BIO 101

INTRODUCTORY BIOLOGY I

THE CELL

A cell may be defined as he standard unit of biological activity bounded by a membrane, and able to reproduce itself independently of any other living system. All living organisms, large and small, plant and animal, fish and fowl, man and microbe, are made up of cells. All cells are basically similar to each other, having many structural features in common. Organisms may be composed of only one cell, when we describe them as being unicellular, or of many cells when we say they are multicellular.

With the exception of eggs, which are the largest cells (in volume) known, cells are small and mostly invisible to the unaided eye. Consequently, our understanding of cells paralleled technical advances in the resolving power of microscopes. Englishman Robert Kooke first saw the remains of dead cells in 1665 in a piece of cork as he was using his newly invented microscope and he coined the work "cell" to describe the tiny structures, thinking that they resembled the unadorned cells occupied by the monks. In 1838 Mathias Schleiden, a German botanist, announced that all plant tissues were composed of cells. A year later one of his countrymen, Theodor Schwann, described animal cells as being similar to plant cells. Schleiden and Schwann are thus credited with the unifying cell theory. Some 20 years after the announcements of Schleiden and Schwann, Rudolf Virchow, a great German physician, made another important generalization, cells come only from pre-existing cells.

Cells are separated from their external environment by an interface or plasma membrane. Everything inside the plasma membrane is sometimes referred to as protoplasm, consisting of the jelly like cytoplasm (cyto-cell, plasma thing) and various structures collectively known as organelleles, including the membrane, bound nucleus. Each organelles represents a highly specialized compartment or submodule in which particular functions of the cell are localized.

(diagram)

STRUCTURE AND FUNCTIONS

The Plasma membrane: Typically the eukaryotic cell is enclosed within a thin, study, differentially permeable plasma membrane. This structure regulates the flow of materials between the cell and its surroundings. In some cells, such as nerve cells, the plasma membrane also is involved in intercellular communication in other cells, such as intestinal epithelium, the plasma membrane is modified into numerous, small, finger like projection called microvilli that increase the surface area of the cell. Chemically, the membrane consists of lipid (fatty material)and protein.

Endoplasmic reticulum and ribosomes: transport, storage and synthesis: The endoplasmic reticulum is visible in great detail with the electron microscope and consist of an extensive network of membrane-enclosed spaces. The space is referred to as the Cisternea. The membranes of the endoplasmic reticulum may appear smooth along their outer surface. However, sometimes the outer surface is studied with small particles called ribosomes, and in this case the endosplasmic reticulum has a coarse appearance and is spoken of as rough. The R.E.R. is found with greater frequency and abundance in cells which are actively synthesizing protein. The manufacture of proteins in the cell is associated with the ribosomes, which are dense particles containing protein and ribonucleic acid (RNA).

The E.R. by virtue of its extensive branching, functions in transport, the cisternea of the |E. R. apparently function as roots for transport of certain substances within the cell. In some cases, the ER accumulates large masses of protein and acts in a storage capacity.

The Golgi complexe: is a stack of smooth, membraneous cisternae that functions in the storage, modification and packaging of protein products, especially secretory products. It does not synthesize protein but may add polysaccharide to the complex. As its products mature, the ends of the cisternea pinch off and become membrane-bound vesicles in the cytoplasm. The contents of some of these secretory products destined to be exported from a glandular cell. Pothers may contain digestive enzymes that remain in the cell that produce them. Such vesicles are called Lysosomes (literally “loosening body”, a body capable of causing lysis, or disintegration). The enzymes they contain are involved in the breakdown of foreign materials, including bacteria engulfed by the cells. Lysosomes are also capable of breaking down injured or diseased cells and worn-out cellular components, since the enzymes they contain are so powerful that they kill the cell that formed them if the lysosomes membrane ruptures. In normal cells the enzymes remain safely enclosed within the protective membrane.

Mitochondria: There organelles are conspicuous organelles present in nearly all eukaryotic cells. They are diverse in size, number and shape, some are rodlike, and others are more or less spherical. They may be scattered uniformly the cytoplasm, or they may be localized near cell surfaces and other regions where there is unusual metabolic activity. The mitochondrion is composed of a double membrane. The outer membrane is smooth, whereas the inner membrane is folded into numerous platelike projections called cristae. These characteristics features make mitochondria easy to identify among the organelles. They are often called “powerhouse of the cell” because enzymes located on the cristae carry out the energy-yielding steps of aerobic metabolism. ATP, the most important energy storage molecule of the cells, is produced in the organelle. Mitochondria are self-replicating.

Chloroplasts: The food we eat and the oxygen we breath are produced by organelles called chloroplasts. They are found in green plants. They are disc-shaped bodies containing a green pigment called chlorophyll. The complex chemical processes of photosynthesis take place in the chloroplast where the energy of sunlight is trapped and utilized for the synthesis of complex organic materials from simple inorganic molecules.

Each chloroplast is surrounded by two membranes that enclosed its contents and separate it from the cytoplasm. The internal portion of the chloroplast consists mainly of two parts: a fluid matrix (stroma) surrounding a complex membrane. The membrane system generally consists of a series of multilayered fluid-fluid discs (grana) resembling a stack of coins and a system of closed flat sacs (lamellae) extending throughout the chloroplast and connecting the grana.

Higher plants contain a variety of intracellular bodies called plastids. Usually there are two types; the chromoplasts (coloured bodies) and leucoplasts (white or colourless bodies). Chloroplasts belong to the chromoplasts group. Other kinds of chromoplasts give many flowers and leaves their colours or yellow, orange or red. Leucoplasts serve as food storage deposits for the cell and contain oil, starch grains and protein.

Vacuoles: inner space: The cell may contain fluid filled spaces surrounded by a membrane, called vacuoles. Plant cells have more prominent vacuoles in young plant cells the vacuoles are many and they are rather small, but as the plant ages (gets older), these vacuoles fuse to form a large, conspicuous central vacuole. The hydrostatic (fluid) pressure of the vacuole forces the cytoplasm to the periphery of the cell, and there it remains as a thin layer closely pressed against the plasma membrane. The vacuole of plant cells contains primarily water and a watery of other substances together called cell sap, because cell sap has a higher osmotic pressure than the external medium, water moves into the cell and the cell becomes turgid. It does not burst because it is surrounded by a rigid cell wall. The turgid nature of the plant cell contribute to the strength of certain plant stems and the crispness of vegetables such as celery and lettuce.

The plant cell stores a number of important substances in the variety fluids of the vacuole, and these include amino acids, proteins, salts, sugars and the red pigment anthocyanin. The red colour of roses, and red onions is due to the presence of anthocynanims in their vacuolar fluid. Vacuoles are formed in animal cells during the processes of pinocytosis and phagocytosis.

Microtubules and microfilament: Cellular movements involve two kinds of rodlike structures: microtubules and microfilaments. Microtubules are capable of rapid assembly and disassembly and are primarily composed of the protein tubulin. Microtubules are the structural framework of cilia and flagella; in the mitotic spindle, microtubules act to move the chromosomes during cell division.

The threadlike microfilaments are smaller in diameter than microtubules and do not contain tubulin. They are often associated with the inner surface of the plasma membrane where they occur in bundles and sheets. The muscle-like contractions of microfilaments are involved in cell movement and changes of cell shape and in cytoplasmic streaming.

Centrioles, cilia and flagella: The centriole ("central body") is a dark central body just outside the nucleus. This densely stained granule plays an important role in the division of animal cells. Centrioles are not indispensable during cell division, however, the cells of higher plants contain no centrioles, and yet are still capable of dividing properly. The centrioles under the electronmicroscope consist of a circlet of nine microtubules, each of which is further subdivided into three smaller tubules. Centrioles are self-replicating.

The surfaces of many cells have short hair like or long whiplike appendages that move fluid across the surface of the cell. If the cell is free to move on its own, the appendages can propel the cell in a watery medium. The hairlike appendages are called cilia and the whiplike appendages are called flagella. The cells of the fallopian tubes of the female (human) reproductive system and the cells of the trachea are lined with cilia. Spermatozoa produced in the testes of the human male are motile because of the activity of their lashing tails, which are really flagella.

In cells that bear cilia and flagella, the centriole replicates itself, and the copies migrate to the cell surface, where they become basal bodies that in turn give rise to the cilia and flagella. Every cilium and every flagellum has the same structure when viewed with the electron microscope. Each cilium and flagellum is covered by the plasma membrane, and internal to this is a ring of nine pairs of microtubules surrounding two central tubules. The basic structure of these organelles is often referred to as a nine-plus-two arrangement of tubules. Only the cylinder of nine tubules continues below the cell surface and there it forms the basal body, which appears structurally identical to the centriole. The ability to move rhythmically or to beat is an inherent property of cilia and flagella, and even when detached from the cell, they can be made to move.

Nucleus: The most conspicuous feature of a cell viewed with a microscope is the nucleus. The nucleus is a relatively large structure, spherical or avoid in shape and separated from the cytoplasm by a nuclear membrane. The electron microscope reveals that the nuclear envelope really consists of two membranes and that the membranes have pores that appear to connect the inside of the nucleus (nucleoplasm) with the cytoplasm. The nucleus contains chromatin and one or more dense, granular structures called nucleoli (nucleolus). The chromatin is a complex of DNA and instore and nonhistone protein and carries the genetic information of the cell. Nucleoli are specialized parts of certain chromosomes that carry multiple copies of the DNA information to synthesize ribosomal RNA. After transcription from the nucleolar DNA, the ribosomal RNA combines with several different proteins to form a ribosome detaches from the nucleolus, and passes through unclear pores to the cytoplasm. The nucleolus may be thought of as the cell’s peacemaker since any change in the activity of the nucleolus will result in a change in the growth rate of the cell.

Prokaryotic and Eukaryotic cells

There are two general classes of cells: the prokaryotic cell typical of bacteria and blue-green algae (cynabacteria) and the eukaryotic cell found in all other organisms, plant and animal.

The prokaryotes, meaning literally “before the nucleus” are the simplest cell known. As a rule, these cells are small in dimension: from 0.1 to 0.25cm (micrometers) among the mycoplasmas, the smallest cells known, a few micrometer in length and somewhat less in with among the bacteria, and a bit larger in the blue-green algae. The living portion of the cells of bacteria and blue-green is limited externally by a plasma membrane, outside of which a more or less rigid cell wall and a jellylike, mucilaginous capsule or sheath are present. They contain a single chromosome comprised of a single, large molecule of DNA not located in a membrane-bound nucleus, but found in a nuclear region, or nucleoid. The DNA is not complexed with histones proteins, and prokaryotes lack membraneous organelles such as mitochondria, plastids, golgi apparatus, and endoplasmic reticulum. During cell division, the nucleoid divides without visible chromosomes, never buy true chromosome (mitotic) division.

Then eukaryotes ("true nucleus") is a far more elaborate structured and partitioned unit than is the prokaryotic cell from which it is presumably division. An internal division of labour has taken place, accomplished by the use of membranes. The exterior of the cell is bounded by a plasma membrane, to which, in the case of plant cells, an outer wall of cellulose and other materials have been added. The hereditary material is enclosed in a membrane-bound nucleus and is segmented into complex nucleoprotein bodies or chromosomes, the number of which is characteristic for each species.

Table : The Table below summarizes the existing differences between prokaryotic and eukaryotic cells

Features	Prokaryotes	Eukaryotes
Cell size	Mostly small (1-10cm)	Mostly large (10-100cm)
Plasma membrane	Present	Present
Nuclear membrane	Absent	Present
Genetic system	DNA with some non histone, protein simple, circular chromosome in nucleus, nucleus not membrane bound	DNA complexed with histone and nonhistone; proteins is complex; chromosomes within the nucleus; nucleus with

		membraneous envelope
Cell division	Direct by binary fission or budding. No mitosis	Some form of mitosis occur; centrioles many, mitotic spindle present
Sexual system	Absent in most; highly modified if present	Present in most; there are male and female partners; gametes that fuse other
Nutrition	Absorption by most, photosynthesis by some	Absorption, ingestion, photosynthesis by some
Intracellular movement	None	Cytoplasmic streaming, phagocytosis, pinocytosis
Mitochondria	Absent	Present
Endoplasmic reticulum	Absent	Present
Golgi apparatus	Absent	Present
Ribosomes	Present	Present
Cell wall	Present, composed of amino acids and muramic acid	Lacking in animals, present in plants, with cellulose a major component
Vacuoles	Absent	Present (particularly in plants)

Table 2:

PLANT KINGDOM

CRYPTOGAMS (Non-flowering plants) PHANEROGAMS (flowering plants)

Thallophyta Bryophyta Pteridophyta Gymnosperms Angiosperms

Liverworts moses

Gymnosperms	Angiosperms
-naked ovule	-enclosed ovule
-flowers without Whorls	-flowers with whorls

Algae Fungi Lichens

Simplified classification

1. OLD CLASSIFICATION

PLANT KINGDOM

DIVISION:

Cryptogams	Spermatophyta
Flowerless plants	Flowering plants
(seedless)	(Seed Plants)
-Thallophyta	- Gymnospermae (naked seed plants) Cycads, conifers, etc.
-Byrophyta	-Angiospermae (closed – seed plants) monocots & dicots
-Pteridophyta	

2. MODERN CLASSIFICATION

KINGDOM PLANTAE

(A) SUB KINGDOM – Thallophyta (plants not forming standard embryo)

DIVISIONS – 1. Algae (phycophyta) 6 classes

- (Cyanophyta) Blue green
- (Euglenophyta) Euglenoids

Classes
- (Bacillarophyta) Diatoms
- (Chlorophyta) Green algae
- (Phacophyta) Brown algae
- (Rodophyta) Red algae

II. Fungi (Mycophyta) 6 classes

- (Schizomycophyta) – Bacteria
- (Myxomycophyta) – Slime fungi
- (Eumycophyta) – true fungi

Classes
- (Phycomycetes) - algalike fungi
- (Ascomycetes) – sac fungi
- (Basidiomycetes) – club fungi

(B) SUB KINGDOM: Embryophyta (Plants forming embryo)

DIVISIONS

I. Bryophyta (Plants with vascular tissues)

Liverworts, mosses

II. Tracheophyta (plants with vascular tissues)

(a) Pteridophyts, ferns etc.

(b) Spermatophyta (i) Gymnosperm (with naked ovules)

(ii) Angiosperm

Dicots 2 cotyledon embryo

Primary root not persist and give rise to tap root system

- Reticulate venation
- Flower with petamerous systems
- Vascular bundles arranged in ring

Monocot

- 1 cotyledon embryo

- Primary root disappear giving rise to fibrous root system
- Paralled venation (except yam)
- Flower with trimerous sysmetry
- Vascular bundles scattered

Taxonomy

Deals with description, identification and naming of plants and classification into different groups according to their resemblance and differences mainly in morphological characteristics.

Units of Classification

Species: group of individual having very close resemblance with one another, structurally and functionally. They interbreed freely and successfully have same number of chromosomes in zn (somatic) and n (gametes) cells.

Genus: collection of species which bear a close resemblance to one another as far as the morphological characteristics of the flora in reproductive plants are concerned.

Nomenclature

The name of a plant has two parts. The first refers to the genus and the second to the species. This method of giving two names to a living organism is called Binomial system of nomenclature.

In this system the two names are latinised. The genus starts with a capital letter. Each is underlined/italicized. They are not underlined when in italics. There are so many systems of classification that have been used in botany today.

- Artificial system
- Linnnaean system
- Natural system
- Bentham and Hooker's system
- Eengler's system
- Phylogenetic system

- Hutchinson's system etc.

Fig. 3: Bacteriophage (Diagram)

VIRUS

Viruses are smallest and possibly the most primitive living organism smaller than bacterial. All viruses are entirely parasitic and are quite inert in their free state in air or water. They grow, multiply and produce disease symptom in the living cells of plants and animals.

Election microscopy and x-ray photography have revealed detailed facts about virus structure. Virus particles have no cellular structure. They are complex organisms with genetic mechanism. They are of varying shapes (10-200mm). a virus structure contains a core of nucleic acid, (mostly DNA and sometimes RNA) surrounded by a thin film of protein (protein coat) with a protective layer.

The DNA is a genetic (hereditary) material responsible for all biochemical activities. Viruses can be isolated, purified and obtained in crystal form (e.g. Tobacco Mosaic Vitus TMV) when a viral particle (also called a virion) gains access to the interior of a specific host, it has the capacity to direct its own replication. The viral nucleic acid which is the infective part of a virion, can monopolize the biosynthetic machinery of a host cell, forcing it to synthesize the molecular component of virus molecules rather than the normal host cell components.

All plans viruses contain RNA and are either nod like relics.

Some viruses called Bacteriophages also attack bacteria and destroy their nuclear materials. Some plant disease caused by virus include (a) mosaic diseases in apple, bean, cabbage, canliflower, cucumber, cassava, tobacco (b) black ring spot of cabbage, (c) leaf roll of potatoes (d) chlorotic diseases in apple, pepper, rose (e) leaf curl in bean, beef, cotton, pawpaw, soyabean, tobacco (f) necrosis in potato, tomato. Some vital diseases in animal include (a) AIDS (b) mumps, small pox, chicken pox, measles, herpes, polio, yellow fever (Hepatitis B), common cold, influenza, etc.

Bacterial and structural organization of prokaryotic cells

Prokaryotes are very small, simple cells having only a single membrane, the cell membrane. This contain no membrane surrounded nucleus and no membraneous organelles such as mitochondria or endosplasmic reticulum. The prokaryotes include the bacteria, blue-green algae etc. They contain only one chromosome, which consists of a single molecule of double helical DNA densely coiled in the nuclear zone.

The bacterium cell is covered by a distinct but complex cell-wall made of proteins and carbohydrate. The cytoplasm is spread uniformly throughout the cell and contains many small vacuoles, food granules (glycogen and volutin). There is no organized nucleus but a nuclear material in front of a coiled double stranded DNA. They reproduce by fission. Shapes of bacteria include the Bacilli (rod), cocci (spherical), spirilla (spiral), commas (vibrio).

(Diagram)

Beneficial effects of bacteria:

(1) Agriculture
    (a) Decay of organic materials
    (b) Nitrification
    (c) Nitrogen fixation
    (d) Fertilizers
    (e) Plant disease control through antibiotics from some plant organism

(a) Curing of tobacco leaves

(b) Fermentation

(c) Curdling of milk

(d) Conversion of hide to leather during tanning

(e) Silage preparation

(f) Medical

(g) Antibiotics

(h) Non-harmful bacteria in human intestine

Reproduction in Cryptogams

- Any member in Thallophyta, Bryophyta or pteridophyta may take to one or more of the three methods of reproduction i.e. (a) Vegetative (b) Asexual (c) Sexual
- Vegetative reproduction is by cell division or fragmentation of part of the plant body.
- Asexual reproduction is by fission or through various types of spores which could be zoospores (motile spores) or ordinary non-motile spores (Gonidia).
- Sexual reproduction takes place by fusion of two gametes. The two games involved may be similar in shape, size, and behavior (isogamy) or may be slightly different in size and behavior (anisogamy). In advanced members gametes become differentiated into male gametes (antherozoids, spermatozoid or microgamets) and female gametes (mega gametes, egg cell or oosplere or ovum).

The fusion of these male and female gametes under this condition is termed oogamy. In oogamous members, the male reproductive cells are small, motile, ciliated, active and initiative while the female gametes are large, non-motile, non-ciliate, passive and receptive. The oosphere is retained in the oogonium.

Alternation of generation

The life cycle (life history) of many flowerless plants especially the higher algae, bryophytes and the pteridophytes is completed in two alternating stages or generation which differ in morphology (body structure) and mode of reproduction. The sporophyte or sporophytic or asexual generation reproduces by spores while the gametophytes or gametophytic or sexual generation reproduces by gametes. One generation gives rise to the other for the life history to be complete. The sporophyte to the Gmetophyte and the Gametophyte to the sporophyte. Therefore, two generations regularly alternate with each other. This phenomenon is termed alternation of generation. In terms of chromosome number, the gametophyte with n-chromosomes (haploid) produces the gametes. Male and female gamete each with c-chromosome fuse to give a zygote with zn chromosome (Diploid). The zygote develops into the sporophyte with Zn number of chromosome.

Meiotic division in some cell of the sporophyte takes place to give haploid spores with n chromosomes. This haploid spore gives the gametephyte which are also haploid.

(diagram)

ALGAE

Characteristics

- Green thallophytes withchlorophyll
- Other pigment may be present in addition to chlorophyll
- They are autothrophic
- Alga body is made of true parenchymatous cells
- Cell wall is of true cellulose
- Algae live in water and wet substrata
- Structures ranges from unicellular, multicellular, filamentous or thalloid
- Reproduction in hem may be vegetative, by cell division or by fragmentation or asexually by spores or sexually by gametes

Blue-green Algae (Cyanophyceae) e.g. Nostoc and Anaebena

The blue green algae seem to be related to the bacteria both being primitive with some characteristics in common. The blue green algae have the blue-green pigment phycocyanin in addition to the chlorophyll. The cell structure is of a primitive type with no definite nucleus nor plastic (i.e. no organized protoplasm). The photoplasm is differentiated into peripheral coloured zone, the chromoplasm and inner colourless zone called the central body. Some are unicellular or filamentous. In some filamentous form such as nostocm Anaebena or oscilatoria there is the Akinete or resting spore from the vegetative body. The Heterocyst, an enlarged vegetative cell with transparent contents and thickened walls may be seen.

Fig 6: (Diagram)

Nostoc is a common blue green filamentous algae occurring in damp soils, ponds, ditches and pools of water. The filament of Nostoc looks like strings of beads. The chains are embedded in gelatinous sheath. Characteristic nature of Nostoc is the presence of Heterocyst always at the end of a filament. The function is likely for food storage and vegetative propagation.

Most produces asexually by means of Akinete which are resting spores. They are regarded as a modified vegetative cell acting as a resting spore, which may develop at any part of the chain or filament.

Nostoc can reproduce vegetatively by fragmentation or filament into several shorter chains called Hokogonia. Each homogonium can give rise to a longer filament or chain by repeated cell division in one direction.

Fungi

- Group of thallophytes lacking in chlorophyll with variety of shapes and sizes
- Lead heterotrophic life either as parasites or saprophytes
- Carbohydrate food is stored in form of glycogen
- They could be unicellular as in yeast or multicellular
- Plant body in the multicellular forms is made of interwoven mass of hyphae collectively called mycellum
- Wall of hyphae are made up of chitin or pure cellulose

Reproduction

(a) (i) Fragmentation of body into parts

(ii) Detachment of a part of the body

(iii) Sclerotium a compact, head and rounded mass of hyphae

(b) Asexual by many types of spores

(i) Zoospores

(ii) Ordinary spores i.e. gonidia borne in sporangia

(iii) Conidia which are formed singly or in chains by special hyphae or condiophores

(iv) Oidia short segments of vegetative hyphae

(vi) Ascospores form in sacs or Asci in numbers of 8 per sac

Basidio spores born in number of 4 in club like Basidium

(c) Sexual reproduction takes place in these phases, which are:

i. Plasmogamy (fusion of protoplasm)

ii. Karyogamy (fusion of nuclei)

iii. With gametes and gametangia which may be isogamous, anisogamous or oogamous

Group of fungi:

Myxomycetes, Phycomycetes, Ascomycetes, Baidiomycetes, Deuteromycetes

Myxomycetes	-	Slime fungi
Phycomycetes	-	Algalike fungi
Ascomycetes	-	Sac fungi
Basidiomycetes	-	Club fungi
Deuteromycetes	-	Imperfect fungi

(Diagram)

(Fig, 7, Fig. 8, Fig. 9 and Fig. 10)

Bryophytes (Byrophyta)

The Byrophytes comprise land inhabiting autothrophic plants which prefer moist and shady places. Vascular tissue is absent. True roots are absent. They have root-like structures called the Rhizoids which help in anchorage and absorption of water and nutrients from the soil. Bryophytes show an advance over most algae by the development of archegonia, multicellular antheridia and a distinct alternation of generation. The sporophyte is dependent on the gametophyte in the Bryophyets. The gametophytic plant body is either thaloid (flattened) as in the mosses. The gametophyte predominates in the Bryophyta.

THE PTERIDOPHYTES

The pteridophytes are seedless vascular plants. They differ from the bryophytes in three key respects.

i. The sporophytes does not remain attached to (a much reduced) gametophyte
ii. It has true vascular tissues
iii. It is larger, long lived phase of the life cycle

Most pteridophytes live in wet humid places, and their gametophyes lack vascular tissues. Good examples are the lycopodium, sellaginella, Fern (Dryopteris).

ANGIOSPERM MORPHOLOGY

Angiosperms are flowering and seed-bearing plants. They are higher plants with well developed root and vascular tissues. Angiosperms are the most successful and most abundant group of plants. They provide most of man's food and raw materials. Over 250,00 species have been reported.

Factors responsible for the success of Angiosperms

(a) Variability in structure
(b) Genetic flexibility
(c) Efficient pollination and fertilization mechanisms

(d) Production of large number of seeds

(e) Fast rate of growth

(f) Short life cycle

(g) Self fertility/bisexuality etc.

The angiosperms dominate the vegetation of West Africa and they are grouped into two classes namely monotocyledons and dicotyledons (*Note: The differences between monocotyledons and dicotyledons).

There is great variation among plants and they are grouped or classified based on the similarities and differences that exist among them. This process of grouping plants is known as classification. To classify plants, it is essential to have good knowledge of the variation in the features of the plants, hence the need to study plant morphology.

The word Morphology was derived from two Latin words Morphe = forme and Logos = study. Plant morphology deals with the study of forms and features of different plant organs such as roots, stems, leaves, flowers, fruits and seeds.

(Diagram)

An angiospermic plant has the root and shoot systems. The root systems is positioned below the ground level and its primary functions are fixation/anchorage of the plant to the soil and absorption of water and mineral salts from the soil into the plant.

The shoot system is the part of the plant found above the ground level. This comprises the stem, leaves, flowers, fruits and seeds. These plant organs are grouped into vegetative and reproductive parts. Vegetative parts are the plant organs that are concerned with the nutrition and growth of the plant i.e. the root system and parts of the shoot system such as the stem and leaves. The stem and leaves perform three major functions which are support, conduction and food manufacture. Reproductive shoot comprises the flower, which is concerned with the reproduction of the plants.

CLASSIFICATION AND NOMENCLATURE OF PLANTS

All plants belong to the plant kingdom. Plants are further put in smaller hierarchical taxonomic groups that reflect their phenotypic and genotypic closeness. The taxonomic groups under the plant kingdom are:

Plant kingdom

Sub-kingdom

Division	Sub-division
Class	sub-class
Order	sub-order
Tribe	sub-tribe
Family	
Genus	
Species	

*Note: Try to classify some common plants

From the kingdom to species, the number of organisms in the groups decreases, and the organisms become more similar. The species is the smallest unit of classification. It is the group of organisms sharing similar characteristics and are capable of interbreeding to produce viable offspring.

Every plant is known by two Latinized names. The system of giving two names to plants is known as the Binomial system of nomenclature.

The first of the two names is the generic name, while the second name is the specific name. The first letter of the generic name is written in capital letter, while the specific name is written in small letters all through.

The two names should be underlined separately or italicized when in prints.

Plants are also known by their common and vernacular names which may vary in different localities, cultures and tribes.

For example:

Botanical name	English	Yoruba	Hausa
Dioscorea alata	White yam	Isu ewura	Doya
Garcinea cola	Bitter colar	Orogbo	Mijigoro
Cola nitida	Kola	Obi gbanja	Goro
Aspilia africana	Marigold	Yunyun	Kausa
Zea mays	Maize	Agbado	Masara

Classification of cowpea

Kingdom	-	plant kingdom
Division	-	spermatophyte
Class	-	Angiosperm
Order	-	Rosales
Family	-	Leguminosae
Genus	-	*Vigna*
Species	-	*unguiculata*

The name of the plant is written as *Vigna unguiculata*

DESCRIPTION OF PLANTS

Plants can be described or classified based on criteria such as size, habit, habitat, life span, behavior etc.

Description based on size

Plants can be described as tree, shrub or herb based on their size.

Trees are plants with single hard or woody trunk that carry branches well above the ground e.g. *Mangifera indica, Khaya senegalensis, Delonix regia, Terminalia catapa* etc.

(Diagram Fig. 12:)

Shrubs are plants or small trees with two or more wordy trunks that developed fron a single rootstock e.g. *Hibiscus sp, Ixora sp, Acalypha* sp, etc.

Herbs are small plants with soft, fleshy stem e.g. *Talinum triangulae, Ageratum conyzoides, Lactuca sativa* etc.

Description based on duration of life

Based on life span, plants can be described as annuals, biennials and perennials.

Annuals are plants that complete their life cycle in one season i.e. one year e.g. *Oryza sativa, Zea mays*,

Biennials are plants that complete their life cycle in two seasons i.e. two years e.g. *Allium cepa, Manihot esculenta*

Perennials are plants that live for more than two years e.g. *Triplochton scleroxylum, Milesia excels, Hildergadia barterii* etc.

Description based on habitat

Plants are also described based on their habitats. Many plants have also developed features that adapt them to their specific habitats.

Mesophytes or land plants are plants growing in regions with average temperatures and moisture e.g. *Tithonia diversifolia, Euphorbia heretophylla* etc.

Xerophytes are plants growing in the desert or dry places e.g. *Cactus sp., Euphorbia sp. Aloe sp., Agara sp.*

Hygrophytes are plants growing in moist and shady places e.g. Ferns, some grasses.

Hydrophytes are plants growing in aquatic places e.g. water lettuce (*Pistia*), water hyacinth

Eichhornia sp, water lily;

Halophytes are plants growing in saline soil or water e.g. *Rhizophora sp., Kandelia sp*., Mangrove plants etc.

Description based on nature of stem

Plants can be described as erect or scandent based on the nature of their stems.

Erect plants are those with strong stem that can stand on their own without any support.

Scandent plants are those having weak, long stem with diffuse which can not carry the plant upright.

Scandent plants are called climbers if they attach themselves to other plants or objects by some means. Examples are rootlet climbers e.g. *Piper guinense*, hook climber e.g. *Bougainvillea*, tendril climber e.g. *Gloriosa superb, Passiflora edulis* and stem climbers or twinnes e.g. *Dioscorea sp., Vigna p*.

Lianes or lianas are very thick and woody perennial climbers usually found in the forest. They climb round their supports e.g. *Alafia barteri, Entad gigas*. Other scandent plants are scramblers and stranglers. Scramblers do not attach to their support but simply lean against nearby plants and spread over them e.g. *Combretum sp* while stranglers start their life from seed which grow on the host or near the host. They produce shoot and roots systems which grow round the host and may later kill host by strangulation e.g. *Ficus sp*.

Description based on behavior of plants

Under this, we have the following plant types

Plant parasites these are plants living on other living plants. They could be total parasite e.g. *Cuscuta* or partial parasites e.g. *Mistletoe*.

Epiphytes these are plants that grow on other plants but they produce their food by themselves. They only attach themselves to the external part of the host e.g. Orchids.

Saprophytes these are plants that grow on dead or decaying organic matter e.g. *Monotropa*.

Carnivorous plants capture insects and feed on them e.g. Bladder wort, Vensu fly-trap, Butter wort, Pitcher plant etc.

Symbionts are two organisms living together as if they are part of the same plant, and the two organisms benefit from the relationship. The relationship is called symbiosis e.g. Lichen which is the association of fungi and blue-green algae which is seen as green patches on tree trunks and old walls.

THE ROOT SYSTEM

The root is the organ of the plant found in the ground that develops from the embryonic radicle.

Regions of the Root

A typical root is made up of three regions that contain cells that are engaged in different cellular activities and the root cap.

The three regions are for cell divisions, cell elongation and cell maturation.

The root cap protects the root apex as it penetrates the soil. The cells of the root cap is regenerated as it is been worn off in the process of soil penetration.

Region of cell division

This is the apex of the root containing meristematic cells that undergo repeated divisions. Cells produced in this region are directed downwards towards the root cap and upwards towards the region of cell elongation.

Region of cell Elongation

The cells in this region undergo rapid elongation and enlargement and are responsible for the growth in length of the root.

Region of cell maturation

Cells in this region undergo maturation and differentiation into various kinds of tissues. Root hairs are produced in this region for absorption of water and mineral salts from the soil.

Functions of the root:

Absorbtion of water and mineral salts from the soil

Anchorage of the plant to the soil

Conduction of the absorbed water upwards to the stem

Storage of food in some plant species

(Diagram)

Types of Root

There are two main forms of root, namely the Tap root system and Fibrous root system. In the tap root system, there is a main or primary root or tap root from which smaller branch roots or lateral roots or secondary roots develop. They secondary roots can also produce smaller branch roots called rootlets or tertiary roots. This type of root system is found in the dicotyledonous plants e.g. *Amaranthus sp, Chocorus sp*.

(Fig. 13: Diagram of roots)

Fibrous roots system has no main root, rather there are small roots of approximate equal size that develop at the base of the stem. This type is typical of the monocotyledonous plants e.g. grasses, onion, sugarcane, maize, bamboo etc.

Roots that grow from any part of the plant body other than the radicle are generally called Adventitious roots. They are of various kinds and they perform normal and specialized functions.

ROOT MODIFICATIONS

Apart from the generalized functions of the root, there are plants that possess specially modified roots that perform special functions. Such special functions include storage, perennation, additional support, respiration, climbing, photosynthesis, parasitism, mycorrhizal association, Rhizobium/root association etc.

Roots modified for storage of food

The storage roots are described by their shape

(1) Napiform root The root is swollen in the upper part and almost becoming spherical and sharply tapering at the lower part e.g. sugar beet

(2) Fusiform foot The root is swollen in the middle portion and gradually tapering towards the base and the apex, giving it a spindle shape e.g. Raddish.

(Fig. 14: Diagram)

(3) Conical root The root is swollen at the upper part and gradually tapers towards the base to give a cone shape e.g. carrot.

(4) Tuberous or Tubercular roots These are swollen roots without definite shape e.g. *Mirabilis, Ipomoea batata*. The roots occur singly and not in clusters.

(5) Fasciculated roots The swollen roots occur in cluster or fascicle at the base of the stem e.g. *Asparagus, Dahlia*.

(6) Nodulose roots These are slender roots that suddenly swell at the tip e.g. *Maranta, Calathea, Curcuma amada*.

(Fig. 15: Diagram)

(7) Moliniform or Beaded root These are roots with swellings that occur at frequent intervals e.g. *Momordica, Portulaca*, some grasses.

(8) Annulated root This is when the root has a series of ring-like swellings on its body e.g. Psychotria.

Roots Modified for Respiration

Respiratory roots Plants growing in swampy or aquatic areas develop respiratory roots called Pneumatophores for the purpose of respiration. Such roots develop from the submerged or underground roots of the plants and rise vertically upwards above the water level to take in air for respiration through the pores that occur on them e.g. *Rhizophora, Heritiera*. Some aquatic plants produce floating branches that produce soft and spongy adventitious root above the water level that serve to store air e.g. *Jussiaea.*

(Fig. 16: Diagram)

Roots modified for Mechanical or Additional Support

Roots modified for additional support fall under different categories. They are (i) Prop roots (ii) Stilt roots (iii) buttress roots (iv) Climbing roots and (v) Epiphytic roots.

(1) Prop roots these are adventitious roots that develop from the lower nodes of the stem of erect monocotyledonous plants such as maize (*Zea mays*), sugarcane (*Saccharum officinarum*), Bamboo (*Bambusa vulgaris*), guinea corn (*Sorghum bicolor*) etc.

(2) Stilt roots These are roots that develop from the main stem or the branches of trees, especially trees growing in swampy or aquatic areas. The roots grow vertically or obliquely downwards and penetrate into the soil to act as pillars supporting the main stem and the branches e.g. *Musanga cercropiodes*, red mangrove (*Rhizopora mangle*), *Ficus bengalensis, Pandanus adoratissimus.*

(Fig. 17: Diagram)

Buttress roots These are huge outward extension at the base of tall forest trees that provide support to the huge trunks against wind current. A portion of the stem may be involved in the formation of the buttress roots e.g. *Ceiba pentadra, Adansonia digitata, Bombax buenoposense, Terminalia catapa* etc.

Climbing roots These are sticky roots developed at the nodes and sometimes at the internodes of climbing plants which attach them to their support, which could be another tree trunk or a wall. e.g. *Piper longum, Piper nigrum, Ficus* sp.

Epiphytic roots These are aerial roots produced by the epiphytes which hang freely in the air. The hanging roots are surrounded by spongy tissues called velamen, which are used to absorb moisture from the atmosphere. Examples are found in orchids like *Vanda* and some *Ficus* species.

Roots modified for photosynthesis (Assimilatory roots)

The aerial roots in some epiphytic plants are modified for photosynthesis. Such roots bear prominent stomata and/or lenticels for gaseous exchange. They possess velamen made up of green chlorophyllous tissues e.g. Vanda sp., Tinospora sp. The submerged green roots of water chestnut (Trapa natans) also perform carbon assimilation.

Roots modified for Parasitism

Such roots are also referred to as sucking roots or parasitic roots or Haustoria. These are roots developed by parasitic plants which penetrate into the tissue of the host plant and suck it e.g. *Cuscuta hispidium*, *Mistletoe (Viscum sp.), Loranthus, Orobanche, Striga hermonthica* etc.

Roots modified for Rhizobium/Root Association

(Root with nodules)

Leguminous plants in the families Papillionaceae and Minosaceae usually possess roots with nodules. The nodules are gall-like swelling on the roots caused by bacteria of the genus Rhizobium. The bacteria fix atmospheric nitrogen and make it available for plant absorption in the form of nitrate. In return, the plant root provides habitat and carbohydrate supply for the bacteria. These could be fond in plants like *Crotolaria retusa, Arachis hypogea, Gliricidia sepium, Vigna unguiculata* etc.

(Fig. 18: Diagram)

Roots modified for Mycorrhizal Association

Roots of some tropical shrubs and trees form symbiotic relationship with fungi. Such roots are termed mycorrhizal roots. There are two types of mycorrhizal association which depend on the nature of interaction between the plant root and their fungal partners. The two partners benefit from the association. While the fungi provide nutrients for the plant, the plant roots provide shelter and carbohydrate for the fungi. The two types of mycorrhizal association are (i) Endomycorrhiza and (ii) Ectomycorrhiza.

In endomycorrhiza, the fungi grow intraradically within the root, but may also grow extraradically e.g. Cassava (*Manihot esculenta*), maize (*Zea mays*), Cassia sp., *Citrus* sp. Etc.

In ectomycorrhiza, the fungi grow extensively extraradically forming a fungal mantle which may completely replace the root cap e.g. *Eucalptus, Anacardium occidentalis* (cashew tree).

THE STEM

The stem is the ascending portion of the axis of the plant, developing directly from the plumule and bears the leaves, branches and flowers. On the stem are nodes and internodes. Leaves and branches develop from the nodes. Stems are usually terminated by either vegetative or floral bud. When the stem or branch ends in a vegetative bud, it continues to grow upwards or sideways. Growth of stem ceases when it is terminated by a floral bud. Buds occurring in the axil of leaves are termed axillary buds.

(Fig. 19: Diagram)

Functions of Stem

- The stem bear the leaves and flowers and spread them out on all sides for proper functioning e.g. light reception and pollinator attraction
- Stem conducts water and mineral salts from the root to the leaves
- Conduction of prepared food from the leaves to other parts of the plant
- Storage of water and food in some species
- Young green stems perform photosynthesis to complement the leaves
- Stem is used for vegetative propagation in some plant species
- Some stems, especially the underground stems are useful for perennation

Types of Stem

Stem could be either aerial or underground. Aerial stems are those existing above the ground, while underground stems remain under the ground, producing aerial shoots when the conditions are favourable. Underground stems are useful for food storage and perennation. The various kinds of stem can be summarized in the following chart:

(Diagram – chart)

Erect/strong stems are stems that are capable of holding themselves in an upright position. Weak stems on the other hand are not capable of holding themselves upright. They either trail or creep on the ground or climb neighbouring plants and other objects.

Types of Erect stem

(1) Bols These are smooth erect wordy stems which branch at the top i.e. the branhes are carried well above the ground. It is found in most tall trees as *Milesia excels, Delonix regia* etc.

(2) Candes is an unbranched, erect, cylindrical and stout stem, marked with scars of fallen leaves. This stem is common in the palms e.g. *Elaeis guinensis, Cocos nucifera, Phoenix sp*. etc.

(Fig. 20: Diagram)

(3) Culms are jointed stems with solid nodes and hollow internodes. This can be found in the bamboos e.g. *Bambusa vulgaris*.

(4) Scape is an underground stem which produces an erect unbranched aerial shoot bearing either a single or a cluster of flowers, such flowering shoot is called scape. Examples can be found in onion (*Allium cepa*), garlic (*Allium sativum*)etc.

(5) Pseudostem is a stem formed by the joining together of the leaf bases of several leaves of theplant e.g. Banana and plantains (Musa sp.), *Ensete gilleti* etc.

Weak stems

Plants with weak stems could be either trailers, creepers, climbers, twinners, lianas, stranglers or scramblers.

(1) Trailers these are plants with thin and long or short branches that trail on the ground without rooting at the nodes. They could be procumbent or prostrate (when the stem lies flat or run parallel to the ground) e.g. *Indigofera sp., Oxalis sp*. etc. or Decumbent (when the tip of the stem is raised) as in *Tridax procumbens* or Diffuse (when the stem branches spread out in all directions) as in *Boerhaavia sp*.

(Diagram)

(2) Creepers are plants with long or short branches that creep on the ground and rooting at the nodes. Creeping stems could be runners, stolons or offsets. Each of the rooted node with shoot can become independent plants if the linking stems (internodes) are cut. Creeping plants could be runners, stolons or offsets.

(3) Runners are creeping stems with long and slender stems that run parallel to the ground surface e.g. *Cucurbita sp., Lagenaria sp., Telfaria occidentalis* etc.

(4) Stolons are creepers with the portion of the stem between two adjacent nodes raised from the ground surface i.e. the internode does not lie flat on the ground e.g. *Fragaria indica*, wild strawberry etc.

(Fig. 21: diagram)

Offsets are similar to runners, but the internodes in offset are shorter and stouter than those in runners e.g. water lettuce (*Pistia sp*.,) water hyacinth (*Eichhornia sp*.).

Climbers are plants that attach themselves to any neighouring plant or object, often by means of some special devices and climb the support to a long or short distance. Different kinds of climber are known, depending on their devices or means of climbing. Examples are:

(1) Hook climbers e.g. *Bougainvillea sp*., Rose (*Rosa sp*)

(2) Stem tendril climbers e.g. *Passiflora edulis, Telfaris occidentalis*

(3) Leaf tendril climbers e.g. *Gloriosa superb*

Root climbers e.g. *Piper betle, Piper guinensis* etc.

(4) Twinners/stem climbers are herbaceous plants with weak stems that climb other plants or objects without any device or means of climbing. They twine round their supports, e.g. Yams (*Dioscorea* sp) *Ipomoea*.

(5) Lianes/Lianas are perennial plants with woody climbing stems e.g. *Entada gigas, Alafia barteri*

(Fig. 22: Diagram)

Other forms of plants with weak stems are scramblers and stranglers.

Scrambling plants do not attach themselves to their supports, but they simply lean against nearby plants or any other support and spread over them e.g. *Combretum sp*.

Strangling plants usually start their life from seeds which grow on the host or near the host. They produce short and root systems which grow round the host or support and may later kill the host or support by strangulation e.g. *Ficus sp.*
(Fig. 23: diagram)

Underground stems

These are modified stems which are developed underground for the purpose of storage, propagation and perennation. They are usually dormant during unfavourable season but give off aerial shoots annually under favourable conditions. They are always thick and fleshy, having deposit of reverse food materials in them.

Types of underground stem

(1) Rhizome is a prostrate, thickened stem, creeping horizontally under the surface of the soil. It has distinct nodes and internodes. Roots and scaly leaves are produced as their nodes. Rhizomes bear terminal and axillary buds which give rise to new aerial shoots during favourable periods.

(Fig. 24: Diagram)

Some rhizomes may be swollen with stored food substance as in the aligator pepper (*Aframomum canna*), ginger (*Zingiber officinarum*) or slender as in grasses such as the spear grass (*Imperata cylindrical*).

(2) Tubers are swollen ends of special underground branches or stems which bear adventitious roots. They have on their surface a number of “eyes” or buds which grow up into new plants. Tubers are often very much swollen, becoming almost spherical and they usually occur singly. Examples of tubers are sweet potato (*Ipomoea batata*), yams (*Dioscoroea* sp.), Irish potato (*Solanum tuberosum*), Tiger nut (*Cyperus esculentum*) etc.

(fig. 25: diagram)

(3) Bulb is an underground modified shoot consisting of a shortened stem with a single, often large terminal bud and numerous scale leaves. The scale leaves grow from the upper surface of the stem or around it while a cluster of fibrous roots grow from the base of the stem. The fleshy scale leaves store food while the dry outer scale leaves give protection. The bulb grows in vertical direction.

(Fig. 26: diagram)

The terminal bud gives rise to the aerial shoot. Some axillary buds may also be produced in the axils of the fleshy scale leaves. These may develop into aerial shoots and finally form daughter bulbs. Examples are the common onion (*Allium cepa*), garlic (*Allium sativum*).

(4) Corm is a condensed form of rhizome consisting of a stout, solid, fleshy underground stem growing in the vertical direction. The corm bears buds in the axils of the scale leaves and some of these bud give rise to daughter corms. Adventitious roots develop from the base and sometimes also from the sides e.g. cocoyam (*Xanthosoma sagittifolia*), taro (*Colocasia esculentum*).

(Fig. 27: diagram)

(5) Sucker is a lateral branch developing from the underground part of the stem node. It grown horizontally outwards under the ground and later upwards and directly gives rise to a leafy shoot or a new plant. The sucker may be short and stout as in banana (*Musa sp*.), pineapple (*Ananas sp*.,) bamboo (*Bambusa vulgaris*) etc.

Further modifications of stem for special functions

The stem or the vegetative and floral buds or other appendages on the stem can be modified to perform specialized functions e.g. stem and floral tendrils for climbing, thorns, hooks and prickles for protection, phylloclade for food manufacture (photosynthesis) and bulbs for vegetative propagation.

(1) Stem tendril is a thin, wiry, leafless, spirally-curled branch usually developing on the stem at the leaf axils, by which climbing plants attach themselves to neighbouring plants or objects and climb them e.g. Passion plant (*Passiflora edulis*), 'Ugwu' (*Telfaria occidentalis*).

(2) Floral tendril is similar to stem tendril in structure, but it has its own origin from the floral bud, usually occurring as an extension of the inflorescence axis e.g. *Corculum sp*.

(fig. 28: diagram)

(3) Thorn is a hard, often straight and pointed structure. It arises endogeneously at the axil of a leaf or at the apex of a branch which is normal position of a bud. Thorns sometimes bear leaves, flowers and fruits e.g. *Citrus sp., Duranta sp*.

(Fig. 29: Diagram)

Thorns are however different from (4) prickles and (5) hooks which are superficial (exogeneous) and occurring as irregular outgrowths on the surface of stem or leaves and never bear leaves, flowers or fruits e.g. *Bougainvillea sp., Hura crepitans.*

(6) Phylloclade is a green flattened or cylindrical stem or branch of unlimited growth, consisting of a succession of nodes and internodes at long or short intervals. It is common in xeromorphic plants growing in the dry regions such as sahel savanna and deserts. The leaves in such plants are usually not well developed or all off early or are modified into spines as a strategy to reduce evaporating surface. The phylloclade therefore performs the duties of the leaves, particularly photosynthesis. The strong cuticle of the stem prevents evaporation and the roots are often scanty.

(Fig. 20: diagram)

They also store water for the plant e.g. Cactus plants (*Opuntia sp*.), Christmas cactus (*Epiphyllum truncatum*) and members of the family Euphorbiaceae e.g. (*Euphorbia cameroonica*).

(7) Cladoles are short, green cylindrical or flattened profusely branching stems with branches of unlimited growth developing from the nodes of the stem in the axils of the scale leaves. The branches have distinct nodes from which they produce further branches of limited growth which are often mistaken for leaves. Leaves in the cladoles are usually reduced to spines e.g. *Casuarina equisetifolia, Asparagus racemosus*.

(Fig. 31: diagram)

(8) Bulbis are special vegetative organs, bulb-like in structure and is essentially meant for the vegetative reproduction of the plant. It may be a modified vegetative or floral bud. At maturity, it detaches itself from the mother plant and grows up into a new independent plant e.g. *Dioscorea bulbifera, Globba bulbifera* etc.

(Fig. 32: diagram)

Shape of stem

The shape of the stem can be clearly seen when the transverse section is made. The following shapes are commonly encountered in different plant species.

Cylindrical or circular stem e.g. *Elaeis guinensis, Cocos nucifera*

Square stem This is common in the Labitae specie e.g. *Coleus sp.*

Triangular stem e.g. *Pinnata*

Polygonal stem Common in species of the family Polygonaceae

Terete these are stems that are spherical in shape

SHAPES OF STEM

(diagrams)

Aplanate stems are stems that are compressed in the middle

Fluted or fissured stem these are stems with vertical grooves e.g. *Chrysophyllum albidum* (star apple)

Stem branching:

This is the mode of arrangement of the branches on the stem. There are two basic types

(1) Lateral branching

(2) Dichotomous branching

Lateral branching This is when the branches are produced laterally i.e. from the sides of the main stem. The lateral branching may be racemose or cymose.

Racemose type The growth of the main stem of the plant is indefinite while producing branches laterally in acropetal succession i.e. the lower branches are older and longer than the upper ones. This type of branching is also termed Monopodial because there is a single continuous or indefinite axis e.g. *Casuarina, Pinus*. This type of branching gives a conical or pyramidal shape to the plant.

(Fig. 34: diagram)

Cymose type In cymose lateral branching the growth of the main stem is definite i.e. terminated after a while and lateral branches are produced below the terminal bud. This process may be repeated over and over again.

Cymose branching can be of the following kinds:

(a) Uniparous cymose branching Here, only one lateral branch is produced at a time. It is also called Monochasial branching. Uniparous cymose branching could be helicoidal i.e. one-sided cyme, when successive lateral branches develop on the same sides as in *Sterculia sp, Terminalia catapa*.

(Fig. 35: diagram)

It could also be Scorpioid i.e. alternate-sided cyme, when the successive lateral branches develop on alternative sides of forming a zigzag patter in Vitis.

(b) Biparous Cymose branching: In this, two lateral branches develop at a time below the terminal bud. It is also called Dichasial branching. It is found in plants like Mistletoe, *Plumerias sp., Mirabilis sp*. etc.

(Fig. 36: diagram)

(c) Multiparous cymose branching More than two lateral branhes develop at a time below the terminal bud. It is also called Polychasial branching. It is common in *Croton sp., Sparsiflorus sp*., some *Euphorbia sp*. etc.

Dichotomous Branching

In dichotomous branching, the terminal bud bifurcates i.e. divide into two, producing two equal branches in a forked manner. There will be no scar at the point or space between the two branches. This shows that the branching is not due to the termination of the life of the terminal bud. This type of branching is common among the non-flowering plants such *Riccia sp., Lycopodium sp*. and in some flowering plants like Hyphaene (a type of palm), *Canscora sp* (a weed).

(Fig. 37: diagram)

THE LEAF

The leaf is the flattened, lateral outgrowth of the stem or the branch, developing exogeneously from a node and having a bud in its axil. It is normally green in colour, due to the presence of chlorophyll, and acts as the photosynthetic organ of the plant. Some leaves may be coloured yellow or red due to the presence of other pigments apart from chlorophyll.

Functions of leaves

The primary functions of the leaves are

(a) Manufacture of food through photosynthesis

(b) Transpiration to get rid of excess water in the plant

(c) Gaseous exchange between plant and the atmosphere

Some leaves are modified or equipped to perform some secondary functions such as

(a) Storage of food and water either for perennation or adaptation to survive dry season e.g. Cactus sp.

(b) Vegetative propagation due to the presence of vegetative buds on the leaves e.g. *Bryophyllum sp., Begonia sp* etc.

Parts of a leaf

A typical leaf consists of the leaf base, stipules, petiole and the lamina or leaf blade.

(Fig. 38: diagram)

The leaf Base is the part of the leaf that is attached to the stem. In monocotyledons, the leaf base commonly expands to form leaf sheath which partially or wholly clasps the stem. In many dicotyledons, the leaf base bears two lateral leaf-like outgrowths known as the stipules. In some families such as the Leguminosae, the leaf base is swollen to form the Pulvinus.

(Fig. 39: diagram)

Stipules are different from stipels which are also leaf-like outgrowths but are developed at the bases of the leaflets of compound leaves.

Petiole is the stalk of the leaf that connects the leaf blade with stem. It contains a vascular system which is continuous with the vascular system of the stem. Leaves possessing petiole are said to be petiolate or stalked while those without petiole are termed sessile or expetiolate or petiolate. Petioles can be of various shapes such as cylindrical e.g. *Chocorus sp., Amaranthus* sp., channeled or grooved e.g. Banana (Musa sp.), Cocoyam, palms, bulbous, swollen or inflated e.g. water hyacinth (*eichhornia sp*.), winged or flattened as in Citrus sp.

(Fig. 40: diagram)

Stipules are the lateral appendages of the leaf borne at the leaf base. Their function is to protect the young leaves in the bud, and when green, they carry out photosynthesis. Leaves possession stipules are said to be stipulate, while those without stipules are called exstipulate. Stipules occur in many dicotyledonous families, but are absent or very rare in the monocotyledons.

Types of stipules

Stipules are described based on their shape, size, position and colour. The following type are identified:

(1) Free lateral stipules these are two free stipules, usually small and green in colour, borne on the two sides of the leaf base e.g. cotton, sida sp.

(2) Sally stipules are very small dry scales, usually two in number, borne on the two sides of the leaf base e.g. *Desmodium sp*.

(3) Folliaceous stipule are two large, green leafy structures that are developed at the leaf base e.g. *Passiflora sp., Aristolochia sp., Cassia auriculata* etc.

(4) Adnate stipules are two lateral leaf-like outgrowths that develop along the petiole up to a certain height, adhering to the petiole and making it look winged in appearance e.g. Rose (Rosa sp.), groundnut (*Arachis hypogea*l), strawberry etc.

(5) Interpetiolar stipules are two stipules that lie between the two petioles of opposite leaves, or alternating with the petioles of whorled leaves e.g. *Ixora*.

(Fig. 41: diagram)

(6) Orhreate stipules grow around the stem like a hollow tube from the node up to a certain height of the internode in front of the petiole e.g. Polygonum

(7) Bud scales these are scaly stipules which enclose and protect the vegetative buds and fall off as soon as the leaves unfold e.g. *Ficus sp., Mussanga sp.*

(8) Spinous stipules are modified into two sharp pointed structures known as spines, one on each side of the leaf base. They protect the leaf against grazing by herbivorous animals e.g. Mimosa sp., Acacia sp.

Leaf Blade or lamina

This is the green, expanded portion of the leaf. It has a strong major vein known as the mid-rib which runs centrally through the leaf blade from its base to the apex. The mid-rib produces thinner lateral veins which in their turn give rise to still thinner veins or veinlets. The edge of the lamina is known as the leaf margin and the tip is called the leaf apex. The major function of the lamina is photosynthesis.

Leaf Apex is the tip of the leaf blade and it could be of various shapes. The various types are described below:

(1) Obtuse or round apex is blunt or rounded e.g. *Terminalis catapa, Talinum triangulae* etc.

(2) Acute Apex: the tip of the leaf is pointed and sharp in the form of an acute angle eg. *Sida acuta*

(3) Acuminate apex: the leaf tip tapers to a long slender structure, which may be either acute or blunt, e.g. *Ficus religiosa*.

(4) Cuspidate apex: the apex ends in a long rigid sharp point. It is similar to acuminate, but there is no abrupt constriction before tapering to a long slender structure e.g. Date palm, Pineapple.

(5) Truncate apex: the apex ends abruptly as if cut off in a straight line e.g. Indian sago palm (*Caryota urens*).

(6) Retuse apex: when the leaf apex is furnished with a shallowly notch i.e. The apex is shallowly depressed e.g. *Pistia* (water lettuce).

(Fig. 42: diagram)

(1) Emerginate apex: this is similar to retuse apex, but the notch or depression is deeper and more pronounced than in retuse e.g. *Bauhinia sp. Oxalis sp.*

(2) Mucronate apex is round but ends in a short point, looking as if the mid-rib is projected further above the apex e.g. *Ixora sp*.

(3) Apiculate apex: the rounded apex is topped by a short point that is smaller than the one in mucronate.

(4) Cirrhose apex: the leaf apex ends in a tendril-like structure or thread-like appendage e.g. Gloriosa superb, banana (*Musa sp*.)

(5) Aristate apex: the apex is drawn into a straight and sharp pointed structure.

(6) Caudate apex: the apex is shallowly depressed making the leaf to be hat-like.

Leaf Martins

The edge of the leaf blade could be of various pattern

(1) Entire margin is smooth and even e.g. cashew (*Amarcadium occidentalis*)

(2) Repand or Sinous margin – the leaf edge is shallowly wary or undulating e.g. Mango (*Mangifera indica*).

(3) Sinuate maring – the leaf margin is deeply undulating e.g. mast tree (Polyalthia), some garden crotons.

(4) Serrate margin – the leaf edge is cut like the teeth of a saw and the teeth are directed upwards towards the apex e.g. *Azadirachta indica*, rose (*Rosa* sp.)

(5) Serrulate margin when the serration is smaller than in serrate.

(6) Bisserrate margin the leaf edge is doubly serrated i.e. there is a further serration of the primary serrate.

(7) Dentage margin the teeth of the serration are directed outwards at right angles to the mid-rib of the leaf e.g. melon, water lily. The teeth may be round or pointed.

(8) Denticulate margin the teeth are directed towards at right angles to the mid-rib of the leaf as in dentate, but the teeth are smaller than those of the dentate.

(9) Runcinate margin is a serrated margin with the teeth directed downwards towards the leaf base.

(10) Crenate margin the teeth are round and directed upwards i.e. the ascending notches are round as in *Bryophyllum sp., Coleus sp*.

(11) Crenulate margin similar to crenate but the notches are smaller and more frequent than in crenate.

(12) Fimbriate margin the margin is fringed with fine segments.

(Fig. 43: diagram)

(13) Ciliate margin: the margin is fringed with hairs

(14) Spinous margin: the teeth are provided with spines

(15) Lobed margin is when the indentation or nothing of the leaf blade has gone moer than half way into the leaf blade towards the mid-rib. The lobes may be pointed or round.

(16) Parted margin: the indentation is deeper than in lobes margin, reaching or nearly reaching the mid-rib. This may lead to the evolution of compound leaves.

Leaf blade bases:

The base of the leaf blade could be of different shapes

(1) Acute base is when the leaf blade base ends sharply

(2) Altenuate base is when the leaf blade extends towards the petiole

(3) Obtuse base is when the leaf blade ends up roundly at the base

(4) Truncate base: the leaf blade base is drawn into a straight line e.g. Banana (Musa sp)

(5) Oblique or Irregular base is when the two sides of the leaf blade base do not end at the same point. It may be pointed or round.

(Fig. 44: diagram)

(1) Hastate base the lower part of the leaf draws outwards before ending at the leaf base

(2) Sagittate base the leaf blade is drawn in at the base e.g. cocoyam (*Xanthosoma sagitifolia*)

(3) Cordate base the leaf blade is drawn in at the base but not as pronounced as in sagitate, giving the leaf a hat-like shape.

Sessile Leaves

These are leaves without petiole. They are also referred to as epetiolate or expetiolate. In sessile leaves, the leaf blade is directly attached to the stem or branch.

Types of sessile leaves

(1) Auriculate: the lobes at the leaf base partially enclose the stem e.g. *Calotropis procera*, basal leaves of Emilia sp., *Sonchus oleraceus*

(2) Amplexiaul the lobing of the leaf blade base completely enclose the stem. The lobes are not fused or attached e.g. wheat, grass, cauline leaves of Emilia sp.

(Fig. 45: diagram)

(1) Semi-amplexicaul: the lobing of the leaf blade base incompletely enclose the stem

(2) Perfoliate: the lobes at the leaf blade base meet across the stem and fuse together, so that the stem seem to pass through the leaf blade e.g. *Aloe perfoliata, Canscora perfoliata.*

(3) Connate: when two sessile opposite leaves meet each other across the stem and fuse together e.g. *Lonicera flava, Canscora diffusa*

(4) Decurrent: the petiole and the leaf base become winged, and the wing extends down the stem, so that the stem also seems to be winged e.g. *Crotalaria alata, Laggera alata, Conscora decurrens* etc.

Shape of Leaf:

Shape of leaf vary from plant to plant. There are plants with different type of leaves in different parts of the plants i.e. leaves at the lower part may be different from those at the upper part of the same plant. Such plants are said to be heterophyllous. Different shapes of leaf are described below.

(1) Acicular leaf: The leaf is long, narrow and cylindrical i.e. the leaf is needle-like e.g. *Pinus*, onion (*Allium cepa*).

(2) Linear leaf: the leaf is long, narrow and flat. All the main veins run parallel to one another e.g. grasses such as *Imperata cylindrical, Zea mays, Panicum maximum.*

(3) Filiform leaf: The leaf is an extreme form of linear leaf. The leaf is very long, narrow and thin.

(4) Subulate leaf: The leaf is linear, but the blade tapers from the base to the apex.

(5) Lanceolate leaf: the leaf is lance-shaped, the broadest part of the leaf is about 1/3 of the leaf length to the base and the blade tapers towards the apex e.g. *Bambusa vulgaris, Oleander (Nerium sp.), Polyalthia sp.* , *Mangifera indica, Lactuca capensis* etc.

(6) Oblaneolate leaf: is an inverted form of lanceolate leaf. The leaf blade has its widest portion towards the apex e.g. *Alternanthera sessilis*.

(7) Ovate leaf: the broadest part of the leaf-blade is below the middle point of the leaf and that margin curves symmetrically to produce an egg-shaped structure e.g. China rose, *Vigna unguiculata*.

(Fig. 46: Diagrams of leaf shapes)

(1) Obovate leaf: The leaf shape is like an inverted egg i.e. inverted form of ovate leaf e.g. *Talinum triangular, TErminalia catapa, Artocarpus sp*.

(2) Elliptic/oval leaf: The leaf margins are symmetrically curved with the broadest part at the mid-point of the leaf blade length e.g. Guava (*Psidium guajava*), Periwinkle (*Vinca sp*.), *Vernonia galamensis*

(3) Oblong leaf: The leaf blade is wide and long, longer than broad with the widest part at the middle point, but unlike elliptic, the two margin run parallel to each other e.g. Banana (Musa sp.), *Ensete gilleti.*

(4) Spathulate: The leaf blade is spoon-shaped i.e. like spatula. The leaf blade is broad and somewhat rounded at the top and narrower towards the base e.g. *Asteri sp., Calendula sp*.

(Fig. 47: Diagrams of leafs shape contd.)

(1) Rhombase leaf: the leaf blade is shaped like a geometric rhombus e.g. *Albizia zygia, Sida rhombifolia*.

(2) Deltoid or Triangular leaf: the leaf blade is triangularly shaped e.g. *Amaranthus sp., Ficus sp*.

(3) Orgiular/Rotund leaf: the leaf blade has rounded or circular outline e.g. *Trianthema portulacastrum*.

(4) Reniform leaf: the leaf blade is shaped like the kidney e.g. *Aristolochia sp*.

(5) Cordotate leaf: the leaf blade is heart-shaped e.g. *Sida venonicifolia, Peperomia pellucid, Piper betle.*

(6) Obcordate leaf: the leaf blade is inversely heart-shaped e.g. Oxalis sp.

(7) Hastate leaf: the leaf blade has the shape of an arrow-head, but the basal lobes are pointed or narrow, more or less at right angle to the base e.g. *Caladium sp., Ipomoea sp., Typhonium sp*.

(8) Sagitate leaf: the leaf blade is shaped like an arrow with the basal lobes blunt and are not at right angle to the base e.g. *Sagittaria, Xanthosoma sagittifolia* (cocoyam)

(9) Peltate leaf: this is when the leaf stalk (petiole) is attached to the leaf blade inside the lamina.

(10) Oblique leaf: the two halves of the leaf are unequal or irregularly or obliquely shaped e.g. *Azadirachta indica, Begonia sp*.

(11) Cuneate leaf: the leaf blade is wedge-shaped e.g. water lettuce (*Pistia)*.

(12) Falcate leaf: The leaf blade is sickle-shaped as in *Albizia sp., Encalyptus globules, Arundinaria falcate* (a kind of bamboo).

(13) Lyrate leaf: the leaf blade shape is like that of a lyre i.e. with a large terminal lobe and some smaller lateral lobes e.g. Mustard, radish etc.

(14) Pedate leaf: this is when the leaf blade is like the claw of a bird with the lobes spreading outwards e.g. *Vitis pedata*.

VENATION OF LEAF:

Veins are rigid linear structures which arise from the petiole and the mid-rib and traverse the leaf lamina in different directions. They are composed of vascular tissues and they perform mechanical and conduction functions. Venation is the arrangement of the veins and the veinlets on the leaf on the leaf blade. Venation should not be confused with vernation, which is the arrangement of leaves when in buds.

Types of Venation

There are two types of venation which are reticulared and parallel venations.

(1) Reticulate venation: the major vein gives rise to lateral branhes which further branch and rebranch to produce veinlets which may join together to form a network pattern. This type of venation is typical of the dicotyledons.

(Fig. 48: and Fig. 49 diagrams)

(2) Parallel venation: the main veins are many and run parallel to each other and they are approximately of equal size. This type is found in the monocotyledons.

Types of Reticulate Venation

(1) Pinnate reticulate venation: The mid-rib gives off lateral veins which proceed towards the margin or apex of the leaf. The lateral veins are then connected by smaller veins which pass in all directions, forming a network e.g. *Ficus sp*., Mango (*Mangifera indica*).

(Fig. 50 diagram)

(2) Palmate reticulate venation: there are a number of more or less equally strong veins which arise from the tip of the petiole and proceed outwards or upwards. There are two types

  (a) Palmate divergent: The main veins arise from the same base and diverge outwards towards the margin of the leaf e.g. pawpaw (*Carica papaya*), castor oil (*Ricinus communis*).

  (b) Palmate convergent: The veins converge to the apex of the leaf blade e.g. *dioscorea sp*.

Types of parallel venation

(1) Pinnate parallel venation: There is a prominent mid-rib which gives off lateral veins which run parallel to each other towards the margin or apex of the leaf blade e.g. Banana (Musa sp.), alligator pepper (*Aframomum melegueta*), ginger (*Zingiber officinarum*), *Canna indica*.

(2) Palmate parallel venation: The veins arises from the tip of the petiole and proceed outwards towards the margin or upwards towards the apex. There are two types:

(a) Palmate divergent: the veins arise from a point and diverge towards the margin of the leaf blade running parallel to each other e.g. fan palms.

(Fig. 51: diagram)

(b) Palmate convergent: the veins arise from the base of the leaf blade and proceed towards the apex, running parallel to each other e.g. Bamboo, rice (*Oryza sativa*).

INCISION OF THE LEAF BLADE

This refers to the pattern of cutting into the leaf blade. Depending on the venation pattern, there could be two types

(1) Pinnate incision type: in the pinnately-veined leaf, the incision or cutting of the leaf blade proceeds from the margin towards the mid-rib.

(2) Palmate incision type: in palmately-veined leaf, the cutting of the leaf blade proceeds from the margin towards the base of the leaf blade.

Incision of the pinnate series

(1) Pinnatifid: this is when the incision of the margin is half-way or nearly half-way down towards the mini-rib e.g. *Launea taraxacifolia*.

(2) Pinnatipartite: this is when the incision is more than half-way down towards the mid-rib e.g. Radish, mustard.

(Fig. 52: Incision of leafblade (Pinnate Series)

(3) Pinnatisect: the incision of the leaf blade is carried down to near the mid-rib i.e. the cutting has gone more than ¾ of the leaf blade towards the mid-rib e.g. Ferns.

Incisions in the Palmate series

(1) Palmatifid: the incision has not gone more than half way towards the leaf base or petiole e.g. *Passiflora edulis*, cotton (*Gossypium sp*.)

(2) Palmatipartite: the incision has gone more than half-way towards the base or petiole e.g. castor oil (*Ricinus communis*), pawpaw (*Carica papaya*).

(Fig. 53: diagram)

(3) Palmatisect: the incision is more or about ¾ of the leaf blade towards the leaf base or petiole e.g. cassava (*Manihot esculenta*), hemp plant (*Cannabis sativa*).

TYPES OF LEAF

A leaf can be simple or compound.

Simple leaf consists of a single blade which maybe entire or incised (lobed) to any depth, but not down to the mid-rib or the petiole i.e. the leaf blade remains intact.

In Compound leaf, the incision of the leaf blade goes down to the mid-rib or petiole, so that the leaf is broken up into a number of segments, called leaflets, which are free from one another and more or less distinctly jointed at their base.

(Diagram)

A bud (axillary bud) is always present in the axil of a simple or a compound leaf, but it is absent in the axil of the leaflets of a compound leaf.

Each leaflet has its own stalks known as the Petiolule. The main vein of the compound leaf is called the rachis while the mid-vein of the leaflet is called rachilla. The lateral leaf-like appendages borne at the base of the leaflets are called stipels.

There are two types of compound leaves, which are pinnate compound leaf and palmate compound leaf.

Pinnately compound leaf is one in which the mid-rib (rachis) bears laterally a number of leaflets, which are arranged alternately or in an opposite manner e.g. *Acacia sp., Mimosa sp., Cassia sp*., etc.

(Fig. 55 Diagram)

Pinnately compound leaves may be of the following types

(1) Unipinnate compound leaf: the mid-rib (rachis) bears the leaflets directly. When the leaflets are even in number, the leaf is said to be Paripinnate e.g. *Acacia sp., Cassia obtusifolia, Sesbania sp*.

(Fig. 56: Diagram)

When the leaflets are odd in number and the leaf is terminated by one leaflet, the leaf is said to be Imparipinnate e.g. Rose, *Azadirachta indica, Murraya sp*. etc.

Pinnate compound leaves can be described based on the number of leaflets on them. The following types are known:

Unifoliate are those having only one leaflet e.g. *Desmodium, Bauhinia sp.*

Bifoliate are those having two leaflets e.g. *Balanites sp*.

Trifoliate compound leaves possess three leaflets e.g. *Vigna sp., Etythrina sp., Vitis trifolia, Calapogonium sp.*, etc.

Quadrifoliate, pentafoliate or multifoliate possess four, five or many leaflets respectively. It should be noted that leaflets may vary in number in the compound leaves of the same plant.

(2) Bipinnate compound leaf this is when the pinnation is of the second order i.e. when the leaflets on the unipinnate compound leaf is further divided into smaller leaflets (double pinnation) e.g. *Caesalpinia pulcherima, Mimosa pudica, Deloniz regia* etc.

(Fig. 57: diagram)

(3) Tripinnate compound leaf this is when the leaf is thrice pinnate i.e. pinnatino of the third order whereby the leaflets are borne on the tertiary axes e.g. *Moringa sp., Oroxylum sp*., etc.

(4) Decompounds leaf: this is when the leaf is more than thrice pinnate i.e. the pinnation is beyond the third order e.g. Carrot (*Daucus carrota*), *Cosmos sp., Coriandrum sp*.

Palmately compound leaf is the one in which the petiole bears terminally a number of leaflets which radiate from a common point like fingers of the palm e.g. *Bombax sp., Polanisia sp., Lupinus sp*., etc. Palmately compound leaves are also described based on the number of leaflets borne on them. Examples are

Unifoliate (those with one leaflet) e.g. Citrus sp. (this is very rare)

Bifoliate (those with two leaflets)

Trifoliate (those with three leaflets) e.g. *Aegle, Oxalis, Dioscorea dumentorum*

Quadrifoliate (those with four leaflets) e.g. *Marsilea quadrifolia*

Digitate or multifoliate (those with five or more leaflets) e.g. *Bombax, Polinisia*

(Fig. 58: diagram)

Trifoliate palmate leaf can be distinguished from trifoliate pinnate in the sense that the three leaflets of the palmate trifoliate leaf are attached to the apex of the petiole, whereas, in trifoliate pinnate leaf, it is only the terminal leaflet that is attached to the tip of the petiole.

LEAF ARRANGEMENT

The arrangement of leaves on the stem is termed phyllotaxy. There are different kinds of leaf arrangement, depending on the number of leaves developing from a node.

(1) Single leaf at a node: the arrangement could be either alternate or spiral

- (a) Alternate: the single leaves are arranged alternately along the length of the stem in a single plane e.g. Mango (*Mangifera indica*)
- (b) Spiral: the single leaves are arranged spirally along the length of the stem e.g. *Hibiscus rosasinensis.*

(Fig. 59: diagram)

(2) Two leaves at a node: this could be opposite or decussate

- (a) Opposite (superposed): the two leaves at the node are arranged opposite each other on each side of the stem in a single plane, with all the pairs of leaves on the stem occurring in the same plane e.g. Cassia sp.

(b) Opposite (Decussate): the pair of opposite leaves at one node are arranged at a right angle to the pair of opposite leaves at the next upper and lower nodes e.g. *Calotropis procera, Ixora sp., Ocimum gratissimum, Psidium guajava*.

(Fig. 60: diagram)

(3) More than two leaves at a node: this is termed whorled leaf arrangement. There may be variation in the number of leaves developing from a node, ranging from three to five or six e.g. *Alstonia boonei, Oleander (Nerium sp.), Allamanda sp.*

(Fig. 61 diagram)

THE FLOWER

The flower is a specialized shoot of limited growth bearing reproductive organs. The flowers are the main reproductive organs of flowering plant. They are the most attractive due to the colouring of the petals. Flowers are the most constant character or organ of flowering plants, hence they are very important n the classification of flowering plants. Flowers that develop from leaf axils are termed axillary flowers, while terminal flowers are formed at the apex of stems or branches. Cauliflorous flowers develop directly on the stem of trees. Some flowers may occur singly or solitary flowers are in Hibiscus sp. or as cluster of flowers known as inflorescence e.g. *Aspilia sp., Emilia sp*., etc. The flower stalk of a solitary flower is called Pedicel while the stalk of an inflorescence is termed peduncle. Flowers with pedicel are called pedicellate flowers while those without pedicel are sessile flowers.

(Fig. 62: diagram)

A flower is composed of our floral parts that are attached to the flower base known as the receptacle or thalamus. The floral parts which are arranged in four different whorls on the receptacle are Calyx, corolla, androecium and gynoecium. Flowers having all the four floral parts are called Complete flowers, while incomplete flowers lack one or more of the floral parts.

The calyx is the outermost whorl of the floral parts on the receptacle. It is made up of two to five small leaf-like structures known as the sepals. Sepals could be numerous in some Cactus species. Sepals are usually green in colour, but when coloured as in *Caesalpinia sp*., they are said to be Petaloid. The sepals may be completely free from one another or fused together to form a cup-like structure as in Hibiscus sp., Crotalaria sp. When the sepals are free, they are said to be polysepalous, and when fused, they are gamesepalous.

The sepals function is protection of the inner floral parts during the bud stage. They could also serve for insect attraction when coloured and served as means of dispersal where they occur in the form of hairs known as pappus as in *Tridax procumbens, Picris humilis* etc.

Some flowers may possess another whorl of green floral parts outside the calyx known as the epicalyx which is made up of episepals e.g. *Hibiscus rosa-sinensis*.

The Corolla is the second floral whorl next and inner to the calyx which is usually composed of five coloured petals. The petals are very conspicuous (due to their large size and bright colour) and serve to attract insects to the flower for pollination. They could also produce scent for insect attraction e.g. 'gueen of the night'. When the petals are free from one another, they are said to be polypetalous e.g. Hibiscus and when fused gamopetalous e.g. *Thevetia neriifolia*. When the petals are fused, they form corolla tube which protects the androecium and the gynoecium e.g. *Allamanda*. When the petals are green, they are said to be sepaloid.

In some flowers, the sepals and petals may be indistinguishable or be found to fused to form the perianth e.g. *Gloriosa*. Each unit of the perianth is called a tepal. There could be an additional whorl of lobes, scales or hairs at the base of the corolla of some flowers. This is known as the corona e.g. Oleander, *Passiflora sp*.

Flowers witout calyx and corolla are said to be naked or achlamydeous. Flowers with either of the two whorls are monochlamydeous, while those with the two are dichlamydeous.

The Endroecium: the third whorl, inner to the corolla is the androecium which is the male reproductive organ of the plant. The androecium is made up of stamens which vary in number in different species e.g. the stamens are three in grass flowers, five in most dicots, ten in Clitoria and numerous in the Cactus flowers. Each stamen comprised a long stalk known as the filament which carries a bean-shaped or elongated yellow body known as the anther. The stamens are said to be epipetalous when the filaments are attached to the petals. The filaments of the stamens may be free or fused into one, two or more bundles. When a single bundle is formed, it gives rise to a tube-like structure known as the stamina tube as in Hibiscus. The anthers are usually free from one another, but they could be joined together in some cases e.g. sunflower (Helianthus sp.). The anther is comprised of two lobes with each lobe containing two pollen sacs, thus, each anther contains four pollen sacs. The anther lobes are connected by a connective tissue. The pollen sacs contain the powdery pollen grains which are the male gametes.

(Fig. 63 diagram)

The Gynoecium or Pistil: this is the female reproductive organ and it is the innermost floral whorl. It may comprise of one, few or many carpels. The pistil is monocarpous if it comprises a single carpel e.g. Clitoria, and it is polycarpous when it comprises who or more carpels e.g. Hibiscus. The pistil is apocarpous when the carpels are free e.g. rose and it is syncarpous when the carpels are fused e.g. lilies.

The carpel is made up an ovary, a style and a stigma. The style connects the ovary to the stigma. The ovary contains the ovules (egg cells) which are attached to the placenta by a short stalk called funicle. The arrangement of the ovules in the ovary is termed placentation. The ovary could be superior ovary when it is positioned above other floral parts e.g. Hibiscus, Cassia etc. and the flower is said to be hypogynous. The ovary is inferior ovary when other floral parts are positioned above the ovary and the flower is said to be epigynous e.g. guava (*Psidium guajava*), *Canna sp*. The ovary is described half-inferior in perigynous flowers when the receptacle did not enclose the ovary completely as in inferior ovary and the other floral parts appear to be positioned slightly above the ovary e.g. Rose.

(Fig. 64: diagram)

The stigma is the sticky surface that receive the pollen grains. The stigma surface may be smooth, hairy or feathery. It may branch as in Hibiscus.

At the base of the corolla or pistil or within the receptacle is the nectar which contains glandular cells that secrete a surgary solution called nectar. The nectar plays important role in pollination by attracting insects which feed on it to the flowers.

In the dicotyledons, the number of each type of floral part is usually four or five or multiples of these numbers. In the monocotyledons, the number of each type of floral part is three or multiple of three.

A flower having only one of the reproductive organ is known as a unisexual flower while those with both reproductive organs are known a bisexual or hermaphrodite flower.

A unisexual flower could be either pistillate (female) or staminate (male). When both male and female flowers are borne on the same plant, but at different portion of the plant is known as Monoecious plant e.g. *Zea mays* (maize), *Elaeis guinensis* (oil palm). A plant is described as dioecios when the mal and female organs or flowers are borne on different plants of the same species e.g. *Carica papaya* (pawpaw). In such cases, male and female plants are identified.

Androecium and gynoecium are regarded as the essential parts of a flower because reproduction can occur without them. Actinomorphic or regular flowers are those that are radially symmetrical i.e. they can be divided into two equal halves by any vertical section passing through the centre e.g. *Hibiscus rosa-sinensis*. Zygomorphic or irregular flowers are those that are bilaterally symmetrical i.e. can only be divided into two equal halves in only one particular plane e.g. *Crotalaria sp., Vigna sp*.

FRUITS AND SEEDS

After pollination and fertilization in the flowers, fruits and seeds are formed. The fruits develop from fertilized ovaries and the ovules in the ovaries become the seeds. In some plants, fruits are formed without fertilization, such fruits are known as parthenocarpic fruits and they are usually seedless e.g. banana, pineapple, etc.

The fruit wall known as the pericarp is made up of three layers comprising of an outer layer called epicarp, a middle layer called mesocarp and an inner layer called endocarp. The pericarp encloses the seeds.

Fruits are described as true fruits and false fruits based on the floral parts that form the fruit. Fruits formed solely from the ovary are known as true fruits e.g. cowpea (*Vigna unguiculata*), while fruits formed not only from the ovary but also from floral parts such as calyx, corolla and receptacle are known as false fruits e.g. cashew, apple. The fruit has two scars, one is the point of attachment to the receptacle and the other is the remain of style. A seed on the other hand has only one scar which is the point of attachment to the placenta.

Classification of Fruits

Fruits are broadly divided into two classes namely fleshy/succulent and dry fruits on the basis of the nature of the pericarp.

Fleshy/succulent fruits have fleshy fruit walls while dry fruits have hard, dry, fibrous or woody fruit walls. Fleshy fruits are usually juicy, they store water and carbohydrate in their tissues and they are indehiscent i.e. they do not split open to release their seeds. While the dry fruits may be dehiscent or indehiscent.

Fruits are also classified on the basis of the number of flowers involved in the fruit formation. The fruit types under this criteria are simple, aggregate and compound (or multiple) fruits.

Simple fruit are formed from a single flower with a monocarpous or syncarpous pistils e.g. cowpea. Aggregate fruits are formed from a single flower with an apocarpous pistil with each carpel forming a fruitlet e.g. strawberry.

Compound/multiple fruit are formed from whole inflorescence or from many flowers that are positioned very lose to one another forming fruitless that fuse together to form a single large fruit e.g. pineapple, fig, etc.

Types of fleshy fruits

(1) Drupe is a true, simple fruit with well-developed pericarp. The pericarp consists of three layers of which one is fleshy or fibrous. The layers are epicarp which is the thin outer skin, the mesocarp which is the fleshy or fibrous middle layer and the endocarp which is the hard and stony inner layer that encloses the seed. Drupes are usually one-seeded e.g. mango, coconut, etc.

(2) Berry is a true, simple fruit with well-developed pericarp but the endocarp is fleshy and it is usually many-seeded e.g. tomato, guava. The mesocarp and endocarp are more or less fused to form a fleshy mass in which the seeds are embedded. It is formed from a syncarpous pistil.

(3) Hesperidium is a true simple fruit with distinct chambers that are separated by sheets of endocarp. The epicarp and mesocarp are fused to form the skin or rind. The chambers are filled with succulent and juicy pulps that are attached to the endocarp. The seeds are formed in the chambers e.g. orange, lime, lemon, etc.

(4) Pome is a simple false fruit that develops from an inferior ovary. The fleshy and edible outer layer is formed by the swollen receptacle, while

the inner core that contains the seeds is formed from the ovary e.g. pear, apple.

(Fig. 65: diagram)

(5) Sorosis is a fleshy, multiple false fruit formed from a closely packed inflorescence. The peduncle swells to become the fruit core, while every part of each flower forms part of the fruit e.g. pineapple. In pineapple, the fleshy peduncle extends beyond the fruit to form the fruit crown.

(6) Synconus is a fleshy multiple false fruit formed from a closely packed inflorescence with a swollen, fleshy and cup-like peduncle which encloses small fruitlets. The peduncle cavity opens to the outside as a small hole that are surrounded by scaly bracts e.g. Fig.

Types of Dry Fruit

Dry fruits could be either dehiscent i.e. those whose pericarp splits open to release their seeds or indehiscent i.e. those whose pericarp do not split.

Dry Dehiscent fruits

(1) Follicle is a simple dry fruit formed from a superior monocarpous pistil and splits longitudinally along one suture only e.g. periwinkle.

(2) Legume is a simple dry fruit formed from a superior monocarpous pistil. It is usually long and flat with two sutures to release the seeds inside it e.g. *Delonix regia, Vigna sp., Crotalaria, Caesalpinia sp*. etc.

(3) Capsule is a simple dry fruit formed from a superior syncarpous pistil. It is usually capsular with more than two sutures. The pericarp splits at more than two sutures e.g. okro, cotton.

(4) Schizocarp is a many-seeded simple dry dehiscent fruit formed from a superior ovary. The fruit breaks up into a number of small one-seeded parts when ripe e.g. castor oil, Desmodium.

(5) Siliqua is a long, narrow, two-chambered capsule-like fruit formed from a bicarpellary ovary. The two chambers are separated by a false calyx and the fruit splits at the two sutures e.g. *Tecoma stan*.

(Fig. 66: diagram)

Dry Indehiscent Fruits they are usually small size, but are produced in large number.

(1) Achene is a small, one-chambered and one-seeded fruit formed from a monocarpous pistil, with superior ovary. The pericarp is dry and is free from the seed coat e.g. sunflower, *Aspilia sp*., *Tithonia diversifolia* etc.

(2) Cypsela is similar to achene, but it is formed from bicarpellary ovary. Many of them bear persistent calyx as tuft of hairs, known as pappus e.g. *Tridax, Procumbens sp., Lactuca, Sonchus sp., Picris humilis* etc.

(3) Nut is similar to an achene but the pericarp is tough, stony or woody e.g. cashew nut, almond, walnut, etc.

(Fig. 67: diagram)

(4) Caryopsis is a small one-seeded fruit formed from a superior monocarpous pistil. The periarp and seed coat fuse to form a thin cover over the seed e.g. maize or cereals in general and fruits of grasses.

(5) Samara is one or two-seeded achene-like fruit with the pericarp extended to form wings e.g. *Combretum, Dipterocarpus* etc.