They are storage molecules e.g. starch and glycogen. They are easily converted to sugar by hydrolysis when required. They also function as structural material e.g. cellulose.

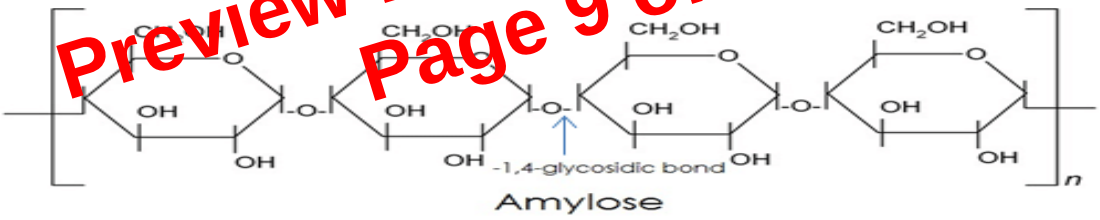
Starch.

starch is a polymer of alpha glucose. in plants, it forms a helices and act a storage compound which on hydrolysis gives a monosaccharide such as glucose for respiration. it is in the form of grains or granules visible in the chloroplast. starch is absent in animals. it has two components that is amylose and amylopectin.

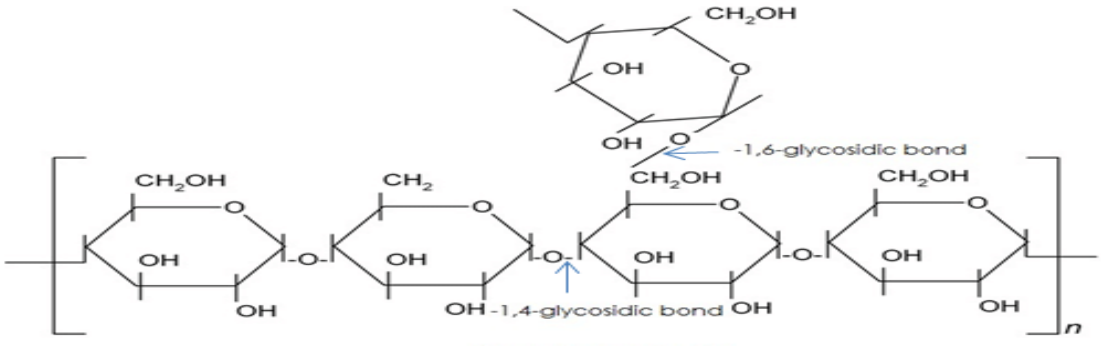
Amylose. it is a straight chain formed from several thousand glucose molecules joined by 1,4 glycosidic bonds. these chains do not usually remain straight but also coils helically into a more compacted structure.

Amylopectin. it is usually longer than amylose and has about twice as many glucose molecules as amylose. it has many branches formed by 1,6 glycosidic bonds between some glucose molecules. diagram.

when iodine solution is added to a suspension of amylose in water, it gives a blue black colour while a suspension of amylopectin gives a red violet colour. this forms the bases of the test for starch.



Amylose



Amylopectin

PROTEINS.

they complex organic compounds which contain the elements CHON and in some cases Sulphur. they are body building macromolecules with low energy value and are used in extreme emergency. they are the most abundant organic molecules in cells and form over 50% of total dry mass. excess proteins can be converted to both fats and carbohydrates and stored in cells. the basic units or monomers of proteins are amino acids. amino acids are linked by peptide bonds by condensation reaction to form a three dimensional structure.

based on structure, proteins are classified into two main groups that is fibrous and globular proteins.

fibrous proteins. they are tough, insoluble and consist of long parallel polypeptide chains, cross-linked at intervals forming long fibres or sheets. perform structural functions in cells and organisms e.g. keratin in hairs, actin and myosin in muscles, collagen in in tendons bone.

globular proteins. they are soluble and consist of polypeptide chain tightly folded to form spherical shape. e.g. enzymes, antibodies and hormones.

a. Amino acids.

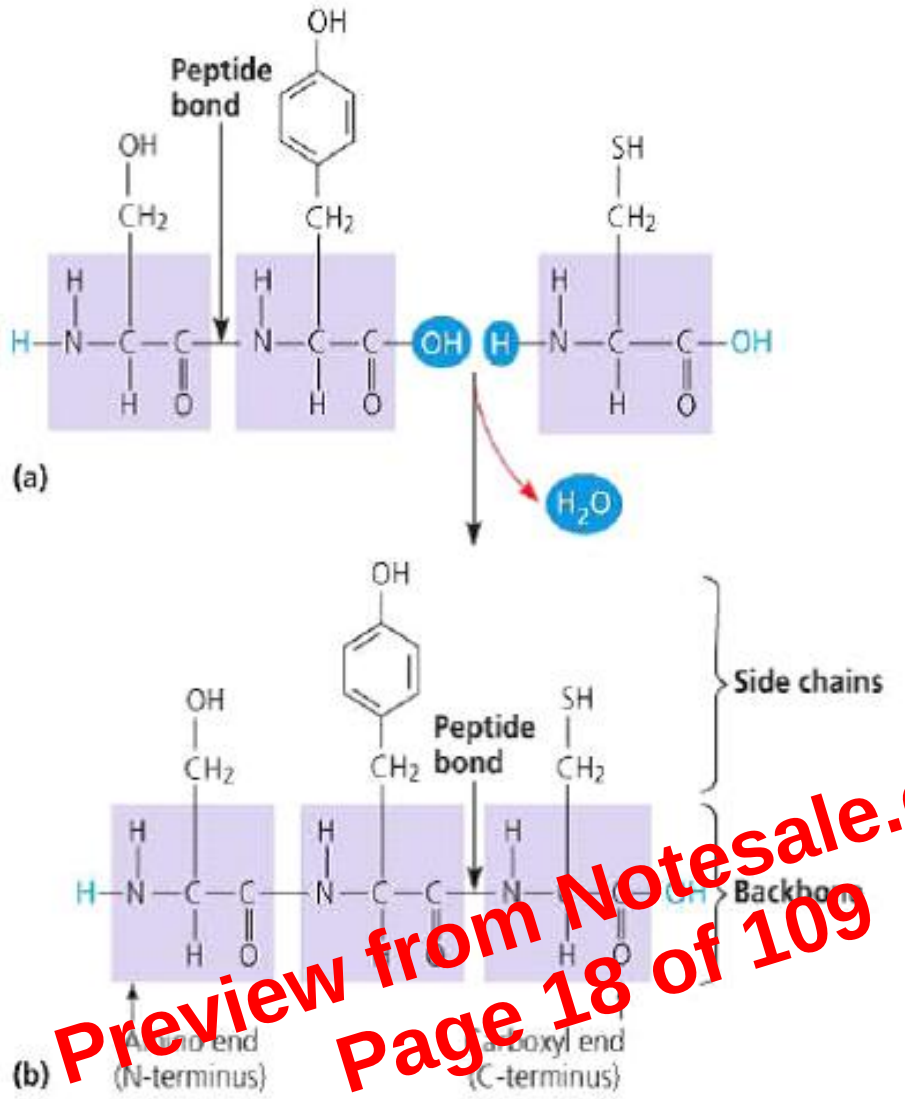
these are the monomers of protein. out of the 170 amino acids that exist, only 20 are found in proteins. some are essential amino acids that is can only be obtained from diet while others are non-essential amino acids that is can be synthesised. some exist in the body but do not enter into the composition of protein like GABA (gama amino butyric acid, inhibitory neurotransmitter) found in the nervous system.

i. **structure of amino acid**.

All amino acids have a central carbon atom called alpha carbon to which is always attached amino group (NH2) which is basic and a carboxyl group which is acidic and a hydrogen atom. the 4th position is occupied by a variable group represented by R group which gives each amino acid it uniqueness. thus amino acid contains both acidic and basic group and is called amphoteric molecule. the simplest amino acid is glycine where R=H. when R=CH3 - alanine and valine when R=C3H7 etc. diagram.

Properties of Amino acid.

- amino acids are soluble in water but insoluble in organic solvent such as ether.



Structure of proteins.

they have three dimensional shape called its conformation. This enable them to have specific activities determined by the amino acid sequence of a polypeptide. the polypeptide chain generally folds spontaneously, assuming the functional structure. This folding is due to the formation of a variety of bonds between parts of the chain, which in turn depends on the sequence of amino acids.

Many proteins are roughly spherical *(globular proteins),* while others are shaped like long fibres *(fibrous proteins)* or globular and tightly bounding non protein material (conjugate protein).

- The two polynucleotide strands are antiparallel meaning that one strands exist in the 5', 3' direction while the other strand exist in the 3', 5' direction.
- once the double helical structure is formed, it recoils itself and become folded held by positively charged proteins called histones.
- it has a very high molecular mass, insoluble and a high melting point.
- it has a constant width of 2nm and a complete turn of the helix has a length of 3.4nm with 10 base pairs of nucleotides. diagram.

Structure of RNA (ribonucleic acid).

- it is made up of single strand of polynucleotide unlike DNA.
- has the pentose sugar ribose with smaller molecular mass?
- organic nitrogenous bases present are 2 purine bases; Adenine (A), Guanine (G) and 2 pyrimidine bases; Cytosine (C) and Uracil (U).
- the ratio of A=U to C=G varies
- they are manufactured in the nucleus but found all over the cell and amount varies from cell to cell.
- soluble and chemically less stable
- there are three forms namely messenger, transfer and ribosomal RNA.

Messenger RNA (mRNA)

Single stranded molecule formed on a single strand of DNA by transcription. during its formation only one strand of DNA molecule is copied. the base sequence in mRNA strand is complementary to that of DNA strand and varies in length according to the polypeptide chain for which it code. most exist in the cell for a short while. constitute 3-5% of RNA in cells.

Ribosomal RNA (rRNA).

Synthesis by genes found on DNA of several chromosomes within a re.g.ion of the nucleolus called nucleolar organiser. base sequence in rRNA is similar in all organisms from bacteria to higher plants and animals. it is found in the cytoplasm where it is associated with protein

- They lack true nucleus that is their genetic material is not surrounded by a nuclear membrane
- Cytoplasm contain few organelles and non are surrounded by a two membrane-envelope
- Ribosomes present are smaller subunit (70s) and are not attached to the ER
- Their cell wall is rigid and contain polysaccharides with amino acid residue
- Sometimes their cell wall is strengthened by the presence of murein.
- Flagella or cilia when present are simple and not constructed from a system of 9+2 microtubules
- Reproduce mainly by binary fission though sexual reproduction is possible
- Respiration is carried out by infolding of cell membrane called mesosome because of lack of mitochondria or cytoplasmic membrane in cyanobacteria
- Some are autotrophic while others are heterotrophic.

Types of bacteria

There are two groups of bacteria

1. **Archaebacteria or primitive bacteria**. They have existed billions of years ago and were found in springs and are referred to as thermoacidophiles.
2. **Eubacteria (true bacteria)**. They are true bacteria and compose of gram –ve and gram +ve bacteria.

Classification of bacteria.

Kingdom- Monera

Phylum- Schizophyta

Class- Schizomycetes

SN- *Escherichia coli*

CN- Escherichia

Habitat.

Bacteria are widely distributed in air, water, soil and in other living organisms as parasites. This is because of the following reasons.

Harmful effects.

- Parasitic bacteria produce toxins as means of defence or as excretory product which cause diseases in plants and animals e.g. cholera, typhoid, dysentery etc.
- Cause food spoilage e.g. Clostridium botulinum
- Decrease soil fertility such as denitrifying bacteria which convert soil nitrate to atmospheric nitrogen
- Attack root vegetables like potatoes, beets, carrots etc. This create an unpleasant appearance on the inside of the potato that devalue it.
- Kill animals which are of economic value to man e.g. Bacillus anthracis that cause anthrax in cow.
- Decompose useful materials like textile, wood and pipes.

Useful effects.

- Saprophytic bacteria help in the decay of dead plants and animals to release nutrients like CO2, H2O and NH3.
- Source of antibiotics e.g. streptomycin is produced by soil bacterium Streptomyces.
- Synthesis vitamin K from breakdown of roughage which help in the production of blood clotting factor (prothrombin) e.g. E. coli in the colon of man
- E. coli is also used to produce human hormone insulin through genetic engineering
- Produce cellulase which help in the digestion of cellulose in herbivores.
- Nitrogen fixing bacteria increase soil fertility by converting atmospheric nitrogen to soil nitrates
- Used in cleaning oil spill such as Acinetobacter, Pseudomonas etc. they breakdown the oil into simple substance
- Used in the production of silage or animal feed
- Used in the production of single cell protein
- Used in industries to breakdown milk sugar lactose to lactic acid which give yoghurt and cheese their sour taste e.g. Lactobacillus
- Used in the production of vinegar i.e. convert ethanol to ethanoic acid e.g. Azotobacter.
- Used in sewage treatment i.e. breakdown sewage to harmless form e.g. Zooglea ramigera.

5. **Excretion and osmoregulation**. Waste products of metabolism produced in the cell like urea, CO2 and excess H2O leave the cell by diffusion through the cell surface membrane. Though the contractile vacuole assists in excretion, its main function is osmoregulation i.e. control water content of the cell. Marine water amoeba lacks a contractile vacuole but if transferred to fresh water, it automatically develops a contractile vacuole. In fresh water environment, water turns to move from the surroundings into the amoeba by osmosis. If this is not controlled, the amoeba continues to increase in size and subsequently the cell may burst. This situation is controlled by immediate development of the contractile vacuole which collect excess water and move towards the cell surface membrane where it is eliminated alongside small amount of salt. This continue until the osmotic concentration between the cell and the surrounding water get to equilibrium.

Phylum. Apicomplexa.

General characteristics.

- They are parasitic protozoans.
- Lack external structures for locomotion thus show limited movement
- Cells have definite shape and are covered by a flexible pellicle
- They are uninucleated and lack contractile vacuole
- Asexual reproduction is by schizogony and formation of spores (sporozoites) while sexual reproduction is by syngamy where large nuclei of spores are formed also called sporozoites.
- Example is the malaria parasite called Plasmodium.

Classification.

Kingdom -Protoctista

Phylum -Rhizopoda

Class -Sporozoa

S.N –Plasmodium vivax, ovale, malariae, falciparium.

C.N –the malaria parasite.

Habitat. Man is the primary host while female anopheles' mosquito is the secondary host.

In man it lives in the RBC

Life cycle of the Malaria parasite (Plasmodium)

- Man is the primary host while female anopheles' mosquito is the secondary host.
- When an infected mosquito bites man, it injects sporozoites into the blood stream.
- Sporozoites migrate through the blood plasm to the liver where it infects liver cells
- Each sporozoites multiply asexually by schizogony to form merozoites
- Merozoites re-infect other liver cells forming more merozoites while others re-infect RBC.
- In the RBC they grow and mature into trophozoites
- Trophozoites multiply rapidly by schizogony to form more merozoites causing the RBC to enlarge and burst releasing toxic substances throughout the body of the host which causes fever.
- Merozoites enter sexual phase when some of them develop into male and female gametocytes.
- If a mosquito happens to bite an infected person, it sucks the gametophytes from blood.
- In the gut of the mosquito the male and female gametophytes develop into male and female gametes respectively.
- Fertilization of male and female gametes produces a zygote which develop in the mosquito's intestinal walls and later differentiate into oocysts.
- In the oocysts, repeated mitotic division by schizogony produces a large number of sporozoites which migrate to the salivary glands of the mosquito and can be injected into the blood stream of man when the mosquito bites. Diagram.

Method of Transmission of Plasmodium.

- Through the bite of an infected female anopheles' mosquito
- Through blood transfusion.

Effects of Parasite on Man or signs and symptoms.

- Causes high fever and vomiting
- Causes anaemia
- Causes joint pains and body weakness
- Causes loss of appetite
- Causes headache

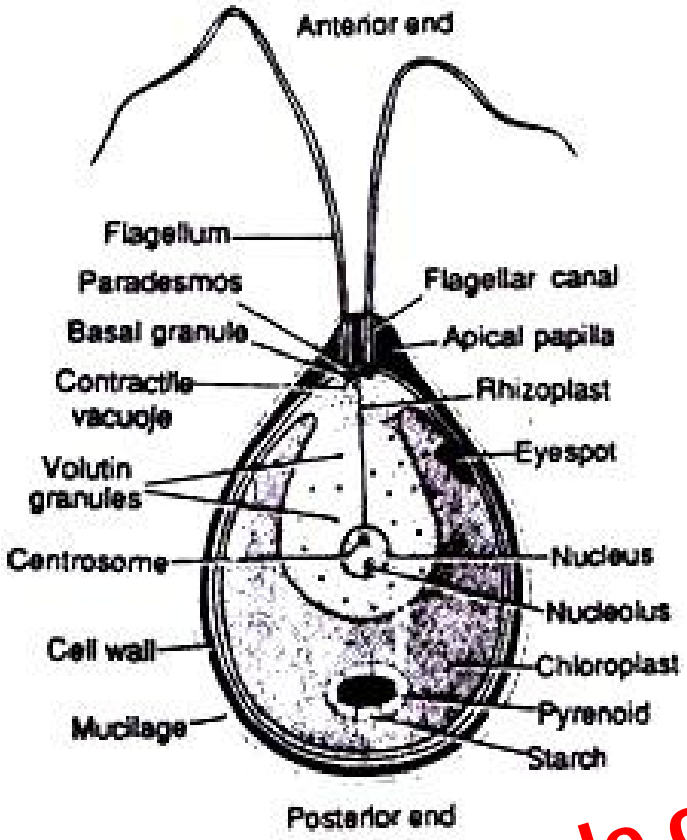


Fig. 1. Thallus of *Chlamydomonas*

Mode of life.

1. Nutrition. It has a cup-shaped chloroplast which contain the pigment chlorophyll. Chlorophyll trap sunlight energy during the process of photosynthesis.
2. Locomotion. It has two whip-like flagella which beat toward direction of movement and the whole body rotate toward a fixed direction in a zigzag manner.
3. Reproduction. It carryout both sexual and asexual reproduction.

   Asexual reproduction is through binary fission. The parent cell divides thrice or four times to daughter cells. Thus about eight or sixteen daughter cells are produced. When conditions are unfavourable, the parent cell passed into a palmelloid stage. This is a resting or dormant stage where a large amount of gelatinous matrix is secreted and released only when conditions are favourable.

   Sexual reproduction is by conjugation. Diagrams.

Habitat. They are saprophyte which grows on damp stale bread, over ripe fruits, decaying vegetables and organic matter.

Classification. Kingdom-Fungi, Phylum-Zygomycota, Class-Zygomycetes, Genus-Rhizopus, Species-nigricans. SN-Rhizopus nigricans, CN-breadmould.

Structure.

Mode of life.

Nutrition. It carryout saprophytic nutrition. Feed on food substances found in decaying organic matter. Rhizoid of the fungus grow into the substrate or organic matter or food, secretes enzymes into it. These enzymes digest the organic matter or food outside the body so that only the soluble products of digestion like glucose, amino acids etc. are absorbed. This type of digestion is called extracellular digestion.

Reproduction.

Rhizopus carries out both sexual and asexual reproduction.

Asexual reproduction is by the formation of sporangiosphores especially during favourable conditions. When there is enough food and moisture, the protoplasm migrates to the swollen tips of hypha making them to enlarge into structures called sporangia. The sporangium is separated from the sporangiophore by a sterile dome-shaped columella. The protoplasm of the sporangium divides repeatedly into small masses each with a nucleus and thick wall.
These masses develop into spores with thicker and darker walls. The walls of the sporangium darken and becomes brittle as the spores mature. When the spores become fully mature, the columella exert pressure that causes the sporangium to burst releasing spores.
Spores are very small, dry and lighter and are dispersed by wind and insects.
When the spores fall on a suitable it grows into a new mycelium.

Sexual reproduction.

- **T**his is by conjugation and occur during adverse conditions such as drought and lack of food.
- Two hyphae of opposite strains (positive and negative) come to lies side by side. At times the hyphae may be from different mycelia.
- Side growth emerges from each hypha with swollen head called progamatangia held by a suspensor.

- Progamatangia touch and push each hypha apart. Cross wall is formed at the point of contact. The progametangia becomes the gametangium containing gametes.
- Cross wall breaks down and gametes fuse to form a diploid zygote which later develop into a zygospore with rough walls.
- The diploid zygote undergoes meiosis to form four haploid cell, three degenerate. The remaining one haploid nucleus grow and divide by mitosis repeatedly forming many haploid nuclei. The haploid nuclei develop into a haploid spore.
- The outer wall of the zygospore burst while the inner wall grows out into a tube called the sporangiophore and later a new mycelium when conditions are favourable.

What are the differences between conjugation in Spirogyra and Rhizopus.

Phylum Ascomycota.

General characteristics.

- They range from microscopic single cell forms such as yeast to multicellular forms penicillium.
- The body is a mycelium, having a network of fine tubular filament called hyphae
- The hyphae are branched with cross-walls and are said to be septate.
- Reproduction is both sexual and asexual. Asexual reproduction is by formation of conidia and no sporangia while sexual reproduction is by formation of ascospore in special structures called ascus.
- Store excess carbohydrate in the form of glycogen and oil in some species.

Case study I-Yeast.

Habitat. It grows in sugar solution, palm wine and overripe fruits.

Classification.

Kingdom-Fungi, Phylum-Ascomycota, Class-Ascomycetes, Genus-Saccharomyces, Species-cerevisiae. SN- *Saccharomyces cerevisiae*., CN-yeast.

Structure

Mode of life.

Nutrition and respiration. It carries out saprophytic nutrition i.e. feed mostly on sugar solution. In the presence of oxygen, its convert glucose in sugar to carbondioxide and water. This require enzymes and it is an aerobic process. In the absence of oxygen, the sugar is

late blight. Late blight is a diseases of tomato, potato, huckleberry etc. and can reduce yield for up to 100%.

Life cycle.

Economic importance of fungi.

Harmful effects.

- They cause disease to man such as athletes' foot, thrush etc.
- Some are poisonous when eaten e.g. Aminata phaloides or "death cap". It is the most poisonous mushroom in the world and contain lethal poisons such as amatoxin and phallotoxin.
- Cause food spoilage e.g. breadmould
- Destroy houses and furniture such as dry rot.

Useful effects.

- Serves as food such as common field mushroom (Agaricus compestris)
- Serve as a source of antibiotics e.g. the fungus Penicillium notatum produces the antibiotic penicillin which is used universally to treat sore throat, abscesses etc.
- They are used to produce protein concentrates such as single cell protein
- Yeast is used in the production of alcoholic fuel to substitute petrol, diesel and liquefied natural gas in vehicles. This is from the fermentation of sugar from sugar cane
- Yeast is used in the production of alcohol in brewery industries. Barley grains are fermented to produce alcohol which is bottled and sold in Cameroon under the trade mark export, Guinness etc.
- Yeast is used in bakeries where they ferment carbohydrates in bread dough to produce CO2 which causes the dough to rise while alcohol evaporate during baking.
- Breadmould is used to make cheese. It makes the cheese to ripen and give flavour to it.
- They are used in large scale production of enzymes e.g. Aspergillus is used to produce amylase needed in brewery industries.
- Help in the decay of dead plants and animals thus release nutrients like CO2, water and NH3 to the environment.
- Used in biological control of some insect pest such as entomogenous fungi

- Provide occupation and income generation such as mushroom farming.
- They form symbiotic relationship called lichen and mycorrhiza. Lichen is an association between a fungus and an alga which is both beneficial (mutualism).

KINGDOM PLANTAE.

General characteristics.

- The vegetative body is divided into roots, stem and leaves.
- Their main photosynthetic pigment is chlorophyll which may be associated with carotenoids
- They are all eukaryotic multicellular organisms
- Carryout both sexual and asexual reproduction. Asexual reproduction is by vegetative propagation while sexual reproduction is by gametes formation
- Their cell wall is made up cellulose
- Have a vascular bundle made up of xylem and phloem
- Undergo alteration of generation in the life cycle.
- Carryout autotrophic nutrition through the process of photosynthesis though a few species are parasitic and lack the chloroplast.
- Cytoplasm contains many membranous organelles and large ribosomes.
- Examples include moss, liverworts, fern, cypress, pine, maize, beans etc.

This kingdom is classified into many phyla namely- phylum Bryophyta, Filicinophyta, Coniferophyta and Angiospermophyta.

I- Phylum Bryophyta.

General characteristics.

- The main plant body is the gametophyte which lack true root, stem and leaves due to absence of vascular tissues (xylem and phloem).
- Show distinct heteromorphic alternation of generation in which the diploid sporophyte is totally or partially dependent on the gametophyte for nutrition and support.
- Carryout both sexual and asexual reproduction
- Exhibit alternation of generation
- Some members of the classes are erect while others form a thallus on the substratum

- The haploid gametophyte survives during wet conditions while the diploid sporophyte survive during the dry conditions.
- Their rhizoids are multicellular and are used for anchorage and absorption of water and mineral salts.
- Lack vascular bundle thus pseudo-root, stem and leaves form a thallus with continuous cytoplasm.
- They are known as amphibians of the plant kingdom since part of their life cycle requires water while the other requires dry conditions.
- They form primary colonizers of barren land such as newly dug roads or field.

Class-Musci.

Case study. Moss plant.

Classification. Funaria hygrometrica.

Kingdom- Plantae, Phylum-Bryophyta, Class-Musci, SN-Mnium hornum, CN-moss plant.

Habitat. It grows on wet walls, slope and bark of trees.

Structure. It is an erect plant with body divided into pseudo-root, stem and leaves. The rhizoids or pseudo-roots are used for anchorage and absorption of water and mineral salt from the soil. The stem-like axis bear minute spirally arranged leaf-like structure. The mature sporophyte consists of a foot which attaches it to the gametophyte, the seta or stalk which carries the capsule at it apex.

Reproduction and life cycle.
Asexual reproduction takes place by the formation of gemmae usually in groups at the apex of the leaflet. When this gemmae detached and fall on suitable substratum, they germinate to form a protonema. The protonema then grows into a new gametophyte.

Sexual reproduction. The life cycle of moss has two alternating phases., i.e. a haploid gametes-producing gametophyte phase and a diploid spore producing sporophyte phase. The moss plant is the gametophyte and at maturity, it bears the sporophyte generation which depends on it for food and support.

The gametophyte phase bears male and female gametes in a highly differentiated male and female gametangia called antheridia and archegonia respectively which develop at the apex of the leafy shoot. The spherically shaped antheridium produces bi-flagellated antherizoids

(sperm) by mitosis while the archegonium produces a large egg or ovum. The archegonium is flask-shaped with a long neck and a thickened middle section called the venter which contains the egg cell. The gametophyte of most mosses are monoecious antheridia and archegonia are borne on the same gametophyte or plant though a few are dioecious. The gametangia are at times associated with a hair-like structure called paraphysis which help to retain water for fertilisation. When there is sufficient moisture, the antherozoids or sperm are released from the antheridia which swim in the moisture in the neck of the archegonium attracted to the venter by chemotaxis. The antherozoids fuses with the egg nucleus in the venter to produce a diploid zygote. The zygote is the beginning of the sporophyte generation. The sporophyte phase develops immediately after fertilisation i.e. the zygote develops into an embryo which later germinates into a sporophyte consisting of a foot, seta and a capsule or sporangium. The foot penetrates the base of the venter and grows into the apex of the leafy shoot. It absorbs water and food from the gametophyte for its growth and development. The seta elongates and expand at its tip to form the capsule covered by the calyptra. The calyptra is the remains of the old archegonium which later falls off. Meiosis occurs in the capsule and each diploid spore mother cell produces four haploid spores. The capsule has a cover called the operculum which covers a ringed teeth-like structure called the peristome. When the structure is dry they open out and the spores are dispersed by wind. When the spores fall on a suitable habitat, it germinates into a protonema which produces buds that grows into a haploid moss plant or gametophyte generation.

Alternation of generation in the moss plant.

Alternation of generation is when the life cycle of an organism passes through two phases i.e. a haploid gametophyte phase which produce gametes and a diploid sporophyte phase which produce spores.

In the moss plant, there is distinct alteration of generation in which the gametophyte alternate with the sporophyte generation to complete its life cycle. The gametophyte generation survive under wet conditions while the sporophyte under dry conditions. The sporophyte depends on the gametophyte for nutrients and support. The gametophyte generation is haploid and produces gametes sexually while the sporophyte generation is diploid and produce spores asexually. The gametophyte generation begins with the germination of spores and include the protonema, leafy shoot bearing gametangia and gametes while the sporophyte begins with the zygote and include the foot, seta and capsule containing diploid spores.

- The plant is monoecious that is have male and female cone on the same plants.
- They are heterosporous with the microspore different from the megaspore. The male cones are borne clusters at the tip of a branch while the female cone are borne in single, double and triple on the branch.
- They grow under cold arid conditions especially in the Western Highlands of Cameroon (Northwest and West Regions).
- Pollination is by wind and fertilization occur once though lack stigma and style.

Case study I. Pine

Classification.

Kingdom-Plantae, Phylum-Coniferophyta, Class-Coniferinae, SN-Pinus sylvestris, CN-scot pine

Habitat. Terrestrial or arid soil.

Structure.

The pine is a tall erect evergreen tree which may grow to a height of 36m. Has well developed tap root system and a stem with numerous aerial branches. Branches are of two types that long and dwarf branches. Long branches are developed from lateral buds in spring and are arranged in whorls. They are usually referred as branches of unlimited growth and bear male and female cones. Dwarf branches show limited growth and carry numerous leaves that is long green needle-like leaves which usually occur in clusters. Small brown scale-like leaves are borne on both long and dwarf branches. Leaves have sunken stomata, thick cuticle to limit transpiration. Have fibrous epidermis and closely packed mesophyll cells with numerous chloroplast and veins found only in the centre of the leaf. The rough stem is equally covered with a scaly bark, which peels off in strips.

Reproduction and life cycle of the pine

The pine tree is monoecious and the reproductive structure is the cone. The male cone is borne at the tip of the branch while the female cone is borne on the branch. The male cone consists of microsporophyll while the female cone consists of megasporophyll. Male cones occur in clusters while female cone occur singly or in groups of two to four. Male cones develop and mature long before the appearance of the female cones to facilitate cross fertilization.

The male cone or pollen cone.

Consist of microsporophyll which contains microsporangia. Each microsporangium has diploid microspore mother cell. At maturity, it undergoes meiosis to produce four haploid cells or microspores which develops into the pollen grain or male prothallus or gametophyte. The nucleus of the haploid microspore undergoes two mitotic divisions to form 2 prothalial cells. One becomes the generative nucleus and the other the pollen nucleus. Large quantities of pollen grains are produced which are light and each bears two air-filled wings to facilitate their dispersal by wind.

Actinomorphic symmetry is when members of each whorl are all alike and arranged radially around a central axis. Such a flower is said to be regular or actinomorphic or has a radial symmetry. This flower can be divided into two equal halves which are mirror images of each other through any plane such as in hibiscus flower (*Hibiscus rosa-sinensis*).

Zygomorphic symmetry. When floral parts are different from each other in shape. Thus such flowers are monosymmetrical or zygomorphic and have bilateral symmetry. Such flowres can be divided into two halves which are mirror images of each other only through one plane as in Crotalaria (rattlewort), bean, pea etc.

When a flower cannot be divided into similar halves through any vertical plane, it is said to be asymmetrical or irregular.

Aestivation. arrangement of sepals or petals in a floral bud with respect to the members of the same whorl. There are several types.

- Valvate aestivation-when members of a whorl are in contact with each other by their margins or without any overlapping as in custard apple.
- Twisted or contorted aestivation-when one margin of the petal or sepal overlaps that of the next. This maybe clockwise or anticlockwise as in cotton.
- Imbricate aestivation. In this type one of the petals is internal and overlapped on both margins. Others are external and overlap each other on one margin. This is common in *Caesapinia*, *Cassia* etc.
- Vexillary aestivation. Produced when flower has five petals, the posterior one is the largest and almost covers the two lateral petals which in turn overlap the two anterior or smallest petals. This is found mostly in family Papilionaceae such Bean, Pea, crotalaria etc.

Placentation. This is the arrangement of ovules within the ovary. Ovules are attached to ovarian walls through special structures called placenta. This can be marginal. Basal, axile, parietal, free central etc.

Types of placentation.

- **Marginal.** The ovules develop in rows near the margin on the placenta formed along ventral suture. It occurs in monocarpellary and unilocular ovary as in legumes.

- **Parietal.** The placenta is formed by the swelling up of cohering margins and on the latter develop ovules in rows. It occurs in bicarpellary or multicarpellary but unilocular ovary. E.g. papaveraceae.
- **Axile**. The placenta develops from the central axis which correspond to the confluent margins of the carpels. It occurs in bi to multilocular ovary. E.g. solanaceae and malvaceae.
- **Free central**. The placenta develops in the centre of the ovary as a prolongation of the floral axis and the ovules are attached on this axis. It occurs in multicarpellary but unilocular ovary e.g. Primulaceae.
- **Superficial or laminar**. Ovules develop over the entire inner surface of the carpels. It occurs in multicarpellary ovary e.g. Nymphaea.
- **Basal**. The placenta develops directly on the thalamus and bears a single ovule at the base of the unilocular ovary. E.g. Asteraceae.

Types of placentation : (a) Marginal (b) Axile (c) Parietal (d) Free central (e) Basal (f) Superficial

Floral diagrams.

A floral diagram is the ground plan of a flower indicating the number of floral parts, their general structure, arrangement and the relation they have to one another and their position with respect to the mother axis. In the diagram, the calyx lies outermost followed by the corolla, the androecium in the middle and the gynoecium at the centre. Sepals and petals are represented by crescents and if they are slightly different, they are distinguished by some slight changes of the crescent. The stamens are represented by points or outlines of the transverse of the anthers. The gynoecium is shown as it appears in transverse section. Cohesion in a whorl is shown by brackets linking the parts concerned. Adhesion of adjacent whorls is represented by a straight line joining the parts concerned. A dot at the top of the diagram indicates the position of the main axis which bears the flower.

Floral formula.

A floral formula is a set of symbols and numbers indicating the different whorls of a flower, the number of parts in each whorl and the relation they bear to one another. In floral formula,