parents are enclosed in the same bag?

8.7.2 Fill in the blanks:

1. _____is the process of an animal or plant breeding with an individual of another species or variety.
2. The physiological adaptation of an organism to changes in climate or environment, such as light, temperature, or altitude are known as_____
3. _____having the male and female organs in separate and distinct individuals; having separate sexes.
4. _____occurs when humans intervene with the natural pollination process.
5. The breed from parents not closely related are called_____
6. _____is the fusion of male and female gametes produced by the same individual.
7. The apex of the pistil of a flower, on which pollen grains are deposited and germinate are called_____
8. _____ is also known as variation breeding.
9. _____ is the condition of flowers whose female parts mature before the male ones.
10. The absence or non-function of pollen grain in plant or incapability of plants to produce or release functional pollen grains is known as _____
11. The bags used after emasculation, are kept on _____till seed-setting is complete.
12. The emasculated flowers are tagged just after _____
13. The tags are attached to the flower or the_____ with the help of thread.
14. The name of the _____is written first and that of the _____is written later.
15. Cold or hot treatment kills pollen grains without damaging_____

8.7.3 Multiple choice questions:

1. Hand emasculation is generally recommended in crops with
(a) Large flowers (b) Very small flowers
(c) Monoecious condition (d) Dioecious condition

2. In the following situation, emasculation will not be needed, although hermaphrodite flower are present and pollen is fully fertile
(a) Genetic male sterility (b) Cytoplasmic male sterility
(c) Self incompatibility (d) Homogamy

3. Cytoplasmic male sterility is commonly used in
(a) All breeding methods involve in hybridization
(b) Pedigree method of plant breeding
(c) In back-cross method of plant breeding
(d) Hybrid seed production

4. The quickest method of plant breeding is
(a) Introduction (b) Selection
(c) Hybridization (d) Mutation breeding

5. Bagging is done to
(a) Avoid cross pollination (b) Avoid self pollination
(c) Achieve desired pollination (d) Prevent contamination from foreign pollen

6. Pure line breed refers to
(a) Heterozygosity only (b) Homozygosity only
(c) Homozygosity and self assortment (d) Heterozygosity and linkage

7. The process of removing stamen from the flower during hybridization is called
(a) Capping (b) Selfing
(c) Emasculation (d) Crossing

8. A plant bearing both male and female flowers is said to be
(a) Dioecious (b) Monoecious
(c) Polygamous (d) None of above

9. A plant breeder is interested to control pollination to
(a) Prevent cross-pollination (b) Control pollination
(c) Both of these (d) None of these

10. Acclimatization is
(a) A process of adjustment by crop plants to environment
(b) Related with the clay
(c) Removal of female parts of a flower
(d) Changing of climatic condition

8.7.1 Answer key: 1. Ethrel and Sodium methyl arsenate. **2.** >40°C, <6°C, 3. Hand emasculation, 4. Cross-pollination, 5. Self-incompatible, 6. Protogyny, 7. Lemma, 8. Inbreeding, 9. Self-pollination, 10. Viable pollen, 11. Genetic or cytoplasmic male sterility, 12. Glassine or fine cloth, 13. Carbon pencil, 14. Crossing is over, 15. Jowar and Bajra.

8.7.2 Answer key: 1-Hybridization, 2-Acclimatization, 3-Dioecious, 4-Artificial pollination, 5-Outbreeding, 6-Self-fertilization, 7-Stigma, 8- Mutational breeding, 9-Protogyny, 10-Male sterility, 11- Females, 12- Bagging, 13- Inflorescence, 14- Female parent, Male parent, 15- Gynoecium

8.7.3 Answer key: 1-(a), 2-(c), 3-(d), 4-(d), 5-(d), 6-(b), 7-(c), 8-(b), 9-(c), 10-(a).

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8.10 TERMINAL QUESTIONS

1. Define the term hybridization and state its objects of application.
2. What is bagging technique? How is it useful in a plant breeding programme?
3. What is meant by emasculation? When and why does a plant breeder employ this technique?
4. What is the necessity of labelling and when is it done? Described how is it done and illustrate with the help of diagram?
5. Define the term 'crossing' and discuss its operation in different crops.
6. What is bagging? When and why is bagging done in the hybridization?
7. Describe the process of pollination and its role in emasculation. Illustrate with the help of diagram?
8. How many steps are involved in the hybridization procedure? Describe only three most important in detail.

9. Write a short note on:
   a) Emasculation
   b) Bagging
   c) Hot water treatment
   d) Suction method
   e) Genetic emasculation

10. Describe the procedure to emasculate flowers of given crop in field for hybridization. Also describe the procedure of bagging and labelling of emasculated flowers.

BLOCK-3 PLANT PHYSIOLOGY AND BIOCHEMISTRY

UNIT-9 PERFORM THE PROCESS OF OSMOSIS, IMBIBITION, PLASMOLYSIS AND DEPLASMOLYSIS AND THE EFFECTS OF TEMPERATURE ON THE PERMEABILITY OF PLASMA MEMBRANE

9.1 OBJECTIVES

After reading this unit students will be able to understand-

- Process of endosmosis and ex-osmosis using potato tuber and egg osmoscope
- Process of demonstration of Imbibitions
- Process of demonstration of plasmolysis and de-plasmolysis
- Effects of temperature on the permeability of plasma membrane

9.2 INTRODUCTION

The movement of materials into and out of the cells in plants takes place in solution or gaseous form. Three physical processes are usually involved in it. They are diffusion, osmosis and imbibition. These movements involve movement along the concentration gradient. Hence, there is no expenditure of energy. The movement of particles or molecules from a region of higher concentration to a region of lower concentration is called diffusion. Whereas, osmosis may be considering as diffusion though a semi permeable membrane. It is defined as "a process by which molecules of a solvent tend to pass through a semi permeable membrane from a less concentrated solution into a more concentrated one."

Demonstration of Osmosis

A thistle funnel, covered at the broad end by a differentially permeable membrane, contains a 10% sugar solution. The beaker contains a 5% sugar solution as shown in fig. 1a. The solute is unable to pass through the membrane, but the water passes freely through in both directions. The net movement of water towards the inside of the thistle funnel occurs because the thistle funnel has a lower water concentration. The level of the solution rises in the thistle funnel until hydrostatic pressure increases to the level of osmotic pressure.

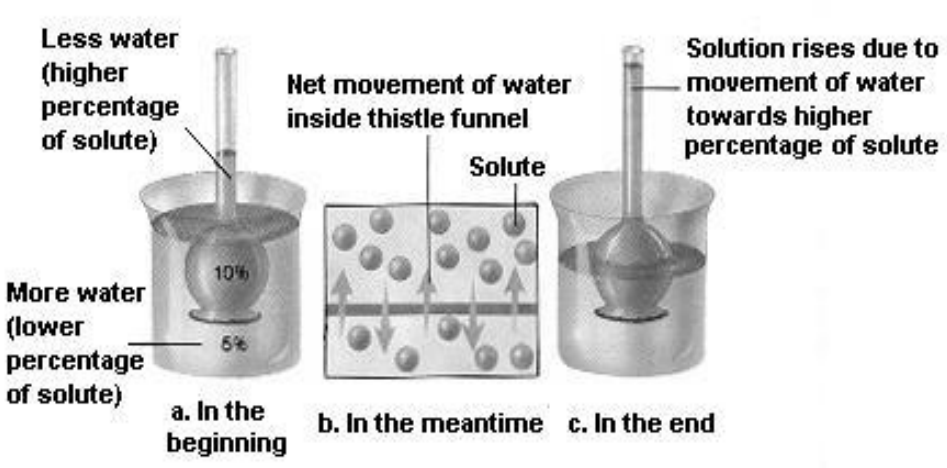

Fig.9.1- Demonstration of process of osmosis

9.3 PROCESS OF ENDOSMOSIS AND EXOSMOSIS USING POTATO TUBER AND EGG OSMOSCOPE

Introduction

If two solutions are separated by a semi permeable membrane, the membrane will be selectively permeable which will not allow passing of solute molecules whereas the solvent molecules will pass through it. According to the law of diffusion the movement of solvent molecules will be from the region of higher concentration to the lower concentration or in other word from the dilute solute to concentrated solution because the concentration of solvent will be higher in dilute solution and lower in concentrated solution.

Osmosis

It is a process involving net diffusion of water molecules from a region of higher water concentration to a region of lower water concentration through a semi permeable membrane. The osmotic movement of water from a surrounding medium into a cell is called endosmosis. Such a medium is described as hypotonic. The diffusion pressure exerted by water molecules on the semi permeable membrane is called as osmotic pressure.

Object 1: To demonstrate the phenomenon of endosmosis and exosmosis using potato tuber

Requirements: Beaker, distilled water, glucose, potato tuber, sugar, beaker, or petridish, knife, water, some sugar crystal or its concentration

Working Procedure: The osmotic entry or exit of water can be recorded by means of potato osmoscope (Fig.9.2). The potato surface serves as a semi-permeable membrane. Peel the skin of a potato and remove the inner contents to form a cup shaped hollow and place the potato in a container with water. Pour 5% sugar solution in to the potato cup up to a particular level. Pierce a pin to mark the initial level. Leave the experimental set up undisturbed for about one hour. At the end of the duration check the level of sugar solution in the potato cup. You will be able to record an increase in level caused by osmotic movement of water in to sugar solution through the tissue of potato tuber (endosmosis) which acts as semi permeable membrane. Water enters in the cavity because of osmosis, i.e. water molecules can diffuse through the semi permeable membrane from the region of higher concentration to lower concentration. In reverse case, i.e. sugar solution in the container and water in the potato cup, and mark the initial level. The movement if water would be in reverse direction and exosmosis would occur. At the end of 30 minutes note the difference. This time you will be able to record a decrease in the level of water inside the potato cup (exosmosis).

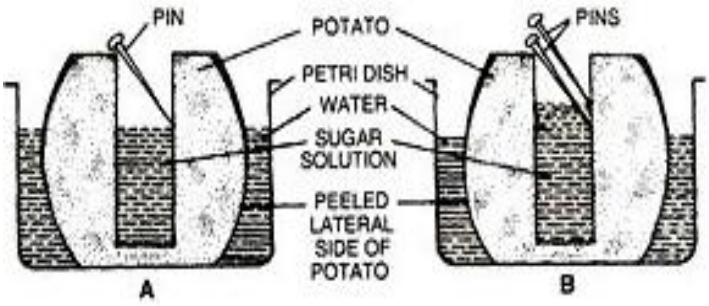

Fig.9.2: Potato osmoscope experiment to demonstrate osmosis A. Original level B. Final level

Object 2: To demonstrate phenomenon of osmosis using egg osmoscope.

Material required: Egg, HCL, beaker, graduated tube, sugar solution, water and stand

Working Procedure: The outer calcareous shell of the egg is removed by dissolving it in HCL leaving thin layer membrane as outer covering. The inner content of the shell is replaced by sugar solution through a small hole made for the purpose and graduated tube is tied in the opening. The membrane bag is hung dipped in the beaker of water with the help of stand. The level of the tube in stand is recorded (Fig.9.3).

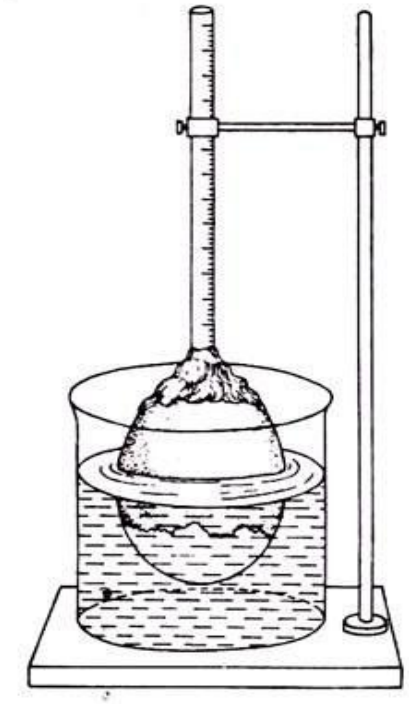

Fig. 9.3: Demonstration of osmosis using egg membrane

A rise of the level is seen after some time due to entrance of water because of diffusion of its molecules from the region of its higher concentration to the region of its lower concentration. The egg membrane acting as semi-permeable membrane permits the movement of water molecules but checks the movement of sugar molecules.

Variation: The egg membrane can be replaced by any other semi permeable membrane e.g., urinary bladder of sheep or goat.

9.4 PROCESS OF DEMONSTRATION OF IMBIBITION

Introduction

The adsorption of water by hydrophilic colloids is known as imbibition. Imbibition of water increases the volume of the imbibant due to which pressure is created which is known as imbibitional pressure. Imbibitional pressure is the potential maximum pressure that an imbibant will develop if it is submerged in water. The relationship of DPD, IP (imbibitional pressure) and TP (turgor pressure) is as follows:

DPD = IP-TP

Different types of organic substances have different imbibing capacities. Proteins have a very high imbibing capacity, starch less and cellulose least. That is why proteinaceous pea seeds swell more on imbibitions than starchy wheat seeds. The amount of water imbibed by a substance is also determined by the degree of cohesion of the molecules of the imbibing substance. Wood swells more than gelatin because there is more of cohesive attraction between wood molecules than gelatin. Increase in temperature brings about an increased imbibitions. The presence of solutes also affects rate of imbibitions. Increase in concentration of the solute decreases imbibitions. Type of a solution may also affect it. Some ions inhibit imbibitions much more than others imbibition is also affected by acidity and alkalinity. Proteins being more amphoteric in nature imbibe least in neutral medium. Towards pH1 or 14 the imbibition increases till a maximum is reached and then again falls down. During imbibition some energy is also released as heat. This is indicated by the warming of kneaded flour. The imbibitional pressure may be play important role in breaking soil profiles by germinating seeds.

Object 1: Demonstration of imbibition

Working Procedure: Dried raisins pieces are soaked in water for a few hours which swell up due to imbibition. They are measured again and an increase in the size of raisins is observed due to imbibition of water. As a result of absorption or imbibition of water, the size of the raisins increases (Fig.9.4 A & B). The difference in mass between the swollen and dry raisins gives the amount of water imbibed by the raisins.

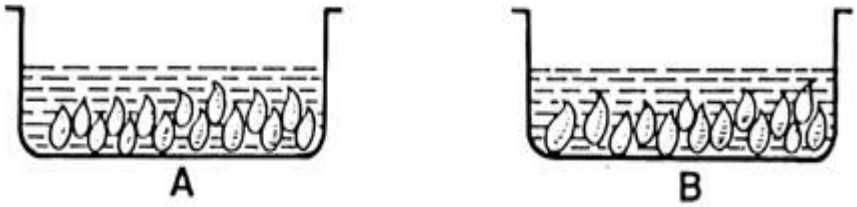

Fig.9.4: Demonstration of imbibitions of raisins

Object 2: Demonstration of imbibitional pressure

Working Procedure: A few gram (*Cicer* sp.) seeds in water are placed in a bottle and disc just above the seed level fitted through the cork of the bottle. The pointer is adjusted at zero on the scale and the apparatus is made airtight and is left for a few hours (may be up to 24 -48 hours). While making the observations, it is observed that disc is displaced above and the

pointer moves down. It happens because gram seeds imbibe the water and swell considerably (Fig 9.5). The imbibition is caused due to hydrophilic colloids present in the gram seeds. The pressure which is responsible to push the disc is called imbibitional pressure.

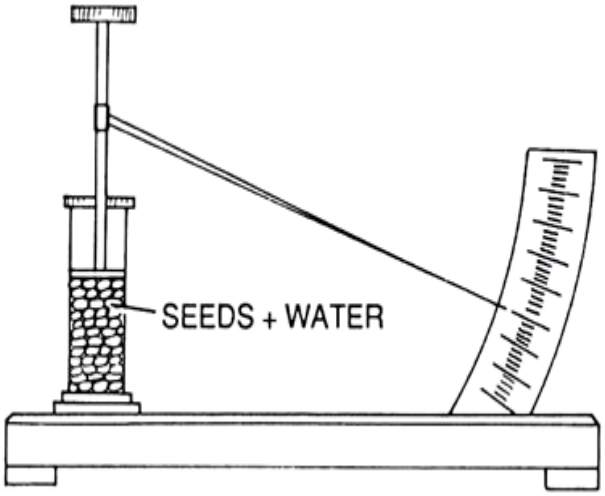

Fig.9.5: Demonstration of imbibitions pressure

9.5 PROCESS OF DEMONSTRATION OF PLASMOLYSIS AND DEPLASMOLYSIS

Introduction

When a plant cell is placed in a solution that has a higher solute concentration (hypertonic compared to the cell sap) water is lost from the cell by osmosis (exosmosis). As the concentration of water molecules in the cell is higher than the outer hypertonic solution, net movement of water molecules is from their region of higher concentration to their region of lower concentration across the selectively permeable plasma membrane. This process is called exosmosis. If exosmosis continues in a plant cell, cytoplasm along with the nucleus and vacuole shrinks to a small irregular mass due to loss of water. Eventually it pulls away from the cell wall. The space between, the cell wall and cytoplasmic mass is filled with the salt or sugar solution due to the permeability of the cell wall. This phenomenon is plasmolysis and the cell is said to be plasmolysed (Fig.9.6).

Plasmolysis is a reversible phenomenon. When the plasmolysed cell is placed in water, which is hypotonic compared to cell sap, the cell gains water due to endosmosis. As a result, the cell membrane, cytoplasm and vacuole regain their normal position. This phenomenon is called deplasmolysis. Through observation of plasmolysis and deplasmolysis, it is possible to determine the tonicity of the cell's environment as well as the rate solute molecules cross the cellular membrane.

Plasmolysis only occurs in extreme conditions and rarely happens in nature. It is induced in the laboratory by immersing cells in strong saline or sugar (sucrose) solutions to cause exosmosis, often using Elodea plants or onion epidermal cells, which have colored cell sap so that the process is clearly visible. Methylene blue can be used to stain plant cells.

Plasmolysis is mainly known as shrinking of cell membrane in hypertonic solution and great pressure.

Plasmolysis can be of two types, either concave plasmolysis or convex plasmolysis. Convex plasmolysis is always irreversible while concave plasmolysis is usually reversible. During concave plasmolysis, the plasma membrane and the enclosed protoplast partially shrinks from the cell wall due to half-spherical, in warding curving pockets forming between the plasma membrane and the cell wall. During convex plasmolysis, the plasma membrane and the enclosed protoplast shrinks completely from the cell wall, with the plasma membrane's ends in a symmetrically, spherically curved pattern.

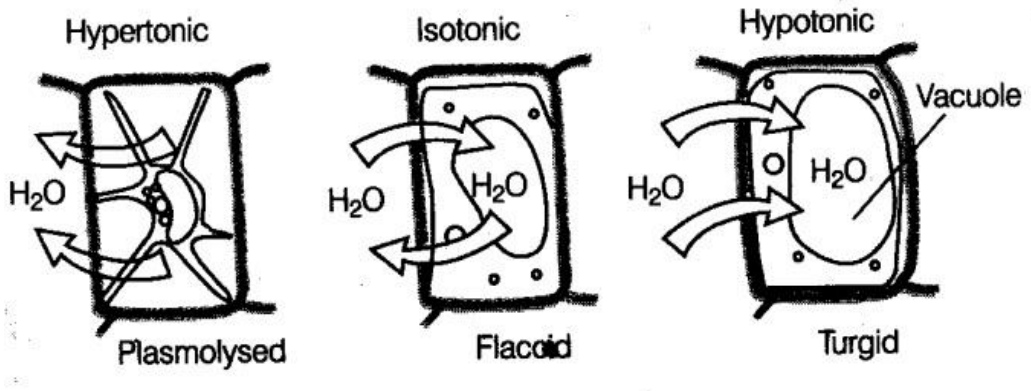

Fig.9.6: Demonstration of plasmolysis and de-plasmolysis

Object 1: To demonstrate plasmolysis

Material required: An onion, glass slide, cover slip, forceps, needle, brush, blade, pipette, petridishes, blotting paper, dropper, concentrated salt or sugar solution, water, compound microscope

Working Procedure:

1. Remove the outermost peel of the onion.
2. Cut out a small part from an inner fleshy scale leaf using the blades.
3. Pull out the transparent peel of the scale leaf using forceps.
4. Using the brush place the piece of onion peel on clean glass slide.
5. Put a drop of the concentrated salt or sugar Solution on the peel with the help of the dropper.
6. Put a clean cover slip by tilting it over the needle.
7. In this way you can prevent air bubbles form getting trapped under the cover slip.
8. Remove excessive solution with blotting paper.
9. Observe the mounted onion peel immediately under the low and high magnification of the compound microscope.
10. Observe it again under the microscope after some time. Note the shrunken cytoplasm of the cells.

Observations

After putting the drop of the hypertonic solution on the cells of the onion peel, their cell membranes withdraw from the cell walls; the enclosed cytoplasm nucleus and vacuole lose

water and shrink to one side of the cell. The cell walls remain at their original positions. The space between the cell wall and the shrunken cytoplasm is filled with the salt or sugar solution.

Object 2- To demonstrate de-plasmolysis
Working Procedure- When a plasmolysed cell is placed in a hypotonic solution, (i.e., the solution having solute concentration lower than the cell sap), the water moves into the cell because of the higher concentration of water outside the cell than in the cell. The cell then swells to become turgid. It is called de-plasmolysis.

9.6 EFFECTS OF TEMPRATURE ON PERMEABILITY OF PLASMA MEMBRANE

Object 1: Effect of temperature on the permeability of the plasma-membrane
Material Required: Beet root, cork borer, distilled water, knife and water bath
Working procedure
Small equal sized pieces of beet root tissue are cut with the help of a cork-borer and thoroughly washed with distilled water. Each of these pieces is placed in a separate test tube containing water at different temperature e.g., 0°C, 10°C, 20°C, 30°C, 40°C, 60°C, 70°C, and 80°C . The experiment is kept for an hour or so and colouration of the water is observed. After sometime it is observed that the water in those test tubes which were kept at lower temperature, room temp, or slightly higher temp remain colourless while the water in test tubes kept at higher temperatures (e.g. 60^0, 70^0 and 80^0 C) becomes red coloured. The low temperature water remains colourless and the intensity of red colour increases with the increase in temperature. The red colour is due to the diffusion of the anthocyanin pigments from the cell sap into the water. The higher temperature kills the cell due to which semi permeable nature of cell membrane is lost and the membrane becomes permeable.

Fig.9.7: Effect of temperature on the membrane permeability in beet roots

9.7 SUMMARY

Water has many fold importance in plant body. Before taking up intake of water by plant, it is necessary to understand osmosis, diffusion, imbibitions and plasmolysis.

1. Molecules and ions are in constant random motion and tend to distribute themselves evenly in the space available to them. They move from a region of higher concentration to a region of lower concentration by simple diffusion along a diffusion gradient; they may also move against a diffusion gradient. Evenly distributed molecules are in a state of equilibrium. Diffusion rates are affected by temperature, molecule size and density, and other factors.
2. Osmosis is the diffusion of water through a differentially permeable membrane. It takes place in response to concentration differences of dissolved substances.
3. Osmotic pressure or potential is the pressure required to prevent osmosis from taking place. The pressure that develops in a cell as a result of water entering it is called turgor. Water moves from a region of higher water potential (osmotic potential and pressure potential combined) to a region of lower water potential when osmosis is occurring. Osmosis is the primary means by which plants obtain water from their environment.
4. Plasmolysis is the shrinkage of the cytoplasm away from the cell wall as a result of osmosis taking place when the water potential inside the cell is greater than outside.
5. Imbibition is the attraction and adhesion of water molecules to the internal surfaces of materials; it results in swelling and is the initial step in the germination of seeds.
6. Active transport is the expenditure of energy by a cell that results in molecules or ions entering or leaving the cell against a diffusion gradient.

9.8 GLOSSARY

Absorb- To suck up

Absorption- The process of **absorbing** or taking up of water and assimilating substances into cells or across the tissues and organs through diffusion or osmosis,

De-plasmolysis- The entrance of water into a plasmolysed plant cell, causing the cell membrane to return to the cell wall.

Diffusion-The movement of molecules or ions of a solute or solvent, be it a solid , liquid or gas from the region of its higher concentration/partial pressure / chemical potential to that of its lower concentration/ partial pressure/chemical potential.

Endosmosis- Osmosis in which fluid flows through a membrane towards a region of higher concentration

Exosmosis- The passage of a fluid through a semi permeable membrane toward a solution of lower concentration, especially the passage of water through a cell membrane into the surrounding medium.

Hypertonic solution- In a hypertonic solution the total molar concentration of all dissolved solute particles is greater than that of another solution, or greater than the concentration in a cell.

Hypotonic solution- A hypotonic solution is any solution that has a lower osmotic pressure than another solution. In the biological fields, this generally refers to a solution that has less solute and more water than another solution

Imbibition- Phenomenon of adsorption of water or any other liquid by the solid particles of a substance without forming a solution.

Isotonic solution - An isotonic solution refers to two solutions having the same osmotic pressure across a semi permeable membrane. This state allows for the free movement of water across the membrane without changing the concentration of solutes on either side or active transport

Osmosis-Diffusion of water/ solvent molecules from a dilute solution to the concentrated solution when the two are separated by a semi permeable membrane.

Permeable- A material or membrane allowing liquids or gases to pass through it.

Plasmolysis- Contraction of the protoplast of a plant cell as a result of loss of water from the cell.

Selective permeable membrane-It is a type of biological or synthetic, polymeric membrane that will allow certain molecules or ions to pass through it by diffusion or occasionally by more specialized processes of facilitated diffusion, passive transport

Semi permeable: A material or membrane allowing certain substances to pass through it but not others, especially allowing the passage of a solvent but not of certain solutes.

Solution -The dispersion of a substance in molecular or ionic form throughout the medium of another is known as solution.

9.9 SELF-ASSESSMENT QUESTIONS

9.9.1 Multiple choice questions:

1- The water readily available to plants for absorption by roots is

(a) Gravitational water (b) Capillary water

(c) Rain Water (d) Hygroscopic water

2-The water potential of pure water at atmospheric pressure is

(a) -2.3 bar (b) +2.3 bar

(c) 0 bar (d) 1 bar

3-During rainy season wooden doors are difficult to open or closure because of

(a) Plasmolysis (b) Imbibition

(c) Osmosis (d) Diffusion

4- Plasmolysis occurs due to

(a) Absorption (b) Osmosis

(c) Endosmosis (d) Exosmosis

5-The marine animals that kept in fresh water burst. It shows the process of

(a) Exosmosis (b) Endosmosis

(c) Plasmolysis (d) De-plasmolysis

6-Osmosis is the diffusion of

(a) Water (b) Solute particles

(c) Gases (d) Energy

7-The outer solution having equal concentration as that of the cell sap is called
(a) Hypotonic solution (b) Isotonic solution
(c) Hypertonic solution (d) Neutral solution

8-The process of imbibition involve
(a) Diffusion (b) Capillary action
(c) Absorption (d) Both A & B

9-Diffusion of water through semi permeable membrane from dilute solution to concentrated solution is
(a) Imbibition (b) Osmosis
(c)Plasmolysis (d) Necrosis

10-Frog eggs placed in an isotonic solution will
(a) Burst (b) Shrink
(c) Remain the same (d) Increase in volume

11-When put in a hypotonic environment, an animal cell will
(a) Swell (b) Shrink
(c) Secrete enzymes (d) Remain unchanged

12-Which of the following conditions would cause red blood cells to burst?
(a) pH of 7.5. (b) Temperature of 3°C
(c) Being placed in distilled water (d) Being placed in an 11% salt solution

13-The cytoplasmic concentration of solute in a cell is 0.05%. This cell is placed in a solution that causes the cell to swell and burst. The solute concentration of this solution is
(a) 0.005% (b) 0.05%
(c) 0.5% (d) 5.0%

14-In an experiment, frog's eggs were placed in a salt solution. After several hours their mass increased significantly. We can therefore conclude that, compared to the frog's eggs, the solution was
(a) Isotonic (b) Saturated
(c) Hypotonic (d) Hypertonic

15-A cell would tend to gain water if it were moved from
(a) Isotonic solution to a hypotonic solution
(b) Isotonic solution to a hypertonic solution
(c) Hypotonic solution to an isotonic solution
(d) Hypotonic solution to a hypertonic solution

16-If the solute concentration of solution A is greater than solution B, then solution A is said to be

(a) Isotonic to solution B (b) Osmotic to solution
(c) Hypotonic to solution (d) Hypertonic to solution B

17-Which of the following moves material against a concentration gradient?
(a) Osmosis (b) Diffusion
(c) Active transport (d) Facilitated transport

9.9.2. Fill in the blank:

1- A cell increase in volume when it is placed in _____.
2-_____ will be zero in a fully turgid cell.
3- Endosmosis occurs when the plant cell is placed in _____.
4- Cell becomes turgid because of _____
5-The rate of diffusion across the cell membrane is affected by the _____
6-Pressure developed on cell wall of plant cell caused by osmotic movement of water is called as _____
7-The membrane which allows the movement of only water molecules to pass through it and not the solute particles _____
8-The membrane which allows passage of solvent as well as some selective solutes and prevents others is called _____

9.9.1 Answers Key: 1-(b), 2-(c), 3-(b), 4-(d), 5-(b), 6-(a), 7-(b), 8-(d), 9-(b), 10-(c), 11-(a), 12-(a), 13-(a), 14-(c), 15-(a), 16-(d), 17- (c)

9.9.2 Answers Key: 1- Hypotonic solution, 2- Suction pressure(DPD), 3- Hypotonic solution, 4- Endosmosis, 5- Temperature and size of molecule, 6- Turgor pressure, 7- Semi permeable membrane, 8- Selectively permeable membrane

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9.12 TERMINAL QUESTIONS

9.12.1. Very short answer type:

1-What is osmosis?
2-How is a living cell act as a osmometer?
3-Why is potato use for making osmometer?
4-What is Osmotic pressure?
5-What is meant by permeability?
6-Why a space is occupied between cell wall and protoplast of plasmolysed cell?
7- Why plasmolysed cell regain original shape when placed in water?

9.12.2 Short answer type:

1-Write about importance of osmosis in plant.
2-Calculate the osmotic potential (Ψ_s) of a 2.4 molar sucrose solution at 24^{o}C. Show your work.
3-Using water potential terminology, explain why: Strawberries become juicy when you add sugar to them.
4-Why don't Plant Cells undergo Plasmolysis?
5-What is the process of plasmolysis?
6-What is the relationship of plasmolysis and hypertonic?
7- Write about imbibition of raisins with suitable diagram.
8-Write notes on Diffusion Pressure Deficit (D.P.D.)
9-Explain term turgor pressure.
10-Explain about imbibition pressure with suitable example.

9.12.3 Differentiate in between following:

1- Plasmolysis and deplasmolysis
2-Endosmosis and exosmosis
3-Osmotic pressure and suction pressure
4-Osmosis and diffusion
5-Osmotic pressure and turgor pressure

9.12.4 Long answer type:

1. Explain various phenomenon found in plant (diffusion, Osmosis, plasmolysis and imbibition) and explain their relationship.
2. What are the governing factors regulating endosmosis and exosmosis?
3. Endosmosis and exosmosis do not take place in plant cell. Justify?
4. Discuss about plasmolysis? How can you make use of it in determining osmotic pressure of cell shape?
5. How is plasmolysis related to turgor pressure?
6. Explain plasmolysis. What are its advantages? How would you determine O.P. of cell sap by plasmolytic method. Discuss water relations of plant cell.
7. What do you understand by diffusion, osmosis and imbibition? How do these processes help plants to absorb water?
8. Explain why Grape fruits usually burst when they are kept in ordinary water?

9. You are provided with *Elodea* leaf epidermis and three test tubes having sugar solution of different concentration. How will you prove with solution is of highest and which one of lowest concentration?
10. Discuss the relation between various osmotic quantities in plant cell under normal and stress conditions.

UNIT-10 STUDY THE STRUCTURE AND FUNCTIONS OF STOMATA, STOMATAL FREQUENCY AND COMPARISON OF RATE OF TRANSPIRATION USING DIFFERENT METHODS OR BY USING DIFFERENT POTOMETERS

10.1 OBJECTIVES

After reading this unit students will be able to:

- Study the structure of stomata, their opening and closing, stomatal frequency
- Comparison of rate of transpiration under different climatic condition using four-leaf method
- Comparison of rate of transpiration under different climatic condition using cobalt chloride paper
- Comparison of rate of transpiration under different climatic condition using different types of potometers

10.2 INTRODUCTION

Transpiration is a process of evaporation of water from the surface of the plant. This keeps the plant cool and transfers minerals and other materials to different parts of the plant. As the plant takes water from the soil, the openings absorb other minerals. For a plant to take water from the soil, water needs to evaporate from the surface of the plant. Once this happens, pressure is developed that forces the roots to absorb water from the soil and transfer it to the tips of the plant. It is through the stomata that the major work of evaporation of water is done.

Stomata were discovered by Pfeffer and name 'stomata' was given by Malphigii. Stomata cover 1-2% of leaf area. Stomata are minute pores found on the epidermis of leaves and young shoots of plants that are used to control exchange of gases and transpiration. The pore is surrounded by a pair of specialised cells called the guard cells that are responsible in regulating the size of the opening. Each guard cell is a modified epidermal cell showing a prominent nucleus, cytoplasm and plastids. The wall of the guard cell is differentially thickened. The inner wall of each guard cell facing the stoma is concave and is thick and rigid (Fig.10.1 & 10.2). The outer wall is convex and is thin and elastic. The Size and shape of stoma and guard cell vary from plant to plant. When fully open, the stomatal pore measures 3-12 in width and 10-40 in length. In many gymnosperms and xerophytic plants (plants growing in desert), the stomata are present embedded deeply in the leaves, so that they are not exposed to sunlight directly. Such deeply embedded stomata are called sunken stomata. Water is released through the stomata into the atmosphere in the form of water vapour through the process called transpiration. Besides this, the exchange of oxygen and carbon dioxide in the leaf also occurs through the stomata. Algae, fungi and submerged plants do not possess stomata.

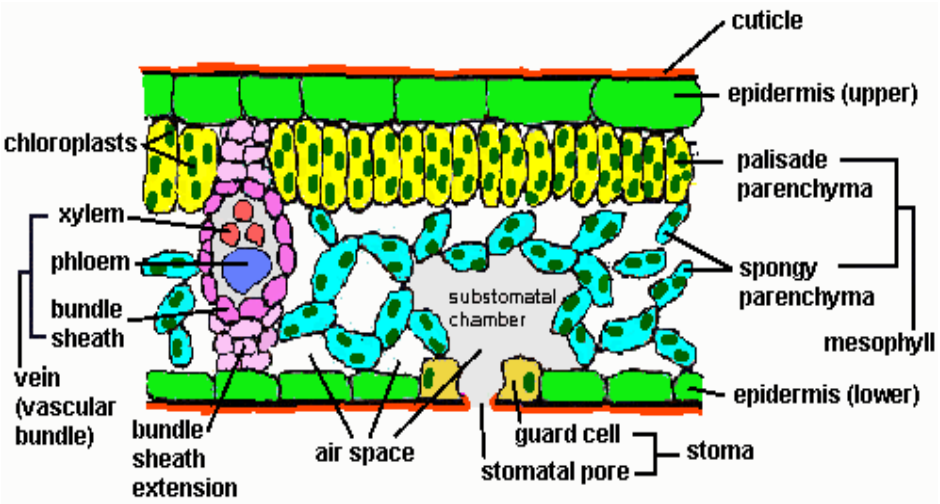

Fig.10.1: Vertical section of leaf blade showing passage of water vapour during transpiration

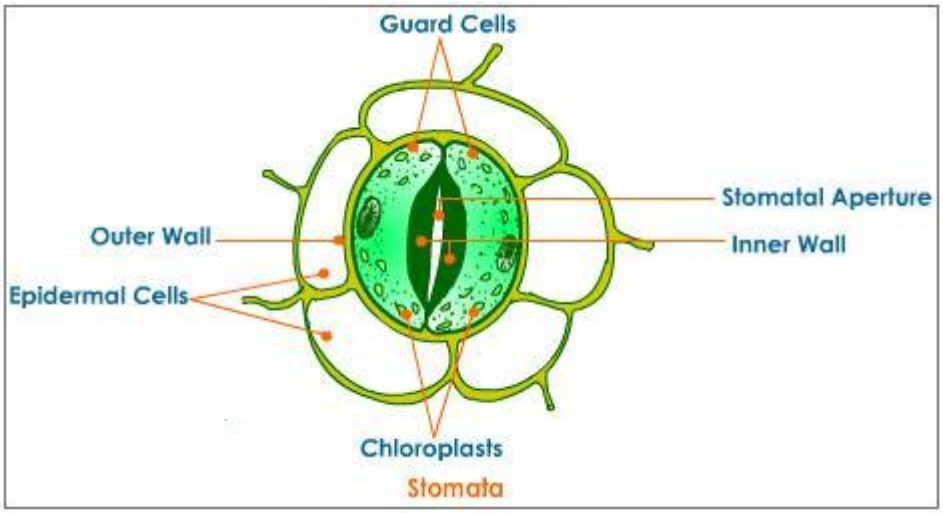

Fig.10.2: A magnified structure of stomata in lower epidermis of leaf

10.3 STUDY THE STRUCTURE OF STOMATA, THEIR OPENING AND CLOSING, STOMATAL FREQUENCY

Mechanism of Stomatal Opening and Closing

Opening and closing of stomata takes place due to changes in turgor of guard cells. Generally stomata are open during the day and close at night. The turgor changes in the guard cells are due to entry and exit of water into and out of the guard cells. During the day, water from subsidiary cells enters the guard cells making the guard cells fully turgid. As a result, the thin elastic convex outer walls are bulged out causing the thick and rigid concave inner walls to curve away from each other causing the stoma to open (Fig.10.3). During night time, water from guard cells enters the subsidiary cells and as a result, the guard cells become flaccid due to decrease in turgor pressure. This causes the inner concave walls to straighten up and the stoma closes.

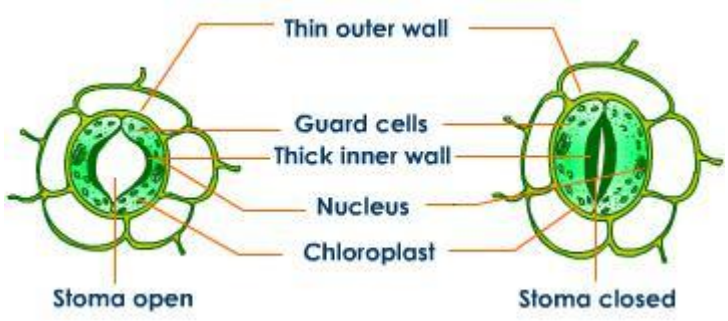

Fig.10.3: Stomatal Opening and Closing

Object-1: To study distribution of different type of stomata

Material required: : Fresh leaf of Petunia or any other herbaceous plant/fresh leaf of lily, forceps, needle, blades, watch glass, petridish, beaker, glass slide, cover slips, safranin, glycerine, water

Procedure:

1. Tear leaves with force keeping lower epidermis upwards.
2. A thin membranous lower epidermis gets separated near the broken edge. Pull this membranous part in to strip with help of finger or forceps.
3. Strip is stained with 1% aqueous solution of safranin, washed in water and then mounted in glycerine.

Observation: Distribution of stomata varies between monocots and dicots, between plant species, and between the underside and top side of the leaves on a plant. Stomata are found more on plant surfaces thriving under higher light, lower atmospheric carbon dioxide concentrations and in moist environments. Usually the lower surface of a dicot leaf has a greater number of stomata while in a monocot leaf they are more or less equal on both surfaces. In most of the floating plants, stomata are found only on the upper epidermis. Depending upon the distribution and arrangement of stomata in the leaves five categories of stomatal distribution have been recognized in plants.

(i) Apple or mulberry (hypostomatic) type: Stomata are found distributed only on the lower surface of leaves, e.g., apple, peach, mulberry, walnut, etc.

(ii) Potato type: Stomata are found distributed more on the lower surface and less on its upper surface, e.g., potato, cabbage, bean, tomato, pea, etc.

(iii) Oat (amphistomatic) type: Stomata are found distributed equally upon the two surfaces, e.g. maize, oats, grasses, etc.

(iv) Water lily (epistomatic) type: Stomata are found distributed only on the upper surface of leaf, e.g., water lily, Nymphaea and many aquatic plants.

(v) Potamogeton (astomatic) type: Stomata are altogether absent or if present they are vestigeal. e.g., Potamogeton and submerged aquatics.

On the basis of number and arrangement of subsidiary cell Metacalf and Chalk recognized following types of stomata (Fig.10.4)-

1- Anomocytic type: In these stomata, accessory cells are absent. The guard cells are surrounded by ordinary epidermal cells, e.g., families Ranunculaceae, Cucurbitaceae, Papaveraceae and Malvaceae.
2- Anisocytic type: In these stomata the guard cells are surrounded by three accessory cells. Of these two are larger whereas one is smaller in size e.g., family Brassicaceae.
3- Diacytic type: In these stomata the guard cells are surrounded by two accessory cells. Their common walls are at right angle to the walls of guard cells, families Caryophyllaceae, Acanthaceae.
4- Paracytic type: In these stomata the guard cells are also surrounded by two accessory cells, but their common walls are parallel to guard cells, e.g., families Rubiaceae, Fabaceae etc.
5- Actinocycytic type: These stoma surrounded by four or more subsidiary cell elongated radially to stomata. e.g., Araceae, Musaceae and Ebenaceae.
6- Cyclocytic: Stoma surrounded by four or more subsidiary cell arranged in narrow ring around the stomata. e.g., *Palmae, Pandanus* and *Cyclanthaceae*.

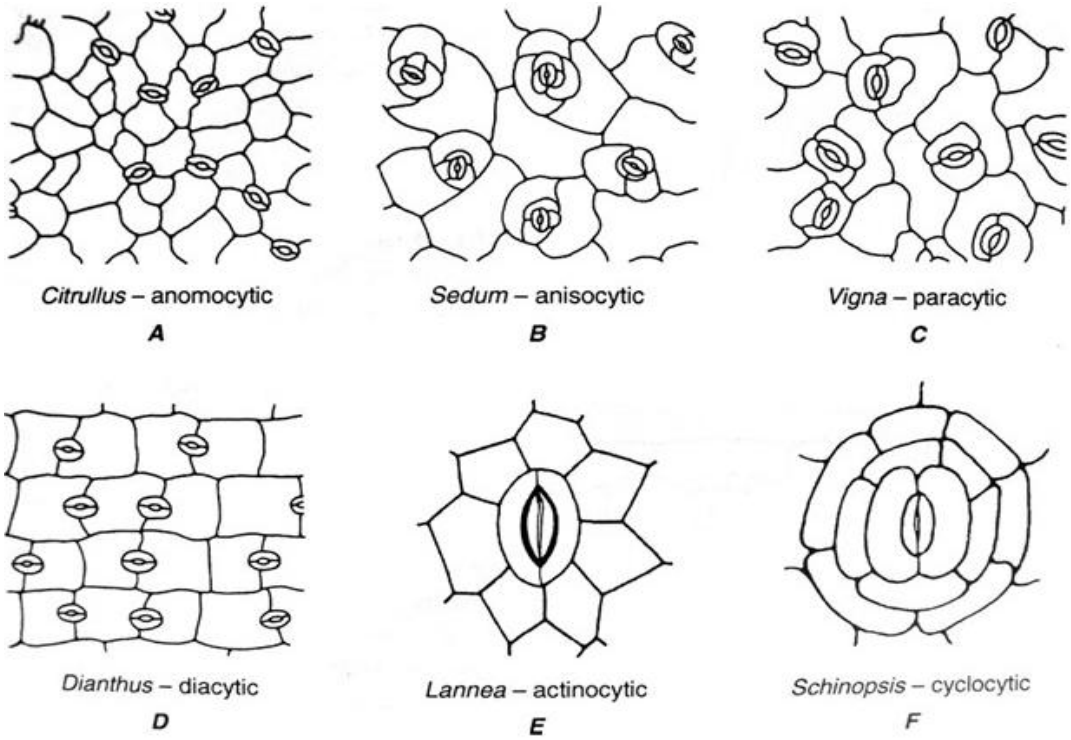

Fig.10.4: Types of stomata on the basis of their structure

On the basis of development (Pant, 1965), There are three types of stomata:
(i) Mesogynous type: In this type of stomata guard cells as well as subsidiary or Accessory cells both are developed from one mother cell. e. g. Rubiaceace &. Brassicaceae family.
(ii) Perigynous type: In this type guard cells are formed from mother cell while subsidiary cells from nearby mother cells, e.g. Cucurbitaceae family.
(iii) Mesoperigynous type: In this type guard cells and subsidiary cells are formed from mother cell while other subsidiary cells develop independently. e.g. Ranunculaceae, Caryophyllaceae family.

Number of Stomata (Stomatal Frequency)

The number of stomata in a definite area of leaf varies from plant to plant. Xerophytes possess larger number of stomata than mesophytes. Number of stomata/sq cm. is 1000-60,000 in different plant species. The number of stomata per unit area of leaf is called Stomatal Frequency. Stomata frequency of trees and shrubs is higher than herbs. Stomata nearly occupy one to two percent of total leaf area when fully open. In isobilateral leaves (in monocots) approximately the same numbers of stomata are found on upper surface (adaxial) and lower (abaxial) surface. But in dorsiventral leaves (in dicots) the number of stomata on the upper surface is much less in comparison to those found on the lower surface.

Calculation of Stomatal index

The distribution of stomata on the upper and lower surfaces of the leaf can be studied by removing the peels of the leaf from the upper and lower surfaces and observing the same under a microscope. The count of the number of stomata and epidermal cells in the microscopic field is taken and the stomatal index of each surface of the leaf can be calculated using the following formula:

$$\text{Stomatal index} = \frac{\text{Total no. of stomata perunit area}}{\text{No. of stomata per unit area + No. of epidermal cells per unit area}} \times 100$$

Object 2: Study the stomatal distribution on the upper and lower leaf surfaces and to calculate the stomatal index.

Material required: Fresh leaf of Petunia or any other herbaceous plant/fresh leaf of lily, forceps, needle, blades, watch glass, petridish, beaker, glass slide, cover slips, safranin, glycerine, water

Working Procedure

(i) Pluck one fresh leaf of a lily plant.
(ii) Take watch glasses and pour some distilled water into the watch glasses.
(iii) Split the leaf from the lily plant obliquely.
(iv) Take the peel from the upper and lower epidermis surface of the leaf using the forceps.
(v) Place the peel into a separate watch glasses containing water.
(vi) Place the peel into the other watch glass containing water.
(vii) Using a dropper, take few drops of safranin solution and put it into the watch glasses.
(viii) Take clean glass slides and place the leaf peel on the slides one by one, using a brush.
(ix) Take a blade and cut a small rectangle or square piece from each peel.
(x) Take some glycerine using a dropper and put one drop of glycerine on both slides.
(xi) Take a cover slip and place it gently on the peel with the help of a needle.
(xii) Take the glass slide and place it under compound microscope.
(xiii) The distribution of stomata on the upper and lower surfaces of the leaf can be studied by removing the peels of the leaf from the upper and lower surfaces and observing the same under a microscope.

Calculation of Stomatal Index

The count of the number of stomata and epidermal cells in the microscopic field is taken and the stomatal index of each surface of the leaf can be calculated using the following formula:

Determine Stomatal index by taking the following readings		
Number of observation	Number of stomata at upper surface	Number of stomata at lower surface
1	-	-
2	-	-
3	-	-

$$\text{Stomatal index} = \frac{\text{Total no. of stomata perunit area}}{\text{No. of stomata per unit area + No. of epidermal cells per unit area}} \times 100$$

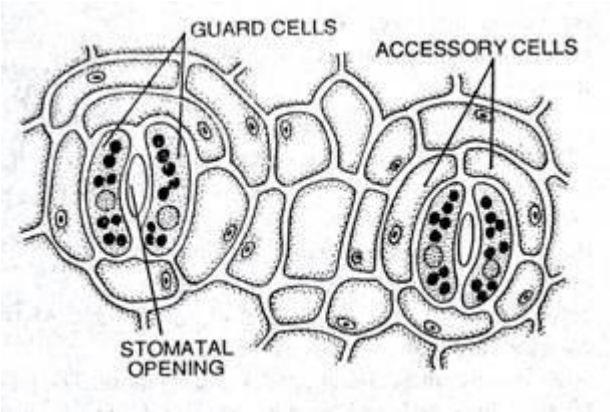

Fig.10.5 Stomata in epidermis layer (surface view)

Observe under the microscope

Count the number of stomata in the peels of both upper and lower epidermis of the leaf appearing in the microscopic field.

Precaution:

1. The curling of peel should be avoided.
2. Always use brush to transfer peel from watch glass to slides.
3. Excess of glycerine should be remove by blotting paper.

Object-3:- To measure the extent of stomatal opening by Darwin's potometer

Material required: A Darwin's potometer, a potted plant, beaker, water grease, stand with clamp and base stand are required for the experiment.

Working Procedure: Darwin's potometer is a useful apparatus for following the changes in stomatal apertures, i.e., degree of opening of stomata. It essentially consists of a vertical tube, one end of which is dipped in a beaker of water. The other end is fixed to a T-tube, into one arm of which is attached a rubber tubing provided with screw-cock. A small glass chamber (potometer cup) is attached with rubber tubing to the other arm (Fig.10.6). The cup

end of the T-tube is fixed air tight with the lower surface of leaf (stomata restricted only on the lower epidermis) using grease and base stand. Water is sucked up to a certain fixed level order to adjust the required level of water in the vertical tube and the screw-cock is closed and all connections made air tight. The air is sucked off through this end in order to adjust the required level of water. The whole apparatus is kept for some known time in light and in dark. The fall in the level of water is recorded under both conditions. The level of mercury falls faster in light condition. The rate of fall indicates the extent of opening of stomata which is more in light than dark.

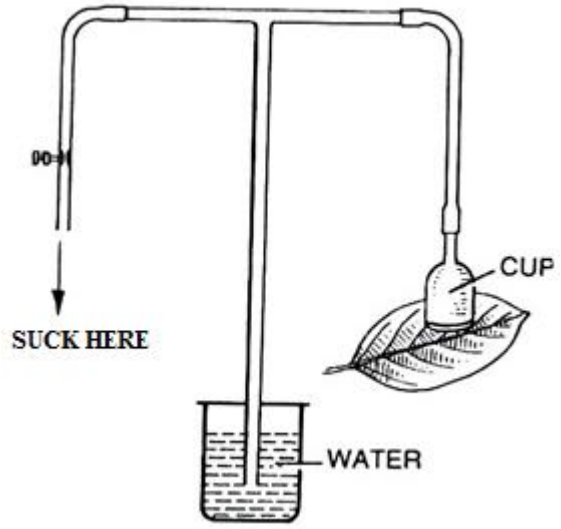

Fig.10.6: Darwin's potometer measuring the extent of stomatal opening

Observation: The rate of fall of water in the vertical tube observed provides a measure of the rate with which air passes out under suction through the stomatal openings of the leaf. If the cup is affixed to upper surface of such a leaf where there may not be any stomata, the water level in the vertical tube is maintained, but no fall in level is observed.

This certainly demonstrates that air cannot pass through the cuticle. The rate of fall of the water level and hence that of passage air is thus roughly indicative of the size of stomatal openings. If the rate of fall diminishes or becomes extremely slow, it evidently indicates that the stomata are closed or about to close.

10.4 COMPARE THE STOMATAL AND CUTICULAR TRANSPIRATION OF LEAF BY COBALT CHLORIDE PAPER

Introduction: Transpiration is the loss of water from a plant in the form of water vapour. Water is absorbed by roots from the soil and transported as a liquid to the leaves via xylem. In the leaves, small pores known as stomata allow water to escape as a vapour. Of all the water absorbed by plants, less than 5% remains in the plant for growth. The number of stomata present in two surface of leaves differ in most of the plant. In mesophylic plant more stomata are present in lower surface of leaves than upper surface of leaves. Therefore, more transpiration occurs by lower surface in comparison to upper surface of leaves.

The cobalt chloride paper is prepared by dipping and drying filter paper in 5 percent

solution of cobalt chloride, which is blue when dry and turns pink when moist. Two equal small dry pieces of cobalt chloride paper ($1cm^2$) are placed on either side of dorsiventral leaf, opposite to one another, covered with the help of two glass slides and clipped and greased are tight. The time required for the colour change from blue to pink is recorded for both the pieces separately.

Object-1:- To compare the Stomatal and Cuticular transpiration of leaf by cobalt chloride paper.

Material Required: A potted plant of dorsiventral leaf of *Tropoelum, Dolichos, Helianthus, or Tecoma* etc., cobalt chloride paper, Glass slides, Grease, Clips and stopwatch are required for the purpose of experiment.

Working Procedure: Soak filter paper in 5% solution of cobalt chloride and hang it up to dry. When dry, quickly cut into strips about 2.5 cm x 1.25 cm and dry these strips again thoroughly in an oven at a low temperature. The original colour of the wet paper is pale pink, but when dried to a standard uniform shade, the colour becomes an intense blue. The uniform-sized dry strips are stored in desiccators. The treated blue dry paper is thus a moisture detector, turning pink when left in the air (the air containing moisture) or when placed in contact or near an evaporating surface. The time taken for a blue colour to disappear and attain a standard pink colour (determined by a stop watch) is a measure of the amount of evaporation as also the rates of water loss from the surface of the leaf to which it is attached. The following tests can be conveniently performed with these dry cobalt chloride paper strips:

(a) Select a suitable leaf attached to a potted plant. Lay a piece of strip on each surface of a leaf and immediately press them gently down between two slides, held one above another with the help of clips (Fig.10.7). Compare the respective rates of water loss from both upper and lower surfaces of a leaf and also from young and old leaves.

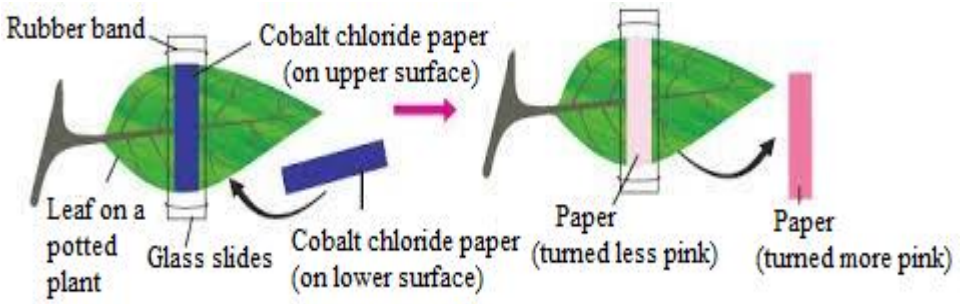

Fig.10.7: Demonstration of stomatal and cuticular transpiration

(b) Compare the respective rates of one leaf kept in darkness for some hours (stomata closed) and the other kept in the open.

(c) Compare the respective rates of water loss from a leaf and also from an open water-evaporating surface (physical evaporation). For open evaporating surface a petri-dish containing water can be taken and the blue paper-strip is held by suitable arrangement as close to the water surface as possible, without actually touching it.

The time in seconds for a standard colour change of cobalt chloride paper over a free water-evaporating surface (s) divided by the time for the same colour change on the leaf (E) is a measure of what is sometimes defined as transpiration index- It is convenient to multiply this index by 100 to obtain the water loss from the leaf surface as a percentage of the evaporation from a free water surface.

Transpiration index= S / E X 100

Observations: It's is observed that the paper piece on the lower side of leaf takes lesser time In changing from standard blue to standard pink as compared to the piece placed On the upper side of leaf. It is because of the faster rate of transpiration from the lower surface of leaf as compared to the upper side of the leaf where due to absence of stomata cuticular transpiration is the only source of moisture.

Precautions:

1. Always take well watered potted plant for experiment.
2. Always handle dry cobalt chloride paper with dry hands or forceps.
3. Leaf surface should not be wet when putting cobalt chloride disc.

10.5 COMPARE THE STOMATAL AND CUTICULAR TRANSPIRATION OF LEAF BY USING FOUR LEAVES METHODS

Introduction: In principle stomatal transpiration takes place through the lower surface of the leaf than transpiration through upper surface of leaf is said to be of the cuticular type in dorsiventral leaves. Thus, if one wants to determine the relative efficiency of transpiration rate by the two surfaces, then two separate experimental sets have to be prepared using the same type of leaves. In one experimental set, the upper surface of the leaf is smeared with grease so that transpiration occurs only through the lower surface (i.e. predominantly stomatal type).

In the other set the lower surface of the leaf is smeared with grease so that transpiration occurs only through the upper surface of the leaf (i.e. predominantly cuticular type). The rate of transpiration per unit time per sq cm of leaf area is calculated separately and then compared. The experimental procedure is identical with conical flask water-oil-leaf method.

Object-1: To compare the stomatal and cuticular transpiration of leaf by using Four leaves methods

Material Required: Four leaves, two stands, Vaseline and a string

Working Procedure: To demonstrate the transpiration from the leaf surface, four banyan leaves are taken. Both the surfaces of the A leaf, lower surface (with stomata) of B leaf, upper

surface (without stomata) of C leaf are vaselined. The Vaseline is not applied on the D leaf which is used as control. Now, as shown in the figure 8 the leaves are hanged so that they may transpire freely.

Observation and Explanation

When the observations are taken after a day or two, they are as follows - the A leaf, which is vaselined on its both the surfaces, looks fresh and green, as no surface transpires. The B leaf is vaselined on its lower surface (with stomata), and transpiration takes place only from the upper surface which is negligible. This leaf also remains turgid and green like the A leaf. If few stomata are present on the upper surface of the leaf, then it shrivels to some extent. The C leaf is vaselined on its upper surface, which contains less number of stomata or no stomata. The transpiration takes place from the lower stomatal surface, and the leaf shrivels to a large extent. The D leaf is not vaselined and both the surfaces transpire freely releasing much water. The leaf wilts completely in this case. This experiment proves that the rate of stomatal transpiration is faster than the cuticular transpiration.

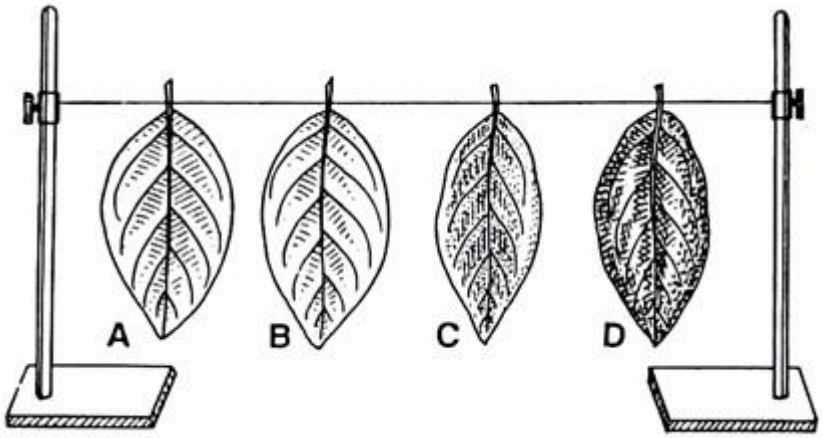

Fig.10.8 Comparison of transpiration of leaf by using Four leaves methods

10.6 TO DEMONSTRATE OF RATE OF TRANSPIRATION BY USING DIFFERENT TYPES OF POTOMETERS

Introduction: The rate of transpiration in a plant varies depending on a range of conditions, including light intensity, relative humidity, wind speeds and temperature, as well as between plant species. In this practical, students have understood the rate of water uptake by a shoot, due to transpiration, using a simple but effective potometer.

The rate of transpiration (expressed in gm per hour per square centimeter of the leaf surface) can be measured with the help of an apparatus known as potometer. Determination of the rate of transpiration by different potometers, excepting Garreau's, is an indirect one where both absorption and transpiration have been taken into consideration.

A potometer is a device used for measuring the rate at which a plant draws up water. Since the plant draws up water as it loses by transpiration, you are able to measure the rate of

transpiration. Potometers are notoriously difficult to set up, because air bubbles in the xylem of the plant or in the apparatus itself will prevent the device from working properly. The basic elements of a potometer are:

(i) A plant cutting
(ii) A calibrated pipette to measure water loss
(iii) A length of clear plastic tubing
(iv) An air-tight seal between the plant and the water-filled tubing

Overview of experiment

1. Assemble potometers
2. Place each potometer at different environment condition
3. Measure water loss in every potometer for every three minutes
4. Calculate leaf surface area for each cutting

The basic design of a potometer

Potometers are designed on the principle that the rate of transpiration is nearly proportional to the rate of absorption of water by the plant. Vaseline is applied around the rubber bungs to ensure an airtight seal, thus the only water loss from the apparatus is via transpiration. The function of the reservoir is to allow the air bubble to travel back to the start of the measuring scale. As water moves up through the plant the air bubble moves along the scale giving a measure of water absorbed by the plant over time and hence the transpiration rate. The potometers described below are generally used in laboratory experiments. It consists of:

a) **A length of capillary tube**: A bubble is introduced to the capillary. As water is taken up by the plant, the bubble moves. The distance the bubble travels in a given time is determined by the rate of transpiration by the plant.
b) **A reservoir**: By turning the tap on the reservoir, the position of the bubble can be set at the start of the experiment. Some designs of potometer use a syringe instead of a funnel with a tap.
c) **A tube for holding the shoot**: In the diagram the shoot is held in place by inserting a rubber bung in the tube. The hole in the bung through which the shoot passes must be thoroughly greased with petroleum jelly to keep it airtight.

Setting up

1- Cut a leafy shoot from a plant (e.g. Pelargonium) and plunge its base into water (try not to get any water on the leaves). This prevents the xylem from taking up any air.

2- Back in the laboratory, put the stem into a large sink full of water and carefully trim the shoot again, by cutting off the bottom under water with a sharp razor blade. Keep the leaves out of the water.

3- Immerse the whole of the potometer into the sink. Move it about until all the air bubbles come out.

4- Put the shoot stem into the bung, grease the joint with plenty of petroleum jelly, then put the bung into the potometer.

5-Make sure the tap is closed, and then lift the whole ensemble out of the water.

6- Leave the end of the capillary tube out of the water until an air bubble forms then put the end into a beaker of water.

Using a potometer

Allow the bubble time to round the corner and start at the beginning of the mm scale. Then time how far the bubble moves in a given period of time. Repeat under different conditions and compare. The usual conditions to try are placing the plant in a bright light, placing it by a fan, and placing it in a humid atmosphere. If the surface areas (both sides) of the leaves are measured then it is possible to compare the transpiration rates of different species of plant. A useful comparison unit could be water loss (ml)/ cm^3/minute.

Limitations of a potometer

1-Introducing the air bubble is not easy.
2- The twig may not fully remain alive for a long time.
3- Any changes in the outside air temperature may affect the position of the air bubble in the capillary tube.

Object 1- To measure the rate of transpiration by using Darwin's potometer

Material required: Darwin's potometer, a plant twig cut end dipped in water, a beaker, water grease or wax and stopwatch are required for the experiment.

Working Procedure: This apparatus consists of a short glass tube from which a side tube bends upward ending in an open mouth (manometer tube) into which a plant twig is inserted through a cork. The upper open mouth of the main tube is closed by a cork. The lower end of the tube is also fitted with a cork through which passes a long graduated (in ml) capillary tube. The end of the capillary tube dips in a beaker containing water.

At the beginning of the experiment, water is filled up in all the tubes maintaining continuity. A twig (cut under water) having some leaves are inserted through the cork of the side tube. All joints should be air-tight. A small bubble is introduced through the lower end of the capillary tube. As the transpiration occurs from leaves of the twig, water is absorbed by the twig from the side tube and this produces a suction force which sucks up water from the capillary tube. As a result, air bubble within the capillary tube gradually moves upward.

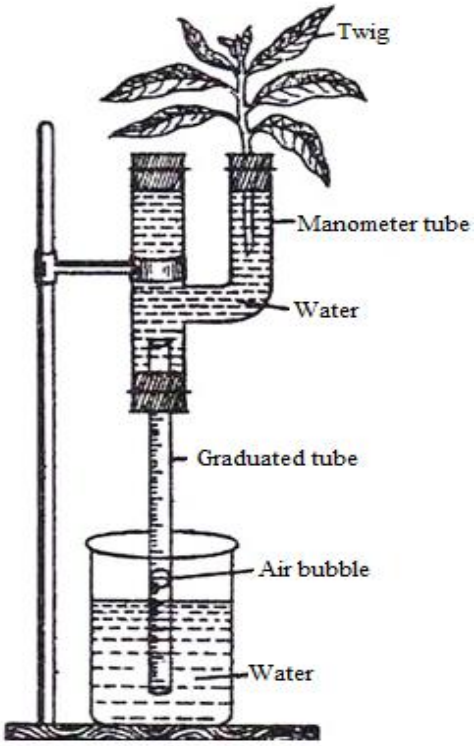

Fig.10.9: Darwin Potometer

Results: The rate of upward movement of air bubble is recorded by noting the height by which it ascends in a given time interval. The rate of transpiration is expressed as the ml of water transpired per minute per unit area of the leaves.

Object-2: **To measure the rate of transpiration by using Ganong's potometer**

Material required: Ganong's potometer, a plant twig cut end dipped in water, a beaker, water grease or wax and stopwatch are required for the experiment.

Working Procedure: The apparatus is filled with water using the reservoir and with the help of cork a cut stem twig immersed in the water is fixed in the side arm. The apparatus is made air tight and air bubble is introduced in the graduated arm. At this time movement of the air bubble should be towards the plant twig. The record is taken of the distance travelled by vacuole in a definite interval of time. The observation are repeated and the average relation of time to distance travelled is calculated. The total area of the leaf is measured with the help of graphic sketches and is multiplied by two due to two leaf surfaces. By using simple mathematical calculation the rate of transpiration is calculated in terms of ml/hour/unit area.

The volume of water can be calculated by formula $V=\pi r^2 l$ (V=volume; π= 22/7 ; r= radius of graduated tube and l= length or distance travelled by bubble.)

This experiment as well as any other similar experiment is based on the principle *that the amount of water absorbed is almost equal to that of water transpired and the difference between two is negligible".*

Modification: - The effect of different factors such as temperature, wind velocity, humidity, light, anaesthetics etc. on the rate of transpiration can be measured by using Ganong's Potometer.

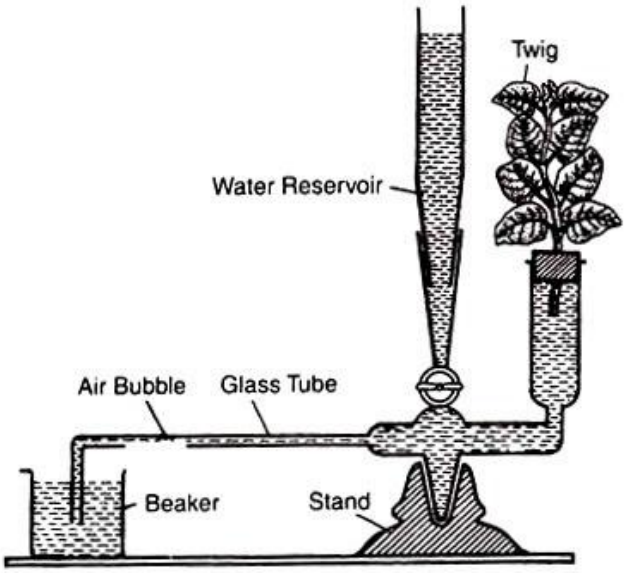

Fig.10.10: Demonstration of Ganong's photometer

Object-3- To measure the rate of transpiration by using Farmer's photometer

Description: The apparatus consists of a wide-mouthed bottle fitted with a rubber stopper having three holes. The bottle is filled with water up to the neck. In one hole a leafy twig (cut under water) is introduced in such a way that its lower cut end remains well under water. In the second hole, a water reservoir having a stopcock in its connecting tube is fitted so as to control the supply of water into the bottle. In the third hole, a narrow bent tube is fitted so that its lower end is well below the water surface of the bottle. The bent part of this tube is horizontal in position and either graduated or fitted with a centimetre scale. The outer end of the horizontal tube is again bent downward and immersed in water.

Working Procedure: At the beginning, the bottle is filled with water by opening the stopcock of the reservoir up to the mouth and also in the horizontal tube. The stopcock is then closed. An air bubble is now introduced into the outer bent end of the horizontal tube in the usual manner. As transpiration occurs from the leaves of twigs, water is absorbed from the lower cut end of the twig and a suction force is produced which sucks water from the horizontal tube. As a result air bubble moves inward. The rate of movement of air bubble is noted, which is considered proportional to the transpiration rate.

Object-4- To measure the rate of transpiration by using Garreau's potometer

Working Procedure: This potometer is conveniently used for quantitative measurement of differential rates of transpiration from both upper and lower surfaces of a leaf. It consists of two wide-mouthed cups which are placed face to face keeping a widely expanded dorsiventral leaf; of a twig from a potted plant in between them.

Before keeping the leaf in between; the cups, some anhydrous $CaCl_2$ contained in two small vials are weighed and placed in both the cups. The ends of the cups are closed with corks through which two mercury manometers are connected in order to keep the vapour pressure within the cups constant. The broad rims of the cups in contact with leaf surface are made Potted air-tight by applying Vaseline carefully. A change in vapour pressure within the cups shown by the manometers is indicative of the fact that either the connections are not air-tight or that all the vapour given out by the leaf surface is not being absorbed by the $CaCl_2$ within the vials. The whole arrangement is clamped vertically on a stand.

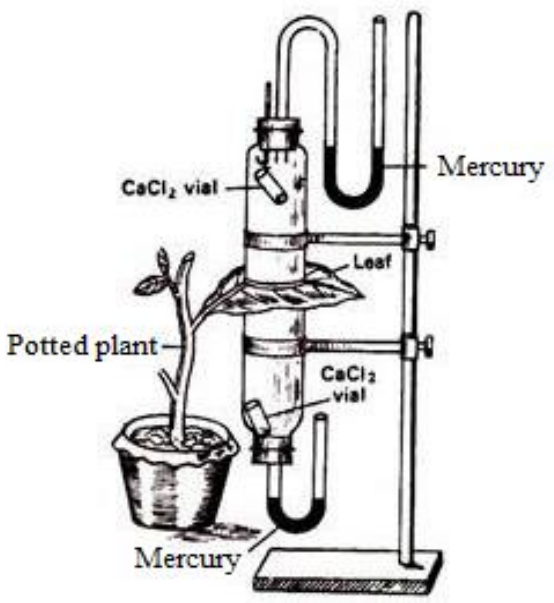

Fig.10.11 Demonstration of Garreau's potometer

Results: After a few hours, $CaCl_2$ vials are taken out and weighed again. The difference between the two weighing is a measure of the amount of water loss from the two leaf surfaces. As the areas are the same, this is also a quantitative measure of the differential rates of transpiration. By Garreau's potometer method, not only the rate of transpiration but a comparative assessment of the rate of transpiration of upper and lower surfaces of a leaf, i.e., cuticular and stomatal transpiration respectively, can be simultaneously determined. This is a very convenient and accurate method for direct and quantitative measurement of the rate of transpiration in contrast to other potometer methods.

10.4 SUMMARY

Transpiration is loss of water from plant in the form of vapour. It is a very important process keeping in view that it directly influences the water status of the plant. It also provides the prime force to pull water up in the plant body. Plants ought to have strict control over the rate of transpiration; otherwise they might land themselves in a fatal situation. Plants regulate the opening and closing of stomata temporally and according to various influencing factors at various climatic condition by controlling the water potential using various type of potometer and resulting turgor pressure in guard cells

10.5 GLOSSARY

Abscisic acid (ABA)- Plant hormone which causes stomatal closure.
Absorb- To suck up
Absorption- The process of **absorbing** or taking up of water and assimilating substances into cells or across the tissues and organs through diffusion or osmosis.
Boundary layer- A thin layer of still air above the leaf surface.
CAM Plants- Plants that take carbon dioxide during night, store it as 4 carbon compound which is decarboxylated during day and the released carbon dioxide is used for photosynthesis.
Capillary tube-Glass tubing which is very narrow inside.
Climate- the weather conditions prevailing in an area in general or over a long period.
Cuticle- In plants, the cuticle is the waxy covering on the surface of many of plant organs, e.g. leaves and young shoots. In plants, this waxy, hydrophobic covering protects the plant by minimizing water loss and curbing pathogen entry.
Cytoplasm-The cytoplasm is the material within a living cell, excluding the cell nucleus. It comprises cytosol (the gel-like substance enclosed within the cell membrane) and the organelles–the cell's internal sub-structures.
Epidermis- One or more layers of cells forming the outermost portion of the skin or integument.
Evaporation-The process in which a liquid changes state and turns into a gas.
Leaf dorsiventral- These leaves grow horizontally, so that the majority of stomata are found on the lower half so that transpiration does not increase during the day.
Lenticels-Pores on woody stems and roots for gaseous exchange.
Osmotic solutes- Osmotically active solutes in guard cells e.g. sucrose, malate.
Phloem-The vessels in plants that transport sugars.
Potometer- A potometer is a device used for measuring the rate of water uptake of a leafy plant shoot.
Relative humidity: The ratio of actual vapor pressure to saturation vapor pressure. Expressed as percentage (%).
Secondary transport: Active transport driven by the energy of proton gradient.
Solution -The dispersion of a substance in molecular or ionic form throughout the medium of another is known as solution.
Stomata frequency- Stomatal frequency can be defined as the number of stomata present per unit area of a leaf.
Stomata- Pores in the epidermis of leaves- usually on the undersides of leaves through which gaseous exchange and transpiration takes place. Singular is stoma.
Stomatal index- It is a function of both the number of stomata plus the size of the epidermal cells.
Transpiration index- Transpiration index is calculated by the relative efficiency of the rate of transpiration with that of physical evaporation.
Transpiration-The loss of water from leaves and stems of plant by evaporation. It is much faster when stomata are open than when they are closed.

Turgor pressure (hydrostatic pressure)- Turgor pressure is the force within the cell that pushes the plasma membrane against the cell wall. It is also called hydrostatic pressure, and more intricately defined as the pressure measured by a fluid, measured at a certain point within itself when at equilibrium.
Vascular bundles- Groups of xylem and phloem tissue in a plant.
Water potential- The free energy associated with water per unit volume.
Xylem vessels-Narrow, hollow, dead tubes with lignin responsible for the transport of water and minerals in plants.
Zeaxanthin- A carotenoid that acts as a blue light receptor.

10.6 SELF- ASSESSMENT QUESTIONS

10.6.1 Multiple choice questions:

1. The water readily available for plant by absorption of root
(a) A Gravitational water (b) Hygroscopic water
(c) Rainy water (d) Capillary water

2. Loss of water from stomata of leaves
(a) Guttation (b) Exudation
(c) Transpiration (d) Evaporation

3. Transpiration is very essential for plants as it
(a) Cools (b) Exchange gases
(c) Removes water (d) Uptake water

4. Rate of transpiration is increased with increase in
(a) Light (b) Temperature
(c) Wind (d) All of Above

5. Water transpiration is done 90% by process of
(a) Cuticular transpiration (b) Lenticular transpiration
(c) Stomatal transpiration (d) Sweating

6. Transpiration that occurs from vital organ lenticels present on stem is termed as
(a) Cuticular transpiration (b) Stomatal transpiration
(c) Lenticular transpiration (d) Translocation

7. In transpiration, water leaves cell of plants in form of
(a) Ice (b) Water droplets
(c) Sugars (d) Dew

8. Layer that restricts evaporation in humans
(a) Hair (b) Epidermis
(c) Cuticle (d) Guard cell

9. Layer that restricts evaporation in plants

(a) Hair (b) Epidermis

(c)Cuticle (d)Guard cell

10.6.2 State true or false:

1. Low humidity in the atmosphere results in a decrease in the rate of transpiration.
2. Transpiration takes place only in the green plants.
3. The wall of a guard cell towards the stoma is thin.
4. Leaves are reduced to spines in xerophytic plants.
5. The loss of water droplets is called bleeding.
6. The pH of the guard cells increase during day time.
7. The escape of plant-sap from the cut surface is called guttation.

10.6.3 Name the following-

1-The respiratory openings found on stems of woody plants.
2-An apparatus to compare the rate of transpiration in cut shoots.
3- The process by which intact plants lose water in the form of droplets.
4- Opening on the stem through which transpiration occurs.
5- Opening found on the under surface of dorsiventral leaves.
6- The paper which is used to show loss of water through stoma of a leaf.
7- An instrument used for measuring the rate of transpiration.
8- The structure through which most of the transpiration takes place.
9- The process of loss of water in the form of droplets.
10- The structure through which guttation takes place.
11- The kidney-shaped cells present on stomata.
12- The plant having sunken stomata.
13- The chemical used to prevent excessive transpiration in plants.

10.6.4 Fill in the blanks:

1-Plants regulate opening of stomata by changing the _____ in the guard cells.
2- _____, _____ and _____ are the three sites of transpiration.
3- The air space present beneath stomata is called _____.
4- When relative humidity is high, transpiration rates are _____.
5- Excessive loss of water from plants under dry conditions can lead to _____.
6- Opening of stomata is stimulated by _____.
7- _____ present above epidermis prevents water loss.

10.6.1 Answer Key: 1. **(**d), 2. (d), 3.(a), 4.(d), 5.(c), 6. (c), 7.(b), 8.(b), 9.(c)

10.6.2 Answer Key: 1-F, 2-T, 3-F, 4-T, 5-F, 6-T, 7-F

10.6.3 Answer Key: 1-Lenticles, 2- Potometer, 3- Guttation, 4-Lenticles, 5-Stomata, 6-Cobalt Chloride paper, 7-Potometer, 8-Stomata, 9-Guttation, 10-Hydathode, 11-Guards cells, 12-Nerium, 13- Silicon emulsions / Phenyl mercuric acetate

10.6.4 Answer key: 1- Turgor pressure, 2- Stomata, Cuticle and lenticels, 3-Substomatal cavity, 4- Low, 5- Wilting, 6-Blue light, 7-Cuticle

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10.9 TERMINAL QUESTIONS

10.9.1 Write Very Short answer type:

1- Guttation.
2- Significance of transpiration
3- Porton transport concept
4- Antitranspirants
5- Transpiration as a necessary evil

10.9.2 Write Short answer type

1- Write about effect of intensity of light on rate of transpiration.
2- Write about effect of humidity of the atmosphere on rate of transpiration.
3-Write about effect of temperature on rate of transpiration
4- Explain about any three conditions which affect transpiration.
5- Write a note on unique structural features of guard cells
6- Transpiration is less during rainy season. Comments.
7- Write about on significance of transpiration
8- Differentiate in between the following
   (a) Transpiration and guttation
   (b) Evaporation and transpiration
   (c) Lenticels and stomata in old plants

10.9.3 Essay type

1- Describe the structure of stomata and its significance.
2- What physical forces drive transpiration?
3- Explain the structure, function, their different positions and working of stomata. Discuss its role in different physiological processes.
4- Give a brief account of mechanism of stomata movement.
5- Write an essay on transpiration and its advantages to the plant.
6- Discuss the mechanism of transpiration in plant and state the factors affecting it? Point out the beneficial and harmful effects of the process.
7- Write an essay on "the Stomata and their role in transpiration.
8- Write explanatory note on stomata regulation of transpiration?
9- Explain the role of light and CO_2 in the mechanism of opening and closing of stomata?
10- Explain how humidity, temperature and light affect transpiration?
11- Describe the mechanism of opening and closing of stomata?
12- What are the different ways of loss of water from plants? Explain the factors affecting transpiration?
13- Write an account of various theories which explain mechanism of opening and closing of stomata?
14-What devices have plants evolved to control the rate of transpiration to prevent excessive water loss.
15-Highest transpiration rates are observed when there is low humidity combined with bright sunlight and moderate winds.

UNIT-11 STUDY THE EFFECT OF INTENSITY AND QUALITY OF LIGHT ON THE RATE OF PHOTOSYNTHESIS BY WILMOT'S BUBBLER AND STUDY R.Q. BY GANONG'S RESPIROMETER IN DIFFERENT SEEDS

11.1 OBJECTIVES

After reading this unit students will be able-

- To Study the effect of intensity and quality of light on the rate of photosynthesis by Wilmot's bubbler
- To Study R.Q. by Ganong's respirometer in different seeds

11.2 INTRODUCTION

Plants need light energy to make the chemical energy needed to produce carbohydrates. Increasing the light intensity will boost the rate of photosynthesis. However, at high light intensities the rate becomes constant. Measuring the rate of oxygen evolution using a water plant is commonly used to measure the rate of photosynthesis. Oxygen is a gaseous product, so can be measured by noting volume changes of the number of bubbles evolved.

As the light intensity increases, the rate of photosynthesis increases. However, the rate will not increase beyond a certain level of light intensity. At high light intensities the rate becomes constant, even with further increases in light intensity; there are no increases in the rate. The plant is unable to harvest the light at these high intensities and the chlorophyll system can be damaged by very intense light levels.

11.3 STUDY THE EFFECT OF QUALITY AND INTENSITY OF LIGHT ON RATE OF PHOTOSYNTHESIS BY WILMOT'S BUBBLER

Object-1: To study the method to use Wilmot's bubbler

Material required: Wilmot's bubbler, water, Hydrilla (fresh plant), Vaseline, cellophane papers of red, blue and green colours, burner, thermometer, ruler, stop watch, Mercury/projector lamp e.g. 60 W.

Working Procedure: Wilmot's bubbler can easily be prepared in the laboratory. It consists of a wide mouthed bottle fitted with a cork through which is inserted a wide glass tube. The lower end of this tube is fitted with a cork with hole through which a twig of *Hydrilla* plant is tied up; its other end terminates in a narrow bent nozzle. The upper half of this tube is surrounded by another glass tube which acts as water reservoir at 25°C. This helps to maintain a constant temperature around the plant. Whole of the apparatus is filled with pond water. Care will take so that the level of water in the reservoir remains above the bent nozzle (Fig. 1). The apparatus will place in sun light/ source light lamp at distance from the plant for definite intervals and count the bubbles coming out. Count the number of oxygen bubbles given off by the plant in 1 minute period. This is the rate of photosynthesis at that particular light intensity. Repeat at different light intensities by moving the lamp to different

distances. When the rate of air bubbles is regular and adequate (>10 bubbles/minute), place the capillary tube/test tube over the cut end of *Hydrilla* twig and then count the number of bubbles. This should be done for 5 minutes. Repeat twice and obtain an average of the results. Record results in a table, then plot a graph of volume of oxygen/minute or number of bubble/minute against the distance between the lamp and the plant. For comparing the effects of different wavelengths of light the bubbler is wrapped in cellophane papers of different colours. Effect of different intensities of light can be compared by placing the bubbler under shade, less intense and more intense light. The intensity of the light can be measured by a lux meter.

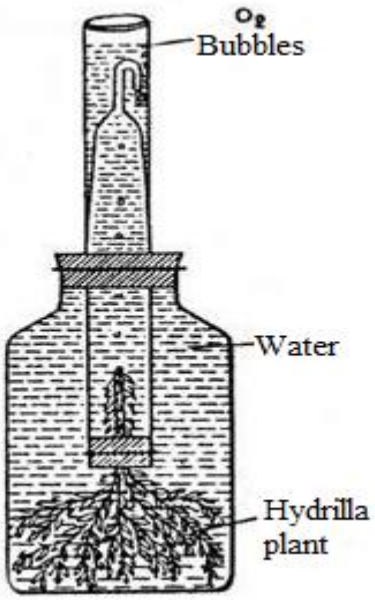

Fig.11.1: Demonstration of Wilmott's bubbler

Observation: The readings show that the rate of photosynthesis is more in sun light. Light energy absorbed by chlorophyll is converted to ATP and H^+. At very low light levels the plant will be respiring only not photosynthesising. As light intensity increases (distance between lamp and plant decreases) the volume of oxygen (or the rate of bubble production) increases. This indicates that the rate of photosynthesis increases with light intensity. However, at sufficiently high levels of light intensity, the rate oxygen evolution remains constant. Light intensity is inversely proportional to the square of the distance, so as the distance is increased the light intensity decreases.

11.4 STUDY R.Q. BY GANONG'S RESPIROMETER IN DIFFERENT SEEDS

Introduction: Plant respiration is the chemical reaction by which plants cells stay alive."*The process of respiration is expressed as:*

Glucose + Oxygen → Carbon Dioxide + Water (+ Energy)

The rate of respiration can be measured with the help of Ganong's respirometer. It consists of a bulb like part and a bent tube. Some germinating seeds are taken in the bulb and mouth of the bent tube is kept immersed in a beaker containing caustic potash (KOH) solution. The respiroscope is fixed in a stand. Thus, the enclosed air in the flask is completely cut off from the outside atmosphere. The apparatus is left undisturbed for a few hours.

This is another aspect of respiration. *"Respiratory quotient is the ratio of CO_2 produced to O_2 consumed while food is being metabolized."* The rate of respiration can be measured by the amount of CO_2 released. The rate of respiration varies in different organs and with age. In general the factors which affect respiration include internal factors such as the activity of the respiratory enzymes, the type of substrate; and external factors such as oxygen, water, temperature etc.

Respiratory substrate may be carbohydrate, protein or fats. The kind of substrate being oxidized is obtained by measuring the respiratory quotient.

$$RQ = \frac{\text{Volume of } CO_2 \text{ evolved}}{\text{Volume of } O_2 \text{ consumed}}$$

Where, RQ stands for Respiratory Quotient

RQ depends on the type of respiratory substrate used in respiration. When carbohydrate is used as substrate and is completely oxidized, RQ becomes 1. It implies equal amount of O_2 and CO_2 are consumed and evolved. This reaction is displayed in the figure below –

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{Energy}$$

$$\text{R.Q.} = \frac{6CO_2}{6O_2} = 1$$

For carbohydrates, $CO_2 / O_2 = 1$ as in stem and roots.

In case, oil containing seeds e.g. mustard are used during the process of respiration, RQ becomes less than 1. Following equation shows the calculation for fatty acid and tripalmitin is used as substrate –

$$\underset{\text{Tripalmitin}}{2(C_{51}H_{98}O_6)} + 145O_2 \rightarrow 102\,CO_2 + 98H_2O + \text{energy}$$

$$RQ = \frac{102\,CO_2}{145O_2} = 0.7$$

Object-1: Procedure to use Ganong's respirometer

Material required: Ganong's respirometer, respiratory substrate such as germinating seeds, saline water, caustic potash solution, stand, water, filter paper, beaker, balance with weighing box, caustic potash solution.

Working Procedure:

1. Pour some water in the lower end of the bulb of respirometer, and on putting a filter paper introduce some germinating seeds.
2. Now partly fill the respirometer with the saline water. The use of saline water is due to the fact that CO_2 cannot dissolve in it.

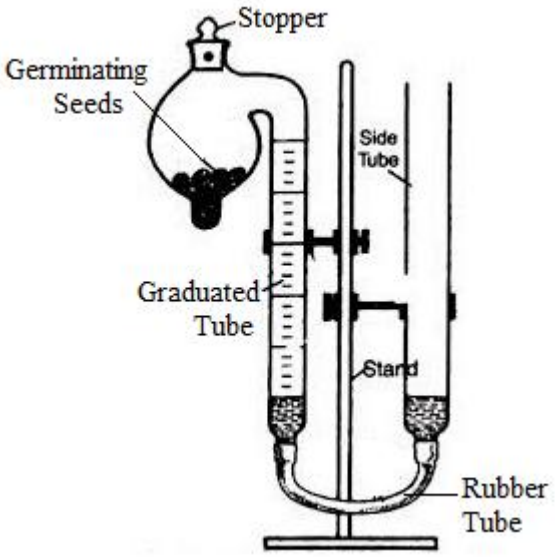

Fig.11.2: Demonstration of Ganong's respirometer

3. Twist the stopper of the bulb in such a way that the two holes come just opposite to each other. In this condition, outside air can pass into the bulbs (Fig 2).
4. Now adjust the level of the levelling tube and graduated tube in a way that saline is present on the same level in both the tubes.
5. Now again twist the stopper in a way that two holes are separated and the bulb is closed.
6. Note the level of the saline water and let the respiratory substrate respire for a few hours.
7. Note the final level and introduce a caustic potash crystal and note the changes.

Observations and results:

(A) If the respiratory substrate is carbohydrate (e.g., wheat, maize, oat, gram, pea, etc.):

There is no change in the level of saline water because in the carbohydrate the volume of the O_2 absorbed is equal to the volume of CO_2 liberated as shown by the following equation:

$$C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O + 673 \text{ kg cals}$$

$$\text{R.Q.} = 6CO_2/6O_2 = 1/1 = 1$$

The volume of the CO_2 released can be estimated by adding crystals of KOH. The latter will absorb the CO_2 produced by the seeds resulting ultimately into the rise of the saline level. The volume of the CO_2 can be calculated by deducting the second level from the first one. Suppose it is 45 c.c.

$$\text{So, R.Q.} = \text{Vol. of } CO_2/\text{Vol. of } O_2 = 45/45 = 1$$

(B) If the respiratory substrate is fat, (e.g., mustard or castor seeds):

In case the respiratory substrate is fat **(e.g., mustard or castor seeds)**, less amount of CO_2 will be released than the O_2 absorbed. A vacuum will be created, and to overcome this vacuum saline level will rise in the tube. This rise will be equal to the excess amount of oxygen. Denote it as V_1.

It can be shown by the following equation:

$$2C_{51}H_{98}O_6 + 145O_2 = 102CO_2 + 98H_2O$$

Tripalmitin

Add crystals of KOH in saline solution. The level of saline again increases because KOH absorbs the CO_2. A vacuum is created and to overcome it the level of saline increases. Denote it as V_2.

Calculate the volume of CO_2 by V_2 (deducting the second rise from the first rise in level) and volume of O_2 by adding both the rises in the level, i.e., $V_1 + V_2$.

So R.Q. $= V_2 / V_1 + V_2 =$ Vol. of CO_2/Vol. of $O_2 = 102/145 = 0.7$

So R.Q. is less than one.

Discussion

During respiration, the germinating seeds absorb $_{O2}$ from the respiroscope and liberate CO_2. The caustic potash absorbs the CO_2 and a vacuum is created. So the KOH solution rises in the tube. This proves that CO_2 is liberated during respiration.

11.5 SUMMARY

As you may recall, photosynthesis occurs in plants cells that contain chloroplasts. Such cells are found in algae and in the leaves and stems of plants. Photosynthetic organisms use light energy and simple building blocks (carbon dioxide and water) to make their own food. Cellular respiration is very widespread. It is completed in mitochondria. Although the details of the two pathways are different, the overall reaction of cellular respiration is photosynthesis running in reverse. Cellular respiration and photosynthesis are interdependent. The glucose and oxygen produced by photosynthesis are used up in cellular respiration. Cellular respiration extracts the stored energy from food molecules. Energy is transferred to "charge up" ATP, and releases carbon dioxide and water as wastes product. The carbon dioxide and water are then available as raw materials for photosynthesis.

11.6 GLOSSARY

Adenosine Triphosphate (ATP) - The molecule from which cells derive energy. Comprised of an adenosine molecule bonded to three phosphates, each phosphate bond contains energy, especially the third bond. By breaking that one bond and reducing ATP to adenosine diphosphate (ADP), the cell can get the energy to carry out its various processes.
ADP - Adenosine diphosphate, product of the Calvin cycle that is used in the light-dependent reactions.
Aerobic respiration - A metabolic process involving oxygen in the breakdown of glucose.

Carbohydrate - A molecular compound containing carbon, hydrogen, and oxygen. Subunits are sugars.

Carbon dioxide (CO_2) - a gas naturally found in the atmosphere that is a reactant for the Calvin Cycle.

Carbon fixation - ATP and NADPH are used to fix CO_2 into carbohydrates. Carbon fixation takes place in the chloroplast stroma.

Chemical equation of photosynthesis - $6\ CO_2 + 6\ H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2$

Chlorophyll - primary pigment used in photosynthesis.

Chloroplast - organelle in a plant cell where photosynthesis occurs.

Diffusion: The movement of particles (molecules or ions) from an area of higher concentration to an area of lower concentration.

Dioxide: An oxide containing two atoms of oxygen in the molecule: e.g. carbon **dioxide** (CO_2).

Glucose ($C_6H_{12}O_6$) : It is a monosaccharide sugar that is the product of photosynthesis and it can exist as several forms.

Light: Electromagnetic radiation; the shorter the wavelength the greater amount of energy. Light supplies the energy for the light reactions of photosynthesis.

Lipid - An organic molecule that is insoluble in water. A main component of cell membranes.

Metabolism - All the reactions occurring in an organism that participate in the acquisition or conversion of energy for use in the organism.

NADPH – A high-energy electron carrier used in reduction

Oxidation - The loss of electrons

Oxygen (O_2): Colourless, odourless gas that is a product of the light-dependent reactions and is essential for respiration.

Photosynthesis - the process by which organisms convert light energy into chemical energy (glucose).

Plant respiration- is the opposite of photosynthesis, which is a biological process performed by green **plants** that creates oxygen and releases it into the air. During **respiration**, **plants** absorb free molecules of oxygen (O2) and use them to create water, carbon dioxide, and energy, which help the **plant** grow.

Protein - An essential molecule found in all cells. Composed of amino acid subunits.

Reduction - the gain of electrons

Respiration - A process that occurs in cells in which cells breakdown food molecules to yield ATP. Can be either aerobic or anaerobic.

Respirometer - It is a device used to measure the rate of respiration of a living organism by measuring its rate of exchange of oxygen and/or carbon dioxide.

Respiratory quotient- the ratio of CO_2 produced to O_2 consumed while food is being metabolized

Stomata- Tiny holes in the epidermis (skin) of a leaf, usually on the undersides of leaves. They control water loss and gas exchange by opening and closing. Singular is stoma.

11.7 SELF-ASSESSMENT QUESTIONS

11.7.1 Objective Type questions:

1. Which of these is true about photosynthesis?
(a) It occurs in both animal and plants (b) It occurs in both fungi and plants
(c) It is a breaking down process (d) It is building up process

2. R.Q. in anaerobic respiration is
(a) 0 (b) $\propto$
(c) 1 (d) > 1

3. The correct relationship of value of Respiratory Quotient is
(a) Glucose symbol > Fats symbol > Organic acid
(b) Glucose symbol < Fats symbol < Organic acid
(c) Fats symbol > Glucose symbol > Organic acid
(d) Fats symbol < Glucose symbol < Organic acid

4. Which of the following respiratory material may show the unit value of R.Q.
(a) Stem of wheat (b) Leaf of barley
(c) Leaf of oat (d) All the above

5. Which knowledge is obtained by knowing the value of R.Q.?
(a) Type of substrate
(b) Number of ATP produced
(c) Type of intermediate products formed
(d) None of the above

6. A mixture containing equal quantity of germinating maize and groundnut seeds are taken. The RQ of this mixture would be
(a) One (b) Less than one
(c) More than one (d) Infinity

7.What is the value of RQ of castor seeds, if the imaginary values of Ganong's respirometer are as follows (i) First rise of saline = 10 ml (ii) Second rise of saline after adding KOH = 30 ml
(a) 0.33 (b) 0.75
(c) 0.85 (d) 3.00

8. R.Q. is defined as
(a) Ratio between CO_2 liberated and O_2 taken
(b) Volume of oxygen taken
(c) Volume of carbon dioxide liberated
(d) Ratio between oxygen taken and fat utilized

9. Number of CO_2 molecules used during photosynthesis.

(a) 2 (b) 5
(c) 6 (d) 10

10. Raw materials for photosynthesis include
(a) Light (b) Organic substances
(c) Nutrients (d) All of these

11. To form one glucose molecule ($C_6H_{12}O_6$), numbers of water molecules required are
(a) Six (b) Eight
(c) Ten (d) Twelve

12. RQ is equal to
(a) C/N (b) N/C
(c) CO_2/ O_2 (d) O_2/CO_2

13. RQ of fatty acid substrate generally
(a) 1 (b) >1
(c) <1 (d) None of the above

11.7.1 Answer Keys:

1. (d), 2.(b), 3.(d), 4.(d), 5.(a), 6.(b), 7.(b), 8. (a), 9. (c), 10. (d), 11. (d), 12. (d), 13. (c)

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11.10 TERMINAL QUESTION

11.10.1 Short answer type Question:

1-What is the difference between respiration and photosynthesis?
2-What is cellular respiration?
3-What is external respiration in plants?

4-Why during day, plants give out oxygen instead of taking it for respiration?
5-How do cells obtain the energy they need to function?
6-Differentiate in between breathing and respiration.
7-Different substrate oxidizes during respiration. How does respiratory quotient (RQ) indicate which type of substrate i.e. carbohydrate, protein or fat is getting oxidize?

RQ= A/B
What do A or B stand?
What type of substrate have RQ of 1, >1, <1

11.10.2 Very Short answer type Question:

1. What is respiration?
2. Name a few respiratory substrates. Which of them is most commonly used?
3. Give the general equation for respiration.
4. What is respiratory quotient or R.Q?
5. What is photosynthesis?
6. What are the important events occur during photosynthesis process?
7. Mention the conditions for photosynthesis. Also mention the process involved in each of these steps.
8. How do aquatic plants get oxygen for photosynthesis?
9. How are photosynthesis and respiration related to each other?
10. How do aquatic plants get oxygen for photosynthesis?

UNIT-12DEMONSTRATION OF COLOUR TESTS AND MICRO CHEMICAL TESTS FOR CARBOHYDRATES, PROTEINS AND LIPIDS

12.1 OBJECTIVES

After reading this unit students will be able to-

- Apply knowledge of biomolecule reagents to identify types of biomolecules.
- Identify the type of biomolecule present per unknown sample.
- Interpret the results when presented with data for each of the biochemical tests.
- Design experiments to identify biomolecules using biochemical tests

12.2 INTRODUCTION

All living things are essentially composed of the same basic groups of molecules. The four types of carbon-based molecules you will perform chemical tests for in this laboratory exercise are carbohydrates (sugars and starch), lipids, amino acids, and proteins. Chemical tests are often used on molecules to distinguish one from another. The chemical interactions typically involved a color change. For example, when iodine (Lugol's solution) is added to a starch, a dark blue-black color will appear. Chemicals of this type are known as **indicators.**

12.3 PROCEDURE OF COLOUR TESTS AND MICRO CHEMICAL TESTS

12.3.1-Carbohydrates

Carbohydrates are polyhydroxy aldehydes or polyhydroxy ketones or any compound which gives these on hydrolysis. Carbohydrates can be either aldoses or ketoses depending upon whether aldehyde group (-CHO) is present or ketonic group (-C=O)**.** The empirical formula of carbohydrates is $Cn(H_2O)n$ or $(CH_2O)n$ where value of n can be 3-7 for monomers. Carbohydrates are synthesized in plants by the process of photosynthesis. Carbohydrates are also called as saccharides since they are made up of sugars. There are three types of carbohydrates monosaccharide, oligsaccharide and polysaccharide. Monosaccharides are simplest carbohydrates which cannot be further hydrolyzed (broken down) into smaller molecules. Monosacharides are crystalline and colourless and exist as solids at room temperature. Monosaccharides are extremely water soluble despite that they possess high molecular weight. Oligosaccharides are defined an sugars formed by polymerization of monosaccharide with a maximum of 9-10 monomeric units linked to one another by glycosidic bond, however most commonly occurring oligosaccharides have 2-6 monomers linked to one another. Oligosaccharides are sweet in taste, crystalline in nature and water soluble.

Oligosaccharides made up two monosaccharide units are called as disaccharides (common examples include sucrose, lactose and maltose), oligosaccharides made up three monosaccharide units are called as trisaccharides (e.g. raffinose), Oligosaccharides with four units are called as tetrasaccharides (e.g. stachyose) and so on. Polysaccharides are polymers

comprising of hundreds and thousands of monosaccharide units. There are two types of polysaccharides based upon their role or function in living organisms. Polysaccharides can be storage polysaccharides such as starch in plants and glycogen in animals. Storage polysaccharides serve as source of energy. Another type of polysaccharides are structural polysaccharides such as cellulose in plants, cellulose is the main component forming the framework of cell wall of plants; Chitin is another structural polysaccharide which is main component of cell wall of fungi.

Reducing and non reducing sugar

Sugar which have free aldehydic or ketonic group and which can reduce Benedict solution Fehling's solution are called as reducing sugar. Reducing sugar have on OH group present on carbon next to carbonyl carbon (aldehyde or ketonic). This OH group reacts with solution of Cu^{2+} (Benedict's solution / Fehling's solution) to form a coloured (red-orange) precipitate and an oxidation product. All monosaccharides (whether aldoses or ketoses) are reducing sugars. Disaccharides such a maltose and lactose are also reducing sugar. Sugar which does not possess free aldehydic or ketonic group and which does not reduce Benedict solution and Fehling's solution are called non reducing sugar. All polysaccharides

1-MOLISCH'S TEST

Molish's test is a general test performed to identify presence of any carbohydrate present in a sample.

Principle

This test is based on reaction of concentrated H_2SO_4 with carbohydrates. When carbohydrate is treated with H_2SO_4, glycosidic bond is hydrolysed and carbohydrate gets dehydrated. This dehydration leads to production of Furfural and its derivatives which react with α-napthol to give purple colour.

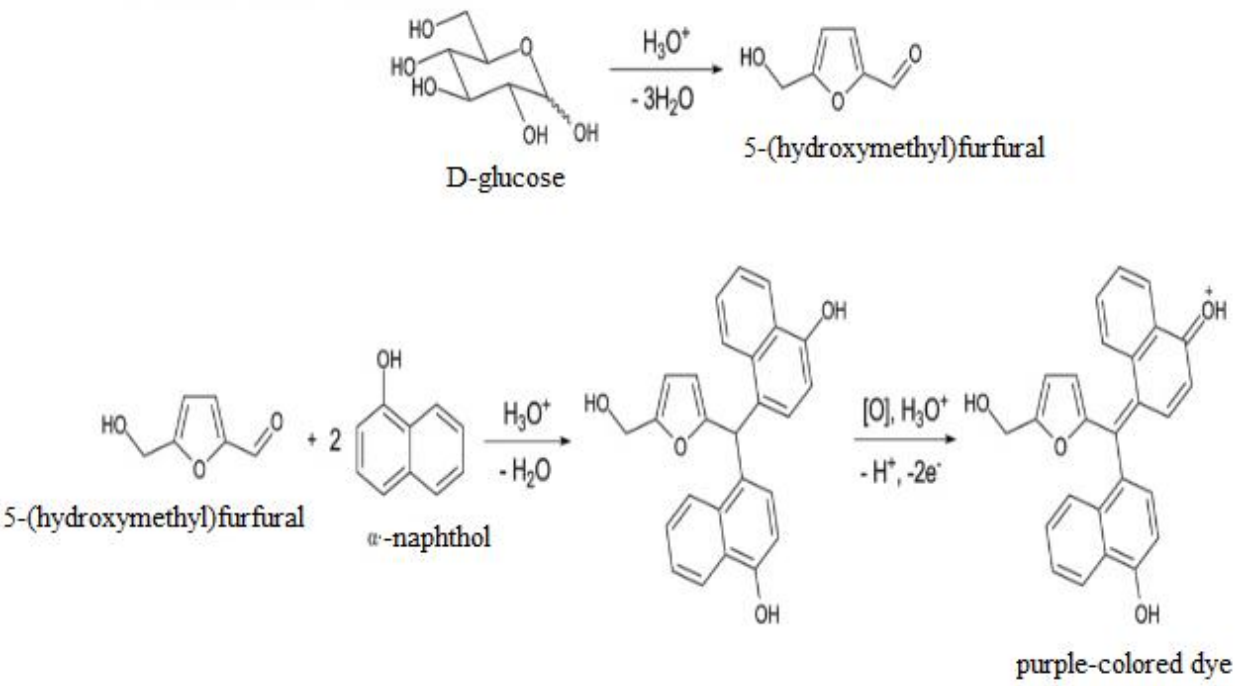
Material required: α-napthol, conc. H_2SO_4, test tube, sample (glucose solution)

Procedure:

- Take about 2ml of aqueous solution of sample.
- Add few drops of α-napthol reagent into it.
- Pour 1ml of conc. H_2SO_4 slowly along the side of test tube.

Observation: Formation of red violet (purple) ring at the junction of two layers shows the presence of carbohydrate.

Reaction involved:



Precautions:

- α-napthol should be prepare fresh each time test is performed
- H_2SO_4 should be handled carefully.

Reagent preparation

α-napthol (w/v) : Prepare 5% α-napthol by dissolving 5gm α-napthol in 100ml ethanol.

2- BENEDICT'S TEST

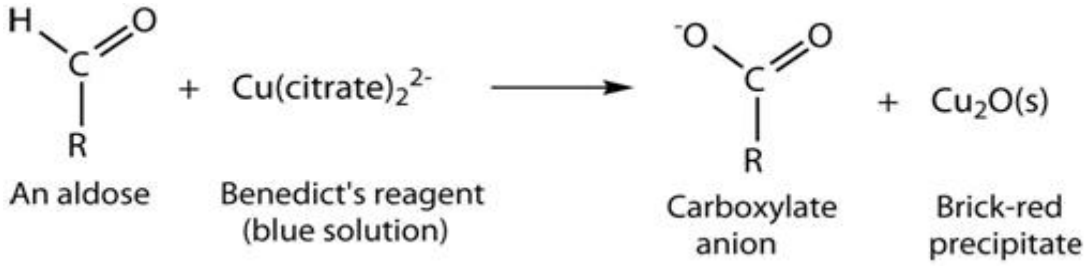
This test is utilized for detection of reducing sugars. A reducing sugar is a carbohydrate possessing either a free aldehyde or free ketone functional group as part of its molecular structure. This includes all monosaccharides (e.g. glucose, fructose, galactose) and many disaccharides, including lactose and maltose. It is a commonly utilized and convenient test due to stability of its reagent.

Material required: $CuSO_4$, Na_2CO_3, burner, dropper, test tube, test tube holder, sample (glucose, fructose solution)

Procedure:

- Take about 4 ml sample in a test tube.
- Add small quantity of Benedict's reagent
- Boil the sample over a burner for 2-5 minutes holding the test tube firmly with a test tube holder.
- Gently shake the test tube during heating.
- A brick red precipitate appears, indicating the presence of reducing sugar in the sample.

Reaction involved:



Conclusion: On boiling sample with the Benedict's reagent, the cupric ion present in the Benedict's reagent is reduced by the reducing agent, sugar, to form a brick red coloured precipitate of cuprous oxide.

Reagent preparation;

A. $CuSO_4$ solution: dissolve 17.3gm of $CuSO_4.5H_2O$ in 100 ml distilled water and then add100ml distilled water to the solution.

B. Benedict's reagent:

Sodium citrate	173gm
Sodium carbonate	100gm
Distilled water	600ml
Finally make the volume 800ml by addition of distilled water	

Add reagent A and B to make 1litre solution ad use it as Benedict solution.

3-FEHLING'S TEST:

This test is utilized for detection of presence of reducing sugar in the sample.

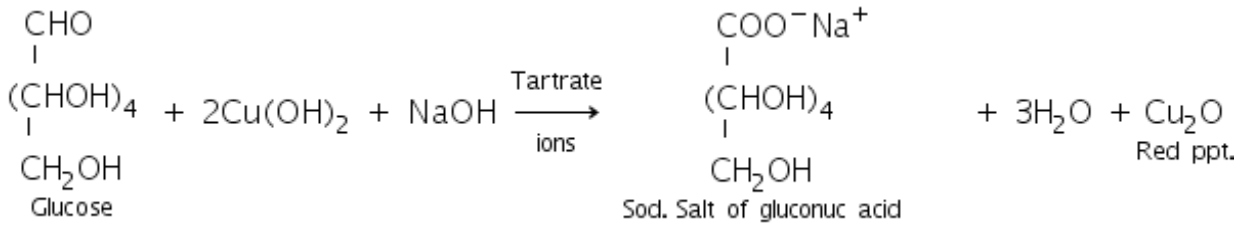
Material required:

Potassium sodium tartrate, hydrated copper (II) sulphate, sodium hydroxide, Fehling's solution A, Fehling's solution B, test tube, test tube holder, burner, dropper, sample

Procedure:

- Take 3-4 ml sample in a test tube
- Add small quantity of Fehling's solution A.
- Then add small quantity of Fehling's solution B to the test tube containing sample.
- Boil the sample over a burner for 2 minutes, holding the test tube firmly with a test tube holder.
- A brick red precipitate appears, indicating the presence of glucose in the sample.

Reaction involved:



Conclusion: The cupric ion present in the Fehling's solution is reduced on boiling by the reducing substance, sugar, to form the brick red coloured precipitate of cuprous oxide. Formation of cuprous oxide indicates presence of reducing sugar.

Reagent preparation:

Fehling's solution I: consists of 7 g of hydrated copper(II) sulfate dissolved in 100 mL of distilled water.
Fehling's solution II: is made by dissolving 35 g of potassium sodium tartrate and 10 g of sodium hydroxide in 100 mL of distilled water.
Fehling's reagent: Equal volumes of Fehling I and Fehling II are mixed to form a deep blue solution.

Precaution:

- Fehling's solution is corrosive and toxic. Wear personal protective devices such as gloves and goggles when preparing the solution and when performing the test.
- Prepare reagent fresh.

4-ANTHRONE TEST

This is another test one for presence of carbohydrate.

Principle: Anthrone test is based on the reaction of conc. H_2SO_4 acid, which causes dehydration of carbohydrate due to hydrolysis glycosidic bond. Dehydration leads to production of furfural and its derivatives. The furfural and its derivatives formed react with anthrone and produce green (or bluish green) colour. Polyssacharides and glycoprotein also give positive test in this reaction.

Materials: Water bath, conc. H_2SO_4, anthrone, sample (glucose solution)

Method:

- Take 1ml of test sample in tube.
- Add 2ml of anthrone reagent. Mix .watch for colour development, it should be bluish green. If you do not see colour development, place the tubes for 10 min in boiling water bath and observe the colour.)

Observation: Addition of anthrone reagent to carbohydrate sample results in appearance of bluish – green colour.

5-IODINE TEST

Iodine has a tendency to form a coloured complex with polysaccharide. The test is utilized for identifying presence of starch and glycogen n a sample. Iodine when reacts with starch it gives blue colour and when it reacts with glycogen it gives reddish brown colour.

Material required: Iodine, potassium iodide, test tube, dropper

Procedure:

- Add about 5 drops of iodine solution to the test tube containing sample
- Blue black colour indicates the presence of starch in the sample

Reagents:

- Iodine solution: Dissolve few crystals of iodine in 20ml of 3% KI solution.
- 3% KI solution: Dissolve 3gm KI in 100ml distilled water.

6-BARFOED'S TEST

The test is performed of distinguish monosaccharides from reducing disaccharides.

Principle: Cupric acid along with acetic acid causes reduction of monosaccharides. Reduction of cupric acetate results in formation of cuprous oxide which is brick red in color. Monosacharrides upon reaction with Barfed reagent produces color within 2-3 minutes whereas disaccharides take longer time for color production. This is because disaccharides are first hydrolysed to monosaccharides and then these monosaccharides react with cupric acetate to form cuprous oxide (red ppt.).

Materials: Copper acetate, acetic acid, sample (glucose solution, fructose solution), distilled water, test tube

Procedure:

- Take 2 ml of sample to be tested in a test tube
- Add 2 ml of freshly prepared Barfoed's reagent.
- Place test tubes into a boiling water bath and heat for 3 minutes.
- Allow to cool.

Observation: Occurrence of deep blue colouration with a red precipitate settling down at the bottom or sides of test tube shows presence of reducing sugars. Appearance of a red precipitate as a thin film at the bottom of the test tube within 3-5 min. indicates presence of reducing mono-saccharide. If the precipitate formation takes more time, then the sample is reducing disaccharide.

Reagents:

Barfoed's reagent

Copper acetate	13.3gm
Acetic acid	1.8gm
Make the final volume of solution up to 200ml with distilled water	

7- SELIWANOFF'S TEST

The test is utilized to differentiate between aldoses and ketoses.

Principle: This test is based upon dehydration of carbohydrates in presence of HCl. This hydration of carbohydrates occurs due to breaking of glycosidic bond and results in formation of furfural and its derivatives. Furfural and its derivates thus formed react with resorcinol to give red color.

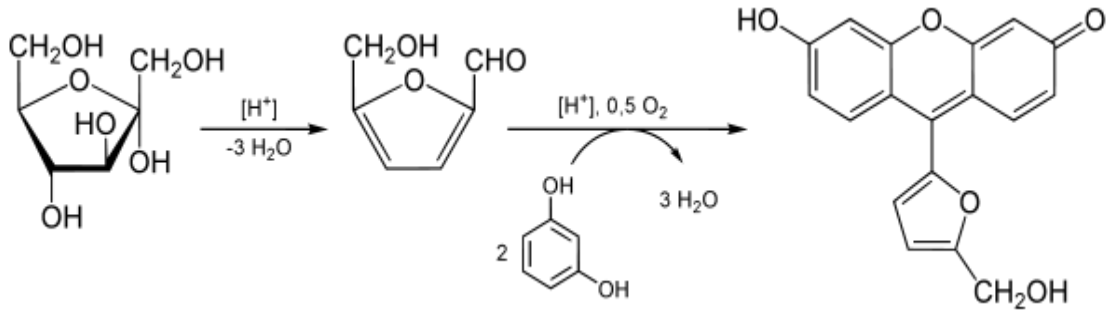
Material: Resorcinol, HCl, sample (glucose and fructose solution), test tube

Procedure

- To 3ml of Seliwanoff's reagent, add 1ml of the test solution.
- Boil in water bath for 2 minutes.
- Observe for color production.

Observation: Formation of cherry red colored precipitate in about 5 minutes shows presence of ketoses whereas appearance of faint red colour shows presence of aldoses.

Reaction involved:



Ketose Sugar Furfural Resorcinol Cherry red compound

Conclusion: On reaction with Seliwanoff reagent, ketoses form a cherry red condensation product within 2 minutes. Whereas Aldoses react slowly, forming the coloured condensation product.

Reagent

- **Seliwanoff's reagent:** Dissolve 50mg resorcinol in 100ml 3N HCl.
- **3N HCl:** Add 25ml HCl to 75ml distilled water**.**

8-BIAL'S TEST

Bial's test is utilized for detection of presence of pentose sugar in the sample. Upon heating a pentose sugar with conc. HCl, furfural is produced. Furfural condenses with orcinol in presence of ferric ions to give blue-green color.

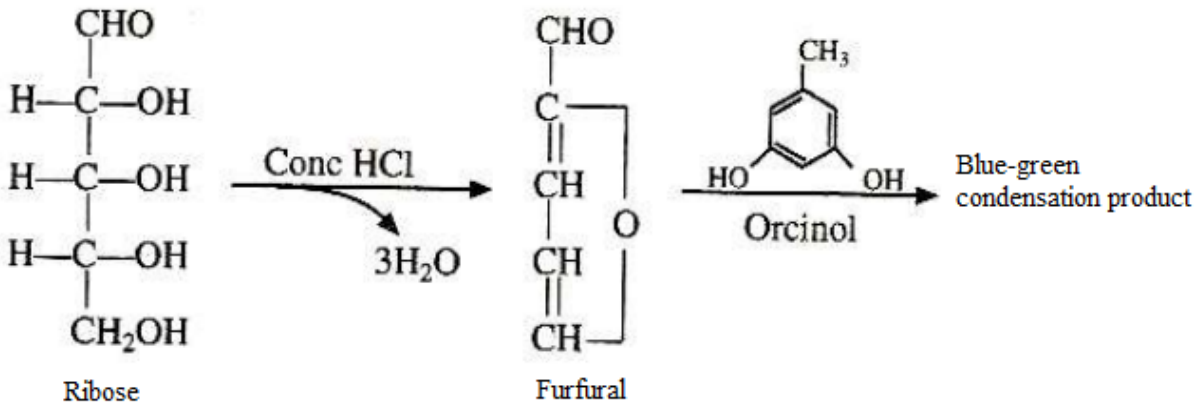
Material's required: Water bath, conc. HCl, Orcinol, Ferric chloride, distilled water, test tubes, sample (pentose sugar only).

Procedure

- Add 3ml of Bial's reagent to 0.2ml of the test solution.
- Heat the solution in a boiling water bath for 2 minutes.

Observation: Formation of blue-green product shows presence of pentoses.

Reaction involved:



Reagents:

1. Ferric chloride solution (10%)	
Ferric chloride	10g
Distilled water	100ml
2. Bial's Reagent	
Orcinol	1.5g
HCl	100ml
10% Ferric Chloride ($FeCl_2$) solution	20-30 drops

9-OSAZONE TEST

Ketoses as well as aldoses react with phenylhydrazine to produce phenylhydrazone which further reacts with two molecules of phenylhydrazine to produce osazone. Crystals of different shapes will be shown by different osazones. Needle-shaped yellow crystals are produced by glucose, fructose and mannose, lactosazone produces mushroom shaped crystals and maltose produce flower-shaped crystals.

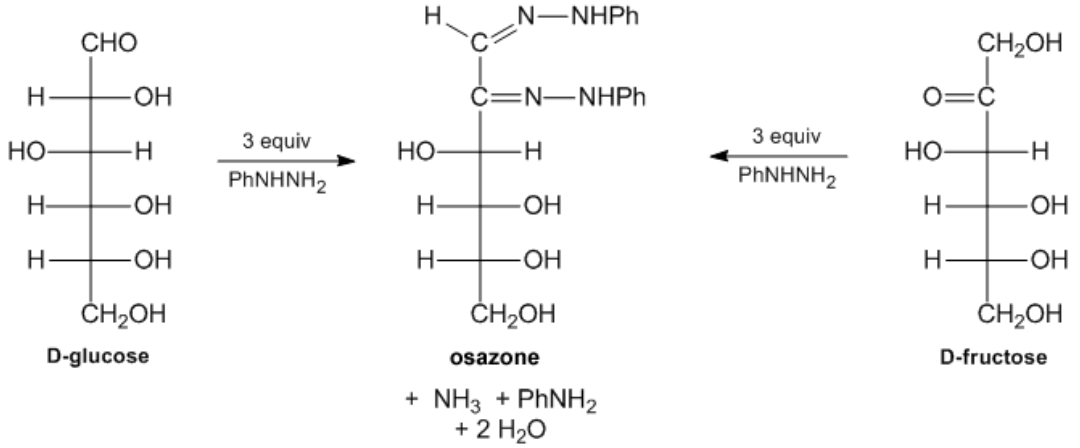
Procedure

- To 2 ml of sample, add 3ml of phenyl hydrazine hydrochloride solution and mix.
- Shake well and heat in a boiling water bath for 30 to 45 minutes.
- Take the tube out of the water bath and let it cool slowly.
- Yellow crystals of osazones will appear.
- Examine the crystals under the microscope and describe the nature of crystals.

Observation: Formation of yellow needle shaped crystals of osazone.

Conclusion: Reducing sugars forms osazone on treating with phenylhydrazine

Reaction involved:



Reagent:

Phenyl hydrazine ($PhNH_2$) solution:

- Phenyl hydrazine mixture is prepared by mixing equal weights of phenyl hydrazine hydrochloride and anhydrous sodium acetate.
- The mixing is to be done thoroughly in a mortar.

10-PICRIC ACID TEST

Picric acid test is done for identification of reducing sugars. Reducing sugars react with picric acid to produce red coloured product.

Principle: In this reaction when sugar solution is mixed with picric acid and boiled, it forms picramic acid. The colour of picramic acid is red.

Materials: Boiling water bath, picric acid, Na_2CO_3. Distilled water, tubes etc.

Method

- Take 1ml of test samples in tube.
- Add 1ml of saturated picric acid
- Add 0.5ml of 10% Na_2CO_3 mix.
- Boil it for 10min.

- Record colour.

Observation: Appearance of red color shows presence of reducing sugars.

12.3.2-Proteins

Proteins are a major class of biomolecule essential for survival, growth and development of all living organisms. Proteins are polymer made up of large number of amino acids (monomeric unit of proteins). Amino acid are linked to one another by formation of a peptide bond. Peptide bond is characterized as a covalent bond formed between two amino acid carboxylic COOH group of one amino acid and amino (NH_2) of adjacent amino acid are involved in the process of peptide bond formation. Addition of large number of amino acids occurs by formation of peptide leads to formation of polypeptide chain. Normally a polypeptide made up of about 20 -25 amino acids or even upto 30 amino acids is generally not considered to be a protein, they are called as peptides or oligopeptides (although many protein are peptides i.e made up of smaller number of amino acids.)

1-BIURET TEST

This is one of the most commonly utilized test to detect presence of proteins in a sample. When protein samples are treated with copper sulphate solution in presence of alkali (NaOH or KOH), protein reacts with copper (II) ions to form a violet coloured complex called biuret.

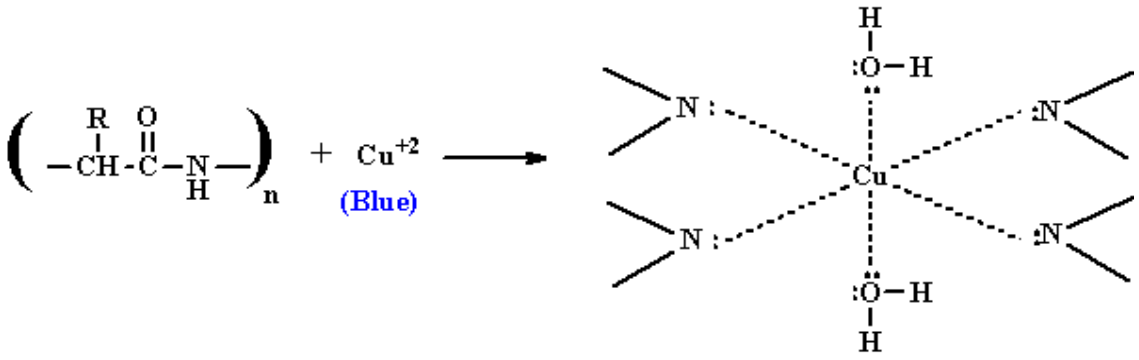
Material required: 1% $CuSO_4$, 40% NaOH, test tube, dropper, sample

Procedure:

- Using a dropper, take a small quantity of 40% NaOH solution.
- Add a few drops of NaOH solution to the test tube containing egg albumin.
- Using a dropper, take a small quantity of 1% $CuSO_4$ solution.
- Add 2-3 drops of $CuSO_4$ solution to the test tube containing egg albumin.
- Shake the solution to mix it well.

Observation: A violet colour appears in the test tube, which indicates the presence of proteins.

Reaction involved:



Violet coloured compound

2-XANTHOPROTEIC TEST

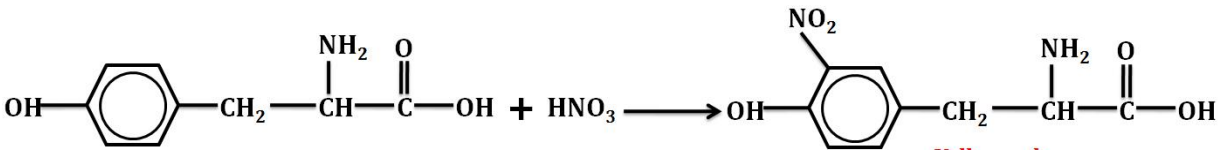
This test is done to identify presence of aromatic amino acids such as tyrosine, Phenyl alanine and tryptophan. When solution of aromatic amino acids is treated with concentrated nitric acid aromatic phenyl ring gets nitrated resulting in formation of yellow colored nitro-derivatives. At alkaline pH, yellow color changes to orange due to the ionization of the phenolic group.

Material required: Conc HNO_3, ammonium solution, dropper, test tube, test tube holder, sample

Procedure

- Take about 2-3 ml sample of solution of any aromatic amino acid in a test tube.
- Add 5 drops of Concentrated HNO_3 to the test tube containing sample.
- Gently heat the sample for about 2 minutes.
- Yellow precipitate appears in the test tube.
- With the help of dropper, add few drops of ammonia solution to the sample.
- Shake the solution to mix it well.
- Yellow ppt. changes to orange in colour, indicating the presence of protein with aromatic amino acids.

Reaction involved:



Yellow coloured complex

3-MILLON'S TEST

This test is used for phenolic amino acids like Tyrosine and its derivatives. Compounds with a hydroxybenzene radical react with Million's reagent to form a red colored complex. Million's reagent is a solution of mercuric sulphate in sulphuric acid.

Materials Required: Million's reagent, dropper, test tube, sample

Procedure:

- Using a dropper, take a small quantity of Million's regent.
- Add few drops of Million's reagent to the test tube containing egg albumin.
- Wait for some time.
- Pink colour appears in the test tube, which indicates the presence of protein.

NOTE: For all the protein test mentioned above BSA (Bovine serum albumin) can be utilized as sample.

4-NINHYDRIN TEST

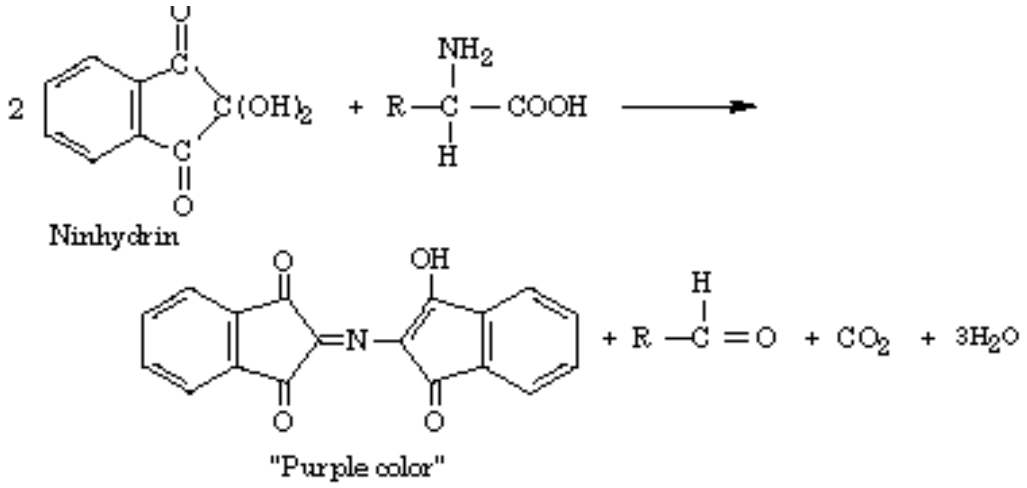
In the pH range of 4-8, all α- amino acids (A molecule containing an amino group and a carboxylic acid group that are separated by one carbon, called the α-carbon) react with ninhydrin, a powerful oxidizing agent to form a purple colored product. All primary amines and ammonia react similarly but without the liberation of carbon dioxide. The amino acids proline and hydroxyproline also react with ninhydrin, but they give a yellow colored complex instead of a purple one. Amino acids containing a secondary amine group sometimes named imino acids.

Procedure:

- Take 1ml of amino acid solution taken in a test tube.
- Add few drops of 0.5% ninhydrin reagent and vortex the contents.
- Place the test tube in a boiling water bath for 5 minutes and cool to room temperature.
- Observe for color change.

Observation: Both free and combined α-amino acids give Ninhydrin test. When free α-amino amino acids are present blue-purple color is produced however when amino group is secondary color produced is yellow.

Reaction involved:



Reagents: solution of amino acids or protein, 0.5% ninhydrin reagent.

12.3.3-LIPIDS

Lipids are mainly made up of a fatty acid esters and variety of alcohols lipids can be and depending upon the nature of these molecules. Lipids can be classified in the three main categories:

1. **Simple lipid:** These are made up of fatty acids esters and alcohols.
2. **Compound lipids :** These kind of biomolecule are made up of fatty acids esters ,alcohols and variety of different molecule which make their physical and chemical properties unique these are further subdivided to

3. **Derived lipids:** these lipids are formed as a result of hydrolysis of simple and compound lipids and these type of derived lipids plays crucial role in the metabolism and normal functions of biological system as hormones, lipid soluble vitamin, steroids etc.

Saturated and unsaturated fatty acids: Saturated fatty acids are solid at room temperature where unsaturated one are liquid. This is because of inefficient packaging in unsaturated fatty acid which results in decreased vander waals interaction, which is responsible for low melting point. Whereas in saturated fatty acids due to compactness and efficient packaging they have high melting point

1-SUDAN III TEST

Material required: Sudan III solution, oil, dropper, test tube, sample

Procedure:

- Using a dropper, take a small quantity of Sudan III reagent.
- Add few drops of Sudan III reagent to the test tube containing egg albumin.
- Shake the solution to mix it well.
- Pink droplets appear indicating the presence of fat in the sample.

2-PAPER SPOT TEST

Materials Required: Peanut seeds and piece of white paper.

Procedure:

- Take a peanut seed from the watch glass.
- Crush the peanut seed and rub it on a piece of white paper.
- Paper becomes translucent at the spot, which indicates the presence of fat.

3-SOLUBILITY TEST

The test is based on the property of solubility of lipids in organic solvents and insolubility in water. Fats and oils are hydrophobic molecules *i.e*. they are non polar in nature and insoluble in water. In general lipids are molecules with large non polar extensions therefore, they are soluble in non polar solvents like benzene, ether and chloroform. There are some amphipathic lipids *i.e*. lipids whose molecules have a hydrophilic portion, (eg. phospholipids) have the property to be dragged by water. Knowledge about solubility of lipid is useful for lipid extraction from different sources.

Principle: The oil will float on water because of lesser specific gravity.

Materials: Burner, lipid samples *viz*. Butter, olive oil, stearic acid, glycerol, lecithin, egg yolk, corn oil, water, acetone, ethanol, chloroform, diethyl ether, test tubes etc.

Method

1. Take 5ml of distilled water and 1ml of different lipids. Shake well and note their solubility.
2. Warm each tube at 50^{o}C for 5min and note change in solubility.
3. Take 5ml of acetone, ethanol, chloroform and diethyl ether in different tubes.

4. Add 1ml of lipid and note the solubility of each lipid.

Observation table:

Type of lipid	Different type of solvents				
	Water	Acetone	Ethanol	Chloroform	Diethyl ether
Butter					
Olive oil					
Stearic acid					
Lecithin					
Egg yolk					
Corn oil					

Results: It should be noted that the solubility of lipids from low to nil in distilled water, while solubility of lipids should be high in organic solvents.

Conclusion: Results obtained clearly demonstrated that solubility of lipids vary from one solvent to other, while lipid solubility in water is minimal, however lipids are insoluble in water.

4-TRANSPARENCY TEST

All the lipids are greasy in nature. Therefore the test may be taken as group test for lipids.

Principle: The oil does not wet the paper.

Procedure: Take 3ml of ether in a test tube and dissolve 5 drops of oil in tit. Put a drop of the solution on the filter paper and let it dry. A translucent spot on the filter paper was observed and this indicates the greasy character of the lipid.

5-To Perform Qualitative Test for Fatty Acid Unsaturation

The fatty acids of vegetable oils are usually unsaturated due to presence of double bond in fatty acids chains. Unsaturation of fatty acids may vary from oil to oil, which can be estimated qualitatively. This test is helpful to compare levels of fatty acid unsaturation among different vegetable oils.

Principle: The presence of double bond in hydrocarbon chain of fatty acid represents unsaturation. These double bonds can be easily replaced by halogens *viz*. Iodine or bromine when it is added to lipid samples. A change in colour of bromine water or iodine solution suggests the presence of unsaturated lipids in specific sample.

Materials: Tubes, bromine , distilled water viz. Olive oil , corn oil, vegetable oil, oleic acid, stearic acid etc.

Method

1. Add 5ml of test solution and add bromine water drop by drop with a burette and mix well every time. Add bromine water in sample till there is no change in colour.

2. Note volume of bromine water added to the sample.
3. Repeat same procedure for other samples.

Conclusion: The double bond of unsaturated fatty acids are be easily replaced by halogens like bromine. Once double bond of fatty acids is replaced by bromine, even additional amount of bromine addition doesnot change its colour. This is the point which suggests the unsaturated bonds of oil are replaced by bromine.

12.4 SUMMARY

1-Three main types of biomolecules present in living organism are carbohydrates, proteins and lipid.
2-Several laboratory biochemical test can performed to identify presence or absence of different bio molecules in different samples.
3-Such test which are utilized to detect presence of specific bio molecules in a sample are called as qualitative test.
4-Molish's test and Anthrone test are done to identify presence of carbohydrates in a given sample.
5-Presence of starch in a sample can be detected by appearance of blue-black colour on addition of iodine to a sample.
6-Samples containing monosacchaarides and disaccharides can be differentiated through Barfoed's test.
7-Monosaccharides react within 1-2 minutes whereas disaccharides take 6-7 minutes to form coloured product in Bardoed's test.
8-Based upon presence of aldehyde or ketonic group carbohydrates are classified as aldoses or ketoses.
9-Seliwanoff's test is utilized to differentiate between aldoses and ketoses as a dark red (cherry) colour in produced with ketoses whereas a pink colour is obtained with aldoses.
10-Reducing sugars can be differentiated from non reducing sugars through Fehling's test as only reducing sugars produce yellow colour in Fehling's test.
11-Reducing sugars can also be identified by Benedict's test and picric acid test.
12-All the lipids are greasy in nature and insoluble in water.
13-However, lipids are soluble organic solvent.
14-Lipids can be saturated or unsaturated. Unsaturated fatty acids contain presence of atleast single doublebond.
15-Presence of saturation and unsaturation can identified through addition of bromine water. Decolourization of bromine water shows presence of unsaturation.
16-Presence of proteins in a sample can be identified by Million's and Xanthoproteic test.

12.5 GLOSSARY

Aldoses: Any class of simple sugar containing an aldehyde group

Glycosidic bond: a glycosidic bond or glycosidic linkage is a type of covalent bond that joins a carbohydrate (sugar) molecule to another group, which may or may not be another carbohydrate.

Peptide bond: A peptide bond (amide bond) is a covalent chemical bond linking two consecutive amino acid monomers along a peptide or protein chain.

Saturated fatty acid: A saturated fat is a type of fat in which the fatty acid chains have all or predominantly single bonds

Unsaturated fatty acid: An unsaturated fat is a fat or fatty acid in which there is at least one double bond within the fatty acid chain.

Reducing sugar: A reducing sugar is any sugar that is capable of acting as a reducing agent because it has a free aldehyde group or a free ketone group.

Non-reducing sugar: Non reducing sugars do not contain free -CHO group or >C=O group on the carbon adjacent to >C=O group.

Osazones: Osazones are a class of carbohydrate derivatives found in organic chemistry formed when sugars are reacted with excess of phenylhydrazine.

12.6 SELF ASSESSMENT QUESTION

12.6.1 Choose the most appropriate option:

1- Molisch's test is utilised for identification of

(a) Carbohydrate (b) Lipids

(c) Protein (d) Fat

2- Iodine test is utilised for identification of

(a) Starch (b) Glycogen

(c) Both a and b (d) Proteins

3-Which test can be used to distinguish between monosaccharide and reducing dissacharides

(a) Molisch's test (b) Barfoed test

(c) Anthrone test (d) All of above

4-Proteins can be detected to be present in a sample by

(a) Iodine test (b) Molisch test

(c) Xanthoproteic test (d) Benedict's test

5-Formation of pink coloured reaction product indicates presence of protein in which of the following test

(a) Anthrone test (b) Biuret test

(c) Fehling's test (d) Millon's test

6-Seliwanoff's reagent is prepared by dissolving

(a) Resorcinol in HCl (b) Resorcinol in water

(c) Resorcinol in H_2SO_4 (d) Resorcinol in HNO_3

7- Barfoed's reagent is a combination of
(a) Copper acetate and acetic acid (b) Water and anthrone
(c) HCl and acetic acid (d) Copper sulphate and HCl

8-Benedict's test is done for identification of
(a) Non reducing sugar (b) Proteins
(c) Reducing sugar (d) Lipids

9- α- napthol is prepared by dissolving
(a) α- napthol in water (b) α-napthol in ethanol
(c) α-napthol in HCl (d) α-napthol in H_2SO_4

10-Oil floats on water because of
(a) Lesser weight (b) Lesser volume
(c) Lesser mass (d) Lesser specific gravity

11-Which of the following statement is not true
(a) All lipids are greasy in nature
(b) Lipids are insoluble in organic solvent
(c) Lipids can be identified by Sudan test
(d) Lipids can made up of fatty acids esters and alcohols

12-Reducing sugar form _____ on treatment with phenylhydrazine
(a) Furfural compound (b) Osazones
(c) Phenyl sugar (d) Hydrides

13-Bial's test is utilised for differentiating
(a) Aldoses and ketoses (b) Aldehyde and acids
(c) Protein and lipids (d) Ketone and lipids

14-Anthrone reagent is prepared by dissolving anthrone in
(a) Nitric acid (b) Hydrochloric acid
(c) Phosphoric acid (d) Sulphuric acid

15-Which of the following is not a polyssacharide
(a) Starch (b) Glycogen
(c) Sucrose (d) Chitin

16-Glycosidic bond is present in
(a) Lipids (b) Protein
(c) Carbohydrate (d) All the above

17-Formation of red coloured product in picric acid test shows presence of
(a) Reducing sugar (b) Non reducing sugar

(c) Lipids (d) Proteins

18-Dehyratioon of carbohydrates in Molisch's test results in formation of
(a) Furfural (b) Osazone
(c) Oxides (d) α-napthol

19-Proteins are polymers of _____ which are linked to one another by _____
(a) Glucose, peptide bond (b) Amino acid, peptide bond
(c) Glucose, glycosidic linkage (d) Amino acid, ester bond

20-Decolorization of bromine water when added to a fatty acid solution indicates presence of
(a) Saturated fatty acid (b) Absence of fatty acid
(c)Unsaturated fatty acid (d) None of the above

12.6.2 Fill in the blanks:

1. _____ is a monosaccharide.
2. Polysaccharides are made up of large number of _____ molecules.
3. _____are building block of proteins.
4. Molisch test is used for identification of _____.
5. _____ is a polysaccharide found in cell wall of fungi.
6. Biuret test is utilised for identification of _____.
7. Lipids are made up of _____ and _____.
8. _____ is main component of plant cell wall.
9. Yellow crystals are formed in phenyl hydrazine test are called _____.
10. Anthrone test is done for identification of _____
11. Paper spot test is utilized for identification of _____.
12. Appearance of _____ colour shows presence of starch in iodine test.
13. Benedict's test is utilised for test presence of _____.
14. Millon's test is utilised for identification of _____.
15. Reaction of furfural with_____in Molish test give purple colour.

12.6.3 State whether following statements are true or false.

1. Monosaccharides are made up of large number of sugar subunits.
2. Amino acids are monomeric units of proteins.
3. Sucrose is made up of glucose and fructose.
4. Anthrone test is used for identification of sugar.
5. Fehling solution is mainly made up of $CuSO_4$.
6. Benedict's test is used for identification of protein.
7. Presence of starch can be detected by iodine test.
8. Anthrone reagent is prepared by dissolving anthrone in HNO_3.
9. Biuret test is done for identification of protein.
10. Decolorisation of bromine water upon addition to lipid sample show presence of unsaturated fatty acids.

11. Sudan test is done for identification of presence of lipids.

12.6.1 Answers Key: 1-(a), 2-(c), 3-(b), 4-(c), 5-(d), 6-(a), 7-(a), 8-(c), 9-(b), 10-(d), 11-(b), 12-(b), 13-(a), 14-(d), 15-(c), 16-(c), 17-(a), 18-(a), 19-(b), 20-(c).

12.6.2 Answers Key: 1- Glucose, 2-Sugar, 3-Amino acids, 4-Carbohydrates, 5-Chitin, 6-Protein, 7- Glycerol , fatty acids, 8-Cellulose, 9-Osazones, 10-Carbohydrates, 11- Lipids, 12-blue-black, 13- reducing sugar, 14- phenolic amino acids, 15- α-naphthol

12.6.3 Answers Key: 1-F, 2-T, 3-T, 4-T, 5-T, 6-F, 7-T, 8-F, 9-T, 10-T, 11-T

12.7 REFERENCES

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12.8 SUGGESTED READINGS

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12.9 TERMINAL QUESTIONS

12.9.1 Very short answer type questions:

1. Define carbohydrate?
2. Why are carbohydrate also called as saccharides?
3. Name different types of carbohydrates?
4. What is chitin?
5. Write the composition of Fehling's solution I & II?
6. Mention most commonly utilised test for identification of glucose?
7. What is benedict's reagent?
8. What is fehlings's reagent?
9. How is phenyl hydrazine reagent prepared?
10. How is anthrone reagent prepared?
11. Define proteins?
12. What is peptide bond?

13. What is biuret test?
14. What are lipids?
15. What is sudan test?
16. What are osazones?

12.9.2 Short answer types questions:

1. What are carbohydrates. Classify them as aldoses and ketoses?
2. How does monosaccharides differ from oligosaccharides?
3. What are structural and storage polysaccharides?
4. Write the composition of benedict's reagent where this reagent utilised?
5. How is fehling's test done for identification of presence of sugar in given sample?
6. Describe how benedicts test is utilised for identification of sucrose.
7. What is molisch test. How it is done?
8. What is biuret test. How is it done?
9. How can xanthoproteic test be utilised for identification of proteins.
10. Differentiate between simple and compound lipids?
11. Explain how Sudan test and paper spot test are utilised for identification of lipids?
12. How does saturated fatty acids differ from unsaturated fatty acids?

12.9.3 Long answer types questions:

1. Define proteins. Mention a biochemical test utilized for identification of protein.
2. What are aldoses and ketoses. Give a biochemical test utilized for their laboratory identification.
3. Give a laboratory method to find out whether a given lipid sample contains saturated or unsaturated fatty acids.
4. What are reducing and non reducing sugars? How can they be identified to be present or absent in a given sample?