1.0 CONTENT OF COURSE

The following units will be covered in this module:

3.0 Written Examination and Admission to the Examination

3.1 Written Examination

The final course examination consists of one two-hour paper to be written at a time decided by the National Open University (NOU).

3.2 Admission to the examination

To qualify to write the final examination, you must have acquired a minimum of 100 points from the three compulsory assignments, you can accumulate your points as follows:

Score		Assignments	
	01	02	3
75 - 100%	40 Points	50 points	50 Points
60 – 74%	40 Points	45 Points	45 Points
50 – 59%	20 Points	40 Points	40 Points
40 – 49%	10 Point	35 Points	35 Points
25 – 39%	5 Point	25 Points	25 Points
Under 25%	0 Point	0 Points.	0 Points

Each assignment is compulsory and must be turned in by the due date.

5.0 Assignments: General Information

One of the reasons you are encouraged to do your assignment and turn it in when due is that it helps to ensure you are following through with the course. Also it provides a channel or communication between the tutor and the student. It also serves as a means to direct you to other reference materials outside the study guide. Three assignments must be completed for this module. Your answers should be brief and to the point. Practice the habit of using diagrams and charts/tables to illustrate or summarise essential points.

Assignment File

Assignment 01

You are encouraged to keep a copy of your answers.

1. **Assignment** 01
(a) With the aid of a chart, show the characteristics of living things indicating how energy is extracted, converted and used from the environment.
(b) Differentiate living things from non-living things by the concept of build-up and disintegration.

2.
(a) Make a clear, labelled drawing of a plant cell and an animal cell.
(b) Illustrate the main features of each.
(c) Highlight observable differences of each.
(d) Explain the organisation within a typical cell.

3 With the aid of a chart of the five kingdom classification
(a) Locate the position of viruses
(b) Explain why viruses are on their own

(c) Highlight the chief characteristics of each kingdom

4
(a) Draw and label a generalized virus
(b) List and discuss the characteristics of a virus

5
(a) Draw and describe the life cycle of the HIV virus
(b) Describe how HIV virus is
(i) contacted
(ii) transmitted
(iii) its signs and symptoms

6. With the aid of a table

Features	**Prokaryotes**	**Eukaryotes**

7.
(a) Draw a typical bacterium
(b) Label the parts
(c) Discuss the features that made you classify bacteria in prokaryotes.

8.
(a) Draw-up a flow chart on types of bacteria
(b) List those features that differentiate them.

9. Describe the following processes in bacteria. (a) Reproduction
(b) Growth (c) Nutrition

10. If a bacteria is placed in a nutrient medium under favourable growth conditions, if it and its descendants divide every 20 minutes complete table 10.1 use the data to draw the following graphs.

Graph A: Number of bacteria and log 10.
Graph B: Number of bacteria on the vertical axis against time (horizontal axis).

	Time (in units of 20 min.)	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
A	Number of bacteria											
B	Log 10 number of bacteria											

	(to one decimal											
C	Number of bacteria expressed as power of 2											

ASSIGNMENTS 02

I. Use a flow chart to differentiate types of fungi on the basis of nutrition, reproduction and location.
2. Draw a typical fungus. Label the parts.
3. List and discuss the characteristics of fungi.
4. With the aid of flow chart, differentiate types of algae on the basis of nutrition, reproduction and location.
5. Draw a typical algae, label its part
6. List and discuss the characteristic of algae
7. (a) Draw a typical flowering plant
   (b) List the main features of the flowering plant
8. Draw and label accurately a typical root
9. Describe how the root takes up water from the soil
10. Draw and label accurately, the structure of the stem of a typical flowering plant.

ASSIGNMENT 03

1. (a) Draw the vascular bundles showing the xylem and phloem
   (b) Explain how water and other minerals are transported through the stem
2. Draw a typical dicotyledonous leaf and label the parts accurately

3. Discuss the functions of the leaf in a flowering plant in relation to photosynthesis

4. (a) Draw a typical flower and label the parts
   (b) Discuss the functions of the parts of the flower.

5. (a) What do you understand by floral diversity?
   (b) List different types of flower and discuss their characteristics.

6. Write short notes on:
   (a) Pollination
   (b) Fertilisation
   (c) Differentiate between (a) and (b)
   (d) Illustrate with the aid of a diagram

7. (a) Explain the mechanism of plant breeding
   (b) Differentiate between pure breeding and hybrid
   (c) What is the biological significance of plant breeding?

8. Explain the chromosomal basis of inheritance.

9. (a) Explain the concept of Osmosis
   (b) What are the various advantages of water in the field of biology?

10. (a) What is pollution?
    (b) Explain the meaning of Eutrophication
    (c) Differentiate thermal pollution from other types of pollution.

UNIT 1: Activities of Living Things

1.0 Introduction

This unit on activities of living things presents the organism, plant or animal as an entity that is capable of existing. To say an organism exists, is the same thing as saying that it is busy, it is full of life, it is going on, it is alive, it is full of energy. If you look into any biology textbook (see reference at the end of the unit), it will give you list of things that living things do to qualify them as living things and differentiates them from non living things.

2.0 Objectives:

When you complete this unit successfully, you will be able to:

1 Differentiate living things from non-living things.
2 List the characteristics of living things.
3 Describe in detail those activities that distinguish living things from non living things.
4 Give examples of living things.
5 Explain how energy is transformed by living things.
6 Classify living things based on oxygen requirement.

1.3.0 Activities of living things.

1.3.1 Ingestion
1.3.2 Assimilation .
1.3.3 Growth
1.3.4 Excretion
1.3.5 Reproduction .
1.3.6 Responsiveness
1.3.7 Co-ordination
1. 3.8 Regulation
1.3.9 Energy transformation in living things
1.3.10 Classification of living things based on energy utilization

1.4.0 Conclusion
1.5.0 Summary
1.6.0 Tutor Mark Assignment
1.7.0 References and further readings
1.8.0 Additional materials

1.3.0 Activities of Living Things

All living things manifest certain characteristics. They demonstrate the ability to use energy from the environment for survival and carry out their various activities. For continuous survival, protoplasm must be added. Waste must be gotten rid off. New ones or offspring must be produced. Nine characteristics distinguish living things from non-living things.

These are:

1. Ingestion
2. Assimilation
3. Growth
4. Reproduction
5. Waste elimination
6. Responsiveness
7. Co-ordination
8. Regulation
9. Movement

1.3.1 Ingestion

All living things feed one way or the other. They take in food for many reasons, chief among these is for energy purposes. The organism needs energy to carry out all the other activities associated with living things. There are two kinds of living things, plant and animal. Plant manufacture food, i.e. basic materials are secured, light energy is utilised to convert the materials to complex nutritive substances, which are used as food. Animals depend on plants for food.

1.3.2 Assimilation

Living organisms utilise food (nutrients) to maintain life. This is done by a process called metabolism. It is a chemical process involved in keeping the life of the organism going. There are two aspects of metabolism, (a) anabolism (substances are synthesised from simpler substances, e.g. photosynthesis..... (b) catabolism (the breakdown of the substances).

1.3.3 Growth

Growth simply put is increase of materials in an organism. This is done in stages, a unicellular organism increases its protoplasm while a multicellular organism increases the number of cells, and every living cell is made up of protoplasm.

1.3.4 Excretion

All living organisms get rid of unwanted products (waste). As a result of cell activities in the protoplasm, many materials formed (byproducts) which are not beneficial to the cell and if left will cause harm to the cell.

1.3.5 Reproduction

All cells of living organisms multiply or divide. This multiplication or division enables the organism to perpetuate their species. Reproduction can take different forms. (a) fission into two or more parts, (b) fusion of protoplasmic material from two sources (i.e. male and female gametes) resulting in an offspring.

1.3.6 Responsiveness

Living organisms respond to forces or anything external, even internal, i.e. any stimuli in the environment, it could be change of weather. Organisms do this by many methods. You will learn some of these in detail as your study progresses.

1.3.7.1.3.8 Co-ordination and Regulation

Chemical and physical changes in the organism are involved in all these activities. There is a general process of co-ordination and regulation by enzymes to keep the system of the organisms balanced and unified. Materials are exchanged, energy is exchanged between the organism and its environment.

You have gone through the various activities most living things carry out. Now think of some living things around you, check through the list of activities and see if your example of a living thing (say, yourself or an insect) manifest these characteristics, non-living things such as wood.

1.3.9.0 Energy Transformation in Living Things

Looking through all the activities of living things, energy seems to be a linking factor between all the activities. Each of the activities expend energy to be carried out. In figure 3.9, energy transformation in living organisms is shown. Study this very well. It is the energy from the external environment that is being used by green plants to synthesize organic nutrients. Animals also use the energy in the environment. Look closely at the flow chart. Green plants synthesize food from the sun, the energy is transferred along the line through some processes and the organism uses the energy for growth, reproduction, locomotion, co-ordination and excretion.

1.3.9.1 Energy Transformation in Living Things

Energy available in the external environment

Kinetic radiation	**Potential: Chemical bonds**
Green plants use light energy to Synthesize organic requirements	Animals and other organism lacking chlorophyll absorb energy-rich compounds previously synthesized by green plants.

NUTRITION

Controlled transfer of energy from chemical bonds is suitable organic molecules to the phosphate bonds in ATP.

RESPIRATION

Chief uses of the energy transferred to ATP bonds

Metabolism (chemical work)		Movements (mechanical work)	Production of heat, light, sound, electrical impulses, etc. (various forms of work).
Enlargement Growth	Multiplication Reproduction	Locomotion and Other movement	Sensitivity, other co-ordinating regulatory processes

All these activities lead to the formation of unwanted byproducts. Energy is expended in the elimination of these.

EXCRETION

Source: Vines and Rees: plants and animal biology p.12.

1.10 Classification of Living things Based on Oxygen utilization

Living things can be classified into three groups, based on their oxygen requirement (a) those that use free oxygen to breakdown complex compound - aerobic, (b) those that can respire without oxygen ,.J anaerobic, (c) those that can exist with or without oxygen, e.g. yeast.
Energy is needed for the organism to move from place to place (locomotion). Plant cells do not move like animal cells, but there is movement within the cells of a plant i.e. movement of the protoplasm.

Activities 1.3.1

a. Take yourself as an example of a living thing. Which of these activities do you do?
b. Describe how you engage in the activities.

c. Do not eat for at least 18 hours, describe how you feel in relation to the activities in this

Activity 2

Living things are different from non-living things. Look at table 1.5, fill the column on the right hand

Table 1.5.1

Living Things Carry out	**Non-Living Things Carry out**
Movement	
Respire	
Reproduce	
Ingestion	
Excretion	
Growth	
Irritability	
Co-ordination	
Regulation	

1.4.0 Conclusion

You have studied those characteristics that make an organism to be classified as living: If an organism is dead, it will not carry out any of these activities, that is why it is said to be dead. A dead organism has lost the ability to use energy and extract materials of any sort from the environment.

1.5.0 Summary

Energy is needed for living things to do these activities in table 1.5. Energy is needed for the manufacture of secretory substances, energy is needed to produce offsprings. Energy is needed for breakdown of complex compounds. Oxygen is required for the breakdown of complex compounds.

1.6.0 Assignment (TMA)

1.7.0 References

Vines, A.E. AND Rees, N( ). Plant and Animal Biology. London: Pitman Publishing.

Roberts, M.V. (1984) Biology: A Functional Approach.

1.8.0 Further Reading

All biology textbooks available to you.

1.9.0 Additional Materials

Videotape on activities of Living Things.

Unit 2

The Cell, Its General Structure and Activities

2.1.0 Introduction

In Unit 1, you learnt that every living organism carries out activities to show that they are alive. In this unit, you will learn that every organism is made up of cells. There are some organisms that are single celled. The cell is very tiny, you will need a microscope to view it. Even though it is tiny and not visible to the naked eyes, it carries out the processes that make the organism a living thing.

2.2.0 Objectives

When you complete this unit, you will be able to:

1. Draw a plant cell and an animal cell and label them correctly
2. Distinguish a plant cell from an animal cell using the drawing in the first objective
3. Distinguish between two given cells
4. Describe some historically important events in cell biology

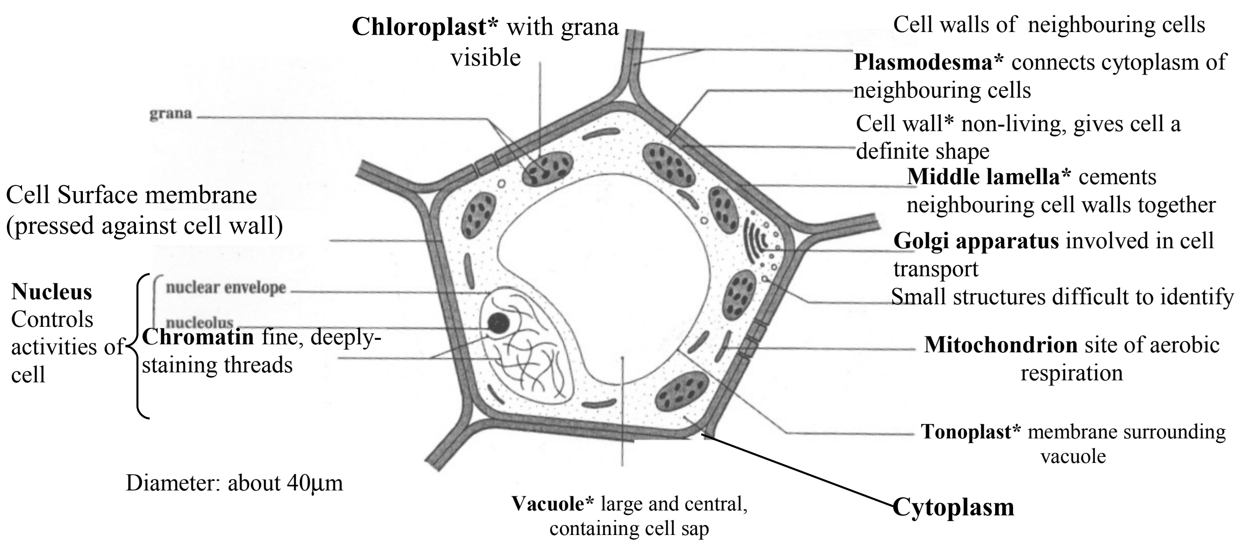
2.3.0 The Cell
2.3.1 Structure of Plant Cell
2.3.2 Structure of an animal cell
2.3.3 Differences between an animal cell and a plant cell
3.3.4 Diversity of cells
2.3.5 Conclusion
2.3.6 Summary
2.3.7 Tutor Marked Assignments
2.3.8 References and Further Reading

2.3.0 The Cell Concept

The cell is the basic unit of structure and function in living organisms. Two scientists, Schlieden and Schwann proposed what is commonly known as cell theory in 1838 and 1839 respectively. In 1855, another idea that new cells can only come from pre-existing cells was proposed. Study table 2.0 for historical developments in the area of cell biology.

An easy way of looking at cells is to consider them as a bag of chemicals that is capable of surviving and multiplying itself. The chemical constituent of each bag is such that it is different in many ways from those outside it. If this difference cannot be maintained, life could not exist. The barrier is a very thin membrane called the cell surface membrane. It serves as a border control point regulating the movement of molecules in and out of the cell.

(Fig 2.1): ***General plant cell as seen with a light microscope***



2.3.1 Structure of plant cells

Plant cells (figure 2.1) are bounded by a relatively rigid well which is formed by the secretion of the protoplasm (living cell) within it. When plant cells divide, primary walls are formed. As the wall continues to thicken, it may later become a secondary wall. Another way of looking at cells is to see them as a small unit of living protoplasm surrounded by a non-living wall in the case of plants. In the case of animal cells, it is always a cell surface membrane. The most prominent structure in the cell the nucleus. It contains a deep staining material known as chromatin. Chromosomes which contain the genetic material (DNA) of the plant cell are regulated by the DNA which is capable of replicating itself so that new cells can be formed. Between the nucleus and the cell surface membrane, there is a living material known as cytoplasm. The cytoplasm contains another distinct part of the cell that has a particular structure and function. It is called organelle.

2.3.2 Structure of Animal Cell

Diagram (a)

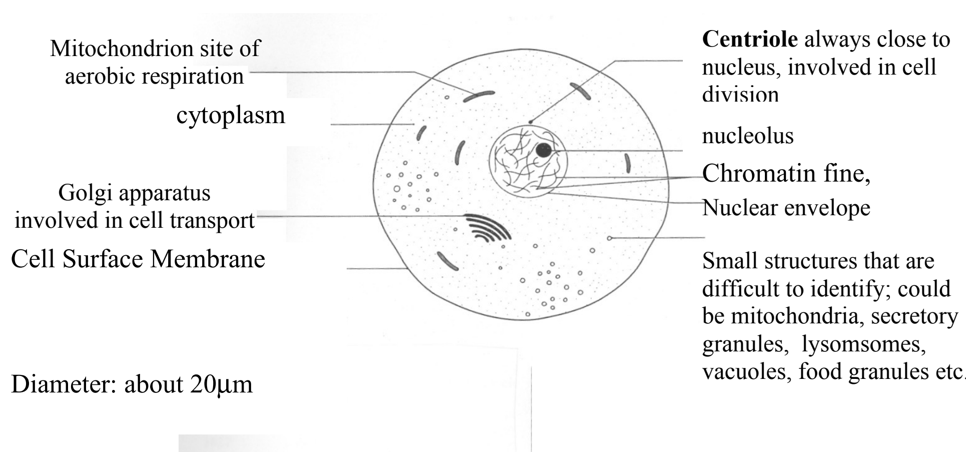
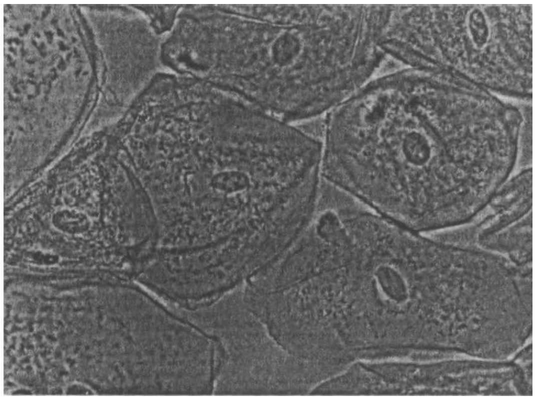


Fig 2.2

(b)



(a) Generalised animal cell as seen with a light microscope. (b) Cells from the lining of the human cheek showing typical characteristics of an animal cell. Each cell contains a central nucleus surrounded by cytoplasm containing many organelles such as mitochondria (x 400).

The structure of a typical animal cell is shown in figure 2.2 Examine the details carefully and note the similarities and differences between plant cells and animal cells. The diameter of a typical animal cell is about one hundredth of a millimetre (l0 um pronounced ten micrometre). It is bounded by a cell surface membrane, which encloses the protoplasm. At the centre of the cell is the nucleus which controls the activities of the cell. The nucleus is surrounded by the cytoplasm. The protoplasm embraces the nucleus and cytoplasm. A nuclear envelop bounds the nucleus (a dense body) and fine deep staining threads called chromatin.

Activity 1

Other structural details of animal cell are contained in figure 2.2 Study them and take note of their functions.

2.3.3 Differences Between An Animal Cell And A Plant Cell

Animal cells have adrenaline, thyroxine and the organelle centriole which are not found in plant cells. Plant cells have chlorophyll, cellulose and starch which are not found in animal cells. Plants have more elaborate structures. Other differences are:

- "a relatively rigid cell wall outside the cell surface membrane; pores containing fine threads known as plasmosdesmata link the cytoplasm of neighbouring cells through the cell walls.
- Chloroplasts in photosynthetic plant cells;
- A large central vacuole: animal cells may have small vacuoles such as phygocytic vacuoles."

Activity 2

Try to look at the slides of a plant cell and animal cell under a microscope. Try to locate some of the structures you find on the diagrams. You can compare what you see in the slide under the microscope with the diagram of the structures.

N.B. Your tutor will help you in this task.

2.3.4 Diversity of Cells

Cells are of different kinds, different sizes shapes and form. But there is one thing common among them, they all possess nucleus and cytoplasm with other organelles structure of kinds of cells (figure 2.4).

a. Epithelial cell
b. White blood cell
c. Nerve cell
d. Smooth muscle fibre
e. Spermatozoon cell
£ Parenchyma cells of plant
G Amoeba

Activity 3

Draw other cells that you know.

Table 2.0 Some historically important events in cell biology

1590	Jansen invented the compound microscope, which combines two lenses for greater magnification.
1665	Robert Hooke, using an improved compound microscope, examined cork and used the term "cell" to describe its basic units. He thought the cells were empty and the walls were the living material.
1650-1700	Antony van Leeuwenhoeck, using a good quality simple lens (mag.x200), observed nuclei and unicellular organisms, including bacteria. In 1676 bacteria were described for the first time as `animalcules.'
1700-1800	Further descriptions and drawings published, mainly of plant tissues, although the microscope was generally used as a toy.
1827	Dolland dramatically improved the quality of lenses. This was followed by a rapid spread of interest in microscopy.
1831-3	Robert Brown described the nucleus as a characteristic spherical body in plant cells. 1838-9 Schleiden (a botanist) and Scheann (a zoologist)

produced the `Cell Theory' which unified the ideas of the time by stating that the basic unit of structure and function in living organisms is the cell.

1840	Purkyne gave the name protoplasm to the contents of cells, realising that the latter were the living material not the cell walls. Later the term cytoplasm was introduced (cytoplasm + nucleus = protoplasm).
1855	Virchow showed that all cells arise from pre-existing cells by cell division.
1828	Haeckel established that the nucleus was responsible for storing and transmitting hereditary characters.
1866-88	Cell division studied in detail and chromosomes described
1880-3	Chloroplasts discovered.
1829	Mitochondria discovered.
1898	Golgi apparatus discovered
1887-1990	Improvements in microscopes, fixatives, stains and sectioning. Cytology+ started to become experimental. Cytogenetics+, with its emphasis on the functioning of the nucleus in heredity, became a branch of cytology.
1900-1990	Mendel's work, forgotten since 1865, was rediscovered giving an impetus to cytogenits. Light microscopy had almost reached the theoretical limits of resolution, thus slowing down the rate of progress.
1930s	Electron microscope developed, enabling much improved resolution.
1946-date	Electron microscope became widely used in biology, revealing much more detailed structure in cells. This `fine' structure is called **ultrastructure**.

2.3.5 Conclusion

In this unit you have learnt about cell; the structure of a plant cell and an animal cell. The differences between the two have been shown you.

2.3.6 Summary

The cell is a unit of living organisms. Some organisms are made of just a single cell, some others are made of many cells (collectively they make up the organism). An easy way of looking at cells is to consider them as a bag of chemicals that is capable of surviving and multiplying itself. Plant cells are different from animal cells in many ways. Cells divide thereby increasing. Different kinds of cells exist.

2.3.7 TMA in study guide

2.3.8 References And Further Reading

Taylor et al, (1998) Biological Science has been extensively referred to
All O'level textbooks on biology provide content on the cell. You may refer to any other biology textbook.

Unit 3

Cell Activities

3.0.1 Introduction

In unit 2 you learnt about cell structure. You learnt that every organism is made up of cells. You learnt that there are some organisms that are single celled while others are multicellular. You saw a cell under the microscope, you saw how tiny it was. You were not able to see a cell with your naked eyes. Despite the fact that you were not able to see a cell with your naked eyes, the cell carries out the process that make the organism a living thing. In this unit, you will study cell activities. Cells undergo cell division Osmosis, i.e. passage of water through the cell membrane and plasmolysis. In this unit you will look at these three aspects of cell activities.

3.0.2 Objectives

By the time you complete this unit, you will be able to:

1. Describe the way cells function.
2. Explain the meaning of cell activity.
3. Differentiate between Mitosis and Cytokinesis.
4. Differentiate between Osmosis and Plasmolysis.
5. List the advantages of Plasmolysis.

3.1.1 Cell Activities

You have seen earlier that cells can exist singly and collectively as in advanced organism like plant. For the organism to become tall or fat or big, series of cell activities must have taken place. This is called cell processes. Each cell formed becomes a permanent structure of a plant. The cell may die, as long as it has not been broken off it is part of the plant.

Cells are formed from the meristem of a plant, and they are formed by cell division. The terminal end of the stem, root, (shoot and root) are regions where cell division take place. As cell divide, the meristem is pushed ahead, adding increase (both in the shoot and root) and the diameter also increases.

3.1.2 Cell Division

You have learnt that cell give birth to cell. A cell must be existing to give birth to another cell. Biologist refer to that s `Cell coming from pre-existing cell.' Cells multiply to keep the organism growing (increase). Even where the organism has substantially stopped growing, cells still multiply to renew old and dead cells. Cell division is very active at the tip of a typical plant (Apex).

Two processes are involved, (a) the nuclei content becomes twin inside and divide. They divide from each other, the DNA of the cell also separate (as the nuclei divide) the DNA materials also divide so that, as the nuclei is separating the divided contents also separate. The biologists call this Mitosis. (b) This is the separation of the cytoplasm and biologists call it <u>cytokinesis</u>. Now the cytoplasm also divide and separate. There are two cells now, each has its own cell wall.

3.1.3 Mitosis and Cytokinesis

Let us examine what really happens during cell division. There are six phases: (look at the following drawings

Figure (3.I)

1. Interphase	2. Prophase	3. Metaphase
5. Telophase	6. Interphase	

Phase 1 Interphase, a cell nuclei can be seen in the middle of the diagram.

Phase 2 Prophase, the chromosome shorten, thickens and coil, revealing a paired nature. A clear zone develops around the nucleus. The nucleus suddenly contracts. The nucleolus dissolves and the nuclear membrane disappears.

Phase 3 Metaphase, chromosome reach their maximum contraction. Each chromosome is made up of two parts, each half termed chromatid. The highly coiled structure of the late prophase and metaphase chromosome involves intertwined helices, which must unwind and become separated during anaphase. At metaphase the spindle is present and composed of individual spindle fibres, one of which appears to be attached to each chromosome at its kinetochore: the chromosomes and the fibrous spindle-comprises the <u>mitotic apparatus</u>.

Phase 4 Anaphase, the chromatids separate and the chromosomes move toward opposite poles with the kinetochores, which are the site of spindle attachment, leading the chromosome movement.

Phase 5 Telophase, the chromosomes return to their dispersive state, the nuclear membrane reforms, the nucleolus reappears, and the nucleus enters the interphase condition.

Phase 6 Interphase, two nuclei are reconstituted where there had been one before, each nucleus having the same number of chromosomes as the one from which it was derived.

Source: Adapted from Torrey, J.G. (1987) "Development in Flowering Plants."

In the above process, i.e. the division of a cell, the nuclei first divide (mitosis). The division of the cytoplasm which surrounds the nuclei follows. The cytoplasm divides and separates from each other resulting in two different cells (cytokinesis). You have just seen one aspect of cell division. Later on you will see another aspect of cell division. The second type of cell division is called Meiosis. It is different from Mitosis. Meiosis is mentioned here because it is part of cell activity. You will meet full detail of Meiosis as you continue to study other topics in this module. We will continue to look at other cell activities like Osmosis and Plasmolysis.

3.1.4 Osmosis

You must have heard the word Osmosis. In most cases, the word is used wrongly. When the biologist says Osmosis, he is simply saying that water passes through some membrane. What are membranes? Instead of defining membranes, let us illustrate it. for instance, if you have solution of a kind and want to separate it from another solution by `something in between' (what we call membrane now), say solution of sugar is to be separated from ordinary water. The membrane is the structure that allows the molecules to pass from one solution to the other. The membrane allows the passage of the smaller molecules to pass through freely but does not allow the bigger molecule to pass through easily. The membrane is said to be selective. When a membrane allows selective passage, it is called semi-permeable or differentially permeable. Examples of semi-permeable membranes are fish or animal bladder, egg membranes.

In plant cell, the ectoplasm (not the cell wall) act as the differentially permeable membrane. When weak and strong solutions are separated by such a membrane, there is a net transfer of the solvent from the weaker solution to the stronger solution.
Osmosis is the process of selective transmission of a liquid in preference to another or a solvent in preference to the solute through a semi-permeable membrane . You will learn more about the exact process, but for now know that this process is made possible by the cell.

3.1.5 Plasmolysis

The knowledge you have acquired from the cell activity in Osmosis will allow you to explain many processes in biology. For instance if you put a fruit that has dried up inside water, after many hours the fruit would have swollen up. What has happened is that (as you learnt earlier) water has moved through the cytoplasm to swell the fruit. You can also put a normal healthy fruit into concentrated solution of salt and leave it for hours, on examination you will discover that water has moved from the fruit into the concentrated solution. The fruit now will look placid, and squeezed. We are talking about a whole fruit.

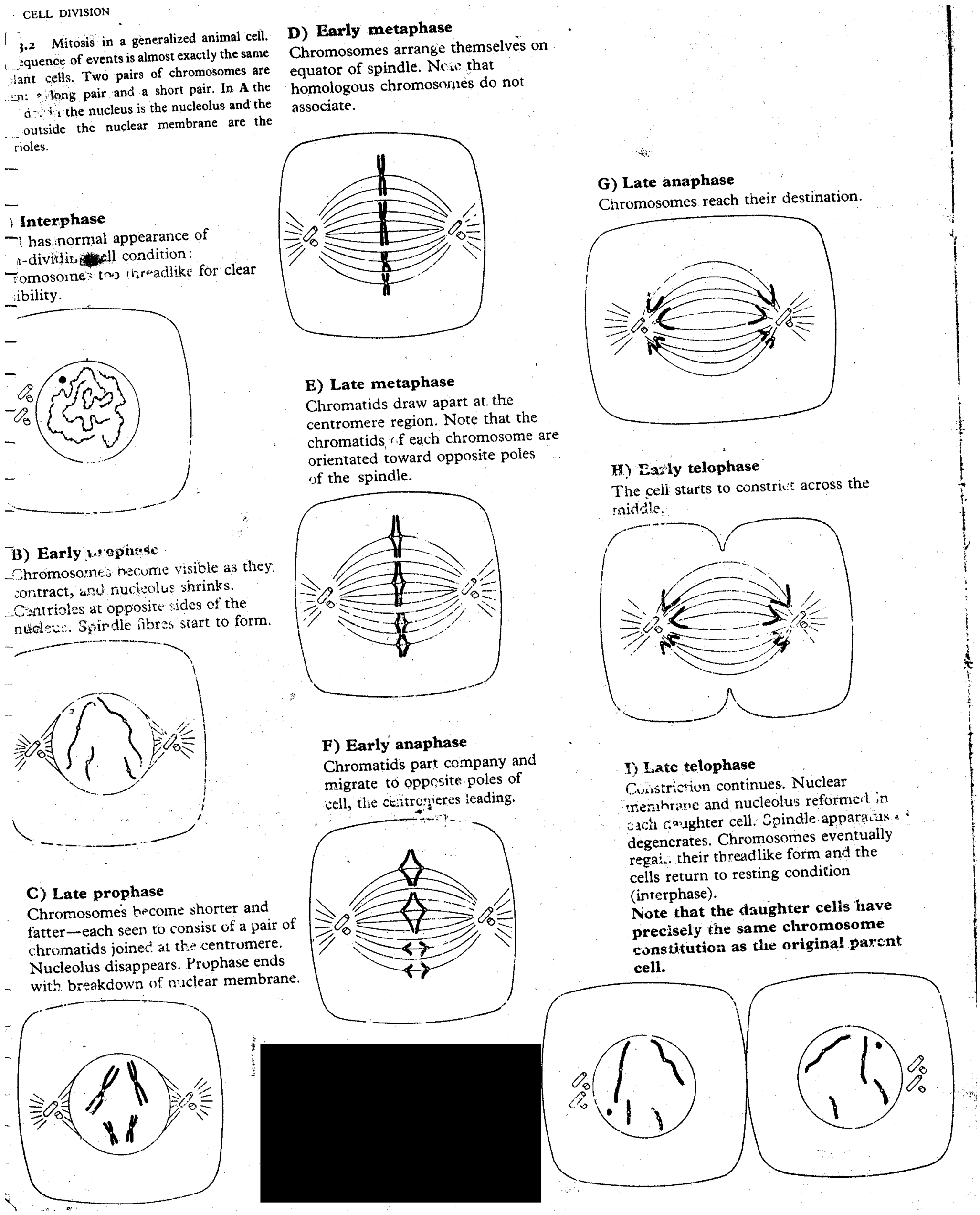


FIG 3.1 CELL DIVISION

If we take a cell and observe it under a microscope under the two conditions, i.e. condition (a) - cell in a very strong solution.

(a) Put the healthy, normal cell in a concentrated solution and observe it, it will loose water to the surrounding environment (i.e. the concentrated solution) and look shrinked, contracted, the protoplasm with the nucleus and the plastids will shrink from the cell wall, forming a rounded irregular mass in the centre. The space between the cell wall and the protoplasmic mass will be filled with sugar solution. The cell wall is the one that is freely permeable to the solution. The protoplasmic membrane is selectively or indifferentially permeable to the solution. Why did the protoplasm shrink? The reason is that the concentrated solution has a greater osmotic value than the cell-sap. The cell looses water by outward osmosis. This process of the cell protoplasm shrinking from the cell-wall under the action of concentrated solution is called plasmolysis

(b) Condition b is that, if this same cell is placed in a pure water solution, the reverse will happen, i.e. the protoplasm will return to its normal position. The reverse is deplasmolysis.

3.1.5.1 Advantages of Plasmolysis

(a) Explains Osmosis
(b) Shows permeability of the cell-wall and semi-permeability of the outer layer of the protoplasm(cytoplasm) to the entrance of certain substances.
(c) Shows that the protoplasm can retain the osmotically active substance of the sap.

3.2 Conclusion

In this unit, you have learnt that the cell as tiny as it is, carries out various activities like cell division Osmosis and plasmolysis which come into the cell or go out of the cell depending on the condition of the surrounding environment of the cell.

3.3 Summary

Cell activities include cell division. Cell division leads to cell increase or growth. There are two types of cell division: Mitosis and Meiosis. Osmosis and plasmolysis are part of cell activities. Plasmolysis has some advantages explaining cell activity like Osmosis.

3.4 TMA (attached)

3.5 References

Unit 4

Viruses

4.1.0 Introduction

Viruses are extremely small organisms. They are even smaller than bacteria. You know that you cannot see bacteria with your naked eyes. You can see bacteria with an optical microscope but you cannot see virus with optical microscope. There is a kind of microscope called electron microscope, it uses electron beam instead of light. With this kind of microscope you can see viruses. In this unit you will learn how scientists came to know about the existence of viruses, their way of behaviour and why it is difficult to treat them. It is difficult to say you are given a particular kind of drug to someone suffering from a disease caused by viruses. Example is the HIV virus.

4.2.0 Objectives

By the time you go through this unit, you will be able to:

(a) Draw a generalized virus
(b) Discuss virus as agents of disease
(c) Discuss the process of HIV infection
(d) List diseases caused by virus and those caused by bacteria
(e) Locate the place of virus among living organisms given a flow chart
(f) List the characteristics of a virus
(g) Draw the structure and life cycle of a retro virus, HIV
(h) Discuss how HIV is transmitted
(i) List Some treatments of HIV-AIDS

4.3.0 Discovery of Virus

Some tobacco plants infected with mosaic disease were crushed, the juice was passed through a very fine filter. The filter was fine enough to trap bacteria. The filtrate which was supposed to be pure was applied to a healthy leaf of a healthy plant. The disease Mosaic was induced in the leaf. This baffled scientists, before this time they knew about bacteria and they knew that bacteria can be filtered using a very fine filter. It then means there are other disease causing organisms that are tinier than bacteria. Later on, you will discover that the diseases caused by viruses are different from diseases caused by bacteria. When you look at the characteristics of viruses, you will see why the viruses can pass through the fine filter. Locate the place of viruses in the table (4.1) among living organisms.

Table 4.1 Classification of Living Organisms

		Eukaryotae Eukaryotes	**Non-**		**Viruses Cellulare**
Prokaryote					
Prokaryotes Bacteria	Protoctista Protoctists	Fungi	Plantae Plants	Animalia animals	
		Heterotrophic	Autotropic	heterotrophic	
		Non-motile	Non-motile	motile	
Predominantly unicellular			Predominatly multicellular		

Source: Taylor et al P. 7

4.3.1 Characteristics of Viruses

Viruses can not be seen with the naked eye. Neither can they be seen with a light microscope because of their sizes. That is why they can pass through a very fine filter. Look again at table 3. Take note of the place of viruses among the kingdom of living organisms. They are on their own. They do not have cell structure. They can not increase except by living inside another living cell. When an organism lives and depends on another organism for its activities, that organism is said to be a parasite. Viruses are parasites because they live in another living cells. While living in other living cells, they cause harm or what medical science refers to as disease. Viruses have very simple structure.

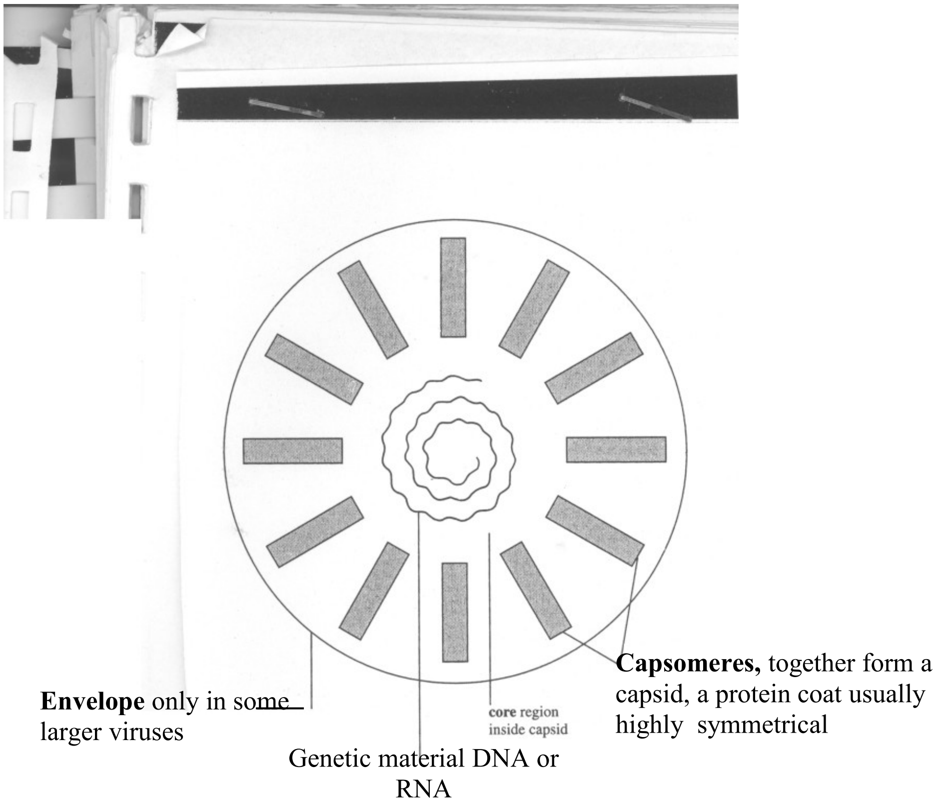


Fig. 4.1: A generalized Virus.
Source: Adopted from Taylor et.al.

The structure of virus consist of either DNA or RNA, (You will get to know more about RNA and DNA) surrounded by a protein or Lipoprotein coat. Viruses are parasite and live only in another living cell, But they choose the cell they live in i.e they are specific to their host. They cannot reproduce outside their host cell. It is believed that virus evolved after cells evolved.

ACTIVITIES

Your tutor will help you to look at a bacterium under a light microscope. Take a very good look at the slide of a bacterium. A virus is 50 times smaller than a bacterium. Can you now see how smell a virus is?

4.3.2 Life Cycle of Virus

You have heard about HIV-AIDS, it is caused by a virus. Let us look at the way an HIV virus reproduce. Figure 4.2 this is the life cycle of a virus.

Carefully study this diagram.

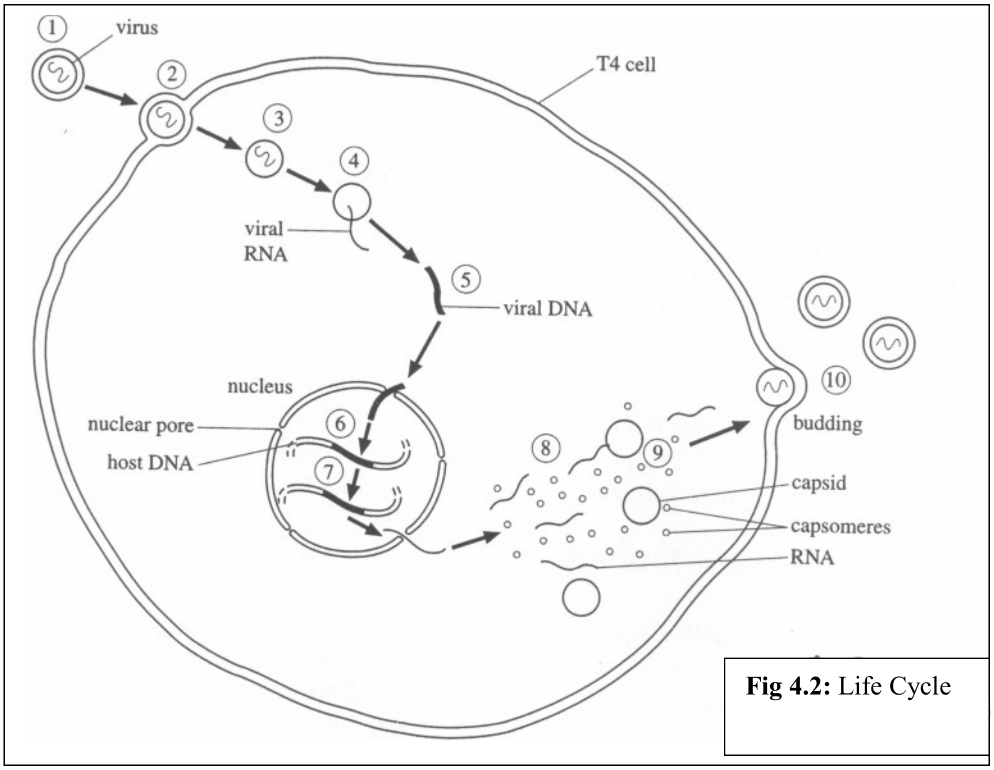


Fig 4.2: Life Cycle

Fig 4.2 Life Cycle of the HIV Virus

(1) Virus approaches

(2) Virus glycoprotein attaches to a specific receptor protein in the cell surface membrane.

(3) Virus enters the cell by endocytosis.

(4) the viral RNA is released into the cytoplasm of the host cell, together with the enzyme reverse transcriptase.

(5) A double-stranded DNA copy of the single-stranded virus RNA is made using reverse transcriptase.

(6) The DNA copy enter the nucleus and inserts itself into the host DNA. Whenever the cell divides, it also makes a copy of the viral DNA. Increasing the number of infected cells.

(7) After a period of inactivity know as the **lantency period**, which lasts on average 5 years, the virus becomes active again. The stimulus for converting a latent virus into an active virus is poorly understood.

(8) New RNA is produced (transcription) and viral proteins are made using the host's protein synthesizing machinery.

(9) New viral particles assemble.

(10) Virus particles bud off from the cell surface membrane of the host by exocytosis.

(11) The cell eventually dies as a result of the infection.

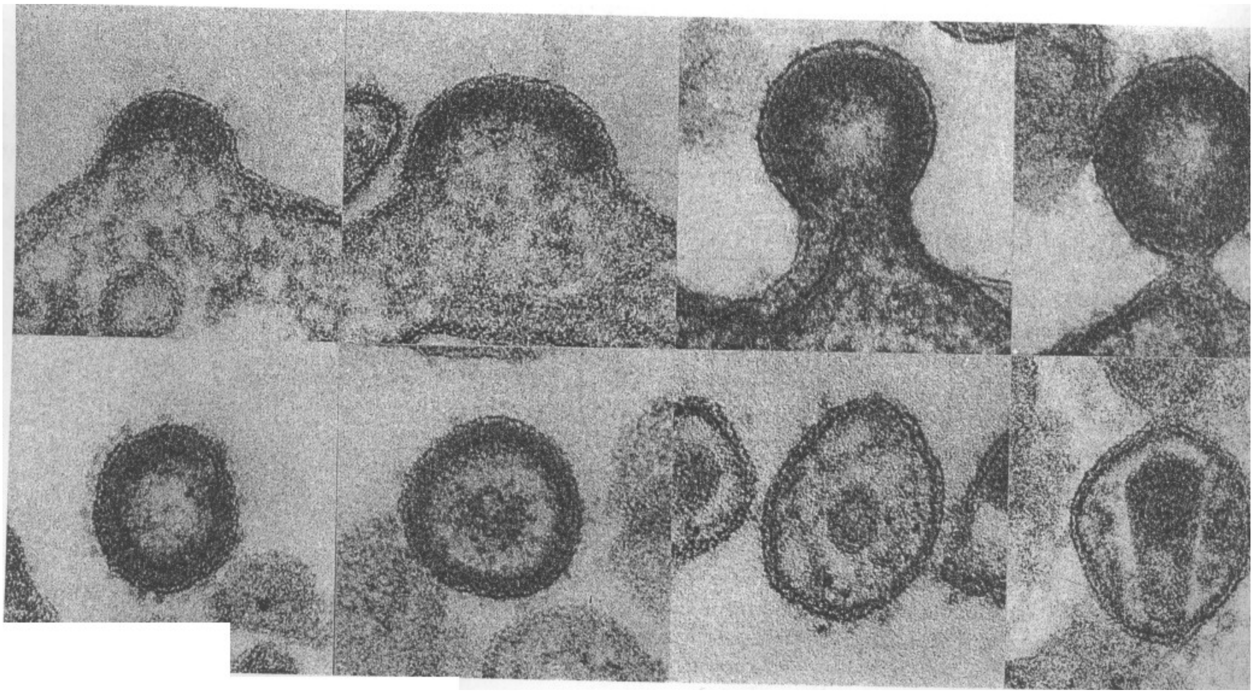


Fig 4.2.1 : HIV Emerging from infected cell.

Source: Adopted from Taylor et. al. p 24

Fig 4.2.2: *Some simplified diagrams of viruses showing different sizes and symmetry. The T2 phage is shown with its tail fibres released prior to infection; the λ (lambda) phage does not have tail fibres.*

HIV or human immune-deficiency virus is the virus that causes AIDS (Acquired Immune Deficiency Syndrome). The interesting thing about HIV virus is that it belongs to a group of RNA viruses known as Retroviruses. This name comes from the fact that these viruses can convert their RNA back into a DNA copy using an enzyme known as reverse transcriptase. Normally a section of DNA (a gene) is copied to make RNA, a process called transcription, and the enzyme controlling it is called reverse transcriptase. The virus infects and destroys certain white blood cells called T. Helper Lymphocytes, thus crippling the immune system.

4.3.3 The Processes

Follow the diagram figure 4.2

(a) Virus approaches a T4 lymphocyte cell.

(b) Virus glycoprotein attaches to a specific receptor protein in the cell surface membrane. (c) Virus enters the cell by endocytosis.

(d) The viral RNA is released into the cytoplasm of the host cell, together with the enzyme reverse transcriptase.

(e) A double stranded DNA copy of the single stranded virus RNA is made using reverse transcriptase.

(f) The DNA copy enters the- nucleus and inserts itself into the host DNA, Whenever the cell divides, it also makes a copy of the viral DNA, increasing the number of infected cells.

(g) After a period of inactivity known as the latency period, which lasts on average of 5 years, the virus becomes active again. The stimulus for converting a latent virus into an active virus is poorly understood.

(h) New RNA is produced (transcription) and viral proteins are made using the host's protein synthesizing machinery.

(i) New viral particles assemble.

(j) Virus particles bud off from the cell surface membrane of the host by exocytosis.

(k) The cell eventually dies as a result of the infection.

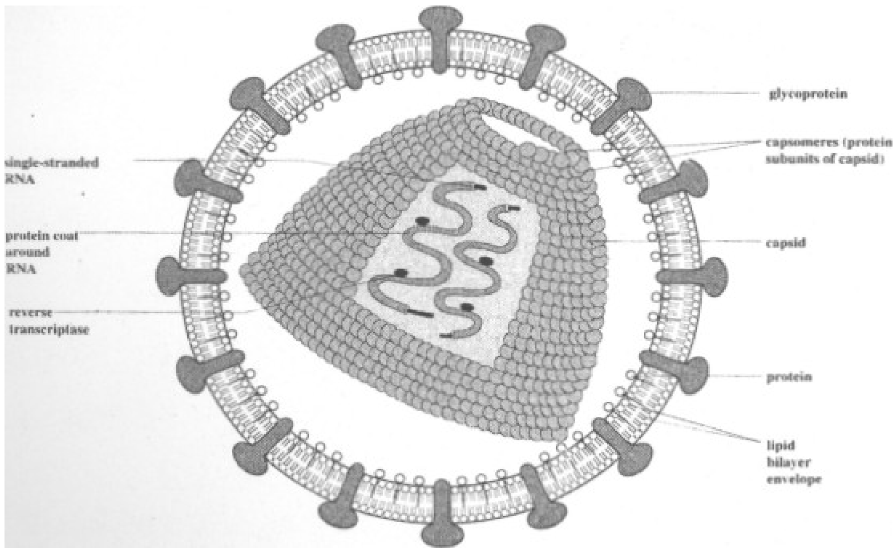
4.3.4 Growth

The virus you saw earlier are not like bacteria. The way you will observe the growth of bacteria in a culture is different from that of the virus. Why can you not grow and observe virus in a culture? You learnt that they grow inside another cell not on their own. Scientists have been making use of this knowledge to culture viruses inside chick embryo. It is grown in petri dishes incubated in sterile room. The process is called cell culture.

4.3.5 HIV-AIDS VIRUS

AIDS- Acquired Immune Deficiency Syndrome

It is a disorder which damages the human body's immune system. It is caused by the HIV (Human Immuno-deficiency Virus)



Source: Taylor *et. al. (1998) p 22*

Fig 4.3: *Structure of the HIV virus, an example of a retrovirus. The cone-shaped capsid is made of a helical spiral of capsomeres. It is cut open to reveal the two copies of the RNA genetic code. Reverse transcriptase is an enzyme which converts single-stranded RNA into double-stranded DNA copies. The capside is enclosed in a protein shell which is ancho in a lipid bilayer, or envelope, obtained from the cell surface membrane of the previous host cell. This envelope contains glycoproteins which bind specifically to helper T-cell receptors, enabling the virus to enter its host*

4.3.6 Transmission

When an individual, even animal (e.g. goat) is infected with virus, that person's or animal's surrounding is saturated with virus. When someone with flu sneezes, he releases trillions of viruses. Any healthy person around contacts the virus. There are three main routes of transmission.

a Physical contact, through blood or semen, e.g. vaccinia virus in AIDS.

b Axial droplets of virus bearing dust particles, e.g. respiratory viruses that cause common colds - influenza A, B and C.

c Faecal-oral transmission, e.g. polio virus and gastroenteritis. Table 4.2 gives examples.

Table 4.2 - Material and route of infection of some human viruses, which are transmitted directly

Viruses	Source	Material	Model route of infection
Proviridae Variola, Vaccinia	Skin	Dried crust scales	Intimate contact Air at Close range
Herpes viridae	Skin	Vesicle fluid	Intimate contact
Herpes virus, type I and II		(Mucosae)	Skin, genitalia
Vercella-zoster		Vesicle fluid (crusts)	
Respiratory Viruses: Influenza A, B and C.	Nasopharynx	Nasopharyngeal secretions or sputum or saliva	Airborne droplets fingers handkerchiefs
Parainfluenza 1-4 Respiratory syncytical (RS), Rhinovirus, corona virus, Adenovirus	Nasopharynx	- do -	- do -
Systemic viruses measles, rubella, mumps	- do-	-do-	-do-
Herpes viridae: Herpes virus type I Cytomegalo virus, EB virus Varicella – Zoster	Faeces	Faeces, sewage	Faecal-oral to mouth via fingers
Picomaviridea, entero virus, polio virus, I, II, III Coxsackie A & B	Faeces	Faeces	Contaminated water & food transmitted through flies
Adenovirus Hepatitis A Gastroentritis Virus Rato virus Intestinal corona virus	Blood	Blood serum	Faecal-oral
Inoculation Hapatitis B, Cytomegalo virus Congenital, Rubella	Blood	Blood products	Direct inoculation (syringes) Contaminated cuts, etc.
Cytomegalo virus Variola, Vaccinia Varicella	Maternal	Maternal blood	Transplacental

Source: Topley and Wilson's Principles of Bacteriology, Virology and immunity, (7th Edition) Vol. 4

4.3.7 Transmission of HIV

You have learnt about viruses. HIV is just an example of viruses. You learnt that HIV virus like any other virus cannot survive on its own, except in another cell or body fluid. HIV virus was discovered among homosexuals, it could also be transmitted in heterosexuals. The virus passes in the fluid of the affected person to the fluid of the unaffected person. Example is the semen, blood or for the homosexuals, anal intercourse.

The linings of the anus are very fragile, the vessels break easily, and the semen therefore passes to the blood in the lining of the anus.

Many people share needle, that is drug users or nurses who use the same needle for different people. AIDS can be contracted through needles.
Many people contract AIDS through blood transfusion. If donor's blood is infected, the recipient contracts the disease. Close contact between infected and non-infected person, through open cuts, and open wounds is another avenue of transmission.
Mothers pass on the virus to their babies through childbirth, through the placenta, or breastfeeding.

4.3.8 Process of HIV Infection

Taylor et al (1998) gave five stages of HIV infection in the body, i.e. after infection.
<u>Stage I:</u> After infection, most people remain symptom free for years, while some may develop symptoms like fever, reduction of T helper cells in the blood and skin rash. The body produces its own anti-bodies against HIV. This can be detected on examination. This stage is between two weeks to 3 months. The fact that some one went for a test and it is negative is not an absence of the virus. It may take between two to ten years before the disease is full blown. When infection occurs, the body produces anti-HIV antibodies. It takes up to three months before antibodies are produced.

4.3.8.1 HIV-AIDS Five Final Stages

I Presence of HIV antibodies in the blood but T. helper cell number in the blood is normal.

2 Presence of HIV antibodies in the blood, T helper cell number in the blood is normal but
chronic lymphadenopathy detected.

3 HIV antibodies present, number of T helper cells in the blood decreases and chronic lymphadenopathy may be there.

4 HIV antibodies present, number of T helper cells in the blood decreases and delayed type of hypersensitivity reaction (DTH) is also suppressed.

5 HIV antibodies present, number of T helper cells in the body decreases, complete loss of delayed type of hypersensitivity (DTH) reaction and appearance of fungal infection in mouth.

4.4 Treatment And Prevention of HIV-AIDS Virus

When one goes for test, essentially what is done is that a sample of blood is taken and mixed with HIV proteins already prepared for the purpose. The test is positive if the blood already has anti-HIV antibodies by binding to the viral proteins. Unlike bacteria, antibiotic cannot be used to treat HIV-AIDS due to the nature of the virus. What is the nature again? You were told that they live in cells of organisms not on their own. For now, scientists (doctors) try to relieve the symptom on sufferers. Taylor et al gave three areas of research aimed at prevention and treatment. They are:

1. Restoring, or improving the damaged immune system of victims.
2. Developing drugs that will stop the growth of the virus and also treat the other infections and symptoms that result from HIV infection.
3. Developing a vaccine against the virus. There are other infections (secondary) associated with HIV infection, table 4.3 (see attached).

4.5 Drugs

Many retroviral drugs have been developed. These are Azidothymidine (AZT), Zalcitabine Glycyrrhizin and Ribavirin. The success of these drugs are still been determined. The best way to prevent the disease is to look at how the disease can be contracted and avoid them.

Table 4.3 secondary Infections associated with HIV Infection

Type of Infection and cause	Signs and symptoms
Protozoal Infection	
Pneumonia caused by Pneumocystis Carinii (PCP or Pneumocystosis).	About 60% of individuals contract pneumocystosis as the first AIDS-related infection and it is the most common cause of death in AIDS. Normally the immune system would keep this infection at bay, but in HIV patients life-threatening pneumonia develops. Treatment is by the drug co-trimoxazole
Cryptosporidiosis cause by a small protozoan in the water supply.	In patients whose immune system damaged, the population of protozoa in the gut rises to high levels and causes diarrhoea. There is great loss of fluid and intravenous fluid replacement is needed.
Toxoplasmosis caused by a protozoan (often associated with cats and raw meat)	Infection can cause leisions in the cerebrum of the brain. The patient

	lapses into paralysis and unconsciousness.
Viral Infections (only most common Shown)	
Herpes simplex virus Cytomegalovirus	Also associated with ARC
Cytomegalovirus (CMV)	In HIV-related illness causes retinitis when the patient may rapidly become blind.
Bacterial Infections	
Tuberculosis (TB)	See section 15.3.2
Salmonellosis	This infection is commonly associated with food poisoning, and is particularly dangerous to AIDS patients who should avoid undercooked foods, particularly eggs and poultry (See section 15.3.6)
Fungal Infections Candidiasis	This is a virulent infection in AIDS patients, and may extend from the mouth down the alimentary tract. (See Table 15.6)
Secondary Cancers (Neoplasms)	Kaposi's sarcoma (KS) A purplish skin cancer was one of the first manifestations of AIDS in the Western World. Not seen in all patients, but when present can be extremely disfiguring, especially if on the face. May develop internally and cause obstructions in the gut.

4.6 Conclusion

In this unit, you have learnt about the nature of virus and the properties and characteristics, with particular reference to the HIV-AIDS virus. The process of infection and stages of development.

4.7 Summary

Virus is about 50 times smaller than bacteria, virus cannot carry out activities on its own like a cell. It lives in other living cells and thrives in such cells. It is non-cellular. Viruses do not have cell structure. They are difficult to culture even through they have been cultured in chick embryo. You have seen how the HIV virus can be transmitted. There is no known method of treatment yet, even though some drugs have been developed and are being tried. The best method so far is prevention. Avoid all means of contracting the virus.

4.8 **TMAS** - Mention two ways each by which HIV-AIDS can be prevented or treated.

4.9 References *Taylor et al (1998) Biological Science Cambridge University Press

4.10 Further Reading

Read books on immunology Diseases and Microbs

Unit 5

Prokaryotes and Eukaryotes Cells

5.0 Introduction

In this unit, you will study about organism, which are different from the ones you are familiar with. The aspect you are going to study are Prokaryotes (they are unicellular). The fungi and the algae (part of Eukaryotes) they are mostly multicellular. The fungi undergo a kind of nutrition called heterotrophic, they do not move. Their food is digested outside their bodies and the products of the digestion are absorbed. Most algae use sunlight to make their food. Prokaryotes are one single cell organisms. You are familiar with bacteria they belong to this group.

5.1 Objectives

By the time you complete this unit you will be able to: 1. Differentiate Prokaryotes from Eukaryotes

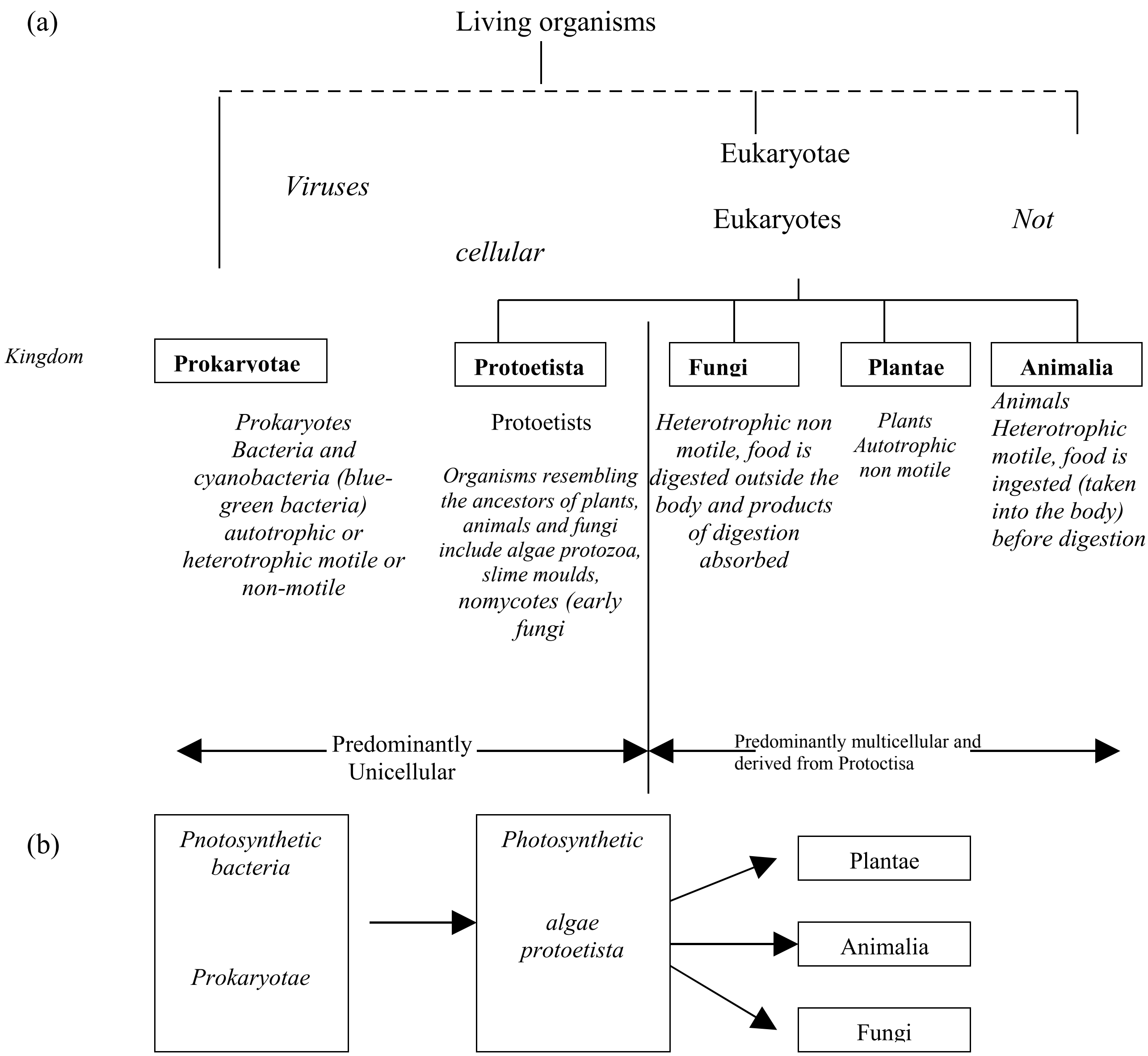
2. List the characteristics of each of the groups
3. Give examples of each group
4. Draw and label the examples of each group correctly
5. Describe the mode of nutrition in each group
6. Explain in your own words what Prokaryotes and Eukaryotes mean

5.2.0 Meaning of Prokaryotes and Eukaryotes
5.2.1 Bacteria as an example of Prokaryotes
5.2.2 Structure of bacteria
5:2.3 Types of bacteria
5.3.4 Nutrition in bacteria
5.2.5 Reproduction in bacteria and population growth
5.2.6 Bacteria opportunistic inflection
5.2.7 Summary
5.2.8 Conclusion
5.2.9 TMA
5.2.10 References Further reading

5.0 Meaning of Prokaryotes and Eukaryotes

Until 1982 it was usual to classify all organisms under two in doms. This classification presented a number of problems that Margulis and Schwartz resolved by proposing a five-kingdom classification. Examine table 5.1 closely to see the classification. Table 5.1 These terms refer essentially to the differences in the location of the DNA. All cellular organisms fall within either of these groups. The term Prokaryotes is used to describe cells in which the DNA lies free in the cytoplasm and is not enclosed by nuclear membrane. Eukaryotes evolved from prokaryotes and they contain true nuclei. From table 5.1 it can be seen that eukaryotes belong to a super kingdom called Eukaryotae. Examine table 5.1 for further comparison of the major difference between prokaryotes and eukaryotes.

Table 5.1



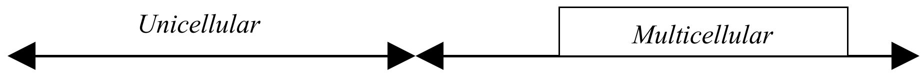


Table 5:1 Classification of organisms under 5 Kingdoms.

5.1 Bacteria as an example of Prokaryotes

Bacteriology is that important branch of microbiology which is concerned with the study of bacteria. Bacteria are the most ancient group of organisms that appeared about 3,500 million years ago. They have a cellular structure but cannot be identified either as animal or plant, but they are often included with fungi. Bacteria range in size from a length of 0.1 to I Oum and an average diameter of about 0.1 um. They can be found in such environments as soil, dust, water, air, on and in plants and animals. Bacteria fall into the group of smallest organisms called microbes.

Some bacteria can survive at very high temperatures of up to 360-degree centigrade or very low freezing temperatures. Their numbers are enormous and with fungi, their activities are crucial to all other organisms. They are responsible for decay of organic matter and subsequent recycling of nutrients. Even though they cause disease, they are of increasing importance to humans because they can be used in many biotechnological processes.

Fig 5.1a: *Structure of a generalized rod-shaped bacterium (a typical prokaryote cell).*

5.2.2 Structure and type of bacteria

Examine closely figure 1, which describes the structure of a bacterium.

Cell Wall: Contains a molecule of murein made up of polysaccharide chains that are cross-linked at regular intervals by short chains of amino acid. This makes the cell wall strong and rigid. Thus each cell is bounded by a net-like sac. Even though its tiny pores allow the passage of water, ions and small molecules the rigid wall prevents it from busting. Bacteria fall into two groups according to their wall structure - - Gram positive and Gram negative. Christian Gram (1884) was the biologist that developed the stain, which led to this classification. The murein net of Gram positive bacteria is filled with polysaccharides, and proteins to form a relatively thick wall. The walls of Gram negative bacteria are thinner, but their outer layer is coated with a smooth, thin membrane-like layer of lipids and polysaccharides. This serves as a protector from Iysozme and anti-bacteria enzyme. Gram negative bacteria are resistant to penicillin because of this outer layer.

Cell Surface Membrane: This is the partially permeable membrane that surrounds the living material of the bacterial cell. Respiratory enzymes are located here. In some bacteria it forms mesosomes and/or photosynthetic membranes.
Mesosomes: These are infoldings of the cell surface membrane. They perform a major role during cell division. They assist in the formation of new cell cross-walls between the daughter cells. Ribosomes: These are the locations where protein synthesis takes place.

Capsules: When the background of a bacteria specimen is stained slimy or gummy secretions around)the cell becomes clear. They make up the capsule, which enable bacteria to stick to surfaces. They provide additional protection to the bacteria.

Flagella: They are fine hair-like protein fibrils that serve as organs of locomotion. There are four ways in which flagella may be arranged. See drawing for types.

a. Monotrichate - a flagellum at one end of the cell, e.g. cholera vibrios.
b. Amphitrichate - a flagellum at each pole of the cell, e.g. alcaligene faecales.
c. Lophotrichate - a cluster of flagella at one end of the cell, e.g. pseudomonas.
d. Peritrichate - several flagella spread around the cell surface, e.g. typhoid bacillus.

- Pili (singular pilus): also known as fimbrial (see figure 5.1a,) are shorter and thinner than flagella. The female pilus type is involved in sexual reproduction.
- Plasmids: small, self-replicating circle of extra DNA with a few genes but provide extra survival advantage.
- Cell shape: the four main types are shown in fig 5.1b

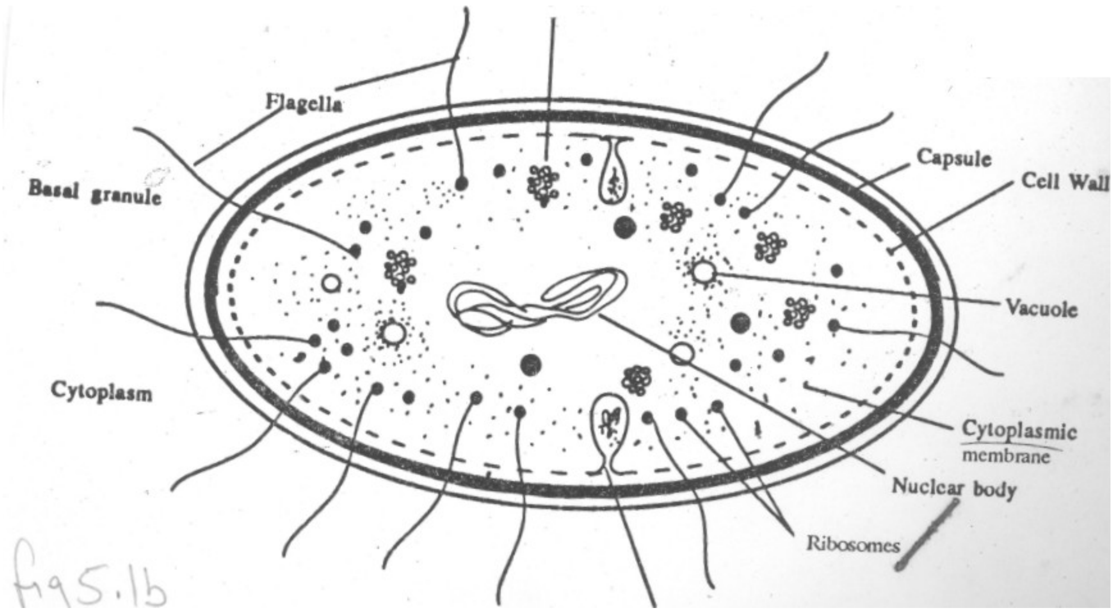


Fig 5.1b: ***Schematic diagram of a Bacterial Cell (Highly Magnified)***

Table 51: **Major differences between prokaryotes and eukaryotes.**

Feature	**Prokaryote**	**Eukaryote**
Organisms	Bacteria	Protoctists, fungi, plants and animals
Cell size	Average diameter 0.5-10ɥm	10-100ɥm diameter common; commly 1000-10000 times volume of prokaryotic cells
Form	Mainly unicellular	Mainly multicellular (except Protoctista, many of which are unicellular)
Evolutionary origin	3.5 thousand million years ago	1.2 thousand million years ago, evolved from prokaryotes
Cell Division	Mostly binary fission, no spindle	Mitosis, meiosis, or both; spindle formed
Genetic Material	DNA is circular and lies free in the cytoplasm (no true nucleus). DNA is naked (not associated with proteins or RNA to form chromosomes)	DNA is linear and contained in a nucleus. DNA is associated with proteins and RNA to form chromosomes.
Protein synthesis	70s ribosomes (smaller) No endoplasmic reticulum present (Many other details of protein	80s ribosomes (larger) Ribosomes may be attached to endoplasmic reticulum

	synthesis differ, including susceptibility to antibiotics, e.g prokaryotes inhibited by streptomycin)	
Organelles	Few Organelles None are surrounded by an envelope (two membranes). Internal membranes scarce; if present usually associated with respiration or photosynthesis	Many organelles Envelope-bound organelles present, e.g nucleus, mitochondria, chloroplasts. Great diversity of organelles bounded by single membranes, e.g Golgi apparatus, lysosomes, vacuoles, microbodies, endoplasmic reticulum
Cell walls	Rigid and contain polysaccharides with amino acids; murein is main strengthening compound	Cell walls of green plants and fungi rigid and contain polysaccharides; cellulose is main strengthening compound of plant walls, chitin of fungal walls (none in animal cells)
Flagella	Simple, lacking microtubules; extracellular (not enclosed by cell surface membrane) 20nm diameter	Complex, with '9+2' arrangement of microtubules; intracellular (surrounded by cell surface membrane) 200 nm diameter
Respiration	Membranes in blue-green bacteria	Mitochondria for aerobic respiration
Photosynthesis	No chloroplasts; takes place on membranes which show no stacking	Chloroplasts containing membranes which are usually stacked into lamellae or grana
Nitrogen fixation	Some have the ability	None have the ability

5.2.4 Nutrition In Bacteria

This is the process by which bacteria acquire energy and materials. Living organisms that synthesize their organic requirement by using light are called phototrophs. Those that do so by using chemical energy are called chemotrophs. Autotrophic organisms are those that source their carbon requirement from inorganic matter. Heterotrophic organisms are those that derive their carbon source from organic matter. Refer to table for the four nutritional categories of living organisms.

Table 2: *The four nutritional categories of living organisms, according to sources of energy and carbon. Examples are given of bacteria in each category. Plants are photoautotrophic. Fungi and animals are chemoheterotrophic.*

		Autotrophic **CARBON SOURCES** Source of carbon is inorganic (carbon dioxide)	**Heterotrophic** Source of carbon is organic
Energy	**Phototrophic**	**Photoautotrophic** e.g blue-green bacteria	**Photoheterotrop**

Source	**(**Photosynthetic) light energy used		**hic** e.g purple non-sulphur bacteria
	Chemotrophic (chemosynthetic) chemical energy used	**Chromautotrophic** e.g *Nitrosomonas* and *Nitrobacter,* nitrifying bacteria involved in the nitrogen cycle	**Chemoheterotrophic** Most bacteria-all the saprotrophs, parasites and mutualists (symbionts)

Table 2

5.1.4.1 Chemoheterotrophic Bacteria

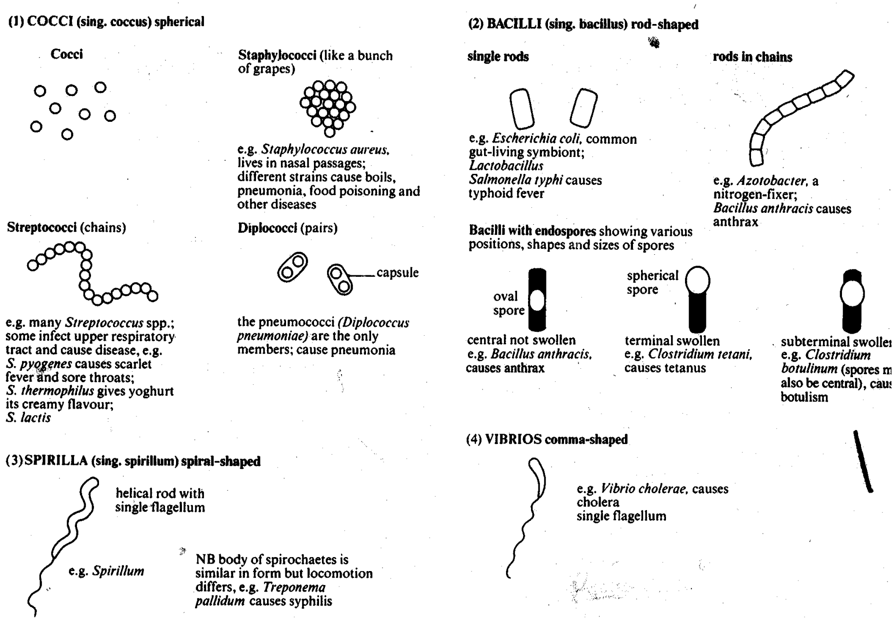
They obtain their energy requirement from chemicals in their food. There are three further subdivisions of this nutritional category of bacteria- saprotrophs, mutuatists and parasites. Saprotrophs are organisms that obtain their food from dead and decaying matter. They digest their food by secreting enzymes onto the organic matter so the digestion actually takes place outside of the organism. Thereafter the products of digestion which are soluble are absorbed and assimilated within the body of the saprotroph. This class of bacteria and fungi play a major role in the process of decay and recycling of nutrients. Therefore they are known as decomposers. They are useful in the process of producing humus from plant and animal remains. On the other hand, they cause the decay of food that is useful to humans.

Mutualists (also known as symbionts). This refers to a process in which two living organisms that have a close relationship derive mutual benefits from each other. For example, the nitrogen-fixing bacterium rhizobium living in the root nodules of legumes. Both organisms benefit from the nutrition process, of each other.

Parasites are living organisms that live in or on other organisms (called host) from which they obtain their food and sometimes shelter. Parasites that cause disease are known as pathogens. Study figure 3.4.3a once more to see some examples.
There are two types of parasites: obligate parasites and facultative parasites. The former can only survive and grow in living cells while the latter infect their host, bring about its death and continue to live on its remains.

5.2,4.2 Photoautrotrophic Bacteria

These are bacteria that carryout photosynthesis and use carbon dioxide as a source of carbon. Refer to table 3.4.5 for details. It is possible that the process of photosynthesis first evolved in blue-green bacteria. They are found on the surface layer of fresh and seawater.



Forms of bacteria, illustrated by some common useful and harmful types.

Fig 5:2

5.1.4.3 Chemoautrotrophic Bacteria

Also known as chemosynthetic bacteria, they source their carbon from carbon dioxide and obtain their energy from chemical reactions. They do so by oxidising inorganic materials like ammonia and nitrite. The nitrification process is like this:

1. BH+4 oxygen NO-2 + energy
2. NO-2 oxygen NO-3 + energy

5.2.5 Reproduction and Population Growth in Bacteria

When suitable conditions are available bacteria can grow very rapidly. The following conditions enhance bacteria growth right temperature, nutrient availability, pH and ionic concentrations. For obligate aerobes, oxygen must be present but it must be absent for obligate anaerobes.
The nucleus to cytoplasm ration determines the optimum size at which a bacteria will begin to reproduce. A bacterium may divide into two identical daughter cell. This is called a sexual binary fission. First the DNA is replicated, then copied, after that the cell division takes place. In fast growing bacteria, reproduction can take place every 20 minutes.

Primitive forms of sexual reproduction where there is an exchange of genetic material also takes place in some bacteria. The process is called Genetic recombination. Refer to figure 3.4.6 for an example of the bacterium E. Coli. Typical growth curve of a bacterial population. Taylor p. 18.

Time (in units of 20min.)	1	2	3	4	5	6	7	8	9	10
A Number of Bacteria										
B. Log_{10} number of bacteria (to one decimal place)										
C. Number of bacteria expressed as power of 2										

Fig 3

Table: Growth of a model population of bacteria

The curve in graph A is known as a **logarithmic or exponential curve.** Such growth curves can be converted to straight lines by plotting the logarithms of growth against time. Under ideal conditions, then, bacterial growth is theoretically exponential. This mathematical model of bacterial growth can be compared with the growth of a real population. Fig 2.15 shows such growth. The growth curve shows four distinct phases.

- During the **lag phase** the bacteria are adapting to their new environment and growth has not yet achieved its maximum rate. The bacteria may, for example, be synthesizing new enzymes to digest the particular spectrum of nutrients available in the new medium.

- The **log phase** is the phase when growth is proceeding at its maximum rate, closely approaching a logarithmic increase in numbers when the growth curve would be a straight line.

- Eventually growth of the colony begins to slow down and it starts to enter the **Stationary phase** where growth rate is zero, and there is much greater competition for resources. Rate of production of new cells is slower and may cease altogether. Any increase in the number of cells is offset by the death of other cells, so that the number of living cells remains constant. This phase is a result of several factors, including exhaustion of essential nutrients, accumulation of toxic waste products of metabolism and possibly, if the bacteria are aerobic, depletion of oxygen.

- Phase of decline follows if the factors that bring about the stationary phase persists or increases. These are persisting or increasing; exhaustion, toxic wastes. It can also be due to lack of nutrients or oxygen depletion of aerobes.

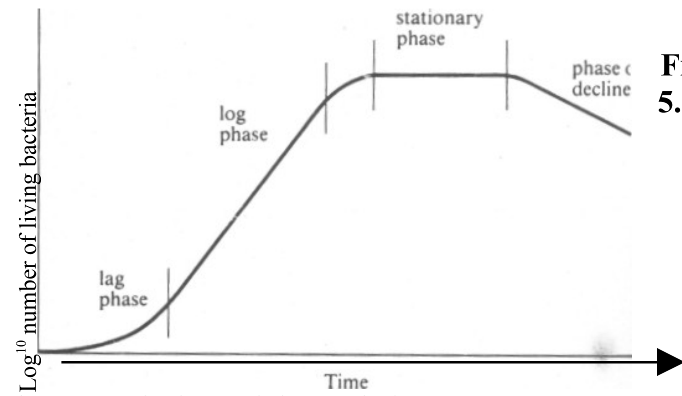


Fig 5.3:

Typical growth curve of a bacterial population

5:2.6 Bacteria Opportunistic Infection

This is a situation where a person whose immune system has been severely weakened falls prey to all kinds of bacterial infection. For example when a HIV patient enters the third phase of the development of the disease (AIDS-related complex ARC) several infections will begin to take place. The bacterial infection becomes prolonged and more difficult to treat. This happens because of the significant drop in the number of T help cells in the patient.

52.7 Conclusion

You have just gone through a unit in Prokaryotes and Eukaryotes. You have seen the differences between the two. Bacteria has been chosen as an example of prokaryotes. You have seen the structure of a typical bacterium, their way of feeding and reproduction. You have seen the differences.

5.2.8 Summary

In this unit on Prokaryotes and Eukaryotes, you have learnt that Eukaryotes evolve from Prokaryotes and they contain true nuclear. Bacteria is an example of Prokaryotes. There are different types of bacteria classified on the basis of their feeding. When condition is suitable, they multiply rapidly.

5.2.9 TMA Assignment (see attached)

5.2.10 References: An extensive reference is made of Taylor et al.

5.2.11 Further Reading. Many texts in microbiology give comprehensive presentation of bacteria.

Unit 6

FUNGI

6.0 Introduction

In unit 4, you learnt about the Prokaryotes and Eukaryotes. You learnt about bacteria as an example of the Prokaryotes. You learnt that these groups are mainly unicellular. Their cell division is mainly by binary fission, they do not have spindle. The cell walls are rigid and contain polysaccharides with amino acids; murein is main strengthening compound.
In this unit you will study Fungi. Fungi belong to the group called Eukaryotes. They are mainly multicellular. Cell division in fungi is mitosis, meiosis or both. Spindle is formed in this group.

6.1 Objectives

By the end of this unit you will be able to:

I . Draw a typical fungus and label the drawing correctly.
2. List and discuss the characteristics of a fungus.
3. Differentiate types of fungi on the basis of their nutrition, reproduction and biological importance.
4. Discuss some uses of fungi

6.2 Fungi

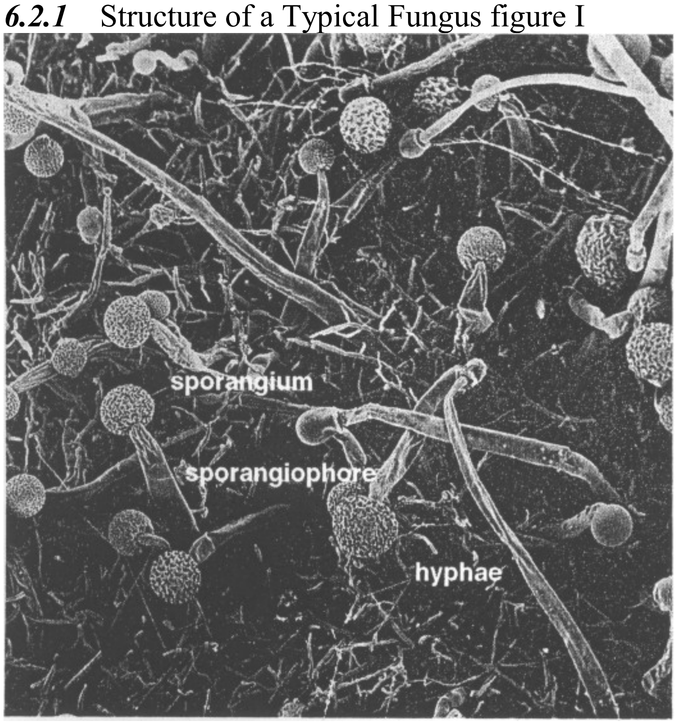
6.2.1 General description

6.2.1 Fungi General Description

Fungi are a large group of organisms. They range from unicellular yeast to toadstool, puffballs, stinkhorns. Toadstool and puffballs are a kind of mushrooms. You must have seen some mushrooms or even eaten some. Some of them are poisonous. They are very numerous, about 80,000 species have been identified. They have some benefits to man. We have just mentioned the mushrooms that are used for food. Others are used for medicine. Yeast is used as raising agents in bread baking..

You must have seen bread with some growth on it. We usually refer to such as moulds. There are different kinds of moulds. Some grow on leather products, like shoes, handbags, rotten vegetable etc. Some grow on fruits causing damage to such fruits while others grow on plants causing the disease of plant called mildews, smuts and rusts. Those who study fungi in detail are called Mycologists and the filed itself is called **Mycology.**

6.2.1 Structure of a Typical Fungus figure I



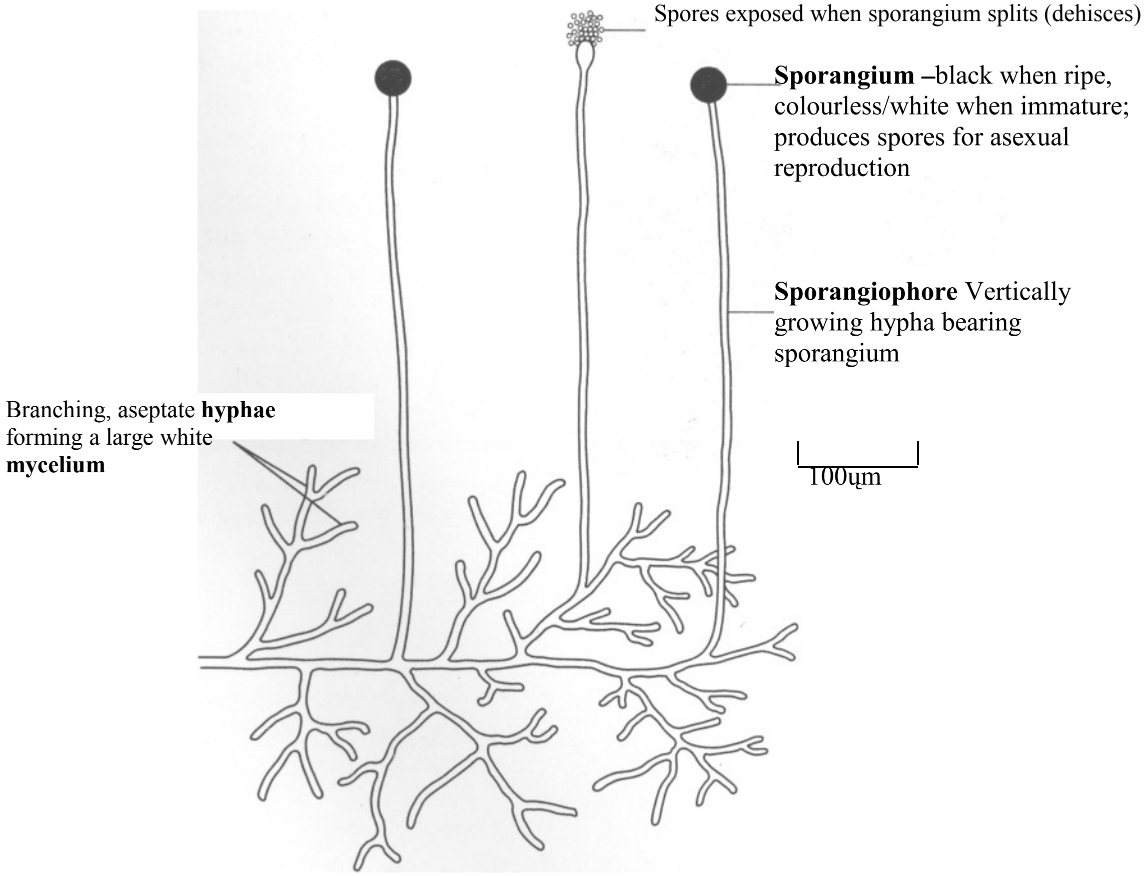


Fig 6.1: (a) A scanning electron micrograph of part of the mycelium of Mucor hiemalis showing sporangia (x 85). (b) Mycelium of Mucor as seen with low power of a light microscope.

Source: Taylor et al., (1998) p. 28

<u>Mucor</u> is a typical fungus. It is made up of <u>hyphae</u>- branches that are like twigs, a single one is called <u>hypha</u>. The hypha is hollow inside. The collection of hyphae is called <u>mycellium</u>. The structure of hyphae is segmented like, this segment is called <u>septa</u>. It divides the hyphae into compartments similar to cells, but in this case the hyphae are not divided into true cells. The hyphae contains chitin. Chitin is a nitrogen containing polysaccharide. A hypha may have cross-walls (septate) as in penicillium or lack cross-walls (aseptate) as in mucor. The cytoplasm like any Eukaryotes cell contains mitochondria, golgi apparatus, endoplasmic reticulum, ribosomes and vacuoles.

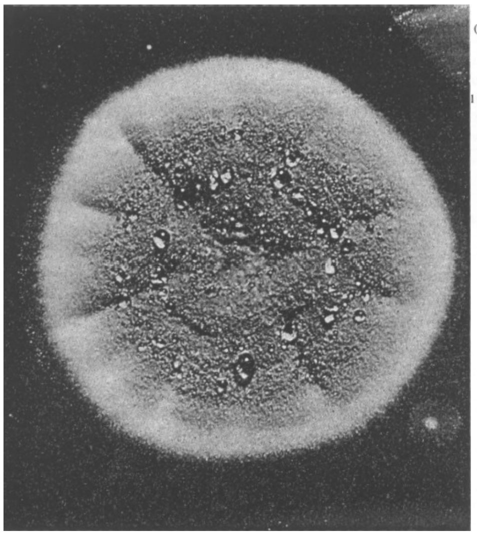
6.2.3 Types of Fungi and Nutrition

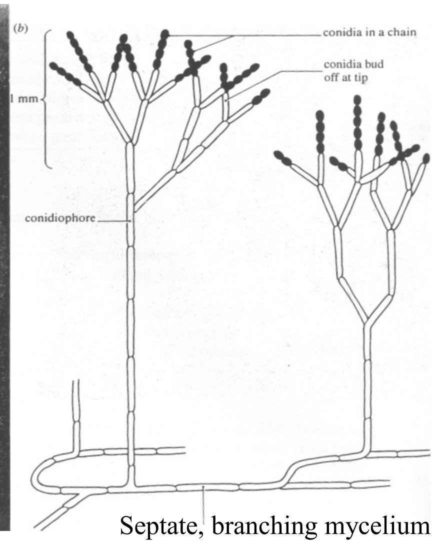
You learnt in the forgoing section that fungi have over 80,000 species. We will talk about the very common ones around us.

a. **Penicillium, Mucor and Rhizopus**-they are the ones we often see on stale bread, rotten food, etc. You do not need a scientist to culture them. If you have eba in the kitchen after two days you will find mould growing on it. If your tutor mount this under a microscope, you will notice the branching threads we call hyphae.

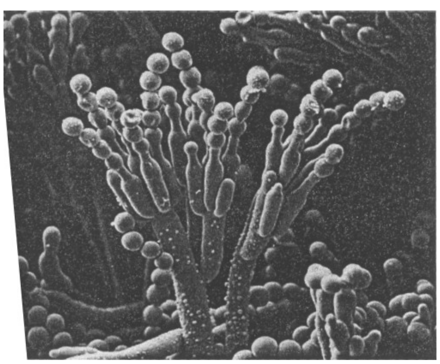
(c)

(a)





(c)



(a) Penicillium growing on nutrient agar in a Petri dish. It typically produces a relatively small circular mycelium. The young outer edge of the mycelium appears white, whereas the mature central portion appears darker where coloured spores have been produced.

(b) Penicillium showing asexual reproduction. It has a characteristic brush-like arrangement of conidia.

(c) Scanning electron micrograph of conidiophore and conidia (spores) of Pencillium. (d) LS hypha showing fine structure visible with electron microscope.

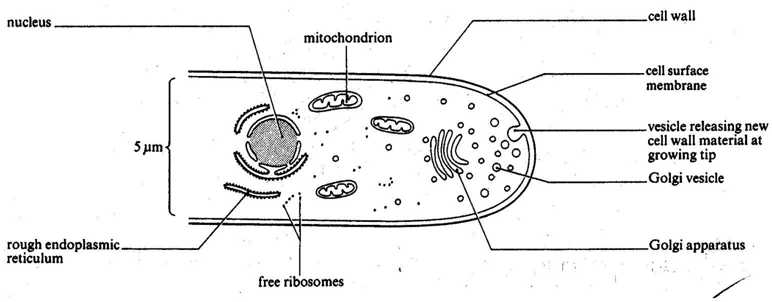


Fig 6.2

b. **Penicillium Species** - there are many types of these and they are identified by their colour - blue, green, yellow and orange. They grow on bread, ripe fruits, etc. Their colour is as a result of the mycelia. Reproduction here is by spores called conidia. When any falls on favourable surface it develops. The spores are produced at the tips of special hyphae called conidiophones. Penicillium is of special interest to scientist because they have been able to produce antibiotic from it called Penicillin.

c. **Mucor** is the common one we find around. They are the white cotton wool-like structure you see growing profusely on bread, smoked fish, etc. The structure of mucor is different from that of others. It produces spores too, like penecillium but in this case the spores are produced on a spherical sporangia borne on very long stalks known as sporangi ophores.

d. Yeast are the simplest of the fungi group because they are unicellular. Yeast can be found on ripe fruits, they give that characteristic sour smell or flavour in cereals. Yeast has a very high economic importance in the brewing industries. Yeast cells multiply by budding rapidly. Bakers use yeast to bake bread. It helps the bread to rise, i.e. by the budding process.

6.2.4 Classification and Characteristics of Fungi

Kingdom Fungi - General Characteristics
Heterotrophic nutrition because they lack chlorophyll and are therefore non-photosynthetic. They can be parasites, saprotrophs or mutualists. Nutrition is absorptive, digestion takes place outside the body and nutrients are absorbed directly. Digestion does not take place inside the body, unlike animals. Rigid cell walls containing chitin as the fibrillar material. Chitin is a nitrogen containing polysaccharide, very similar in structure to cellulose. Like cellulose it has high tensile strength. It therefore give shape to the hyphae and prevents osmotic busting of cells. Body is usually a mycellium, a network of fine tubular filaments called hyphae. These may be septate (have cross-walls), e.g. Penicillium, or

aseptate (no cross-walls, e.g. Mucor. If carbohydrate is stored, it is usually as glycogen, not starch. Reproduce by means of spores. Non-motile.

Table 6.2.4 Classification and Characteristics of Fungi

Phylum Zygomycota	***Phylum Ascomycota***	***Phylum Basidiomycota***
Asexual reproduction by conidia or sporangia containing spores	Asexual reproduction by conidia. No sporangia	Asexual reproduction by formation of spores. Not common.
Non-septate hyphae and large well-developed branching mycelium	Septate hyphae	Septate hyphae
e.g *Rhizopus stolonifer,* Common bread mould, a saprotroph, *Mucor,* common moulds, saprotroph	e.g *Penicillium Aspergillus,* saprotrophic moulds *Saccharomyces* (yeast), unicellular saprotrophs, *Erysiphe,* obligate parasites causing powdery mildews, e.g of barley	e.g *Agaricus campestris,* field mushroom saprotroph

Source: ***Taylor et. al. (1998) p 25***

6.2.5 Uses of Fungi

1. Yeast - different species and strains of yeast are used in the brewing industry for alcoholic fermentation.

2. Penicillium - a blue-green mould is the source of the world famous penicillin (an antibiotic). Certain species of penicillium are used industrially in making various organic acids and in making special types of flavoured cheese.

3. Aspergillus - is economically an important fungus. Some species are used industrially in the manufacture of alcohol from rice starch, and manufacture of certain organic acids (e.g. citric, gluconic acid) on a commercial basis. Some species are sources of certain antibiotics.

4. Agaricus (Mushroom) use as food by humans.

6.3 Conclusion

You have learnt about the general description of fungi. There are many types of fungi. The drawing of a fungus is just an example. You learnt that the most common fungi that you can easily observe on your own are the mucor, penicillium and rhizopus. You have also learnt that they digest their food outside their body and absorb what is digested. They feed on alsmost anything. They are referred to by the method of their feeding as saprotrophs, parasites and mutualists.

6.4 Summary

Fungi are diverse in nature. There are about 80,000 species known. They could be more. Some of them are very beneficial to man like the mushrooms,, while some are destructive. If you leave your eba or bread outside for long, the spores fall on it and start to grow. The spores are found in the air, even in your refridgerator. The refridgerator does not destroy them but slow down their activity.

6.5 TMA (See attached)

6.6 References

Talor et. al. (1998) has been referred to extensively. All the figures present in this unit have been adopted form Taylor et. al.

6.7 Further Reading - You are advised to read variety of biology textbooks.

UNIT 7: ALGAE

7.0 Introduction

In unit 6, you learnt about Fungi as an example of Eukaryotes. You learnt that the fungi lack chlorophyll because of that they do not make their food, instead they feed on already made food. You learnt about the three different types of feeding in fungi i.e. parasitic, saprotrophic and mutualism.

In this unit we are going to study another group of organisms called Algae.Algae are plant-like, photosynthetic and mainly aquatic. They are named or classified on the basis of the pigment they contain, like blue-green, brown and green algae.

7.1 Objectives

By the time you complete this unit, you will be able to:

1. Draw a typical Alga and label the drawing correctly.
2. List and discuss the characteristics of two main groups of algae.
3. Differentiate types of algae on the basis of their nutrition, reproduction and biological importance.
4. Differentiate between algae and fungi

7.2. Algae
7.2.1 General description of Algae
7.2.2. Classification and Characteristics of Algae
7.2.3 Structure of a typical Algae
7.2.4 biological importance of Algae
7.2.5 Types of Algae on the basis of their nutrition and reproduction.
7.2.5.1 Differences between Algae and Fungus
7.3 Conclusion
7.4 Summary
7.5 TMA
7.6 References and further readings

7.2 Algae

7.2.1 General Description

The flow-chart below shows the place of algae among the Protoctista

Protoctista

Algae Plant-Like Photosynthetic and mainly	*animal-like, unicellular and acquatic*	*Phylum: Oomycota Furgus-like*	*Slime Moulds, Motile like animals, produce spores*

Phylum Chlorophyta

green algae
e.g Chlorella

Phylum: Phaeophyta
brown algae
e.g focus laminaria

Phylum: Rhodophyta
Red algae

Plylum: Bacilliariophyta
e.g diatons

Source: Taylor et al. Figure 7.2 (other features of figure 7.2 p.31 has been left out).

Algae belong to the group Protoctist. They are believed to have evolved in water and have remained in water. Some alga have escaped unto land and have successfully lived on land but they are not plants since they lack true stern and leaves. Instead of stem, roots and leaves, they have undifferentiated body called Thallus. They are grouped according to the pigment they contain. They make their own food (photosynthetic) like the plants. Common green algae you see around are spirogyra, Chlorella, etc.

7.7.2 Classification and characteristics of two of the main groups of Algae

Alge
General Characteristics
Almost all are specialized for an aquatic existence. Great range of size and form, including unicellar, filamentous, colonial and thallaoid forms. A thallus is a body which is not differentiated into true roots, stems and leaves and lacks a true vascular system (xylem and phloem). It is often flat. Photosynthetic, eukaryotic.

Phylum Chlorophyta ('green algae')	*Phylum Phaeophyta* ('brown algae')
Dominant photosynthetic pigment is chlorophy II; therefore green in appearance. Chlorophylls a and b present (as in plants)	* Dominant Photosynthetic pigment is Brown and called fucoxanthin. Chlorophylls a and c present.
Store carbohydrate as starch (insoluble)	* Store carbohydrate as soluble laminarin and mannitol. Also store fat.
Mostly freshwater	Nearly all marine (3 freshwater genera only)
Large range of types e.g unicellular, Filamentous, colonial thalloid	Filamentous or thalloid, often large
e.g *Chlorella,* a unicellular, non-motile alga, *Chlamydomanas,* a unicellular, motile alga, *Spirogyra*, a filamentous alga, *Ulva,* a	e.g *Fucus, a thalloid, marine alga* Laminaria, large thalloid, marine alga; one of the kelps

thallaoid marine alga

Source: Taylor et al (1998:33) ** a diagnostic feature*

7.2.3 Structure of a Typical Alga Chlorella

Chlorella

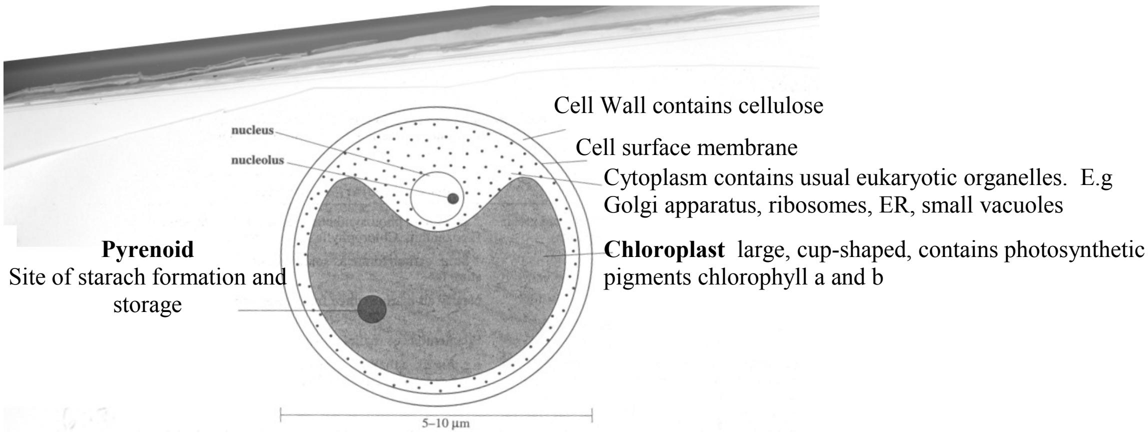


Fig 7.1 Structure of Chlorella, a green alga.
Source: Taylor el. al., (1998, 34)

Chlorella is atypical algae. It is unicellular non-motile green alga. It is a aquatic, found in fresh water ditches and ponds.

Activities

Go round your environment, look out for ditches and ponds. Using a container, collect water containing green substance found in water. Some of them are slimy. When there are a lot of them, they appear like green threads in the water. Spirogyra is a common algae. Your tutor will show you the structure of algae under the microscope. You will be able to see different types of algae from that collection. Draw the structure or appearance of at least five. You will enjoy this exercise. Note any stagnant water during rainy season could contain a lot of algae. They are in their peak when the rains have stopped and before the dry season. Your instructor will also show you prepared slide of types of algae. Compare what you see on the slide with what you see under the microscope.

7.2.4 Types of Algae on the basis of their nutrition and reproduction

Algae are classified into six classes on the basis of their pigments:

1. Blue-green algae
2. Euglena
3. Green algae
4. Diatoms
5. Brown algae
6. Red algae

Algae are autotrophic plants, they manufacture their own food with the help of chlorophyll. Reproduction is vegetative by cell division or by detachment of a portion of the mother plant or asexual.

7.2.5.1 Biological Importance of Algae

Algae are useful to man in many ways. Some serve as food in many parts of the world. Algae start a very good point in food chain. The example you saw earlier, i.e. chlorella, a non-motile alga is a good starting point for the evolution of higher green plants, since it has lost motility. Various algae have various biological importance.

Table 7.0 Difference between Algae and Fungi

Algae	**Fungi**
Green thallophytes with chloerophyll	Do not have chlerophyll
Autotrophic-make their own food	Heterotrophic, feed on already made food. Have diverse mode of nutrition parasitic or saprophytic in habit
Have a true parenchymatous tissues	False tissue (hyphae)
Cell-wall-true cellulose	Cell-wall, chitin
Live in water or wet substrata	Live as parasites on other plants or on animals as saprophytes on decaying animal or vegetable matter
Reserve carbohydrate is starch	Glycogen

Reproduction by vegetative cell division or asexual or sexual by gametes	Vegetative, asexual spores, sexual

7.3 Conclusion

In this unit, you have learnt about algae. They are plant like plants in the sense that they make their food. You have seen from the table in this unit that their characteristics are diverse.

7.4 Summary

Algae belong to a large group called protoctists. They are of high economic value. They are aquatic, living in fresh water as well as in seawater. There is no single way you can characterise algae. Their characteristics are as diverse as the organisms are. They make their food. The colour (pigment) of algae makes the algae to be classified into its group. Example some are green, blue-green brown, etc.

7.5. TMA (see attached)

7.6 References -Taylor et al. (1998)

7.7 Further reading - Look up algae in any botany textbook

UNIT 8

Root

8.0 Introduction

In Unit 7 you studied the algae you learnt that the algae belong to a large group called protoctists. They are found in water or moist areas. You learnt that they are plant - like and photosynthetic. The Chlorella was chosen as a typical example of algae, it has an evolutionary importance. In this unit, you will study the root of flowering plants. Generally the root is the part of the flowering plant that is below the soil. There are different types of roots. Some roots are modified for certain purposes

8.1 Objectives

By the end of this unit, you will be able to:

a) List 2 main type of roots.
b) List and describe regions of roots.
c) Give six characteristics.
d) Discuss modification in roots.

8.2 Roots

8.2.1 TYPES OF ROOTS

You will learn in this unit about different types of roots. You have two main kinds of roots. (You will study other types in future botany) Roots of monocotyledon are fibrous in nature and are referred to as fibrous roots. Roots of dicotyledon grow down wards and are known as tap root.

Let us examine each type.

Fig I

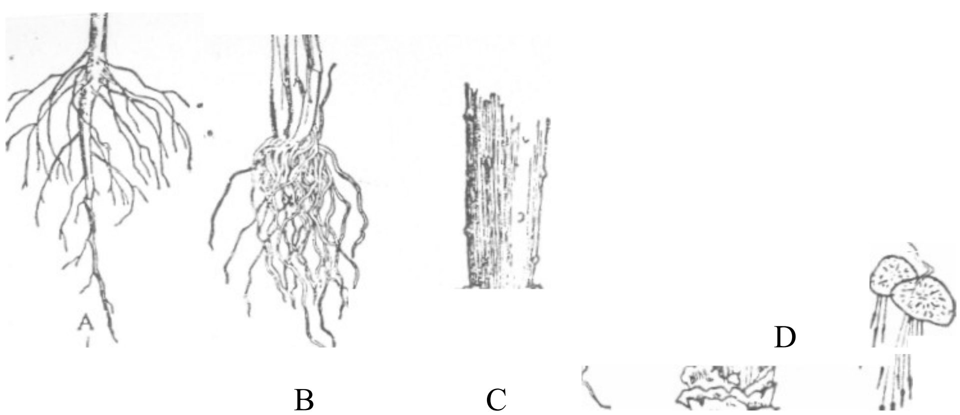
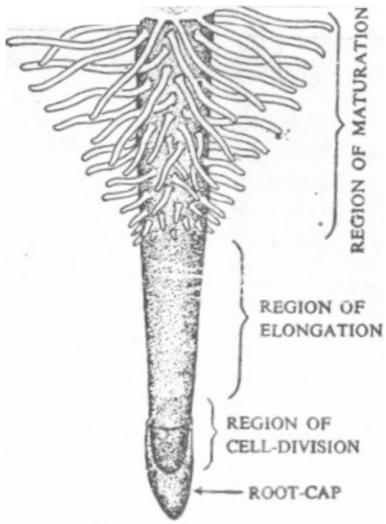
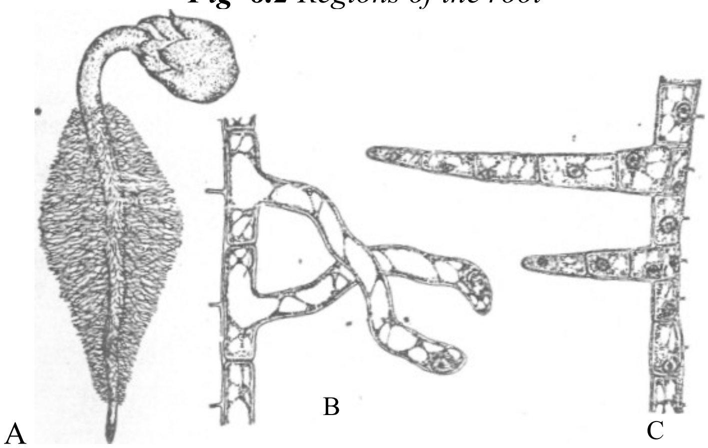


Fig 8.1: A, tap and lateral roots in a dicotyledon; B, Fibrous roots in a monocotyledon; C multiple root-cap in screwpine (*Pandanus);* D, root-pocket in duckweed *(Lemna).*



8.2

Fig 8.2 *Regions of the root*



A, root-hairs in mustard seedling; B, two root-hairs (magnified) – unicellular; C, two shoot-hairs (magnified) – multicellular.

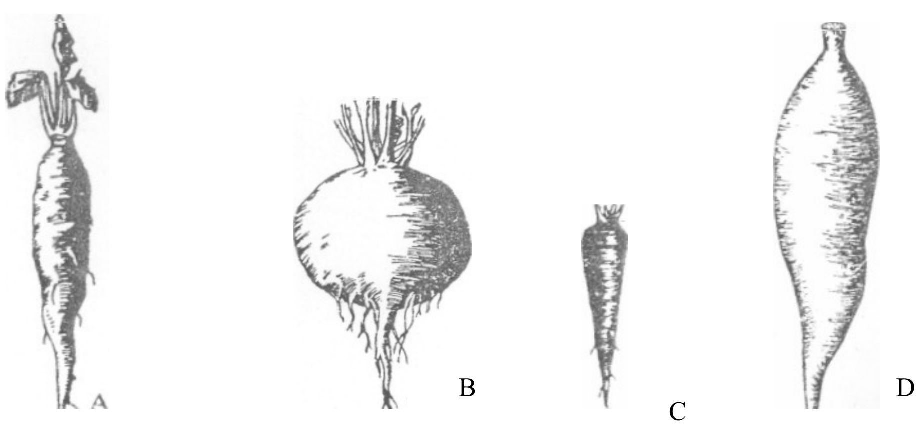
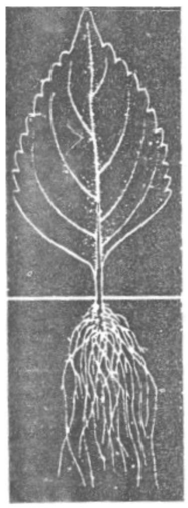


Fig 8.3 Modified Roots. A, fusiform root of radish; B, napiform root of turnip; C, conical root of carrot; D, tuberous root of *Mirabilis.*



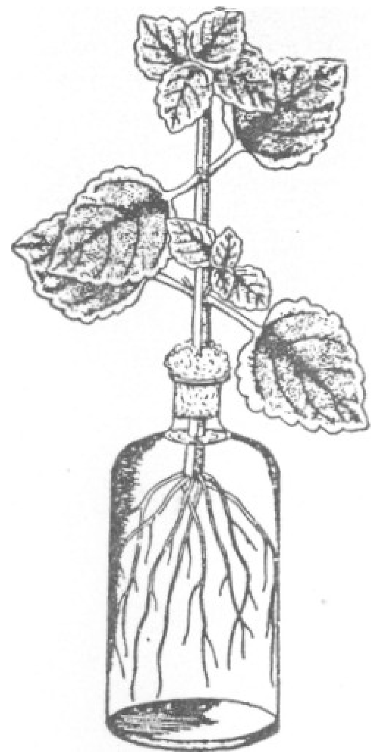
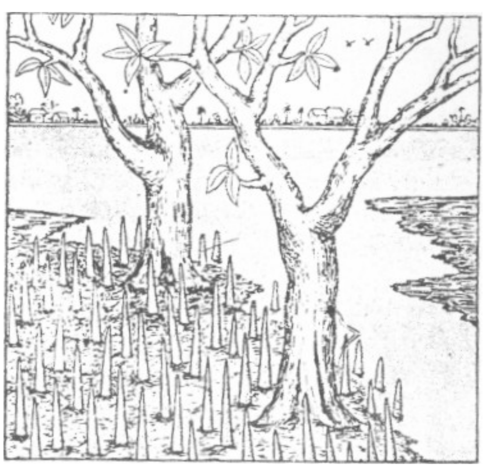


Fig 8.5 : Foliar (adventitious roots in *Pogostemon.*)

Adventitious roots in *Coleus*.



A

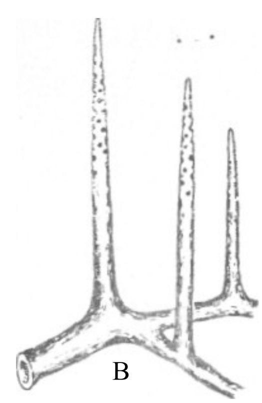


Fig 8.5: Pneumatophores. A, two plants with pneumatophores; B, pneumatophores growing vertically upwards from an underground root.

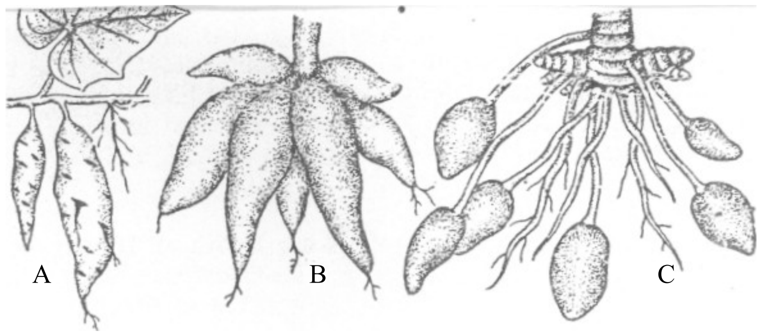


Fig 8.6 Adventitious Roots. A, tuberous roots of sweet potato; B, fasciculated roots of *Dahlia;* C, nodulose roots of mango ginger

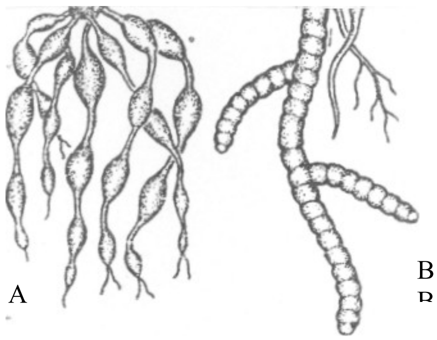


Fig 8.7: Adventitious Roots (*Contd.*) A, moniliform roots of *Momordica;* B, annulated roots of ipecac.

Fig 8.8: Adventitious Roots (*Contd.*) A, prop or stilt roots of banyan (*Ficus bengalensis*); B, the same of screwpine (*Pandanus odoratissimus).*

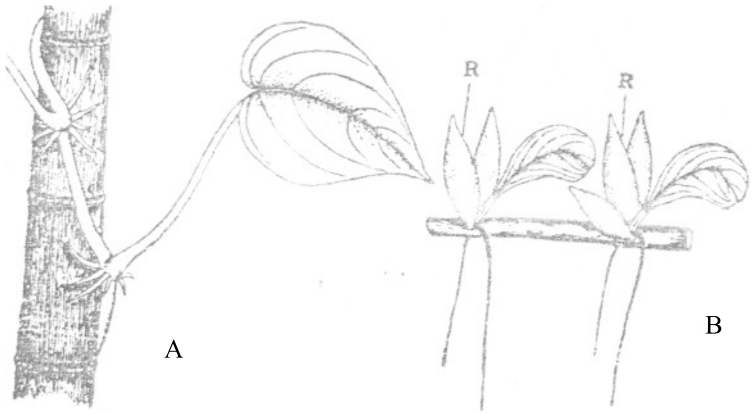


Fig 8.9: Adventitious Roots (*contd.*) A, climbing roots of betel (*Piper betle*). B, respiratory roots (R) of *Jussiaea repens.*

Fig 8.10: Epiphytic roots of Venda (an orchid)

8.2.2. Fibrous Roots

Moncot plant have fibrous roots. They usually are in clusters and arise from the base of the stem e.g is maize plant, onions.

8.2.3 Tap Root

Tap root is the primary root that grows downwards, it has branches which are not as big as the primary root. The branches grow obliquely downwards or spread horizontally downwards, example is carrot. The nature of the tap root depends on the kind of plant. However all roots serve two major purposes:

a) Anchorage to the plant.
b) Absorb water and mineral salts from the soil and conduct then to the stem.

8.2.4 Parts Of a Root

You learnt that the root has many parts in the examination of the inner structure. Looking at the external structure, we can divide the root into:

(1) ***Root-cap***

You have studied the root hairs, how they push their way through the soil. In the process of pushing its way through the soil, the tip of the root needs protection because the tip is delicate. The tip of the root has a covering called root cap.

(2) ***Growing Apex of the Root***

Immediately after the root cap is a region where cells divide. The cell of this region are tiny, with thin wall and contain a dense mass of protoplasm. It is also known as meristematic region - region of cell division

(3) ***Region of Elongation***:

The region following the region of cell division is the region of elongation. The cells of this region undergo rapid elongation and enlargement, and are responsible for growth in length of the root.

(4) ***Region of Maturation:***

Above the region of elongation is the region of maturation. This region extends upwards. The root-hairs are found in this region. In the cross-section of the root you saw in section -. You learnt that this region, is where maturation and differentiation take place, differentiation into various kinds of primary tissue.

(5) ***Region of Secondary tissues:***

The region of maturation merges into the region of secondary tissues. Go back and look at the internal structure of the root again, you will see the beginning of the primary tissue and the end where it merges with the secondary tissues.

8.2.5 Characteristics of roots

How do we know that a structure is a root not a stem? It is a root if it; (1) Is not green in colour, descends below the soil

(2) Does not bear buds expect in sweet potatoes and some few other roots
(3) Ends in and is protected by a cap the root-cap.
(4) Bears unicellular hairs
(5) Develops from an inner layer (pericycle) i.e the lateral roots. They are therefore said to be endogenous (inner producing). There are branches that produce from a few outer layer and are said to be exogenous
(6) Does not have nodes and internodes as in the stem

8.2.6 Modified Roots

There are many ways roots have formed or are modified for certain purposes.

(a) Tap root modified for storage of food e.g in carrot, radish, yam.
(b) Branched root modified for respiration. Many plants like the mangroove growing in marshy places and salt lakes, develop special kinds of roots called respiratory roots for respiration.
(c) Adventitious roots modified for storage of food, e.g sweet potatoes, cassava..
(d) Prop or stilt roots. These roots grow Vertically or obliquely downwards and penetrate into the soil, gradually they grow in stature and act as pillars to support part of the branches or even the plant itself.
(e) Climbing roots
(f) Buttress roots
(g) Sucking roots
(h) Respiratory roots Assimilation roots

Activities 1

(1) Up root a young dicotyledonous plant and examine the root, take note of the -root cap,-the region of elongation, - the hair roots.
(2) Up root a monocotyledonous plant and examine the fibrous roots. (b) differentiate the two types of roots dicot roots and monocot roots.
(3) You are familiar with Yams, cassava, sweet potatoes, Irish potatoes carrot. Collect them, classify them into their mode of food storage.

8.3 Conclusion

In this unit you learnt:

(1) Two types of roots (a) Fibrous and (b) Tap roots
(2) Regions that make up the root-cap, - Growing Apex, - region of elongation, -Region of maturation.
(3) Characteristics of roots and Modified roots

8. 4 Summary

Roots are the structure of flowering plants that are generally below the soil the root has three regions, root caps, growing apex, region of elongation and region of

maturation. Roots have various modifications: Some have been modified to store food for the plant. The yams, Cassava and carrot are typical examples of root modification.

8.6 TMA

(1) Differentiate between fibrous roots and Tap roots
(2) Draw a typical root and label the regions
(3) List six characteristics of roots
(4) What do you understand by root modification? Give examples

8.6 References and Further Reading

Vines, A.E and Reads N(1987) Plant and Animals Biology. Vol I&II

Dutta,

UNIT 9: The Stem

9.0 Introduction

You have learnt about the root as the part of the flowering plant that is below the soil. In this unit you will learn about the stem. The stem is the portion that grows above the soil. The stem develops from the plumule and bears leaves, branches and flowers. A young stem is green in colour. The stem has nodes and internodes. Leaves and branches normally develop from the nodes.

9.1 Objectives

After going through this unit you should be able to: a) Identify the stem of a plant.

b) Classify stems into their various forms
c) Discuss the characteristics of weak stems
d) Discuss the nature of buds and how they are protected
e) Name and draw, at least, four forms of stem modification

9.2.0 The Stems
9.2. I Forms of stems
9.2.2 Nodes and internodes
9.2.3 Buds
9.2.4 Natural ways by which buds are protected
9.2.5 Modification of buds
9.2.6 Habits of plants
9.2.7 Modification of stems
9.2.8 Underground modification of stems
9.2.9 Aerial Modifications
9.3 Conclusion
9.4 Summary
9.5 TMA
9.6 References and Further Reading

9.2.1 Forms of Stem

Here, we are going to look at the structures different plants possess as stem. There are two major forms the stem normally takes - they are aerial (those stems above the ground) or underground (as the name implies, they are developed below the ground).
Aerial stems are usually erect or upright and strong while some are weak and frail on the ground or support themselves by climbing on stronger and erect objects. Examples of plants with erect stems are mango, cashew, etc. Those with weak stem are pumpkin, dodder, etc. Can you think of other examples? While some stems are above the ground, some are permanently underground and sometimes produce aerial shoots. Examples include onion, ginger, etc. Let us now examine the stem closely.

Dicotyledonous Stems.

Fig. 9.1

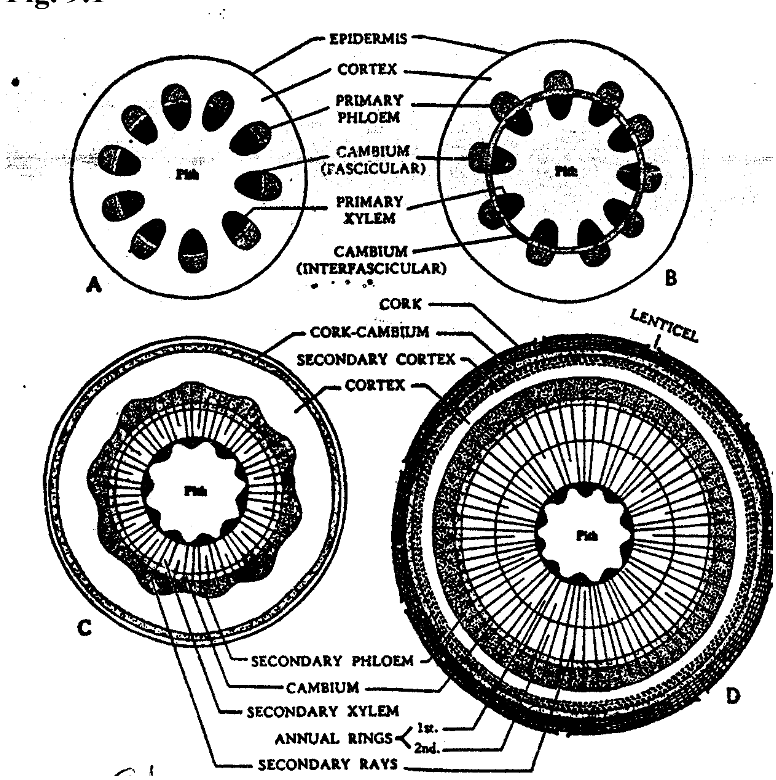


Fig 9.1: A diagrams showing stages in the secondary growth of a dicotyledonous stem up to two years.

9.2.1 Erect and strong stems:

The stem that is erect, cylindrical and has no branches is called caudex. Such stems have the mark of scars of fallen leaves on the body. Example, palms. Stems with hollowed internodes and joined nodes are called culm, e.g. bamboo. As earlier pointed out, there are some underground stem that produce erect unbranched shoots which late bear single or group of flowers. Such shoots are called scape.

9.2.1.2 Weak Stems:

Weak stems can be classified as (i) Trailers, (ii) creepers, (iii) climbers. Trailers have their stem running on the ground without rooting at the nodes. When the stem lies prostrate on the ground it is called procumbent while after trailing for some distance, it rises at the apex, it is called decumbent. If the stem has many branches and trail at direct directions, it is said to be diffuse. What distinguishes trailers from creepers is that creepers produce root at the node while trailers may not. A plant is said to be a climber if its weak stem climb other objects or plants around it.

9.2.2 Nodes and Internodes:

The node is the point on the stem or branch where one or more leaves develop. While the space or distance between two nodes is termed internodes.

9.2.3 The Bud:

A bud is a young undeveloped shoot consisting of a very short stem and tender leaves. The bud can be at the apex of the stem (usually called terminal or apical bud) or the branch or axil of the leaf (axillary bud). In some cases, buds develop beside the axillary bud. Such buds are called accessory buds. Buds can develop on other parts of the plant such as the leaf (foliar buds), root (radical buds). When buds arise on other parts of the stem or branch outside those parts mentioned above, they are called adventitious buds.

9.2.4 Natural ways by which buds are protected:

The buds are very important because they produce the stem, branches and leaves. To protect it from damage they are naturally protected by:

a. Overlapping and fielded leaves
b. Some are covered with hair or gummy secretion
c. Dry and scaly outer leaves called bud scales
d. Coated by wax on the leaf surface control water loss and getting wet.

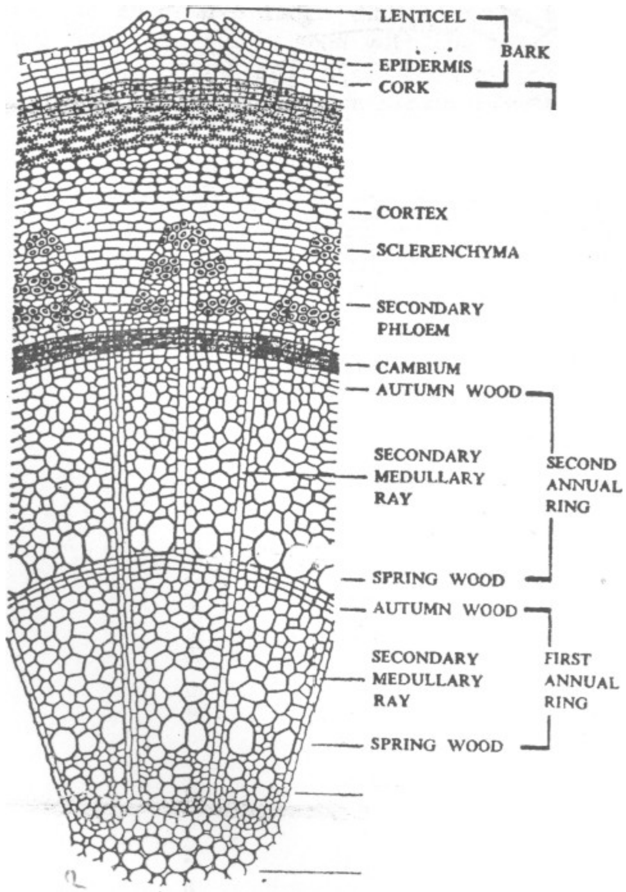


Fig 9.2: *A two-year-old dicotyledonous stem (a sector) in transaction showing secondary growth in thickness*.

9.2.5 Modification of Buds:

Apart from the bud developing into stem, branch or leaf, some buds develop into tendrils (rope-like structure), as in fluted pumpkin. Some others become thorns while some become modified into special reproductive bodies called bulbils. Readers are encouraged to observe these features out in a field for better understanding of these features.

9.2.6 Habits of Plants

The habits of plants are known from the mode of their life, the height of the plants, the nature of the stem and the duration of life.
Herbs: Plants that are small and have soft stems are called herbs.
Shrubs: Plants in this group are of medium size but with hard and woody stem. They do not have distinct trunk but branch a lot near the ground. Such plants are not as small as herbs and are not as large as trees. Trees: Trees consist of very large plants with hard and word trunk and branches.
Climbers: Plants classified as climbers have tiny and long stems with or without branches. They are very weak and so cannot stand erect on their own.

By the duration of life, plants can be describe as:

a. annual plants (those plants that when planted can reach their maturity and are harvested the same year) biennial (those that live for two years) perennials (those ones live for many years, normally from three years and above).

9.2.7 Modifications of Stems

We have identified that while some stems are aerial, some are underground. Those stems whether aerial or underground take different shapes and sizes. Different functions are performed by the stem, some of which include:

a. helping the plant to survive throughout the year in bad or adverse seasons
b. vegetative propagation by which the stem of plant is used to produce new ones
c. some store food for the plant
d. some stems that take the form of tendrils allow the plant to attach itself to other plant around it. Let us consider the modification under two headings namely:

1. Underground modification of stems: Underground stems are usually thick and fleshy with enough food stored in it. Plants with such stem normally shade their leaves during unfavourable condition or at maturity and send out aerial shoots during favourable conditions. They can be distinguished from roots with the presence of nodes and internodes, scale leaves and buds on their body. However, because they are underground, they develop root like features, non-green colour. Modified underground stems can be classified into rhizome, tuber, bulb and corm.

2. Rhizomes possess the characteristics of prostrate, thick stem that grows horizontally but sometimes vertically in the soil. They have clearly displayed node with short or long internodes bearing scaly leaves at the nodes. The buds are found both at the leaf axil and apex (terminal bud). Some rhizomes have branches developing from the axillary buds while some are unbranched. They produce aerial shoots during vegetative season. Examples of rhizomes are ginger, water-lilly, ferns, etc.

3. Tubers are swollen ends of underground branch arising from the axillary bud. Found on the body of tubers are `eyes' or buds, which can develop into new plant. The swollen nature of tubers is due to the food deposit. Examples of tubers are yam, potato, cassava, etc.

4. Bulb is another form of modified underground stem. These are usually fresh scaly leaves or foliage often regarded as scales growing from the stem and around it. Adventitious roots are always developing from the base during vegetative growth.

While the fleshy leaves store food, the dry ones give protection. Common examples of bulb are onion, lillies, garlic, etc.

5. Corm is much like rhizome except it is of large fleshy stem, more or less rounded in shape. The heavy deposit of food materials makes it larger in size. Few buds are found at the axil of the scale leaves. Examples include coco-yam, saffron, etc.

9.2.8 Aerial Modifications

Aerial stems are modified into runner, stolon, offset, tendril, thorn and phylloclade to perform different functions.

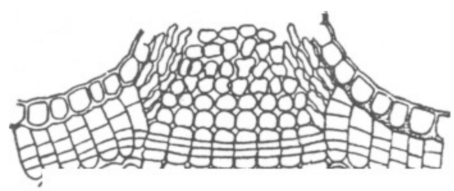


Fig 9.3 A lenticel, as seen in transection

Runner: The stem of some plants are structure in tiny slender form that creep on the ground. Normally characterised by short or long internodes (depending on the plant) the axillary buds give rise to new runner. The development of roots at certain intervals enables the new runner to grow independent of the mother plant in case it breaks off.

Stolon: The stolon has the characteristics of the runner. However, stolon starts by growing upward and later bend to the ground. Where it touches the soil, it develops roots and bud and rise again and continue to grow laterally (sideways). Each of these buds can grow as a new plant, e.g. wild strawberry.

Offset: This is another form of stem. It is a horizontal branch from the mother plant characterized by thick cluster of leaves at the apex with roots at the based. Like the runner, sudden break from the mother plant gives rise to a new plant. Examples of offset are water-lettuce and water hyacinth.

Tendril: This is a tiny rope-like structure used by the plant to climb other objects. The tendril may develop from the axillary bud or terminal bud. The climbing is made possible as the tendril curled round any near by object.

Thorn: This is another form which stems of plant can take. These are hard pointed structures arising from the body of plant. Thorn is said to be modified stem because they develop from the position when the normal branch takes off.

Phylloctade: This type of stem modified into thick flat or cylindrical structure weakly joined at successive points. The leaves are modified into spines, e.g. prickly pear, cocoloba, christmas cactus.

9.3 Conclusion

In this unit, you have studied The stem
Forms of stem
- erection stems
- weak stems Nodes, Internodes Buds

Habits of plants Modification of stems

9.4 Summary

Stems are generally considered to be part of the flowering plant above the ground. But there are exceptions, some stems are below the ground and are said to be underground. There are erect and strong stems and weak stems. The weak stems are said to be weak because they need the help of something, stone, another plant or whatever to spread their leaves for photosynthesis. Among the stems referred to as weak stem, there are climbers of various sorts and creepers. Some plants have modified their stems for food storage or other purposes.

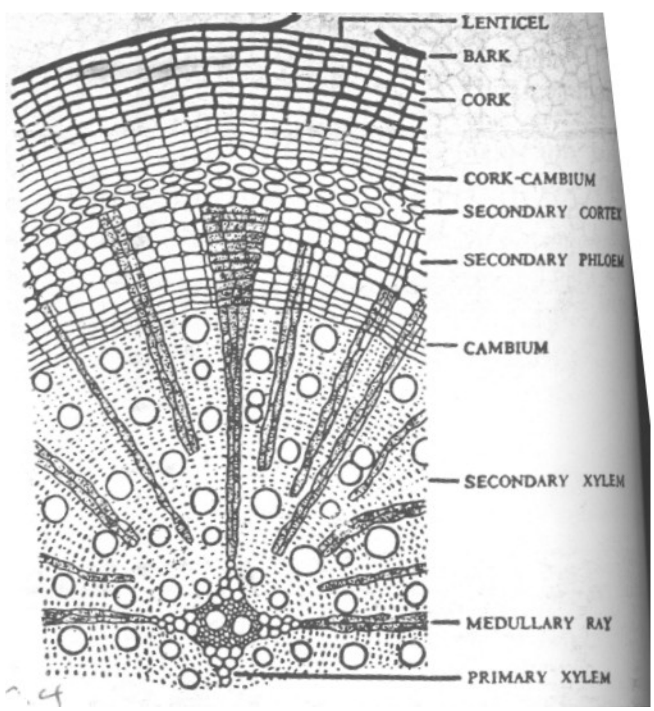
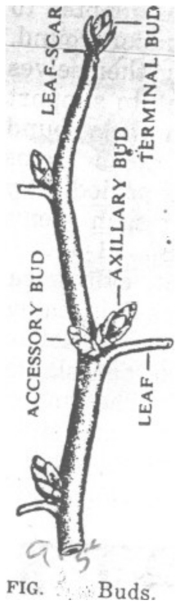


Fig 9.4: A dicotyledonous root (a sector) in transaction showing secondary growth in thickness.



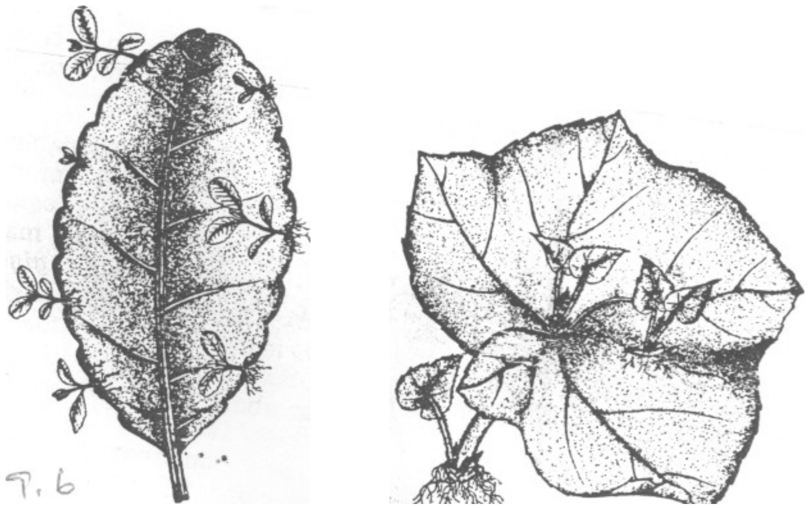


Fig 9.5: Bud

Fig 9.6: A foliar buds and adventitious roots of *Bryophyllum pinnatum;* B the same of *Begonia.*

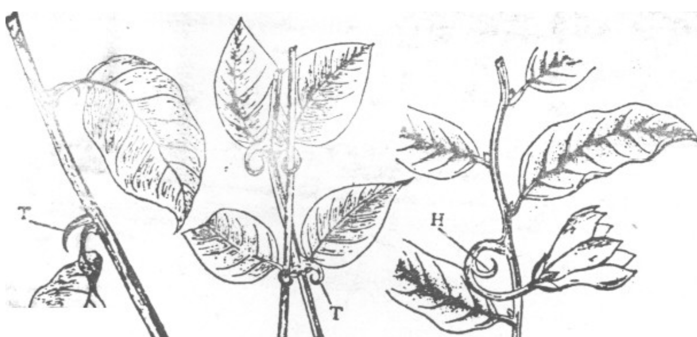


Fig 9.8: Hook and Thorn Climbers. A Glory of the garden (*Bougainvillea*); T, Thorn; B, *Uncaria;* T hooked thorn; C *Artabotrys*; H hook.

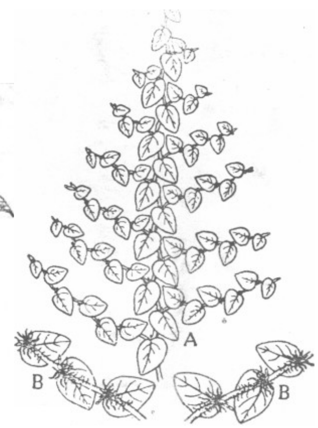


Fig 9.7: Indian ivy (*Ficus Pumila)* a rootlet climber.
A, upper side; B, lower side

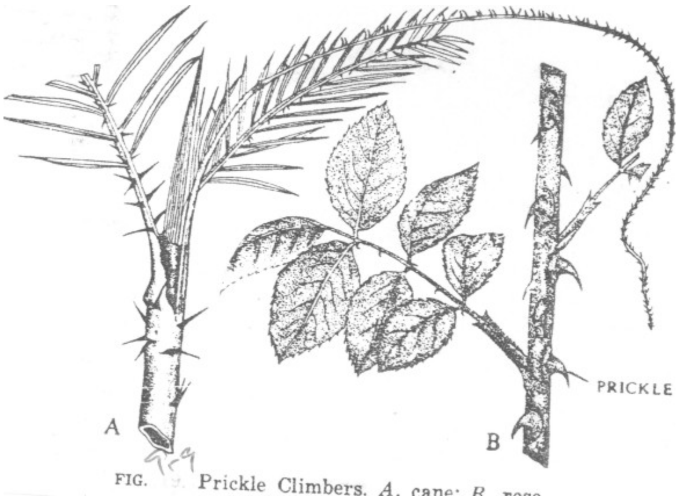


Fig 9.9: Prickle Climbers. A, Cane; B, Rose.

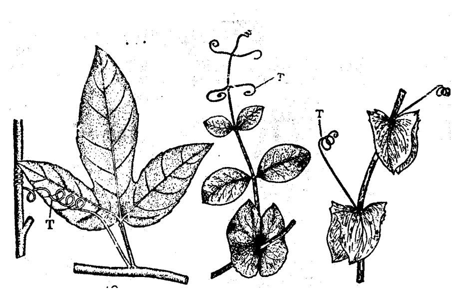


Fig 9.10: Tendril Climber. A, Passion-flower; B, Pea; C, Wild pea (*Lathyrus*); T

Fig 9.11: Leaf Climbers, A, *Clematis;* B, Glory lily (*Gloriosa*); C, Pitcher plant (*Nepenthes;)*

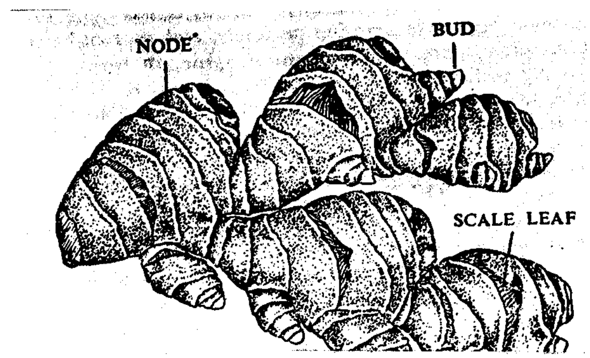


Fig 9.12: Rhizome of ginger.

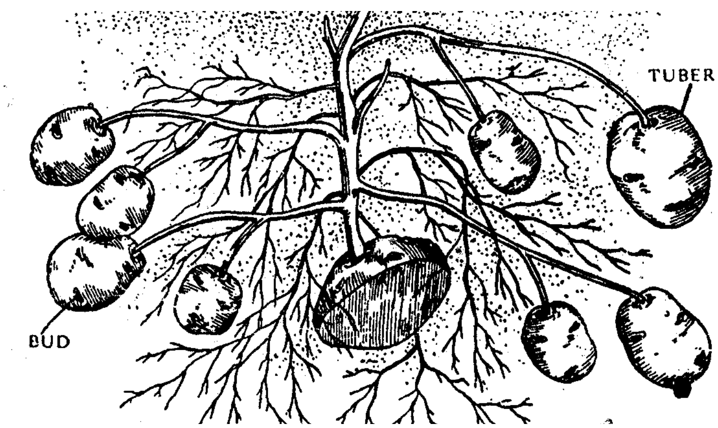


Fig 9.13: Tubers of potato.

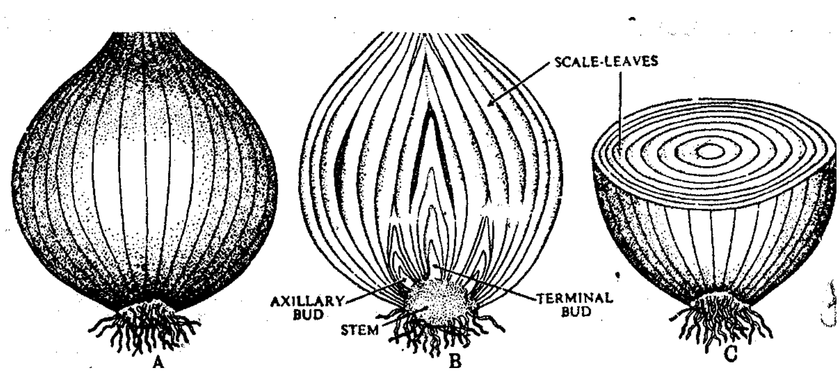


Fig 9.14 Bulb of onion. A,

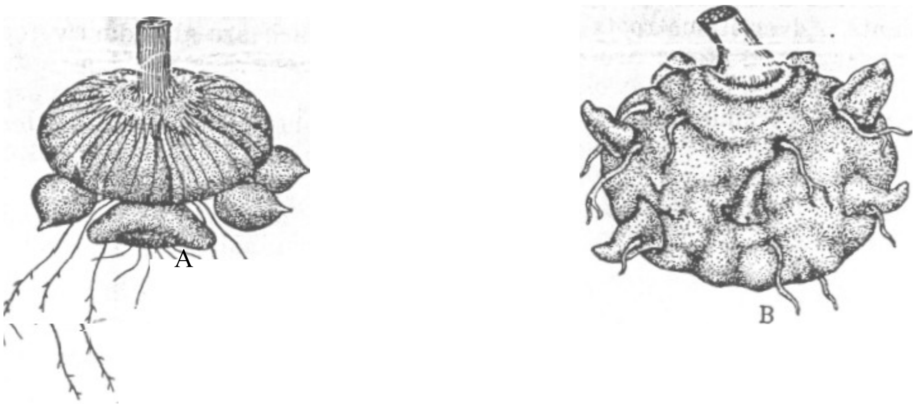


Fig. 9.15: A, Corm of *Gladiolus*; B, Corm of *Amorphophallus*.

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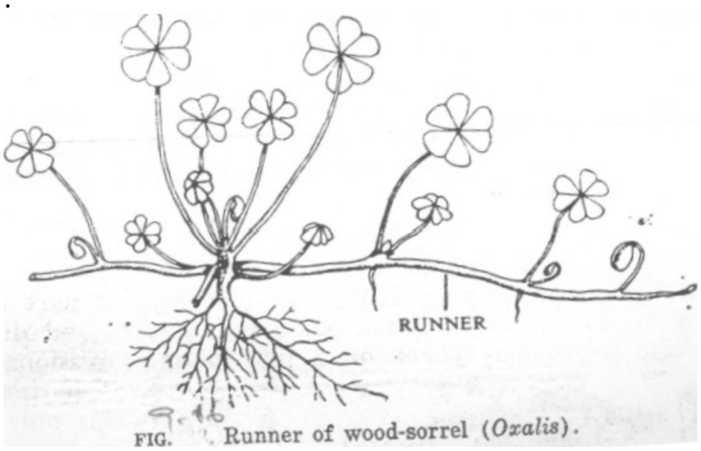
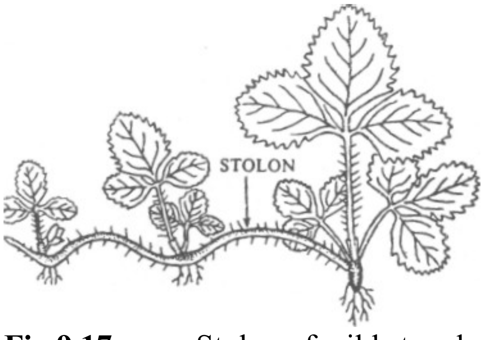


Fig 9.16: Runner of wood-sorrel (*oxalis*)



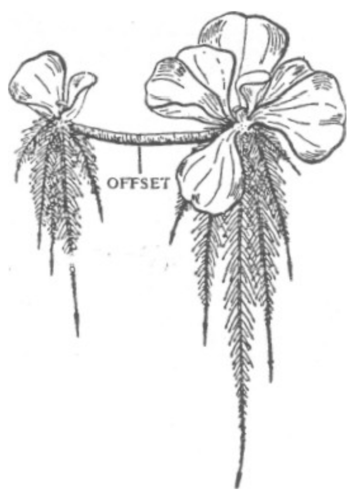


Fig 9.17: Stolon of wild strawberry (Fragari7. indira). Offset of water lettuce (*Pistia)*

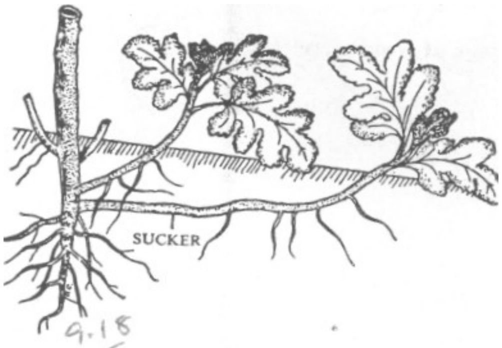


FIG. ~~85~~. Suckers of *Chrysanthemum*.

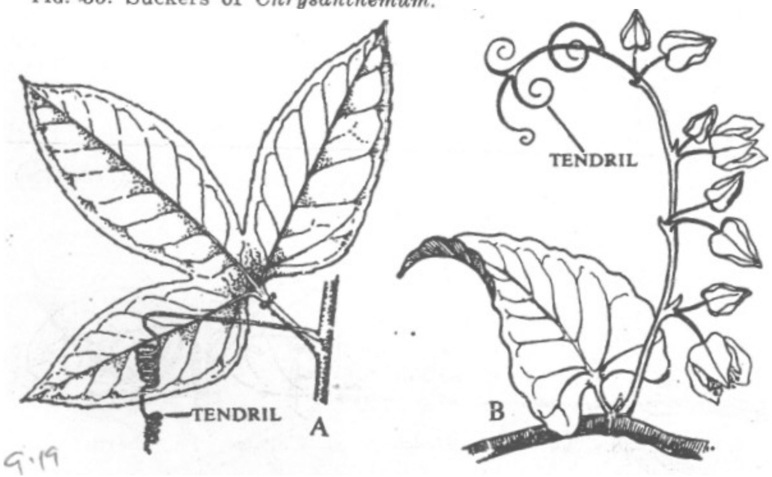


Fig 9.19: Stem-tendrils. A, Tendril of passion-flower (*Passiflora*); B, tendrils of Sandwich Island climber (*Corculum = Antigonon*)

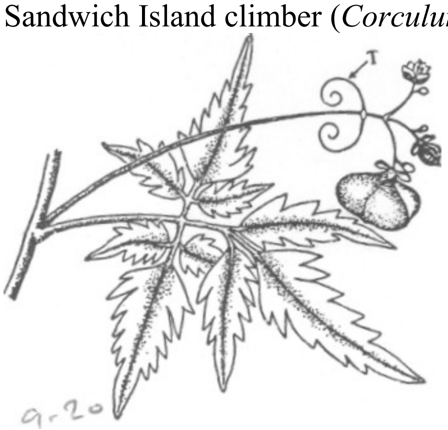


Fig 9.20: Tendrils of balloon vine (*Cardiospermum*). T, a tendril.

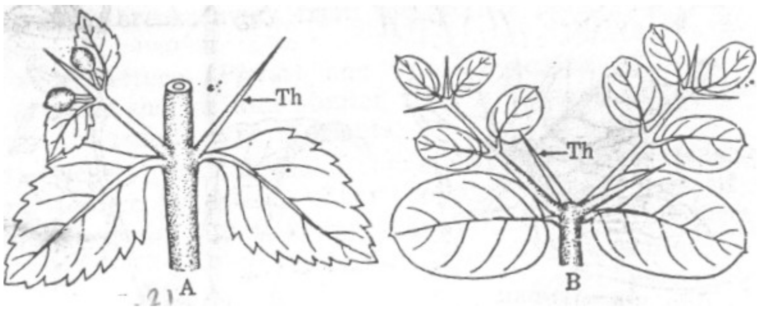


Fig 9.21: " Thorns. A, *Duranta*; B, *Carissa;* Th, thorn.

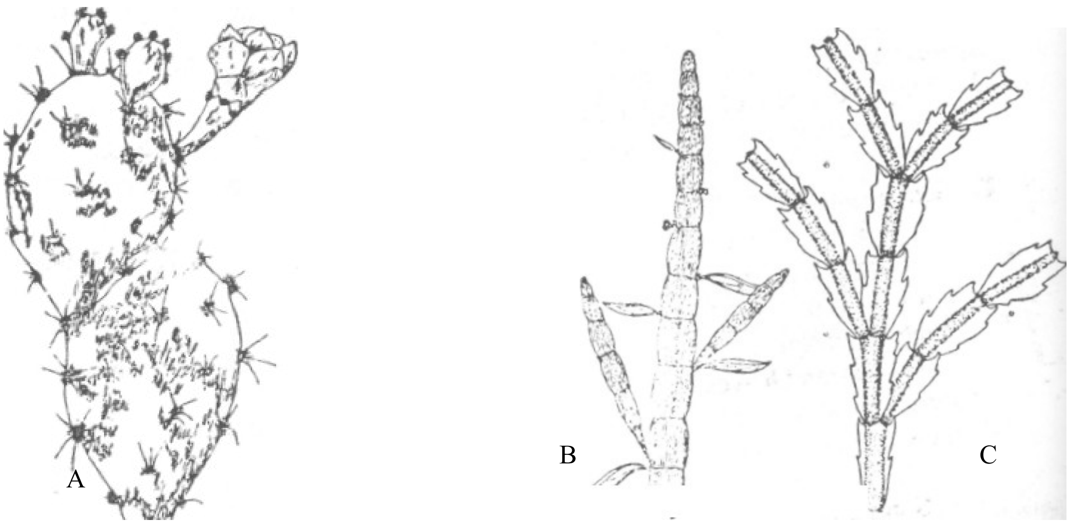


Fig 9.22:. Phylloclades. A, prickly pear *(Opuntia dillehii); B, cocoloba* (*Much-lenbekia platycladlos*); *C, Christmas cactus (Epiphyllum truncatum*).

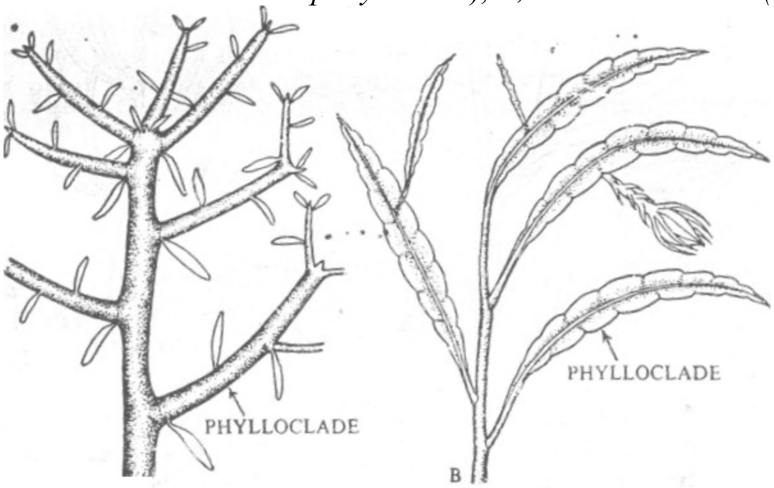


Fig 9.23: A, *Phylloclades of Euphorbia tirucalli*; B, the same *of Phyllocactus latifrons*.

Unit 10

The Leaf

10.0 Introduction

You have learnt the structure of the roots and the shoot. The shoot or the part above the ground is the structure which bears the leaves of a flowering plan. The leaves are the organ of photosynthesis. In this unit, you will study how some leaves are modified for certain function. You will study types of leaves, leaf venation, simple and compound leaves.

10.1 Objectives

By the end of this unit, you should be able to;

1. mention at least five forms of leaf modification.
2. Discuss any three of the forms of modification
3. Explain the concept of venation in leaves
4. Differentiate simple leaves from compound leaves.

10.2.0 The Leaf

We have in the previous unit identified the leaf as one of the parts of a plant. You must have observed leaves of plants and note that the shape and size of these leaves are not the same. If you have not consciously done this before, just look critical at the leaves of different plants around you. Do you notice any difference among the leaves?
We will now identify and classify leaves into the various types.

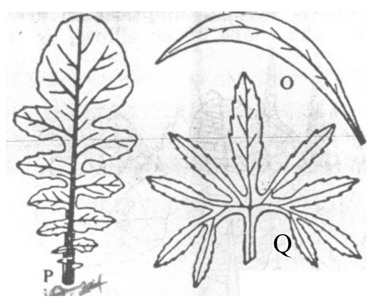


Fig 10.1: O, Falcate leaf of *Eucalyptus globules;* P, lyrate leaf of radish; Q, pedate leaf of *Vitis pedata.*

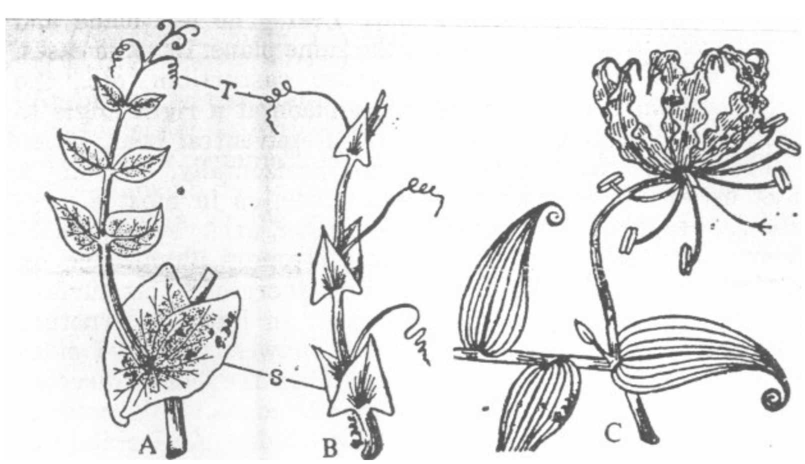


Fig 10.2: Modified leaves: Leaf-tendrils. A, leaf of pea (*Pisum*) with upper leaflets modified into tendrils; B, portion of wild pea (*Lathyrus*) stem; T, tendrils; S, stipules; C, portion of glory lily (*Gloriosa)* stem with the leaf apex modified into a tendril.

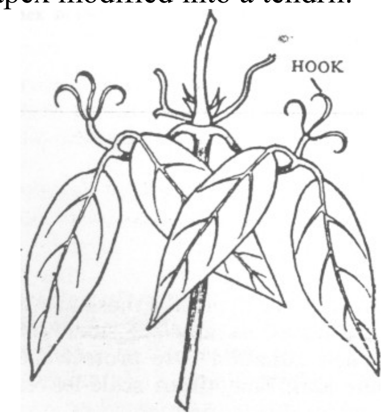


Fig 10.3: Leaf of *Naravelia* with the terminal leaflet modified into a tendril

Cat's nail (*Bignonia unguis-cati)* with hooks.

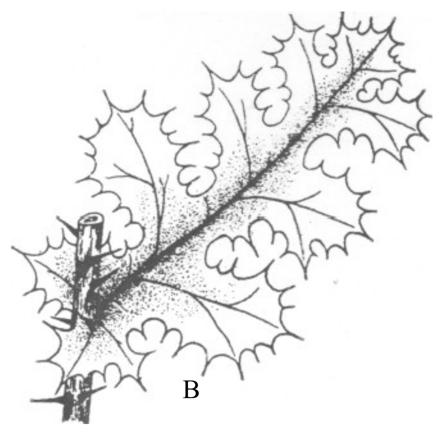


Fig 10.4: A barberry (*Berberis*): primary leaves modified into spines (S); B, Leaf of prickly (*Argemone*) showing spines.

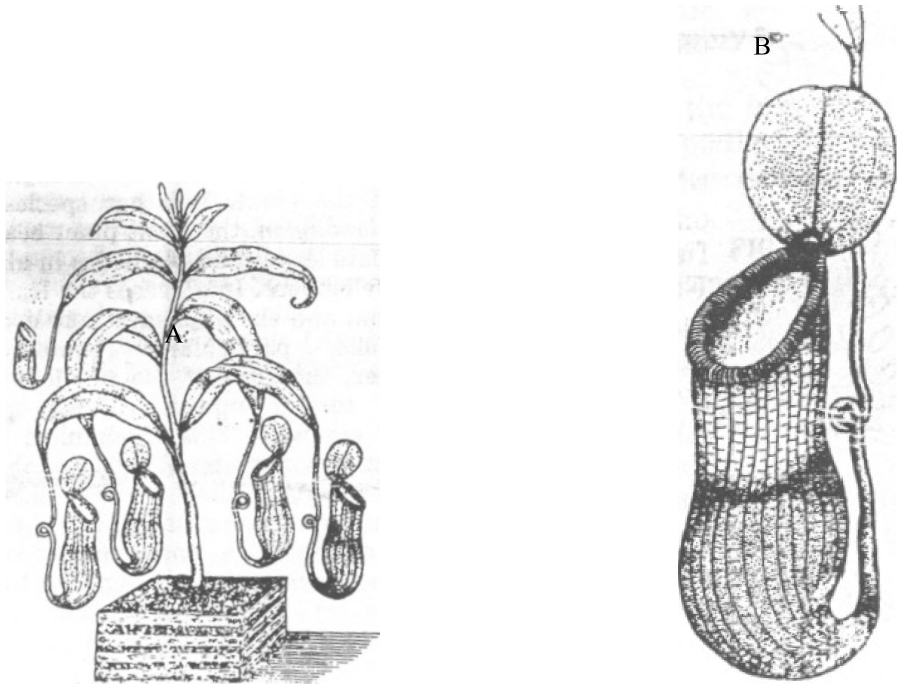


Fig 10.5: A Pitcher plant (*Nepenthes*); B, a Pitcher

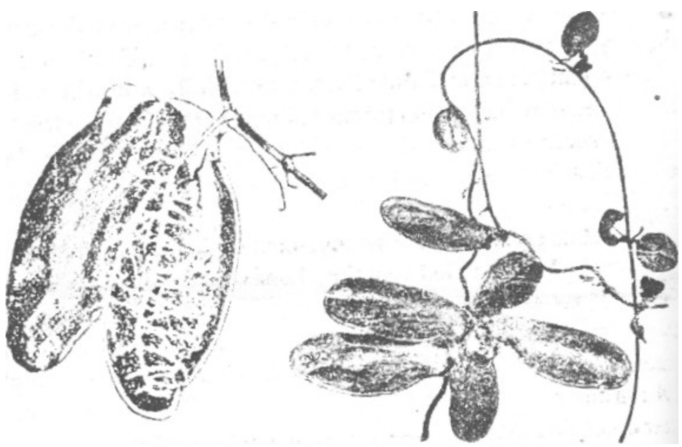
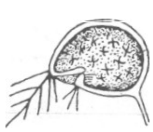


Fig 10.6: Dischidia rafflesiana; left, a pitcher opened out.



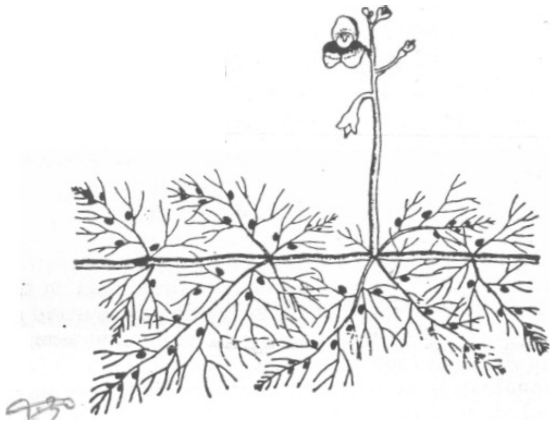


Fig 10.7: Bladderwort (*Utricularia*) with many small bladders; top, a bladder section (Magnified)

10.2.1 Types of Leaves

Leaf-tendrils: Just like the stem that develops as tendril, the leaf also possess this structure. They are tiny, slender structures that arise from the leaf apex, or terminal leaflet. The plant climbs other objects by the sensitive tendrils coiling a round the object e.g. of plants mith leaf-tendril are traveller joy, venus flower, glory lily.

Leaf-spine: Spines are like the thorn found on the stem of plant but might not be necessarily as sharp and strong as the thorns. Such leaves are modified as form of protection for the plant. These spines are found at apex of the leaf as in date-palm, leaf margin as in prickly poppy or the entire leaf is modified into spine as in barberry. The spine is called modified leaf because it develops from the point the leaf develops.

Pitcher: The pitcher plant has its leaf modified into a sack like structure called linked to leaf by a tendril. The pitcher caputes and digest insects.

Scale-leaves: These are fresh or dry leaves that protect mostly underground stems. Scale-leaves are found to protect the auxiliary buds. When they are thick and fresh as in onion, they store food and water but when dry they serve as protective cover.

Bladder: Some plants like bladderwort, which float freely in water possess structures that look like bladder on its segmented body with an entrance through which any aquatic animal that enters can not come out again.

10.2.2 Leaf Venation

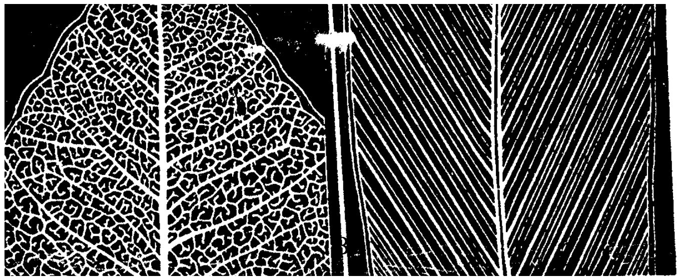


Fig 10.8: Systems of Veins. A, reticulate venation in a dicotyledonous leaf; B, parallel venation in a monocotyledonous leaf.

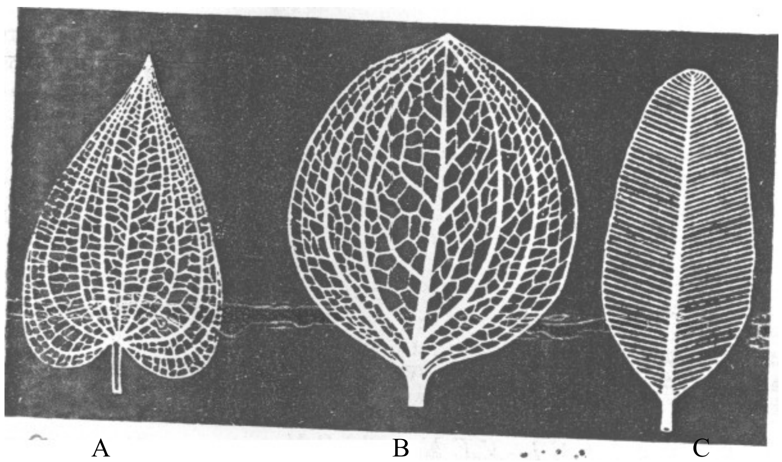


Fig 10.9: A, Leaf of Dioscorea (a monocotyledon) showing reticulate venation; B, leaf of *Smilax* (a monocotyledon) showing reticulate venation; C, leaf of *Calophyllum* (a dicotyledon) showing parallel venation.

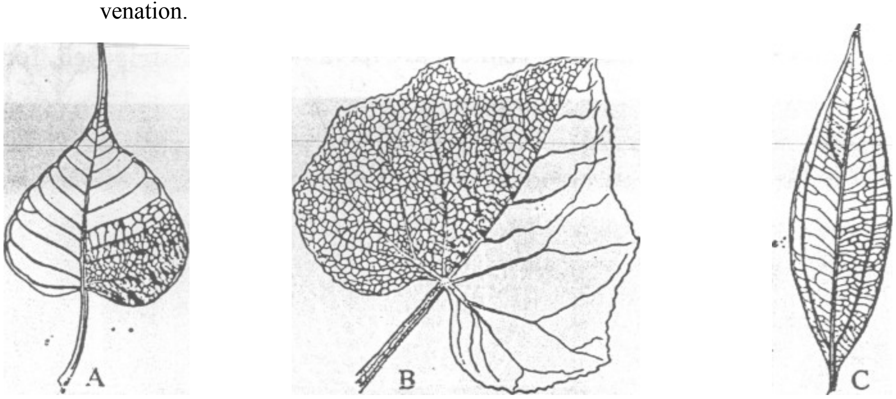


Fig 10.10: Types of Reticulate Venation. A, pinate type in peepul (*Ficus*) leaf; B, palmate (divergent) type in cucumber. (*Cucumis*) leaf; C, palmate (convergent) type in bay leaf (*Cinnamomum*).

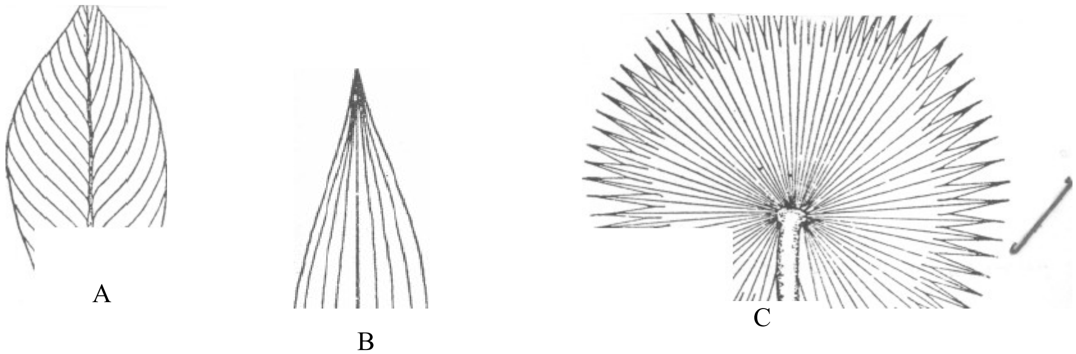


Fig 10.11: Types of Paralle Venation. A, Pinnate type in *Canna leaf;* B, Palmate (Convergent) type in bamboo leaf; C, palmate (divergent) type in pamyra-palm leaf.

Activity 1

Pick two, three or more leaves from different plants and observe them carefully as you read along. If you cannot identify all that will be discussed hereon the leaves collected, attempt getting more and various types to help you understand this unit.

When you pick a leaf and observe it carefully, you will notice some lines running through the leaf. These lines may be parallel (almost along the length of the leaf) or lateral towards the leaf margin. . This linear structures are called veins. The very tiny ones are called veinlets. They help to leaf margin. They help to distribute water and other nutrients as well as the food manufactured in the leaf to other parts. You still remember photosynthesis? The rigid nature of the veins helps to strengthen the leaf.

Now let us go back to the arrangement of the veins. The term used to describe the arrangement these veins on the leaf is called venation. Leaf venation is classified into two types based on the nature of the arrangement of the veins. The leaf is said to have parallel venation when as the name implied all the veins run parallel to one another. On the other hand, when the veinlets are distributed without any given pattern, such venation is known as reticulate venation. Parallel venation is found in palms, Clalophyllum and most monoclotyledonus plants while reticulate venation can be found as in mango and some other dicolyledons, Parallel venation and reticulate venation can further be subdivided into two groups each.

Parallel venation; There are two types of parallel venation- pinnate (unicostate type) and palmate. Pinnate venation is found in banana, ginger. Canna etc. The leaves very strong mid- rib from which the lateral feins take- off running parallel to one another towards the apex or the margin of the leaf blade. A leaf is said to have palmate venation if the veins develop from the petiole (stalk) and not from the mid-rib of the leaf and run toward the apex of the leaf, or the leaf margin. If the veins run towards the margin of the leaf-blade, it is described as divergent.

Reticulate Venation: Like in parallel venation, reticulate venation can be classified as pinnate of palmate depends on the direction of the veins. Pinnate type of reticulate venation has a single strong mid-rib with lateral veins running towards the margin or apex of the plant. Note that the difference between this and that of parallel pinnate is that here the direction of the veins are not parallel as observed in parallel pinnate. E.g. of pinnate type of reticulate venation are mango, guava etc.
Figure 2

Palmate or multicostate type have more than a single rib which may or may not be strong which develops from the petiole and not the mid-rib as in the pinnate. When the ribs or veins run outwards towards the leaf margin as in pawpaw, it is said to be divergent while when the veins run upwards towards the apex, it is described as convergent. E.g. bay leaf.

10.2.3.1 Compound Leaf

With your knowledge of primary science and secondary school biology what constitutes compound leaf may not be new. However, as a reminder, a compound leaf when the leaf-blade are separated right to the mid-rib (rachis) or to the petiole, presenting a number of independent leaflets not connected by lamina.

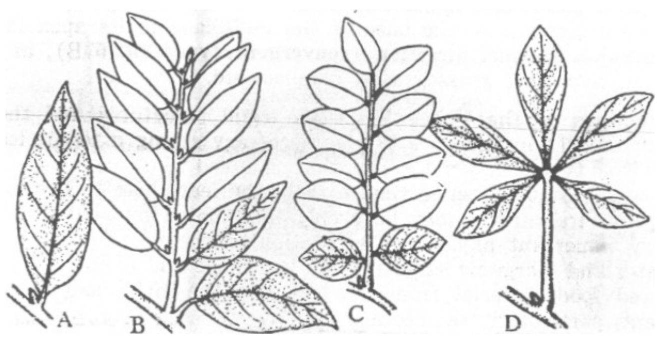


Fig 10.12: A, a simple leaf; B, a branch; C, a pinnately compound leaf with the leaflets articulated to the mid-rib; D, a palmately compound leaf with the leaflets articulated to the petiole. Note the position of the bud in each case.

Bifoliate leaf of **Balanites.**

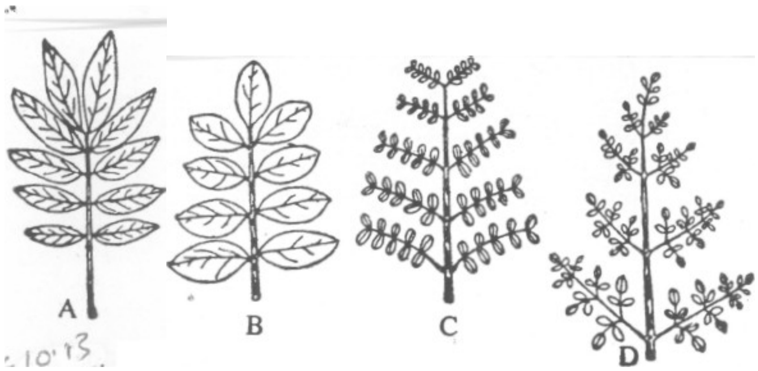


Fig 10.13: Pinnate Leaves. A, unipinnate (paripinnate); B, unipinnate (Imparipinnate); C, bipinnate; D, tripinnate.

Compound leaf

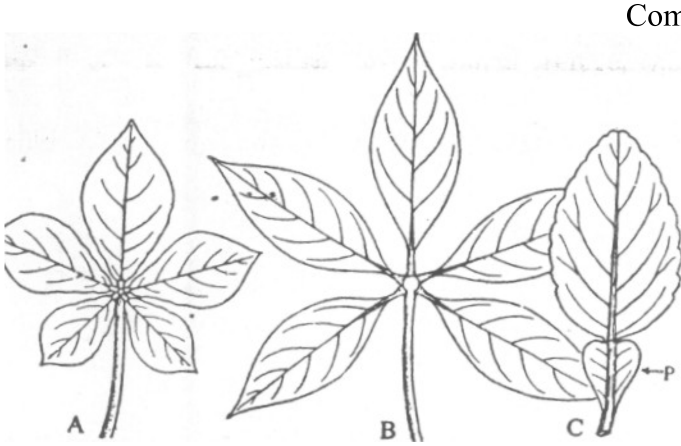


Fig 10.14: Palmate Leaves. A, digitate leaf of *Gynandropsis;* B, the same of silk cotton tree (*Bombax*); C, unifoliate leaf of pummelo (*Citrus*); P, Winged petiole.

To understand clearly the different natures of compound leaf, it is important to distinguish between mid-rib or rachis of a compound leaf and a branch. Some rachis if not closely observed may be taken for a branch. This because mid-rib or rachis in compound leaves holds more than one leaf called leaflets.

(1) A branch bears terminal bud which rachis do not
(2) A branch normally occupies the place of the axillary bud - develops from the bud while mid-rib or rachies in compound leaves bear buds in their axils.
(3) There is presence of nodes and internodes on a branch while rachis have neither nodes nor internodes.

10.2.3.2 SIMPLE LEAF

A simple leaf is one that the leaf-blade runs from the apex of the leaf to the petiole. The petiole is attached to the stem.
Now let us examine the different forms of compound leaves:

(a) **Pinnately compound Leaf:** A compound leaf is said to be pinnate when the rachis or mid-rib bears a number of leaflets arranged in opposite or alternate manner. The rachis can branch off producing opposite or alternate manner. The rachis can branch off producing another rachis bearing leaves. The number of branching off from the main rachis determine further classification into unipinate, bipinnate, tripinnate and decompound.

(b) **Unpinnate:** This is when the rachis of pinnately compound leaf bears the leaflets directly. When the number of leaflets are even, it is said to be paripinnate whereas, if the leaflets are in odd number, it described as imparipinnate. E.g. of unipinnate are rose margosa. If the rachis of a pinnate leaf bears a single leaflet, it is called unifoliate, in pair (bifoliate), three leaflets (trifoliate), four leaflets (quadrifoliate) etc.

(c) **Bipinnate:** Remember these names are given according to the number of times the rachis branch off the main stem. While unipinnate of times the rachis branch off the main stem. While unipinnate is the first rachis that bears the first leaflets, in bipnnate, the first rachis produce secondary rachis which bears the leaflets. E.g. are sensitive plant and gum tree.

(d) **Tripinnate**: In tripinnate, the secondary axis give rise to a third or tertiary rachis that bears the leaves. E.g. drumstick.

(e) **Decompound:** When the duplication of rachis goes beyond the tripinnate, it is described as decompound. E.G, carrot, coriander.

(f) **Palmately Compound Leaf:** Remember we had explained palmate venation to mean vein arrangement when the veins arise from the petiole and not from the mid-rib of the leaf. So palmately compound leaf shows a number of leaflets commonly joined like fingers arising from the petiole.

E.g. silk cotton tree. Palmately compound leaves are classified according to the number of leaflet borne by a petiole. It is said to be unifoliate when there is a single leaflet, bifoliate (two leaflets), trifoliate (three leaflets), quadrifoliate (four leaflets), and multifoliate or digitate (five or more leaflets).

Activities 2

(a) Collect different types of leaves
(b) Classify them into their leaf-type
(c) Identify leaves of monocotyledon and dicotyledon. Write down the Differences you see among them.
(d) Draw parallel venation and reticulate venation from the leaves you identified in (b).

10.3 Conclusion

Leaves are of different types. They are modified to serve different purposes. Each leaf has some veins that are arranged in a particular pattern - parallel or reticulata.

10.4 Summary

In this unit you have learnt that leaves are modified for various functions. There are various types of leave. The arrangement of leaves on the stem could be single as in compound leaves or cluster as in compound leaves.

10.5 'TMA (see course guide)

10.6 References and further reading.

Dutta

Vines and Rees

Unit 11

GENERAL STRUCTURE, ANATOMY, PHYSIOLOGY OF THE ROOT

11.0 Introduction

In unit 10, you studied the leaf of a flowering plant. In this unit you will study about the structure, anatomy, and physiology of the Root. You will study the main features of a flowering plant. a typical flowering plant is made up of the roots, the stem and the leaves, how the roots functions in taking up water is discussed. A lot of drawing has been included in this unit, learn how to draw the root, and how it takes water up.

11.1 Objectives

By the end of this unit you will be able to:
List and discuss the main features of a flowering plant. Draw and label accurately a typical flowering plant. Draw and label the structure of the root.
Describe how the root takes up water from the soil.

l 1 2 General structure, anatomy, physiology of the root.
11.2.1 Main features of a flowering plant
11.2.1.1 The Structure of a flowering plant.

11.2.2 The structure of the Root
11.2.3 Uptake of water by the Root.
11.2.4 Growth of root and stem in a flowering plant.
11.2.5 Main features of a flowering plant.

11.2.1 Main Features of a Flowering Plant

We will take a dicotyledonous plant as our example in this unit. What do we know about a typical flowering plant?

11.2.1.1 The Structure of a flowering plant.

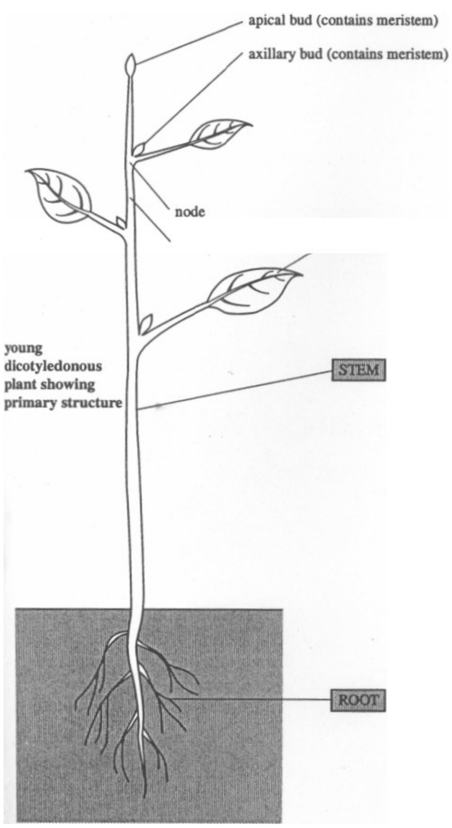
The diagram is a drawing of a young dicotyledonous plant. It shows the root which is below the ground, the stem holding the leaf up and the leaf.

Activity 1:

Pull up a young dicotyledonous in your environment (Make sure it is one that the whole root can come out easily. Observe the uprooted plant and draw the plant showing the main features: roots, stem and leaves. What do you notice about the features?

Diagram 1

The structure of a flowering plant



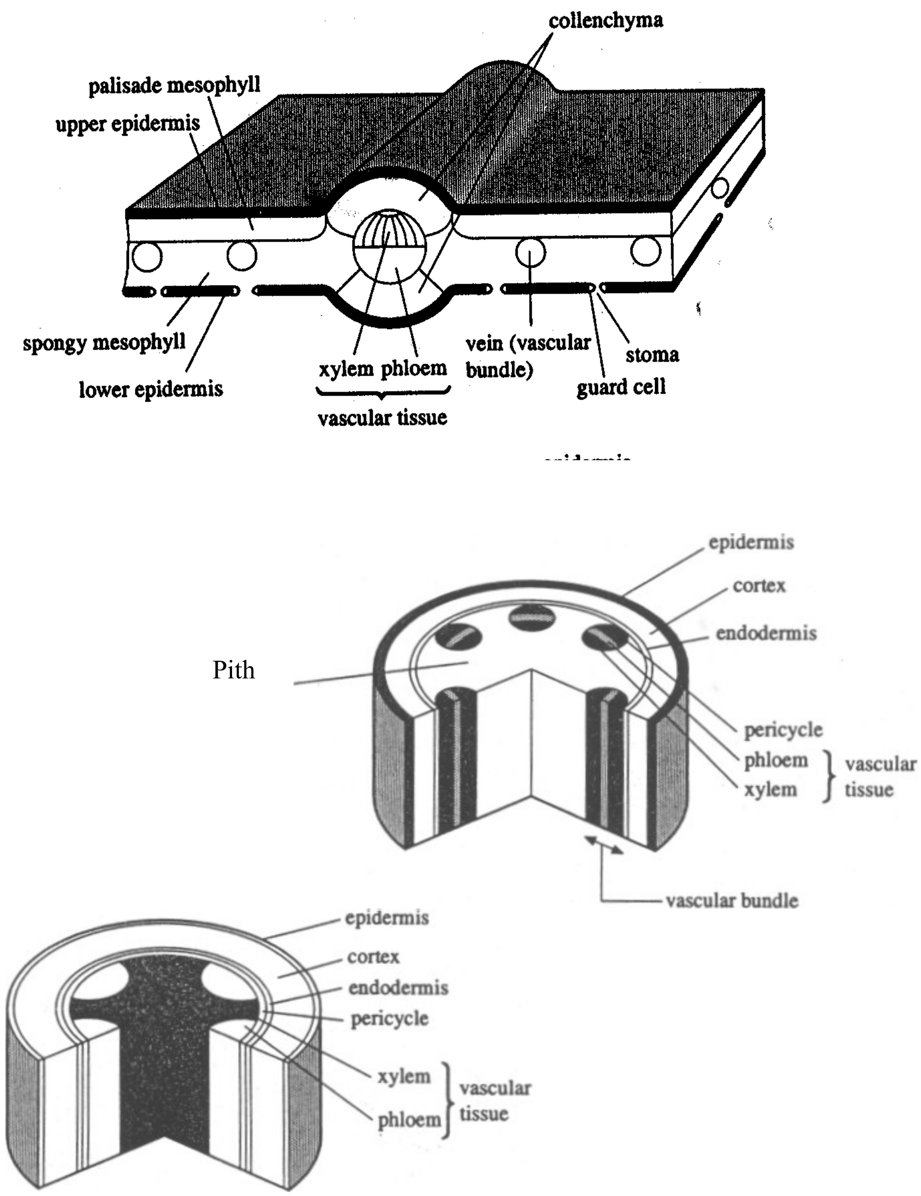


Fig 11. 1 *Young dicotyledonous plant showing main features of primary structure of leaf, stem and root. The regions named are referred to during discussions of plant tissues.*

Source: Taylor, et al. (1998; 16p)

11.2.1 The structure of the Root

The root is the part of the plant that is below the ground. Now we will look at the root in detail.

Fig. 1 Structure of a dycotyledonous root.

Examine the drawing critically, you will notice a surface layer of epidermal - type cells, and a central core of vascular tissues. In between these two, you will notice parenchyma cells (they are turgid in nature. Even though they are closely packed, you can still notice some separation by small water-filled intercellular spaces. Can you see the endodermis?, within the endodermis are vascular tissue (remember this) we will came back to that later. Locate the piliferous layer it is called like that because it is covered with root hairs. The root hair is a slender layer is found only in young plants. In older plants, the out layer of parenchyma is the one present and it is called the epiblem.

Activity 2:

Draw the structure of the root in your note book, label the parts correctly.

Diagram: 2

11.2.2 Uptake of Water by the root

The fact that the root is under the ground means that it is fulfilling a purpose there. What purpose does the root serve? The root takes up water from the soil and send it upwards. Let us see how this is done. Look back at the diagram of the structure of the root. Take note of the arrow going from the soil into the root hair then to the epiblem through the cortex (parenchyma) up to the xylem.

The root hair serves several functions: a) it holds the plant to the soil, (b) it also takes up water in the plant. Remember in the above passage, we have said that the root hair is slender and flexible, this is an advantage. The nature of the root hair makes it to penetrate the soil particle and absorb water from the intervening spaces of the soil. This work of uptake of water is facilitated by the absence of cuticle in the root hair in the root hair. They are also numerous.

The process by which water is draw up the root is a series processes. You have learnt about osmosis in unit 3. The process is simply this. Inside the cells of the plant, there is solution that contain sugar, and other metabolises, the concentration of solutes in the sap vacuole is greater than that of the surrounding soil water, water molecules are drawn across the cellulose wall and the semi permeable protoplast into the vacuole. The route water is believed to go through:

(a) The sap vacuoles, water being drawn from one vacuole to the next by osmosis.
(b) The cytoplasm, water diffusing from cell to cell via the plasmodesma strands.
(c) Along and between the cell walls, water diffusing through the cellulose of adjacent cells and through the small intercellular spaces between them.

Biologists are not sure which of these three are in operation, however, it is possible that the three could be going on at the same time.

How does water continue up the plant and even into the leaves and are transpired?

Biologist are guessing that the osmotic pressures developed in leaf cells as a result of transpiration result in water being drawn into and along the vascular tissues. It is like water is being

Fig 11.2 Uptake and Transport in Plants

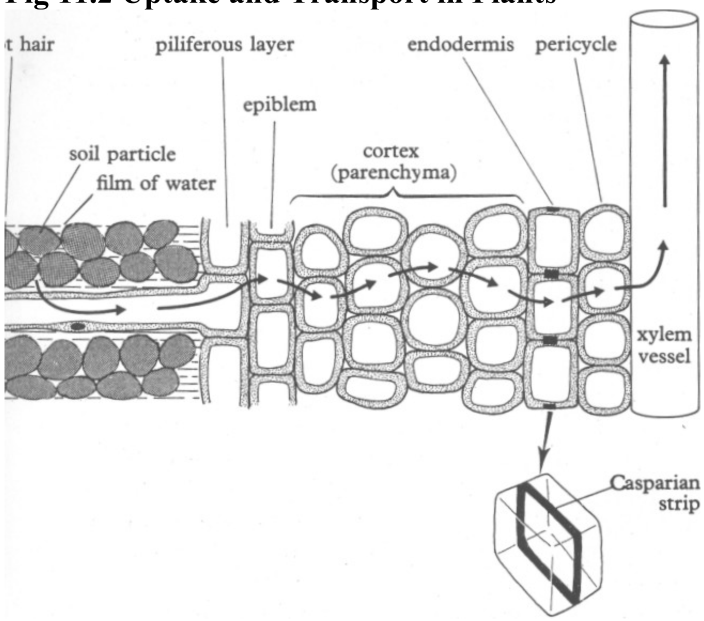


Fig 11.2: *Structure of a dicotyledonous root showing one of the routes by which water and mineral salts may be drawn from the soil into the vascular tissues. The forces involved, and possible alternative pathways, are discussed in the text.*

Source: *Roberts, M.V. (1987;185).*

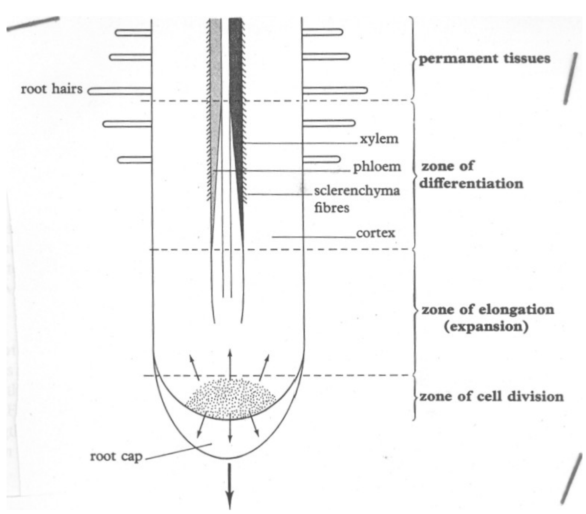


Fig 11.3: Growth of root in a flowering plant
Source: Roberts, M.V. 1987. p.426

pulled up (a force is pulling water up) - a force exerted by the leafs. You must have seen a plant that has been cut completely at the stem. If you look closely at such a plant, (note, the leaves are not there) water still comes out of the stem. It confirms that the pull is not by leaves. There must be some thing else that forces water up the plant. What is it? The force is called **root pressure**.

How does water move up from the root to the leaves? We will see that when we study the stem.

Activity 3

You can demonstrate Osmosis on your own. Simply take a piece of yam. Peel the yam, cut a length of about 4 inches, Scoop the inside almost 3 inches round and deep, Be sure not to perforate it. Get a large size bowl with clean water, enough to cover the yam half. Place the yam in the water. Place some cubes of sugar in the yam. Leave this over night and record your observations. What do you conclude from this simple experiment?

11.2.3 Growth of Root in a flowering plant.

The drawing of fig. 7.3 is a typical illustration of how the root grows. Cell division in the epical meristem produces daughter cells that with the continued formation of new cell Is at the tip, get pushed back towards the zone of elongation. Fig. 7.3 Growth of root in a flowering plant. Increase in length is achieved mainly by cell elongation. There is no sharp destination between the zones of elongation and differentiation the cells beginning to differentiate while they are still expanding.

11.3 Conclusion:

You have learnt in this unit that a flowering plant is made up of three parts. The root, stem and the leaves you have learnt how the root takes up water in a flowering plant.

11.4 Summary

In a typical flowering plant, the roots are in the soil. The root is made up of the surface layer of epidermis, central care of vascular tissues and in between these tissues are the parenchyma cells. The root hairs are numerous and slender, which confer an advantage of pushing their way through the soil.

11.5 TMA (attached)

11.6 References

Extensive reference is made of Roberts, M. V. (1987)

Taylor, et al (1998).

Unit 12

GENERAL STRUCTURE, ANATOMY, AND PHYSIOLOGY OF THE STEM

12.0 Introduction

In unit 11 you learnt about the general structure of the flowering plant, you learnt that a typical flowering plant is made up of the root, the stem and the leaf. In this unit we are going to study the stem. The stem is the part of the flowering plant that is above the soil. For water to get to leaves and for manufactured food to get to the root, they must pass through the stem.

12.1 Objectives

By the time you complete this unit you will be able to:

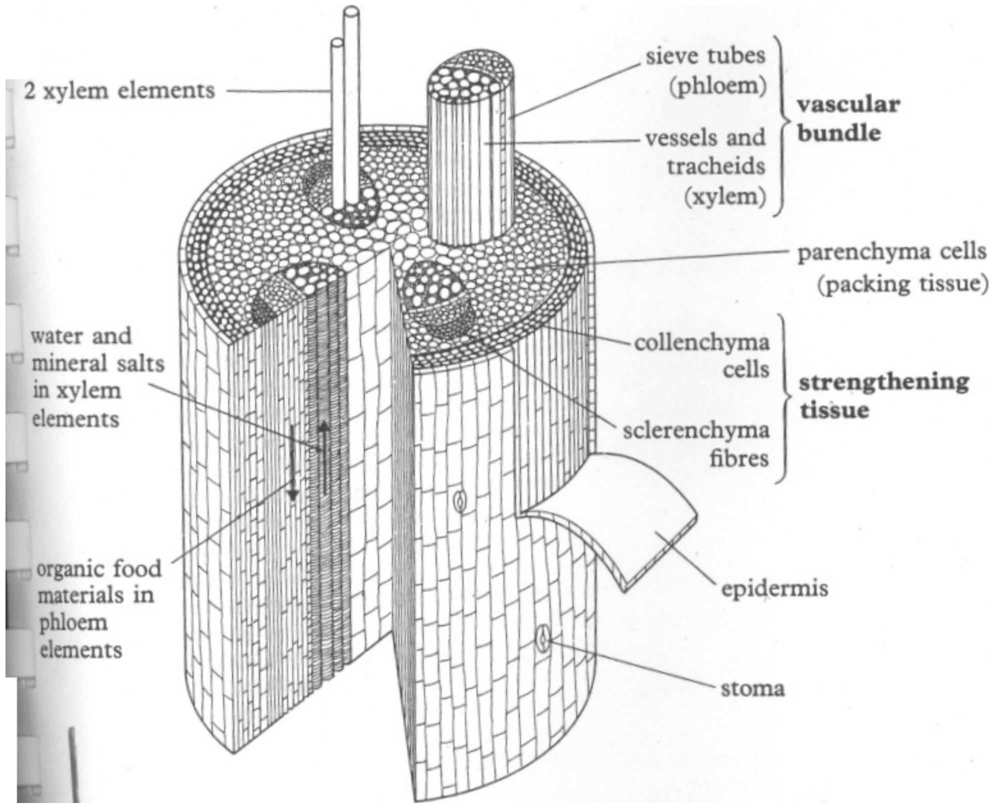
(1) Draw and label accurately the structure of the stem.
(2) Draw the vascular bundle showing the Xylem, and the phloem.
(3) Explain how water and other minerals are transported through the stem.

12.2.0 General Structure, anatomy and physiology of the stem.

12.2.1 Structure of the stem

The stem as you saw in the first section of the unit is the part between the root and the stem position the leaves in such a way that the leaves receive sunlight. Let us have a look at the stem. What does the inside of the stem look like?

Fig 12.1: *Stereogram of pan of a dicotyledonous stem. The conducting tissues are confined to the vascular bundles: the xylem contains vessels and tracheids and the phloem contains sieve elements.*



Source: *Roberts, M.V. (1987 p187)*

Study the drawing critically. The xylem is contained in a series of vascular bundles that also include the phloem. Where do you think the stem got its strength? The collenchyma and sclerenchyma tissue contribute to the strength of the stem. They help the stem from drooping. The vascular bundle are the continuation of the ones we saw in the structure of the root. They continue from the root to the leaves.

12.2.2 Xylem Tissue

The xylem is made up of two types of conducting element: vessels and trancheids. The vessel is formed from a chairs of elongated cylindrical cells placed end to end. The cells are in open communication with each other.

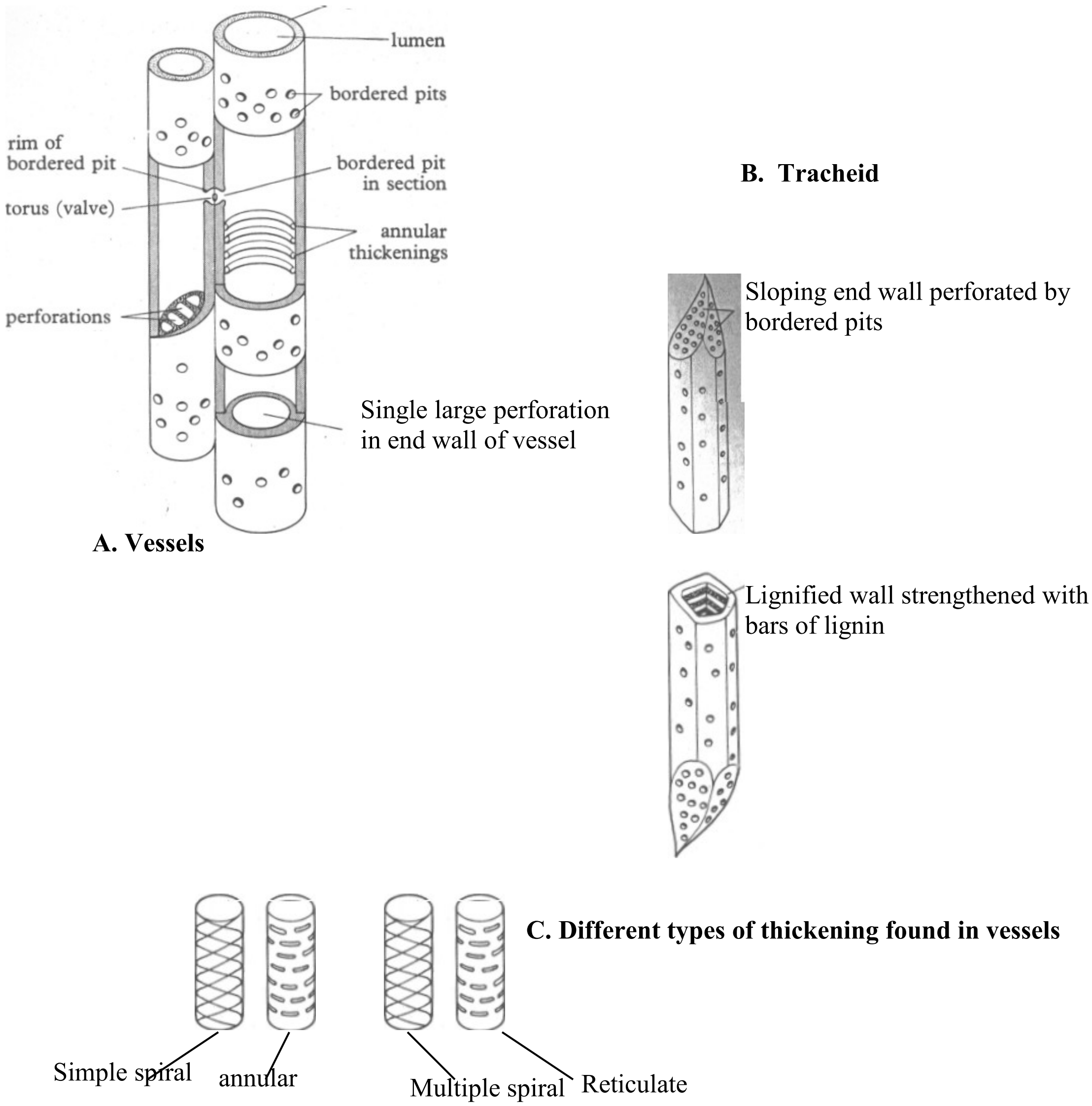


Fig.12.2 Xylem elements of higher plants.

The diagram shows the structure of vessels and tracheid.

12.2.3 Xy1em and Water Transport

You saw the structure of the xylem above. How does it transport water? Biologists have demonstrated this by using coloured dye (red or blue). They put cut stem in a red dye solution. After a while the stem is cut and examined under a microscope it was concluded that only the xylem took up the dye. Series of experiments have been done to establish that the xylem is the part that transport water and the specific area is the lumina area is the lumina of the dead vessels and tracheids.

12.2.4 Ascent of Water up the stem

You have seen that the xylem is responsible for water to move up the plant. How does it do it exactly? Series of experiments have made Biologists to arrive at two forces responsible for water to go up a plant.

(a) Adhesion: i.e. the force of attraction between unlike molecules.
(b) Cohesion: i.e. the force of attraction between like molecules.

Within the vessels and tracheids in the leaves and stem, cohesive forces between the water molecules prevent the water column breaking in the middle. Two forces are at place: Cohesion and Adhesion, these keep the water moving upward. Even in tall trees, the two forces operates to keep water going up when the leaves loose water, cohesive force draws up water to replace the one lost. In this process, there is a continuos flow of water up the plant through the stem.

Activity 3

You can demonstrate water uptake in a simple plant (Water leaf). Make a solution of blue or red dye. Uproot a plant of waterleaf. Wash the roots then place the root in your dye solution. Leave this for an hour. Break a stem of the plant, use a sharp razor and make a clean cut of the stem (cross section) mount this under a microscope. (Your tutor will help you with a microscope) draw what you see. In your drawing label the Xylem (the part that has taken the ink stain).

12.2.5 Phloem

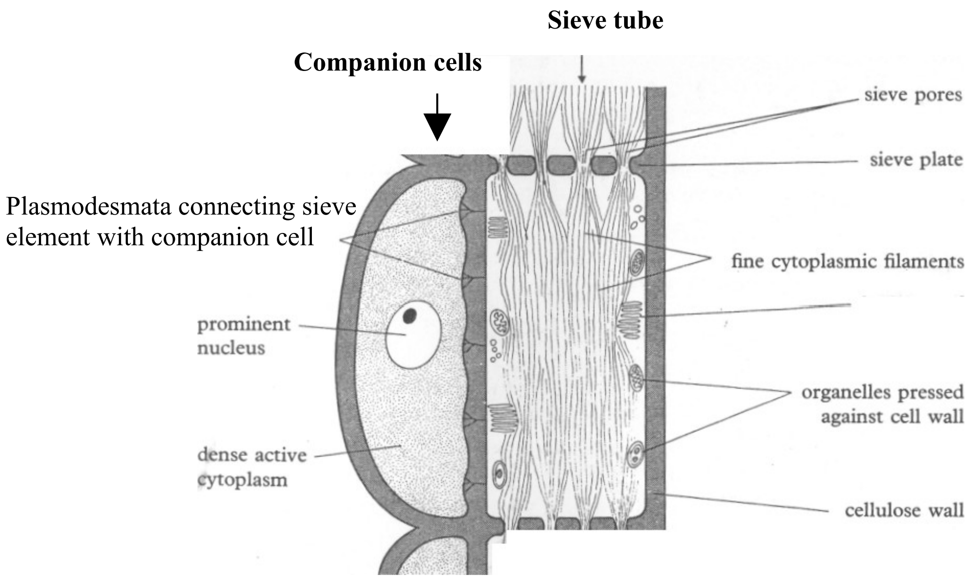
The vascular bundle is made up of the xylem and the phloem. In unit 8.1 you learnt about the xylem, in this section you will study the Phloem. The Phloem also possess tabular structures like the Xylem, the tabular structures are modified for translocation. The tubes are composed of living cells with cytoplasm and have no mechanical function. There are five cell types:

(1) Sieve tube elements
(2) Companion cells
(3) Parenchyma
(4) Fibres
(5) Sclereids

12.2.6 The Structure of the Phloem

You have learnt that the stem transport water and mineral salt. In the section on Xylem, you learnt that the xylem carry water up the plant. It is certainly not the same vessel that carry manufactured food down the plant. Experiments have shown that the Phloem is the vessel responsible for carrying water in the stem. Let us look at the structure that makes it possible to do this.

Fig. 12.3: *Structure of the Phloem*



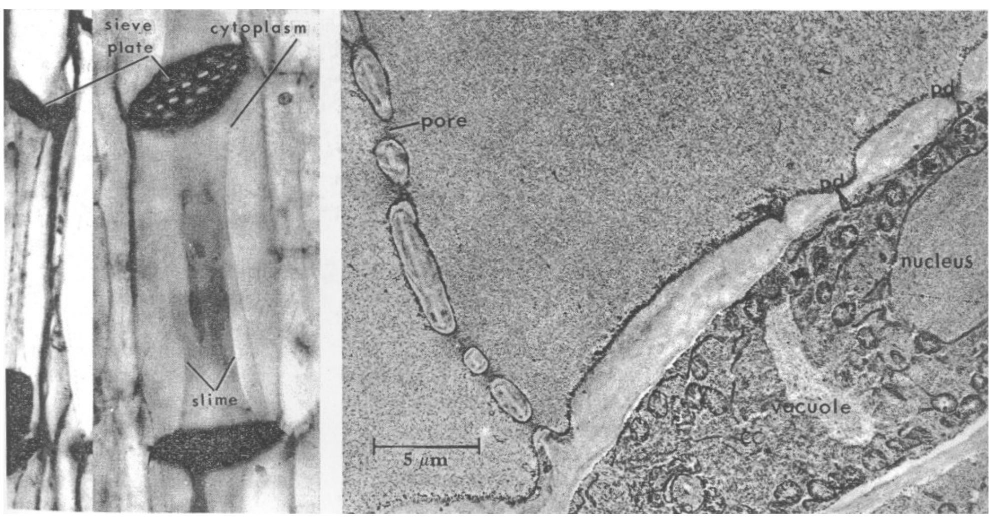


Fig 12.3: The structure of the phloem. r. Diagram of a sieve element and its companion cell. The sieve element has no nucleus and not many organelles, what few there are being pushed to the side. In contrast the companion cell has a prominent nucleus and dense cytoplasm containing numerous mitochondria, abundant endoplasmic reticulum and ribosomes. (*Modified after Clowes and Juniper*). i) Photomicrographs of sieve tubes from the phloem of flowering plants. C) Electron micrograph of part of a sieve tube and neighbouring companion fragment of cell. Notice the pores in the sieve plate and the plasmodesmata (**pd**) piercing the cellulose wall between the sieve tube and companion cell (CC).

(B and C: K. Esau and V. I. Cheadle, University of California)

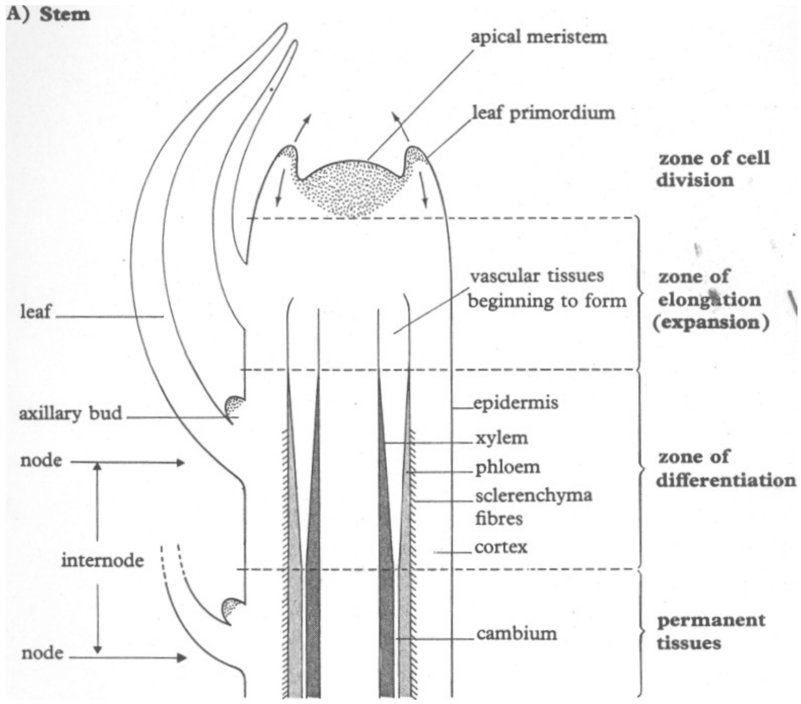
Look very critically at this drawing of the structure of the Phloem. You will notice the elongated sieve elements. They are connected end to end forming sieve tubes. They run parallel with the long axis of the plant. Locate the sieve plates they are perforated by numerous pores that allow the passage of materials from one sieve element to the next. You can see the companion cells, they have a nucleus, dense endoplasmic recticulum, ribosomes and numerous mitochondria. Each sieve element is connected by plasmodesmata. The sieve has its adjacent companion cells. The companion cells are the site of intense metabolic activity. It is believed or speculated that translocation of food materials take place along the sieve tubes.

A simple experiment to show that the Phloem is the structure responsible for translocation of food material.

In a mature tree bark, the Phloem is the part that is nearer the outside while the xylem is inside. The tree trunk was ringed round and stripped off. It was found that sugar concentration above the ring increases, while the concentration below the ring decreases. The ringing round blocked the sugar from moving down. (Roberts. 1987). Other methods like radioactive tracer have been used, to determine that the Phloem is the one that carries the food down the plant.

Activity 4

Carry out a simple experiment. Get a young dicotyledonous plant, ring it round and remove the section of the bark. Give it a whole day test for sugar above the ring and below the ring. Your instructor will show you how to test for sugar. Record the observation, is there more sugar above or below?



Source: *Robert M. V. 1987*

Fig 12.4: Development of the Stem

12.2.7 Development of the Stem (Secondary thickening)

You have learnt about how cell divide and produce new cells. Addition of new cells make the apical meristem to increase in size.

Cell division in the apical meristem produces daughter cells that with the continued formation of new cells at the tips get pushed back towards the zone of elongation. Increase in length of stem is achieved mainly by cell elongation. There is no sharp distinction between the zones of elongation and differentiation, the cells beginning to differentiate while they are still expanding. The plants grows sideways also.

12.2.7.1 Secondary thickening in stem.

Secondary thickening of the stem is used to describe the processes of growth that occurs in the stem after the primary tissues are fully formed. This processes lead to increase in the thickness of the stem due to additional secondary tissues cut off by the cambium and the cork-cambium in the stelar and extra-stelar regions respectively. From the above, it will be notice that the cambium plays essential role in the secondary growth of the stem. Therefore, there are various activities that go in the cambium.

During the process, the meduI lary ray cells and the cambium of vascular bundle called fascicular cambium become meristematic leading to the development of and cambium called the interfascicular cambium. It is called interfascicular because it is found between two vascular bundles. When this joined with the first facicular bundle on both sides, a complete ring is formed. This is called cambium ring.

The activities of the cambium ring will lead to the formation of secondary tissues in the stem. This begins when the cambium ring becomes meristematic forming new cells both within it and externally. The external cells give rise to the secondary phloem made up of tubes, parenchyma, companion cells and parches of bast fibres. Some of the fibres used in textile industries like Jute, Hemp are obtained from the bast fibres of secondary phloem.

While the external cells give rise to phloem, the inner cells of the cambium ring develop into secondary xylem made up of scalariform, pitted vessels, tracheids, wood fibres arranged in rows and some wood parencloyma. The xylem increases in size faster than the phloem because the cambium is more active inside than outside. This also account for why the xylem constitute major part of the plant. As the xylem continue to increase, it exert pressure so the Phloem, the cambium and the tissues around them are pushed outward thus crushing most of the primary tissues. However, the primary xylem remain intact in around the centre of the stem.

The changes in the season also affect the activities of the cambium. During the rainy season, much leaves are formed leading to the formation of more leaves. This equally increase the need to transport sap so the cambium becomes more active through the formation of more vessels with wider cavities. The reserve is the case during the dry season, fewer vessels and narrower cavities are formed. The cambium formed are called growth or annual ring. This can be use to determine the age of plants when they are cut especially timber, pine.

Apart from the cambium, the cork-cambium also plays essential role in secondary thickening of the stem. The cork-cambium is formed in the outer layer of collenchyma, the epidermis or cotex as the collenchyma becomes meristematic. New cells begins to form at both sides of the cork-cambium as it becomes active thus forming secondary cotex in the inner side and the cork in the outer side.
The cells of the secondary cotex (phelloderm) contain chloroplast and carry out photosynthesis. The cork (phellem) which is at the outer side of the cork-cambium are suberized and so does not allow water and food materials. Because of this, they soon die off and become the back of the plant - a protective tissue.

12.3 Conclusion

You have learnt the structure of the stem. You have learnt that the Xylem carries water up the plant while the Phloem carries food (manufactured by the leaf) down the plant. You have learnt the structures found in the Xylem and the Phloem that make this possible.

12.4 Summary

In a flowering plant, the plant continuous to grow because the cells continue to divide. The apex (apical) is a growing point and the root also. The tissue where new cells are being added are called meristematic tissue. Meristematic tissues are found in the root tip and stem tip. The stem is able to stand erect and strong because it has cells like:

(a) Parenchyma tissue
(b) Collenchyma cells
(c) Sclerechyma fibres.

12.5 TMA

12.6 References and further reading.

Vines and Rees. Plant and Animal Biology

UNIT 13

GENERAL STRUCTURE, ANATOMY AND PHYSIOLOGY OF THE LEAF

13.0 Introduction

In unit 12 you learnt about the stem as the part that grows above the soil. You learnt also that water is transported upwards through the stem, and sugar (manufactured food) is transported downwards through the stem. The stem holds the leaves in such away that they receive sunlight to make food for the plant. In this unit, you will study the structure of the leaf. Why is it possible for the leaf to make food?

13.1 Objectives

By the end of this unit you will be able to:

a) Draw a typical dicotyledonous leaf and label the drawing correctly.
b) Draw the internal structure of the leaf and label it correctly.
c) Discuss water movement in the leaf.
d) Discuss the functions of the leaf in a flowering plant in relation to photosynthesis.

13.2.1 Structure of The Leaf

You must have seen leaves, you are surrounded by different types of plants. If you look at a plant you will see that its leaves are different from the leaves of another plant. What do you notice most in leaves?

(a) They are flat, some are very wide but they are all flat
(b) Most of them are thin with large surface area.

What is the advantage of the leaves being thin? The thinness minimizes the distance over which diffusion of carbon dioxide has to take place.

Fig 13.1 : The leaf is a complex organ for photosynLnesis. The photosynthetic cells are held in the best position for gaining maximum light. Strengthening tissue maintains the shape of the leaf. Stomata allow the entry of carbon dioxide whilst the cuticularized epidermis prevents excessive water loss. Conducting elements in the midrib and veins bring water and mineral salts to the leaf, and remove the products of photosynthesis from it. (*based mainly on Brown*)

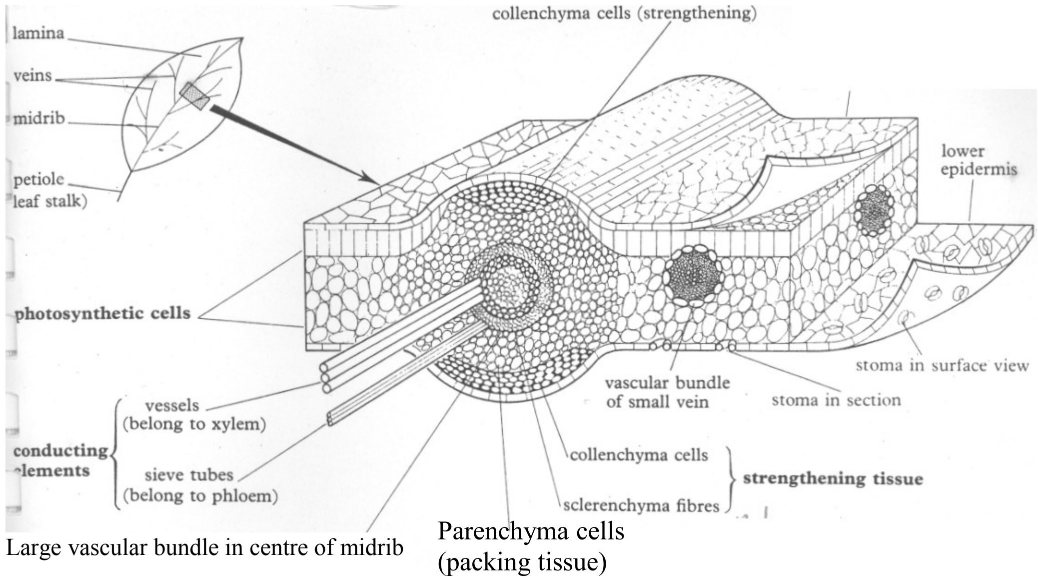
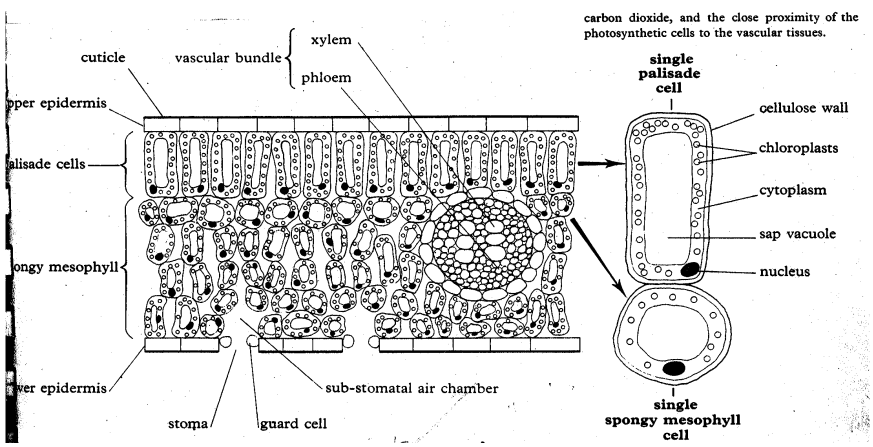


Fig 13.2: (*below*) Photosynthetic cells as seen in a transverse section of' a leaf. Note the inter-cellular air spaces allowing free diffusion of carbon dioxide, and the close proximity of the photosynthetic cells to the vascular tissues.



Source: *Roberts, M. V. (1987) Biology: A Functional p 151 Approache.*

Look at this drawing critically, you will notice the layer of cuticularized epidermal cells. The cuticle is generally thicker on the upper surface than the lower. Take note of the inside of the leaf. There are cells (plenty) that contain chloroplasts. There are two types of this cell

(a) Palisade cells (these are immediately beneath the upper epidermis, they are elongated, with their long axis perpendicular to the surface. They are separated from each other by narrow air spaces and are densely packed with chloroplast. The palisade layer may be one or several cells in thickness.

(b) Spongy mesophyll cells. These cells fill the leaf between the palisade layer and the lower epidermis. Spongy mesophyll cells are irregular in shape and arrangement, they also contain chloroplasts, but fever than in palisade layer take note also of the large ain spaces between the spongy mesophyll cells. The air spaces are linked to each other. They allow gases to diffuse freely between the cells. The lower epidermis has numerous pores called stomata. The stomata are bordered by guard cells. The guard cells open and close the pore. What is the function of the stomata? It regulates the passage of carbon dioxide, oxygen and water vapour across the surface of the leaf.

13.2 1 Water movement in the leaf

In section 13.1 you learnt the structure of the leaf. In the diagram of the internal structure of the leaf you saw some structure that reminded you of the structure you saw, in the stem. Some structures are continuous, like the xylem and the phloem. That is why the water from the root will get to the leaves.

The phloem. Also carry food from the leaf to the root. There is a continuity of these structures from root to the leaf. You learnt that when water evaporates from leaf, more water is pulled from the root upwards. How is this done?

When water evaporates from the walls of the spongy mesophyll cells into the sub-stomaal spaces, water molecules diffuse out of the sap vacuoles to replace those which have been lost to the atmosphere. This results in the solutes becoming more concentrated so that the osmotic pressure of the outermost cells exceeds that of the cells further in. water is drawn into the surface cells from the next cell. This cell that water is drawn from acquire a higher osmotic, pressure and will draw in water from neigbouring cells. The mechanism is too difficult for you at this stage. This process continues if water is transpired (lost into the atmosphere) osmotic pressure is involved in drawing water from the vascular tissues in drawing water from the vascular tissues to the mesophyll cells.

13.2.3 The leaf as an organ of photosynthesis

You have being hearing that some plants, (most plants) make their own food. How do plants do this? Photosynthesis is a process whereby sunlight (energy) is trapped from the sun by the chlorophyll and used in the manufacture of carbohydrate from carbon dioxide and water. This is how it happens:
$C0_2 + H_2O$ light energy chlorophyll $CHO + H_2$

Carbondoixde + water - Carbohydrate and oxygen. Take a look at this equation. Where does the leaf come in? Do you remember the chloroplasts in the mesophyll and palisade cells? The water and mineral salts drawn from the soil through the root, stem and into the leave are now used to manufacture the food. The leaf becomes the factory where this manufacturing takes place. The leaf is not just a site of photosynthesis, oxygen and excess water vapour diffuse out of the leaf via the intercellular air spaces and stomata. The stomata has a vital part to play in photosynthesis. When the stomata opens, the rate of the photosynthesis is increased. Carbohydrate (sugar) and other product s of photosynthesis are moved to other parts of the leaf in the sieve tubes. The leaf is green because it contains chlorophyll and this is why it can manufacture food. The process of trapping sunlight is a photochemical reaction. When you study more biology you will get into the detail. For now know that green plant photosynthesize (photo - light, synthesize-making) while non-green plant do not because they do not contain chlorophyll

Activity 1

Collect leaves from different plants examine the leave in terms of the upper surface and lower surface write down your observation. Your instructor will help you to carry out an experiment to show that photosynthesis takes place in the leaf.

13.3 Conclusion

You have learnt that the leaf is the organ that is responsible for manufacture of food in the plant. All the vascular tissues are continuous from root to the leaf. The leaf also has special structure that enables it to regulate water loss.

13.4 Summary

The leaf contains chlorophyll, which enable it to carry out a process called photosynthesis. Photosynthesis is the process of the green part of a plant tapping energy from the sun and with the combination of carbon dioxide and water manufacturers food.

$$\text{Carbondioxide + Water} \xrightarrow[\text{Chlorophyll}]{\text{Light energy}} \text{Carbohydrate + oxygen}$$

13.5 TMA (see attached)

13.6 References

Extensive reference is made to

Roberts M. V.

Taylor *e.t al*.

13.7 Further Reading

Many plant biology textbooks have sections on anatomy and physiology of root stem and leaf.

UNIT 14

FLOWERS

14.0. Introduction

In unit 13, we learnt about the leaf. You learnt that it performs many functions including photosynthesis. In this unit you will learn about flowers. You will learn about the parts of a flower and the types of flower.

Flower is a part of a flowering plant that we studied in earlier unit . Higher plants are distinguished by the production of flowers' that is why they are called flowering plant. In this unit, you will learn how the flowers help in reproduction in flowering plants. The flower is believed to be kind of modified leaves.

14.1 Objectives:

By the end of this unit you will be able to

1. Draw and label a typical flower correctly
2. Discuss the functions of the parts of the flower
3. Discuss the concept of floral diversity
4. List different types of flower and discuss their characteristics features
5. Describe the development of the following
    a) Pollen Grain
    b) Ovule
    i. Differentiate between pollination and fertilization
    ii. List different types of pollination and explain the process of each

14.2 Flowers and floral diversity
14.2.1 Structure of a typical flower
14.2.2 Types of flower
14.2.3 Development of the pollen grain
14.2.4 Development of ovule
14.2.5 Types of pollination
14.2.6 Fertilization
14.3 Conclusion
14.4 Summary
14.5 References
14.6 Further Reading

14.2. Flowering and Floral Diversity

The higher plant in evolutionary trend is the one that is called flowering plant. Plants as you have learnt do not move about like animals. For them to perpetuate their young ones, they must have special features that help in that process. Look around you, they are everywhere on land. Biologists will refer to that as successful on land. Wiry is it possible for them to be so successful on land?

Flowering plants produce seeds, seeds can be carried about by many ways. The flowering plant is the reproductive structure of a flowering plant. Flowers are seen as specialized leaves.

14.2.1 Structure of a typical flower

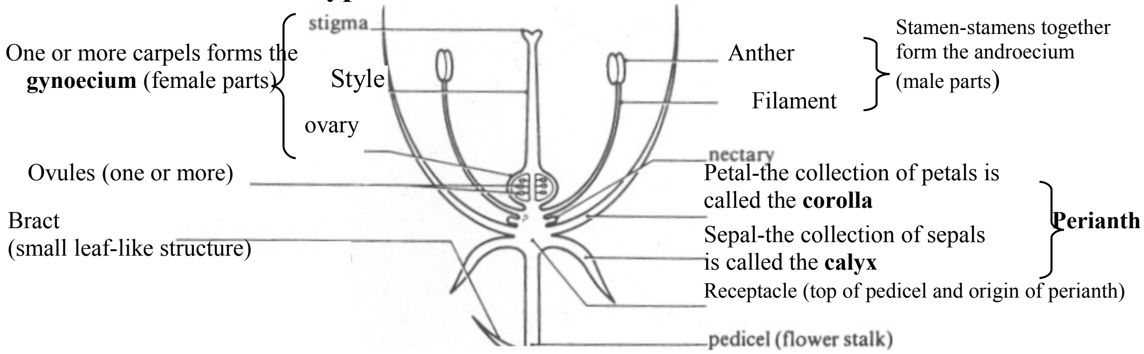


Fig 14.1: ***Longitudinal section of a generalized flower.***

Source: Taylor et. al. 1998: 713

Examine the drawing of a typical flower below.
From the drawing, you can see the receptacle, (pedicel). Locate the perianth (perianth segments. The outer whorl of sepals (calyx), an inner whorl of petals (corolla).

Activity 1
Go out and pick a few flowers, locate the part just mentioned. Do you have any difficult with that? Get a sharp blade and make a longitudinal section of any of the flowers you picked. Can you now locate the

- Calyx - collection of sepal. The sepals are the green leaf-like structure that covers the bud before it opens.

- **Corolla** - collection of petals. The brightly coloured petals attract insects and far man; they are eyecatching, that is why you see people go for them for beautifying their houses

- **Androecim and roecium** - collection of stamens (male reproductive organ of the flower). Both the filament and anther made up the stamen. The pollen bag at the tip of the filament and another make up the stamen. The pollen bag at the tip of the filament is where the pollen is made.
  Look closely at the flower you are studying, you may even see some pollen grains.

- **Gynoecium** - collection of carpels, this is the female part of the flower. It consists of the stigma, style and ovary. What does the stigma do? It receives the pollen grains during pollination.

- **Ovule** - structure in which the embryo sacs develop, after fertilization ovules become seeds

  Have you been able to locate these parts? If you have any difficult in locating these parts, hold your flower against the drawing above
  Now try the exercise again until you locate the parts.

14.2.3 Development of pollen grain

14.2 2 Types of flower

The lower are of various kinds. There are name for each types, and this is based on the kind of arrangement of the parts of the flower. - In some flower/ the carpels are separate and free

- In some flower the carpets are fused to form a single structure
  In some flower the receptacle and flower are said to be hypogynous if the stamens and periath are inserted below the gynoecium

- In some flower if the stamens and perianth are inserted above the ovary, it is epigynous

- In some flower, if the receptacle is flattened or cup-shaped with the gynoecium at the centre and the stamens and perianth is attached around the rim it is perigynous.

Ovaries are of two types

(a) a superior ovary i.e. if located above the other flower parts on the receptacle as in hypogynous flower

b) an inferior ovary, if it is located below the other flower parts on the receptacle, as in epigynous flower. Flowers have special glands called nectaries, sugary fluid is secreted in the nectaries. This is what insects, birds, etc. go to suck from flowers.

Activity 2

Pick more flowers of different kinds. Classify the flowers according to their structure into:

(a) Carpels are free and separated.
(b) Carpels are fused to form a single structure .
(c) Stamens and perianth are inserted below the gynoecium.
(d) Stamens and perianth are inserted above the ovary
(e) The receptacle is flattened
(f) The receptacle is cup-shaped

How many types of flowers could you put in each group?

Activity 3

Look among the flowers, how many of them have superior ovary and how may have inferior ovary?

14.2.3 Development of pollen grain

The pollen grains are the tiny powdery substance found at the tip of the anther. The anther looks like a sac there are four of such sacs. The anther is held up right, usually in such a way that the pollen produced in the sacs will get to the stigma. The filament contains a vascular bundle; this supplies food to the pollen sacs. The biology involved in this may be too difficult for you now.

Activity 4

Collect more flowers, observe the anther. Can you see the sac-like structure?

14.2.4 Development of the ovule

The ovule is the part that develops to become the seed after fertilization. The ovule develops in the ovary. It could be one or more. The ovule is attached to the ovary at a point called the placenta. Through this structure, food is passed to the ovule.

Activity 5

Open some of the flowers you collected locate the ovule and the placenta. From what you see can you tell if fertilization has taken place?

14.2.5 Types of Pollination

Have you heard the word Pollination?

What does it mean to you? Pollination is simply defined as the transfer of pollen grain to the stigma the male gametes are found in the pollen grains. For continuity the pollen grains must reach the stigma for pollination to occur. This can be done by the anther shedding the pollen grain directly on the stigma (self pollination) or the pollen is carried to the stigma of another plant (cross pollination). Insects and wind are the main agents of pollination. You heard earlier that plants do not move about like animals, something must be responsible for the perpetuation of their off-springs. There are differences between wind-pollinated flower and insect pollinated flower. Some of such differences are:

Activity 6

Fill the gap, write out the differences

Wind – Pollinated flower	Insect-pollinated flower
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14.2.6 Fertilization

Fertilization is what happens after pollination has taken place immediately the pollen grains land on the stigma, it grows downwards by producing a tube, known as a pollen tube. This grows into the ovary as a pollen tube. Enters the ovule through the micropyle, the tube nucleus degenerates and the tip of the tube bursts, releasing the male gamete near the embryo sac, which they enter and fertilization takes place.

14.3 Conclusion

You have learnt about flower, types of flower, why we have diversity in flowers. You have learnt the development of the pollen grains, ovule. You have also learnt about pollination and fertilization.

14.4 Summary

Flower is very important. It is the reproductive structure of a flowering plant. There are many types of lower classified based on the structure. Pollination classified based on the structure. Pollination is the transfer of the pollen from the anther to the stigma. There are two major agents of pollination, wind and insects and there are two kinds of pollination self-pollination and cross-pollination.

14.5 T.M.A (see attached)

14.6. References

Extensive reference has been made to Taylor et al (1998) Biological Science.

14.7 Further Reading

Read as many textbooks on Biology as Possible.

Unit 15

Floral Arrangements

15.0 Introduction

In unit 14, you studied the flower and learnt that the flower is the reproductive structure of a flowering plant. You learnt that different plants have different flowers. The difference in the flowers are shown by the arrangement of the parts of the flower. The way the parts of the flower occur and are arranged is constant for a particular plant, e.g. hibiscus flowers have the same arrangement of petals, sepals, etc. The arrangement of hibiscus is not the same with that of another flower of another plant. The arrangement of the flowers is known as the <u>inflorescence</u> of the plant. In this unit you will study the arrangement of flowers, it is also known as floral diversity.

15.1 Objectives

By the time you complete this unit you will be able to:

1. Explain common floral arrangements.
2. List common floral arrangement
3. Discuss two types of inflorescence
4. Distinguish among six categories of flower structure
5. Identify three patterns of position of flower parts on the receptacle

15.2 Floral Arrangement.

15.2.1 Common floral arrangement
15.2.2 Types of inflorescence
15.2.3 Indefinite inflorescence
15.2.4 Definite inflorescence
15.2.5 Categories of flower structure
15.2.6 Patterns of position on the receptacle
15.3 Conclusion

15.2.1 Common Floral Arrangement

i. Flowers at the apex of the main shoot or one of its branches. When this occurs, the vegetative activity at the apex ceases and the vegetative part are replaced by the reproductive parts (flowers).

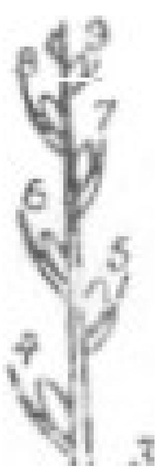
ii. Flowers may be found where the buds are in the axis of the leaves.
iii. Flowers may be grouped together on an axis called the peduncle.
iv. Some flowers may or may not possess a stalk or pedicel.
v. Flowers may simply look like foliage leaves - appear smaller and scale-like.
vi. Flowers may be coloured (petaloid).

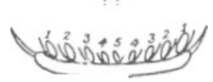
15.2.2 Types of Inflorescence

In the previous section you learnt that the inflorescence is the arrangement of flowers on the shoot. In this section you will study two types of inflorescence - indefinite inflorescence and definite inflorescence.

15.2.3 Indefinite inflorescence:

In this group (or race mose), flower buds are produced at the apex of the plant and it does not end the reproductive life of the plant. The flower can continue to produce. Example as in plantain, orchis.





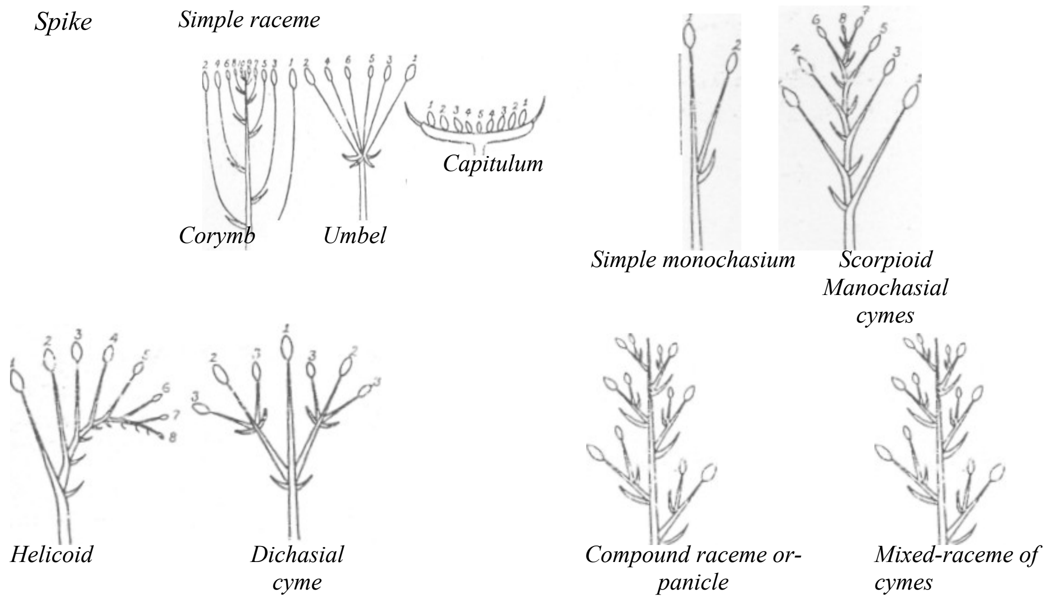


Fig. 15.1: *Diagrams of the types of inflorescences. The numbers indicate the sequence of development of the flowers.*

Study the diagram in figure 15.1 very well. You will notice five types of flower arrangement.

1. **Spike** - look at number 1-9 arrangement, they are individual, without stalk and are arranged along a single undivided peduncle.

2. **Raceme** - Look at number 1-9, they are on stalked (unlike the spike that are un-stalked) and arranged along a single peduncle, e.g. hyacinth.

3 **Corymb**-The arrangement is as in raceme, but here the peduncles have different lengths. They are shorter as they approach the apex. Take not of the flowers, the lowermost flowers have the same level with the uppermost flowers. Look at the numbering 1-9 alternately.

4 **The Umbel** - Here flowers all have stalk, the stalk all have the same length and the stalk all arise from the same point (the terminal point of the axis, e.g. carrot.

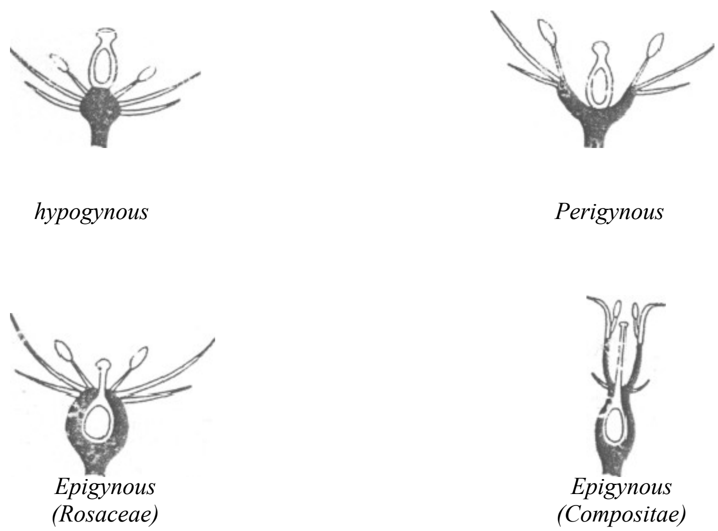
5. **The Capitulum** - The apex of the axis is expanded, the flowers are arranged on the apex but on the same plane, e.g. sunflower.

15.2.3 Definite Inflorescence

This group is referred to as c nose. Here the growing apex produce flower buds in growing succession. Several types of cymes are presented. Look at the above diagram.

1. **Monochasial cyme** -The flower formed in the terminal position on the axis is followed by the development of another axis from the axil of a bract behind it. In this group you could find other forms, e.g. the scorpioid and the helicoid. They are a variation of monochasial.
2. **Dichasial Cyme**-In this group of inflorescence the flower formed on the axis is followed by the development of two more from the axils of oppositely-placed bracts behind it. The drawing illustrates the point.

3. **The compound raceme or** panicle - When the raceme are produced in multiples, look at the above



F ig 15.2: *Positions of floral parts on the receptacle.*

4. **Mixed-Raceme of Cymes**- This is the combination of raceme and cymes.

15.2.4 Categories of Flower Structure

In this unit 14 you learnt the general structure of the flower. You learnt that the flower is the vegetative shoot that carries on the reproduction of the plant. The flower has two organs that are responsible for reproduction. These organs are:

a. **The Androecium** - the stamens collectively form the androecium.
b. The Gynaecium - the carpels collectively form the gynaecium.

There are other parts, their function is for protection and attraction of insects. When you look at a particular flower, what makes it different from another flower? A hibiscus flower is different from canalily flower, etc. Let us look at the structures of the flower that determine the differences. We will look at six categories on the receptacle.

Category 1. How are the parts inserted? Botanists call that floral phyllotoxis

Category 2. What is the number of parts? How little or how much?

Category 3. How freely do the parts fit together?

Category 4. What are the relative position of the parts on the receptacle?

Category 5. Can the flower be divided in such a way that one half is a mirror of the other half?

Category 6. How are the sexual parts within the flower distributed?

Let us look at each category in details.

1. **Floral Phylotaxis**: This is determining the manner of insertion of the parts of the flower. The parts can be arranged or inserted in:
   a. spiral or acyclic
   b. separate
   c. cyclic
   d. hemi-cyclic
   e. on the receptacle.

2. **Numbers of parts**: Reduction and multiplication you learnt earlier that most flowers have their parts in constant number. There are a few cases where this rule is not followed. Some parts in certain flowers occur in indefinite numbers.

3. **Freedom or fusion of parts:** Generally, it seems as if flower parts are separate and freely inserted on the receptacle. But it is not so in all cases, and this has resulted in different terms like:

   a. Polysepalous - whorls members are separately inserted. Same can be applicable to petal - polypetalous, polyandrous and apocarpous as the case may be.

   b. Gamosepalous - the whorls members are united, laterally, in the petal - gamopetalous.

   c. Adelphous - if the parts are fused by their filament.

   d Syngenesious - if the parts are fused by their anthers.

   e. Syncarpous - if the carpels are fused laterally.

   f. Monaldelphous - if the stamens are in groups and fused by their filaments - diadelphous, polyadelphous, which is applicable.

g. Epipetalous - the stamens are inserted on the corolla segments.

h. Gynandrous -the stamen are adherent to the gynaecium.

4. **Relative position of parts on the receptacle**.

15.2.5 Patterns of Position on the Receptacle

Fig 15.3: *Floral symmetry. (a) Radial symmetry of lily. (b) Bilateral symmetry of garden pea. Plan views of parts in the bud stage.*

You will identify three patterns of position of flower parts on the receptacle.

Pattern 1: Hypogynous. In this pattern, the receptacle develops as a conical or domed end of the pedicel and the flower parts are inserted in the order calyx, corolla, and roecium, gynaecium from base to apex of the receptacle.

Pattern 2: Perigynous - here the receptacle grows with a dish - or saucer-haped expanded head and the very young initials of the calyx, corolla, and androecium are formed on the outer rim with the gynaecium centrally placed.

Pattern 3: Epigynous - here the calyx, corolla and androcium are inserted at a level above the gynaecium.

5. The symmetry of the flower. It is possible for the parts of a flower to be arranged in such a way that when the flower is split into two halves, one half is a mirror of the other half. Such a flower is said to be actionomonphic and to possess radial symmetry.

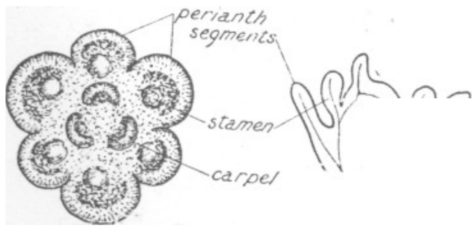


Fig 15.4: Floral apex of the onion. (a) Upper surface view. (b) L.S.

6. **Distribution of sexual parts**. When the male part of a flower is present together with the female part, the flower is said to be bisexual or hermaphrodite. When only one - male or female appears, but not the two, the flower is said to be unisexual. In some plants, the male and female flower may be on the same plant but in different inflorescence, monoecious. In other flowers the sexes are separate on a different plant - dioecious.

15.3 Conclusion

You have learnt in this unit that:

i. Flowers are diverse in nature
ii. They are all over in the environment but they are different from each other.
iii. The differences are as a result of the arrangements of the parts of the flower.

15.4 Summary

You have studied floral arrangement in this unit. The arrangement of flowers on the receptacle is called inflorescence. This arrangement could be definite or indefinite. A flower may look different from another flower by the structure of the flower, in terms of how the parts are inserted. What the number of the parts are, how freely the parts fit together, the relative position of the parts on the receptacle, symmetry and the nature of the sexual parts within the flower. The

position of the parts on the receptacle shows three patterns: hypogynous, perigynous and epigynous.

15.5 TMA

1. What do you understand by floral arrangement?
2. With the aid of diagrams, explain six types of floral arrangement?
3. Discuss two types of inflorescence.

15.6 References and Further Reading

Vines, A. E. and Rees N (1987) Plant and Animal Biology Vol. 1.

Unit 16

Pollination

16.0 Introduction

In Unit 15, you studied flower. The flowers are the reproductive parts of a flowering plant. You saw the various structures of flower, the arrangements of the parts of the flower and the pattern of arrangement. The appearance of the flower, either brightly coloured, big or small confer some advantage on the flower. If the flower is brightly coloured, it attracts insects. Insects go to suck nectar of the flower, in the process, the insect carries the pollen grains from the anther to the stigma of another flower. When the pollen grains are carried from the anther to the stigma, pollination occurs. In this unit, we will look in detail at Pollination. You will study the various ways flowers are adapted for pollination. Two main types of pollination (self and cross pollination), are presented. You will also study the role played by wind and insects in pollination.

16.1 Objectives

By the time you finish this unit, you will be able to.

1. Explain the term pollination
2. Identify two major types of Pollination
3. Distinguish between xenogramy and gectonogamy.
4. Discuss why certain flower are pollinated only through cross-pollination.
5. Explain the following terms: (1) Homogamy (2) Deistogamy (3) Entomophily (4)Anomphily.

16.2 Pollination

16.2.0 Pollination

To effectively grasp the content of this unit, you should recall the various parts of a typical flower. Go back and read the section on flowers. The term pollination may not be new to you. It involves the process of carrying the pollen grains from the anther to the stigma in the same flower or another flower by man, wind, insect, etc. When pollination occurs among flowers of the same parent, it is called self pollination. Anotherterm for self pollination isautogamy(self pollination). Self pollination is of two types-bisexual and geitonogamy.- Bisexual type of self pollination takes place when the pollen grains from the anther are deposited on the stigma of that same flower. But when the pollens are from the anther of one flower to the stigma of another flower but still on the same parent plant, it is described as gectonogamy.

It is also possible for pollination to occur between flowers of two different plants of the same species or related species. This type of pollination is known as cross-pollination. Cross pollination can also be called Xenogatny. The products of cross pollination are often better than those of self pollination. This is because through cross-pollination, the characters of both plants are reflected in the off-spring (fruits or seeds that will result from the pollination).

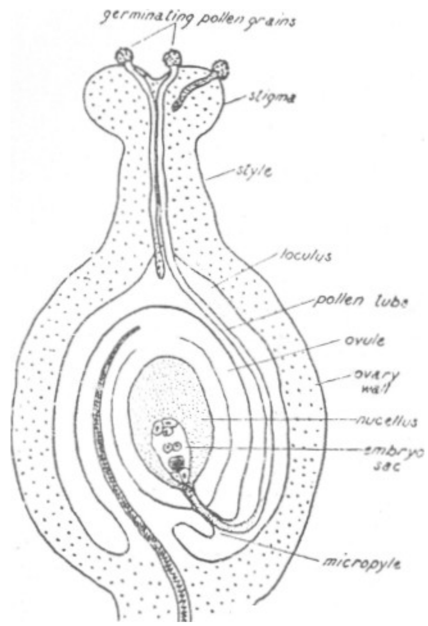
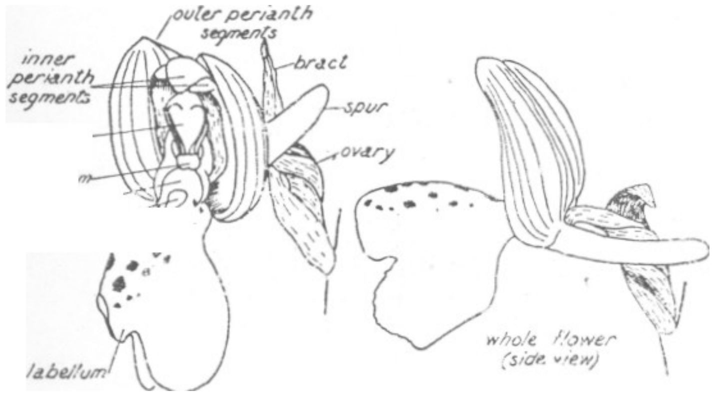
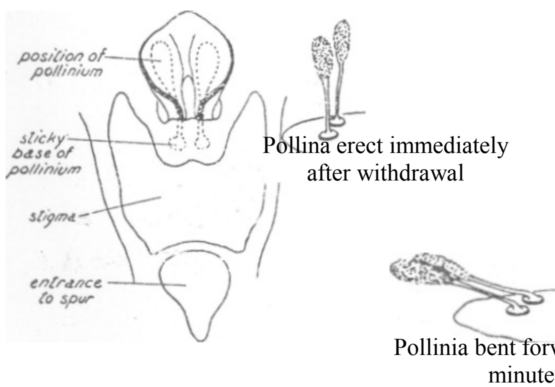


Fig 16.1: *Diagram of the fertilization process in an angiosperm.*

16.2.1 Adaptation for pollination

To enhance pollination, be it self-pollination or cross-pollination, the flowers of plants have certain characteristics that make pollination possible. Let us closely examine these characteristics in self pollination and cross-pollination.





The flower is pollinated by the bee which in extracting nectar from the sticky bases of the pollinia. These adhere firmly to the insects head and later bend forward so that, as the bee enters another flower, they are thrust against the stigma lobes.

Fig 16.2: *Pollination mechanism in early purple orchis.*

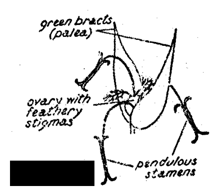


Fig. 16.3: Wind-pollinated flower of a grass.

16.2.2 Self-Pollination or Autogamy:

Some characteristics have been identified among certain plants that are self-pollinated to bring about this pollination.

(a) **Homogamy:** We have earlier said that pollination can occur in the same flower when the flower has both the anther and stigma (bisexual pollination). This makes it possible, the anther and the stigma of that flower mature at the same time. Homogamy is used to describe the condition where the stigma and the anther of a flower mature at the same time.

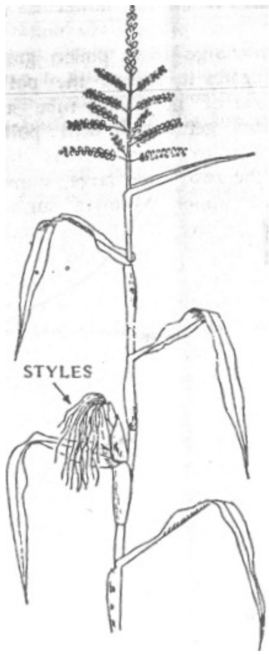
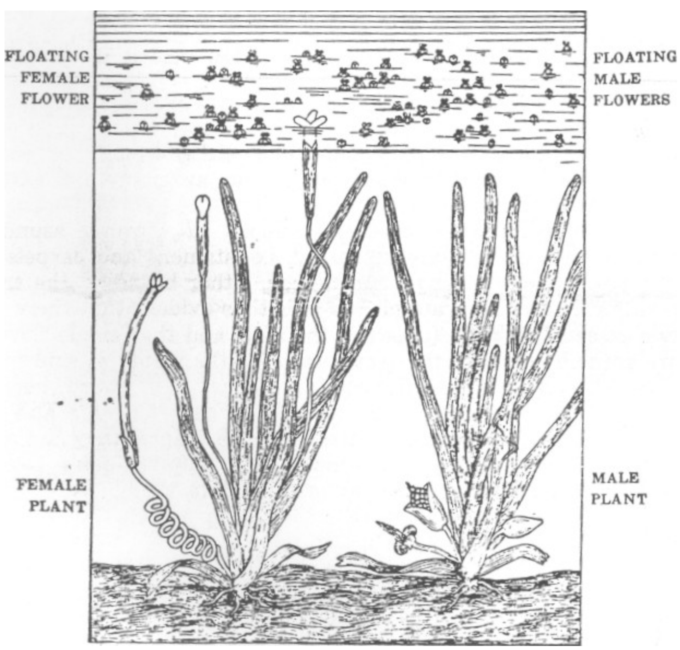


FIG.16.4 *Anemophily in maize plant. Male flowers in a panicle (on the top) and female flowers in a spadix (at the bottom).*



PIG 16.5: *Hydrophily in VallisneHa. Female plant with a floating flower, a submerged flower (-bud) and a fruit (15 cm. long) maturing under water. Male plant with three spadices-young (covered by spathe), mature (with the spathe bursting) and old (after the escape of the male flowers). Male flowers are now seen floating on water.*

b) **Cleistogamy:** There are a lot of plants that their flowers do not open to bring about pollination from other flowers. Such flowers are called Cleistogamous or closed flowers. In such flowers, pollination occurs within their enclosed form and the form of pollination is known as Cleistomgamy. E.g. Balsam, Sage, Wood-Sorrel.

16.2.3 Cross Pollination or Allogamy:

Many external agents are known to bring about pollination especially in cross-pollination. These agents are insects, animals, wind, and water. As observed under self pollinated flowers, cross-pollinated flowers also possess some characteristics to bring about pollination by the different agents.

1. Entomophily- This is pollination associated with insects. Flowers pollination have three major adaptations - insects, colour and nectar. We must note that insects do not come to flowers deliberately to pollinate them. They are attracted to the flower by one thing or the other. One of such things that attract insects is the scent of the flower. This is common among nocturnal flowers (flowers that occur at night)

   Even though they may have the good colour which is one of the things that attract insects, it will not be possible for the insects to see such beautiful colour at night. The scent there is an alternative means of attraction. The scent that brings insects to a particular flower may be irritable to man.

   As noted above, many insects are found on flowers because of their bright and beautiful colouration. The colour is in the petals or when the colour of the petals is not bright, or conspicuous enough to seen, other parts assume the function or the flowers are found clustered together.

   The presence of nectar is another common adaptation by flowers to attract insects. Most gamopetalous corolla produce sweet nectar contained in the gland called nectary. It can also be found in a part called spur. Nectar serves as food to some insects.

   Apart from the above mentioned reasons, insects may visit a flower when in search of a shelter. For whatever reason insects may be found in flowers, the sticky pollen grains, stick to their body and as they move from one flower to another they (pollen grains) drop on the stigma thereby bringing about pollination.

2. Anemophily: Just like flowers that are pollinated by insects have peculiar adaptations, those flowers pollinated by wind have their peculiar characters . Anemophily is used to describe the flowers that are pollinated by wind. Flowers that are pollinated by wind do not secret nectar, have no smell, neither are they brightly coloured as associated by insect pollinated flowers. Rather, they produce large quantities of pollen grains (because of the wastage involved), they are light and dry and in some plants like pine, the pollen grains have wing like structure to enhance movement by wind.

While the pollen grain posses the above characteristics, the stigma of wind pollinated flowers are usually large, well exposed and may brach eg of such flowers are grasses, bamboo, cereals etc.

3. Hydrophily - There are some plants that exist in water generally called aquatic plants. Some of the plaints may be submerged in water and so their flowers are not exposed outside for other agents pollination. Flower pollinated through this means are described as hydrophily. However, those acquatic plants whose flowers extend above the water level can be pollinated by wind or insect.

16.2.5 Contrivances for Cross-Pollination

We have earlier examined those factors that make pollination in some flowers possible only through self-pollination (homogamy and cleistogamy), now we will study those characteristics that make pollination possible mostly through cross pollination.

(1) Dicliny (Unisexuality). This is a situation where the stamen and carpel (male & female reproductive system) are each found on separate flowers but on the same plant (monoecious) or on separate flowers on two different plants (dleclous).

(2) Self-Sterility: There are some species of plants like orchids, passion flowers etc that when the pollens are taken to the stigma, of that same flower, fertilization does not occur, but when brought from other flowers, pollination will occur leading to fertilization. In such plants, only cross pollination is possible.

(3) Dichogamy: This condition is used to describe the pollination that occurs in flowers whose anther and stigma mature at different times constituting obstacles to self-pollination. Therefore, such flowers can only be pollinated through cross-pollination. When the gynoecium (female) matures earlier than the anther (male) it is called protogyny. On the other hand, if the anther (gynoecium or female) matures before the stigma, it is said to be protandry.

16.3 Conclusion

In this unit, you have learnt that pollination is the carrying of pollen grains from anther to stigma. This can be done by insects, wind, man etc. Flowers are variously adapted for pollination.

16.4 Summary

You have looked at the meaning of pollination. You have learnt that flowers have adapted themselves for the kind of pollination that takes place in them. Self-pollination and cross-pollination are the two types of pollination that occurs in flowers. Insects, wind and man are agents of pollination.

16.5 TMA

1) Explain the term pollination
2) Describe two major kinds of pollination
3) Explain the following terms
   - homogamy
   - cleistogamy
   - entomophily
   - anemophily

16.6 References and further reading.

1. Dutta, A.C. (1984) Botany for Degree Students.
2. Vines and Rees. Plant and Animal Biology

Unit 17

FRUITS AND SEEDS

17.0 Introduction

In unit 16 you learnt about pollination and fertilization you learnt that when the pollen grain is transferred from the another to the stigma, pollination is said to have occurred. The pollen grain, once on the stigma develops a tube that grows downward to the ovary of the flower. Through the tube the male part meets with the female part in the ovary and fertilization takes place. In this unit, the process of development of the seed is presented. You will study the classification of fruits. You will study how the seed and fruit is dispersed.

17.1 Objectives

By the time you complete this unit you should be able to:

(a) Discuss fruits
(b) Classify fruits
1) Describe how seed is formed in the dicotyledonous plants.
2) Describe how seed is formed in the monocotyledonous plants
3) Differentiate seed formation in Dicot from seed formation in monocot.
4) Discuss the concept of seed dispersal
5) Identify at least three methods of seeds and fruits dispersal
6) Discuss common characteristics of wind dispersal seeds and fruits.
7) Explain the term, "explosive mechanism.
8) Discuss the characteristics of animal dispersed seeds and fruits.

17.2 Fruit

Fruit simply put is a mature or ripened ovary. This is because it is the ovary of the flower that develop to form the fruit. A typical fruit has three distinct parts. They include the epicarp, mesocarp and endocarp. The epicarp is the outer part of the fruit. It may be thick or thin and normally act as the skin of the fruit. The mesocarp is the fleshy part of the fruit, in most fruits, it constitute the edible part. The endocarp is usually hard and it is the innermost part of the fruit. These three parts joined together is called the pericarp.

Fruit can be classified into two types depending on what part of the flower develops to form the fruit. They are true fruit and false or spurious fruit. A fruit is said to be a true fruit when it is only the overy that develop to form the fruit. On the other hand, a false fruit is that which formed from other parts of the flower like the receptacle, thalamus or calyx. For e.g. apple and pear fruits are from the thalamus while cashed is formed from the peduncle.

17.2.1 Classification of fruits

A B C

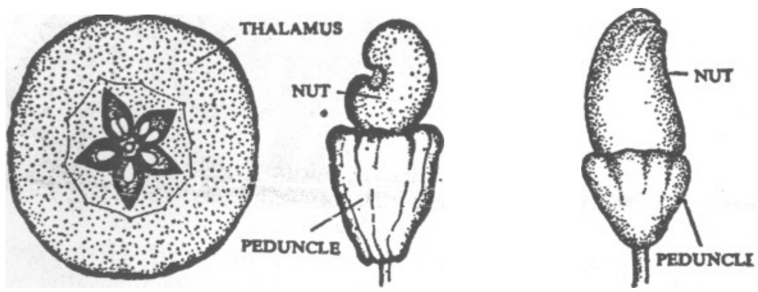


Fig 17.1: A, Apple (*Malus*) cut transversely; B, cashew Nut (*Anacardium*); C, marking nut (*Somecarpus*).

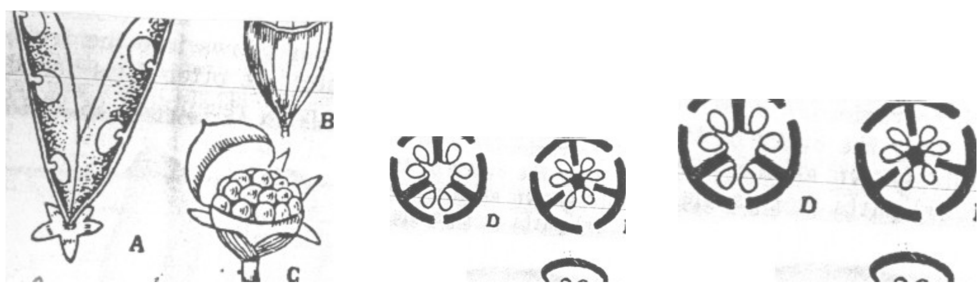
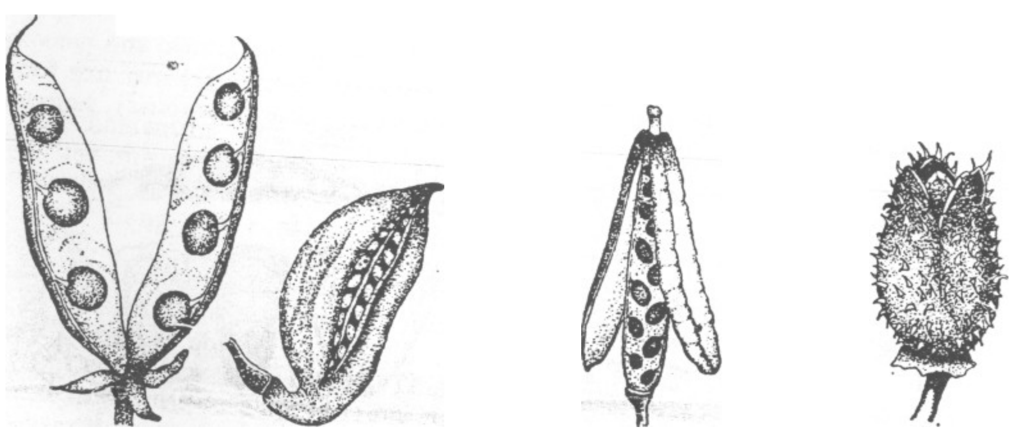


Fig 17.2: Dehiscence of fruits. A, sutural (pea); B, porous (poppy); C, Transverse (cock's comb); D, loculicidal; E, septicidal; F-G, septi-fragal.



A B C D

Fig 17.3: Fruits, A, Legume or pod of pea; B, Follicle of madar (Calotropis) C, silliqua of mustard; D, capsule of thorn-apple (Datura).

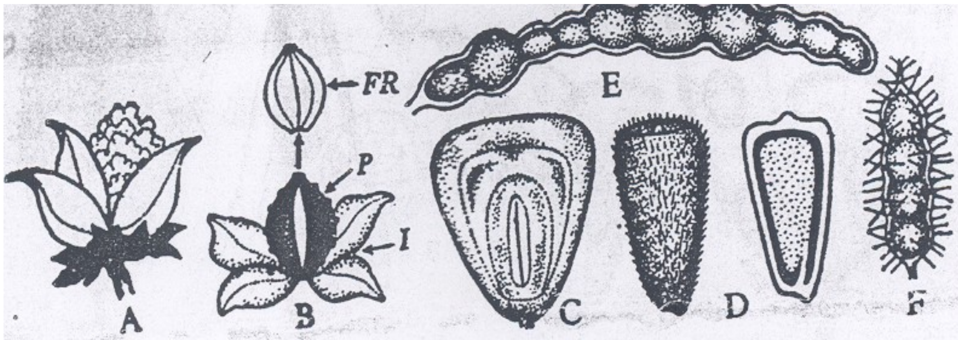
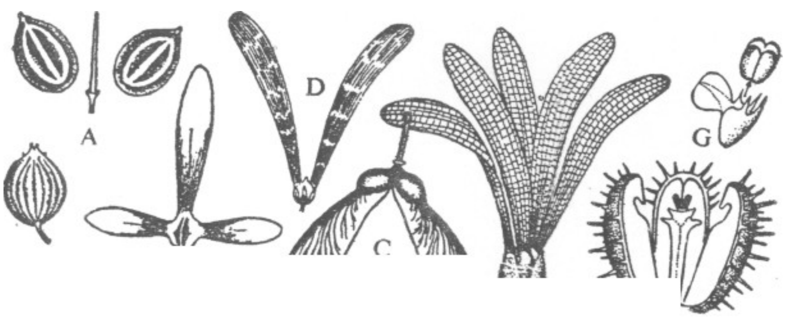


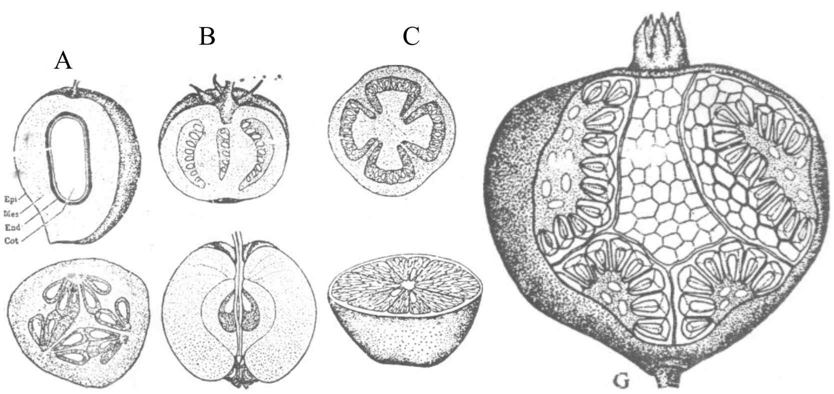
Fig 17.4: ***Fruits (contd.). A, capsule of cotton; B, achene*** *of Mirabilis,* (I, involucre; P, dry persistent perianth; FR, fruit – achene); C, caryopsis of maize, D, cypsela of sunflower; E, lomentum of *Acacia;* F, the same of *Mimosa.*



B

Fig 17:5 Fruit (contd.) A, cremocarp of coriander; A1, the same splitting away from the axis (carpophore) into two mericarps; B, samara of Hiptage; C, double samara of maple (Acer); D, samaroid of Hopea; E, the same of Shorea; F, regma of castor; G, carcerule of Ocimum.

A B C



D E F

Fig 17.6: Fruits (contd.) A, Drupe of mango; Epi, epicarp; Mes, mesocarp; End, endocarp; Cot, cotyledon; B-C, berry of tomato in longitudinal and transverse sections; D, pepo of cucumber; E, pome of apple; E, hesperidium of orange.

Balausta of Pomegranate (*Punica granatum)*

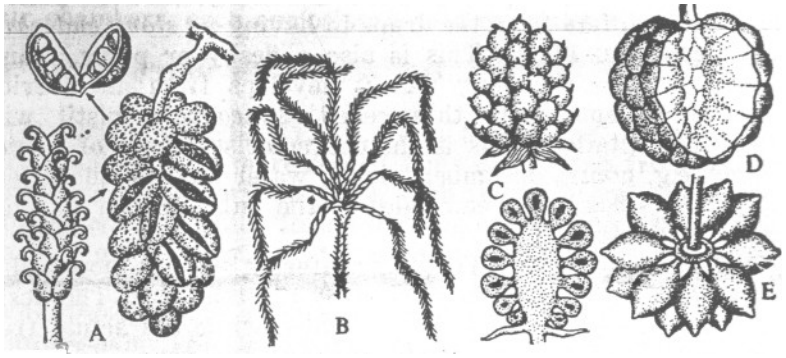
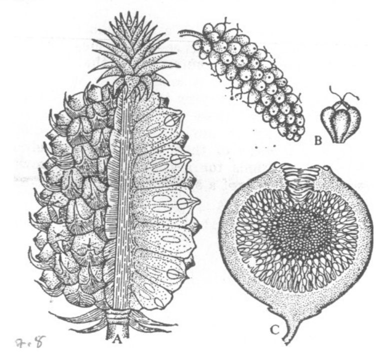
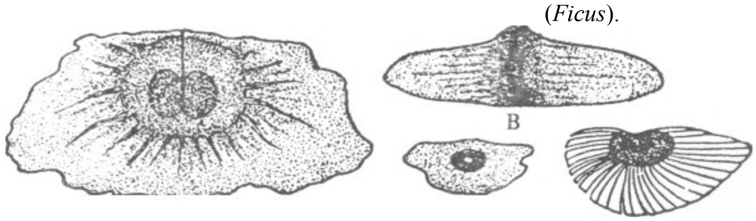


Fig 17.7: Aggregate fruits. A, an etaerio of follicles in Michelia; B, an etaerio of achenes in Naravelia; C, an etaerio of drupes in *Rubus;* D, an etaerio of berries in custard-apple (*Annona*); E, the same in Artabotrys.



A C

Fig 17.8: Multiple fruits. A, Sorosis of pineapple (*Ananas*); B, the same of mulberry (*Morus)*; C, syconus of fig (*Ficus*).



A C D

Fig 17.9: Winged Seeds, A, *Oroxylum;* B, *Cinchona;* C, *Stereospermum; D, Lagerstroemia.*

Fig 17.10: A Winged Seed of drum-stick (*Moringa*): B, winged fruit of yam (*Dioscorea)*

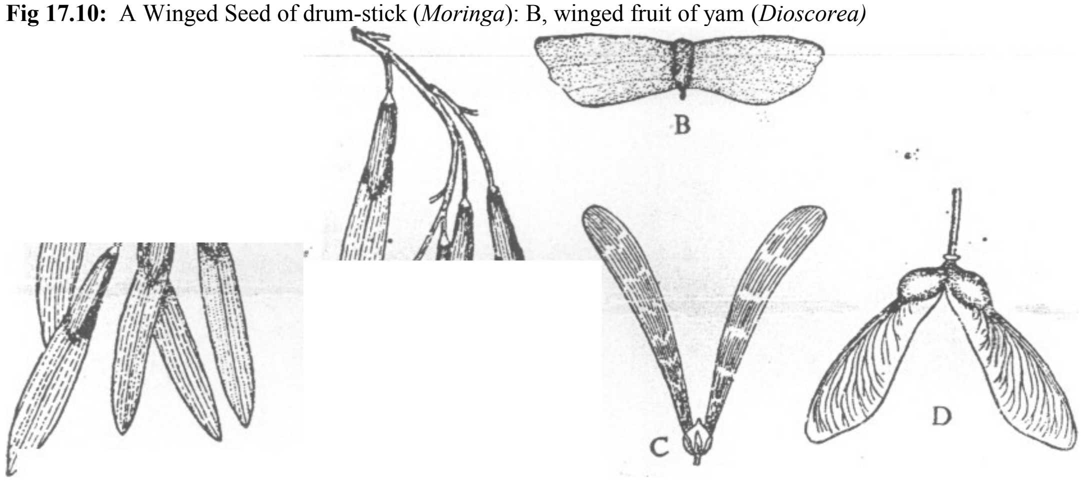


Fig 17.11: Winged fruits. A, ash (*Fraxinus*); B, *Terminalia myriocarpa;* C, *Hopea;* D, maple (*Acer*).

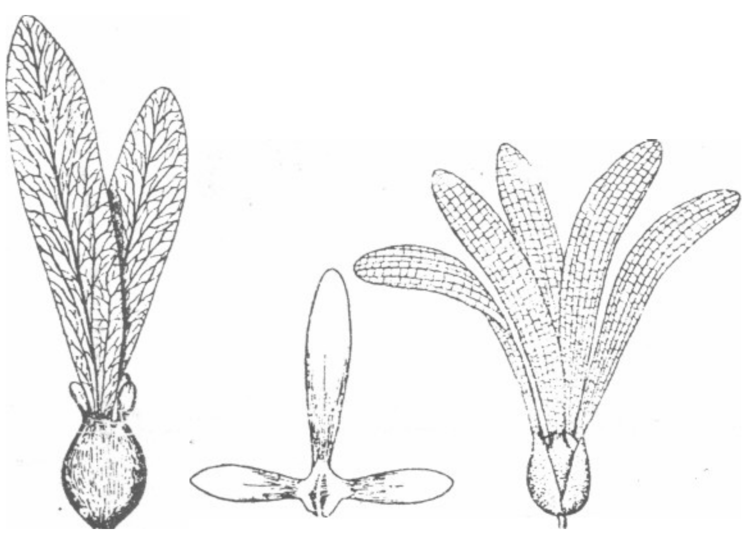
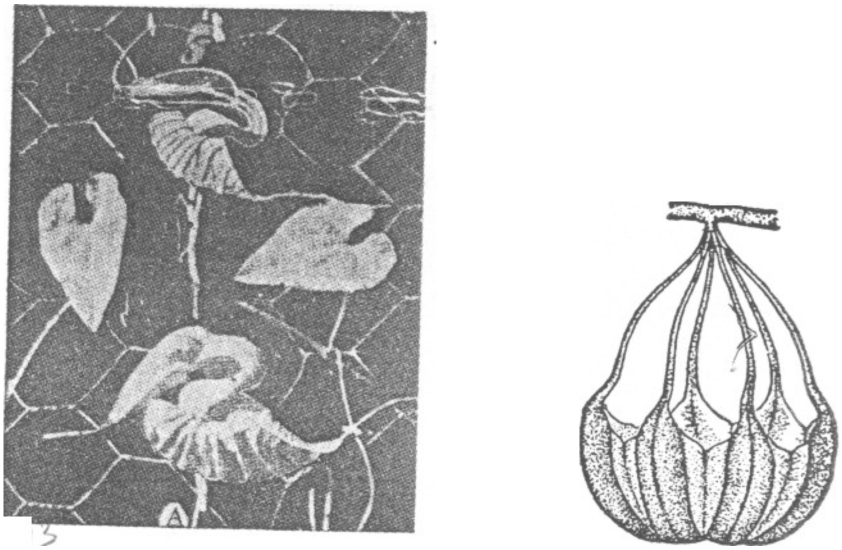


Fig 17.12: Winged Fruits (*Contd.)* A, Dipterocarpus; *B, Hiptage; C, Shorea.*



A B

Fig 17.13: A, Pelican flower (*Aristolochia gigas*) with duck-shaped flowers, B, a fruit of the same like a hanging basket.

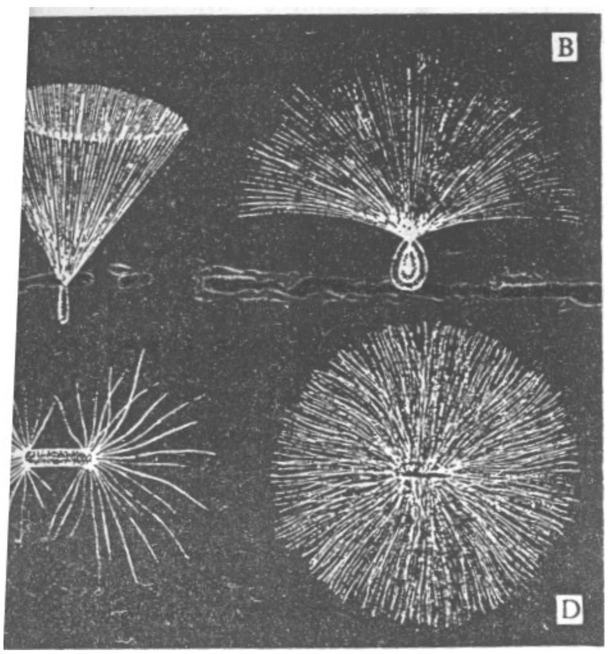


Fig 17.14: Pappus and Hairy Seeds. A, pappus of a *Compositae fruit;* B, hairy seed of madar (*Calotropis*); C, hairy seed of devil tree (*Alstonia*); D, hairy seed of cotton.

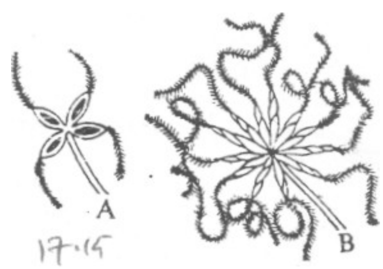


Fig 17.15: Persistent styles. A, fruits of *Clematis;* B, fruits of *Naravelia.*

Fig 17.16: Double coconut seed (*Lodoicea*)

Fig 17.17: Ruellia tuberose; note the explosive fruit.

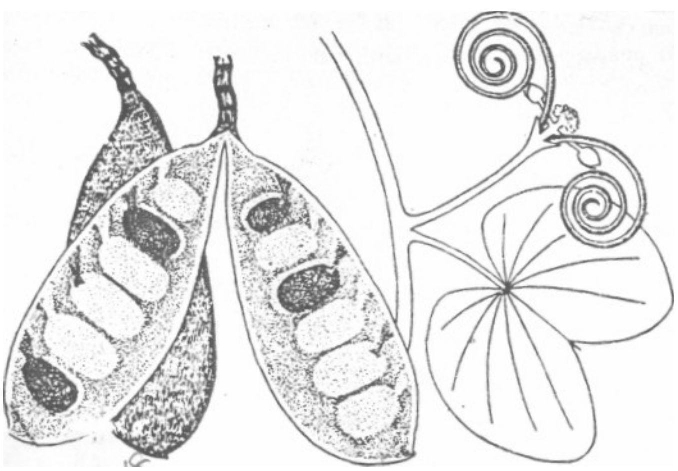


Fig 17.18: *Bauhinia vahlii;* note the explosive fruit.

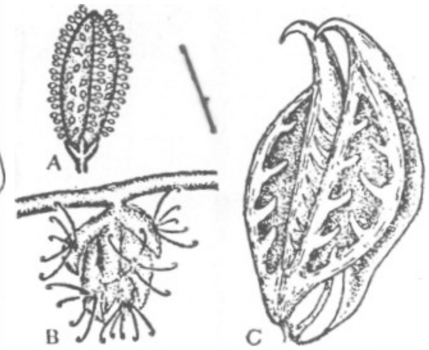


Fig 17.19: A, fruit of *Boerhaavia* with sticky glands; B, flowers of *Pupalia* with hooked bristles; *C,* seed of tiger's nail (*Martynia)* with a pair of sharp, curved hooks.

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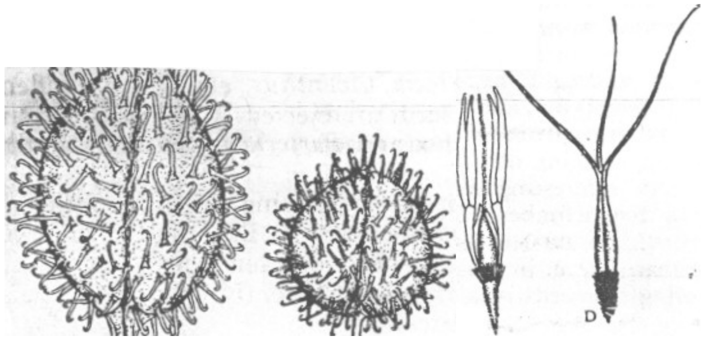


A B C D

Fig 17.20: A fruit of *Xanthium* with curved hooks; B, fruit of *Urena* with curved hooks; C, spikelet of love thorn (*Chrysopogon*) with stiff hairs; D, seed (fruit) of spear grass (*Aristida*) with stiff hairs.

Apart from classifying fruits on the basis of what part of the flower develops to form it, fruits can be grouped base on the number of fruit arising from a single ovary of flower. On this ground, fruits are classified into simple, aggregate and multiple or composite.

(1) Simple Fruits: A fruit is said to be simple when only one fruit developes from an ovary of a flower i.e. one ovary, one fruit. Simple fruit is further grouped into dry and fleshy fruit. Again, dry fruit is classified into dehiscent and indehiscent (schizocarpic). Let us examine each of these groups starting with dry fruit.

Dry fruits usually have hardcover. Two types of dry fruits are, dry dehiscent and dry indehiscent
fruits.

Dry dehiscent fruit: Classification here is based on how the fruit split open (dehisces) to release its seeds. The various groups of dry dehiscents are:

(a) Legume or Pod: Fruits in this group are formed from one usually with many seeds. To set its seeds free, the pod splits into halves i.e. the fruit breaks along the sutures or what looks like the edges of the fruit.

(b) Follicle: Follicles are also formed from one carple but break or split on only one side to release its seeds. E.g. sodom apple, madar.

(c) Capsule: Capsules develop from two or more carpels and have many seeds. It splits open along many longitudinal sides. E.g. okro, cotton, lastor oil.
Dry Indehiscent Fruit: the different classes of dry indehiscent include:

(a) Caryopsis: This type of fruit has its pericarp fused tightly with the seed coat. E.g. of such fruits are rue, maize, wheat.

(b) Achene: Achene has one seed covered by the pericarp but not tighly fused as in caryopsis. The fruit is free from the seed-coat. E.g. hogweed, sunflower.

(c) Nut: Nuts have the characteristics of an achene but the pericarp or seed coat is hard E.g. cashew. It is important to note that by this classification, groundnut and coconut can not be said to be nut.

(d) Samara: Fruits that belong to this class have their pericarp structured like wing. Example are fruits seen on the shoot of yam, African rosewood.

(e) Cypsela: Like samara, the calyx above the ovary remained and formed a parachute -like hair called pappus. E.g tridex, marigold.

So far we have discussed the different classes of simple dry fruits. Let us examine the simple fleshy fruits. Remember we said simple fruit arise when only one fruit develop from an ovary.
Fleshy fruits as the name implies have succulent part which in most cases is eaten. The belong to different groups.

(a) Drupe: These are fruits that have three distinct parts namely the epicarp (the outer part or skin), the mesocarp (the middle layer, usually the edible part), and the endocarp which is the hard part. E.g. mango, coconut, palmnut.

(b) Berry: Berry have the characteristics of the drupe (three parts) except that the endocarp is fleshy. So the entire fruit is fleshy e.g. of berries are guava, orange, tomato, banana etc.

So far, we have discussed the various sub-groups of a simple fruit (one fruit from one ovary). Now we shall examine the other remaining types of fruits - aggregate and multiple fruits.

(1) Aggregate Fruits: In these types of fruits, a single flower or ovary give rise to more than one fruit called fruitlets as seen in cola. This collection of fruits in a single ovary is called etaerio. With our knowledge of the various characteristics of simple fruit base on whether they can split open on one side (follide) or both sides (legume) to release their seeds, or berry because the entire fruit including the endocaap is fleshy (berry) etc, we can equally group aggregate and simple in to such group. Remember the major differences between aggregate fruit and simple fruit is the number of fruit arising from a flower/ovary. Having said that, aggregate fruits can be grouped into an etaerio of follicle (many fruits from one ovary that split open on one side) eterio of berries, etaerio of drupes etc.

(2) Multiple fruits. These are otherwise called composite fruits. Simply put, fruits of this nature do not develop from one flower, rather they are formed from inflorescence. Common example is pineapple. Each of the marks on the body of a pineapple fruit represents a flower.

17.2.2 Seed Development

After fertilization occurs, there are a lot of changes that normally take place in the ovary leading to the formation of seed(s). The processes of development of seed in monoctyledonous plant is different from that of dicotyledonous plant. Let us now examine how seed develop in each of these groups of plant.

17.2.3 Development of Seed in Dicotyledonous Plant:

When Fertilization takes place, the ovum (egg cell) produce a wall around itself from the substance it secretes. As the ovum is within this wall, it is called oospore. Here, it divides into two cells, one part which is the upper part is away from the micropyle while the lower part is towards the micropyle. This lower part further divides into a number of cells again called the suspensor. The suspensor starts growing and as it grows, it helps to push the embryo into the embryo sac. The embryo also derives its food from the suspensor. One of the cells of the suspensor that is closet to the embryo is called hypohysis. This hypohysis grows to form radicle apex. As the embryo develops, the radicle emerge and the formation of radicle will lead to the disintegration of the suspensor.

Fig 17.21:

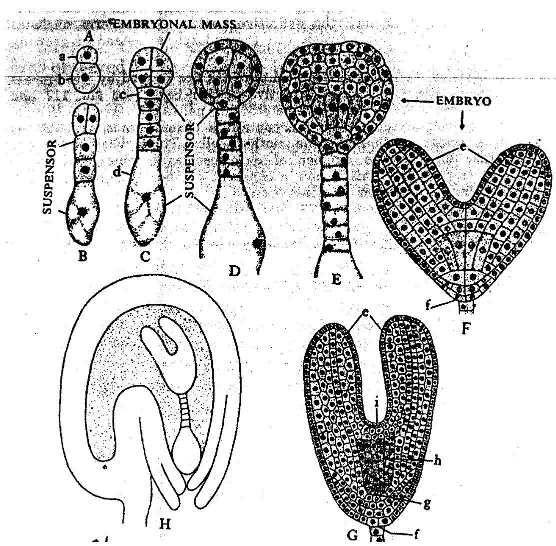


Fig 17.21: A-H, development of dicotyledonous embryo, a, embryonal cell; b, suspensor cell; c, hypophysis cell; d, basal cell of the suspensor; e, cotyledons; f, root-cap; g, root-tip; h, hypocotyls; and I, stem-apex; h, embryo within the seed.

As the lower part develops, the-upper part also develops (remember we said above that the enclosed ovum divides into two forming the upper and lower parts). These upper cell away from the micropyle is called embryonal cell. It increases in size and divides into eight cells (octants) four of these cells are closed to the suspensor (posterior octants) while the other four are away from it (anterior octant). Further divisions leads to the formation of the seed with the two cotyledons and the plumule derived from the anterior octant while the posterior octant give rise to the radicle and hypocotyls.

17.2 Development of seed in monocotyledonous plant:

One distinction between a monocot plant and dicot plant is that while the monocot seed has single cotyledon, dicot seed has two cotyledons. The development of seed in both monocot and dicot is almost the same except that in monocot as tile oospore divides, the upper part forms the suspension while the lower part forms the embryonal cell. Through continuous division of the embryonal cell a single cotyledon is formed similarly the continuos division of the suspensor give rise to the stem apex, the hypocotyle and the root-tip.

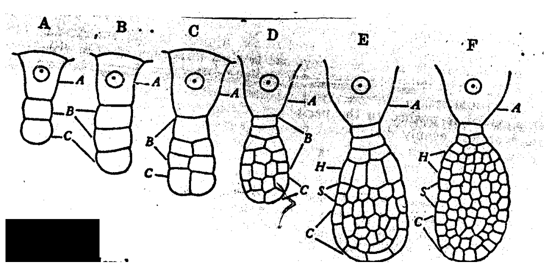


Fig17.22: A-F, development of monocotyledonous embryo. A, 3-celled pro-embryo; A, basal Cell; B, middle cell; C, terminal cell; at successive stages (B-F) A gives rise to the suspensor; B to the stem-apex (S), hypocotyl (H) and root-tip with some accessory cells above (E-F); and C to cotyledon.

17.2.5 Dispersal of seeds and fruits

Have you ever at any time why certain plants for example, mango that is always deliberately planted grows like any other wild plant? Can you presume how the plant come to grow in such a place? Is it naturally created to grow there or the seed must have come there by chance? Again what would happen if all the seeds or fruits from a particular plant fall under it each year and all of them germinate into plants? There will be completion for light, soil nutrient, air, space etc. most, if not all may not survive well. Therefore, to avoid these problems, there are devices by which seeds or fruits are scattered away from the parent plants. This process is called dispersal. As you read through, think of examples of parent plants within your locality that falls within the various groups. This process is called dispersal.

17.2.6 Methods of fruits and seeds dispersal

There are different means by which seeds or fruits are dispersed. These are (1) by wind (2) by water (3) by explosive mechanism (4) by animals. Each of these will be treated as follows:

Dispersal by Wind: When the wind blows, it has the ability to carry seeds and fruits of some plants away from the parent pant. Seeds or fruits dispersed by this method have certain characteristics that makes it easy for wind to carry them. These include:

(a) wings-There are many seeds and fruits that possess light, dry and flat extensions on their bodies that look like wings. This parts facilitate dispersal by wind.

(b) Light seeds and fruits: Some seeds may not necessarily posses any other structure but their weight is so light that they can be blown by the wind. Examples are cinchona plant, bucklandia.

(c) Hairs: Like those seeds that have structure like wings, there are some seeds or fruits that are naturally hairy either all over the body or in strains that adapt them to wind dispersal.

(d) Parachute Mechanism: The calyx of some plants are modified in such a way that it opens out m umbrella. This structure mostly in composital plants is called pappus. It acts like a parachute to .nits when they fall off the parent plant and are carried by wind to far distance.

Dispersal by Water: As some seeds and fruits are dispersed by wind, some others are dispersed by water. As they drop from the parent plant, they are carried by any moving water either as it rains or such seeds drop into anybody of water like stream, river or sea. The devices that enable such fruits or seeds dispersed through this means are their ability to float on water, have membrane that prevent water soaking it, some may be light. examples of seeds and fruits that are dispersed by water are: coconut, water lilly, lotus etc.

17.2.7.2 Dispersal by Explosive Mechanism

term explosive is derived from the sound that accompanied the pod of fruits or seeds as they burst I. Many seeds and fruits carried in pod are liberated from their pod when ripped and dry. The burst)wed by sound and the seeds or fruits are scattered some distance away. The distance vary from t to plant. Examples of plants whose seeds/fruits are dispersed through this method are balsam, Ilia tubersosa etc.

17.2.8.3 Dispersal by Animals

Animals including human beings constitute another method by which fruits dispersed. There are certain characteristics that adapt fruits and seeds within this group to be spread by animals. These characteristics include the following.

(a) Edible parts: Many animals including man depend on plants for food. The edible portions of the Is and fruits are eaten while the seeds or fruits are dropped or planted (as in human beings). Birds 1 on some fruits including the seeds. The undigested seeds are passed out with faeces and many minate wherever they are dropped. Animals like squirrels carry fruits of palms to far distances. Human being have even carried fruits and seeds across national boundaries.

(b) Hooked fruits and seeds - Can you remember seeds of plant sticking to your cloth walking) through a field, path or farm? Certain seeds and fruits have this adhesive characteristic as they get hooked to clothing and animal body. These seeds or fruits are shed off in places distant from the parent plant.

(c) Sticky fruits and seeds: Just like some seeds and fruits have hooks, there are some that have sticky glands on their body. Such seeds adhere to cloths, animal hair etc. by this means, they are) dispersed.

17.3 Conclusion

or fertilization, the seed starts to develop in the ovary. This follows a series of cell divisions. The development of the seed of a monocot is different from that of a dicot.

17.4 Summary

When the seed develops and its fully matured, it gets disperse one way or the other. Animals eat the by part of the fruit (surrounds the seed). These seeds are thrown away anyhow. It is not all fruits that down and grow under the same tree. There are very many methods of the fruits (and seeds) being -led away some plants have some special mechanism for spreading its seeds. Man and other animals -ad the seed - this spreading of the seeds is called fruit dispersal.

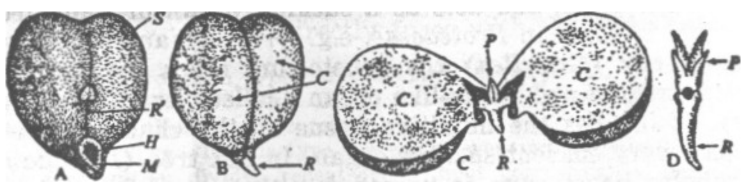
17.5 TMA

(i) Describe seed formation in a dicot and a monocot plant
(ii) Discuss the concept of seed dispersal
(iii) Identify three methods of seeds and fruit dispersal
(iv) Explain the term "explosive mechanism".

17.6 References and Further reading.

Dutta, A.C. (1984) Botany for Degree Students.
Vines and Rees. Plant and Animal Biology

3.0



Gram seed (Cicer arietenum). A, entire seed; B, embryo (after removal of the seed coat.); C. embryo with the cotyledons unfolded; and D, axis of embryo. S, seed-coat; R, raphe; H, hilum; M, micropyle, C, cotyledons; R, radicle; and P, plumule.

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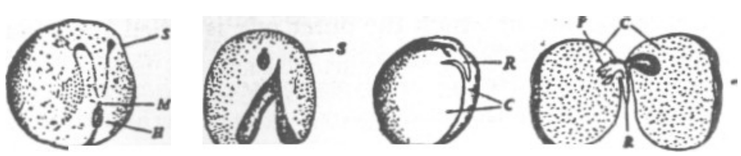
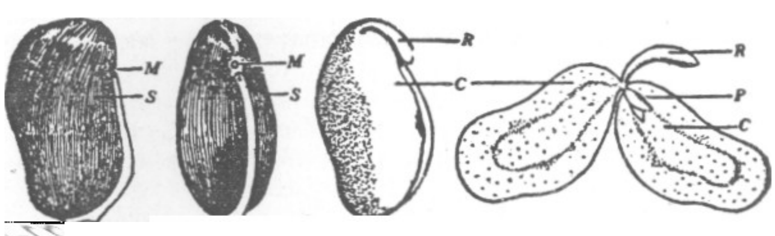


Pea seed (*Pisum sativum*). A, entire seed; B, seed-coat with hilum and micropyle; C, embryo (after removal of the seed-coat) ; and D, embryo with the cotyledons unfolded. S, seed-coat-testa (it encloses a thin membranous tegmen); M, micropyle; H, hilum; R, radicle; C, cotyledons; P, plumule.



H H

Fig 17.23: Country bean seed (*Dolichos lablab*). M, micropyle; S, seed-coat; H, hilum; R, radicle; C, cotyledons; P, plumule.

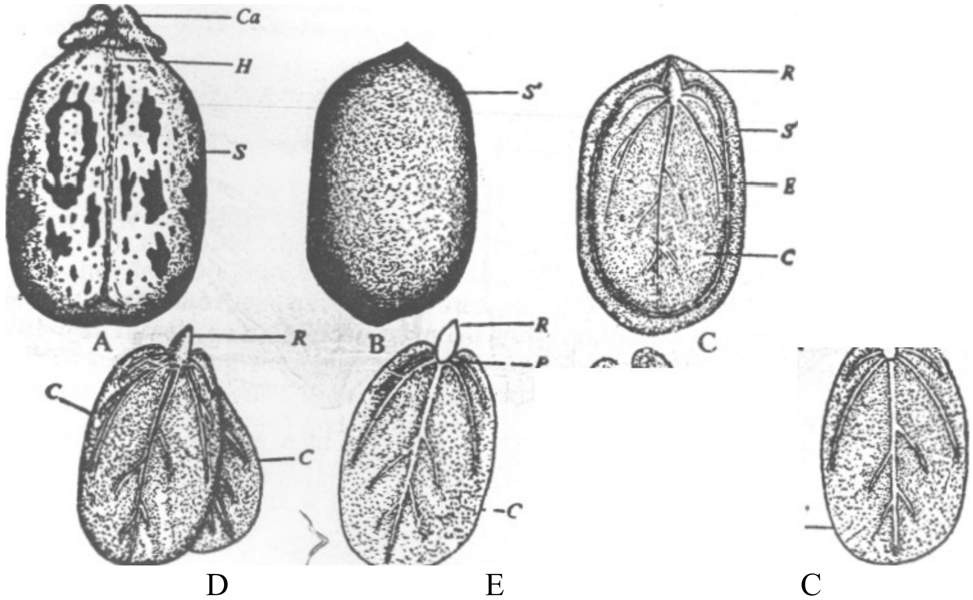
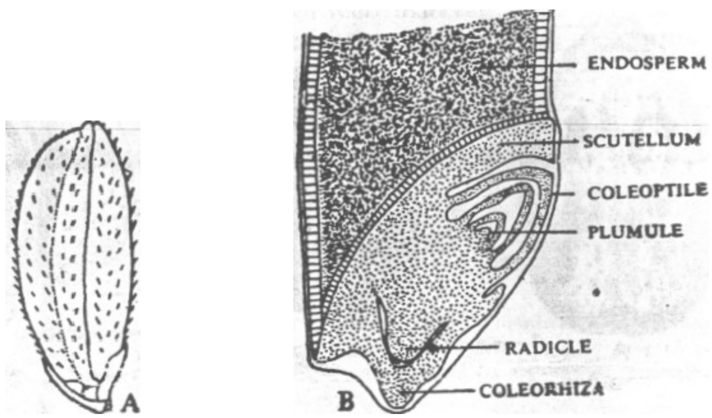
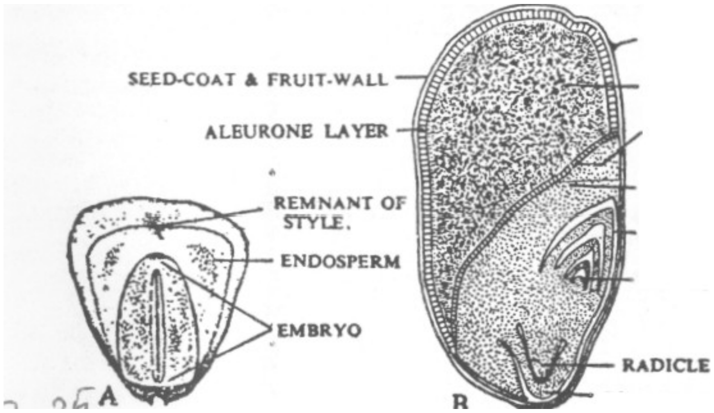


Fig 17.24: Castor seed (Ricinus communis). A, an entire seed; B, the seed enclosed by the perisperm; C, the same split edgewise showing the embryo lying embedded in the endosperm; D, embryo; and E, the same with the two cotyledons separated. Ca, caruncle; H, hilum ; S, testa; S', perisperm; R, radicle; E, endosperm; C, cotyledon; and P, plumule.



Rice grain (Oryza sativa). A, the grain enclosed in husk (consisting of glumes); B, the grain in longitudinal section
(a portion)

(3) Embryo is very small and lies in a groove at one end of the endosperm. It consists of only (a) one shield-shaped cotyledon known as the scutellum, and (b) a short axis with (i) the



Maize grain *(Zea mays*). A, the entire grain; B, the grain in longitudinal section.

Unit 18

Seed Germination

18.0 Introduction

You have studied the formation of seed. You have learnt about different types of seed. Seeds allow for perpetuation of life of the plant. In this unit you will study how this perpetuation is possible. The seed has to remain in order to produce the roots and the shoot. You have learnt that the seed has to germinate in an inactive stage called seed dormancy for some period of time. After dormancy, the seed needs water or moisture to geminate. All seed have different ways of germinating.

18.1 Objectives

By the end of this unit, you will be able to:

a) Distinguish between epigeal and hypogeal germination.
b) Describe certain characteristics peculiar to hypogeal germination in monocot plants.
c) Explain at least three conditions necessary for seed germination.

18:2 Seed Germination
18.2.1 Epigeal Germination of dicot seeds.

18.2.2 Hypogeal Germination of Monocot Seeds.
18.2.3 Special type of Germination.
18.2.4 Conditions necessary for Germination.

18.2 Seed Germination

The process of germination of seed begins when the seed absorbs moisture. This occurs when the dormant seed on absorption of moisture produce the radical that emerge through the seed coat. The young growing seed or seedling is sustained by the food stored in the cotyledons.
There are two main types of germination.

18.2.1 Epigeal Germination of dicot seeds.

When seeds germinate, the cotyledon are carried above the soil or remain below the ground. There are two types of germinations - epigeal germination and hypogeal germination.

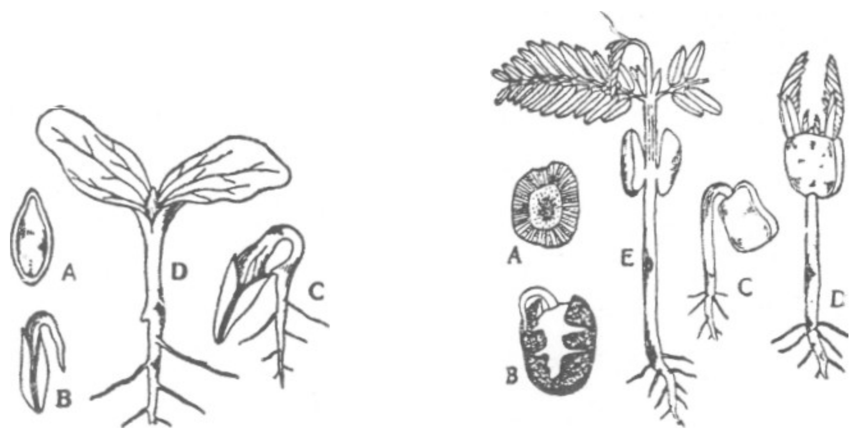


Fig 18.1: Epigeal Germination. Fig. 18.1 Gourd seed (*Cucurbita pepo)*. Fig 18.1 Tamarind seed (*Tamarindus indica).*

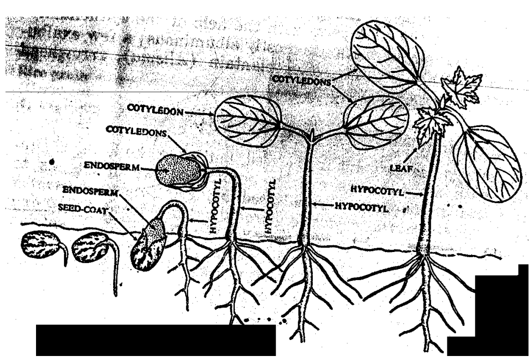


Fig 18.2: Epigeal Germination. Castor seed (*Ricinus-communis)*

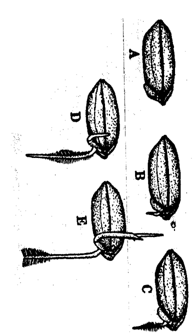


Fig 18.3: Hypogeal Germination Paddy (*Oryzasativa*). A-E,

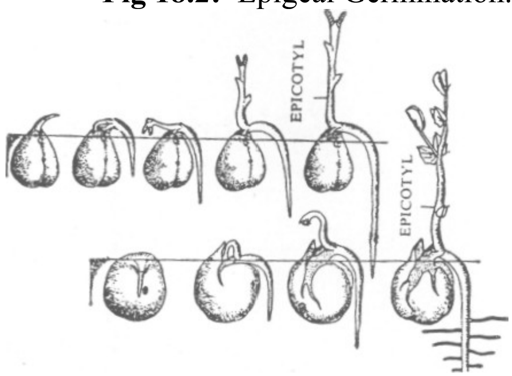
stages in germination.

Epigeal germination is that where the cotyledons of the seeds are carried above the soil. Eg cotton, pawpaws. On the other hand, when the cotyledons remained in the soil such germination is said to be hypogeal. Examples of seeds that exhibit epigeal germination are mango, groundnut etc.

18.2.2 Hypogeal germination of monocotyledonous seeds:

Germination in most monocot plants is hypogeal. That is, their endosperm and cotyledons remain in the soil. The growth in monocot seeds like maize and rice is made possible by absorbing the food stored in the endosperms. When the seed is germinating, the ridicule break through the root-shealth called coleorhiza while the plumule makes its way through the coleoptile. While the plumule develops to form the shoot, the radide gives rise to the root.

Fig 18.2: Epigeal Germination. FIG..15-5- Castor seed (*Ricinus.communis*).



Hypogeal Germination **Fig 18.4** Gram seed (*Cicer arietenum)*

Fig 18.5: Pea Seed (*Pisum Sativum)*

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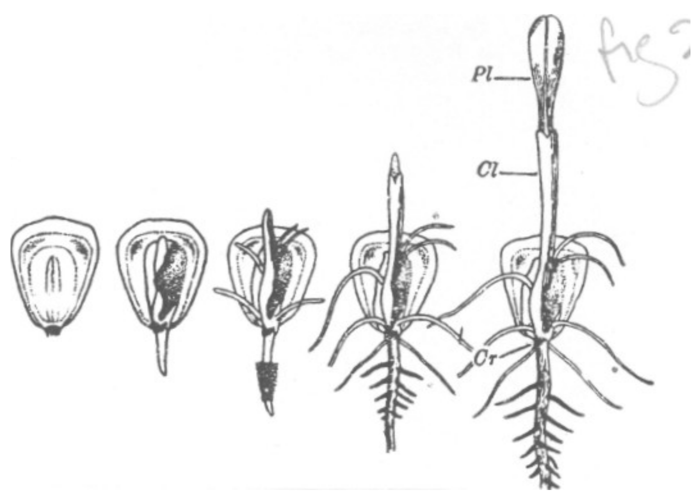


Fig.18.6. Hypogeal Germination. Maize-grain (*Zea mays*). *Pl* plumule; *Cl* coleoptile; *Cr* coleorhiza

18.2.3 Special type of Germination.

There are some plants that are found in salt-lakes and sea-coast that adopt special ways of germinating. Germination in such plant occurs when the fruits are still attached to the parent plant. This type of germination is described as vivpary. The seedling falls off, when the weight increased on the soil, the radicle develops into roots.

18.2.4 Conditions necessary for germination

Healthy seeds harvested and stored under good condition can remain alive for some durations depending on the type. When they are planted, they need the following conditions for them to germinate. They are water or moisture, temperature and air.

Water or moisture: It has been said earlier that the process of seed germination begins only when the seed must have absorbed moderate water or moisture. This moisture is needed to soften the seed-coat dissolve some organic substances, stored in the endosperm and also to enhance some chemical process that goes in the plant.

Temperature: Certain level of temperature is needed for a seed to germinate. The level of temperature required may vary from seed to seed. For example, cucumber and melon germinate at a minimum temperature 20°c, maize at 10°c etc.

Air: Another major condition necessary for germination of seed is air; like a growing plant, seeds need oxygen for respiration. Through this process, the energy stored in the food materials is used by the protoplasm of the plant. It is important to note that light is needed during growth in plant and not for germination. There are some seeds that may germinate better and quicker in the dark.

Activities:

Demonstration of Germination.
For this activities you will need

- A potted plant with rich soil.
- Some groundnut seed (healthy seeds).
- Some maize seeds (healthy seeds)

(1) Really wet the soil in the potted plant everyday for three days (by this time the soil will be soft not soggy.
(2) Plant the groundnut seed and the maize seeds.
(3) Examine the surface of the potted plant everyday.
(4) Keep record of your observation.
(5) a) What did you notice with the maize seeds and the groundnut seeds.
b) Which is epigeal and which is hypogeal?
(6) You can carry out the experiment by eliminating moisture,
(a) Eliminating air.

18.3 Conclusion

You have learnt that a seed needs moisture for germination. There are two types of germination:

1) Epigeal germination and
2) Hypogeal germination. For germination to occur, certain conditions are necessary.

18.4 Summary

Two types of germination
a) Epigeal
b) Hypogeal

Germination is a function of the type of seed i.e dicotyledonous seed and monocoty ledonous seed. Water or moisture, temperature and air are necessary for germination.

18.5 TMA

1) List the conditions necessary for germination
2) Differentiate between epigeal and hypogeal germination.
3) Describe an experiment to demonstrate that water/moisture is necessary for germination.

18.6 References and further reading

Dutta, A.C. (1984) Botany for Degree Students.

Vines and Rees. Plant and Animal Biology

Unit 19

MENDEL'S WORK AND PLANT BREEDING

19.0 Introduction

In this unit, you will study the principle Biologists have used over the years to produce the kinds of crops they want. You will learn about the man MENDEL Gregor" who has led to how man chose and use the kind of plant he wants. When you hear of plant breeding, it is all about selection of species, man selects Species that will do better, that will survive Adverse conditions. You will learn how Man leaves the natural way of pollination And use artificial way of pollination because he wants the crop to be to his taste.

19.1 Objectives

By the end this unit, you will be able to

(1) Explain the Mechanism of plant breeding
(2) Differentiate between pure breeding and hybrid
(3) Discuss the advantages of plant breeding
(4) Give the details of how Mendel's work gave impetus to plant breeding

19.2.1 Mendel's Work

Have you ever considered who you look like? What of your brothers and sisters? Look at your parent, do they look like their parents or your uncles and aunties? Take a close look at your friends and see whether they look like their parents. Ordinarily you notice that "Likes tend to beget likes". In the unit in cells, you learnt that cells come from pre-existing cells In the unit on cell activity, you saw how cells divide to make another cell. In the process of cell division the DNA and whatever is found in the nuclei also divide half-half i.e. the two new cells that emerge. Each has what the others have. For you to understand this unit on plant breeding, remember what you have learnt about cells.

Mendel a monk in Austria did many experiments with peas. What he did essentially was that he took note of the shape of peas and even the plant. He noticed that some pea plants have its flower at the apex (terminal) of the plant and some have it at he axial i.e. along he stem. He watched this for a number of generations (generations in plant means: from one planting season to another, when it is harvested, until it is planted and harvested again is called a generation). There were no changes. He now believes that the plant is pure. The seeds he selected from plant with axial flower were producing seeds that when grown gives plant with axial flower. The same is true with plants with terminal flower. He determined to cross the two plants and see what happens.

What he did was that he removed the anther from one variety before self-pollination, this plant he called the female plant. He transferred pollen from the second type of plants which he calls the male plant and rubbed the pollen on the stigma of the female plant. He controlled other factors that might intervene with the experiment. He called this **Reciprocal Crosses.**

Pollen grain ⟶ stigma
"Male flower" female flower"

Results - All the seeds from this experiment produce plants with axial flowers. What happened to the other one? Le plants with terminal flower.He planted the seed got from this experiment. This time he did not cross with another. He allowed the experimental seed grow and self-pollination took place.

Result: The plant flowered and there were some with axial flower and others with terminal

flower.
Take note of this, the first time, it was plant with axial flower that appeared and terminal flower which did not appear in the first experiment, appeared.

Mendel came out with this conclusion: axial flower is dominant Terminal flower is recessive

From other experiment Mendel concluded that the dominant traits are three times higher than the recessive traits
When only one character like axial flower or terminal flower is inherited, it is termed Monohybrid Inheritance

Summary of the experiment

Parents axial flower x terminal flowers
F 1 all axial flowers
F2 651 axial flowers 207 terminal flowers F2 ratio 3 :1

Where FI is first filial generation . F2 is second filial generation

You will learn one or two lesson from Mendel's work:
(1) That characteristics do not blend but pass from parent to offspring as discrete (separate) units

(2) That these unit which appear in the offspring in pairs, remain discrete and are passed on to subsequent generations by the male and female gametes which each contain a single unit.

The units are the genes (by Danish botanist Johannsen 1909). The American geneticist Morgan, in 1912 demonstrated that the genes are carried on the chromosomes.

In the unit on cell, you learnt about the chromosome in the nucleus of each cell. When the cell divides the chromosome also divide. Each cell has the same number of chromosome. Understanding of the chromosomes will help us in understanding inheritance. Chromosome is treated in the next unit.

19.2.2 Breeding methods

Mendel used varieties of traits (characters) to conduct his experiment. Table 19.1 result of breeding different kind of characters.

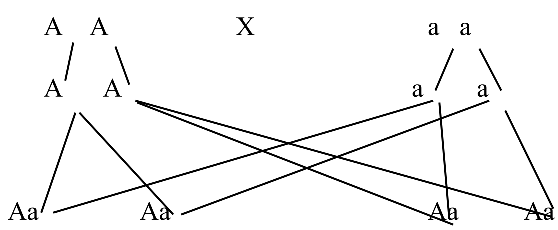
Table 19:1: Result of Breeding Kinds of characters

Contrasting Characters of parents	Frequency of each in first generation	Frequency of each in second generation	Ratio in 2^{nd} generation
Seed form; round x wrinkled	All round (Dominant	5,474 round 1,850 wrinkled (recessive)	3.1
Colour of reserved food in the cotyledon yellow x Green	All yellow (Dominant)	6,022 Yellow 2,001 green	3.1
Flower position axial x terminal	All axial (Dominant)	651 axial 207 terminal (recessive)	3.1
Stem length tall x Dwarf	All tall (Dominant)	787 tall 277 dwarf (recessive)	3.1
Colour of flower red x white	All red (Dominant)	705 red 224 white	3.1
Shape of pod inflated x Constricted	All inflated Dominant	882 inflated 299 constricted	3.1

Mendel Used single character to cross each other. This is referred to as monohybrid cross. Example of a Monohybrid cross:

Pure Breeding axial flower x Pure breeding terminal flower.

Fig 19.1:



All heterozygous axial flower (the alleles 'A' and 'a' remain distinct in spite of the dominance of A

Table 19.2 Glossary of common genetic term with example based on fig 19.1

Genetic Term	*Explanation*
Gene	The basic unit for a given characteristics
Allele	One of a number of alternative forms of the same gene responsible for determining contrasting characteristics.
Locus	Position of all allele within a DNA molecule
Homozygous	The diploid condition in which the alleles at a given locus are identical

Hetero	The diploid condition in which the alleles at a given locus are different
Phenotype	The observable characteristic of an individual usually resulting from the interaction between the genotype and the environment in which development occurs.
Genotype	The genetic constitution of an organism with respect to the alleles under consideration.
Dominant	The allele which influence the appearance of the phenotype even in the presence of an alternative allele
Recessive	The allele which influence the appearance of the phenotype only in the presence of another identical allele.
F_1 generation	The generation produced by crossing homozygous parental stocks
F_2 generation	The generation produced by crossing two F_1 organisms

19.2.3 Pure Breeding

As you learnt in the first part of this unit, Mendel used different kind of seed to do different kinds of experiments in this area of gene and inheritance. You learnt also that he continued to use the same seed for some generation, until he was satisfied that what is left is the true unit of that seed. It could be gene for tallness. If the resulting offspring is tall, the conclusion is that the parent plant is tall. Well can use TT for tallness. If we self-pollinate TT, we will continue to get TT. This is known as pure breeding. If the offspring is self-pollinated, generation to generation, you will continue to get the same result. Mendel used pure breeding peas for all his experiments.

19.2.4 Hybridization

You saw how Mendel used position of flower to do the first experiment. Axial, flower and terminal flower. Plants showing a single pair of contrasted characteristics were grown for a number of generations. These pure breed plants were crossed; bringing the two pure breed seeds together and crossing them is hybridization. Hybridization is making crosses between plants. You should read the first part of this unit on Mendel's work

19.2.5 Principle of plant breeding

You have learnt about Mendel's work with peas. From his work he came up with 3.1 F2 ratio. The first sets of experiment concluded with Mendel's first law. It was also called the principle of segregation which states **that the characteristics of an organism are determined by internal factors that occur in pairs. Only one of a pair of such factors can be represented in a single gamete.**

Mendel continued his experiment, this time he was out for the inheritance of two pairs of contrasted characteristics. This time he used:

Pea shape
Pea cotyledon colour
Remember that in the first sets of experiments, he used axial and terminal flower. The procedure was essentially the same. He crossed pure breeding (homozygous) plant having round and yellow peas with pore breeding plants having wrinkled and green peas

Fl	-	seeds round and yellow
F2	-	315 round and yellow -101 wrinkled and yellow -108 round and green
	-	32 wrinkled and green

He arrived at 9.3.3.1 ratio, known as dihybrid ratio. Mendel arrived at two deductions

1. Two new combinations of characteristics had appeared in the F2 generation: these are.

   "Wrinkled and yellow
   " Round and green

2 The ratio of each pair of all allelomorphic characteristics (phenotypes determined by different alleles) in the monohybrids ratio of 3:1 that is 423 around of 133 wrinkle. 416 yellow to 140 green

   This led to the principles of independent assortment: which state that: - Any one of a pair of characteristics may combine with either one of another pair this is presented in fig 19.2

Fig 19.2:

a)

R	-	Represent round seed (dominant)
r	-	Represent wrinkled seed (recessive)
Y	-	Represent yellow seed (dominant)
y	-	Represent green seed (recessive)

Parental phenotypes	*ound seed and yellow seed (homozygous)*	X	*wrinkled seed and green seed (homozygous*
Parental genotypes (2n)	*RRyy*	*X*	*rryy*
Meiosis		*X*	*all (ry)*
Gametes (n)	*all (RY)*		
Random fertilization			
F_1 genotype (2n)	*All RrYy*		
F_1 phenotypes	*All heterozygous round and yellow seeds*		

b)

F_1Phenotypes	*round and yellow seed*	*X*	*round and yellow seed*
F_1 genotypes (2n)	*Rr Yy*	*X*	*RrYy*
Meiosis			
Gametes (n) (as shown by O and+O)			

Random fertilization (ash shown by Punnett square)

F_2 genotypes (2n) (listed in each square)
F_2 phenotypes

♀ ♂	*RY*	*Ry*	*rY*	*ry*
RY	*RY* *RY*	*Ry* *RY*	*rY* *RY*	*ry* *RY*
Ry	*RY* *RY*	*Ry* *Ry*	*rY* *Ry*	*ry* *Ry*
rY	*RY* *rY*	*Ry* *rY*	*rY* *rY*	*Ry* *rY*
ry	*RY* *rY*	*Ry* *Ry*	*rY* *ry*	*ry* *ry*

9 round yellow: 3 round green: 3 wrinkled yellow 1 wrinkled green seeds

Fig19.2: (a) Stages in the formation of F_1 phenotypes from homozygous parents. This is an example of dihybrid cross since two characteristics are being considered. (b) Use of the Punnett square to show all possible combinations of gametes to form F_2 genotypes.

19.4 Conclusion

You have learnt that Mendel is the first man to publish articles on principles of plant breeding. He cam up with two laws. Mendel's work with peas has thrown light on the field of genetics. You have only learnt the basic principle. Two laws were derived from these experiments. You have only learnt the principles of inheritance- monohybrid inheritance and dihybrid inheritance.

19.5 **TMA** (see attached)

19.6 References

Extensive reference is made to Taylor etc.

Extensive reference is mad to Roberts, M.V.

Unit 20

UNIT 20 CHROMOSOMES

20.0 Introduction

In the last unit, you learnt that Mendel was the scientist that open the "door" to this field of study. You can read about his experiments again. Johannsen, a Danish botanist called the units mentioned in Mendel's experiment as genes in 1909. A American genetist name Morgan showed that the genes are carried on the Chromosomes. You have heard in the unit on cells that the chromosomes n the nuclei of every living cell. In this unit you will learn more about chromosomes. You will learn the chromosomes that carry the genes pass on factors that are on the gene to off-springs.

20.1 Objectives

By the time you finish this unit, you will be able to:

(i) Draw chromosomes and explain how they function
(ii) Explain the chromosomal basis of inheritance
(iii) Discuss the concept of independent assortment
(iv) Discuss the inheritance of disease

20.0 Chromosome

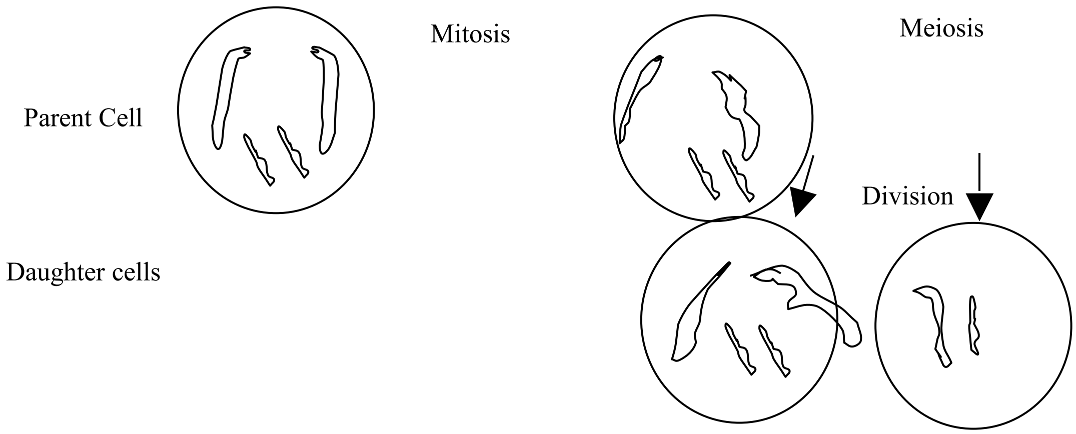
When you see someone looking like his father or mother, we say, "that person has inherited some features from his parents". Some characters pass on from the parents to the offspring.

20.2 Chromosomes

Chromosomes are those structures in the nuclei of cells that carry hereditary materials, determining the organisms characteristics and transmitting these to subsequent generations. When you talk about a cell,)u can not leave out the chromosomes. When a cell divides, the chromosomes are correctly distributed each daughter cell. The chromosomes in each cell has a fixed number. Chromosomes in cells occur in pairs. (diploid).

In the unit on cells you learnt of a kind of cell division, i.e mitosis. Here you will add to that knowledge. here is a second kind of cell division - meiosis. Look at the drawings below.

Fig 20.1 Mitosis and Meiosis**.**



A mitosis is a kind of cell division that will preserve the number of chromosomes in each cell after the division. Meiosis, is a kind of division that will half the chromosomes after the division. In each cell, sere are two pairs of chromosomes two large and two small. Mitosis will produce exactly that in each daughter cell (diplaid). Meiosis will contain only one large and one small in each daughter cell (haploid). Meiosis is the type of division in the formation of gametes (sex cells) such as eggs and sperm. A gamete a cell that cannot divide further until it fuses with another gamete. A spermatozoon and an egg have future unless they unite to form a Zygote. Zygote is the one that develops into an adult. While Mitosis doubles the next stage, meiosis does not. This is of advantage, if the meiosis was doubling, like in mitosis, Chromosome number would have being in multiples.

Meiosis is a kind of cell division that consist of two successive divisions that consist of two successive division.

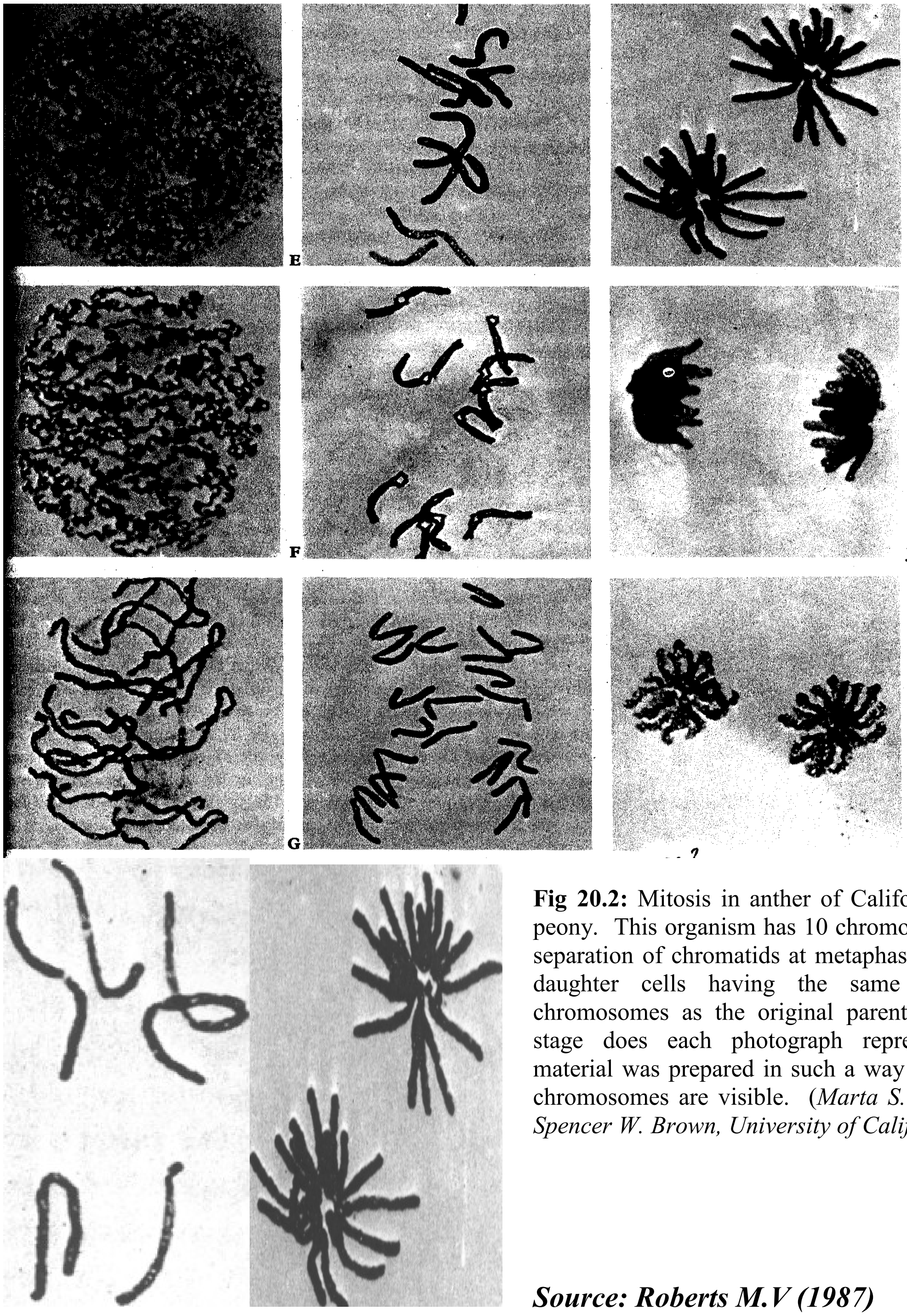


Fig 20.2: Mitosis in anther of Californian coastal peony. This organism has 10 chromosomes. Note separation of chromatids at metaphase resulting in daughter cells having the same number of chromosomes as the original parent cell. What stage does each photograph represent? The material was prepared in such a way that only the chromosomes are visible. (*Marta S. Walters and Spencer W. Brown, University of California)*

Source: Roberts M.V (1987)

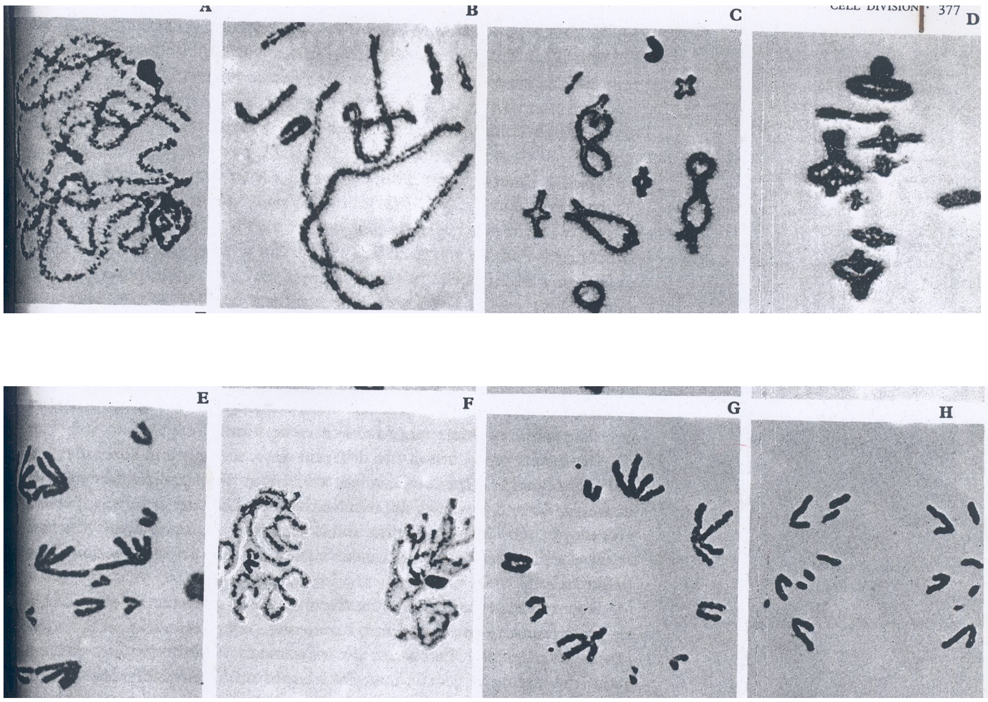
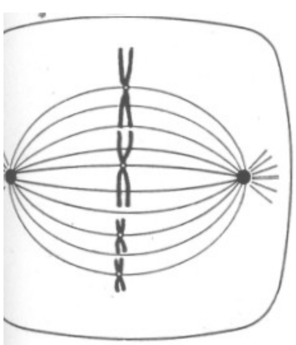


Fig 20.3: Meiosis in testis of grasshopper. This organism has 8 pairs of chromosomes plus, in the male, one X chromosome. Note halving of the chromosome number: ignoring the X chromosome, the parent cell has a total of 16 chromosomes (diploid), whereas the products have only 8 (haploid). The X chromosome has no partner: in the first meiotic division it goes to one of the two daughter cells, and its constituent chromatids separate in the second meiotic division. (*Bernard John, University of Southampton)*

(A) **Metaphase of mitosis** **(B) Metaphase I of meiosis**



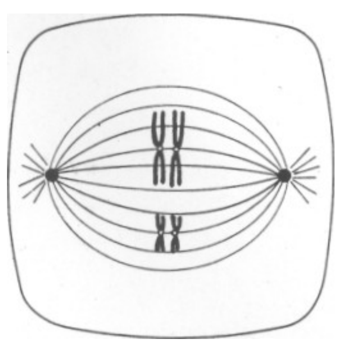


Fig.20.4: The essential difference between mitosis and meiosis lies in the behaviour of the chromosomes. This can be seen at metaphase when they arrange themselves on the spindle. In mitosis (A) homologous chromosomes do not associate with one another, whereas in meiosis (B) they come together and then segregate.

First stage: or first meiotic division the parent cells divide into two. Homologous Chromosomes get separated from each other and go into different cells.
Second stage: the products divide again. The 20.3.1.2Chromatids separate

Stages of meiosis.

Fig 20.5: Forty-six chromosomes in humans

Fig 20.5: Full set of human chromosomes arranged in sequence. Each chromosome can be seen to consist of a pair of chromatids joined at the centromere. The chromosomes differ from one another in size and position of centromere. A Normal male. B) Mongol male: notice the extra chromosome 21. (A: E. H. R. *Ford, University of Cambridge*. B:G.E. *Roberts, Ida Darwin Hospital, Fubourn*).

Take note of the way the chromosomes are. The way they appear in a set as you can see is called Kryotype. There are 23 pairs. One set comes from the male (sperm) and one set from the female (egg) in the meiosis section you learnt that, the division can not be like that of the mitosis. Why? What was the reason given? During fertilization the resulting cell - zygote will have two sets of Chromosome.

Otherwise, there will be multiple and multiple chromosomes in successive generations.

Take a closer look again at fig.10.2. Do you notice the Xy chromosome? They are the sex chromosomes. The Longer one (X) is the female chromosome while the shorter one (y) is the male Karyotype. How will you determine that it is a female karyotype? A female karyotype is (xx) while a male karyotype is xy.

20.2.2 Haploid and diploid cells.

If a nucleus has two sets of chromosomes it is called diploid. Example is in humans, many plants species are diploid. Organisms that have only one set of chromosomes are haploid Some organisms have more than two, they are called polyploid.

What are the advantages of possessing. Two sets of chromosomes?

1) The gene variation is diverse i.e mixture of characters from both parents.
2) If a gene on one chromosome of a pair is faulty, the second chromosome provides a normal backup.

20.2.3 Chromosomal explanation of independent assortment.

To understand this, let us look at fig.3

Fig. 3 Independent assortment of chromosomes in meiosis.

Nuclei of possible cells
resulting

Possible arrangements of bivalents in metaphase I

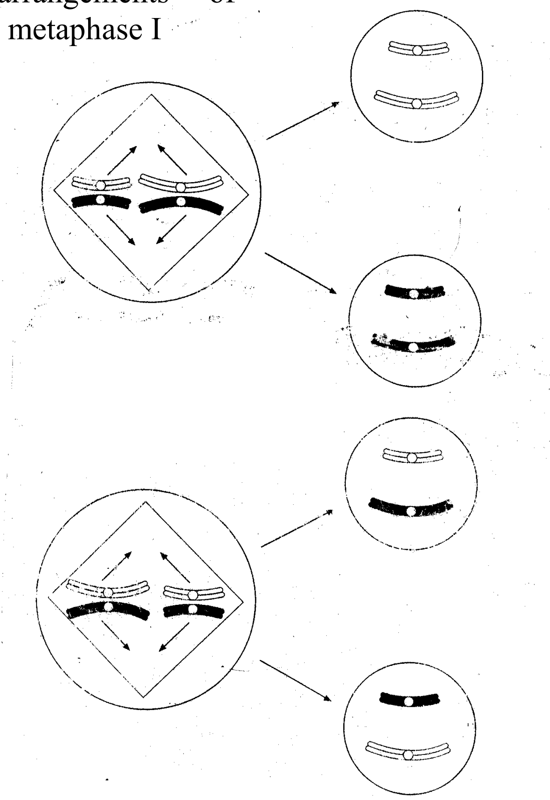


Fig 20.6: Independent assortment of chromosomes in meiosis. Two bivalents are shown. Each bivalent lines up on the equator independently of other bivalents, so that both possibilities shown in the diagram are equally likely. This increases the potential variation in the gametes, which are also shown.

Independent assortment refers to the fact that the bivalents line up independently and therefore the chromosomes in each bivalent separate (assort) independently of those in order bivalents during anaphase IV. The diagram represents material and paternal chromosomes.

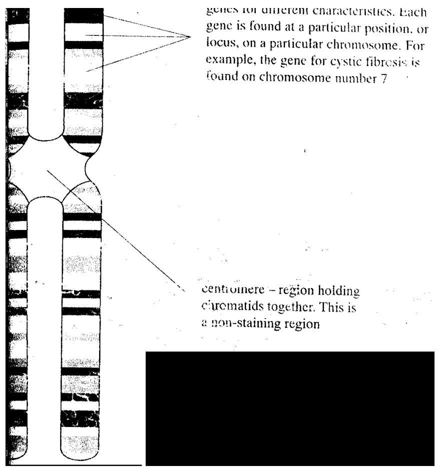
20.2.4 Chromosome and Karyotypes.

You will wonder why you have to look at those diagrams on cell division, mitosis and meiosis. You have learnt about the division because you must know how life is continued. Why are the chromosomes the structures responsible for inheritance?

*Chromosomes contain DNA
*DNA is the molecule of inheritance.

You have seen how cells divide and when they divide, you have seen what happens. Briefly, when the nucleus divides, one DNA molecule is made so that at nuclear division the chromosome is a double structure containing two identical DNA molecules. The two parts of the chromosomes are referred to as chromatids. Let us examine the structure of the chromosome below:

Fig 4: Structure of the Chromosome.



One chromosome

Fig 20.7: Simplified diagram of a chromosome. In reality there would be several hundred to several thousand genes. The number and size of genes is variable.

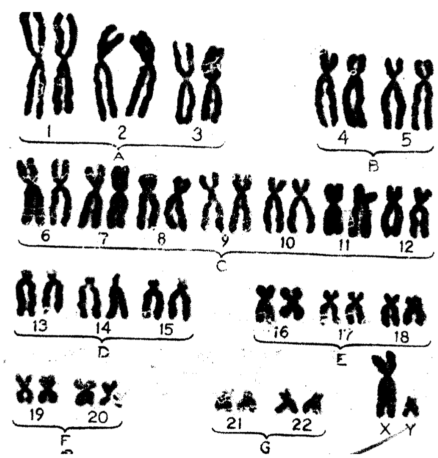


Fig 20:8: Karyogram of a human male, prepared from fig 2. Non-sex chromosomes (autosomes) are placed in groups of similar size (A to G). The sex chromosomes are placed separately. X, female, Y, male. Note there are 22 pairs of autosomes and one pair of sex chromosomes. Genes on the autosomes are described as autosomal. Genes on the sex chromosomes are described as sex-linked.

They appear as long thin threads in the nucleus, in this form, they are referred to as chromatin (coloured material). But before nuclear division, they are more compact, thick and shorter. Look at the drawing chromosomes. Take note of the following:

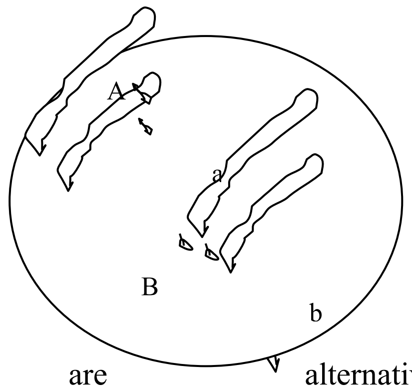
(i) There are two chromatids (46 in human beings)
(ii) Point of attachment is the centromere
(iii) They are in pairs (homologous pairs)

We have been using characters and traits referring to those things transmitted in the nuclei. You have learnt cell division and the work that Mendel did. Mendel actually referred to them as "factor". You learnt that Johannsen in 1909 called them genes. In unit 9. You learnt the many terminologies used for field of study. Go back and look at the table on common genetic terms.
The gene is the unit of hereditary. In inheritance, two characters appear.

Fig 20.9: Mendel's Principle of independent

(i) Phenotypic character
(ii) Genotypic character

Fig 5: ***A cell showing two pairs of homologous chromosomes.***



Alleles are alternative forms in which a gene may exist. They occupy the same loci (locus) on homologous Chromosomes. Look at fig. ..... 2-3 A. a, B, b are gene loci. Independent assortment can be explained in terms of chromosomes moving during cell division meiosis). Mendel's principle of segregation factors (alleles) A and a described in terms of the separation homologous chromosomes which occurs during meiosis.

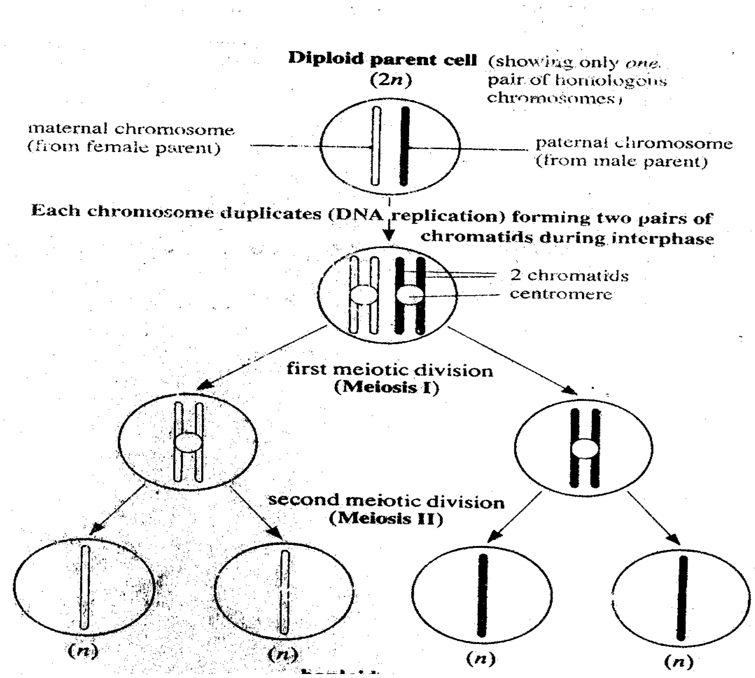
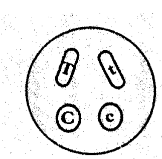
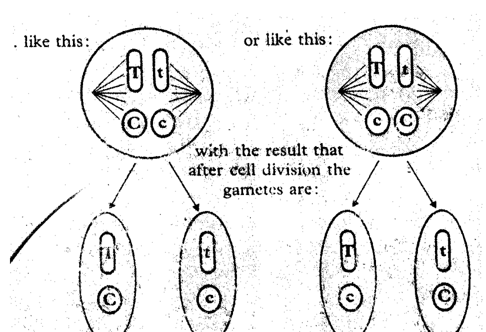


Fig 20.9: Mendel's Principle of independent

Fig 20.9 : The basic characteristics of meiosis showing one chromosome duplication followed by two nuclear and cell divisions. Note that, as for mitosis, chromosomes may be single or double structures. When double, the two parts are called chromatids.



In meiosis the homologous chromosomes come together (assort) but they arrange themselves on the spindle **independently** of each other. Thus they may arrange themselves.



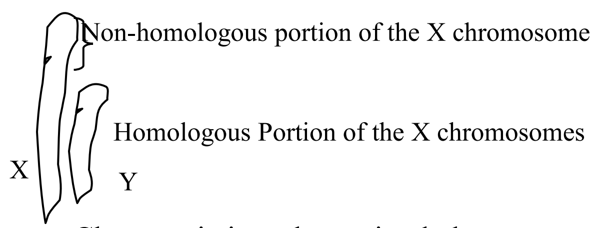
Thus meiosis results in the formation of four types of gamete which, since the process is random, occur in approximately equal numbers.

Assortment of factors (alleles), A, a, B, b described in terms of the separation of homologous chromosomes which occurs during meiosis. Independent assortment of homologous chromosomes is the random alignment or assortment of homologous chromosomes on the equatorial spindle during metaphase I of meiosis, and their subsequent separation during metaphase I and anaphase I, that leads to the variety of all e.t.c. recombination in the gamete cells. Look back at the mitosis and meiosis diagrams in unit 9. How are characters like eye colour, hair colour blood group, ability to cloth blood, etc, transmitted? If your father has a kind of blood group or light in complexion you inherit it or you have heard that a particular kind of disease runs in a family. How is it possible?

The simple explanation is that all these characters are located on the gene of the person who has the character. So many characters are carried on the gene. Because the genes are carrying so many characters and are located on the chromosome, they are said to be linked. All genes on a single chromosome form a linkage group and are inherited together. Genes in the linkage group do not show independent assortment.

20.2.4 Inheritance of disease

Which human disease do you know? Let us examine some like the hemophilia, sickle cell, Genes carried on the sex chromosome are said to be sex linked. When you looked at the chromosomes in Fig 4, you learnt that the X is longer than the Y. In the case of the heterogamic sex, there is a portion of the X chromosome for which there is no homologous region of the Y chromosome



Characteristics determined by genes carried on the non-homologous portion of the X chromosome therefore appear in males even if they are recessive. This is a special form of linkage – sex linked traits e.g colour blindness (red, green)

- Premature baldness
- Haemophilia

Haemophilia is a disease in which those who are suffering from it, do not have a gene for factor VIII that is, they do not have the ability to clot blood. If they have a wound, they will continue to bleed till they loses all their blood. The gene for factor VIII is carried on the portion of non-homologous chromosome. Their sons will suffer the disease but it is the female that carries.

20.3 Conclusion

In this unit, you have studied the chromosome, what it looks like. How the chromosome is the basis of inheritance and the chromosomal basis of inheritance. You will study Genetics in more detail later on.

20.4 Summary

21.1 Objectives.

21.1 Objectives.

The cells are the structures that make continuation of life possible. Cells multiple to have increase. There are two types of cell division, mitotic and meiosis. In mitotic cell division, two daughter cells result, with the same number of chromosomes in each cell. In meiosis, the materials divide into two and instead of two daughter cells, with the same chromosome number, the chromosome number is half. This is so because gamete have to be half, if not you will keep having double chromosome each time there is a uniting of male and female gamete.

Chromosomes are located in the nuclei and genes are located on the chromosome. The genes are the basis of inheritance. The Characters or traits you see in each off-spring has been passed on to it through the gene located on the chromosomes. In each cell division the genes sort themselves out in a special way.

20.5 TMA (see attached)

20.6 References

Taylor *et. al.* (1998) Biological Science An Extensive use of this book is made. Many of the diagrams and tables have been adapted from the book.

Roberts M.V. (1987) Biology: A functional approach. This book has been referred to extensively many tables and figures have been adapted from this book.

20.7 Further Reading

Unit 21

Inheritance

21.0 Introduction

In unit 20 you learnt that chromosomes are located in the nuclei and genes are located on the chromosome. You learnt that the genes are the basis of inheritance. The characters or traits you see in each offspring has been passed on to it through the gene located on the chromosomes. In this unit you 11 study inheritance. You will study more detail of how the parents pass on their characters. Specifically, monohybrid and dihybrid inheritance are explained.

21.1 Objectives.

By the end of this unit you will able to:

(i) Explain the concept of inheritance

(ii) Differentiate monohybrid inheritance from dihybrid inheritance

(iii) Given examples of certain inheritance found in man e.g. Albinsm and how it happens

(iv) State the two laws of inheritance

In unit 19 You learnt about Monohybrid inheritance, you also learnt about Mendel's work, how he used peas to arrive at two laws. What is the first and second Law? Mendel's first law states that:

The characteristics of an organism are controlled by genes occurring in pairs. A pair, Of such genes, only one can be carried in a single gamete.

Do you still remember meiosis? Go back and read the section on meiosis if you want to get more understanding of this first law. Let us go briefly over it, in meiosis homologous chromosomes segregate

- From each other, as a result of which a gamete
- Receives only one of each type of chromosome
- Instead of the normal two. Genes also occur in pairs, each being located on one of two homologous chromosomes. When homologous chromosomes
- Segregate in meiosis they take their genes with them
- And thus the gametes receive only one of a pair of alleles -just as they receive only one of a pair of chromosomes.

You saw Mendel's work with peas which resulted in the first law. You have studied the differences between a plant cell and an animal cell. Let us look at the kind of work Mendel did with peas in man. Studying the something in man is not going to be as easy as it was in the peas. We will take an example.
Albinism (no pigment) is a condition which genetists believe is associated with a single pair of genes as you saw in the peas (axial flower and terminal flower) let us replace the gene for albinism as (a) and gene for normal person as (A). One is dominant and one is recessive. Do you still remember these terms when Mendel was doing the experiment with pure breed peas? In the first generation (fl) all the seed from the experiment produced plants with axial flowers. Remember, we were wondering what happened to the terminal flower that it did not appear in the

first generation. At the end we saw how the one that appeared was referred to as dominant and the one that did not appear in the fi as recessive. Two of them (i.e axial flower and terminal) appeared in the second generation.

Let us follow this same method here. If a normal man and his wife have a child that is an albino. It means both of them had a recessive gene for albino. They are heterozygous for (Aa)

Father Mother
Aa Aa
These parents are said to be carriers. Let us follow Mendel's example as in the peas.

Fig. 21.1

Father A a

Mother A a

Gametes

Offspring

Normal Phenotype Albino

When a phenotypical normal phenotype man and woman marries. Let us say that they have four children. One child will be normal. Two of the children will appear normal. The fourth child will be an albino.

Aa appear normal because of (a) is a
Aa recessive gene
aa is fully manifest albino.
AA perfectly normal

While A is dominant, a is recessive. This is an example of genes appearing in pairs, and only one of it is carried in a single gamete. Remember the 3.1 ratio we saw in the unit under breeding? What this means essentially is that a couple who are heterozygous (Aa +Aa) are likely to have one child albino. This is an example of monohybrid inheritance in man. We have other examples like that in man e.g cystic fibrosis, it is a disease whereby, connective tissue develops in various glands of the body, particularly the pancreas.

Activity 1

a) If a man who is normal (AA) marries a woman who is (Aa) a carrier, assuming they have four children, draw a flow chart (as you have above) of what these four off-springs will be like. How many will be dominant, how many will be recessive (carrier) and how many will be normal. b) If an albino man marries an albino woman what will be the result of their offspring

c) If an albino woman, marries a carrier (Aa) man, what will be the result of their offspring?

21.2.2 Dihybrid Inheritance

You have just seen how Mendel's work can applied to man, based on the first law. The second law also can be applied man. The second law states that:

Each member of a pair of alleles.
May combine randomly with either of another pair.

Because we are using more than a single pair, the probability that a particular character will appear is not certain. In the section on breeding we saw a 9 3.3.1 ratio 9 9.3.3.1

Which gene is transmitted based on colour, size, are independent events. Let us take the gene for tallness (TT). In the F2, the probability of any plant being tall is 1/4, and any being short is 1/4 . In terms of colour, there is a probability of 3/4 in the f2 that will be coloured and 'A that will be white. What then is the probability of an F2 plant being tall and coloured? It will be 3/4 x 3/4 = 9/16 i.e nine out of sixteen will be tall as well as coloured. The two pairs of genes are transmitted independently and assort freely.

Explanation.

Again, your knowledge of meiosis will help you understand this second law. Genetists belief that the genes carrying the colour are located on one pair of chromosomes. While the one for size are located on another pair of chromosomes. Go back to the drawing of meiosis. Look at the stages of division in meiosis. Let us continue.

In metaphase of the first meiotic division, homologous chromosomes line up side by side on the spindle prior to separating. In this process, different pairs of homologous chromosomes behave independently of each other; the way one pair of homologous chromosomes arrange themselves on the spindle and subsequently separate has no effect whatsoever on the behaviour of any other paid of chromosomes. This is simply saying that the chromosomes arranging themselves in that manner is simple random.

The summary is, you have two genes, size and flower colour and in meiosis they segregate and assort independently, reason is that they are carried on separate chromosomes. Remember that in meiosis the chromosomes segregate and assort independently. Dihybrid inheritance is when two pairs of characters are inherited. In the next unit, you will see how pairs of characters can be inherited.

21.3 Conclusion

In this unit you have learnt about inheritance. You have learnt about two laws that explain inheritance. They are called Mendel's first and second law of inheritance.

21.4 Summary

The first law of inheritance states that the characteristics of an organism are controlled by a genes occurring in pairs. Of a pair of such genes, only one can be carried in a single gamete. The second law states that: each member of a pair of alleles may combine randomly with either of another pair. Two terms-monohybrid inheritance and dihybrid inheritance were coined from this laws.

21.5 TMA

21.6 References.

Dutta, A.C. (1984) Botany for Degree Students. Vines and Rees. Plant and Animal Biology