- **Biology** is a special discipline which is the **science of life and all living systems.**
- **Biological sciences** embrace the field of **Zoology** which is the **science of animals**.
- A branch of zoology specializing in the study of insects is termed **Entomology**.
- Another branch of zoology dealing with parasitic animals is called **Parasitology**.

PARASITIC DISEASES

- Amoebiasis
- Ascariasis
- Babesiosis
- Balantidiasis
- Baylisascariasis
- Chagas disease
- Clonorchiasis
- Cochliomyia
- Cryptosporidiosis
- Dracunculiasis (caused by the Guinea worm)
- Elephantiasis
- Enterobiasis
- Gnathostomiasis
- Hymenolepiasis
- Isosporiasis
- Katayama fever
- Leishmaniasis
- Lyme disease
- Malaria
- Metagonimiasis
- Myiasis
- Onchocerciasis
- Scabies

- Schistosomiasis
- Sleeping sickness

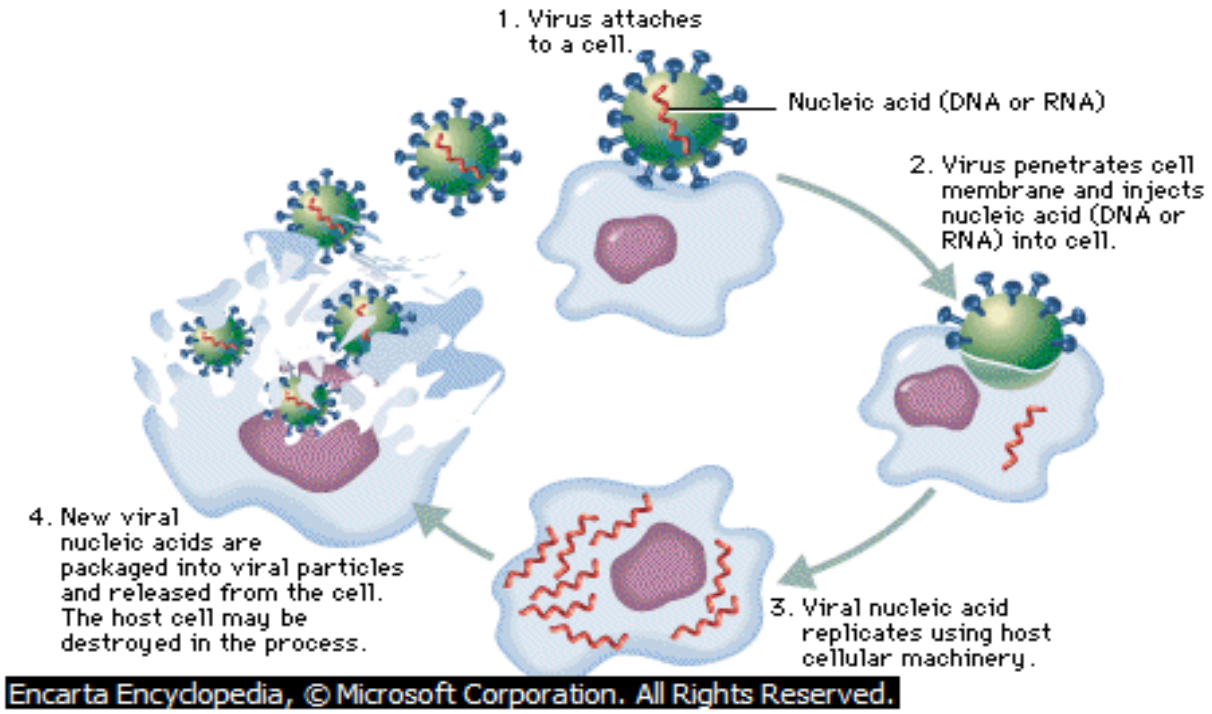
OTHER BRANCHES OF BIOLOGY

- The science of plants is known as **Botany**, alternatively term **Phytology**.
- The study of fungi termed **Mycology**.
- The study of Bacteria is covered in the discipline of Biology called **Bacteriology**.
- The special study of viruses is termed **Virology**.
- The fields of ***bacteriology***, ***mycology*** and ***virology*** constitute a major discipline of biology called **Microbiology**-i.e. the study of microscopic organisms (bacteria, fungi, viruses).

The special study of viruses is termed **Virology**.

- Approximately 35 years ago a role of human papillomaviruses (HPV) in cervical cancer has been postulated. Today it is well established that this very heterogeneous virus family harbours important human carcinogens, causing not only the vast majority of cervical, but also a substantial proportion of other anogenital and head and neck cancers.
- In addition, specific types have been linked to certain cutaneous cancers. In females, HPV infections on a global scale account for more than 50% of infection-linked cancers, in males for barely 5%. Vaccines against the high risk HPV types 16 and 18 represent the first preventive vaccines directly developed to protect against a major human cancer (cervical carcinoma).
- This review will cover some of the historical aspects of papillomavirus research; it tries briefly to analyze the present state of linking HPV to human cancers and will discuss some emerging developments (JOURNAL OF VIROLOGY)

Viruses



Morphology, Anatomy & Genetics

- Biology can be studied from several angles that embrace such branches as:-
  - **Morphology** – a field which deals with the form and structure of organisms
  - **Anatomy** - a field of biology that involves the study of internal structures of organs and the associated tissue types.
  - The branch of biology dealing with heredity and biological variation is called **Genetics**.

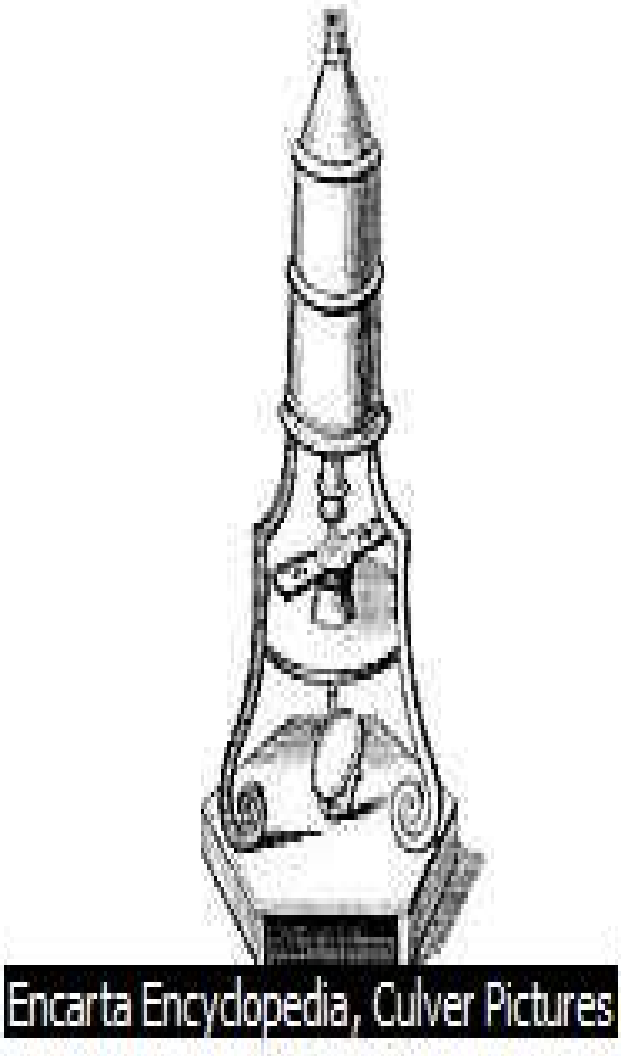
Other branches

- A technique or methodology applied in anatomical studies is termed **Histology**.
- The application or use of **dyes** in histology and textile industries is referred to as **Histochemistry**.
- **Cytology** – is a form of study which deals with the structure and function of cells; and this includes changes in cell structure as well as involving aspects of cell division.
- **Physiology** – involves the study of biological processes and functions that take place within the plants, animal and fungi.
- **Physiology** – involves the study of biological processes and functions that take place within the plants, animal and fungi.
- For instance, consider the following physiological phenomena:
  - The **assimilation of CO_2** by plants in the process of **photosynthesis**;
  - The oxidative digestion of sugar and its consequent break down to release **CO_2** in the process called **respiration**.
  - The person's condition in a ***state of anger*** or ***fear*** of the snake.
- **Ecology** – the study that involves the interrelationship between plants and their respective environments; and this field also entails some aspects of interactions between individual plants and animals in a given community.
- Ecology can be broadly divided into such areas:
  - **Synecology** – the study of plant, animal or fungal communities.
  - **Autoecology** – the study of any given biological species in relation to its natural environment.
- **Ecosystem**: this holistic assemblage of the **biotic** and **abiotic** components of the environment.
- **Ecophysiology**: This is a study of the physiological adaptation of organisms to a particular habitat or environment.
- **Habitat** is the locality, site or a particular type of environment occupied by an organism.

- **Phytogeography** – This is an aspect of geography which involves the spacial distribution of plants in a given area, country or region
- **Biogeography** is an aspect of geography which deals with special distribution of animals and plants.
- **Phytochemistry** – the study of chemical compounds synthesized by plants and these include the **alkaloids, anthocyanins,** saponins,flavonoids and carbohydrates**, essential oils, lipids, proteins**
- Chinese herbal medicines based on Phytochemicals

Microscope, 16 - 18th Century

- compound microscope .
- First developed in the late 16th century,
- compound microscopes use two or more sets of lenses to achieve high magnification.



Microscopy

The cells are so minute that they can only be studied under the **microscope**.

- The **light microscope** is the most common instrument used in the laboratory, capable of revealing the general feature of the cell, such as the cytoplasm and the nucleus.
- The light microscope, which consists of a **system of lenses**, floods the specimens with light waves.
- The **electron microscope**, developed in the 1950s,is yet another innovation which can reveal much finer detail(or ultra-structure) of the cell components.
- The electron microscope floods the specimens with a beam of electrons

Main features

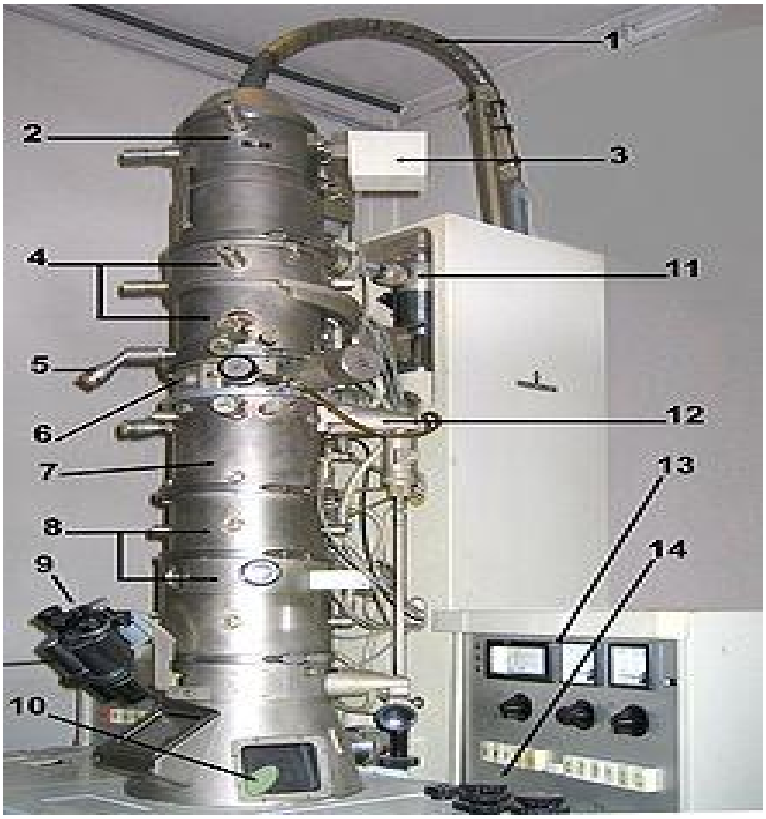
- **The two main features of the microscope are: magnification and resolving power.**
- **Magnification is the ability of the microscope to enlarge specimens for the viewer.**
- **The light microscope can magnify the cell structure to about 1,000 times the normal size.**
- **The electron microscope can magnify the image to about 250,000 times or more.**

Laboratory microscopes

- **The resolving power is the ability of the microscope to reveal fine details of the specimen.**
- **The resolving power is the ability to separate minimum distance between two points.**
- **Therefore, microscopes are *the essential tools for studying cell structures*.**
- **Two types of microscopes used in the laboratory are the transmission types and the dissecting types.**

Dissecting Microscope
(SEM opened sample chamber)

Transmission Microscope



- **The electron source of the TEM is at the top, where the lensing system (4,7 and 8) focuses the beam on the specimen and then projects it onto the viewing screen (10). The beam control is on the right (13 and 14)**

OPERATIONS OF THE MICROSCOPES

- **In transmission microscopes the light waves are transmitted through the specimen,**
- **wheras in electron microscopes electrons are transmitted through the specimen.**
- **In dissecting microscopes the light is reflected on the surface of the specimen to reveal surface features or ornamentations.**
- **A variant of the powerful dissecting microscope is the scanning electron microscope (SEM) designed to reveal the surface features of the specimen.**
- **A variant of the transmission microscope is the transmission electron microscope (TEM) designed to reveal internal structures of the specimen.**

TAXONOMY

- **Field which deals with the process of describing, naming and classifications of organisms.**
- **Name acts as means of reference**
- **It aids communication in science**
- **Avoids the use of descriptive words when referring to an object**
- **Name should not be vague**

Use of scientific names

- **Vernacular names can not be used in scientific purposes.**
- **To curtail obvious confusions and make information to be conveyed accurately.**

Nomenclature

- **Usage or application of names in Biology**
- **In Biological systematics- system of naming organisms.**
- **Rules devised to offset any form of confusions in Scientific literature.**
- ***INTERNATIONAL CODE OF BOTANICAL NOMENCLATURE***
- **ICBN**

Some provisions of ICBN

- **(i)Botanical names to be in Latin- avoid controversies among nations**
- **Latin was ac common language of the learnt people in ancient Europe- botany originated**
- **Latin is a dead language.**
- **(ii) Specific organism to have two names**
- **generic and specific epithet (*Bidens pilosa*)**

Binomial system of nomenclature

- **Two names are applied to a given species**
- ***Bidens pilosa* L.**

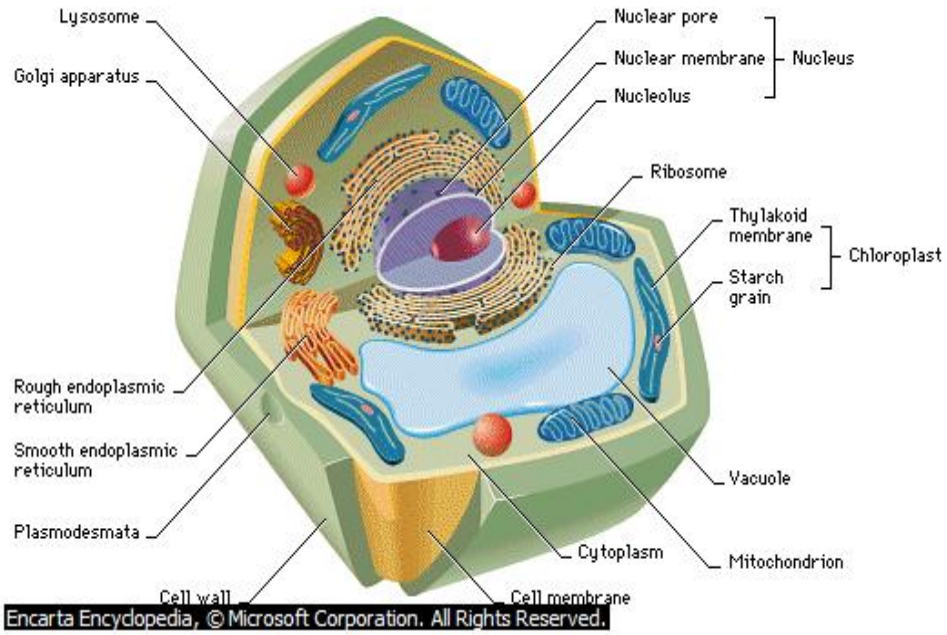
(III)Scientific name must be underlined when hand written : typed in italics

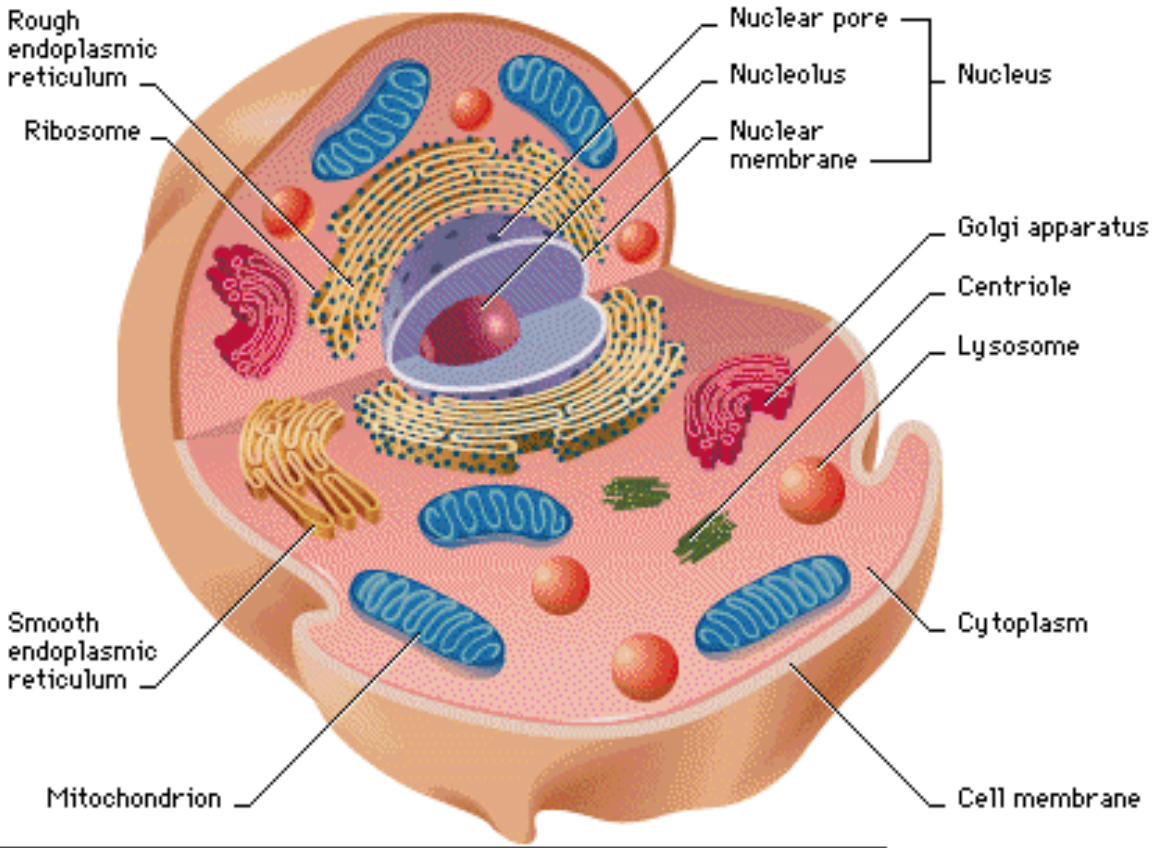
- **Species belonging to one genus could have evolved from a single plant ancestor (Bidens sps.)**
- **Polynomial system of nomenclature.**
- **Example Jack Bwalya Chishilu.**

Scientific names for common Plants

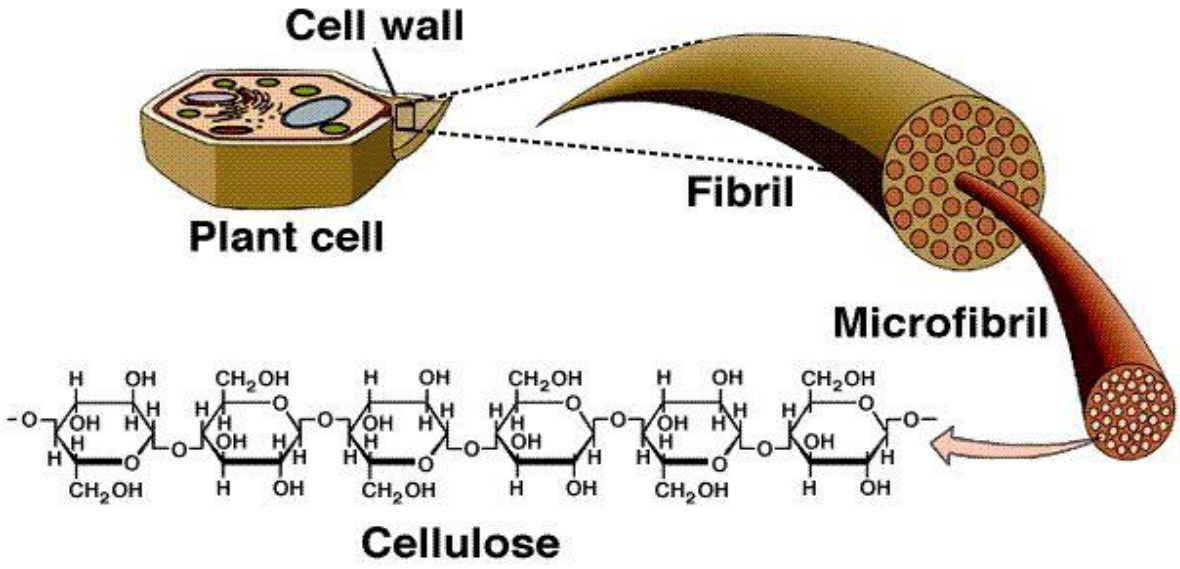
- **Bambara nuts, Nkalanga, Ntoyo, Nzyama= *Vigna subterranea***
- **Baobab, Mubuyu, Mulambe = *Adansonia digitata***
- **Black jack, Kasokopyo,kasokopye= *Bidens pilosa***
- **Finger millet, Bule *Eleucine coracana***
- **Ground nuts Ndonge,Nshawa =*Arachis hypogea***

ANIMAL AND PLANT CELLS

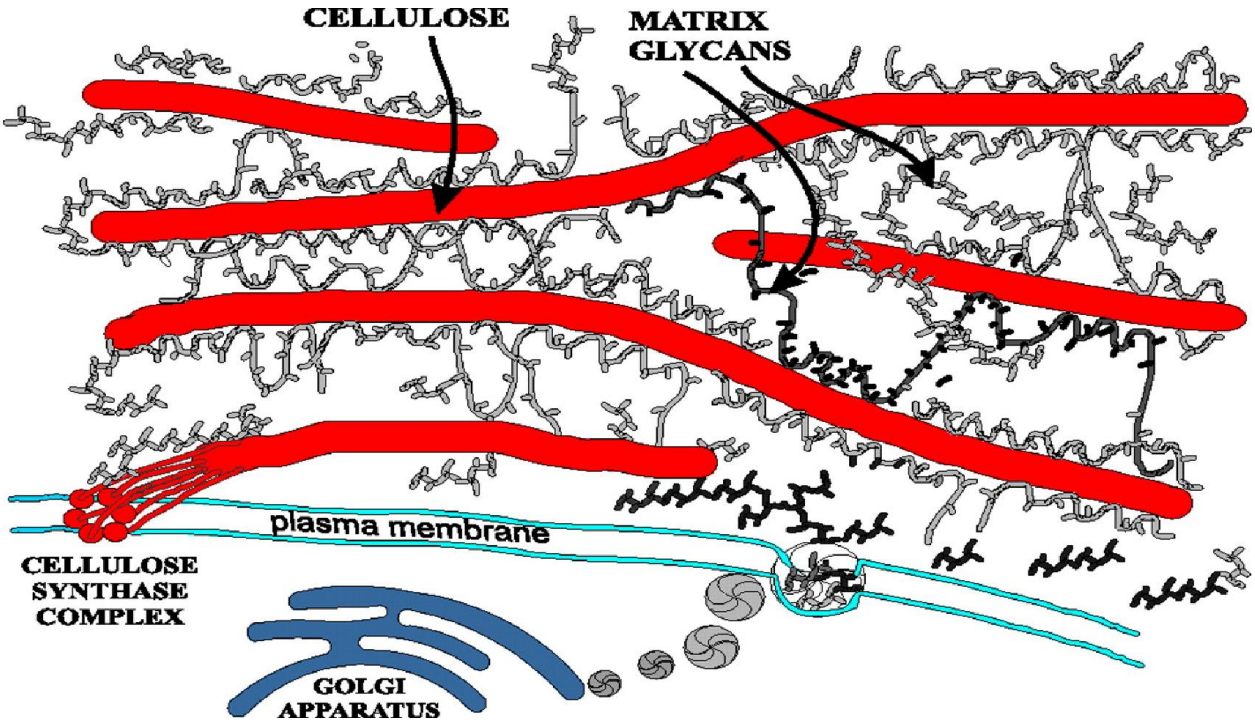




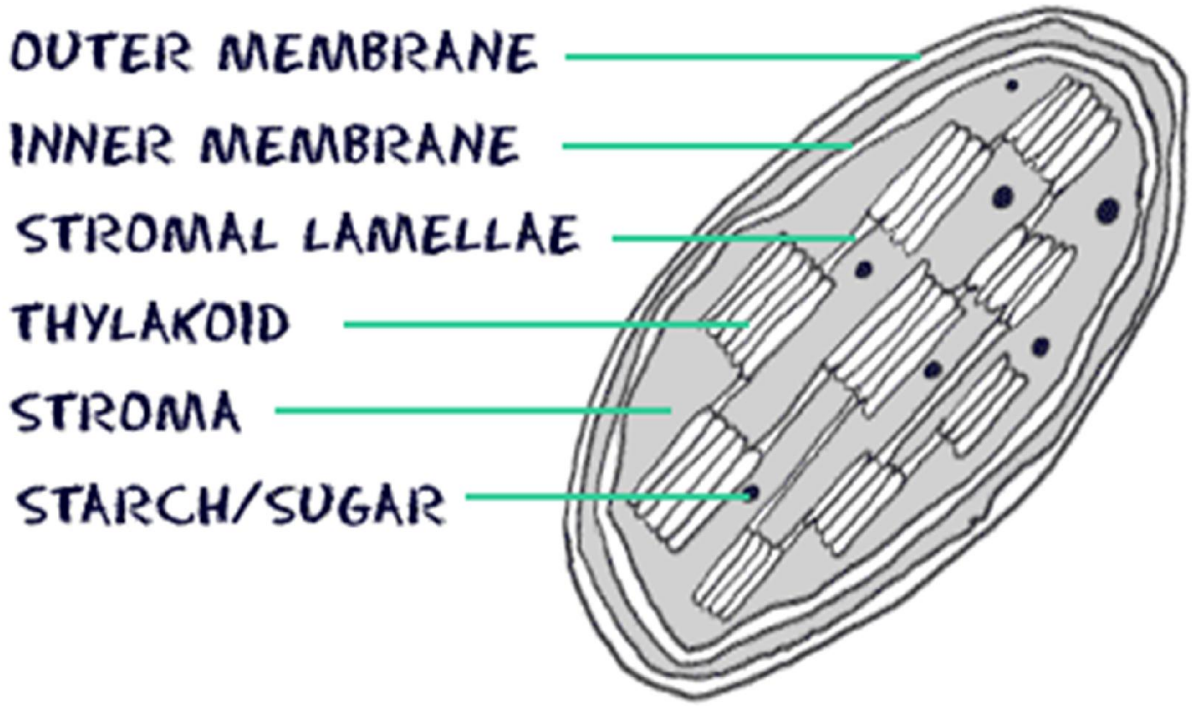
Arrangement of Fibrils, Microfibrils, and Cellulose in Cell Walls



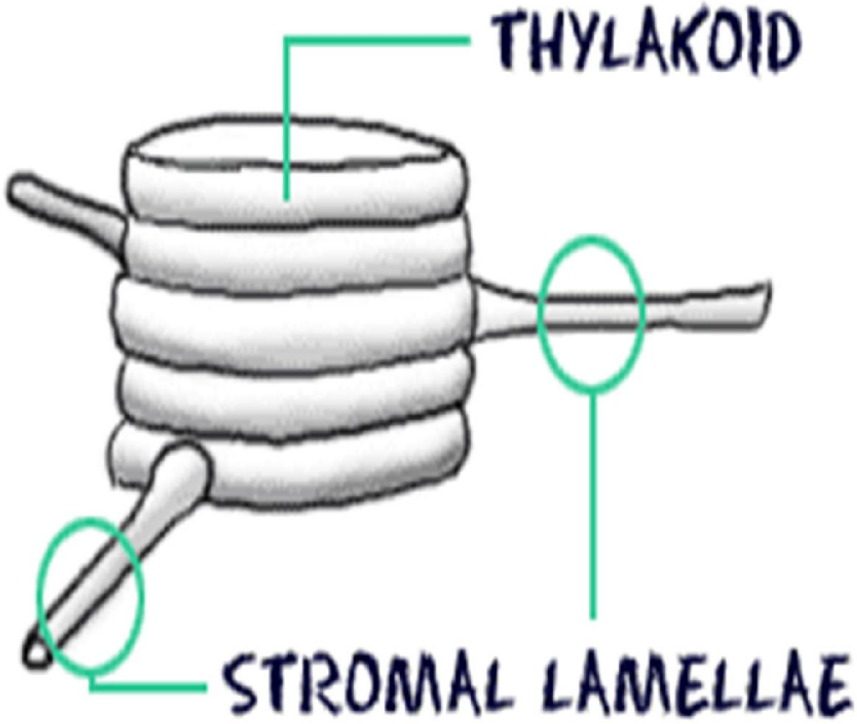
CELLULOSE SYNTHASE



CHLOROPLAST

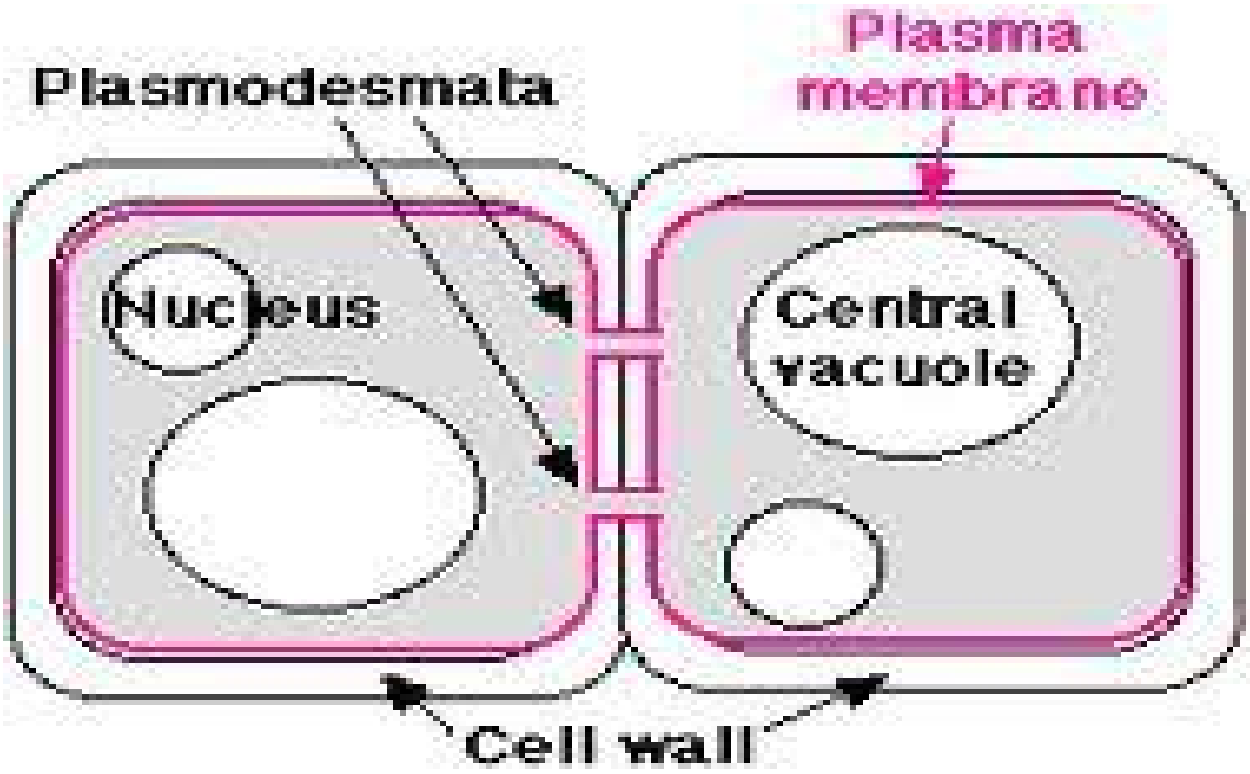


GRANUM



- **The stroma is an area inside of the chloroplast where reactions occur and starches (sugars) are created.**
- **One thylakoid stack is called a granum. The thylakoids have chlorophyll molecules on their surface**

PLASMODESMATA

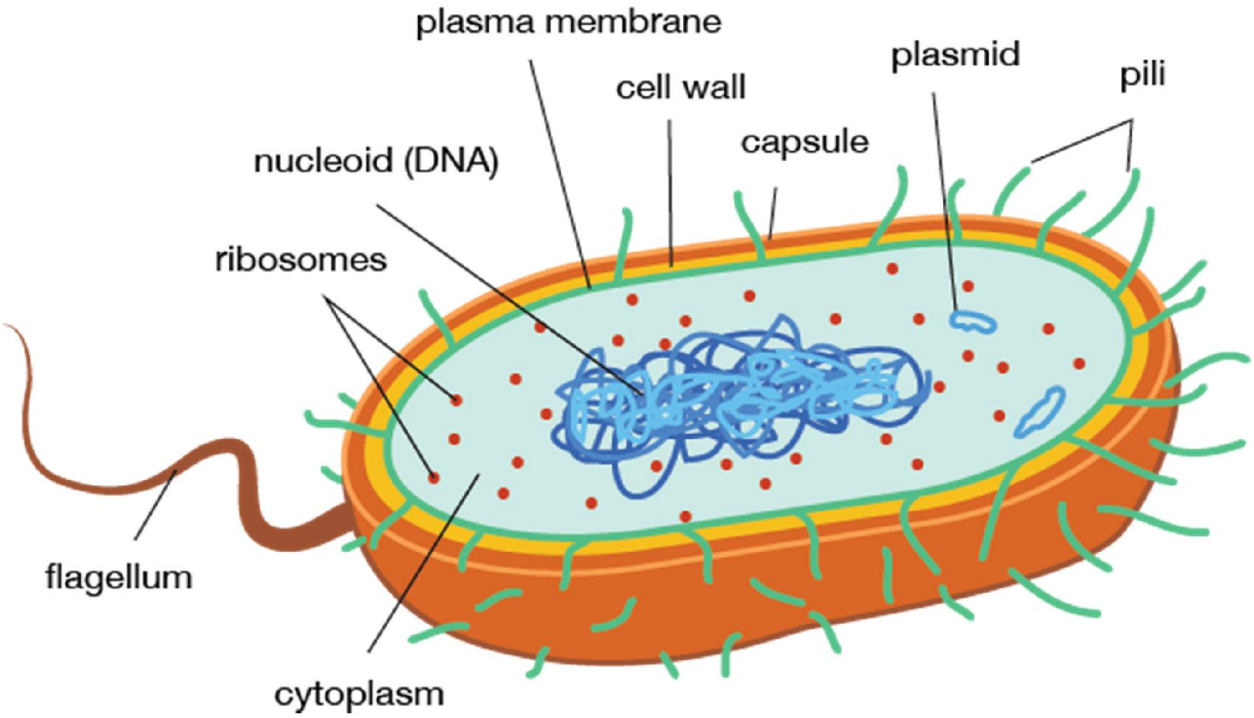


The Prokaryotic Cells

Introduction

- **The prokaryotic organisms are structurally the simplest forms of life forms.**
- **The prokaryotic organisms on this globe embrace the bacteria and the blue–green algae.**
- **In the evolutionary terms, the bacteria and blue –green algae are the oldest forms that are known to have *evolved much earlier* than the eukaryotic organisms.**
-

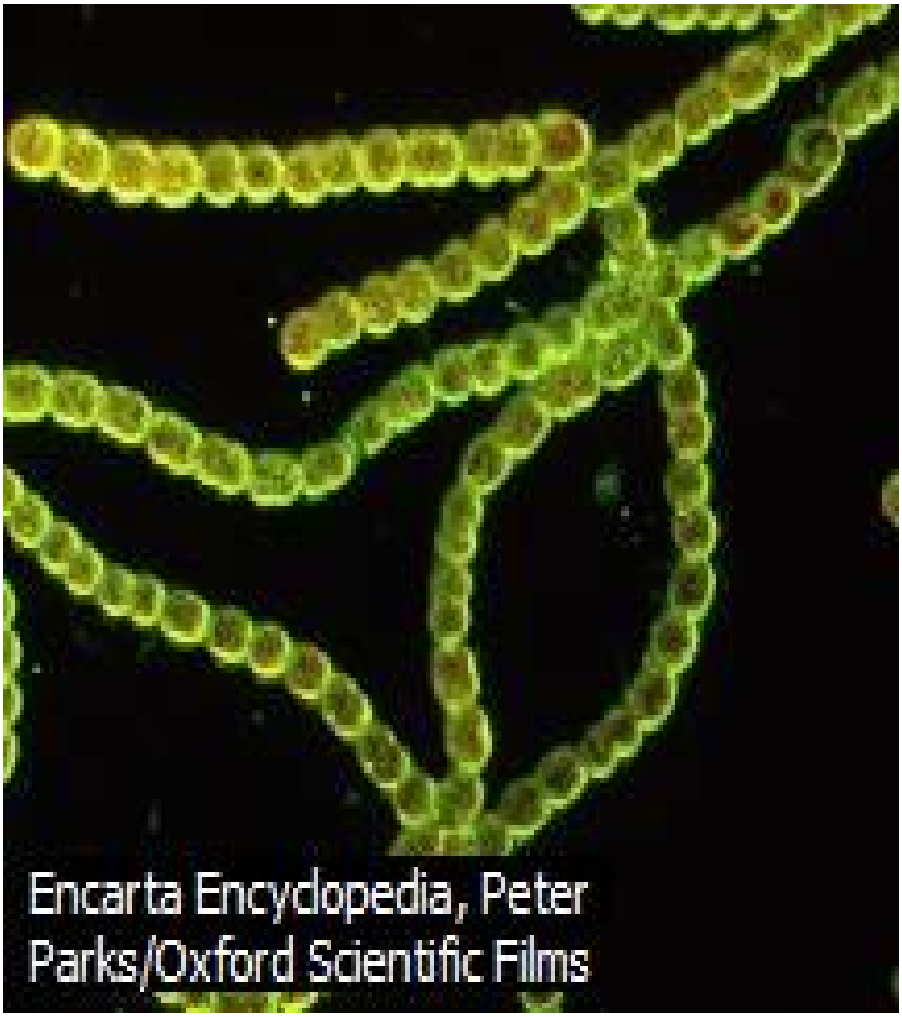
Cell structure of Bacterium cell



Streptococcusa Bacteria

- **This scanning electron micrograph shows disease-causing Streptococcus bacteria, commonly found in the human mouth, throat, respiratory tract, bloodstream, and wounds. Often airborne in hospitals, schools, and other public places, Streptococcus bacteria are responsible for infections such as strep throat, scarlet fever, and some types of pneumonia.**

Blue –green algae



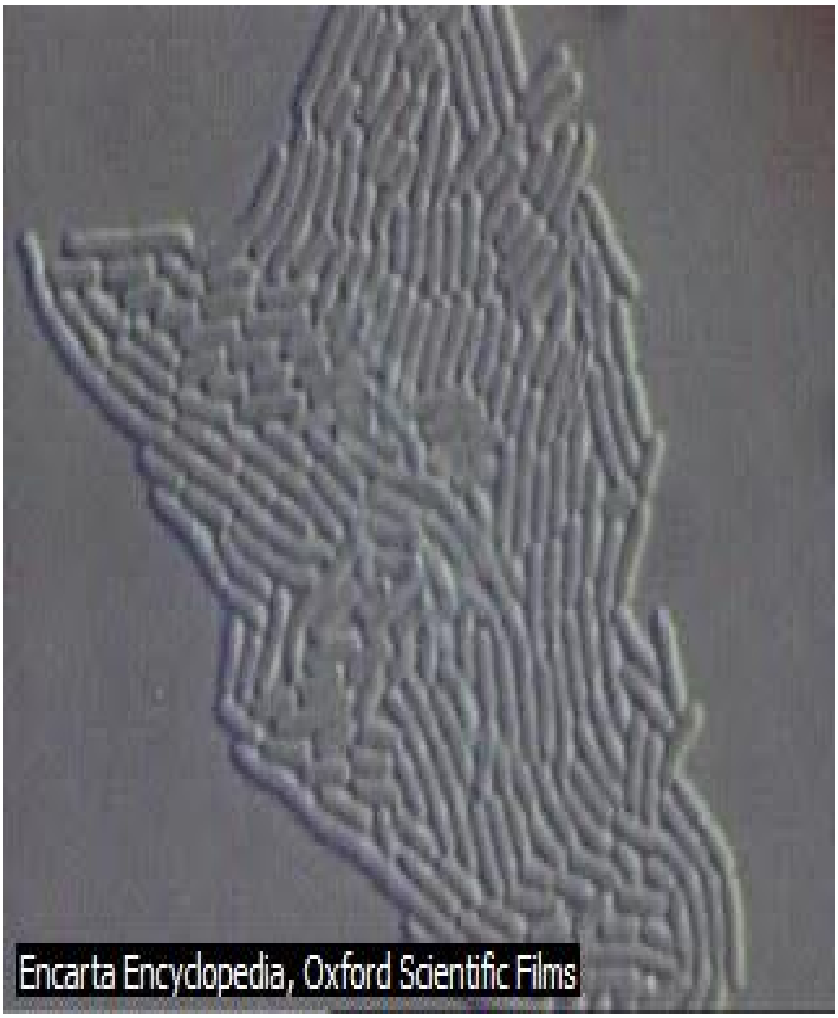
- **Cyanobacteria (formerly blue-green algae) are among the most ancient organisms on Earth.**

- **These photosynthetic organisms can be single-celled, connected in a filamentous form as shown here,**
- **Cyanobacteria are capable of enduring a wide variety of environmental conditions ranging from freshwater and marine habitats to snowfields and glaciers.**

The Cell Structure

- **The prokaryotic organisms have simpler forms of cells which are relatively small.**
- **Prokaryotic cells lack membranes –bounded nuclei and other membrane –bound organelles.**
- **Since the organelles are not membranes bounded, therefore the nucleus is not distinct.**
- **The cells also lack the presence of such cellular components as the mitochondria, chloroplasts, the Golgi apparatus and the lysosomes.**
- **In prokaryotic cells genetic information is located on a single chromosome which consists of a circular double –strand of DNA.**
- **The nuclear region where DNA is located is called the nucleoid, a region which is not surrounded by a separate membrane envelope.**
- **The DNA is devoid of the basic proteins called the histones, which are found in chromosomes.**
- **The nucleus of prokaryotic cell has no nucleolus.**
- **The cytoplasm is not divided into compartments, but has the feature of fine granular appearance due to the presence of numerous ribosomes of as many as 10,000 per cell.**
- **The cytoplasm contains storage granules of glycogen and poly-B-hydroxybutyric acid.**
- **The cells are characterised by the presence of cell walls composed of a blend of carbohydrates and the amino acid that surround the plasma membrane.**
- **The cell wall is thus comprised of the polymers (chain) of peptidoglycan - a chain of amino sugars.**
- **The prokaryotic organisms are very common in our environment.**
- **They are characterised by rapid growth and short generation time (short life –span /short lived.)**

They are characterised by rapid growth and short generation time



- **Upon reaching a critical size and metabolism, bacteria and.**
- **A bacterium may divide as often as every six minutes,**
- **Quickly forming a colony such as the one shown here that is visible to the human eye**

THE FUNGI CELLS

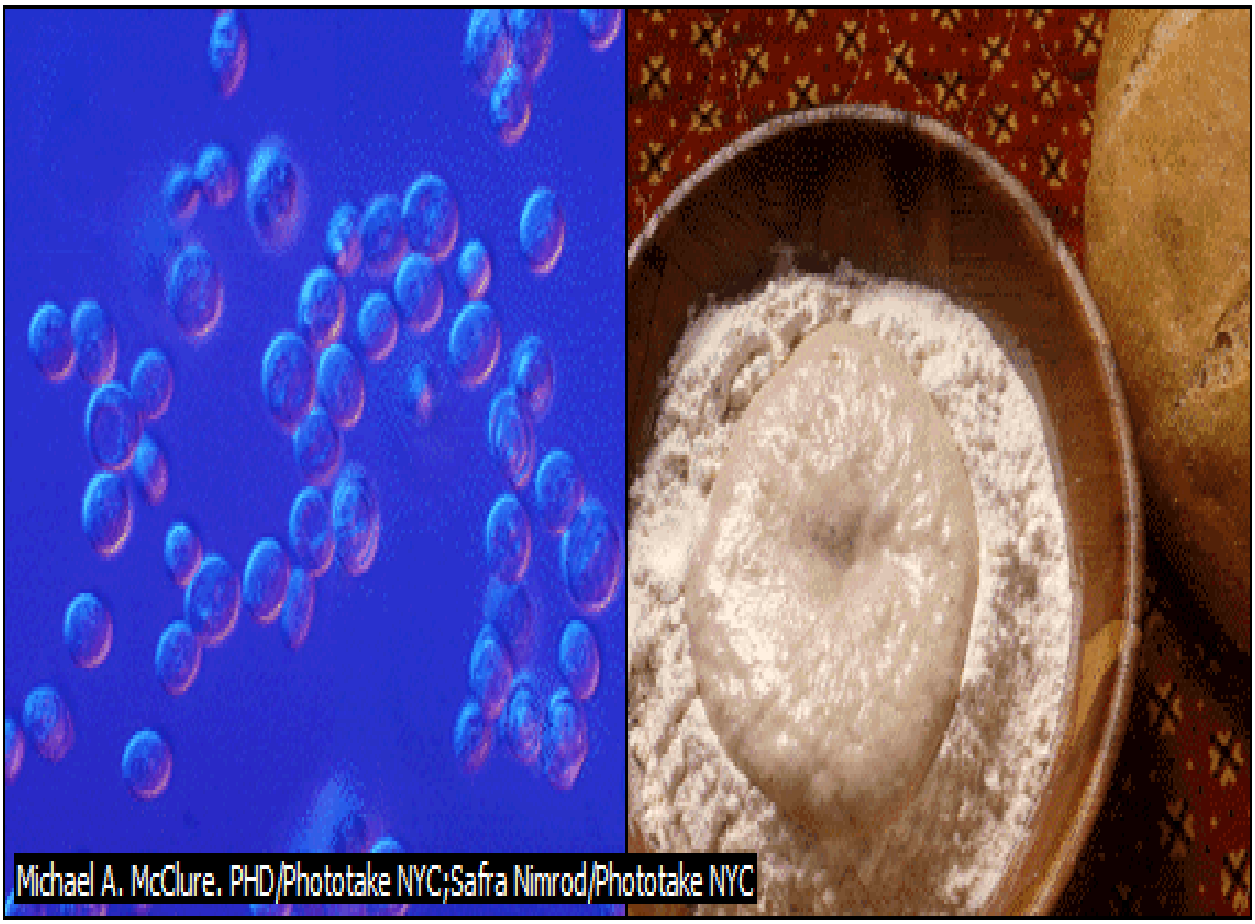
- **Fungi cells bare all the characteristics of eukaryotic organisms**
- **Most Fungal cells particularly higher groups of fungi:**
- **Zygomycetes ,Ascomycetes,Basidyomycetes all**

consists of chitin and carbohydrates

Zygomycetes (Black Bread Mold)

- **phylum Zygomycota, this black bread mold growing on a piece of stale bread shows the mycelium, or interwoven filaments that make up the vegetative portion of the fungus.**
- **The small dark spots are the fruiting bodies, or sporangia, from which the spores are released.**

Ascomycetes- bakers yeast



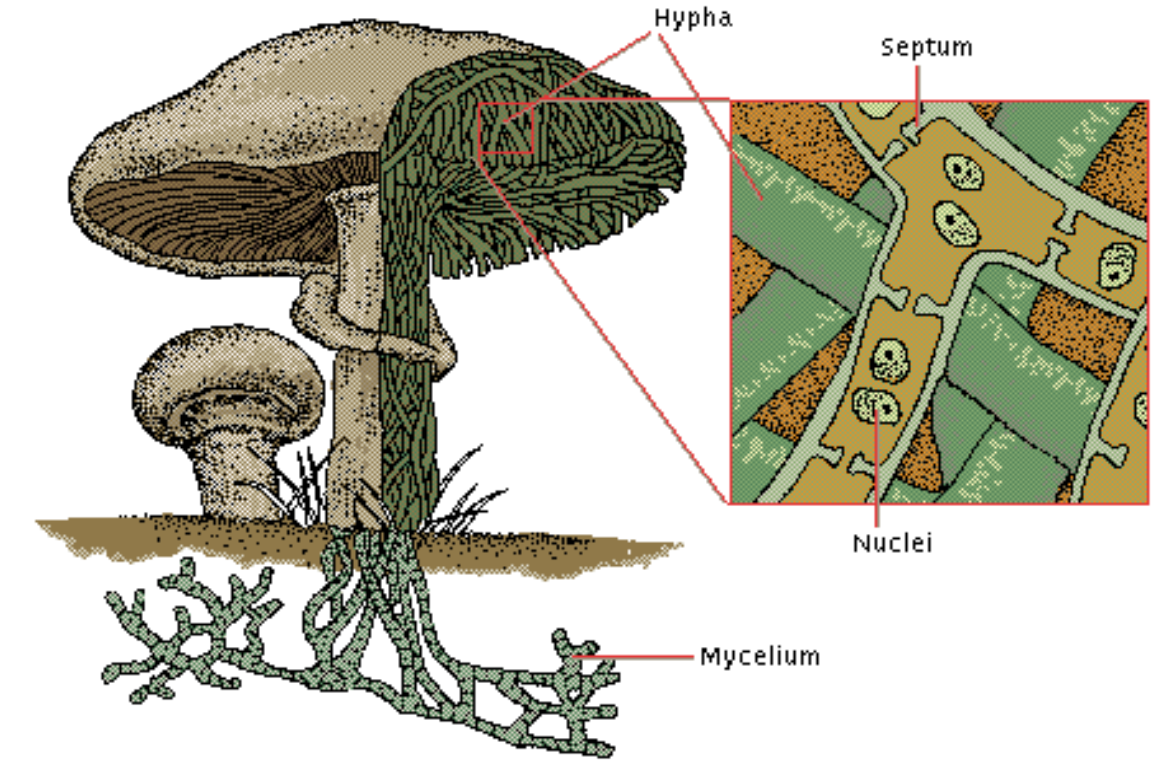
- **Bread yeast, Saccharomyces cerevisiae, or baker's yeast, a type of fungi,**
-
- **Bread yeast causes bread to rise by releasing carbon dioxide, which gets trapped in the dough.**

Basidyomycetes(Mushroom)

Structure of a mushroom

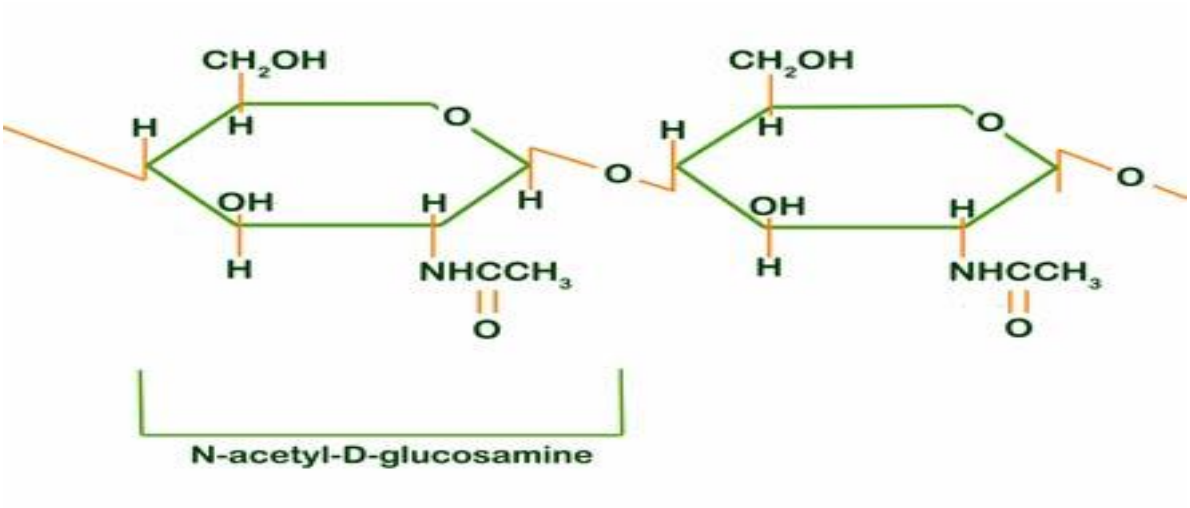
- **Fungi are made of filamentous tubes called hyphae.**
- **In many species, perforated walls, or septa, divide the hyphae into cells containing one or two nuclei.**
- **Protoplasm flows through the opening in the septa to provide the cells with nutrients, which are stored in the hyphal walls as glycogen.**
- **The entire mass of hyphae is collectively called the mycelium.**

Mushroom



Chitin

.Chitin is simillar to cellulose but its molecules contain nitrogen



Chitin is a compound comprised of Glucosamine and acetic acid

A glucosamine is a form of the amino-sugar based on the glucose molecules.

The Amino- sugars are compounds where the amino acid is linked to the sugar molecule.

The microfibres (microscopic fibres) of chitin run parallel to the surface of the cell

- **In some lower groups of fungi the cell wall comprises cellulose which is masked with chitin**
- **The cytoplasm of all fungal cells lacks chloroplasts.**
- **Fungi are non- photosynthetic plant like organisms The mode of Nutrition is Saprophytic or Parasitic.**

The Biology Molecules: Carbohydrates

Introduction

- **Organic compounds are based on the chemistry of the element called carbon.**
- **Carbon forms the framework for all Biological molecules.**
- **Molecules consisting of carbon and hydrogen - hydrocarbons.**
- **Hydrocarbons - diesel, petrol, paraffin and propane are good sources of fuels.**
- **Other atoms, such as hydrogen, nitrogen, oxygen, and sulphur are attached to the carbon skeleton to form a range of organic molecules.**

The concept of life is almost synonymous with the chemistry of carbon in that carbon has properties that are both unique and essential for the life of all organisms.

- **There are a million of possible carbon compounds**

varying in the number of carbons they contain

- **varying in the types and the number of non –carbon atoms they contain.**
- **The main types of biological molecules are: carbohydrates, lipids, proteins, nucleic acids.**

The Carbohydrates

- **Carbohydrates are defined by two criteria:**
- **They usually contain the elements carbon, hydrogen and oxygen.**
- **The ratio of hydrogen to oxygen attached to carbon (hydrogen: oxygen) is close to 2:1**
- **A group of organic molecules that contain carbon, hydrogen and Oxygen**

FUNCTIONS

Energy in living organisms is stored in the form of carbohydrates.

- **Carbohydrates are the major compounds that makes up plants- dry biomass**

Carbohydrate classification

- **Carbohydrates are broadly classified into such groups as:**
- **Monosaccharide (mono- = one)**
- **Disaccharides (di- = two) and**
- **Polysaccharides (poly- = many)**

Monosaccharides

- **Monosaccharides are small molecules that cannot be hydrolyzed or broken down into simpler compounds**
- **They are further classified *according to number of carbon atoms* they posses in their molecules,**

and such classes of sugar includes :

- **The trioses with a chain of three carbon atoms**

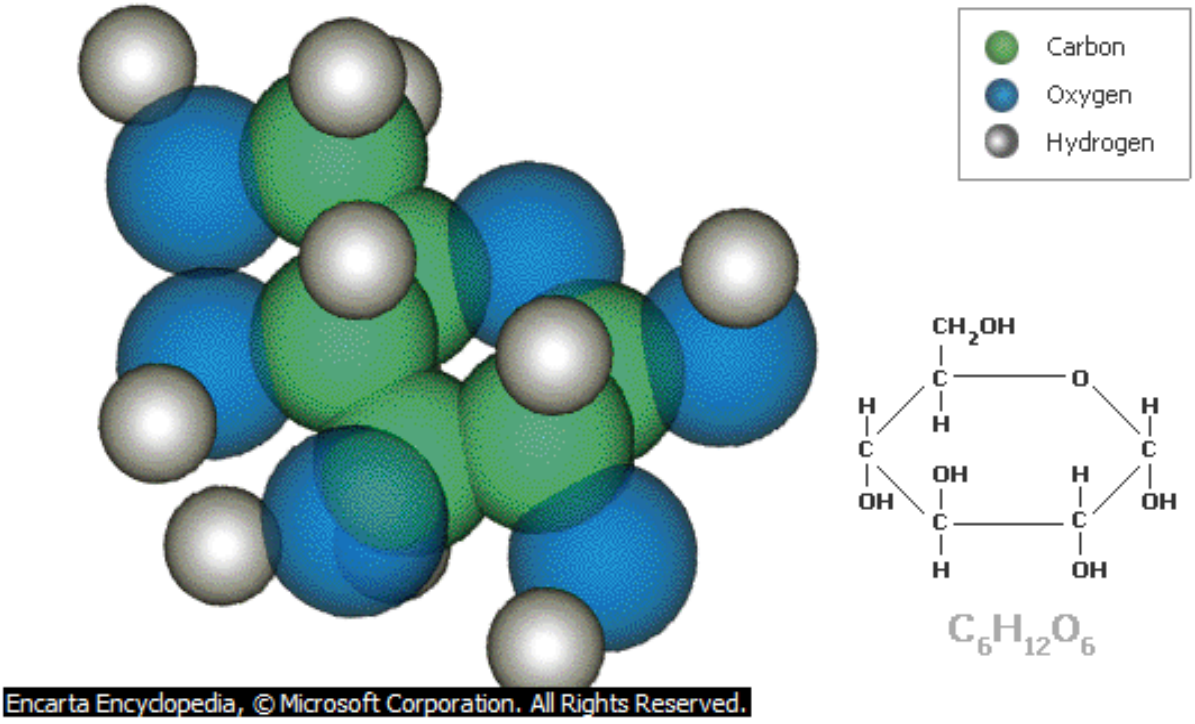
.

- **They are further classified *according to number of carbon atoms* they posses in therir molecules, and such classes of sugar includes :**
- **The trioses with a chain of three carbon atoms**
- **The tetroses with a chain of four carbon atoms**
- **The pentoses with a chain of five carbon atoms**
- **The hexoses with a chain of six carbon atoms**

Function of Monosaccharides

- **The most important energy storage molecules are in the form of sugars.**
- **These four groups are the simplest forms of sugars, which may link together to form disaccharides and polysaccharides.**
- **The Monosaccharides, considered as simple carbohydrates, are described by the formula(CH_2O)n, giving a ratio of 1:2:1.-proportion of one carbon atom to two hydrogen atoms to one oxygen atom.**
- **The above proportion helps to explain the meaning of the term 'carbohydrates'**
- **carbohydrates' literally means ''carbon (C) with water (H_2O) added'' to it**
- **The Monosaccharides that are known to be physiologically important in living organisms include, arabinose, deoxyribose, ribose, fructose, glucose, galactose, mannose.**
- **Arabinose, ribose and deoxyribose are a form of pentoses ($C_5H_{12}O_5$).**
- **Fructose, galactose and mannose are a form of hexoses($C_6H_{12}O_6$).**

Glucose



Function of Glucose

- **Glucose is thus the form in which sugar is mostly transported through the circulatory systems of animals –including humans.**
- **Glucose is known to be the main metabolic fuel for animal tissues and is thus referred to as the ‘‘blood-sugar’’.**
- **In higher animals glucose ($C_6H_{12}O_6$) is the main metabolic fuel for mammals such as humans, cattle, elephants.**
- **Glucose is a constituent of many polysaccharides such as starch.**
- **In clinical cases, such as a physiological disease called diabetes**
- **glucose, which is not metabolized due to lack of insulin, is execreted in the urine**
- **Hypoglycaemia -a deficiency of glucose in the blood-stream causes muscular weakness, mental confusion and sweating.**
- **This sugar is important in energy metabolism of animals –it is a source of energy**
- **Treatment of hydroglycaemia is administered by the injection of glucose if the patient is in a state of coma, or by oral administration of glucose if the patient is conscious.**
- **The sources of glucose for animals are the fruit juices; and also obtained by hydrolysis of sucrose, lactose and maltose.**

Fructose

- **This is a simple hexose sugar which is a component of sucrose**
- **The hydrolysis of sucrose (cane sugar) produces (sets free) glucose and fructose.**
- **Fructose ($C_6H_{12}O_6$) occurs in green plants, fruits and honey, and it is known to taste much sweeter than sucrose.**
- **Fructose is extensively used in the manufacture of soft drinks, caned fruits and jam.**

Disaccharides

- **These are groups of carbohydrates composed of two simple sugars.**
- **Disaccharides serve as a form of transport molecules in plants,**
- **provide nutrition to the animals.**
- **In plants glucose is converted into a transport form before it is moved from one region to another region**
- **Disaccharides serve as reservoirs of glucose.**

- **Condensation reaction :The process that leads to the synthesis of a disaccharide**
- **entails that fusion of two Monosaccharides is accompanied by the loss of one molecule of water.**
- **The above process is known as the dehydration synthesis**
- **The splitting (break down) of a disaccharide into 2 simple sugars is the process that involves the addition of water molecules –and this process is referred to as hydrolysis.**

Sucrose

- **Sucrose is an example of a disaccharide composed of fructose and glucose**
- **It is a form of sugar transported in plants from the leaves to other organs of plant.**
- **In sugar –cane plants sucrose accumulates in the stems.**
- **In beetroots plants sucrose accumulates in the modified root tubers and such plants are the source of sugar in Europe.**

Lactose

- **This is form of disaccharide found in milk, composed of galactose and glucose.**
- **Many mammals supply energy to their young in the form of lactose contained in milk.**

Polysaccharides

- **These are the macromolecules comprised of long chains of simple sugars.**
- **They are polymers made up of more than two Monosaccharides.**
- **The Monosaccharides are linked to form complex molecules through the process of condensation**
- **The functions of polysaccharides are two- fold :**

(a) they act as storage forms of the sugar;

(b) They are involved in the structural role of cells and their components.

Starch

- **This is a polysaccharides composed of chains of glucose molecules.**
- **Thus starch serves as the principal storage form of carbohydrates in plant tissues.**
- **Amylose is a variant of starch made up of the unbranched chains of glucose**

- **In water, amylose reacts with iodine to give a characteristic blue color.**
- **Amylopectin is yet another variant of starch made up of branched chains of glucose.**

Cellulose

- **Cellulose which is also composed of glucose molecules.**
- **As noted earlier, cellulose is the main component of cell walls in plants.**
- **When glucose molecules are incorporated in plant cell walls in form of cellulose then glucose as a constituent of cellulose is not available as the source of energy.**
- **in plants wood consist of about 50% cellulose**
- **cotton fibre is comprised of 100% cellulose**
- **cellulose is not digested by most animals, but can only be digested by such organisms as the bacteria, fungi, cockroaches, termites, and ruminants which possess enzymes that break down cellulose to release glucose as a source of energy**

Glycogen

- **This polysaccharide is similar to starch, made up of highly branched chains of glucose molecules**
- **It is a major storage form of polysaccharide as a source of energy in animals, fungi and some prokaryotic organisms**

Chitin

- **It is also structural polysaccharide made up of acetylglucosamine which consist of molecules of glucose to which a nitrogen compound has been attached.**
- **Chitin is a polysaccharide which forms the cell walls of fungi**
- **Some chemical variant of chitin form the exoskeleton of such arthropods as the insects and crustaceans.**

The Biological Molecules: Proteins

- **Proteins are a group of macromolecules that possess such elements as carbon, hydrogen, oxygen and nitrogen.**
- **Some variants of proteins also contain the element of sulphur**

Functions of Proteins

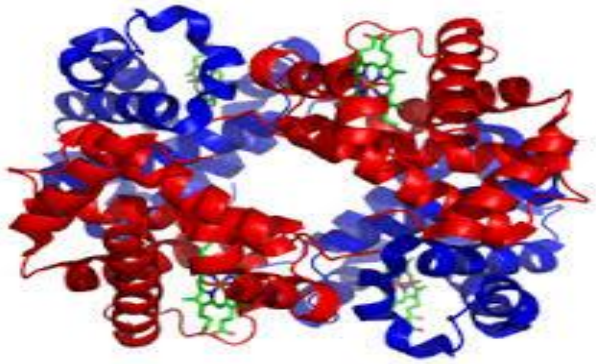
- **The breakdown (catalysis) of macromolecules into simpler compounds, as effected by enzymes.**
- **The provision of defense, as effected by antibodies in the immune systems of humans, and as the poison of snake venom.**
- **Provision of support in the form of protein fibres.**

Functions

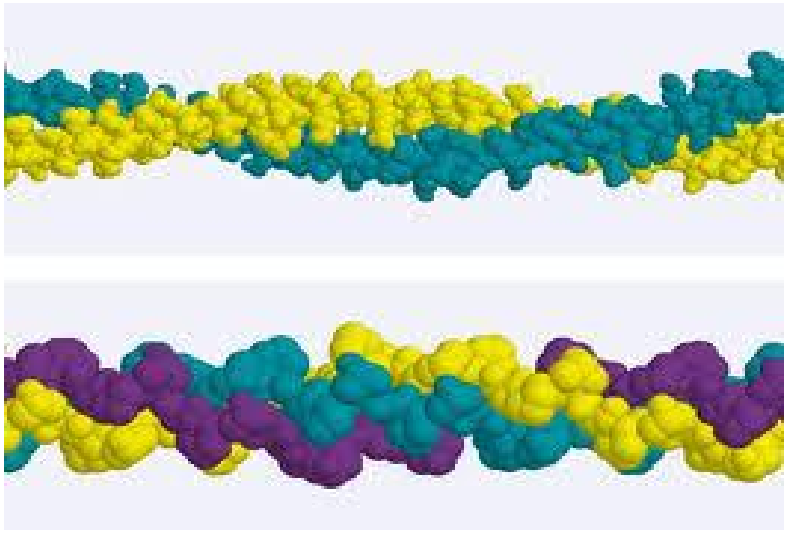
- **Facilitation in the motion of body parts, as effected by muscles.**
- **Regulation of physiological processes, as effected by hormones. (e.g adrenaline, insulin).**
- **Transport of oxygen and iron as effected by hemoglobin.**
- **Play the role of storage, as effected by some storage proteins that bind onto iron and calcium.**

Globular and fibrous proteins

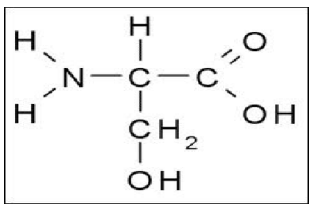
- **The structure of proteins may be globular or fibrous**
- **Globular proteins have compact rounded molecules and are usually water-soluble.**
- **Haemoglobin**



- **Globular proteins are usually in the form of enzymes, antibodies, haemoglobin.**
- **Collagen**



- **Fibrous proteins usually in the form of coiled strands or flattened sheets which impart strength to organs.**
- **The clotting of blood involves the fibrous proteins called fibrin**
- **The largest concentration of proteins in plants is found in the seeds where they act as they are storage forms of amino acids.**
- **The building blocks for proteins are the amino acids.**
- **Amino acids are formed within the living cells using sugars as the starting materials (or using sugars as (precursors).**
- **The amino acid is a molecule in which the carbon atom is attached to a hydrogen atom, a carboxyl group and the amino group**
- **It is the amino group that contains the nitrogen atom.**
- **Plants usually obtain nitrogen from ammonia, nitrates and nitrites.**
- **Animals are able to synthesize some of their own amino acids using ammonia derived from their diet as source of nitrogen.**
- **E.g Serine**



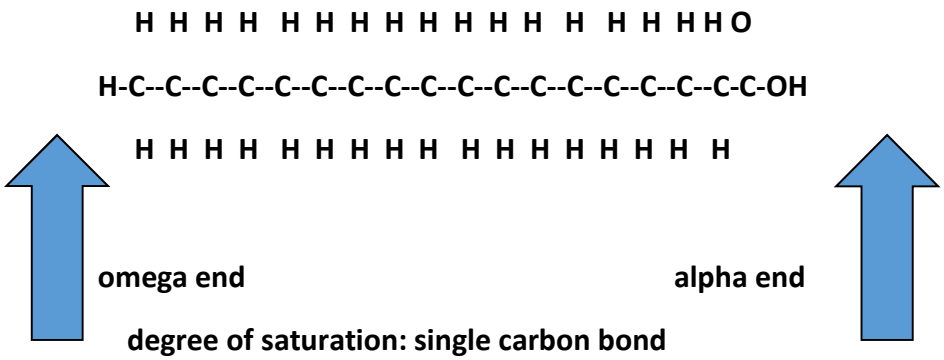
- **The amino acids which animals cannot synthesize are referred to as the essential amino acids which are usually obtained from the diet contained in plant and animal foods.**
- **There are 20 common amino acids, and these include alanine, aspartic acid, glutamine, glycine, histidine, isoleucine, leucine, lysine, methionine, tryptophan.**
- **Note that beans we eat are deficient in amino acids *cysteine, methionine and tryptophan;* but are a good source of *isoleucine and lysine.***
- **Rice is deficient in *isoleucine* and lysine; but has adequate amounts of other aminoacids.**
- **Vegetarians are advised to eat beans and rice which provide a perfect combination of the essential amino acids.**

Lipids

Properties of Lipids

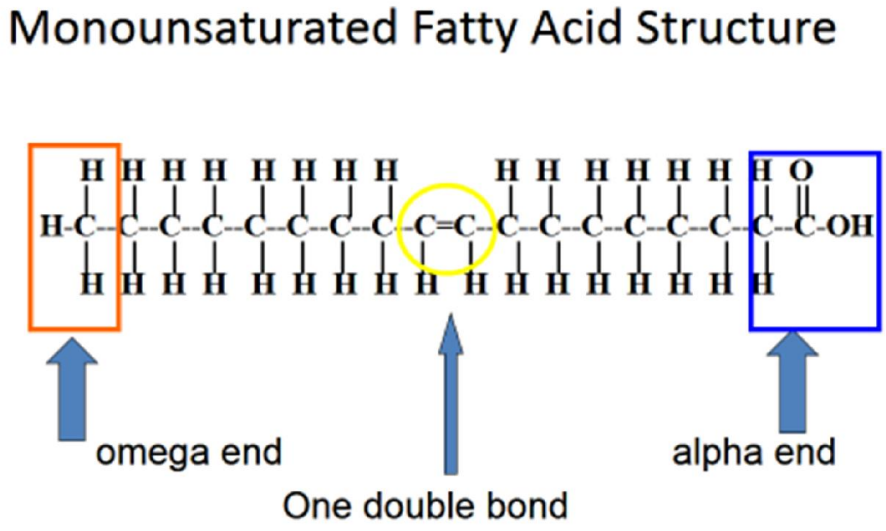
- **Do not readily dissolve in water**
- **Fats are solid at room temperature**
- **Oils are liquid at room temperature**
- **Triglycerides are the main form of lipids in food and body (storage)**
- **Energy dense (9 kcal /gm)**
- **Lipids are fats or fat like substance that are generally *hydrophobic***
- **Examples of lipids are: storage fat, such as the *animal fat* which are the saturated lipids.**
- **Other forms of lipids are oils, such as cooking oil (the sun flower oil) which are the unsaturated lipids.**

Saturated Fatty Acid Structure



degree of saturation: single carbon bond

Monounsaturated Fatty Acid Structure



- **Lipids derived from plants and fish are usually unsaturated and are thus in liquid state at normal temperature.**
- **Other lipids are in form of cutin which forms the cuticle on the surface of the leaf epidermis,**
- **suberin which is a component of cork cell walls.**
- **The waxes (beeswax made by bees, and ear wax in humans) are other variants of lipids .**
- **When placed in water many *lipids molecules clusters together and floats on the aqueous surface.***

Functions of lipids

- **Lipids serve the role as structural materials, as well as being a form of energy reserves.**
- **In plants cells fats are synthesized from sugars.**
- **The building blocks for lipids are the fatty acids and glycerol;**
- **The hydrolysis of lipids gives rise to fatty acids and glycerol as the principal component.**

Classification of Lipids

Glycerolipids

- **These are mainly composed of:**
- **mono-glycerols,**
- **di-glycerols**
- **Triglycerols**
- **Figure 1**

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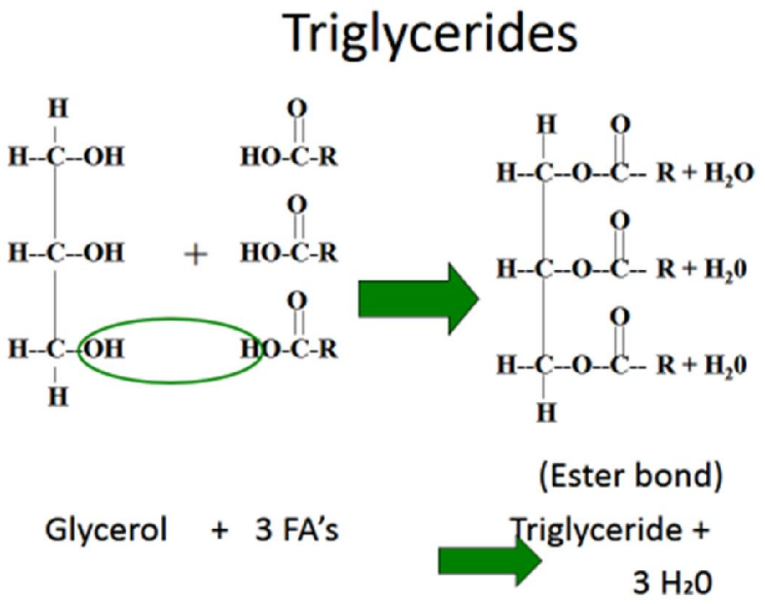
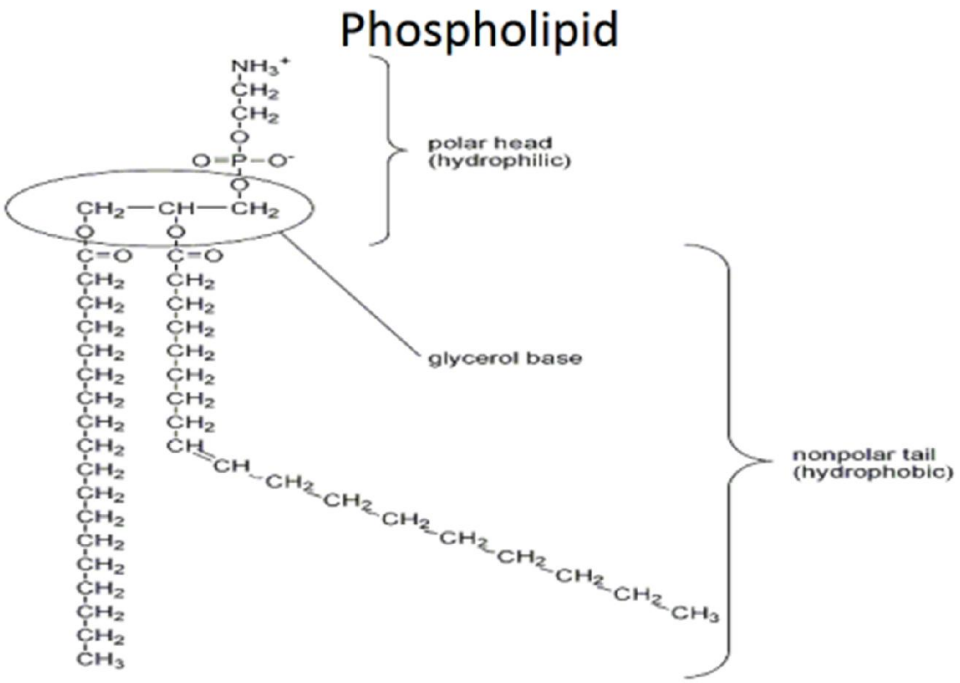


- **These lipids contain the bulk of storage fat in animal tissues.**
- **Lipids derived from animals are saturated.**

- **The saturated lipids which appear in solid state at normal temperatures are called fats**

  Glycerophospholipids
- **These are referred to as the phospholipids**
- **Phospholipids contain two fatty acids and one phosphate linked to the glycerol. Figure 2**
- **They are the main components of the membranes**
- **Membranes are composed of layers of phospholipids and proteins.**



CONTENT REVIEW

- How are saturated fatty acids different from unsaturated fatty acids?
- What are the main functions of lipids in human beings.
- Distinguish phospholids from glycerolipids
- Explain how the hydrogen bonds affects the function of Lipids.

Nucleic acids

- **Nucleic acids were discovered by Friedrich Miescher in 1869.**
- **These are a category of biological molecules that are essential for most forms of life on this planet.**
- **The Nucleic acids were named as such because they were discovered within the nucleus of eukaryotic cells.**
- **For the presence of phosphate groups that are related to phosphoric acids.**
- **Nucleic acids are known to be found in all kinds of life forms, including the prokaryotic organisms such as the bacteria and viruses**

Nucleic acids

- **Outside the nucleus, nucleic acids are also found in such organelles as chloroplast and mitochondria.**

FUNCTIONS

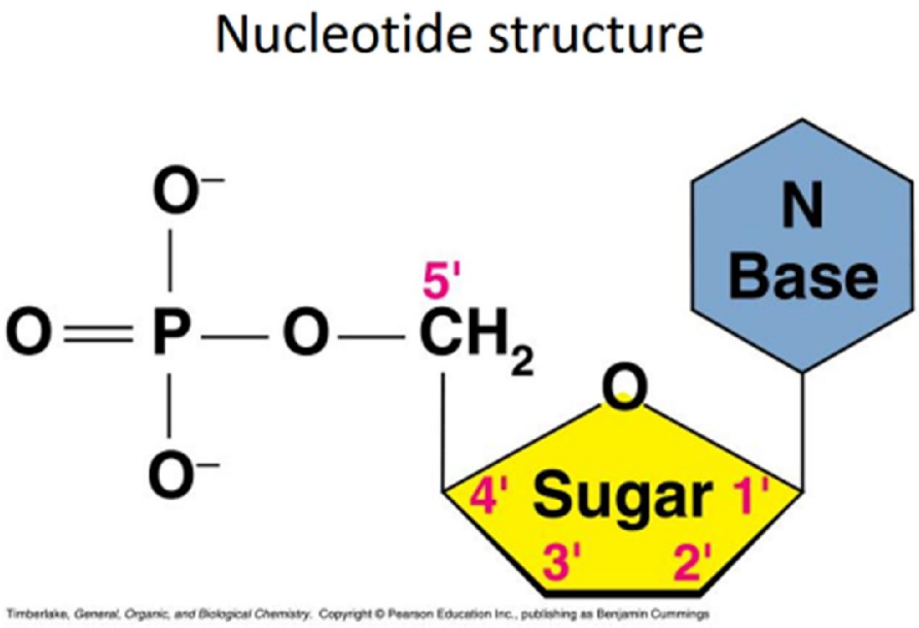
- **Nucleic acids are the molecules that:**

carry genetic information that determines the structures and physiological processes in the nature of organisms.

- **The two types of nucleic acids are: DNA and RNA and these are generally very large molecules.**
- **All living cells and organelles contain both DNA and RNA**
- **viruses contain either DNA or RNA, but usually not both**

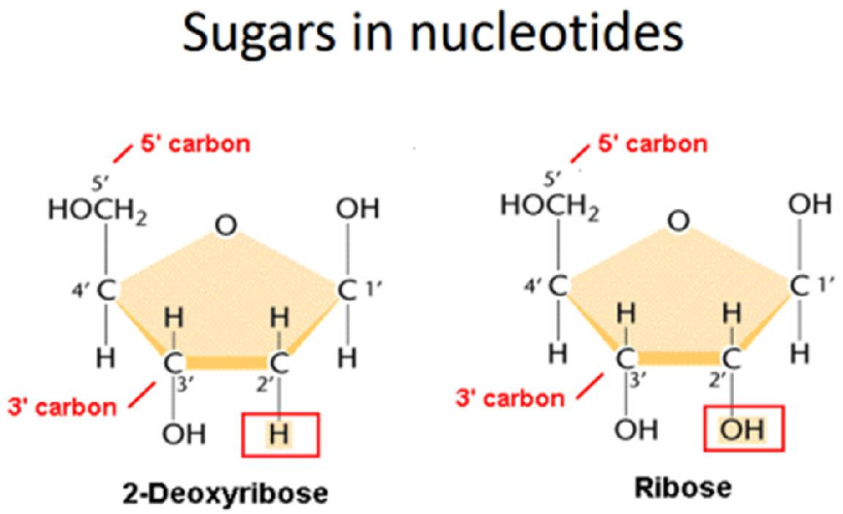
Structure of Nucleic Acids.

- **Nucleic acids consist of long chains of nucleotides.**
- **These molecules are linear chains (or polymers) of nucleotides.**
- **A nucleotide consists of a phosphate group, 5-carbon sugar and nitrogenous base.**

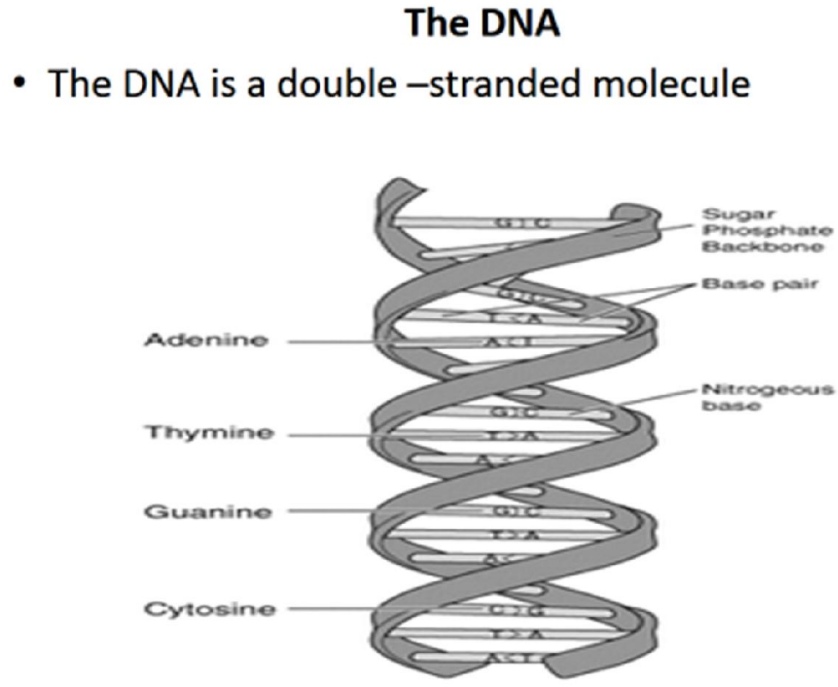


- **Examples of the nitrogenous bases are adenine, cytosine, guanine, thymine and uracil.**
- **Adenine, cytosine and guanine are found in both DNA and RNA**
- **Thymine is only found in DNA whereas uracil is also restricted to RNA.**
- **The two pentose sugars contained in the nucleotides are known as ribose and deoxyribose.**
- **Both ribose and deoxyribose exist in furanose ring form.**

- **Ribose is 5-carbon sugar which is found in nucleotides that form ribonucleic acids (RNA); whereas deoxyribose is another kind of a 5-carbon sugar that is found in nucleotides that form deoxyribonucleic acids (DNA).**



(Klug & Cummings 1997)



- **DNA is the main component of the chromosomes and is the carrier of genetic messages (or the genetic code).**

- **It contains the genetic instructions that are used in the development and functions of all forms of living organisms.**
- **The main function of DNA molecules is the long term storage of genetic information.**
- **DNA contains the instructions needed to construct other components of cells.**
- **The DNA segments that carry this genetic information are called the genes.**

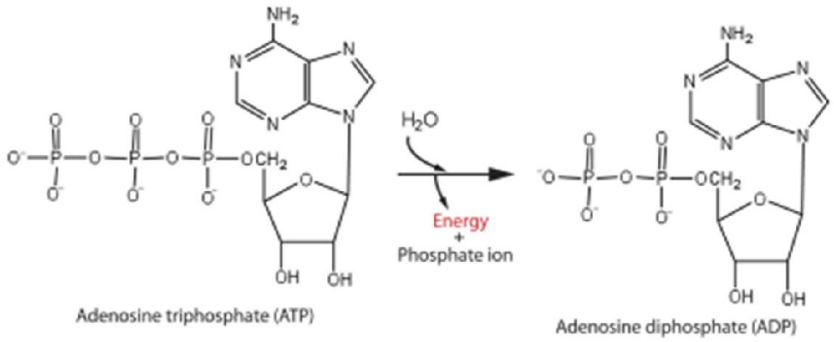
The RNA

- **The RNA molecules is comprised of a single strand**
- **The function of RNA is to translate the generic message contained in DNA into formation of proteins.**
- **There are three types of RNA.**
- **Transfer RNA (tRNA) serves as the carrier molecules for amino acids to be used in the synthesis of proteins.**
- **Messenger RNA (mRNA) acts to carry genetic information between DNA and ribosomes and thus involved in protein synthesis.**
- **Ribosomal RNA (rRNA) is a major component of the ribosomes and is involved in the formation of peptide bonds.**
- **RNA is prominently involved in synthesis of proteins.**

ATP and ADP

- **Other components of the nucleotides are ATP (adenine triphosphate) and ADP (adenine diphosphate).**
- **ATP is a carrier of metabolic energy.**
- **The hydrolysis of ATP releases a phosphate group in a process that reverts into ADP and the generation of large amounts of energy to drive metabolic processes.**

Hydrolysis of ATP



- **Value of Nucleic Acids**
- **Studies on nucleic acids are very vital in modern biological and medical research**
- **These molecules form a foundation for genome and forensic science.**
- **Nucleic acids also form a basis for application of this variant of biology in biotechnology and pharmaceutical industries.**
-

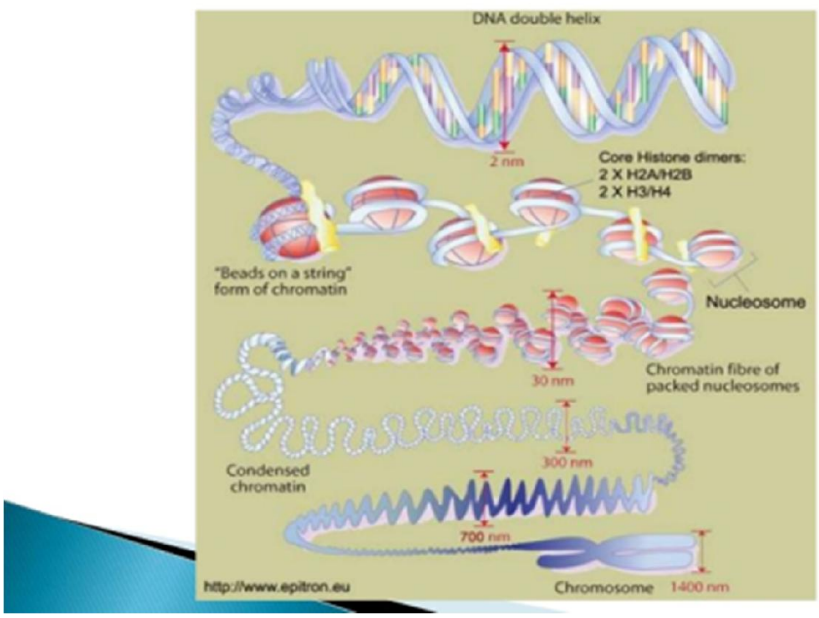
Chromosome Structure & Cell Division

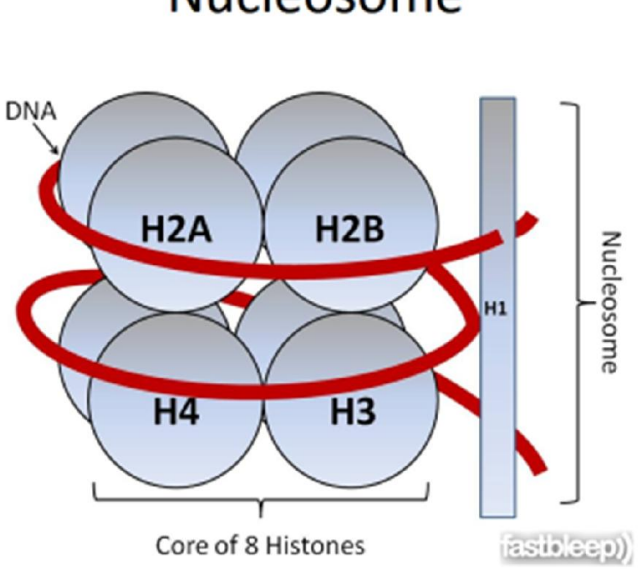
- **Chromosomes were first discovered in 1897 by the Germany biologist called Walther Flemming [1843 -1905]**
- **Flemming observed minute threads within the nuclei in the diving cells of the salamander larvae.**
- **At the time of their discovery, chromosomes were found in cells of eukaryotic organisms.**
- **It was noted that the nucleus of each cell is packed with thread-lik**
- **The major function of the nucleus has been known to contain chromosomes.**

- **As the field of cytology developed , there was a gradual acceptance of the idea that the chromosomes were the material basis of heredity.**
- **Heredity is a concept that relates to the transmission of characters from parents to the offspring's.**

The structure of chromosomes

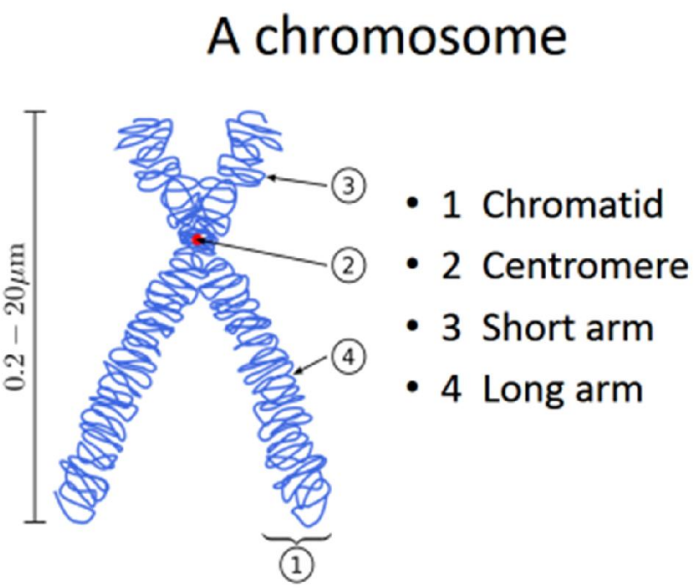
- **In eukaryotic cells chromosomes appear more visible during the process of cell division.**
- **In cells, the chromosomes is a structure that is comprised of DNA and protein.**
- **The type of protein contained in chromosomes is called histones, which has a high amount of amino acid residues.**
- **The DNA molecules is thus wrapped around the histones to form globular structures which give the appearance of beads attached along the string.**
- **Therefore, histones plays an important role in the packaging of DNA.**
- **The non-histone protein found on chromosomes are known to be enzymes that catalyze the transcription and replication of nucleic acid-thus referred to as polymerase enzymes**
- **The DNA molecules may be circular of linear depending on the nature of the organisms.**
- **In eukaryotic organisms, nuclear chromosomes are packaged by proteins into a condensed structure called the chromatin.**

- 



- **This condensed form allows very long DNA molecules to fit into the cells nucleus.**
- **Thus chromatin is a complex consisting of DNA and protein.**
- **Most chromosomes are comprised of about 40% DNA and 60% protein.**

- **Each chromosome divides lengthwise (or longitudinally) to form two chromatids that are held together at the centromere.**



- **A centromere is a constricted part of the chromosome.**
- **The centromere holds a pair of chromatids together; and thus it is the region of attachment to the spindle fibre during the process of cell division.**
- **The DNA of the chromosome reproduces itself exactly so that each chromatid has the complete amount of DNA content.**
- **Chromosomes are classified according to their length and location of their centromere.**
- **The location of the centromere provides a distinct feature of the chromosome.**
- **A chromosome with its centromere located in the centre is said to be metacentric.**
- **A chromosome with its centromere located towards one end is described as being acrocentric.**
- **A chromosome with its centrommere located at the extreme end is described as being Telocentric.**

Cell division

- **The knowledge on the structure of chromosomes and the process involving mitosis and meiosis are vital in the understanding of how genes are transmitted from one generations to the next generation.**
- **The nucleus is the component of the cell in the chromosomes exist between successive stages of cell division.**
- **In the resting cell each chromosome exist as a thread in a coiled state.**

Cytokinesis & karyokinesis

- **In multicellular organisms, such as animals, fungi and plants , cell division along with cell enlargement represents the phenomenon of growth.**
- **Cell division is also the means by which worn-out or injured tissues are replaced or repaired in animals.**
- **The concept of cell division involves two processes.**
- **The process which involves the division of protoplasm is termed cytokinesis.**
- **Cytokinesis involves a process of changes taking place in the cytoplasm, and it entails the division of the cell proper.**
- **The process which involves the division of the two nucleus is termed karyokinesis.**
- **In the process of cell division the two types of the nucleus is termed karyokinesis are known as mitosis and meiosis.**

Cell division : Mitosis

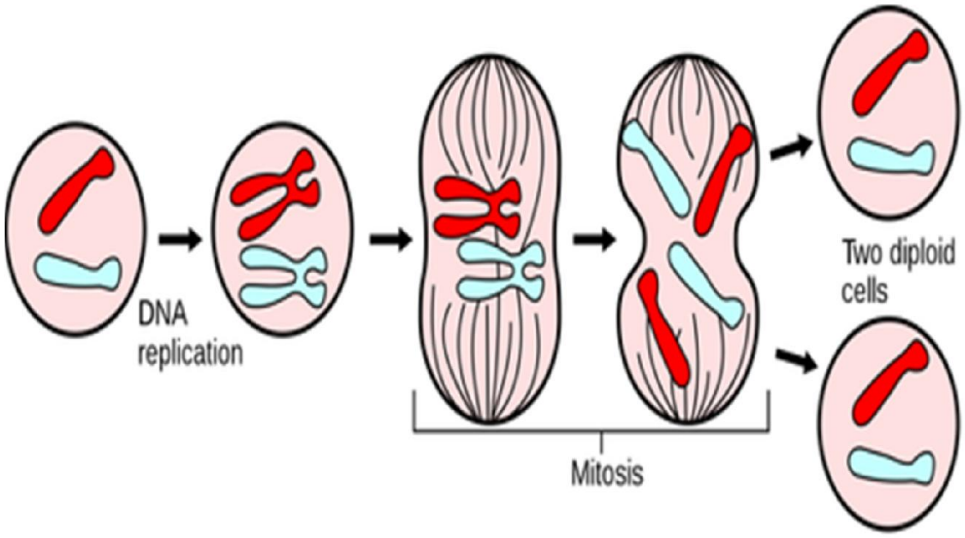
- **Mitosis is the process through which single cells reproduce themselves**
- **It is the process involving an increase in number of cells**
- **This increase in the number of cells is the phenomenon of growth in multi cellular organisms**
- **In unicellular organisms , the process of mitotic cell division is equivalent to reproduction in that two new individuals are produced from the original unicellular parent.**
- **Mitosis only occurs in eukaryotic cells.**
- **However ,prokaryotic cells , which lack a nucleus , merely divide by a simple process called binary fission.**

- **Binary fission is a type of asexual reproduction in which the parent cell divides to form two daughter cells.**
- **In human skin, cell division is rapid process throughout the life of an individual;**
- **but this process is merely a phenomenon of replacement as it does not lead to an increase in the number of cells to an adult body.**
- **Mitosis is kind of cell division involves which can be viewed as a process of replication.**
- **The most fundamental aspect of cell division involves the replication (copying) of genes in the nucleus.**
- **The replication of genes occurs early in the stages of mitosis.**

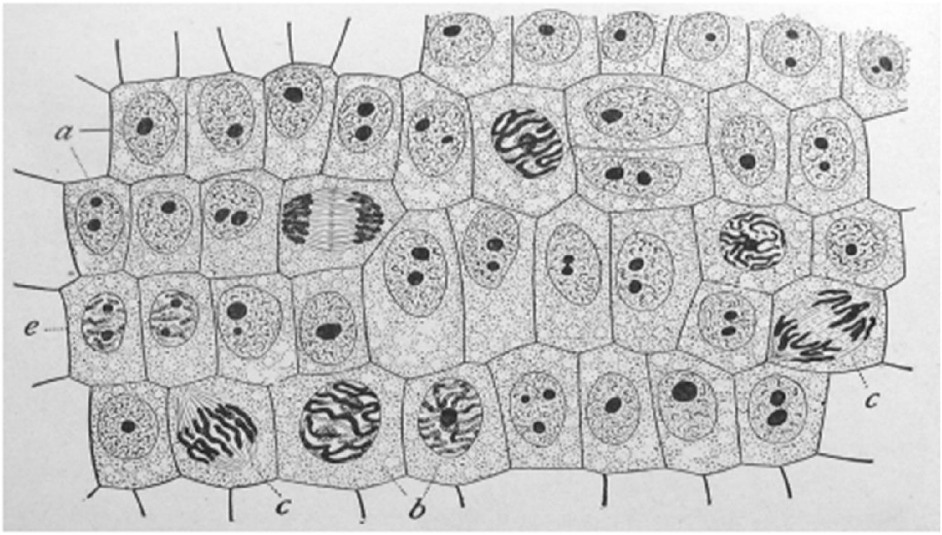
The Mitotic Spindle

- **A mitotic spindle is a system of microtubules called the spindle fibres.**
- **These spindle fibres guide and pull the chromatids that have been replicated towards the opposite poles of cell.**
- **The spindle id formed by the assembly of protein into microtubules.**
- **The microtubules become oriented parallel to each other.**

Mitotic spindles



Cells of Onion in different phases of the cell cycle.



Interphase

- **This is the resting phase of the cell between successive mitotic divisions.**

- **At this stage chromosomes exist as long threads**

- **The Interphase is actually a period of intense biochemical activity that involves the synthesis of DNA.**
- **Normally, the period of Interphase takes up about 90% of the cells life-span.**
- **The sequence of events in mitosis is divided into stages known as prophase, metaphase, anaphase and telophase.**

Prophase

- **This is the initial stage of mitosis that leads to cell division.**
- **Prophase is the stage in which chromosomes become visible as coiled threads.**
- **At this stage chromosomes condense as they become thicker and shorter.**
- **The nucleolus gradually becomes less distinct, and eventually disappears at the end of prophase.**
- **A set of microtubules form a spindle in the nucleus and these extend from one pole to the other.**
- **The movement of chromosome is guided by the spindle when the centromere is attached to the microtubule.**
- **The nuclear membrane also breaks down to mark the end of prophase.**
-

2.Metaphase

- **This is the second stage of mitosis.**
- **When the microtubules in the spindle are attached to the centromere, they push and pull the chromosomes and gradually move them to centre of cell.**
- **The centromere of the chromosome converge to position themselves at the centre of the spindle to form the metaphase plate.**
- **At the end the metaphase, the centromeres are duplicated, and the two chromatids of each chromosome are set free from each other.**
- **The exact cause of separation of the chromatids is not known.**
- **This is the time when the number of chromosomes is doubled.**

Anaphase

- **In the initial stage of anaphase, the protein that bind the sister chromatids together are cleaved.**
- **The sister chromatids now become separate daughter chromosomes to be pulled apart by microtubules.**
- **This is the stage of mitotic cell division in which the chromatids separate.**
- **At this stage the microtubules of the spindle pull and drag the chromosomes towards the poles.**
- **The segregated chromatids thus move to the opposite sides of the poles of the spindle**
- **Towards the end of anaphase, the two identical sets of chromosomes will have moved to the opposite poles.**

Telophase

- **This is the 4th stage of the mitotic cell division**
- **At telophase the polar microtubules continue to lengthen, thus elongating the cell even more.**
- **This is the phase when chromosomes approach the ends of spindle.**
- **During this phase the *nuclear membrane is being synthesized.***
- **The nuclear membrane is actually synthesized by the endoplasmic reticulum(ER).**
- **The total surface area of the two newly formed nuclei becomes larger than that of the original nucleus.**
- **Once more, the chromosomes become less distinct as they begin to uncoil.**
- **Eventually a new nucleolus appears to form in each of the daughter nuclei.**
- **The resultant two daughter nuclei are genetically identical.**
- **Karyokindnesis is later followed by cytokinesis.**
- **Cytokinesis is the process in which the cytoplasm is divided into two regions resulting in the formation of two new cells.**
- **The division of the protoplasm (cytokinesis) is a much simpler process than the division of the nucleus (karyokinesis).**

- **Each half of the divided cell contains some mitochondria, some ER, some ribosome, some vacuole (in plant cells) and the rest of other cellular organelles.**

Significance of Mitosis

- **Mitosis ensures the maintenance of the chromosomal set, where each cell receives a set of chromosomes that alike, and equal in number to the chromosomes of the parent cell.**
- **Mitosis is vital in the development and growth of the organism due to increase in the number of cells.**
- **In some parts of the body, such as the skin and digestive tract, cell are constantly cast off and replaced by the new cells which are the exact copies of cells that are being replaced.**
- **In some organisms, such as starfish, a member of the invertebrate phylum called Echinodermata, the regeneration of some lost body parts (arms) is achieved by the process of mitotic cell division.**
- **Mitosis is a vital process in such organisms that also includes the fresh water lower animals known as hydra which reproduces by means of asexual reproduction to produce genetically similar organisms.**
- **The cells at the surface of hydra divide to form a bud which grows into a new individual.**

Mitosis and Phenomenon of Cancer

- **In humans the uncontrolled growth of cells leads to the disease called cancer**
- **Cancer is linked to failure in the cell control of cell division.**
- **The gene that plays a key role in normal form of cell division is known as the p53gene.**
- **This p53gene produces a protein which monitors the integrity of the DNA to make sure that the DNA is not damaged.**
- **If the p53 protein detects any damage on the DNA, it halts the process of the cell division and then proceeds to stimulate the activity of special inherent enzymes to repair the damage.**
- **As soon as the DNA has been repaired, then p53 will allow cell division to proceed.**

- **In case where the DNA damage is irreparable, then the p53 protein directs the cell to kill it self**
- **By *the halting of the process of division in the damaged cells, the p53 gene prevents the development of many mutated cell.***
- **Therefore, if p53 is absent or becomes non-functional, then cells are bound to divide repeatedly and uncontrollably because there is no factor to halt the dividing process.**
- **This is the basis of the disease called cancer which is usually linked to mitosis in somatic cells.**
-

Meiosis

Introduction

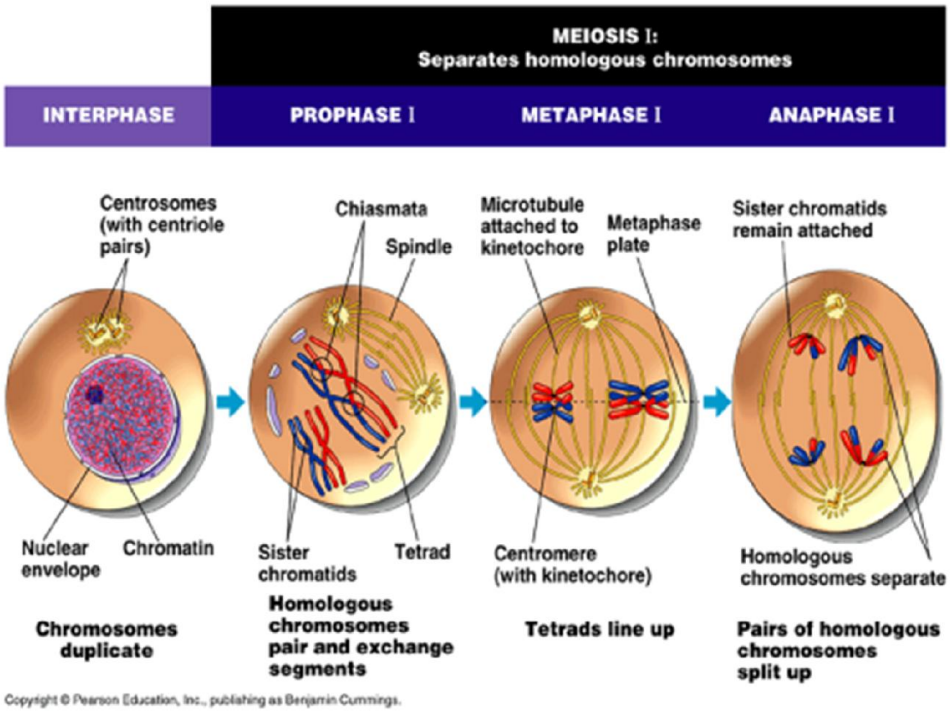
- **Sexual reproduction is one of the major features of eukaryotic organism; and this process involves alternation between phenomenon of meiosis and fertilization.**
- **Therefore meiosis is a special type of cell division necessary for sexual reproduction in eukaryotic organisms.**
- **Meiosis occurs when it is ripe time to produce an organism.**
- **It important to note that the genetic diversity or variation exhibited in various plants and animals is due to meiosis.**
-
- **Meiosis was first discovered and described in the eggs of the urchin by a German biologist, Oscar Hertwig in 1876.**
- **Meiosis is a type of cell division in which the chromosome number is reduced from the diploid (2n) state to the haploid (n) state.**
- **This variation of cell division results in the production of haploid sex cells.**
- **Meiosis occurs in specialized diploid cells at a particular time in a life cycle of an organism.**
- **In flowering plants meiosis occurs in the flowers, specifically within the anther of the stamens and within the ovules.**
- **In mammals meiosis specifically occur in the follicles, located in the ovaries in female in mammals; and in the tests of male animals.**

- **Meiosis thus is a process in which a single diploid cell gives rise to a set of four haploid daughter cells.**
- **The daughter cells arising from the meiosis may be either in form of gametes or in the form of the spores.**
- **In this regard a gamete is a sex cell that will unite with another sex cell to a diploid zygote.**
- **A spore is a cell that can develop into an organism without necessarily uniting with another cell, but rather will undergo mitotic division to produce a haploid multicellular organism.**
- **Meiotic processes are similar to those observed in mitosis in many ways.**
- **In mitosis there only one nuclear, and cytokinesis occurs once produce to daughter cell.**
- **Each daughter cell resulting form from a mitotic division contains a diploid number of chromosomes.**
- **Meiosis there two successive processes of a nuclear and cell division.**
- **The 1^{st} meiotic division; and (b) the 2^{nd} meiotic division.**
- **The first meiotic division separates the homologous chromosome, whereas the second meiotic division separates the chromatids.**
- **Each of the daughter cells resulting from the meiotic division contains a haploid number of chromosomes.**
- **The chromosomes in meiosis undergo a recombination process which shuffles the genes to produce different combination in each gamete.**

THE FIRST MEIOTIC DIVISION

- **The first meiotic division states at interphase and goes through the *prophase I*, *metaphase I*, *anaphase I*, and *telophase I.***
- **Interphase**
- **This is a very active period where the cell synthesizes a vast array of protein.**
- **In human, at this point, cells contain a set of 46 chromosomes, (23 diploid chromosomes identical to those found in somatic cells.**

- **Each chromosome reveals to be consisting of two identical sister chromatids after the process of duplication.**
- **The interphase thus is a stage during which chromosomes are replicated in the nucleus**

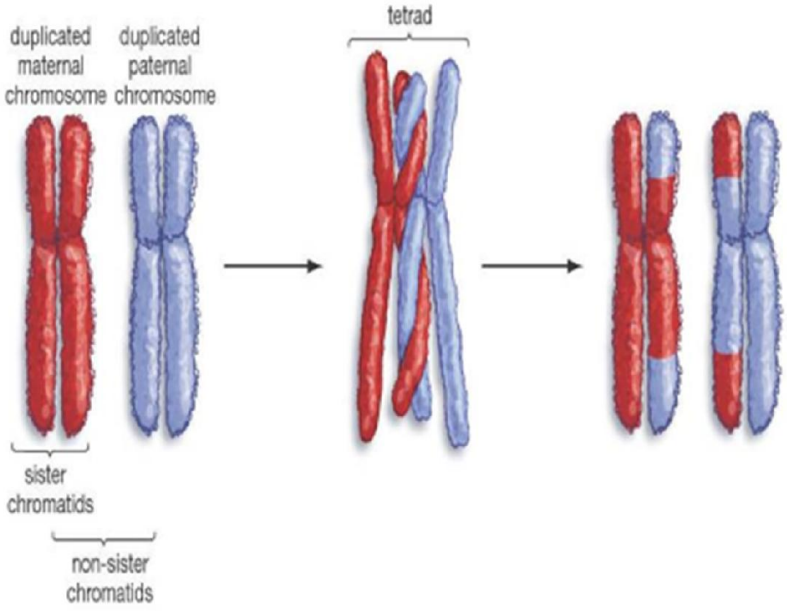


Prophase I

- **This is the longest phase of meiosis.**
- **Initially, the chromosomes appear to be long, slender thread when observed under the microscope.**
- **At this stage the chromosomes had already undergone duplication during the previous (preceding) interphase.**
- **Consequently, each chromosome at the beginning o the prophase I consist of two identical chromatids that are attached at the centromere.**
- **This is the stage when the homologous (similarly structured) chromosomes pair with each other.**
- **The pairing process is very precise, where the *chromosome link up in a zipper-like* fashion.**

- **Therefore, the pairing process gives rise to a condition where the same feature on the homologous chromosome lie side by side.**
- **Since *each chromosomes made up of two identical chromatids* the resultant homologous pair consist of *four chromatids.***
- **The process in which homologus chromosome go through the event of pairing is termed as synapsis.**
- **The associated pairs of homologous chromosomes are called bivalents.**
- **When the pair of chromosome lie side by side, this is a stage at which genes from one chromatid transferred to another chromatid in the process called cross over.**
- **The cross-over process involves gene exchange which gives rise to recombination of traits (or character).**
- **Towards the end of *prophase I* the *nuclear membrane* (envelope) breaks down.**
- **This is also the stage at which the nucleolus disappears.**
- **In the late prophase, and after the cross- over event, the homologous chromosomes begin to repel each other.**

Exchange of parts of non-sister chromatids.



Metaphase

- **At this stage the spindle forms and becomes more conspicuous.**
- **The individual microtubules become attached to the centromeres of the chromosomes.**
- **The homologous pair moves to the equatorial plane of the cell and relocate along the metaphase plate.**
- **The centromeres of the paired homologous chromosome line up on the opposite sides of the equatorial plane.**

Anaphase I

- **The homologous chromosomes separate and begin to move towards the poles.**
- **In *meiotic anaphase I* the centromeres do not separate such that the sister chromatids still remain attached to each other.**
- **However, it is the *homologous chromosomes* that undergo the process of separation.**
- **Due to the process of *cross-over* that resulted in the gene exchange during *prophase I,* the chromatids on each chromosome are no longer identical.**
- **The cytoplasm begins to undergo cleavage as initial process of cytokinesis**

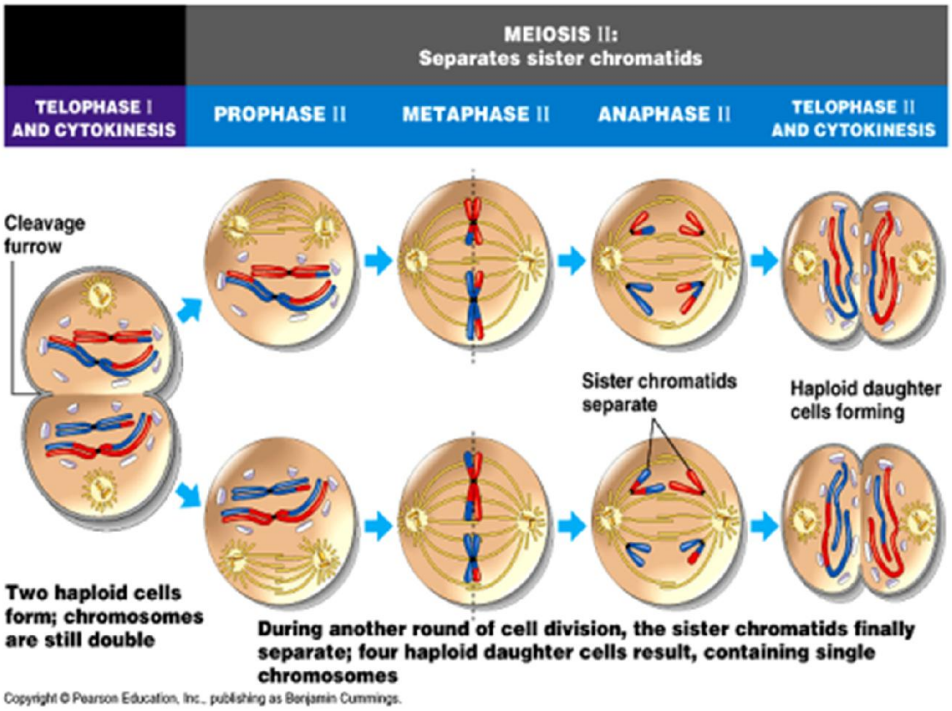
Telophase

- **At this stage the chromosomes arrive at the poles and later become elongated and distinct.**
- **Each daughter cell contains the half number of chromosomes, but each chromosome consist of a pair of chromatids.**
- **The sister chromatids remain attached during telophase stage.**
- **The *endoplasmic reticulum* (ER) forms a new nuclear membrane which surrounds each set of chromosomes.**
- **Finally also the spindle disappears.**
- **The nucleus is formed and protein synthesis commences once more in preparation for the second phase of meiotic division.**
-

THE SECOND MEIOTI DIVISION

- **On the onset of the second meiotic division the chromatids are still attached to each other by the centromeres.**
- **The second meiotic division is the process which results in the production of set of four haploid cells.**
- **Meiotic II proceeds along four steps known as prophase II, metaphase II, anaphase II and telophase II.**
- **Interphase**
- **The cells go into a resting period called interkinesis.**
- **This is the stage that is intermediate between meiotic division I and meiotic division II.**

- **The cells enter into interphase II, a resting period where no replication of the DNA occurs at this stage.**



Prophase II

- **The nuclear membrane, which was formed during telophase I, breaks down again.**
- **The nucleolus also disappears.**
- **The new spindle forms for the second time.**
- **The chromosomes, each consisting of two chromatids, become visible.**
- **However, during the cross- over events during prophase I, the chromatids are longer identical to each other.**
- **The process of synapsis (or cross-over) does not occur in prophase II.**

Metaphase II

- **The two spindles are formed at right angles to the original spindle.**
- **The chromosomes, each consisting of two chromatids held together by their centromeres, move the equatorial plate (metaphase plate).**
- **The new equatorial metaphase plate is rotated by 90° so as to be aligned perpendicular to th the previous metaphase plane of the meiosis I.**
- **The centromeres are aligned along the new equatorial plate.**

Anaphase II

- **This is stage when centromeres divide.**
- **The sister chromatids, which now become new chromosome, migrate towards the opposite poles of the spindle.**

Telophase II

- **The spindle disappear.**
- **The chromosomes complete their separation process to form a set of four nuclei.**
- **The nuclear membrane begins to form around a set of chromosomes.**
- **The second stage of cytokinesis set in as the cell membrane begins to form a new set of chromosomes.**
- **The four new cells are *cytologically* haploid, containing half the number o chromosomes.**

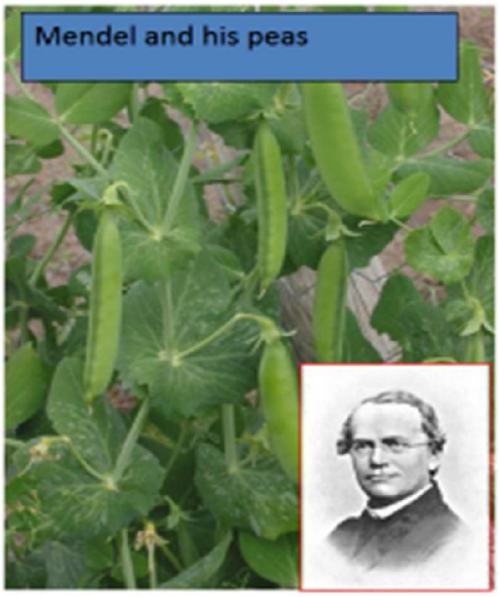
Significances of meiosis

- **The ultimate result for meiosis is that the original cell gives rise to a total of four daughter cells.**
- **Each of the final daughter cells half of the number of chromosomes compared to the original diploid nucleus.**
- **Due to the process of crossing-over events in prophase I, each chromosome contains some segments that have been delivered from both parents.**
- **Hence, meiosis produces cells that are not identical.**
- **The event of cross-over in an important mechanism that *ensures the recombination of the genetic materials* from the two parents.**
- **Meiosis is essential in the production of sexual gametes.**
- **This process is the foundation for our understanding of the phenomenon of heredity.**
- **The different cells that are produced in the process of meiosis help explain the behavior of the observed traits in animals and plants.**

Differences between mitosis and meiosis

Mitosis	Meiosis
Mitosis facilitates asexual reproduction	Meiosis facilitates sexual reproduction
This a variant of cell division restricted to the vegetation (somatic) cells.	This is a variant of cell division restricted to reproductive organs
The process involves one nuclear division	The process involves the two successive nuclear divisions.
Cell division results in the formation of a set of two daughter cells	Cell division results in the formation of a set of four daughter cells.
Each of the two nuclei produced during mitosis has the same diploid number of chromosomes as the original nucleus.	Each of the two nuclei produced during meiosis has a haploid (half) number of chromosomes compared to the original nucleus.
The nucleus of each daughter cell produced during mitosis contains identical gene	The nucleus of each daughter cell produced during meiosis contains different gene

Discovery 6: Genetics



- He showed that offspring received characteristics from both parents, but only the dominant characteristic trait was expressed

His work only came to light in 1900, long after his death

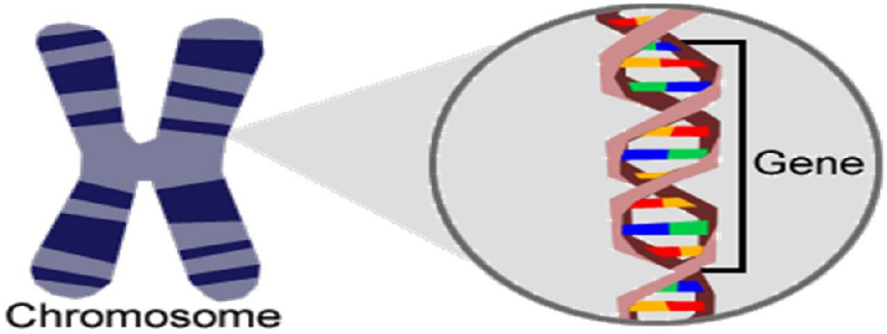
Introduction

- **The phenomenon of resemblance, dissimilarity or variation among organisms has a historical evolutionary basis**
- **In ancient times, the concept of inheritance was viewed as traits being transmitted from parent to the offspring through blood**
- **This understanding to concepts of inheritance still persists in several human societies/communities today**
- **However, if this form of inheritance through blood was the case, many individuals would have opted to systematically alter their traits by modern techniques of blood transfusion**
- **Genetics is the science that deals with the concepts of variation and inheritance; variation is a fundamental feature of life**
- **Thus, genetics is the scientific study of heredity and variation**
- **Observe the variations among ten students around you end explain the sources of the variations.**

- **Science of genetics was developed in the era of Gregor Mendel (1822 – 1884), an Austrian Priest-Monk**
- **Between 1856 and 1863, Mendel conducted hybridisation experiments on garden peas (*Pisum sativum*) from 29,000 cultivated pea plants**
- **The molecular basis of genetics lies in the genetic constitution of the organisms**
- **The most vital cellular component of any organism that determines aspects of variation and inheritance are chromosomes**
- **DNA as a component of chromosomes, *serves as the main store for information* that *determines the nature of the body, its structure, mode of metabolism* and other biological features of an organism**
- **Cells *differ in shape* because they *contain different types of proteins***
- **The enzymes are made up of proteins and each type contains different kinds of enzymes**
- **For instance, *enzymes involved in the synthesis of flower colour* occur in the petals, not in the roots or stems**

The Nature of Genes

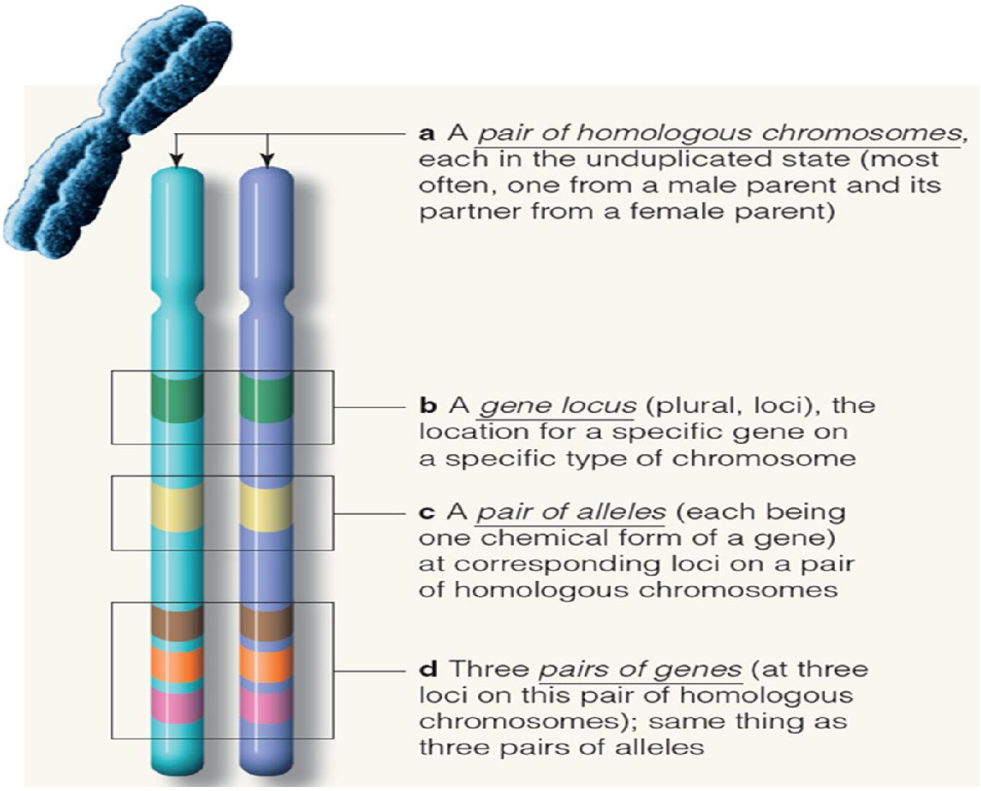
- **Modern science reveals that parents do not transmit physiological traits directly to their offspring**
- **Rather parents transmit distinct inheritance characters through factors known as the genes**
- **The gene *is a basic unit of inheritance* located on the chromosomes**
- **The gene is thus a discrete particle forming part of a chromosome**
- **The gene *can determine a particular feature of the organism***
- **It occupies a specific position (locus) on a chromosome**



- **In terms of modern molecular genetics**

- **Gene defined as the sequence of nucleotides of dna that is concerned with a specific function i.e. synthesis of a single polypeptide chain**

- **There each region of the DNA which is responsible for coding (constituting) the amino acid to form a particular protein is called a gene**
- **Hence, *each protein type* has its own gene**
- **Genes that are located in the chromosomes, transmit information from one cell to another through the process of mitosis and meiosis**
- **The genes that are *responsible for genetic variation* in organisms are *referred to as the* alleles**
- **The gene is thus known to *exist in different forms* called alleles**
- **In a diploid cell there are two alleles of any one gene which occupies the same position or locus**
- **Such allelles may be the same; or alternatively one allele may be dominant whereas the other is recessive**
- **Alleles usually *undergo pairing during the process of meiosis***



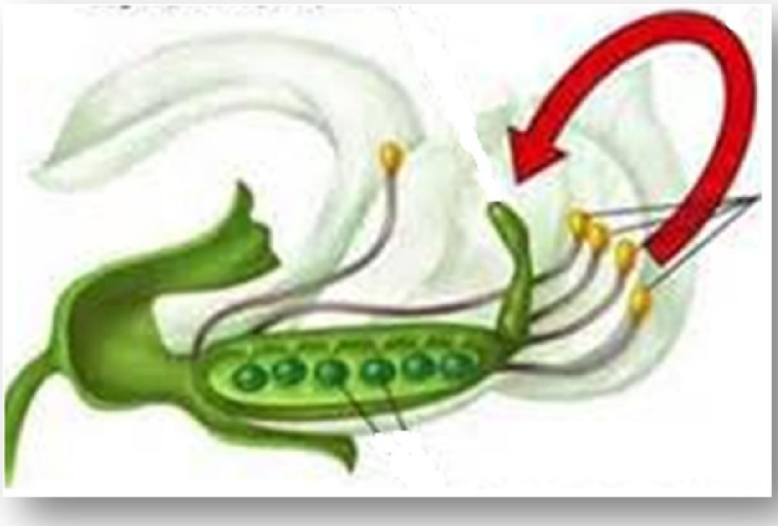
The Concept of Heredity

- **The transmission of information by genes from one generation to another is referred to as heredity**
- **The gene is the basic unit of heredity**
- **The gene is the chemical basis of genetic inheritance**
- **The types of alleles found in an organism are known as its genotype**
- **The manner in which the alleles express themselves in terms of *size*, *shape* or the *nature of metabolism* in a given organism is known as its phenotype**

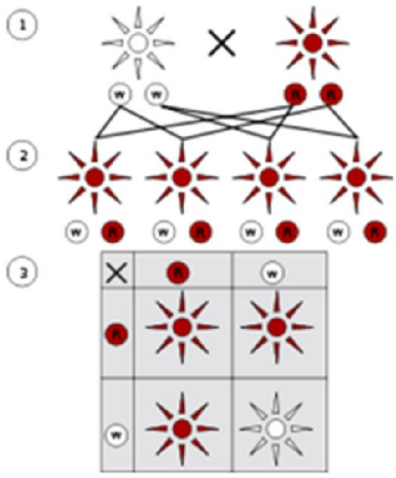
- **Thus the variation observed in animal and plant populations suggests a corresponding variation of genotypes and phenotypes**
- **The branch of biology that deals with heredity and variation is termed genetics**
- **Genetics is, therefore, the science of inheritance**
- **Genetic variation may also be affected by interactions among several genes, by a single dominant gene and by some environmental factors**

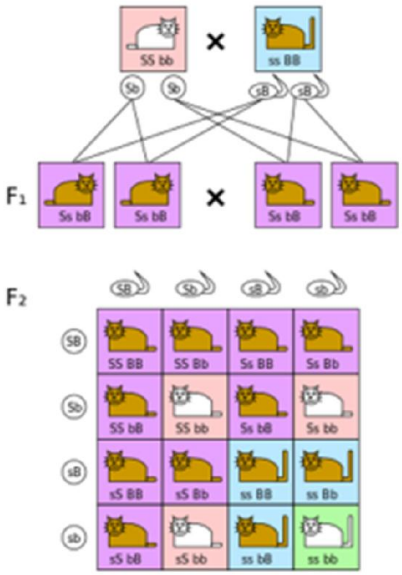
Mendelian Genetics

- **Principles of genetics were laid down by the Austrian Monk known as *Gregor Mendel* (1822 – 1884)**
- **Mendel's studies revealed that the inheritance of characters was due to the transmission of specific units of inheritance known as genes**
- **A branch of genetics that deals with biological characters (traits) and their inheritance is known as Mendelian genetics, in honour of Gregor Mendel**
- **Mendel's research also predicted the concept of meiosis and the existence of haploid and diploid cells**
- **Mendel carried out his studies on peas (*Pisum sativum*) as his experimental organism, which is an annual plant with well defined traits**
- **His studies on the variation observed on peas were strictly based on qualitative characters**
- **The characters chosen were based on the *colour of flowers* and the *shape of seeds***
- **This process was made easier because peas exhibit a feature of *self–pollination***



- **A cross between individual parents that differ in one trait is called a monohybrid cross**
- **A cross between individual parents that differ in two traits is called a dihybrid cross**



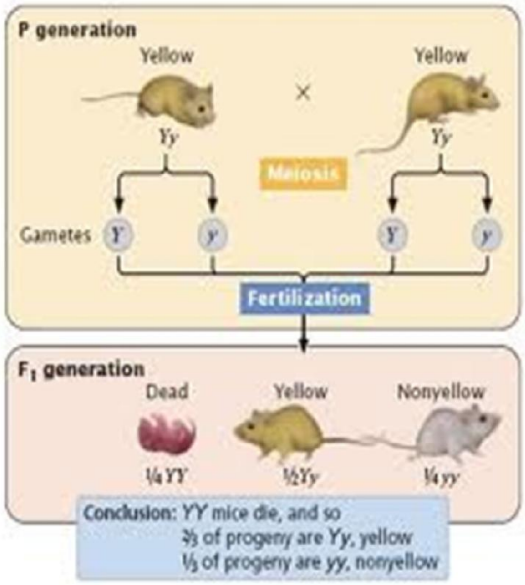


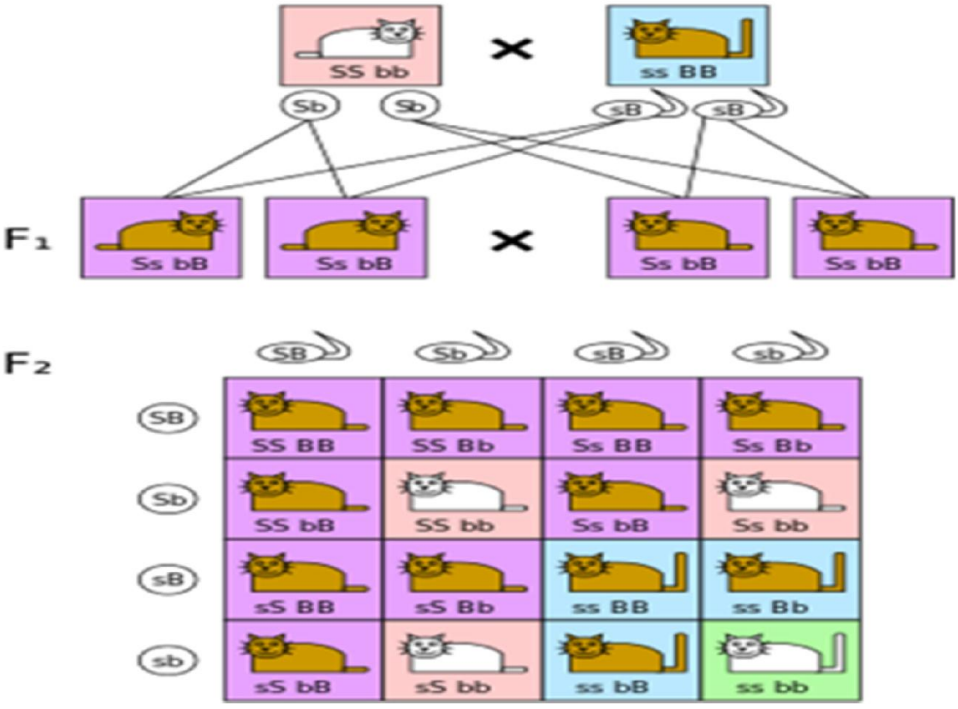
Principle or Law of Segregation

- **An important genetic principle that Mendel formulated is known as 'the principle of segregation' also referred to as *Mendel's 1st Law***
- **The *principle of segregation* states that *individual organisms carry pairs of alleles for each trait***
- **According to this principle, hereditary characters are (or features) are determined by discrete (or distinct) alleles**
- **The pair of alleles *are separated* or *segregated during meiosis***

Principle or Law of Independent Assortment

- **Referred to as Second Law is also known as the Inheritance Law**
- **This Law states that separate genes for separate traits are passed independently of one another from parents to offspring**
- **This means that the biological selection of the particular gene in the gene pair for one trait to be passed to the offspring has nothing to do the selection of the gene for any other trait**





Mendel's Breeding Experiments

- **The principle of segregation was demonstrated by experiments Mendel conducted on varieties of peas**

- **One of Mendel's experiments involved the crossing of tall and dwarf varieties of peas**
- **It was observed that the offspring in the first (F_1) generation were tall**
- **The letter 'F' represents the term 'filial' derived from *Latin* to mean progeny**
- **Alleles for tall plants are represented by the letters 'TT', whereas the alleles for dwarf plants are represented by the letters 'dd'**
- **After meiosis, the gametes for tall plants are segregated into the alleles T and T**
- **Gametes for dwarf plants also become segregated into the alleles d and d**
- **The genetic constitution of all possible genotypes produced after a Mendelian genetic cross is reflected in Punnet Square**

Cross between Homozygous Plants

	T	T
d	Td	Td
d	Td	Td

F_1 generation

Explanation

- **The hybridization of the tall (TT) plants and the dwarf (dd) plants gives rise to progeny that will all contain the Td alleles in the F_1 generation**
- **Since all the progeny in F_1 generation express that tall feature in the resultants plants, then it can be said that the dwarf trait has not been expressed in the first (F_1) generation.**
- **Only the tall trait appears to have been well expressed in the F_1 generation**
- **In this regard the genotype of the F_1 progeny (offspring) is Td.**

- **All the progeny in the hybrid plants contain the alleles Td.**
- **The phenotype expressed in all the F_1 progeny is exhibited in the tall features of the plants.**
- **This suggests that the tall (T) allele is dominant whereas the dwarf (d) allele is recessive**

Cross between Hybrid Plants

- **After meiosis the gametes contained in the hybrid plants with Td alleles will be segregated into alleles T and d.**
- **The cross between the two hybrid plants (with Td alleles) is illustrated in the Punnett Square below.**

Cross between Hybrid Plants

- After meiosis the gametes contained in the hybrid plants with **Td** alleles will be segregated into alleles **T** and **d**

	T	d
T	TT	Td
d	Td	dd

F_2 generation

-

Explanation:

- **Products of the F_2 generation reveal the presence of such genotypes as: *TT, Td, Td and dd.***
- **The plants with TT and dd alleles is said to be homozygous.**
- **The plants with Td alleles is said to be heterozygous.**

- **The phenotypic expression of the F_2 generation reveals a ratio of $^{3}/_{4}$ being tall plants and $^{1}/_{4}$ being dwarf plants.**
- **When the tall hybrid plants were self-fertilized, the F_2 generation revealed the occurrence of both the tall and dwarf plants.**

Dominance, Recessiveness and Co-dominance

- **A dominance allele is one whose trait is fully expressed in the organism.**
- **This entails that the dominant allele is the one that produces a functional product.**
- **In the case of a heterozygous organism, as in Td above, tall features will be expressed in the phenotype because of the presence of the dominant allele (T).**
- **A recessive allele is the one that is not expressed when it interacts with the dominant allele.**
- **A recessive allele will only be expressed phenotypically in a homozygous organism (dd).**
- **When both alleles of pair are fully expressed in a heterozygous organism, such alleles are said to be co-dominants.**

Lethal Genes

- **Animals or plants that carry lethal genes have their viability placed at great risk.**
- **Lethal genes tend to impair the biochemical functions in the organism.**
- **A lethal gene is one that has the effect of rendering the non-viability to the organism.**
- **If the lethal gene is dominant and imparts an immediate expression, the individual carrying the gene is likely to die.**
- **If lethal genes are received and carried in a heterozygous condition, this may have no effect to the life of organism.**

The Prokaryotic Organisims: Domain Bacteria

INTRODUCTION

- **The Prokaryotes are the oldest forms of organisms on this planet Earth.**

- **They were abundant for over a billion years before the Eukaryotes appeared on Earth.**
- **These organisms are structurally the simplest forms with simpler forms of cells which are relatively small.**
- **Prokaryotes are the most dominant and successful forms.**
- **Scientists have so far documented up to 5,200 species of prokaryotic**
- **Yet more thousands species are believed to be exist awaiting discovery.**
- **These organisms exhibit a great deal of metabolic diversify and rapid rate of cell division.**
- **The characteristic feature of prokaryotic organisms is the possession of cells that lack membrane –bounded nuclei and other membrane bound organelles**
- **Genetic information is located onto a single chromosome which consists of circular double – strand of DNA.**
- **Since the organelles are not membrane bounded, the nucleus is not distinct.**
- **The Nuclear region where DNA is concentrated is not surrounded by a separate membrane envelop.**
- **The nucleus lacks a mitotic apparatus and nucleoli.**

Classification of Prokaryotic Organisms

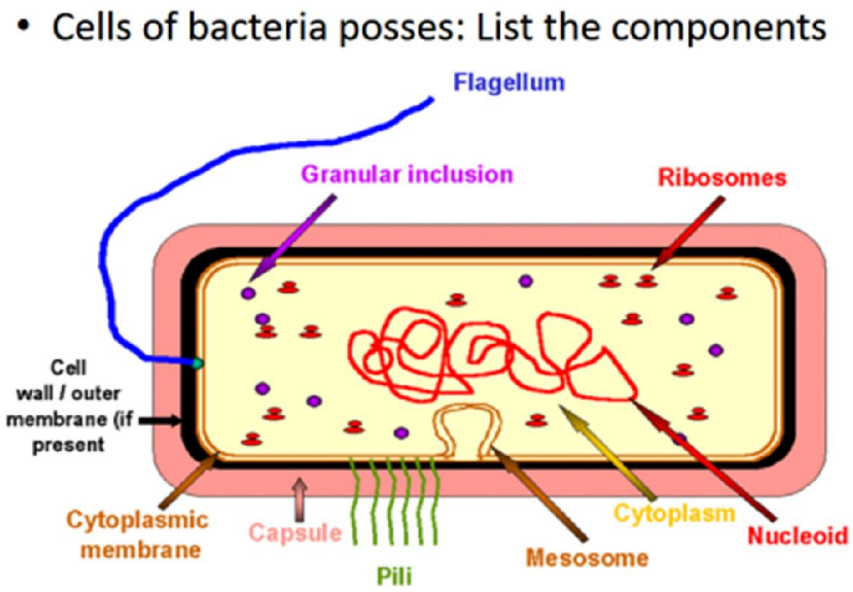
- **Based on the recognition of the existence of two Superkingdoms: Prokaryonta and Eukaryonta.**
- **The Superkingdom Prokaryonta was known to be comprised of the Kingdom Monera, consisting of the divisions Schizophyta (the bacteria) and Cyanophyta (the blue- green algae)**
- **Recent studies conducted in the period 1970s- 1980s have given rise to the discovery of the new groups of prokaryotes .**
- **This discovery has led to the division of prokaryotes into two groups**
- **(a) the Bacteria and (b) the Archaea**
- **In modern classification systems the Superkingdoms are now known as Domains**

- **The three Domains of life are currently known as Domain Bactera, Domain Archaea and Domain Eukarya**
- **The two domains Bacteria and Archaea embrace the prokaryotic organisms: where as the domain Eukarya consists the eukaryotic organisms.**
-

The DOMAIN BACTERIA

INTRODUCTION

- **The domain Bacteria include the commonly known bacteria and the photosynthetic algal-like forms called cyanobacteria**
- **In earlier classification the common bacteria were classified under the division (or phylum) known as Schzophyta.**



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Non- membrane bound Ribosomes, but lack nuclei, mitochondria, chloroplasts, endoplasmic reticulum, Golgi apparatus , lysosomes.

- **A rigid cell wall- frame work that supports the cell and maintains the characteristic cellular shape.**

- **In hostile environments, a capsule in the form of a slime layer, is produced outside the cell wall.**
- **This capsule acts as protective cover, particularly as found in the most pathogenic bacteria**

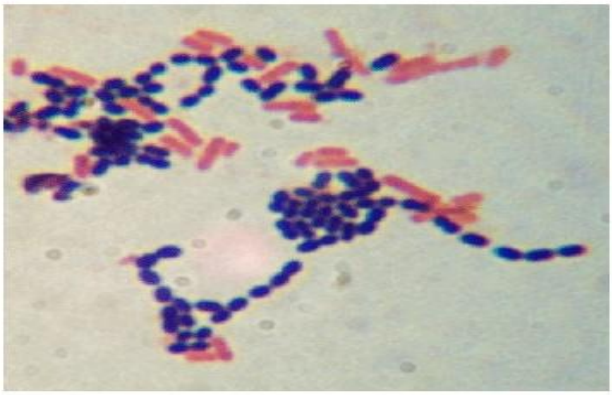
  Apparently, the antibodies administered to treat bacteria –caused diseases are usually targeted to destroy this bacteria capsule.

CLASSIFICATION OF BACTERIA

- **About 5,200species scientifically documented and described.**
- **It is believed that as many as 100,000- 200,000species of bacteria do exist.**
- **The characteristic feature of bacteria is their possession of the cell wall composed of Peptidoglycan responsible for the mechanical strength of their walls**
- **Peptidolgycan consists of chains of amino acids called N-acetylglucosamine and the N-acetylmuramic acid linked to such amino acids as Alanine, glutamic acid and lysine**
- **Peptidoglycan does not occur in species of Archeae nor Eukaryotes.**
- **Therefore, Petidoglycan is thus a taxonomic marker for differentiating species of Bacteria from species of Archaea**
- **Species of the domain Bacteria can be divided into two main groups : The Gram-positive bacteria and the Gram -Negative bacteria.**
- **This classification is based on the capacity of the cell wall to retain the pink colour of the dye called Crystal Violet.**
- **The Gram stain is a cytological staining method used to differentiate two groups of bacteria.**
- **In this technique, the bacteria sample is smeared on the microscopic slide :, Crystal violet stain is applied: then a mixture of acetone and alcohol is applied : the finally counter stained with a red dye called Safranin.**
- **The Gram -positive bacteria will retain the first violet dye and appear pink or bluish under the microscope, because such bacteria have a thick layer of peptidoglycan their cell walls.**

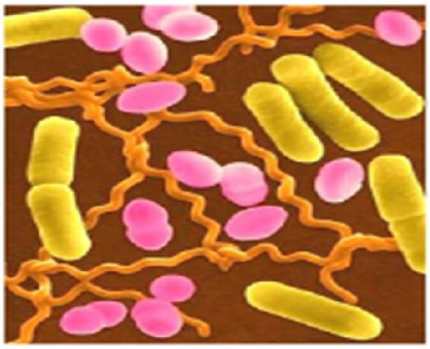
Domains Bacteria and Archaea

- Gram negative
  - Pink
  - Tend to be more pathogenic (disease causing)
  - Have a thinner cell wall
- Gram positive
  - Purple
  - Have a thicker cell wall



- **The Gram -negative do not retain the pink dye , instead take up the red stain, because such bacteria have a thin cell wall of peptidoglycan.**
- **Bacteria can also be classified based on morphological features**
- **The three major groups of bacteria are The Coccus bacteria, the Bacillus bacteria and the Spirillum bacteria**

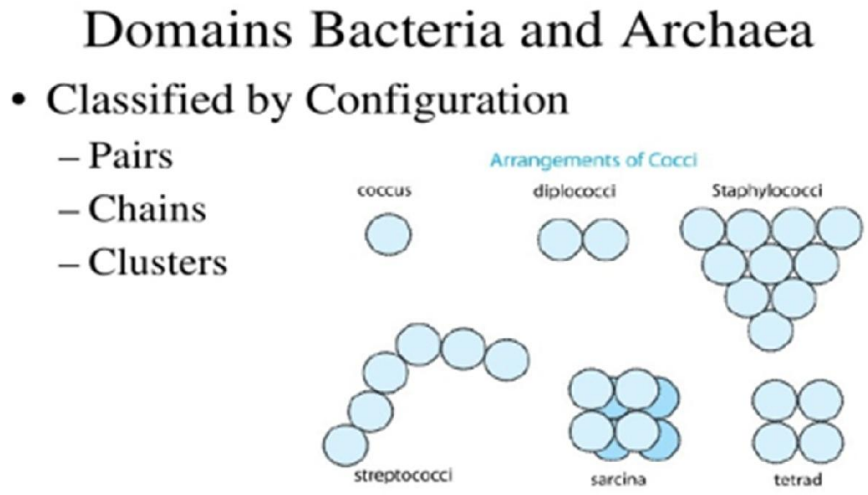
Classification based on shape



- Identify the three types of bacteria

The Coccus forms of bacteria are spherical.

- **Coccus bacteria may occur singly, or pairs, in groups of four on in several clusters of several cells such as staphylococcus*: or occur in chains as in Streptococcus***
- ***Staphylococcus and Streptococcus are* a genera of spherical Gram positive bacteria some of which cause diseases in humans and in animals**
- **The Bacillus forms are the rod shaped Gram positive bacteria which have a tendancy to form chains.**



- **Many species of Bacillus bacteria and are responsible for the rotting of stored food**
- **The Spirillum forms , as the name suggests are spirally –shaped bacteria**
- **The Spirilla are the Gram negative sand highly motile bacteria**

Other features of Bacteria

- **The mode of nutrition is by way of absorption of nutrients or heterotrophic,in that they obtain food from complex organic molecules, such as amino acids and sugars from other organisms.**
- **But some species are photosynthetic-hence they are said to be autotrophic**

- **Reproduction is asexual, usually effected by binary fission or budding**
- **Some bacteria are motile in that motility is facilitated by the presence of the filamentous appendages called the Flagella; in some species motility is effected by glidding**

Human bacteria diseases

- **Several bacterial diseases are pathogenic in higher animals and plants**
- **caused by *Bacillus anthracis*; vectors are animals, humans,: transmission through contact or ingestion**
- **Cholera; caused by *Vibrio cholera*: vectors –human faeces; symptoms being diarrhea and dehydration: a major killer due to poor sanitation**
- **Gonorrhoea; caused by *Neisseria gonorrhea*; vectors- humans: an STD of world-wide occurrence**
- **Pneumonia: caused by the bacteria species of the genera *Chlamydia, Haemophilus, Mycoplasma,treptococcus;* vectors- humans : symptoms being acute lung infection.**
- **Syphilis; An STD caused by *Treponema pallidium*; vector – humans: also transmitted through a (a)kiss (b) mother – to – fetus**
- **Tuberculosis: an acute bacterial lung infection caused by *Mycobacterium thuberclusis*: vectors- humans.**

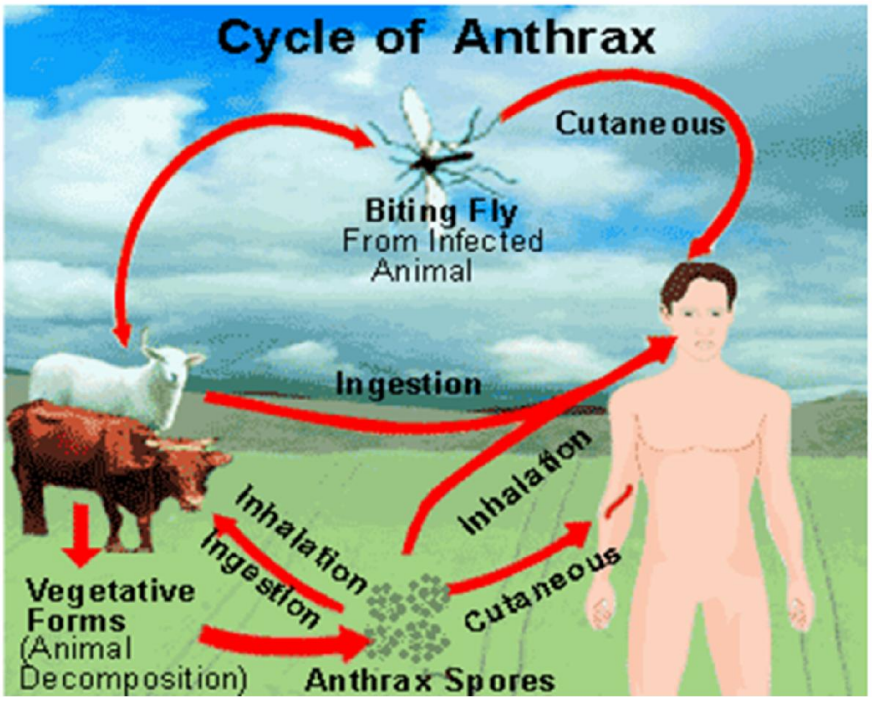
BACILLUS ANTHRAX

Vectors:

- are animals, humans,

Transmission

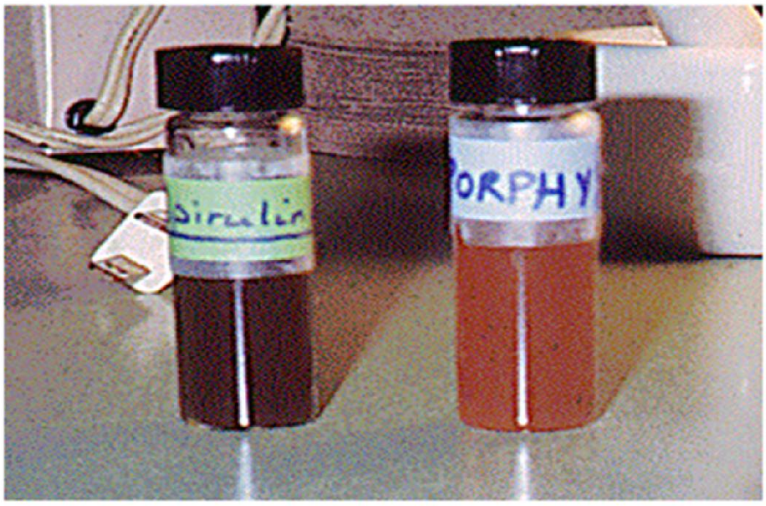
- through contact or ingestion



The Cyanobacteria

- **Domain bacteria – algal-like and photosynthetic organisms referred to as blue – green algae cyanobacteria**
- **7500 species have been documented**
- **Classification – division Cyanophyta also called Cyanochloronta**
- **Importance- ecological importance with regard to the global carbon and nitrogen**
- **They contain chlorophyl a , and the pigments Phycobilins**
- **Phycobilins are Phycocyanin – blue pigment**
- **Phycoerythrin red form**
- **They also contain Thylakoids which are present in chloroplasts**
- **Main storage product of blue green algae is**
- **Glycogen**
- **They also produce mucilaginous layer that holds the cells of the filaments together**

Phycobillins



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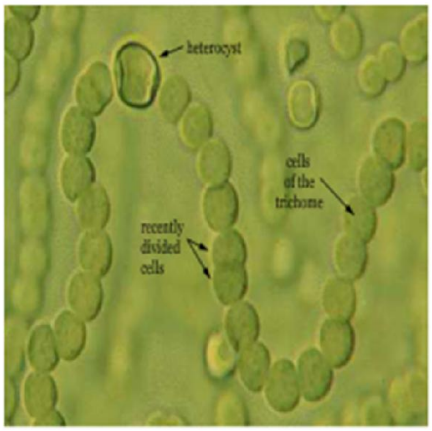
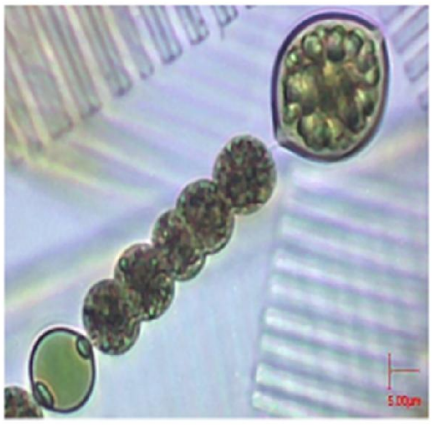
STRUCTURE

Structure of hetrocysts



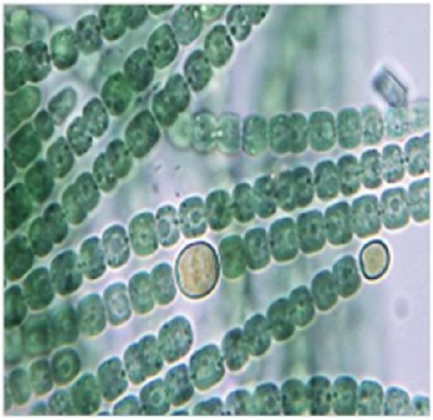


- **Sites for nitrogen fixation**

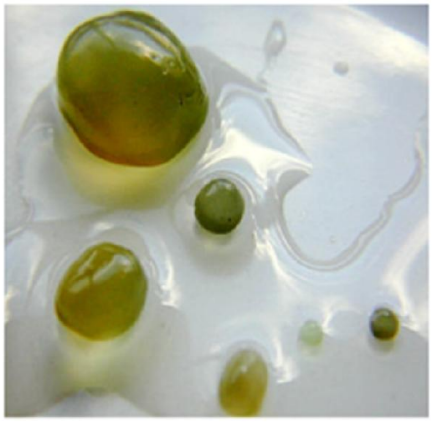
- **Heterocysts are surrounded by thick cell walls**
- **cells have glycolipids – prevent oxygen from diffusing into the cells**
- **Enzyme Nitrogenase is sensitive to oxygen**
- **Nitrogen converted to Ammonia**

Examples of Cyanobacteria

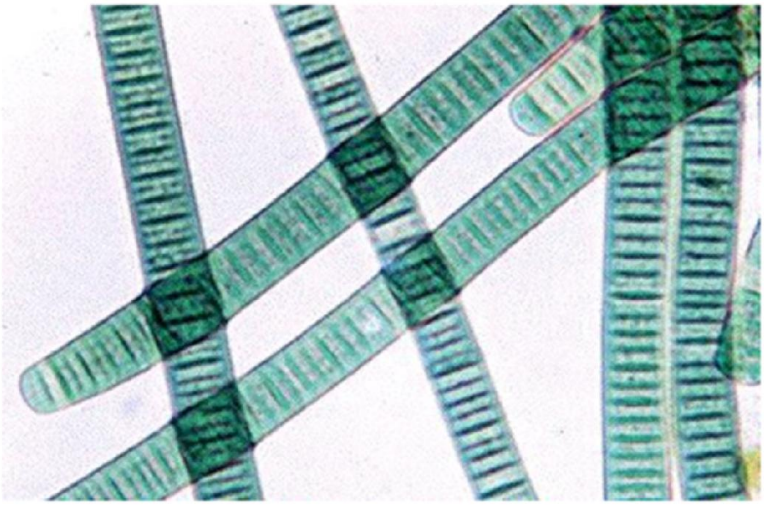
Anabaena



Nostoc

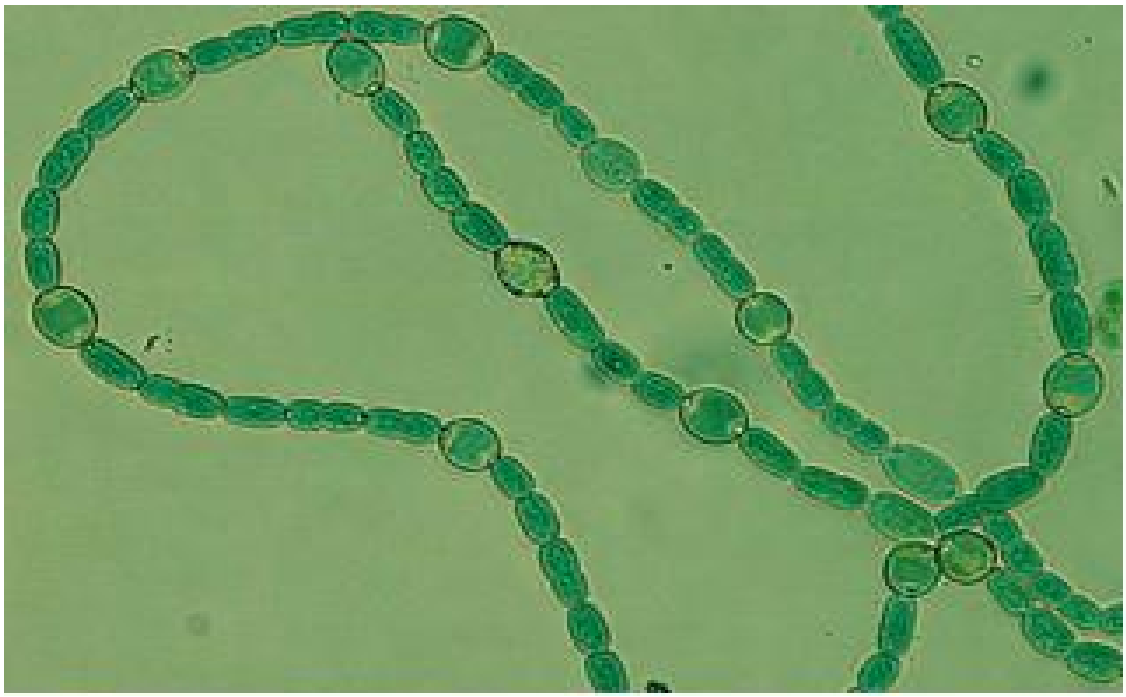


Oscillatoria



Ecology

- **Found – ponds, lakes, swimming pools, barks of trees, shrubs and on moist cells along dambos and open woodlands**
- ***Anabaena azolla – cavities of water ferns Azolla***



Domain Archaea

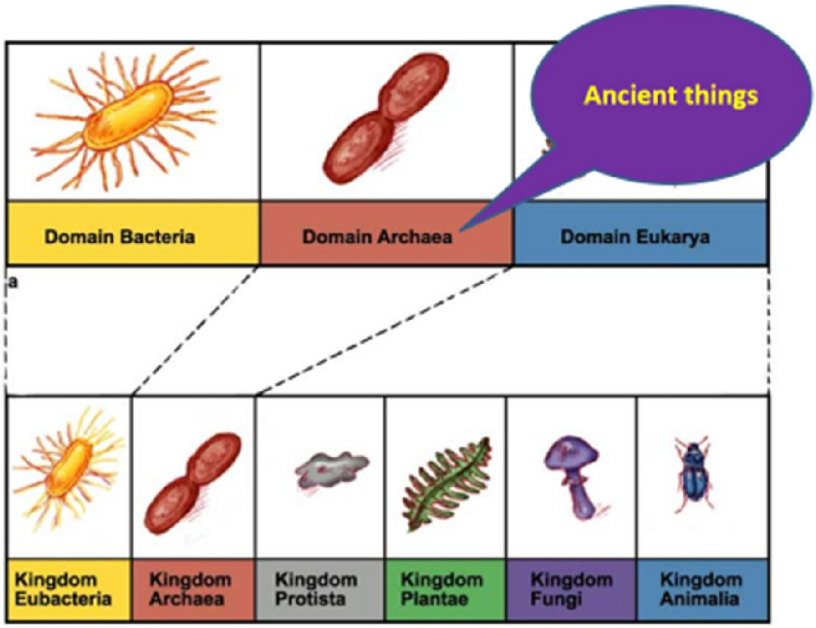
Introduction

- Old classification

Superkingdom Prokaryonta

Superkingdom Eukaryonta

New group of prokayotes discovered in late 1970s

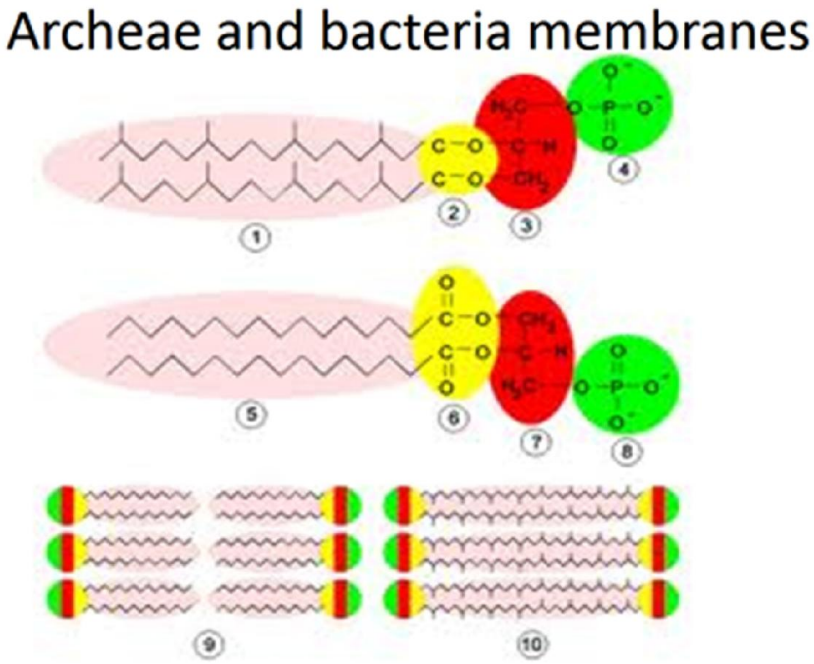


Introduction

- **Domain Archaea – group of prokaryotes lacking:**
  - **nuclear membranes**
  - **Mitochondria**

- **Membrane-bound organelles**

- **Cell walls**
  - **Do not have peptidoglycans but pseudomurein**
- **Pseudomurein consists of N-acetylglucosamine and N-acetyltalosaminuronic acid**
- **Membranes lipids – Domain Bacteria and Eukarya are unbranched**
- **Domian Archaea are unique in that the membranes lipids are branched**



Classification of Archaea

- **Number of species**
  - **220 species**
- **Major component of:**
  - **oceanic *picoplankton* (<1µm)**
- **Categories of Archaea Bacteria**
  - **Extreme halophiles**
  - **Methanogens**
  - **Extreme thermophiles**

Extreme Halophiles

- **Halophile – "salt loving"**
- **Thrive in saline (salty – very high concentration of salt) habitats**
- **Have a very high salt (NaCl) requirement – range of 12 – 23%**
- **Cell walls, ribosomes & enzymes**
    - **Sodium ions (Na^+)**
- **Many saline environment are hypersaline (strongly salty) – organisms would get dehydrated**
- **Source of energy**
    - **oxidation of organic compounds**
- **Hence they require oxygen for their metabolic processes**
- **Example of extreme halophile**
    - ***Halobacterium halobium***
- **Where is it found?**
    - **Great salt lakes & Dead sea**

Methanogens

- **Only known prokaryotes that produce methane**
- **Are anaerobic – do not require oxygen**
- **Where are they found?**
    - **environments rich in toxic gases such as methane and hydrogen**

Rice fields **Landfills** **Anaerobic digesters**

- Are also found in sewage ponds & in deep zones of the oceans
- Methanogens produce methane from hydrogen and CO_2
- They use ammonium ions (NH_4^+) as a source of energy
- It is estimated that a cow usually belches about 50 litres of methane per while chewing the cud
- Methanogens are important members of microbes that breakdown cellulose from plant materials

Extreme Thermophiles

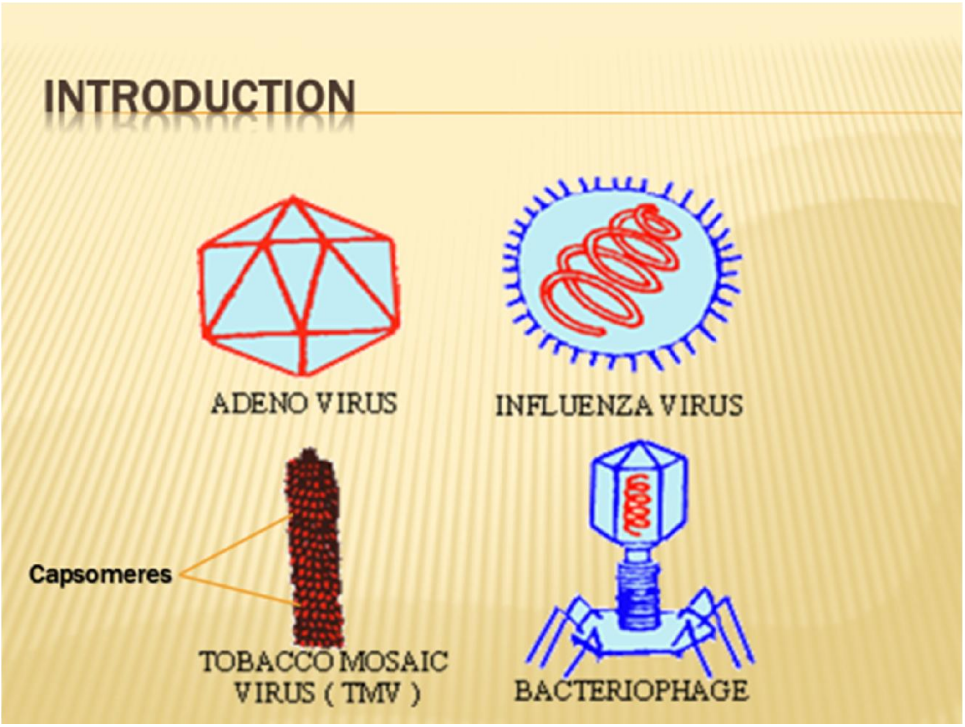
- Are found in very hot environments
- Membranes and enzymes are unusually stable at high temperatures
- Can survive and operate at optimal temperatures of around 80°C
- Some species can grow and thrive at temperatures above 110°C
- Most thermophiles metabolise sulphur
- They are found in hot springs rich in sulphur which is emitted in form of sulphur dioxide
- Most species are strictly anaerobic

Role of Prokaryotic Organisms

- They play an important role in global ecology.

- **Such organisms are involved in the process of recycling important elements such as carbon, oxygen and nitrogen.**
- **Some species have symbiotic associations with vascular plants and thus are involved in the fixation of nitrogen into nitrates.**

The Viruses

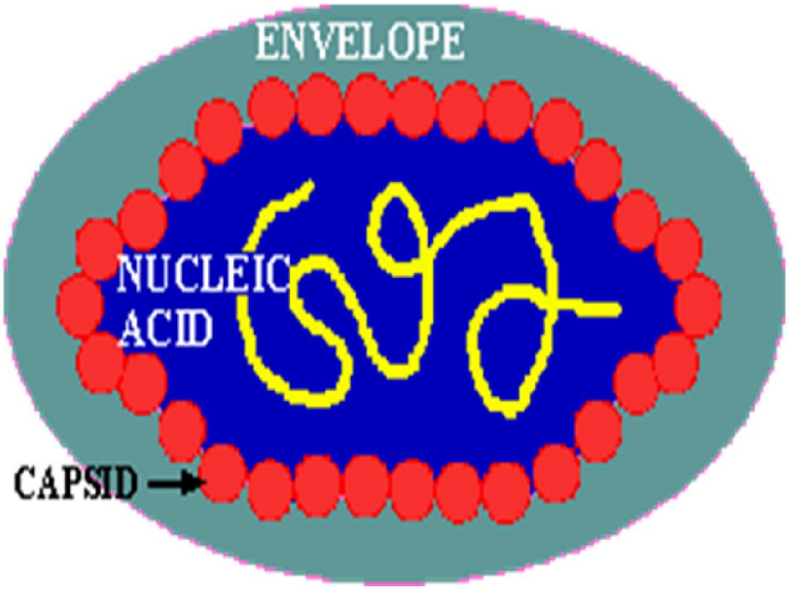


- **Virus – derived from Latin to mean poison and other noxious substances**
- **Virulent – refers to an agent that causes infectious disease**
- **The term "virion" is applied to a single infective viral particle**
- **Each kind of virus is normally associated with a specific host**
- **A symptom of viral infection in plants is expressed by reduced growth rates**
- **In humans viruses are responsible for diseases such as chicken pox, measles, colds, influenza and mumps**
- **A viral disease that affects both wild and domesticated and humans is rabies**
- **The latest known deadly diseases that have inflicted the human race are AIDS and Ebola**
- **The true nature of viruses was discovered by Wendell Stanley in 1933**

- **Are comprised of a core of nucleic acid (known as *viral genome*) which is surrounded by a protein coat**
- **The *genome* plus the *protein coat* are referred to as the virion**

Nature of Viruses

- **The protein coat is in form of a *sheath* which is known as the capsid**



- **The protein coat protects the genome and also helps the virus to attach itself to the host cell**
- **A virus *lacks cytoplasm* (protoplasm) and is therefore not considered a cell**
- **A virus contains a single nucleic acid which is either DNA or RNA**
- **The DNA or RNA can either be linear (straight) or circular**
- **The virus or virus particle is metabolically inert (or *inactive*) outside the host cell**
- **Viruses can remain dormant for many years**
- **Viruses occur as obligate intracellular parasites in any organism that they infect**

Classification of Viruses

- **Since viruses lack characteristics of a cell such as the cytoplasm, they are not considered organisms**

- **Viruses are classified according to the nature of their genomes**
- **The three major classification groups of viruses are:**

a) **RNA Viruses**

b) **DNA Viruses**

c) **Retroviruses**

Mechanism of Viral Infection

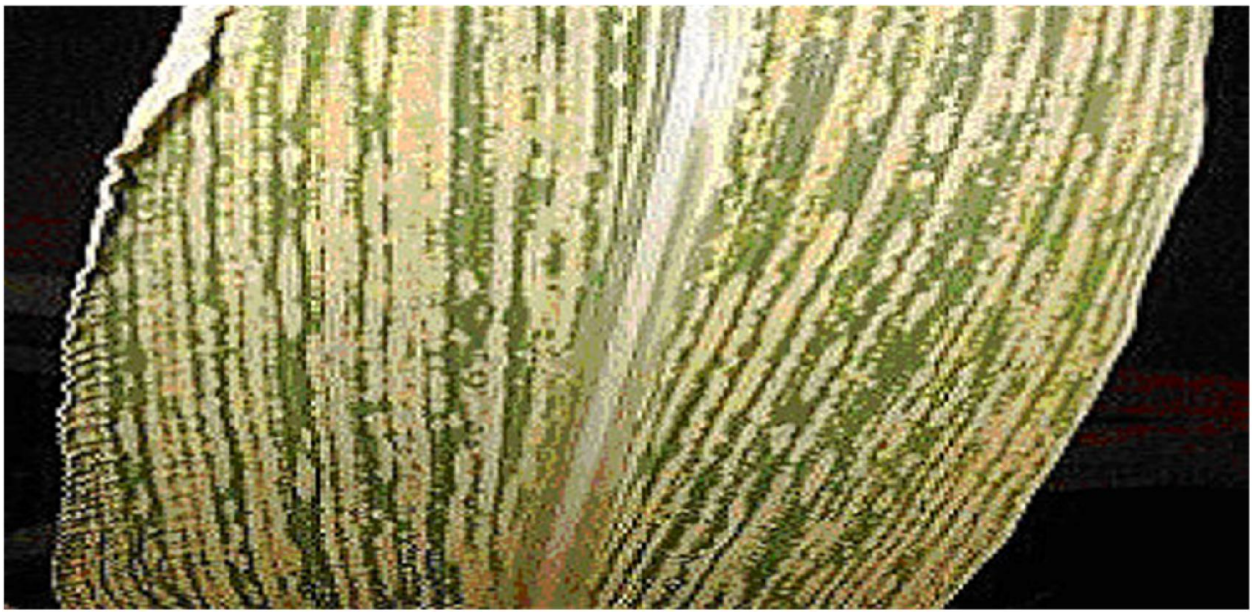
- **1. Attachment to the cell**
- **2. Penetration (injection) of viral DNA or RNA**
    - **when the virus infects a host cell, the viral genome induces enzymes of the host cell to make several copies of a particular virus**
- **In a similar manner, an infected cell is often damaged by the virus**
- **3. Replication (transcription) of new viral proteins and nucleic acids**
    - **The virus will hijack the transcription process to produce their own viral proteins**
- **Transcription is the process which involves the replication or making of copies of protein molecules**
- **4. Assembly (Maturation) of the new viruses**
- **5. Release of the new viruses into the environment (cell lyses)**
- **This concept has been extended to the phenomenon of computer viruses**
- **Viruses can only reproduce when they enter a living cell**
- **Viruses do not have ribosomes nor enzymes that are involved in protein synthesis**
- **Such viral actions cause disorder to the host and such disruption to normal physiological function of the animal or plant is referred to as disease**

Important Plant Viral Diseases

- **Tobacco mosaic virus**
- **Tomato spotted wilt virus**
- **Tomato yellow leaf curl virus**
- **Cucumber mosaic virus**

Cassava mosaic virus

- **Maize streak virus**



Cassava Mosaic Virus

- **Cassava mosaic diseases were first reported and documented from East Africa in 1894**
- **Causative agent is a virus belonging to the genus *Begomovirus***
- **Virus is circular single-stranded DNA**
- **Virus gives rise to colouration in leaves of cassava**

- **So far 9 species of the virus have been identified from Africa and India**

Maize Streak Virus (MSV)

- **Is a member of the genus Mastrevirus which is endemic to sub-Saharan Africa**
- **The disease brings about elongated coloured stripes on the leaves of maize**
- **Symptoms**
    - **Dwarf or stunted plants**

Chicken Pox

- **Is caused by the viral pathogen *Varicella zoster***
- **Genome of virus is double-stranded DNA**
- **Transmission: contact with infected persons**
- **Vaccines are available to control its spread**

Smallpox

- **Viral pathogen is *Viriola virus***
- **The genome is made up of a double-stranded DNA**
- **Transmission: contact with infected persons**
- **Last recorded case of smallpox was in 1977**
- **A world-wide vaccination campaign has wiped out the disease globally**

Ebola Viral Disease (EVD)

- **Ebola viral disease is a haemorrhagic fever that infects humans**
- **The viral pathogen are the Filoviruses**
- **EVD is caused by species of viruses under the genus *Ebolavirus***
- **The virus particles are filamentous and the genome is a single-stranded DNA**
- **The disease is confined to parts of central Africa (Congo DR)**
- **Vectors**
    - **Primates (monkeys, chimpazees)**

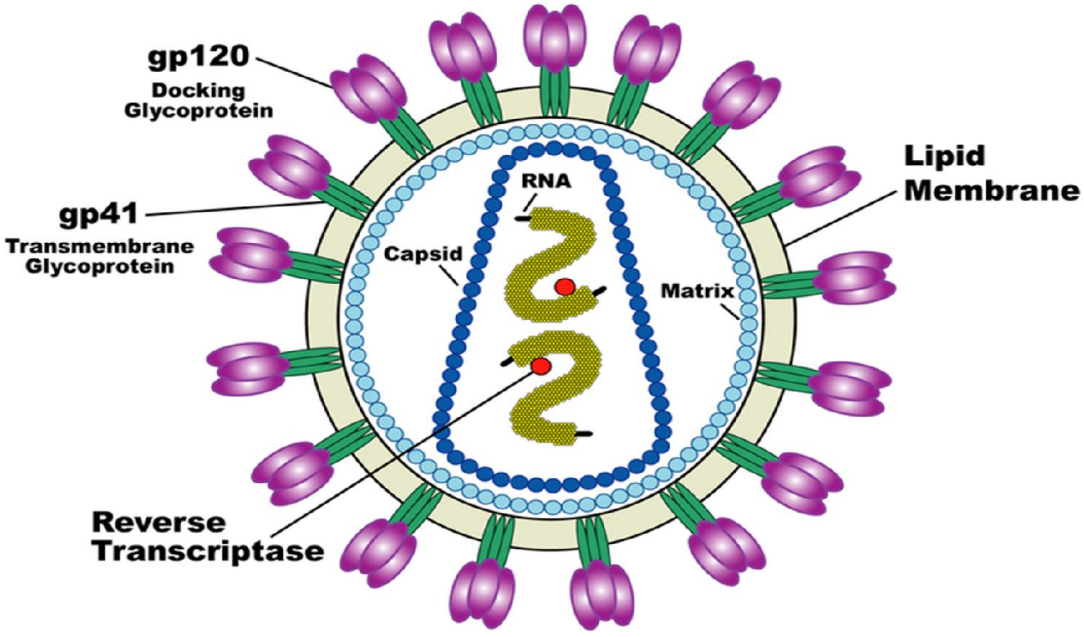
- **The virus attacks connective tissue leading to extensive hemorrhage and death – peak mortality of 50 – 90% if not treated**

Rabies

- **The viral pathogen is the Rhabdovirus**
- **The genome of the virus is a single-stranded RNA**
- **The virus is transmitted by an infected animal (bats, foxes, dogs)**
- **The virus attacks the nervous system**
- **Symptoms appear after an incubation period of 10 days**
- **Protection is possible by vaccination of domestic animals (cats, dogs)**

Acquired Immune Deficiency Syndrome (AIDS)

- **The viral pathogen is the Human Immunodeficiency Virus (HIV)**
- **The viral species is a member of the genus *Lentivirus* classified under the family Retroviridae**
- **The genome of the virus is a single-stranded RNA**



- **HIV is spherical**
- **Diametre ~ 120nm or close to 60 times smaller than a red blood cell**
- **Viral RNA is tightly bound to the nucleocapsid proteins**

- **AIDS was first identified in Los Angeles (USA) in 1981**
- **The virus destroys the immune system thereby giving rise to numerous secondary diseases (TB & a host of cancers)**

Mechanism of HIV Infection

- **Sexual intercourse is the major mode of HIV infection**
- **The virus is present in seminal fluid which is passed on from male to female or vice versa**
- **The virus then infects numerous cellular targets and spreads into the whole organism**
- **In 2005 the WHO estimated that about 40 million people were infected with HIV**
- **Globally more than 25 million people have died from AIDS since 1981**
- **Studies in France identified HIV as a retrovirus**
- **A retrovirus is *an RNA-containing virus* that is able to convert its genetic material into DNA**
- **When the virus enters target cells, the viral genome is converted (or transcribed) into a double-stranded DNA**
- **This mechanism enables the virus to become integrated into DNA of the host's cells**
- **HIV targets the CD4 cells which are normally *involved in the immune response* against foreign invaders**
- **CD4 is a form of glycoprotein found on the surface of immune cells called T-helper cells**
- **T-helper cells are important for immune resistance to viruses**
- **CD4 protein was discovered in the late 1970s**
- **In humans, the CD4 protein is encoded by the CD4 gene**
- **The virus is usually transmitted via blood, semen and other body fluids**
- **HIV has recently been isolated from semen, tears, urine and breast-milk**
- **However, HIV is a very fragile virus in that it cannot survive outside the human body**
- **Contact with HIV-positive persons <u>does not</u> bring about the risk of viral infection**

KINGDOM PROTISTA

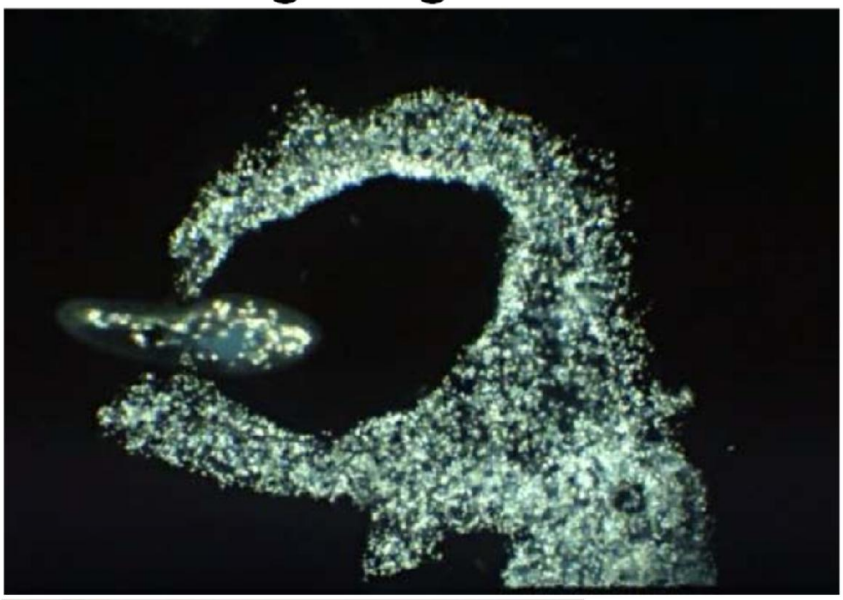
- **How Protists move**
    - **flagellum**
    - **cilia**
    - **pseudopod**

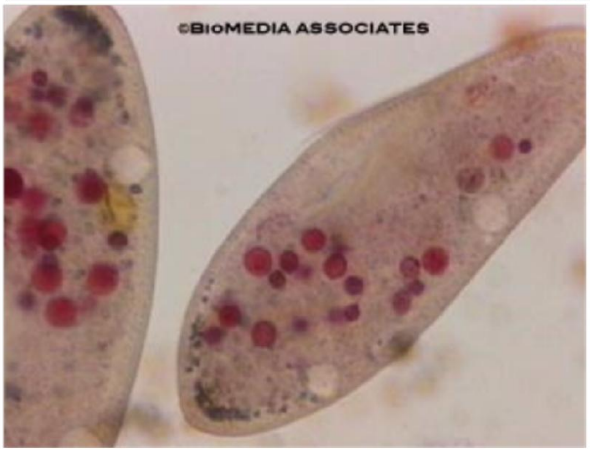
- **Are the simplest of the eukaryotes**
- **Can be unicellular, multicellular or colonial**
- **Reproduce sexually and asexually**
- **Protistans**
    - **display intermediate features found in both animals & plants**
    - **some are animal-like whereas some are plant-like**
- **The most important protistans are amoeba, *Plasmodium* & *Euglena***

INTRODUCTION

- **Animal-like Protists**
    - **heterotrophs, predators**
        - **Amoeba**
        - **Paramecium**

Amoeba ingesting a Paramecium





Paramecium with food vacuoles stained red

Plant-like Protists

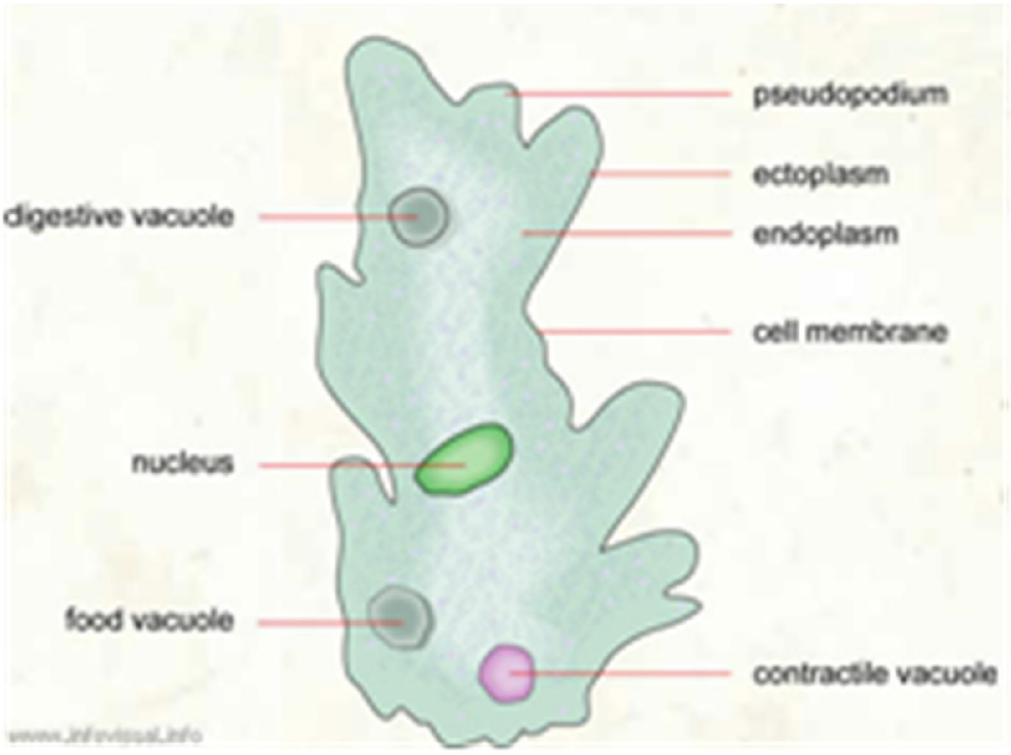
- **autotrophs, photosynthesis**
  - **Euglena**
  - **algae**
  - **diatoms**

- **Parasitic & pathogenic Protists**
    - **malaria**
    - ***Giardia***
    - **trypanosomes**
- **Are tiny microscopic unicellular organisms**
- **Amoeba derived from Greek word amoibe which means change**
- **Found in freshwater, salt water & soil**
- **Some amoeba are found in the digestive tract of humans**
- **Move by way of creeping, stretching of cytoplasm into finger-like extensions called pseudopodia (pseudopodia means false foot)**

Structure of Amoeba

Cell membrane is thin and flexible allowing amoeba to change shape

- **The nucleus is centrally located**

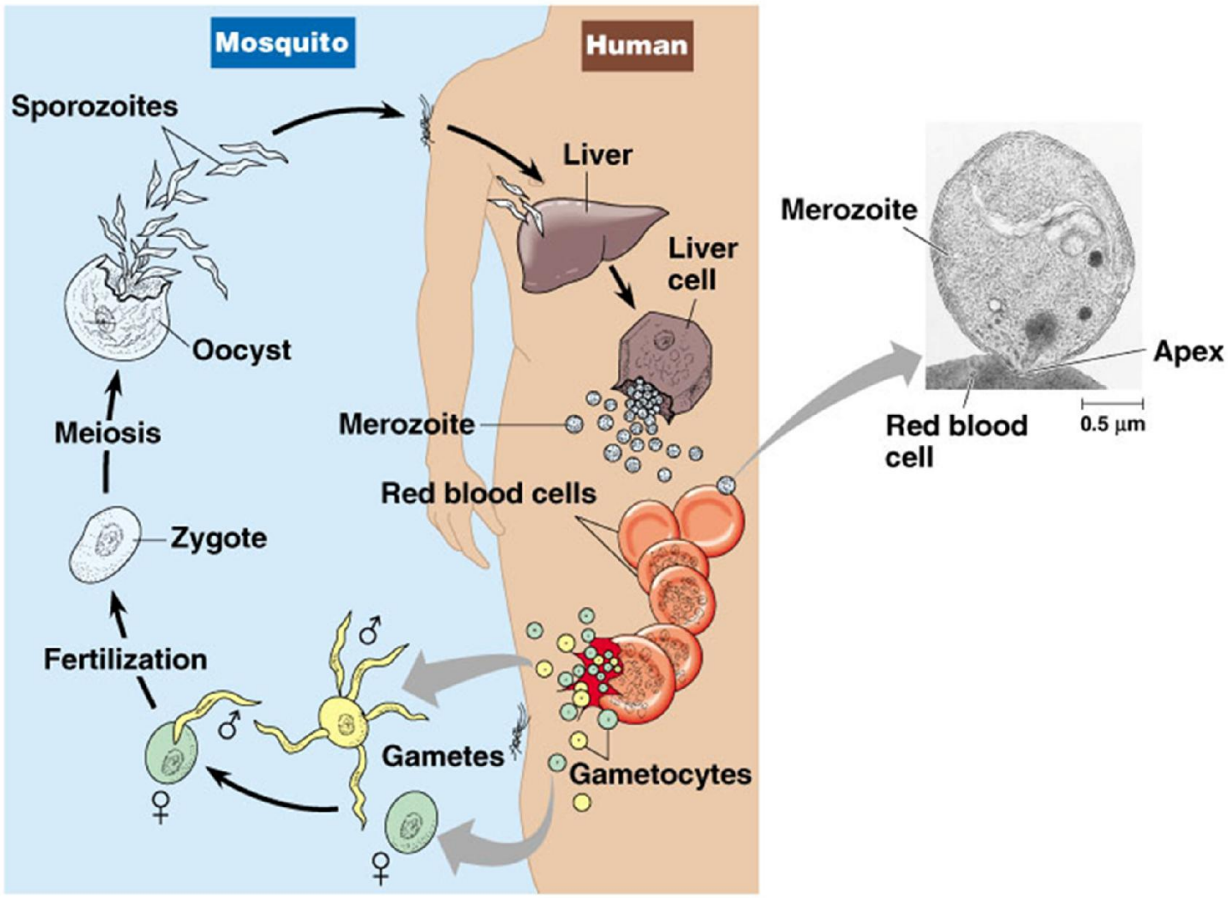


- **Cytoplasm exhibits two regions:**
    - **Ectoplasm – lighter and located near the plasma membrane**

- **Endoplasm – located towards the interior**

- **Possess organelles to carry out complex functions**
  - **Respiration – Cell membrane**
  - **Water Balance – Contractile vacuoles**
  - **Digestion – Food Vacuoles**
  - **Locomotion – Pseudopodia**
- **Some forms of amoeba can cause disease called Amoebic Dysentery**
- **Humans get infected by drinking contaminated water**
- **Malaria causing parasite**
- **The genus *Plasmodium* was described in 1885 by Ettore Marchiafava & Angelo Celli**
- **Genus has over 200 species but only 11species are known to infect humans**
- **This malaria parasite has two hosts in its life cycle: the mosquito & a vertebrate host**
- **Vector of malaria causing *Plasmodium***
  - ***Anopheles* spp**

Plasmodium



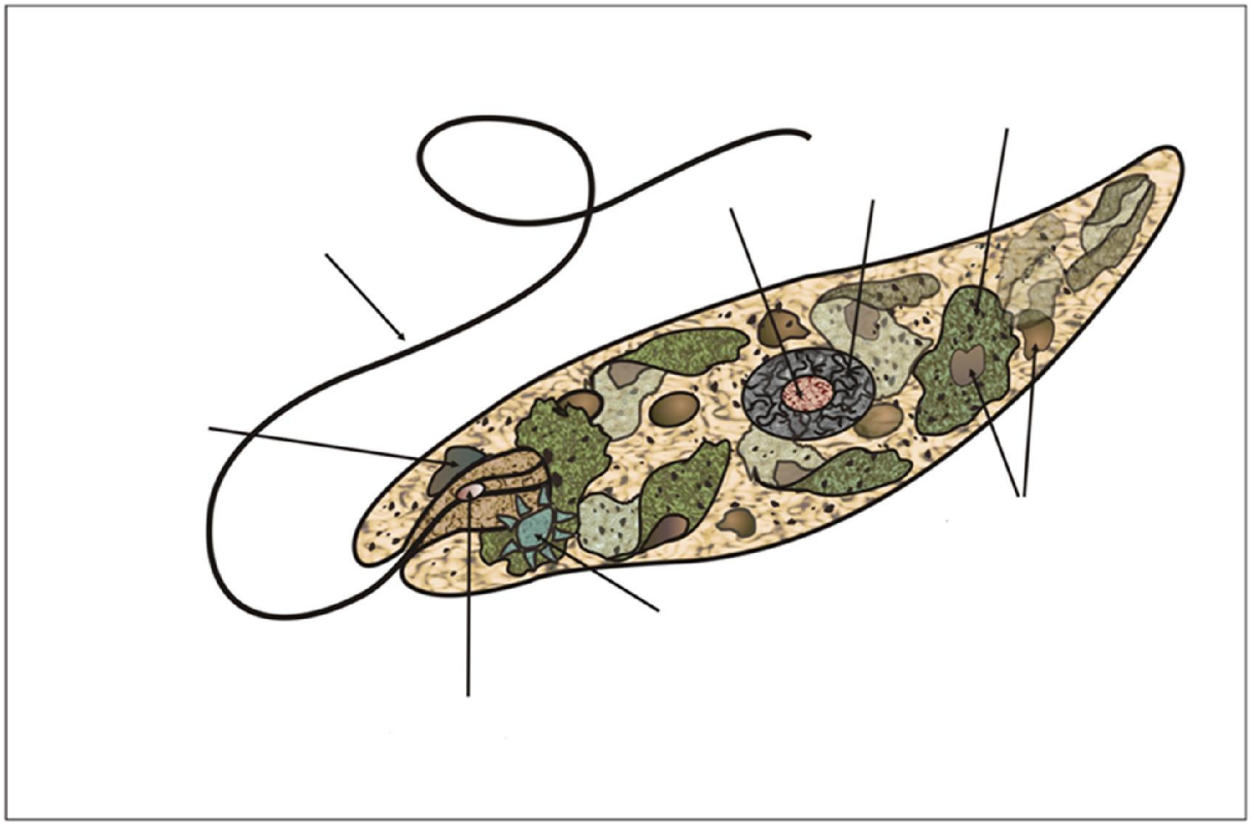
Life Cycle of *Plasmodium*

1. **Female mosquito carrying parasite feeds on human blood and injects the parasite in form of sporozoites into blood stream**
2. **The sporozoites move to the liver and infect liver cells**
3. **During the incubation period of 5-16 days, sporozoites grow, divide, replicate & are transformed into parasites called merozoites**
4. **The merozoites move from the liver cells into the blood stream**
5. **Merozoites divide asexually and the repeated release of newly formed merozoites from red blood cells can lead to illness**
6. **Merozoites in infected blood cells develop into sexual forms called the male and female gametocytes that circulate in blood**
7. **When a mosquito bites an infected human, it actually ingests the gametocytes**
8. **In the mosquito gut, the infected red blood cells burst releasing the gametocytes which further develop to form gametes**

9. **Male and female gametes fuse to form zygotes which develop into oocysts that reside in the mid-gut wall of the mosquito**
10. **Further growth and division of each oocyst produces thousands of active sporozoites**
11. **After 8-15 days, the oocysts burst to release sporozoites into the body cavity of the mosquito, from which they move to the salivary glands**
12. **Life cycle is complete when the mosquito bites another person**

- **Domain Eukarya**
  - **Kingdom Excavata or Protista**
    - **Phylum Euglenophyta or Euglenozoa**
      - **Class Euglenoidea**
        - **Order Euglenodales**
          - **Family Euglenaceae**
            - **Genus *Euglena***

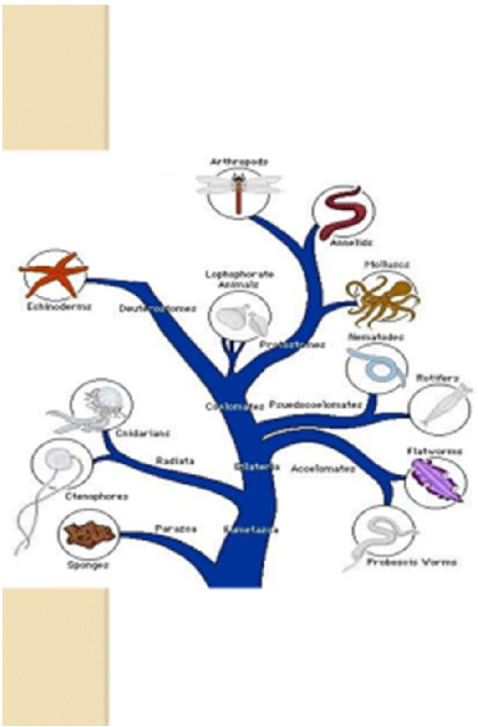
Euglena



- ***Euglena*** **is comprised of unicellular flagellate protists**
- **Species of *Euglena* are found in fresh and salty water bodies**
- **Euglena can be:**
    - **autotrophic (photosynthetic) - chloroplasts**
    - **Heterotrophic (feed like animals) – devoid of chloroplasts**
- **Their chloroplasts are surrounded by three membranes whereas chloroplasts of plants & green algae have only two membranes**
- **The chloroplasts contain pyrenoids which are proteinaceous bodies involved in starch formation**
- **Pyrenoids are also found in algae & bryophytes**
- **In *Euglena*, pyrenoids synthesize a starch-like polysaccharide called paramylon starch**
- **The presence of chloroplasts in *Euglena* has given rise to a claim that the organism is a plant**
- **On the other hand the display of motion and occurrence of colourless forms of *Euglena* has given rise to another claim that they are animals**

Diversity of Animals

The Invertebrates



Introduction

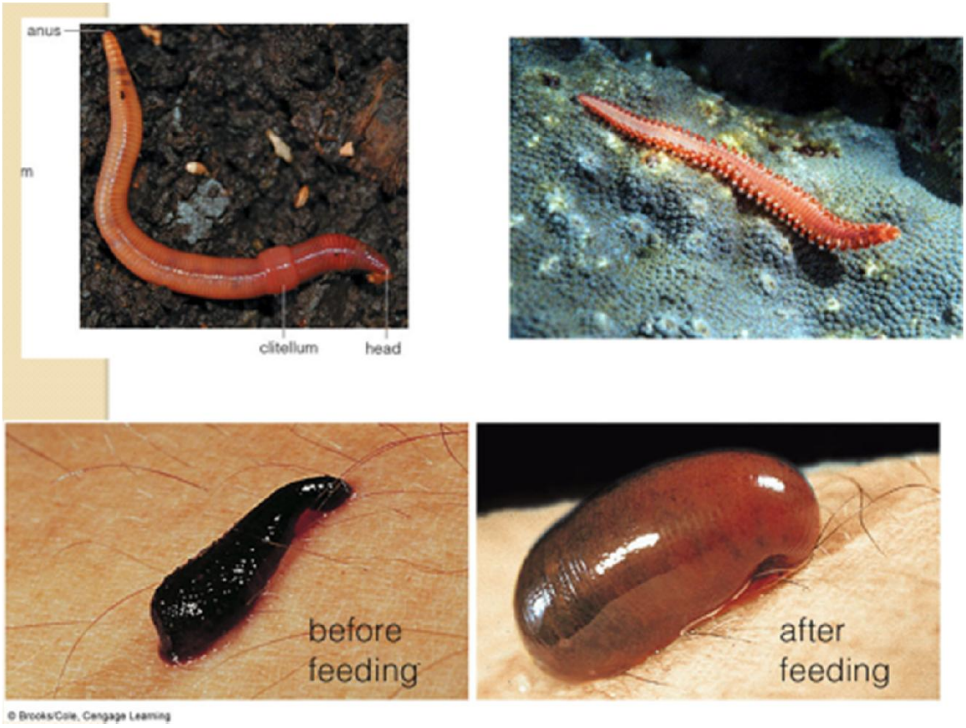
- **Kingdom Animalia is composed of:**
    - **Invertebrates (lower animals)**
    - **Vertebrates (higher animals)**
- **Invertebrates are animals without a backbone or lack a vertebral column**
- **A vertebral column is a flexible bony column that extends down the long axis of the body to provide the main skeletal support**

Examples of Invertebrate Phyla

Phylum Annelida

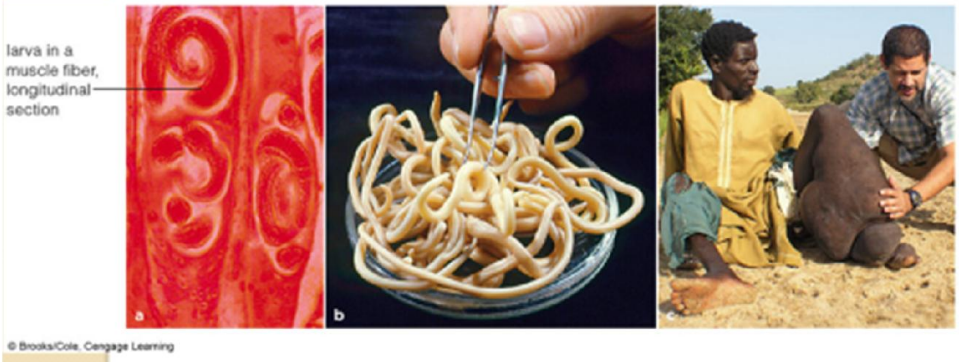
- **Is comprised of segmented worms**
- **Are a common feature of soils**

- **They move by means of alternate contraction of circular and longitudinal muscles**
- **Examples of annelids include earthworms and leeches**



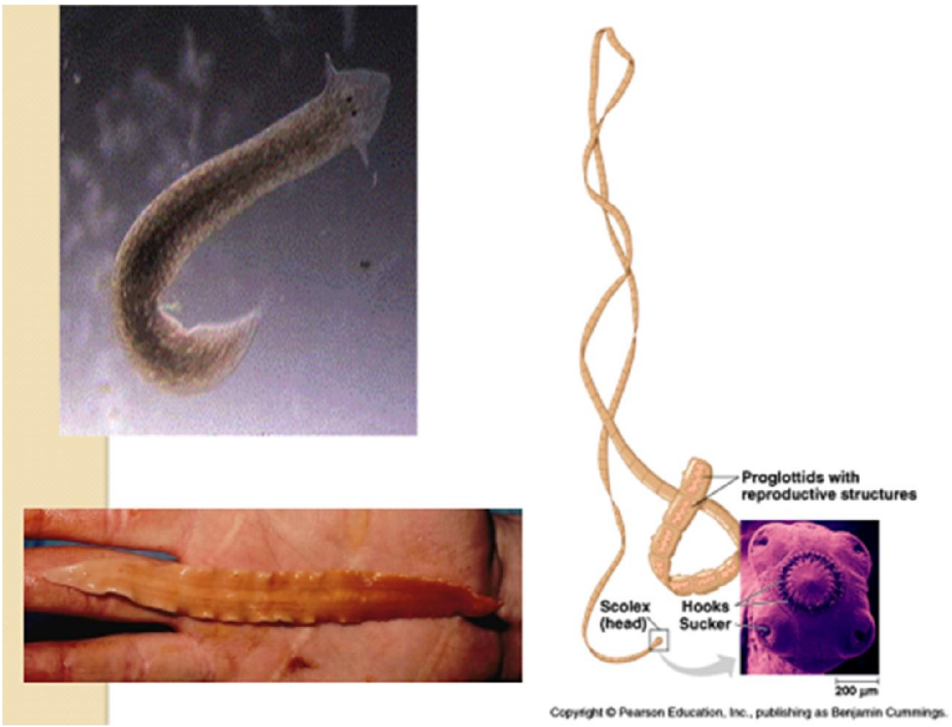
Phylum Nematoda

- **Is comprised of unsegmented worms**
- **Are found in soil and aquatic sediments**
- **The worms are typically smooth, cylindrical bodies tapering at both ends**
- **Are mostly parasitic**
- **Parasitic forms are the *Ascaris lumbricoides* (intestinal worms), the hookworms (*Necator* sp.) and Filarid forms that cause elephantiasis**



Phylum Platyhelminthes

- **These are the flatworms**
- **Have a flattened body**
- **Flatworms include tapeworms, liver flukes, blood flukes and planarians**
- **Many forms are parasitic to animals**
- ***Schistosoma* is a genus of blood flukes – a form of flatworms that cause bilharzia**



Phylum Cnidaria

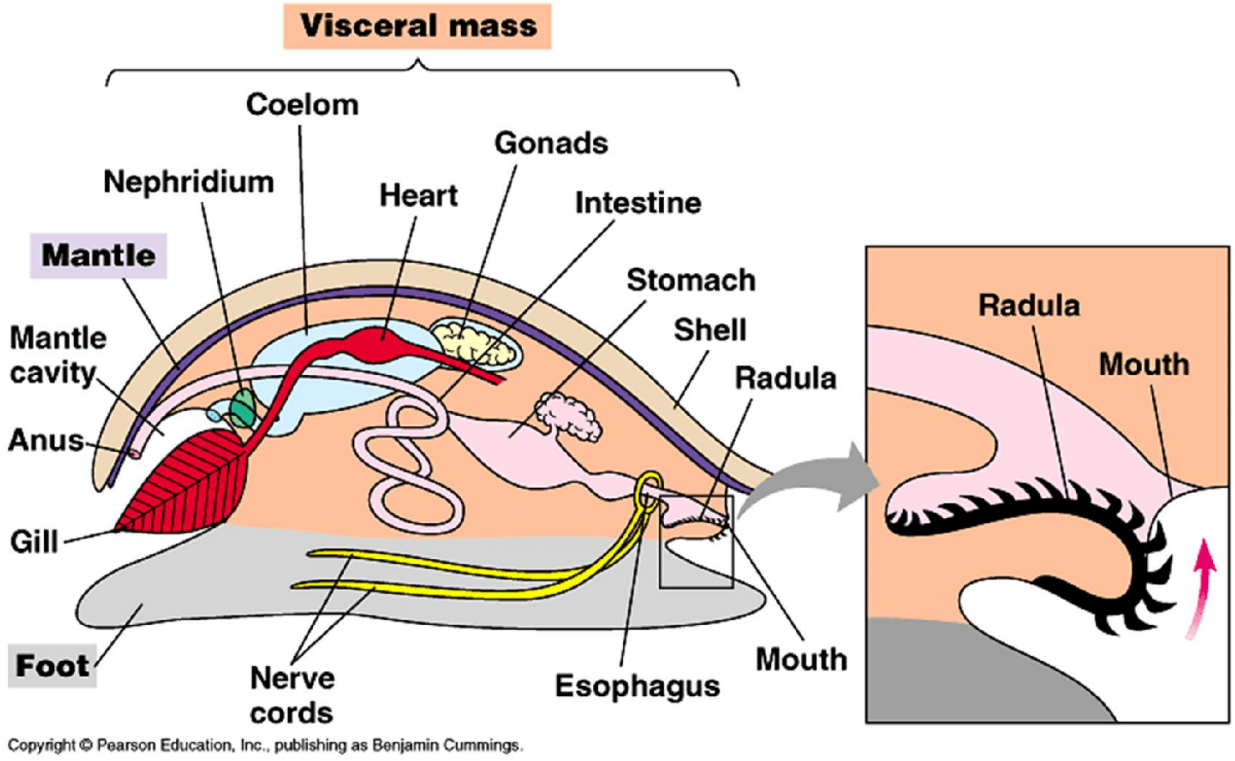
- **Is a group of over 10,000 species of aquatic animals with soft gelatinous bodies**
- **This group comprises jellyfish, hydra and corals**
- **Free-swimming jellyfish possess tentacles armed with stinging cells**
- **Hydra and corals are sedentary (stationary) non-motile**
- **Coral reefs protect shore buildings against ocean currents and tides**
- **Examples - Jellyfish, Hydra, sea anemones, and corals**

Phylum Mollusca

- **Commonly referred to as mollusks or molluscs**
- **The group is comprised of about 85000 extant species**
- **Are numerous in freshwater, salty water and terrestrial habitats**
- **Aquatic species are vectors of bilharzia parasites called *Schistosoma***
- **Are mostly herbivorous as they feed on algae and plants**

Phylum Mollusca

- **Key organisms are: snails, mussels, slugs oysters, etc**
- **Important features of the snail are the foot, mantle, alimentary canal and the shell**
- **These animals are characterized by soft bodies with rasping tongues like a file**
- **Many molluscan species bear hard shells, mainly made up of calcium**



Phylum Arthropoda

- **Generally called arthropods**
- **Arthropods possess bodies with hard exoskeletons**
- **The exoskeleton is made up of the cuticle, a non-cellular material secreted by the epidermis**
- **The exoskeleton is composed of mucopolysaccharide, chitin and proteins**
- **Mucopolysaccharide is any group of polysaccharide that contains amino acids such as glucosamine**
- **A glucosamine is described as an amino sugar – i.e. any sugar-containing amino acid**

- **Exoskeleton**
    - **prevents dessication (dehydration)**
    - **provides structural support to the animals**
- **Arthropods shed their old exoskeleton (facilitated by enzymes) in a process called moulting**
- **Movement of joints is controlled by muscles attached to the exoskeleton**
- **Arthropods consist of segments with each bearing a pair of appendages**
- **The phylum comprises bees, butterflies, centipedes, crabs, millipedes, mites, scorpions, spiders, termites, ticks, etc**
- **This phylum is the largest of all animal phyla**
- **Arthropods are cosmopolitan in their distribution – occur in all continents of the world**

Table 25.2 Living Arthropod Subgroups

Group	Representatives	Named Species
Chelicerates	Horseshoe crabs	4
	Arachnids (scorpions, spiders, ticks, mites)	70,000
Crustaceans	Crabs, shrimp, lobsters, barnacles, pill bugs	42,000
Myriapods	Millipedes and centipedes	2,800
Insects	Beetles, ants, butterflies, flies	>1 million

Major Groups of Arthropods

Class Arachnida

- **Are terrestrial arthropods characterized by the possession of 4 pairs of legs**
- **Arachnids include mites, scorpions, spiders and ticks**
- **Most of them are carnivorous except mites which are largely herbivorous**
- **Mites and ticks are closely related**
- **Ticks are ectoparasites of vertebrates**

- **Ticks are vectors of many diseases that affect domestic animals**
- **Spiders play a major role in ecosystems (predators of insects)**
- **Scorpions are predatory animals with a reputation of killing small lizards and mice**
- **Their venom is a mixture of neurotoxins and enzyme inhibitors**
- **Of the1000 known species – 25 species are deadly to humans**

Class Chilopoda

- **Is comprised of worm-like arthropods bearing legs**
- **Is represented by the centipedes**
- **Are characterized by the possession of one pair of legs per body segment**
- **Their legs vary in number from 20 to over 300 legs**
- **Their head is round or flat and bears a pair of antennae used for seeking prey**
- **Possess a pair of venom (poison) claws which are a form of modified first (anterior or front) pair of limbs**
- **Behind the head, the body is divided into 15 or more segments**
- **Each body segment has one pair of legs**
- **Are found in forests, woodlands & savannas, especially in moist habitats**
- **Are mostly nocturnal**

Class Diplopoda

- **Characterized by worm-like invertebrates**
- **Each body segment bears two pairs of legs**
- **Examples**
    - **millipedes (chongololo or chiyongoli)**
    - **pill millipedes**

    - **keeled millipedes**

- ***Millipede* derived from Latin word "*mille*" meaning thousand**
- **Only rare species of millipedes known to have 750 legs; most of them have between 36-400 legs**
- **Millipedes are scavengers (detritivores) – feed on dead organic matter**
- **Some species of millipedes emit poisonous secretions or hydrogen cyanide through microscopic pores**

Class Crustacea

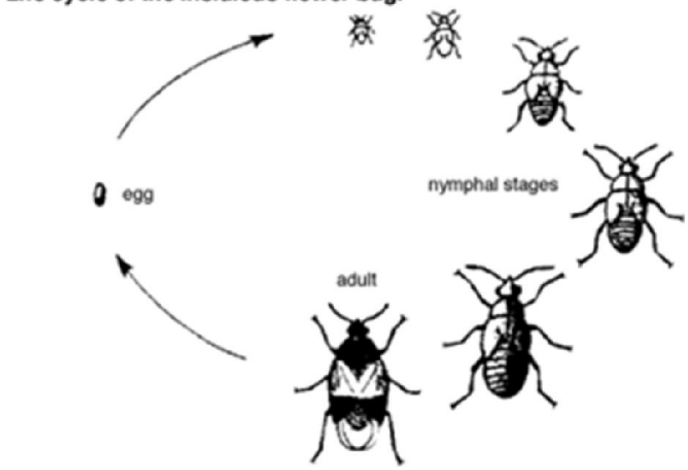
- **Are aquatic arthropods found in marine as well freshwater bodies**
- **This group comprises crabs, crayfish, lobsters & shrimps**
- **Crustacea have 3 body regions (tagmata) but the two anterior segments are fused to the head to form a cephalothorax**
- **Most crustaceans have two pairs of antennae**
- **The thorax and abdominal appendages are variously *modified for feeding, walking (legs) or swimming***
- **Shrimps are part of sea foods that are commonly supplied in hotels**

Class Insecta

- **Insects are the most diverse and abundant of all arthropods.**
    - **~28 orders**
- **Most are terrestrial or inhabit freshwater.**
    - **Few are marine.**

Introduction

- **Majority of species are winged**
- **Class Insecta also known as Hexapoda**
- **Number of insects: 800, 000 – 1million spp**
- **Examples of insects**
    - **Bees, beetles, butterflies, moths, fleas, houseflies, tsetse flies, grasshoppers, termites, etc**
- **Body of insect divided into three: head, thorax and abdomen**
- **Body covered by exoskeleton which provides framework for muscle attachment**
- **Growth is achieved by moulting (ecdysis) – shedding of old exoskeleton & formation of new cuticle**
- **Moulting is controlled by a hormone called ecdysone which is secreted by a pair of thoracic glands**



The Head

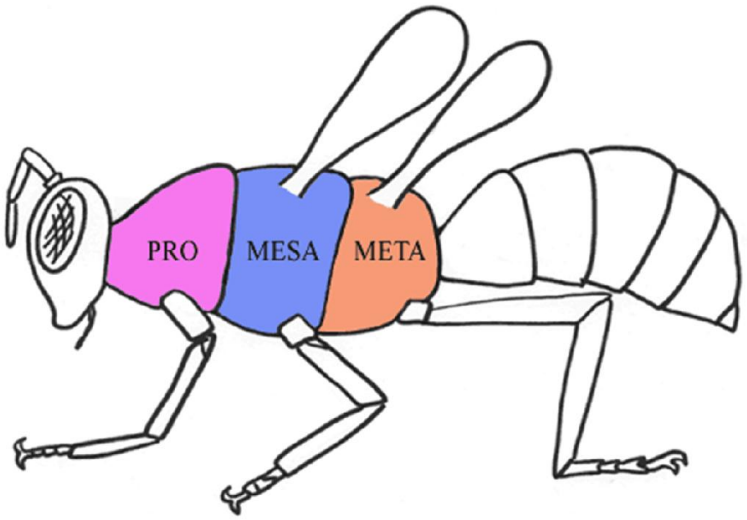
- **Has mouth parts, eyes, and a pair of antennae**
    - **chewing (grasshopper, cockroaches)**

- piercing-sucking (mosquitoes, bugs)
- lapping and sponging (flies)

- Most insects have a pair of compound eyes & sometimes ocelli
- Antennae are involved in the sense of smell and touch
- Antennae are variable and thus used in the identification of different groups of insects

The Thorax

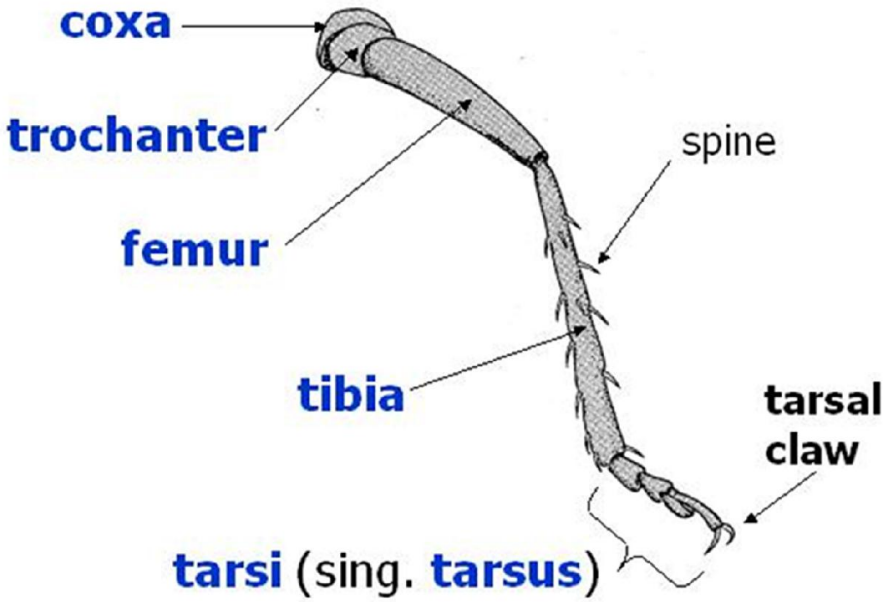
- Made up of three segments:
  - Prothorax – anterior segment
  - Mesothorax – middle
  - Metathorax – posterior
- Each thoracic segment bears a pair of legs
- Legs are divided into 5 main segments:



Thorax

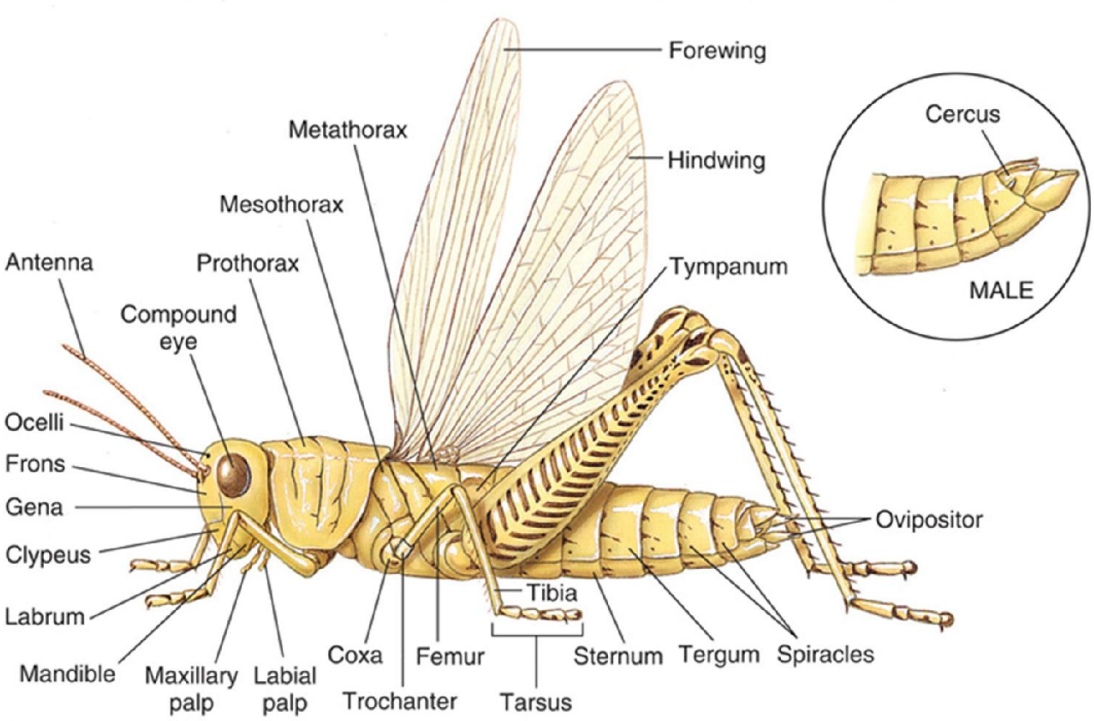
Insect Legs

- Basic plan: 5 segments



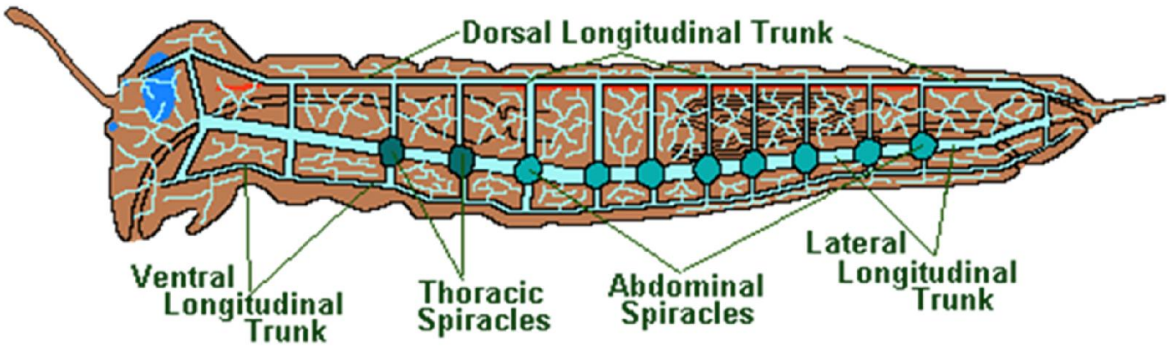
Abdomen

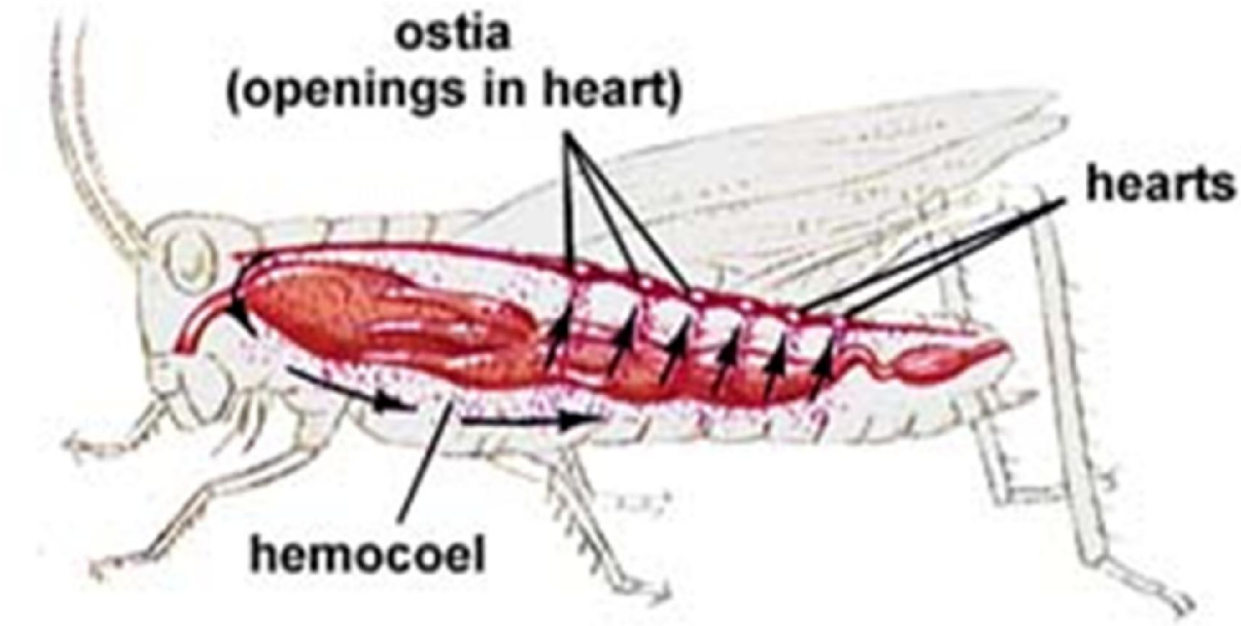
- **Generally, made up of 11 segments**
- **In insects such as the silverfish & mayflies, the 10th segment bears 2 – 3 pairs of appendages called cerci**

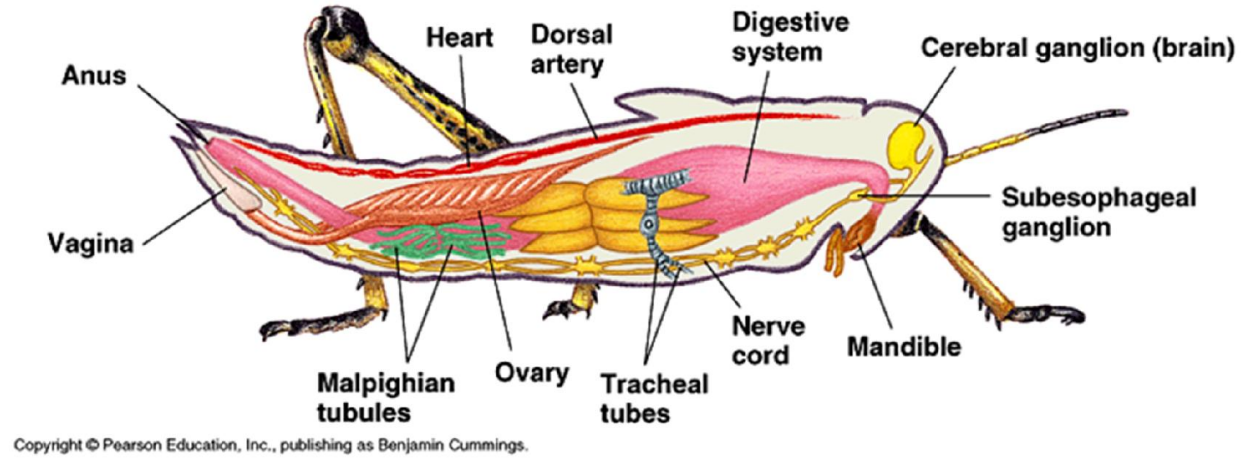


A

Diagramatic Representation of the Insect Tracheal System







Classification of Insects

- **The most common groups of insects prevalent in Zambia are represented by the orders:**
    - **Coleoptera – beetles**
    - **Diptera – flies**
    - **Hymenoptera – bees, wasps & ants**
    - **Isoptera – termites**
    - **Lepidoptera – butterflies & moths**

- **Orthoptera – Grasshoppers, cockroaches, crickets & mantids**

Order Coleoptera

- **Commonly known as beetles**
- **Front pair of wings modified into hard horny or leathery structures called elytra**
- **Larvae of some beetles are edible (white grubs, finsenda, fisololo)**
- **Some beetles with more or less circular bodies are called ladybirds**
- **Other beetle species with elongate black bodies tinged with yellow, brown or red stripes are known as blister beetles**

Order Diptera

- **Possess one pair of membranous wings**
- **Mouth parts modified into piercing & sucking structure called proboscis**
- **Typical members of this order are houseflies, mosquitoes, hoverflies, horseflies & tsetse flies**
- **Many species are vectors of disease**
- **Houseflies, *Musca domestica* is associated with human habitation, feeding on human food & excrement**
- **Houseflies are known to breed in fresh manure, garbage & rotting vegetation**
- **Houseflies also transmit several diseases such as cholera, diarrhoea, leprosy & typhoid**
- **Vectors of malaria: *Anopheles* spp lay their eggs on pools of water & in seepage areas**
- **Vectors of filariasis (elephantiasis):**
    - ***Culex* spp are associated with human habitation & known to breed in stagnant waters**
- **Vectors of yellow fever:**
    - ***Aedes aegypti* is characterized by black & white-banded legs**

- **They usually bite in broad daylight**

Order Hymenoptera

- **A group of social insects bearing two transparent wings**
- **Group comprises bees, wasps & ants which often possess stings**
- **Bees are social insects involved in ~70% pollination of flowering plants**
- **Bees and wasps lay their eggs in prepared nests & feed their young with nectar**
- **Fig wasps have evolved with some species of fig trees**

Order Isoptera

- **Another group of social insects which live in nests called termitaria (termite mounds)**
- **Some termite species build trails (soil nests) on tree trunks**
- **Adult termites (reproductives) bear two pairs of wings**
- **A termite colony has four different forms (castes)**
    - **Large first forms which are dark make up the primary reproductives – queens and kings**
    - **Less pigmented 2nd forms make secondary reproductive caste**
    - **3rd forms make sterile male & female soldiers with modified hardened heads**
    - **The 4th caste are workers made up of male & female types**
- **Wood feeding termites are able to hydrolyze or breakdown cellulose to release glucose with the aid of enzymes**
- **Colonies of termites can exist for decades even centuries in some species**
- **Termites are of economic and ecological significance in this part of Africa**
- **Some termite species have added unique landscapes in form large termite mounds in Miombo woodlands**
- **In southern Africa, termites are a source of food to humans**

Order Lepidoptera

- **Includes brightly coloured & hairy flying insects**
- **Comprises butterflies and moths**
- **Are characterized by having two pairs of broad and brightly coloured wings**
- **Butterflies are usually small-bodied and active during the day**
- **Moths have comparatively larger bodies and are active at night**
- **Edible caterpillars are reproductive larval stages of moths**
- **The destructive army worms are the caterpillar stage of the moth**
- **The species of army worm that invaded crops in several parts of Zambia was *Pseudaletia unipuncta***
- **Another species of army worm is *Spodoptera frugiperda***
- **The diet for these worms is mainly derived from grasses & legumes**
- **Female moths lay their eggs in clusters on the lower side of grass leaves**
- **Each cluster may contain 500 or more eggs**
- **When food is exhausted, the caterpillars migrate to new areas in *army-formations***

Order Orthoptera

- **The group includes grasshoppers, crickets & locusts**
- **Possess enlarged hind legs adapted for jumping**
- **Flying species have two pairs of wings**
- **Are divided into two groups based on length of antennae**
- **Short-horned group includes grasshoppers & locusts**
- **Long-horned group includes crickets**
- **The Red Locusts known as *Nomadacris semptefasciata* are ecological importance in Africa**
- **They form migratory swarms of 30–60km long & 3–4 km wide**
- **Habitat: grasslands**

- **The *International Red Locust Organization* was established to monitor & control outbreaks of Red Locusts in Central and Southern Africa**

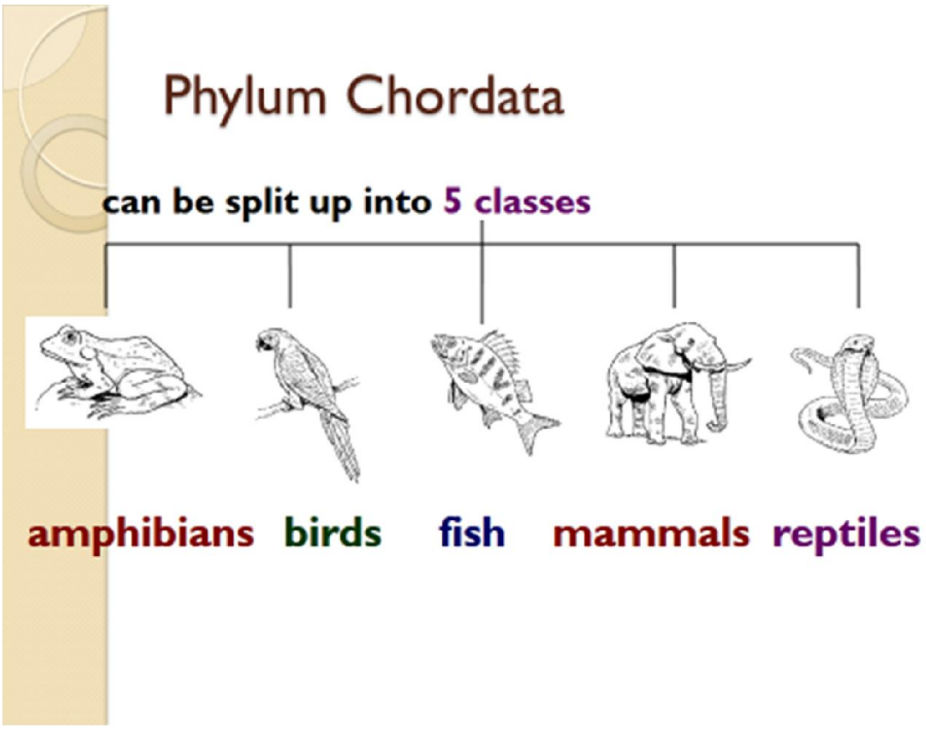
Beneficial Insects

- **Pollinators**
- **Research and discovery- fruit fly for genetic research**
- **Food producers- honey**
- **Textiles- Silk & beeswax**
- **Biological control agents**

Harmful insects

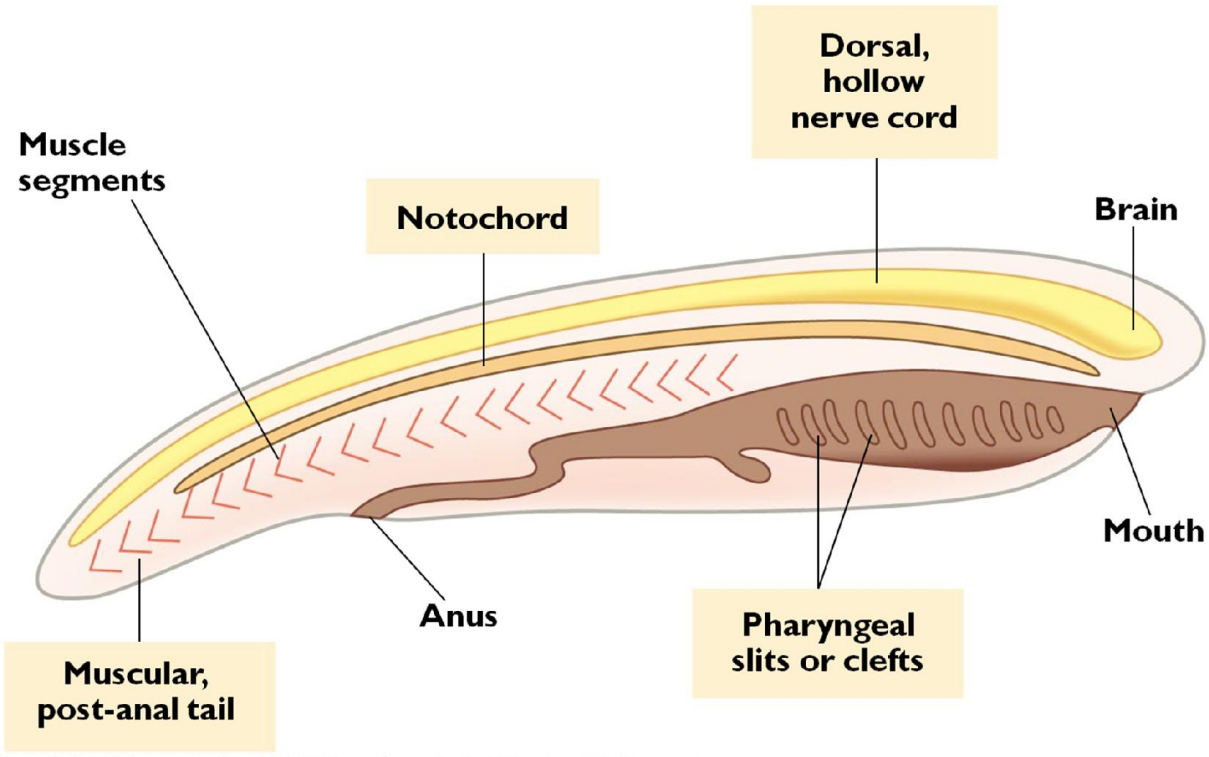
- **Disease vectors**
- **Crop/food destruction**
- **Textile destruction**

The Vertebrates

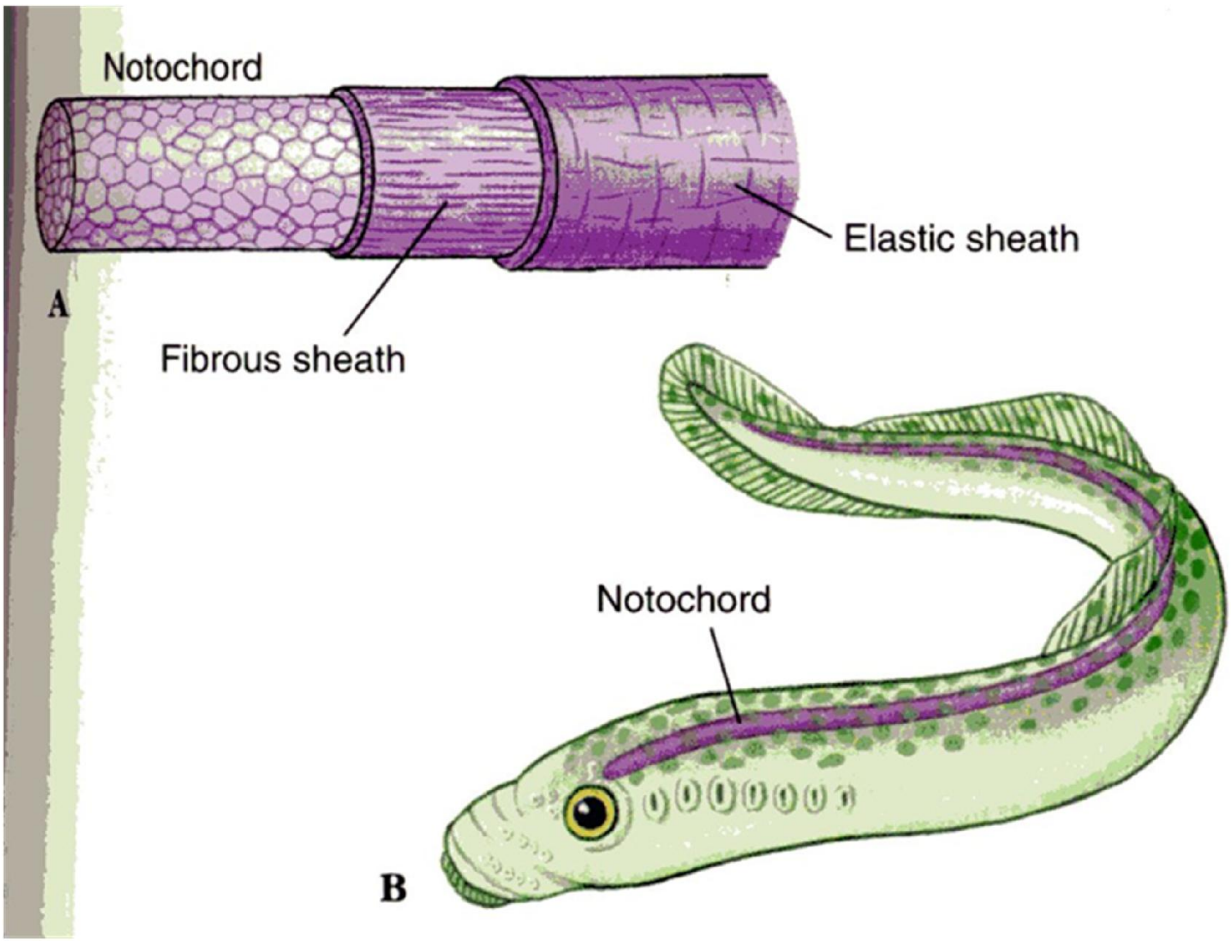


Phylum Chordata

- **All chordates share certain characters**
- **Four key characters of chordates:**
  - **Notochord**
  - **Dorsal, hollow nerve cord**
  - **Pharynx**
  - **Pharyngeal slits or clefts**
  - **Muscular, post-anal tail**



- **The Notochord and gill slits open from the pharynx**
- **Pharynx is a cavity located between the mouth and the wind pipe**
- **The Notochord is a flexible rod comprised of large cells surrounded by a stiff sheath**
- **In developing embryos**
    - **Notochord located on dorsal side of gut**



- **Notochord present in all chordates esp. early stages of development**
- **Notochord may persist in some chordates**
- **In some groups, the notochord is replaced by the *vertebral column* or backbone**
- **The backbone is either made of bone or cartilage**
- **The brain is protected by the cranium**
- **During early development, chordates possess a *post-anal tail* which extends beyond the anus**
- **The Post-anal tail disappears at adult stage in some animals but persists in others (cats, cattle, dogs, goats, monkeys)**
- **Phylum Chordata is comprised of about *56000 species***

The Fishes

- **Major group of vertebrates which are strictly aquatic**

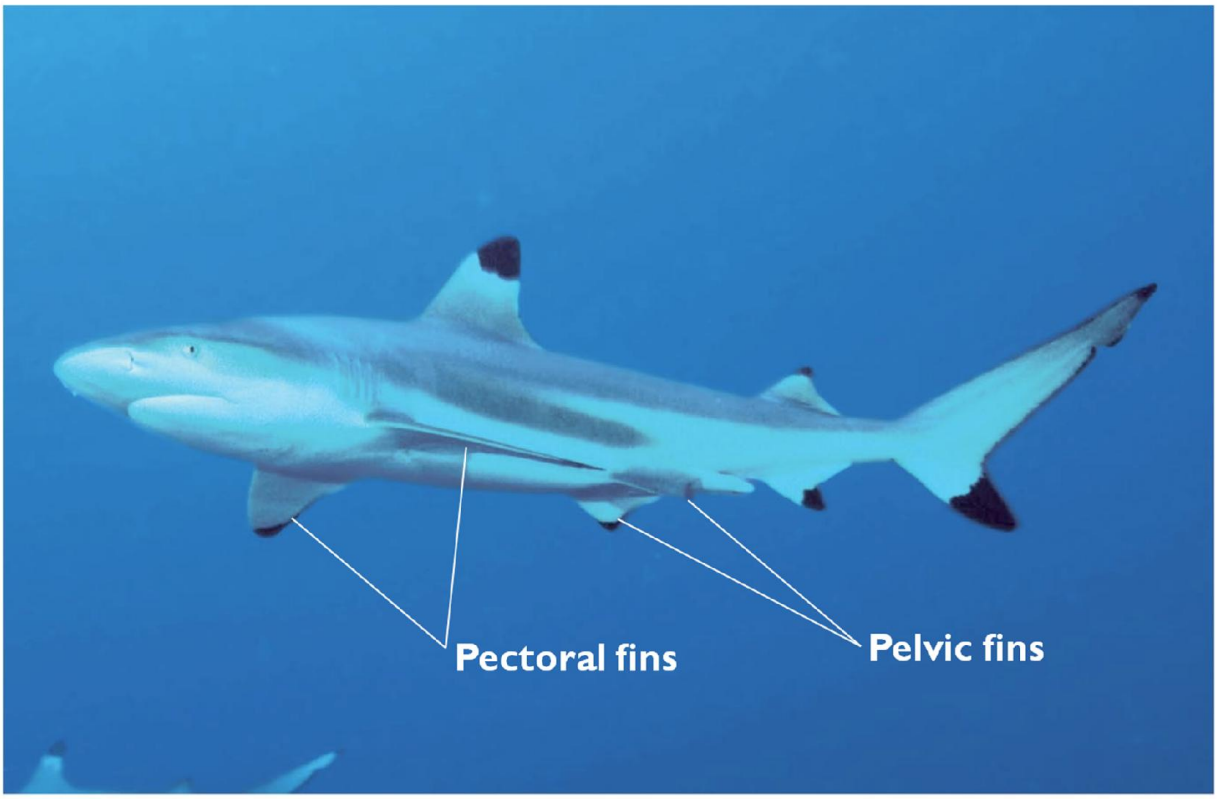
- **Fishes**
    - **Marine**
    - **Freshwater**
- **Classified under 3 major Classes:**
    - **Agnatha**
    - **Chondrichthyes**
    - **Osteichthyes**

The Class Agnatha

- **Comprised of jawless fishes**
- **Embraces hagfishes and lampreys**
- **Hagfishes hide in mud or sand during the day & emerge at night to scavenge on dead animals and organic matter**
- **Lampreys occur in marine water as blood sucking fishes (use suckers for attachment)**

The Class Chondrichthyes

- **Group of *marine fishes* – cartilaginous and without bones**
- **Most are *marine carnivores* armed with powerful jaws**
- **Have pairs of stabilizing fins**
- **Mouths are adapted for biting prey**
- **Have no bladders – swim constantly to avoid sinking**
- **Class of fishes includes sharks, skates, sting rays**



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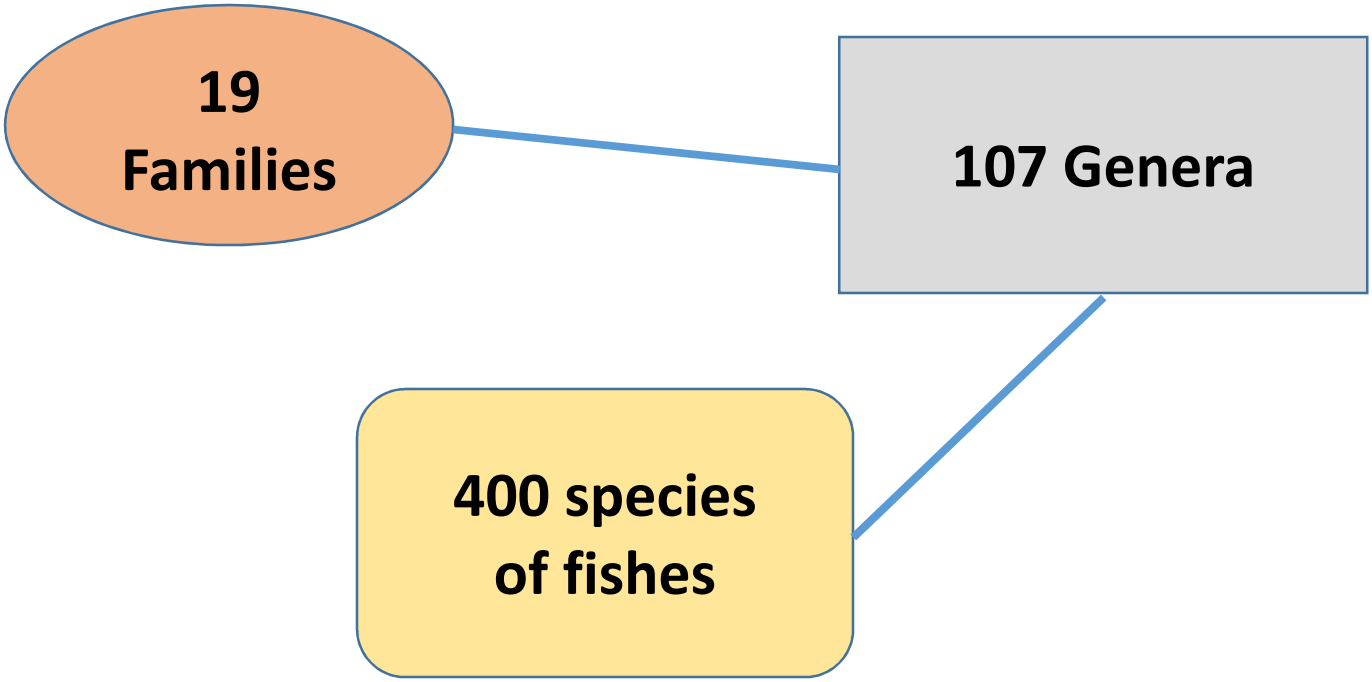
The Class Osteichthyes

- **Embraces bony fishes**
- **Have a well developed endoskeleton with a bony spine**
- **Have jaws**
- **Paired appendages in form of pectoral fins & pelvic fins**
- **Body covered in scales in some spp (breams) while (catfishes) lack scales**
- **Possess gills for respiration**
- **Bony fishes possess a swim bladder**
- **In some species of bony fishes, the swim bladder acts as a lung**



- **>50% of known species occur in Lake Tanganyika (many are endemic)**
- **Examples of bony fishes in Zambia**
    - **Tiger fish**
    - **Nile Perch**
    - **Catfish**
    - **Breams**
    - **Sardines (Kapenta)**

The Amphibians

- **Have a set of four legs**
- **Most of them lay their eggs in water**
- **Fertilization is external**
- **Respire through gills, lungs and moist skin**
- **Examples**
    - **Frogs**
    - **Toads**

- **Salamanders**

- **In Zambia:**
  - **7 families**
  - **30 genera**
  - **78 species**
- **In Evolutionary terms**
  - **Amphibians more advanced than fishes**

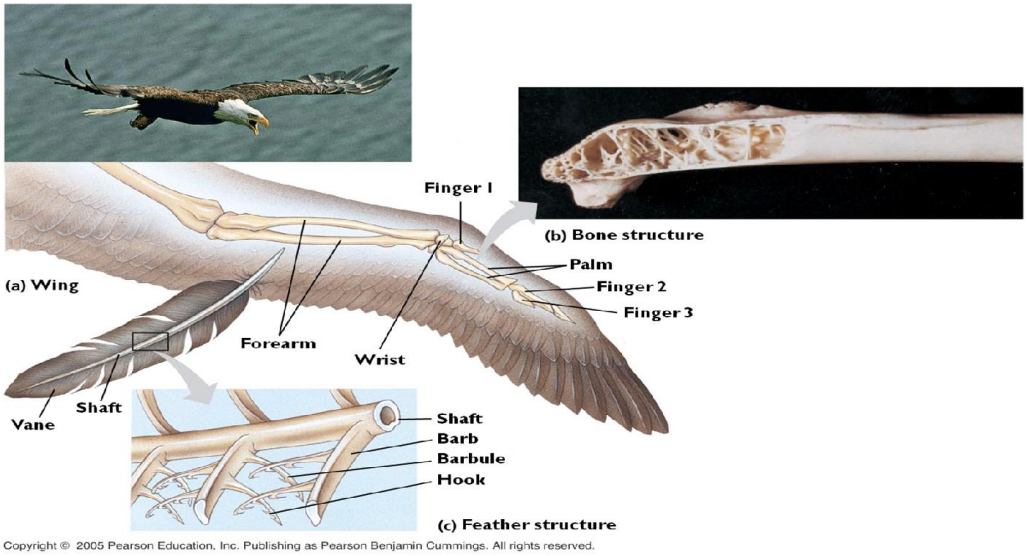
The Reptiles

- **Mostly terrestrial vertebrates**
- **Majority lay water-tight eggs**
- **Most reptiles are oviparous (egg-laying animals)**
- **A few are viviparous – give birth to live young**
- **Their skin is dry, water-tight & covered by a layer of horny scales composed of keratin**
- **Reptiles breathe by means of lungs**
- **All reptiles are ectothermic**
- **Are thus described as cold-blooded animals**
- **Examples**
  - **lizards**
  - **chameleons**
  - **Snakes**
  - **Tortoises**
  - **Alligators**
  - **crocodiles**
- **Some snakes are poisonous (puff adders, cobras, black mamba); others are non venomous (house snakes, pythons)**

- **Zambia has two species of crocodile**
    - **Nile crocodile (*Crocodylus niloticus*)**
    - **African long snouted crocodile (*Crocodylus cataphractus*)**
- **Zambia has:**
    - **18 families, 71 genera and 152 species of reptiles**

Class Aves – Birds

- **Study of birds is termed ornithology**
- **Birds possess feathers – modified scales**
- **Role feathers**
    - **Flight**
    - **Conserve heat**
- **Body is spindle shaped & is comprised of:**
    - **Head, neck and trunk**
- **Birds have wings, their beaks lack teeth**
- **Bones are thin with hollow cavities filled with air**



- **Limbs are paired, fore-limbs are modified as wings**

- **Most species do fly but some do not**
- **The flightless birds include penguins, ostriches etc.**
- **Exhibit high metabolic rates**
- **Are endothermic**
- **Respiration effected by lungs**
- **Birds are oviparous**
- **Fertilization is internal**
- **Beak shape determines type of food birds feed on**
- **Some birds, especially parrots are among the most intelligent**
- **Many bird species undertake long distance yearly (annual) migrations**

Examples of Birds

- **African Fish Eagle – common along large rivers and lakes, used as a component of the national logo**
- **African Vulture – spends most its time in the sky. Feeds on carrion**
- **The Francolin – common throughout Zambia; occurs in grassland & savannah woodland**
- **Guinea fowls – found in thickets & grasslands; move in flocks of 5 to 100 birds**
- **European Swallows – migrant birds that come Zambia from Europe & russia; fly in flocks**
- **Pied Wagtail – common bird in villages & urban areas; breed in september**
- **Pied Crows – common in villages, towns & floodplains**

Class Mammalia – Mammals

- **Group of animals that possess hairs on their skin**
- **Function of hairs:**
    - **conserve body heat**

    - **camouflage**
- **Most mammals possess sweat glands & specialized teeth**
- **Females bear mammary glands for milk production**
- **Mammals are endothermic**
- **Female mammals carry their developing young in the uterus**
- **By 2005, scientists had recorded 5702 species of mammals classified under 1229 genera and 153 families globally**
- **Mammals common in Zambia:**
    - **Antelopes**
    - **Bats (flying mammals)**
    - **Buffaloes**
    - **Cattle, cheetahs, elephants, giraffe, goats, hippos, hyenas, impalas, lechwes, leopards, lions, moles, rodents, zebra**
    - **Primates (baboons, monkeys)**
    - **humans**

Examples of Mammals

- **Antelopes, buffaloes, cattle, impalas, lechwes are grazing herbivores**
- **The Puku is known to graze specifically in grassland ecosystems**
- **Bats – are unique for their ability to fly; feed on insects & fruits**
- **Giraffes (mainly browsers)and zebras are mainly grazers**
- **Elephants – are large mammals; restricted to the old world (Africa & Asia); mainly browsers & grazers**
- **Monkeys & baboons – characterized by their grasping hands (arboreal); are omnivorous; usually found close to human habitation**
- **Hyenas, leopards, cheetahs & lions – are carnivorous; have long claws & canines**
- **Lions (*Panthera leo*) – inhabit grasslands & savanna; are social; active at night; can live for 10–14 years**
- **Cheetah (*Acinonyx jubatus*) – occurs in Africa & the Middle East; can attain speeds of between 112 – 120 km/h**

- **Leopard (*Panthera pardus*) – occurs in forests, woodland & thickets; has the ability to climb trees; nocturnal**
- **Hyena – are mostly scavengers in Zambia; known to hunt in Tanzania**

Diversity of Fungi

Lower & HIGHER FUNGI

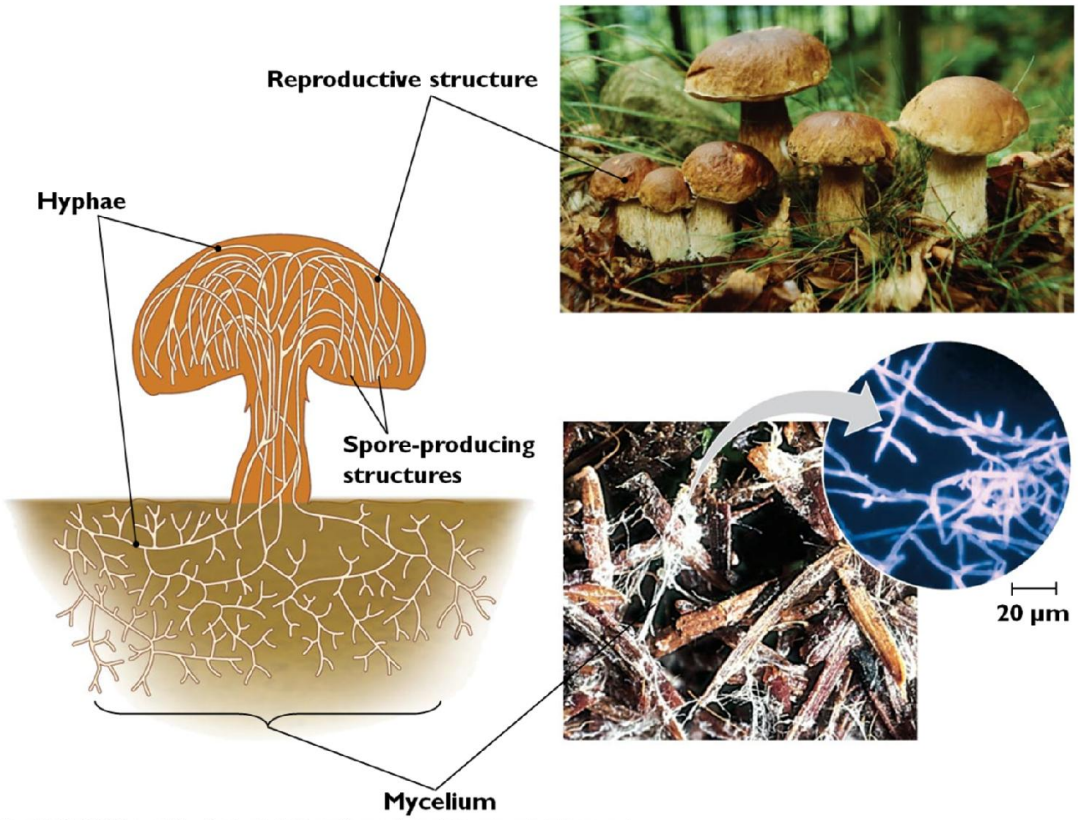
Introduction

- **Classified under the Kingdom Myceteae**
- **Organisms embraced by this Kingdom are commonly called fungi**
- **~ 400,000 – 1.5million species**
- **Fungi are closely related to animals than plants**

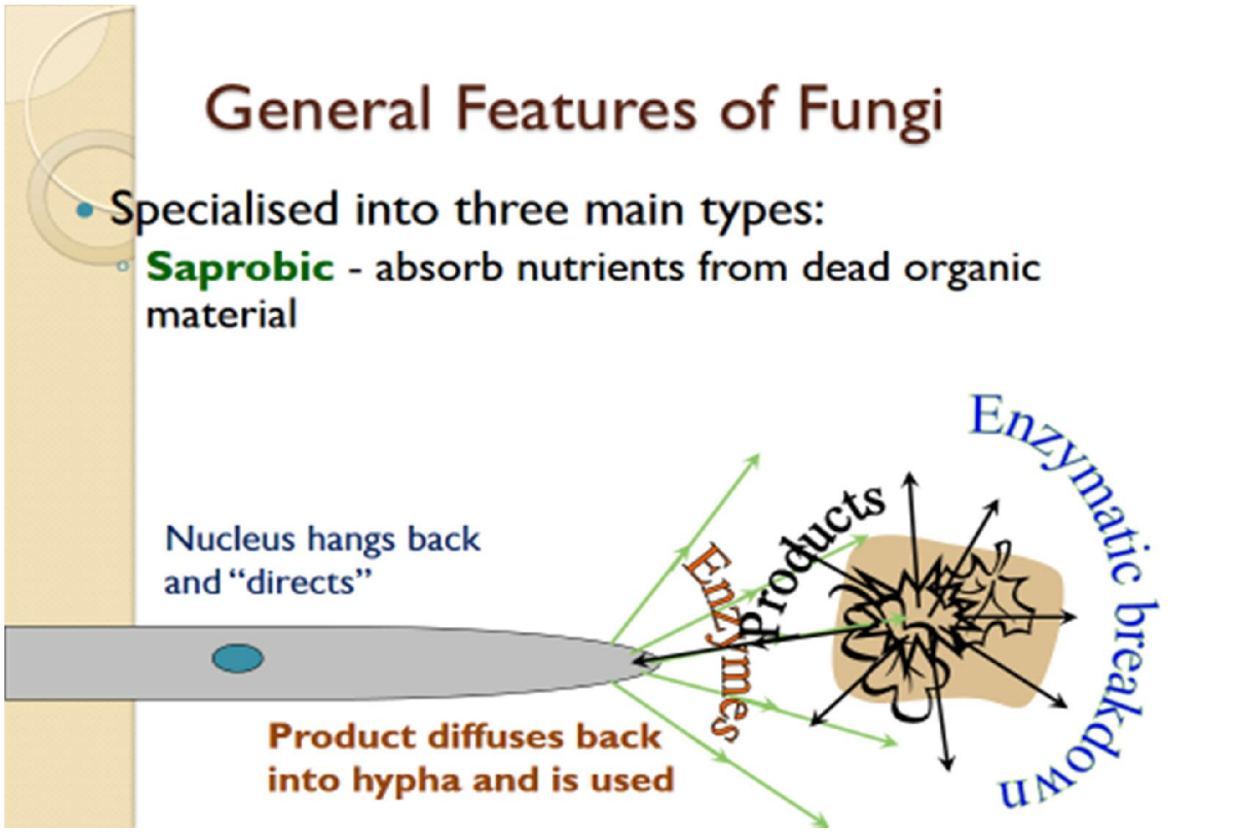
General Features of Fungi

- **Eukaryotic cells**
- **Cell walls of chitin**
- **Sexual & asexual reproduction**
- **Terrestrial**
- **Stationary**
- **No roots**
- **Most multicellular**
    - **mushrooms**
- **Some unicellular**
    - **yeast**
- **Multiple nuclei per cell**

- **Few or no storage molecules**
- **Have filamentous tube-like strands called hypha or hyphae (plural)**
- **Aggregates of hyphae make up a mass of fungal tissue called mycelium (mycelia)**



- **Mitosis in fungi different from plants & animals**
- **Two types of mitosis**
  - **Open mitosis – nuclear membrane breaks down**
  - **Closed mitosis – nuclear membrane remains intact**
- **Since fungi lack chlorophyll, they are said to be achlorophyllous**
- **Specialised into three main types:**
  - **Saprobic - absorb nutrients from dead organic material**



- **Parasitic fungi - absorb nutrients from cells of living hosts; some are pathogenic**
- **Mutualistic fungi - absorb nutrients from a host, but reciprocate to benefit the host**

- **A *saprobic mode of nutrition* is a condition in which organisms live on dead, decaying organic matter**
- **A saprobic mode of nutrition is a feature used to categorize fungi as heterotrophs**
- **A *parasitic mode of nutrition* is a condition in which organisms dwell on living tissues**

Classification of Fungi

- **Were classified under Kingdom Myceteae & comprised of division Mycota**
- **Most common groups of fungi in Zambia fall under:**
  - **Classes: Oomycetes and Zygomycetes (lower fungi)**
  - **Classes: Ascomycetes and Basidiomycetes (higher fungi)**

The Lower Fungi

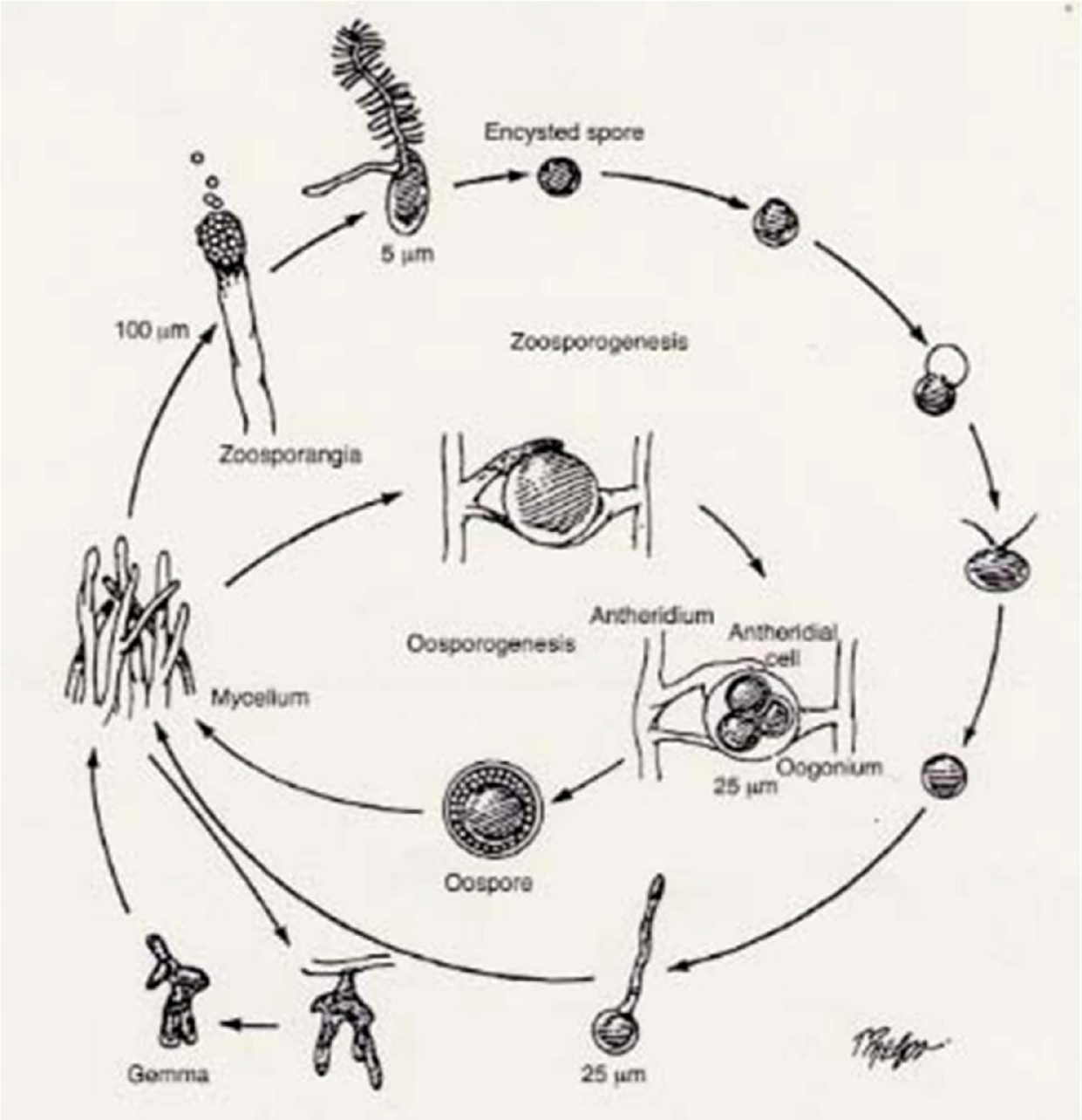
The Class Oomycetes

- **Comprised of the water molds**

The Class Oomycetes

- **But some members of this class are *terrestrial obligate parasites***
- **Complete life cycle on host & depend on wind for dispersal of spores**
- **Reproduction is asexual by production of sporangia called zoosporangia**
- **Zoosporangia contain flagellated motile spores known as zoospores**

- **A common water mould is the genus *Saprolegnia***
- **Species of *Saprolegnia* are aquatic and occur in freshwater**
- **~ 3% occur in salty water**
- **Some species of *Saprolegnia* are saprobic whereas others are parasitic**
- **Parasitic forms are known to infect gills of fish & some aquatic animals**
- **Somatic (vegetative) structures in the form of hyphae branch out profusely**
- **The septa which separate the somatic cells from the reproductive structures form hyphae**



***Saprolegnia*: life cycle**

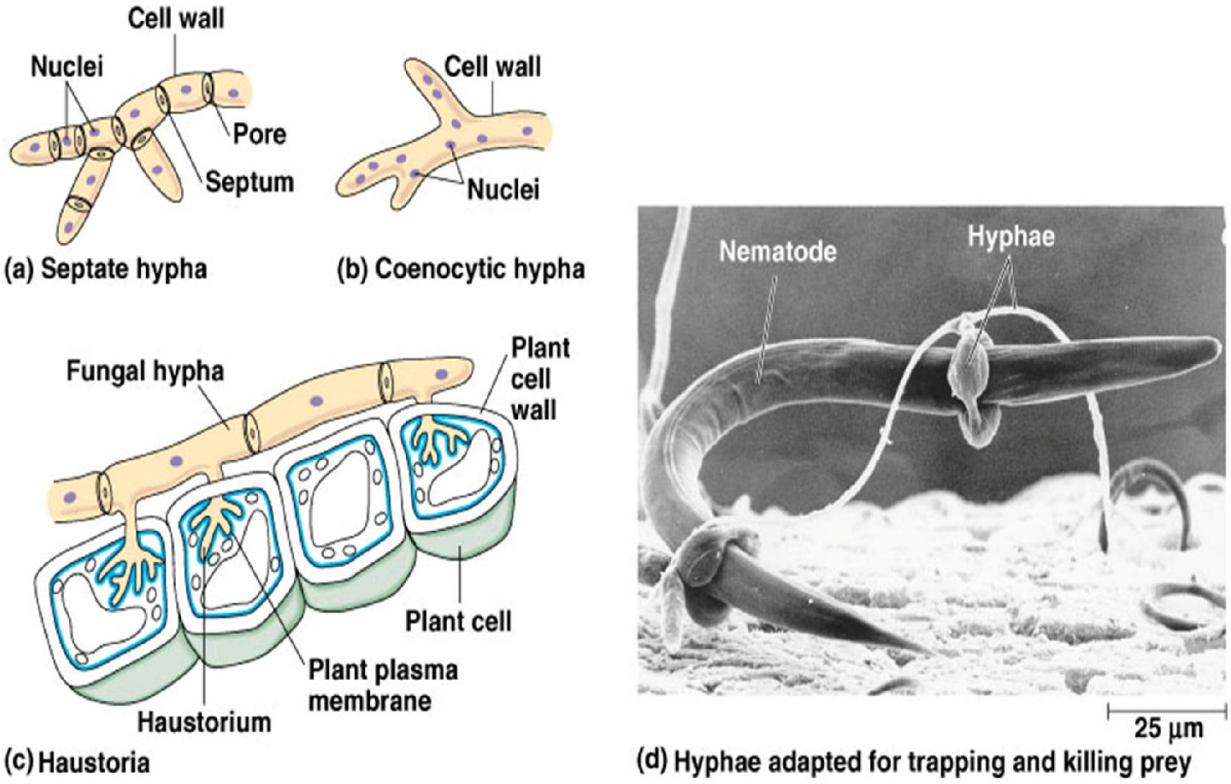
The Zygomycetes

- **Zygomycetes refers to the production of sexual resting spores called zygospores**
- **Members of this class are species of *Rhizopus* (the bread or nshima mold)**

- ***Rhizopus*** **is a genus of the common saprobic fungi found on organic substrates such as fruits, vegetables, syrups, leather, bread and peanuts**

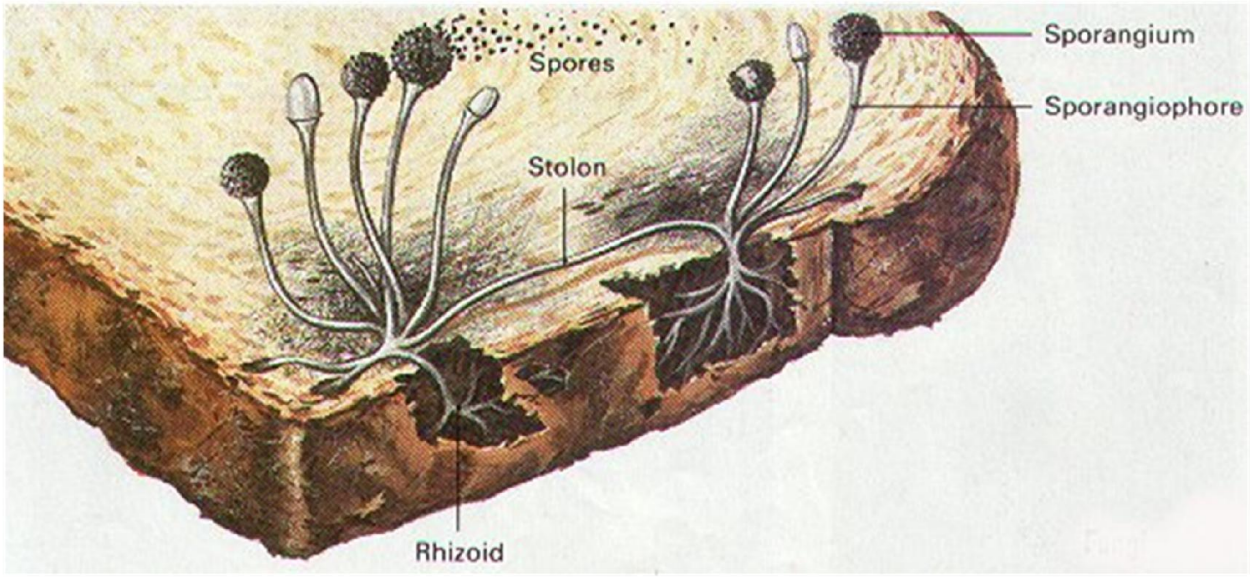
The Class Zygomycetes

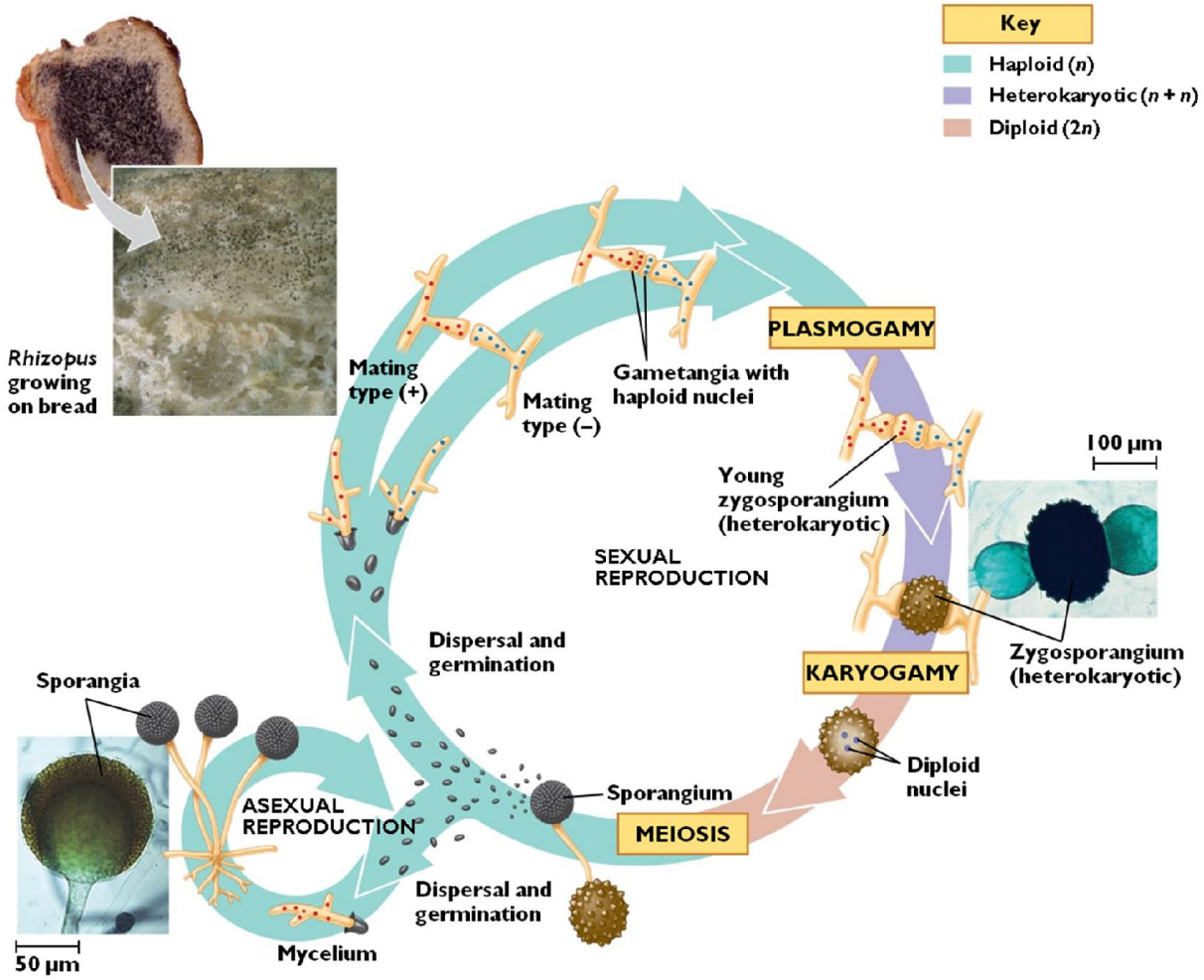
- **Species of *Rhizopus* grow as branching filamentous hyphae which lack cross walls**



- **Two main characteristics of Zygomycetes are:**
    a. **Asexual reproduction – non motile spores**
    b. **Sexual reproduction – gametangial copulation to form zygospores**
- **They reproduce by forming asexual and sexual spores**
- **In asexual reproduction, spores are produced in the sporangium**
- **Each sporangium is supported by an elongate stalk called the sporangiphore**
- **Sporangiophores arise from a region with distinct root-like rhizoids**
- **In sexual reproduction, a dark zygospore is produced at the point were two mycelia fuse**

- **When the zygospore germinates, it produces colonies of the fungal mycelia that are genetically different from either parent**



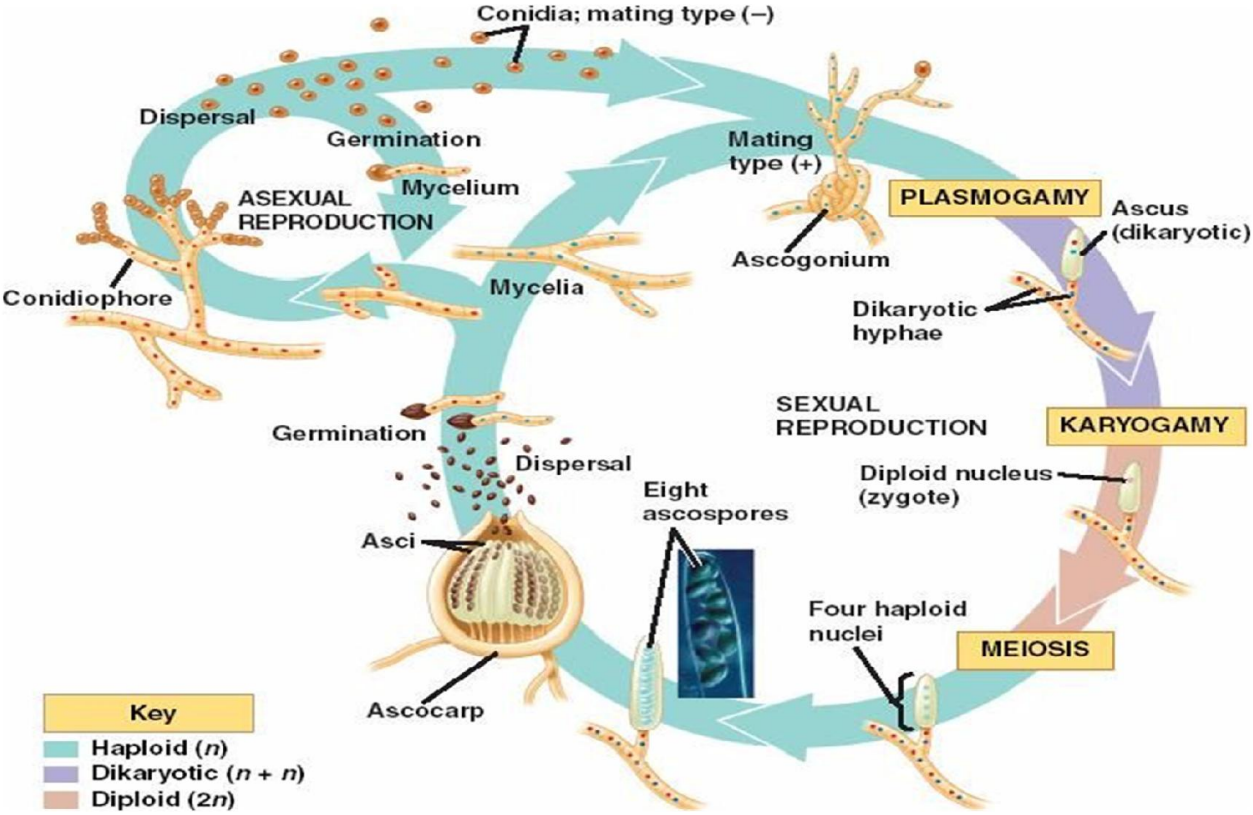


Higher Fungi

- **Higher fungi are classified under the fungal classes:**
    - **Ascomycetes**
    - **Basidiomycetes**
- **Some members of this group (higher fungi) are microscopic whereas other species especially Basidiomycetes are macroscopic**

The Class Ascomycetes

- **Are found in diverse habitats such as terrestrial, marine and freshwater ecosystems**
- **Many species in this group are decomposers**
- **Characteristic feature:**
    - **Special type of spores called ascospores found in a sac called ascus**
- **Reproduction**
    - **Produce structures called conidia formed at tip of conidiophore**
- **A conidium is a spore formed by constriction of the tip of a specialized fertile branch called the conidiophore**
- **The mycelium of the Ascomycetes is composed of septate hyphae**
- **Hyphae are well developed, slender or stout and profusely branched**



***Penicillium* species**

- **Is a member of the class Ascomycetes that produces conidiophores**
- **Species of *Penicillium* are commonly known as the green or blue molds**
- **They are cosmopolitan**
- **Usually grows as a saprophyte on decaying fruit especially citrus fruits & vegetables**
- **Decaying citrus fruits often display a bluish growth of *Penicillium* on their surfaces**
- **The mycelium is well developed and well branched as the hyphae run in all directions on the substratum**
- **The fungi secrete enzymes and absorb nutrients from the substratum**
- **Asexual reproduction is dominant & accomplished by fragmentation**
- **Hyphae break up into short fragments which grow by repeated division to form mycelia**
- **The mycelium is well developed and well branched as the hyphae run in all directions on the substratum**

- **The fungi secrete enzymes and absorb nutrients from the substratum**
- **Asexual reproduction is dominant & accomplished by fragmentation**
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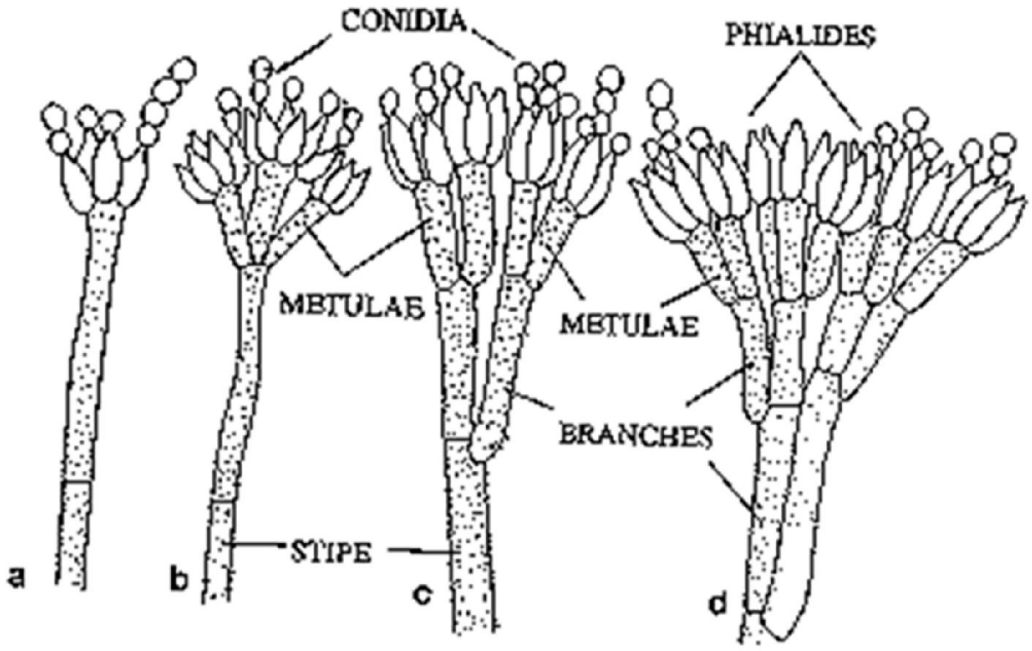
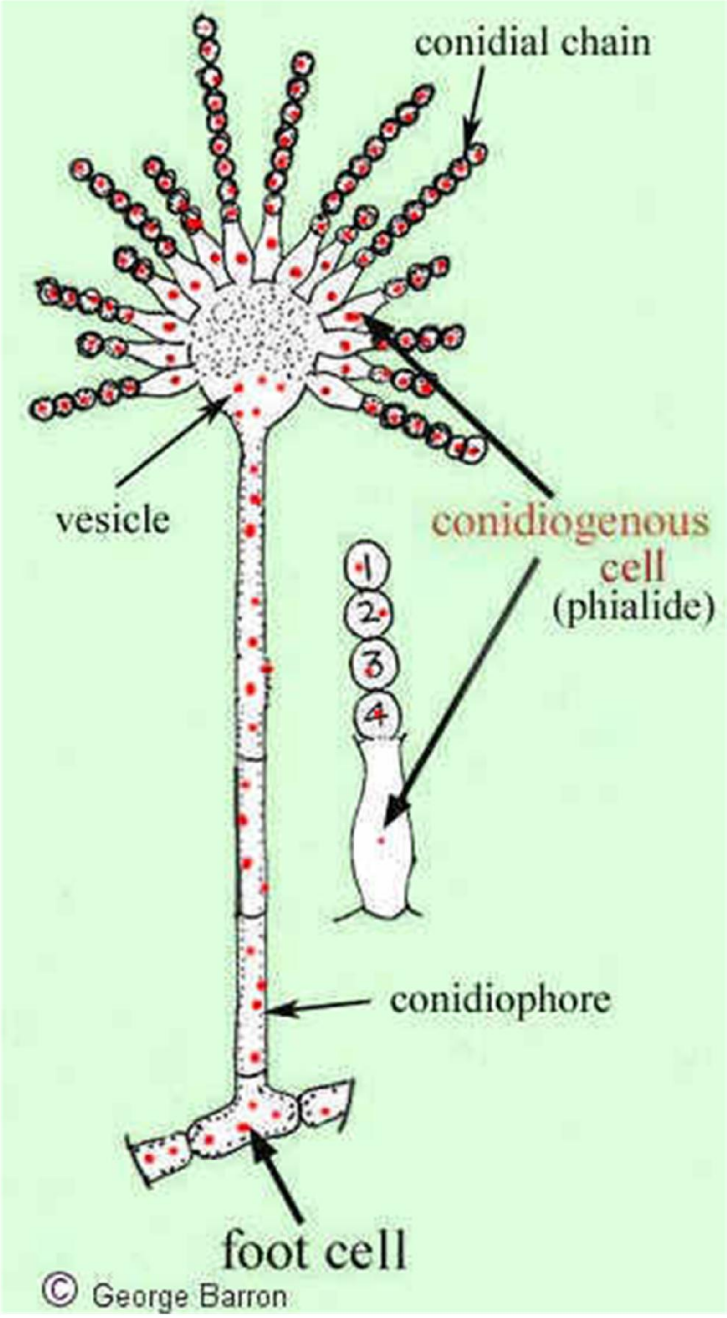


Penicillium: **fertile hyphae with conidia**

Aspergillus **species**

- **Are both saprophytic & pathogenic**
- **The conidiophore develops into a head from which sterigmata arise to bear chains of conidiophores**
- **This fungus causes a disease called black mold on fruits, vegetables, onions and nuts**
- ***Aspergillus*** **spp. can also cause a lung disease in humans called aspergillosis**
- ***Aspergillus*****: vegetative and fertile hyphae**

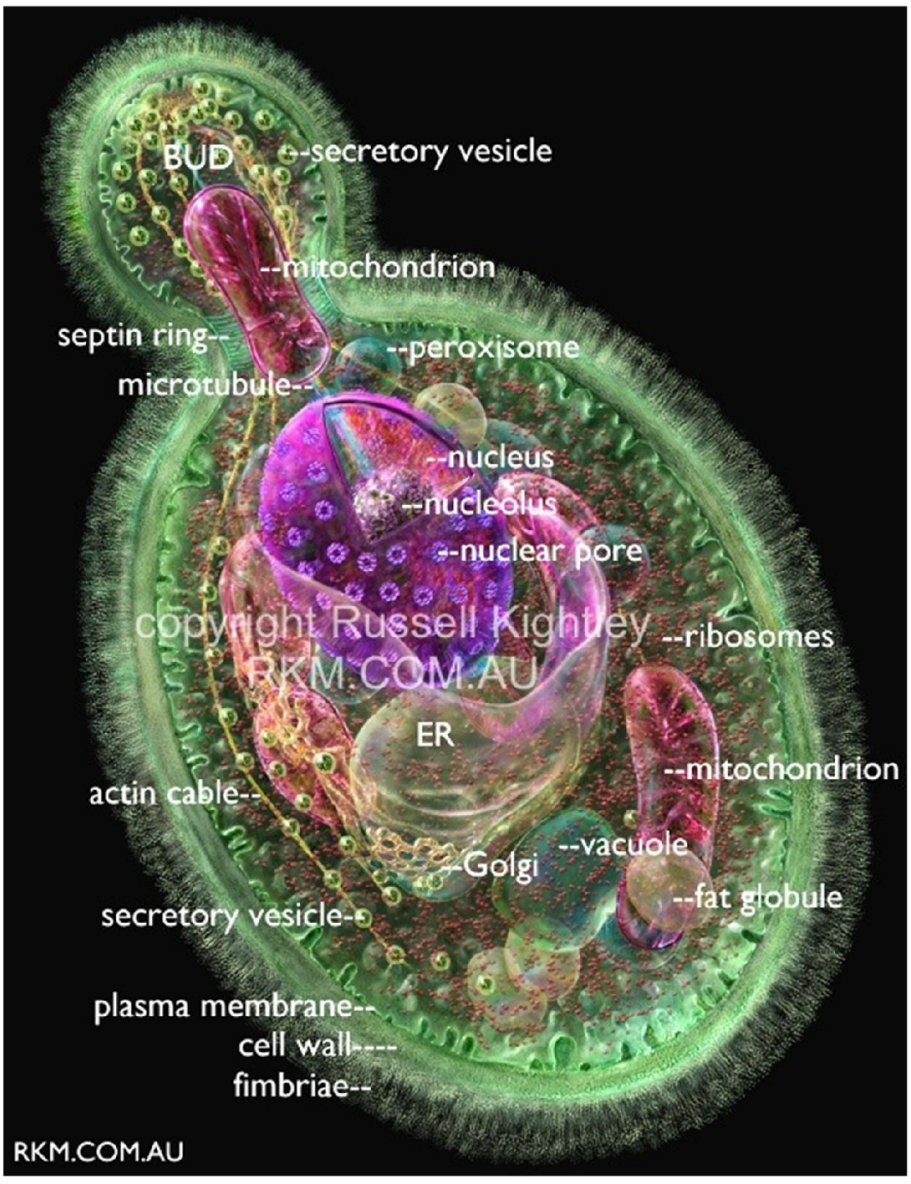


The Yeasts

- **Do not develop hyphae but are unicellular**
- **May produce a chain of cells *to form a false mycelium***
- **Reproduction**

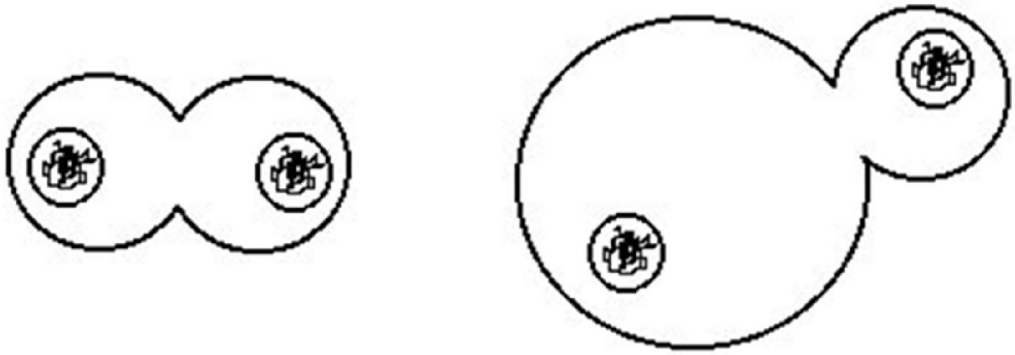
- **Fission**
- **Budding**
- **Formation of an ascus**

- **An ascus is a sac-like structure which contains a definite number of spores (8) which are called ascospores**



Candida albicans

Replicating Yeasts: Fission vs. Budding



yeasts undergoing fission

Schizosaccharomyces spp.

budding yeasts

Saccharomyces spp.

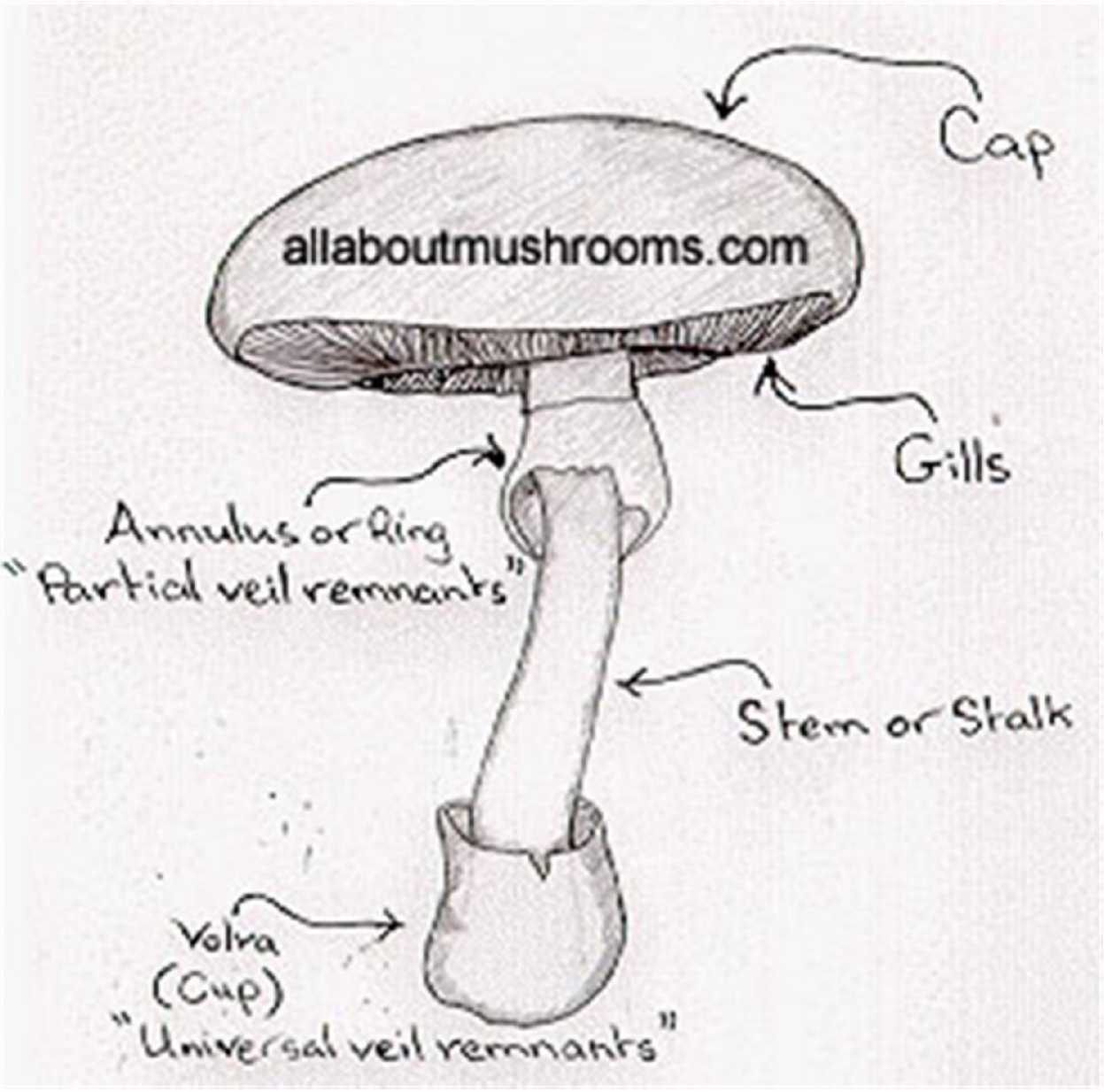
= nucleus containing DNA genome

Ascus containing ascospores

Class Basidiomycetes

- **Are mostly macroscopic**
- **Examples are the mushrooms, puff balls & shelf fungi**

- **They develop spore-bearing structures called basidium**
- **Each basidium bears a set of four spores known as basidiospores**
- **The vegetative mass of mycelium is more or less subterranean but the fruiting body is an aerial (above ground) structure called basidiocarp**


Cap
allaboutmushrooms.com
Gills
Annulus or Ring
"Partial veil remnants"
Stem or Stalk
Volva
(Cup)
"Universal veil remnants"

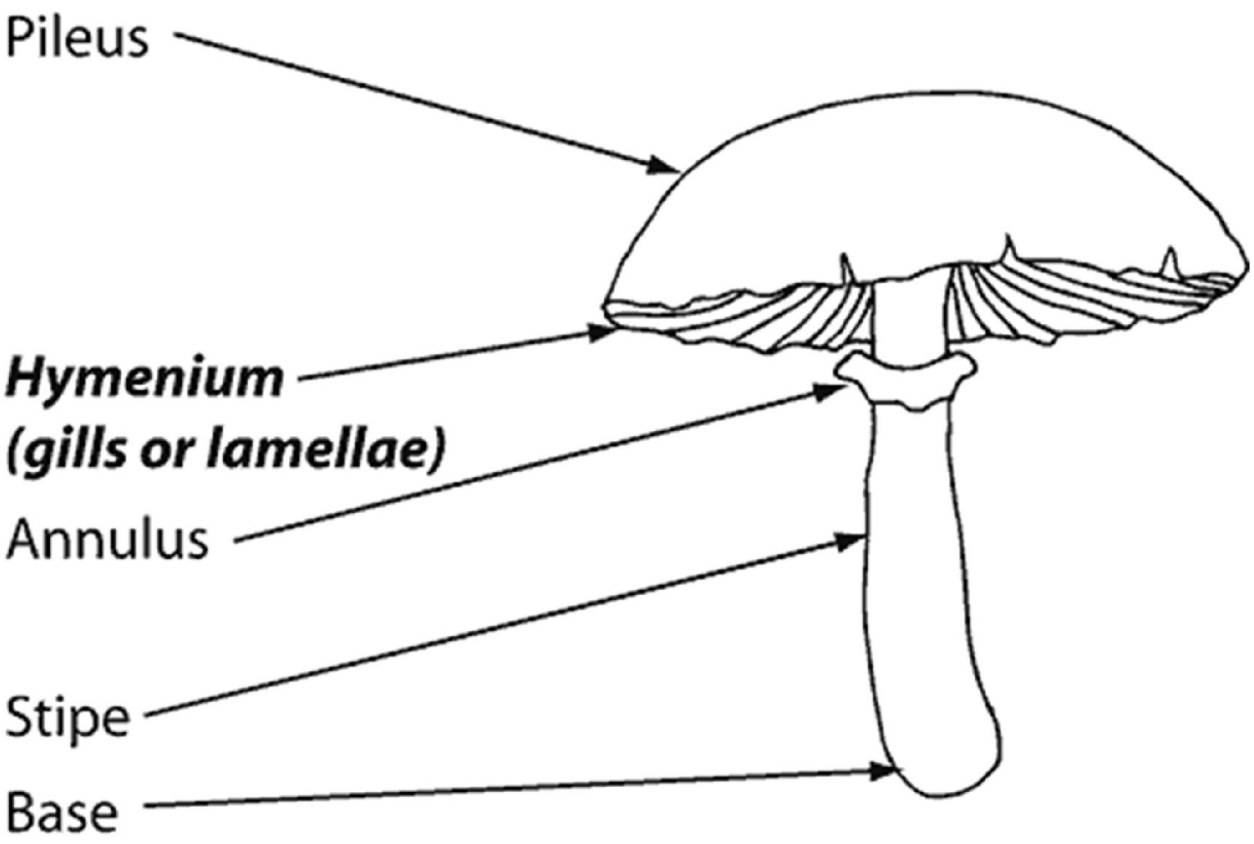


Fig. 1D - Lamellae/gills

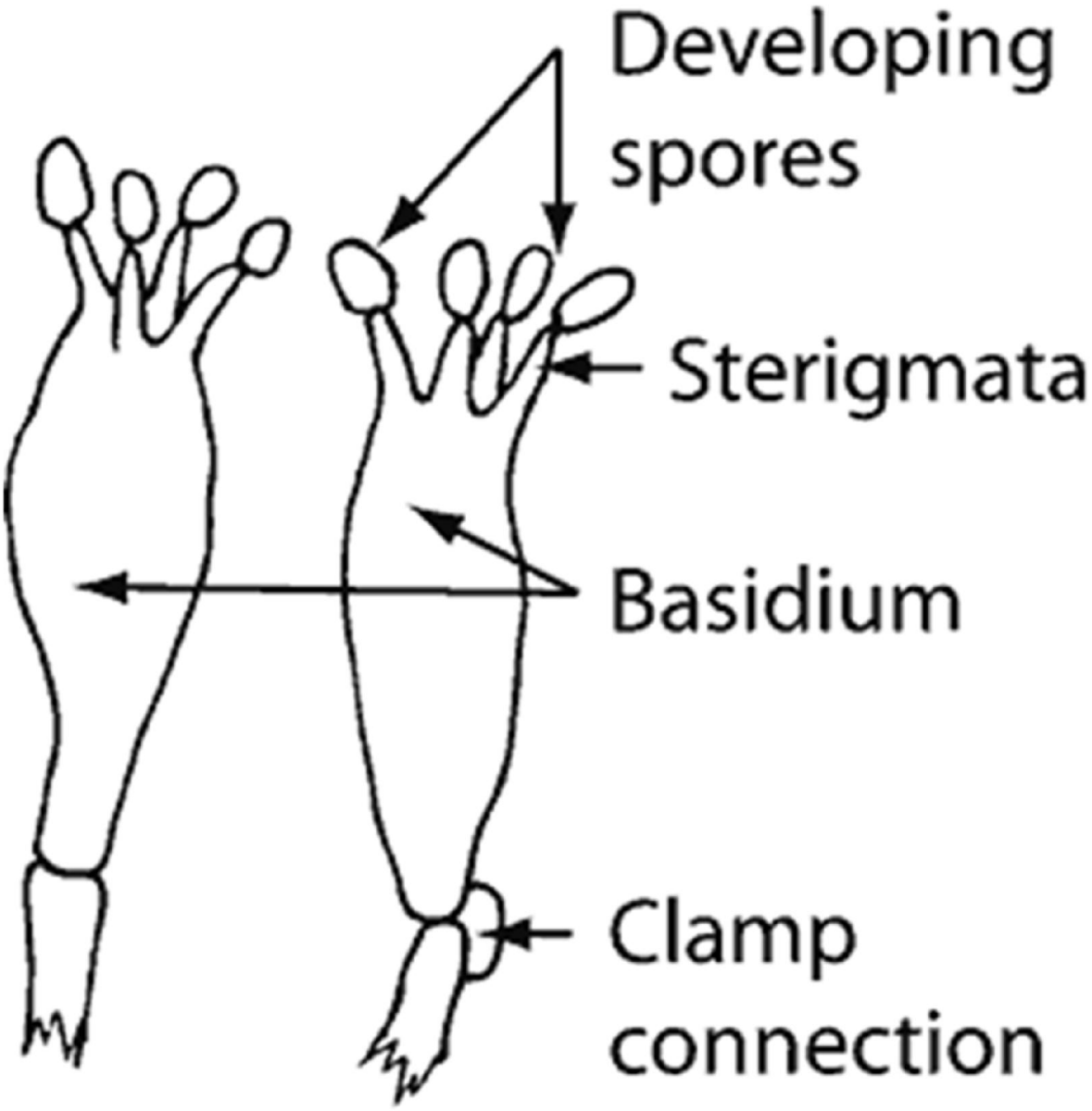
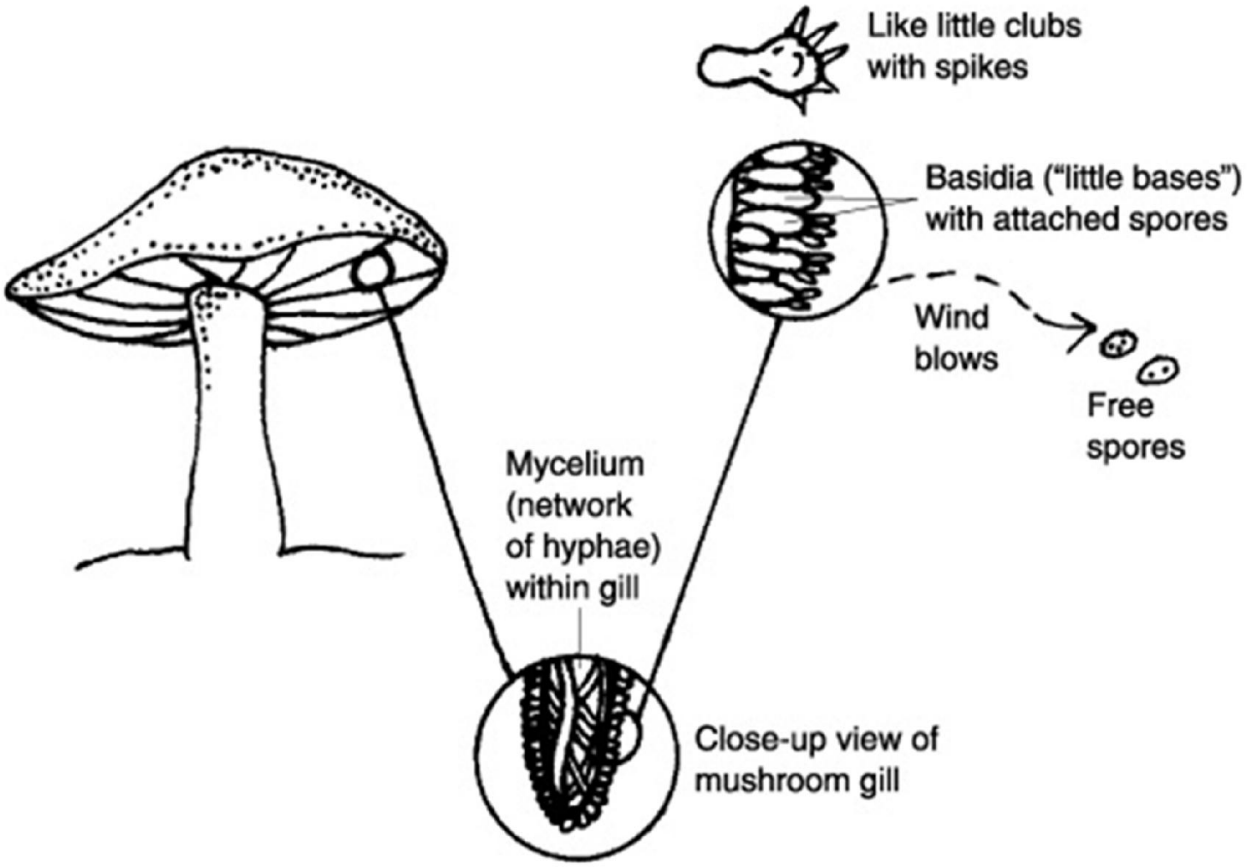


Fig. 1E **Basidia**



Practical Uses of Fungi

- **Fungi are a source of food**
- **Fermentation - cheeses, alcoholic beverages, and bread**
- ***Aspergillus* – flavour soft drinks**
- **Genetic research on fungi is leading to applications in biotechnology**
- **Antibiotics produced by fungi treat bacterial infections – penicillin**
- **Mutualisms with algae**
    - **Lichens are nature's biological monitors of pollution and air quality**
    - **Ants & fungi**
    - **Termites & fungi**
    - **Mycorrhizae (fungus roots)**

Organismic Diversity

The Algae

Introduction

- **Belong to Kingdom Plantae**
- **Kingdom Plantae embraces organisms called plants**
- **All plants contain chloroplasts and thus share the property of possessing chlorophyll a**
- **Plants utilize radiant energy to drive their metabolic reactions**

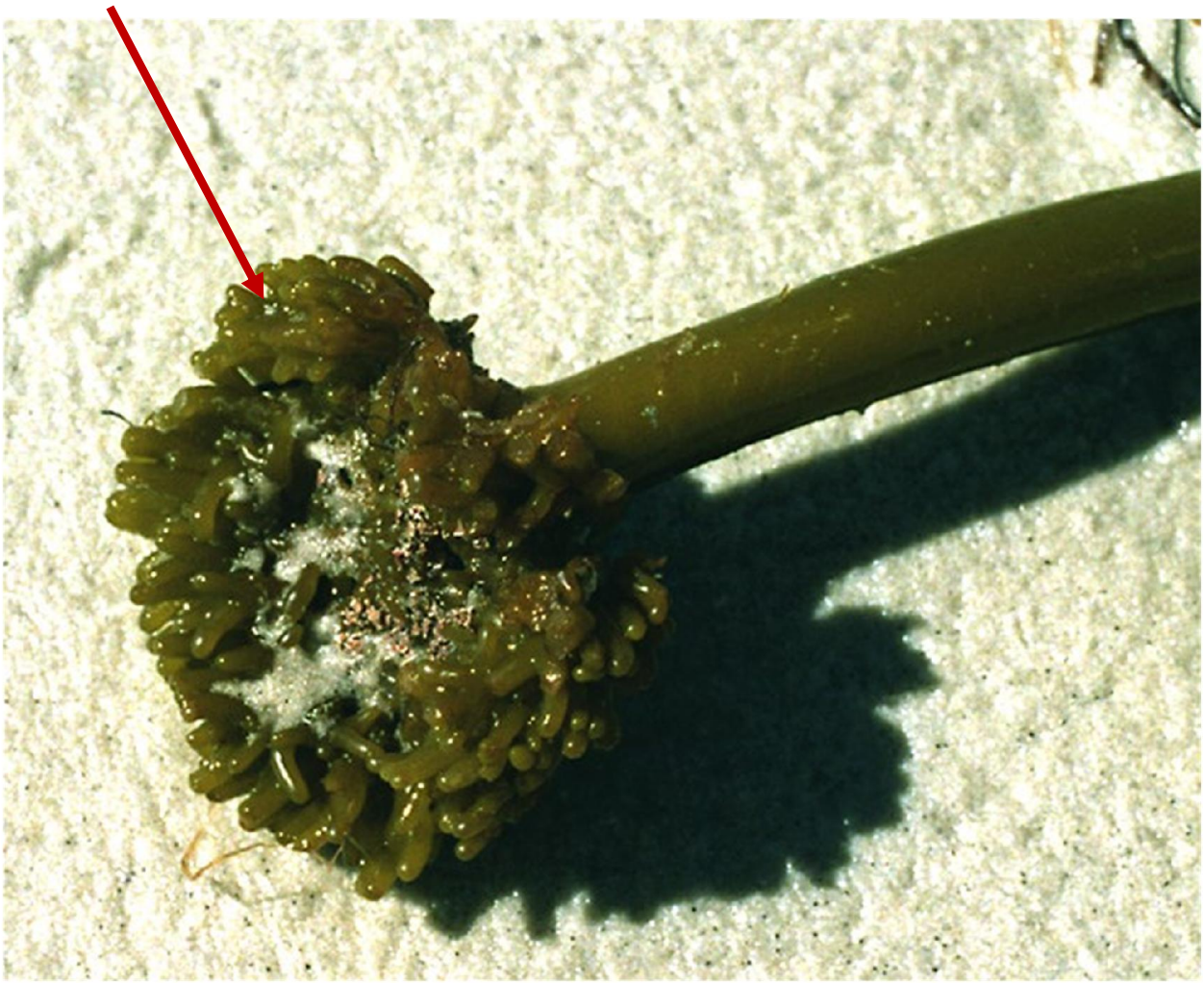
- **Thus organisms which use sunlight to synthesize food are termed autotrophs**
- **Kingdom Plantae comprised of ~350,000 species**
- **Plants include such major groups as the Algae, Bryophytes, Pteridophytes, Gymnosperms and the Angiosperms**
- **Current classification systems of green plants have identified 20 divisions but only a few will be discussed at this level**
- **Are *chlorophyll-bearing* aquatic organisms**
- **Algae are eukaryotic**
    - **Unicellular**
    - **Filamentous – form chains of cells**
    - **Multicellular (thallic)**
        - **Thallus**
- **Multicellular algae usually consists of:**

leaf like **blades**

stem like **stipes**

Branched **holdfast**

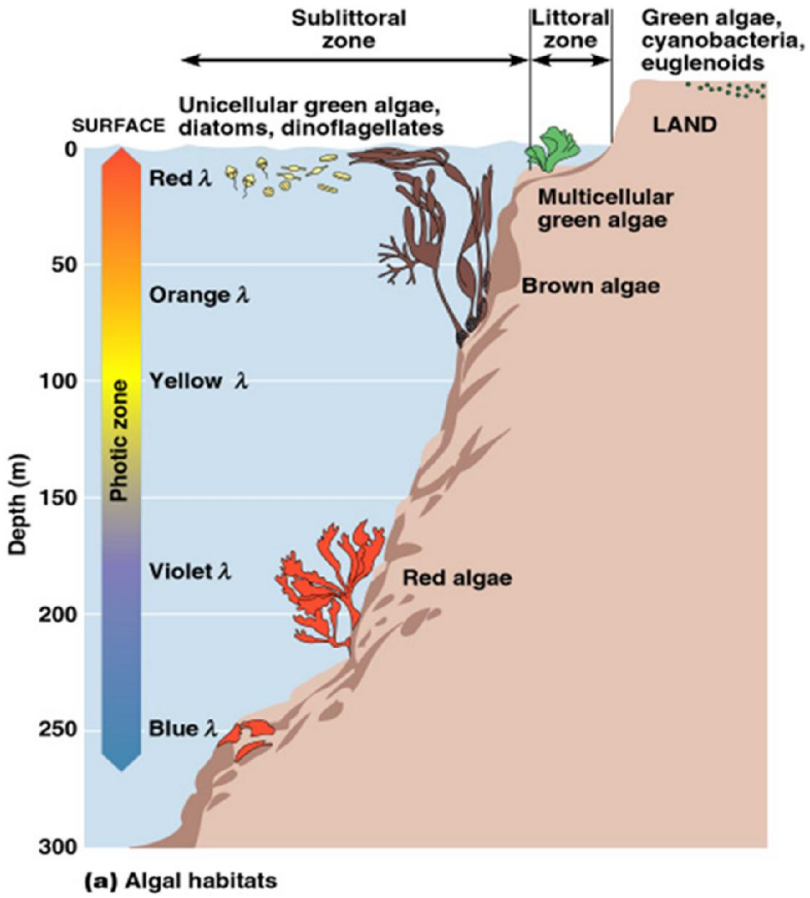
Holdfast



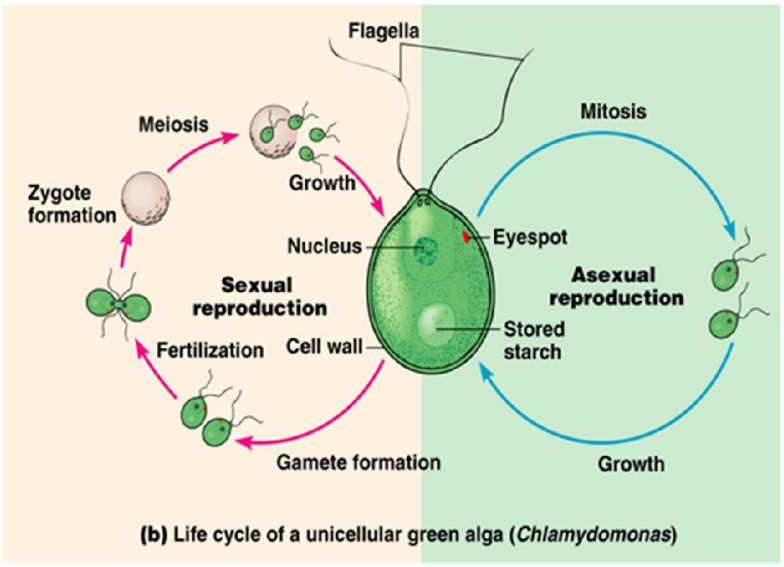
- They are dominant in freshwater habitats such as streams, rivers, ponds & lakes
- Are also found in marine waters
- Play an important ecological role in aquatic ecosystems
- The *study of algae* is known as Phycology
- The term *phycology* is derived from Greek words ‘phycos’ meaning *algae* and ‘logos’ meaning *study*
- Most Algae are **photoautotrophs.**
- **Cellulose** wall
- Their location depends on:

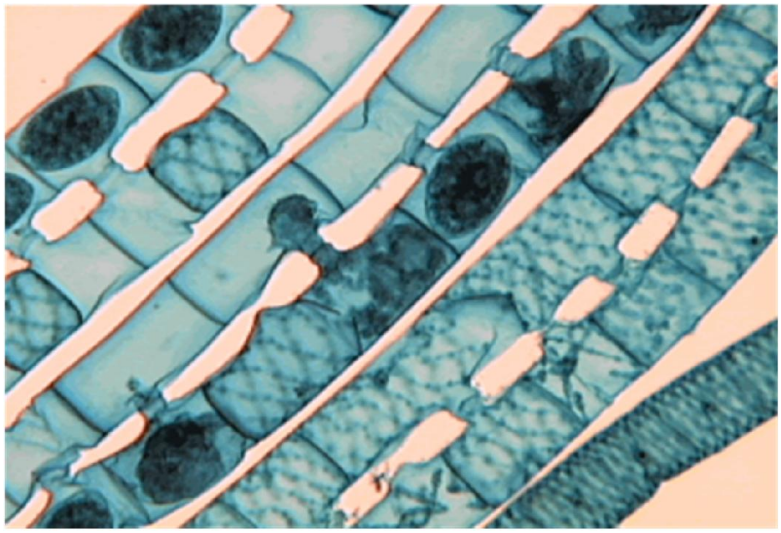
- wavelength of light
- appropriate nutrients
- surfaces on which to grow

- Algae reproduce:
  - Asexually by cell division
  - Fragmentation
  - Sexually



- **Isogamy** is the form of sexual reproduction in which the gametes produced are identical in shape, size and motility
- C**onjugation** - less commonly - *Spirogyra sp.*

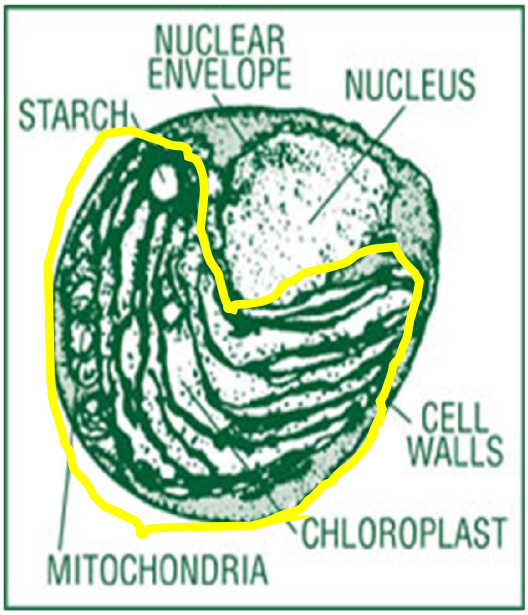




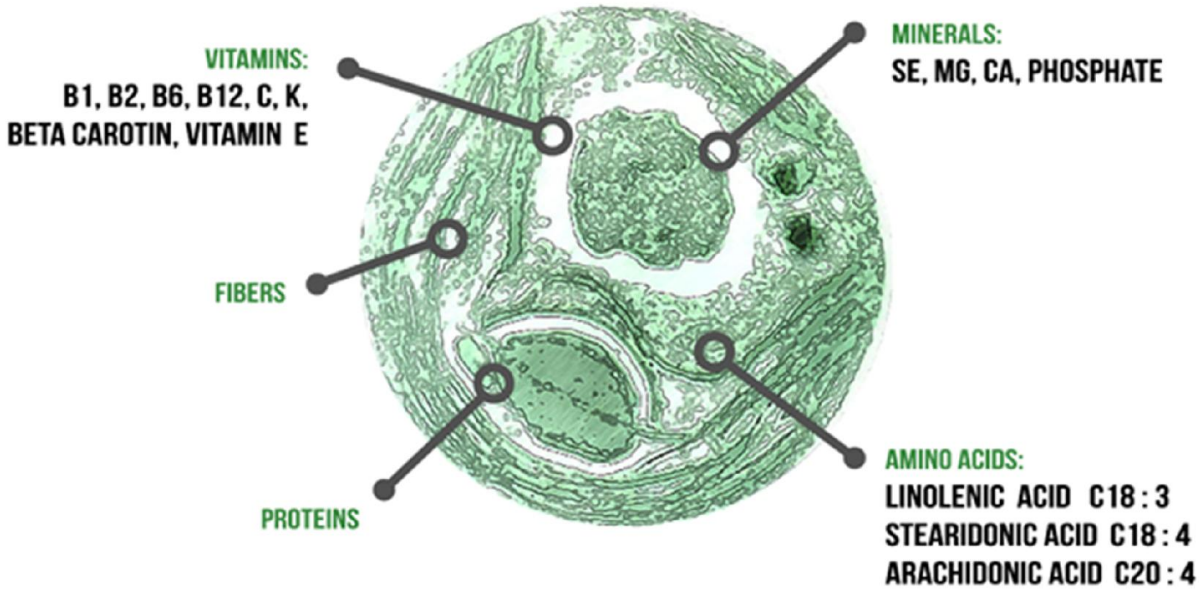
- There are three major groups of algae known to be prevalent in freshwater & Marine waters in southern Africa:
    - Division: Chlorophycophyphyta (Chlorophyta)
    - Division: Phaeophycophyta (Phaeophyta)
    - Division: Rhodophycophyta (Rhodophyta)

Division Chlorophycophyta

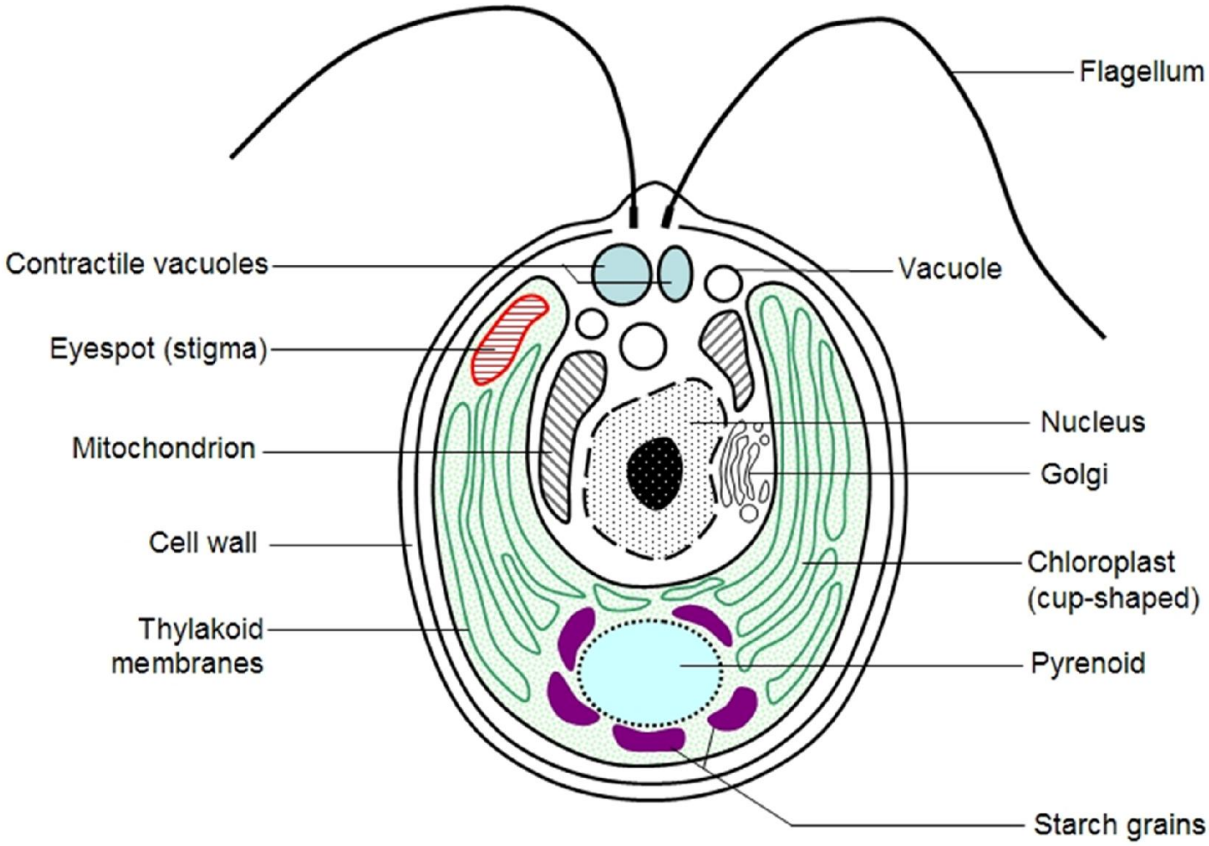
- Commonly referred to as the green algae
- Are comprised of about 17000 species
- Are the most abundant & widely distributed of all algae
- Are characterized by possession of chlorophylls a & b including alpha-carotenes, beta-carotenes and xanthophylls
- >90% occur in freshwater, some are marine
- Can be unicellular or multicellular
- Multicellular forms
    - Filamentous
    - Thalloid (have a thallic body)
- Unicellular forms include such species as *Chlorella* and *Chlamydomonas*
- Species of *Chlorella* are non-motile unicells that are spherical and contain a single cup-shaped chloroplast
- *Chlorella* is cultivated as a food additive for humans in Japan
- Species of *Chlorella* occur in small ponds, moist ditches and wet places around leaking taps
- *Chlamydomonas* is a unicellular motile algae; motility is facilitated by a pair of flagella
- Many species of *Chlamydomonas* are mostly found in stagnant water pools & swimming pools & they tend to form a green scum on such water bodies



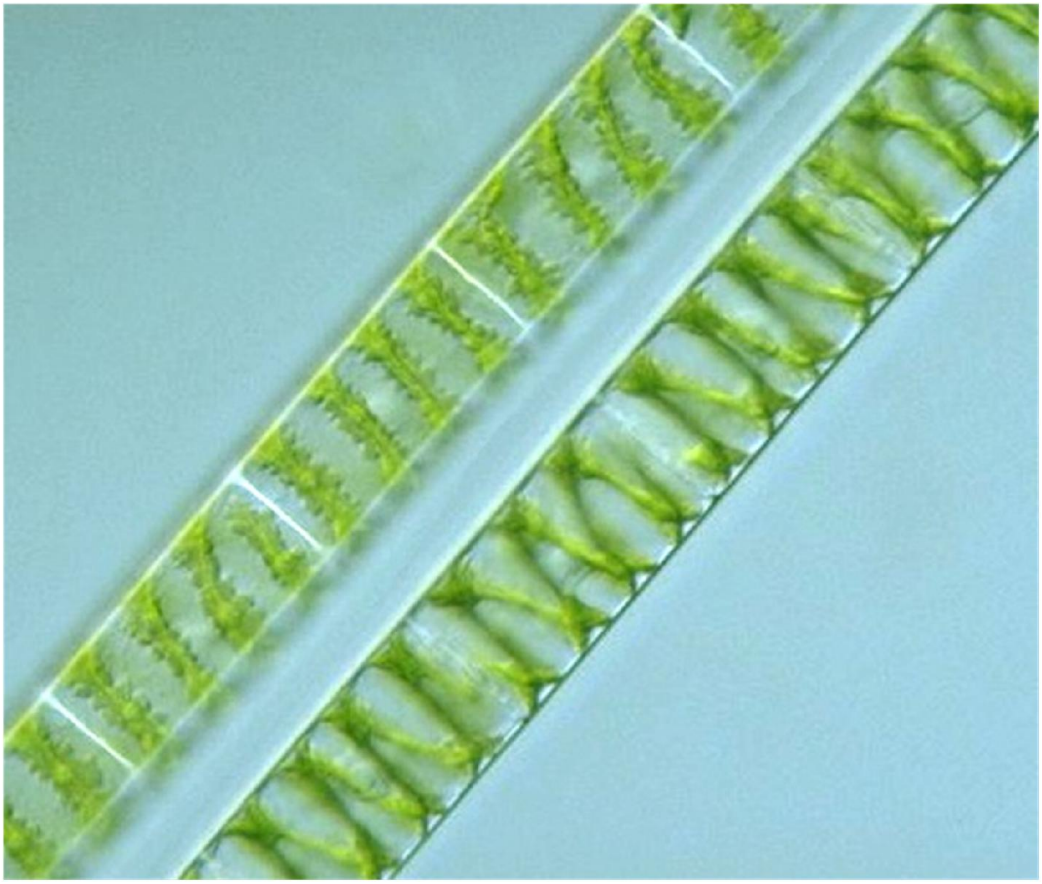
Chlorella



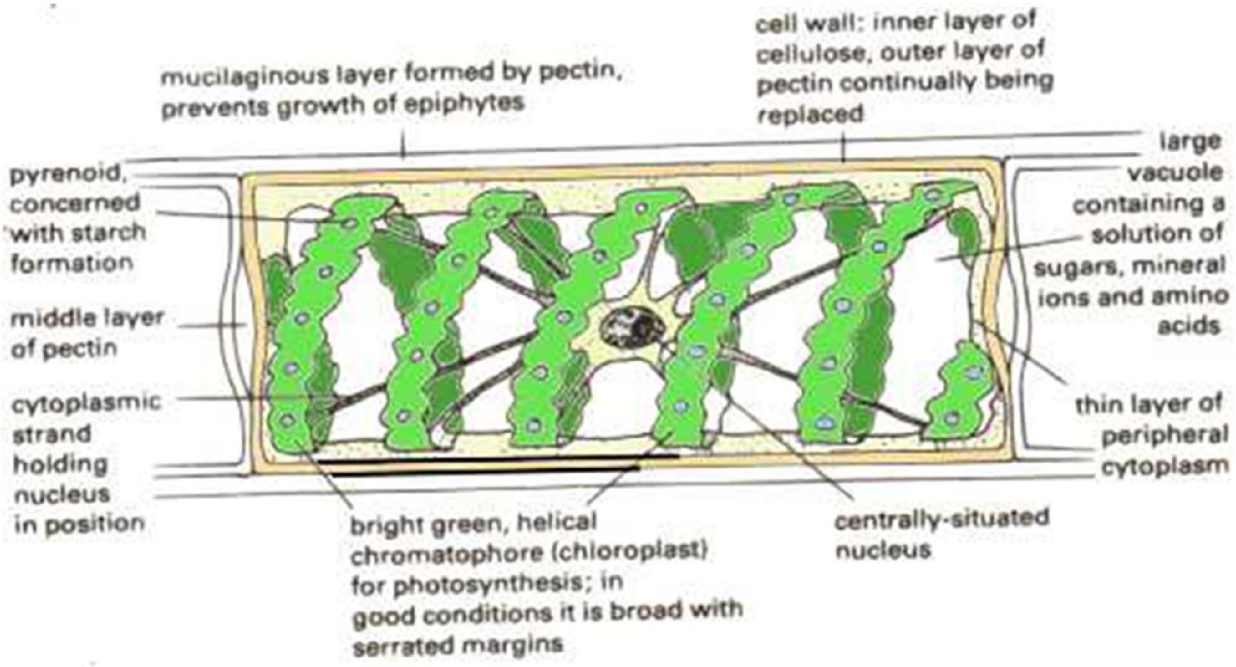
Chlamydomonas



- The most common multicellular filamentous algae include the genus *Spirogyra*
- Species of *Spirogyra* are widespread in all freshwater habitats
- Are very common in slow moving water and stagnant shallow ponds
- Filaments are either free-floating or attached to substrates
- Spirogyra is sometimes referred to as *green silky-strand algae* (or Limbwelimbwe)



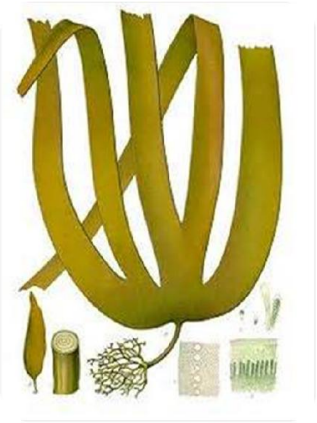
Spirogyra: filamentous fragments



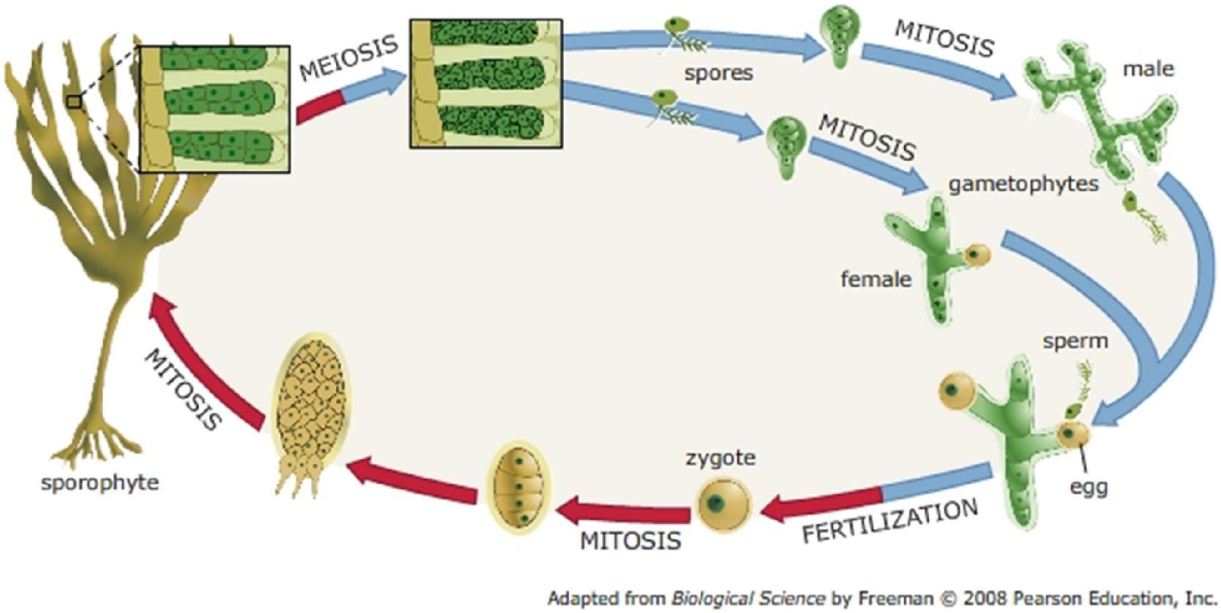
Spirogyra: close-up of a single cell

Division Phaeophycophyta

- Commonly referred to as Brown Algae
- The brown algae are predominantly marine plants
- Their brown colour is due the abundance of a Xanthophyll pigment called FUCOXANTHIN which masks the green colour of chlorophylls a and b
- Brown algae occur in shallow waters along regions of seas and oceans
- Instead of producing starch, brown algae produce a form of carbohydrate called Laminarin
- *Laminaria* is a macroscopic (large) thalloid form of marine algae



Laminaria: structure showing root-like holdfast, stipe &



Adapted from *Biological Science* by Freeman © 2008 Pearson Education, Inc.

Division Rhodophycophyta

- Commonly referred to as Red Algae

- Red algae possess chlorophylls a and d
- Green chlorophylls are masked by a red pigment called Phycoerythrin
- Carbohydrate is stored in form of Floridean starch
- The cells are usually surrounded by a slime layer
- Examples of the red algae are species of *Nemalion* – a marine algae
- Batrachospermum is a freshwater red algae first recorded on the Chifubu River in the Kafulafuta area
- It has also been recorded from the Rufunsa River along the Great East Road

Commercial uses of Algae

- **Algin – a thickening agent for food processing (brown algae)**
- **Carrageenan – foods, puddings, ice cream, toothpaste (red algae)**
- **Iodine (brown algae)**
- **Agar – for growth media used in research (red algae)**
- **As food – red and brown algae**
- **As plant fertilizers**

Organismic Diversity

The Bryophytes

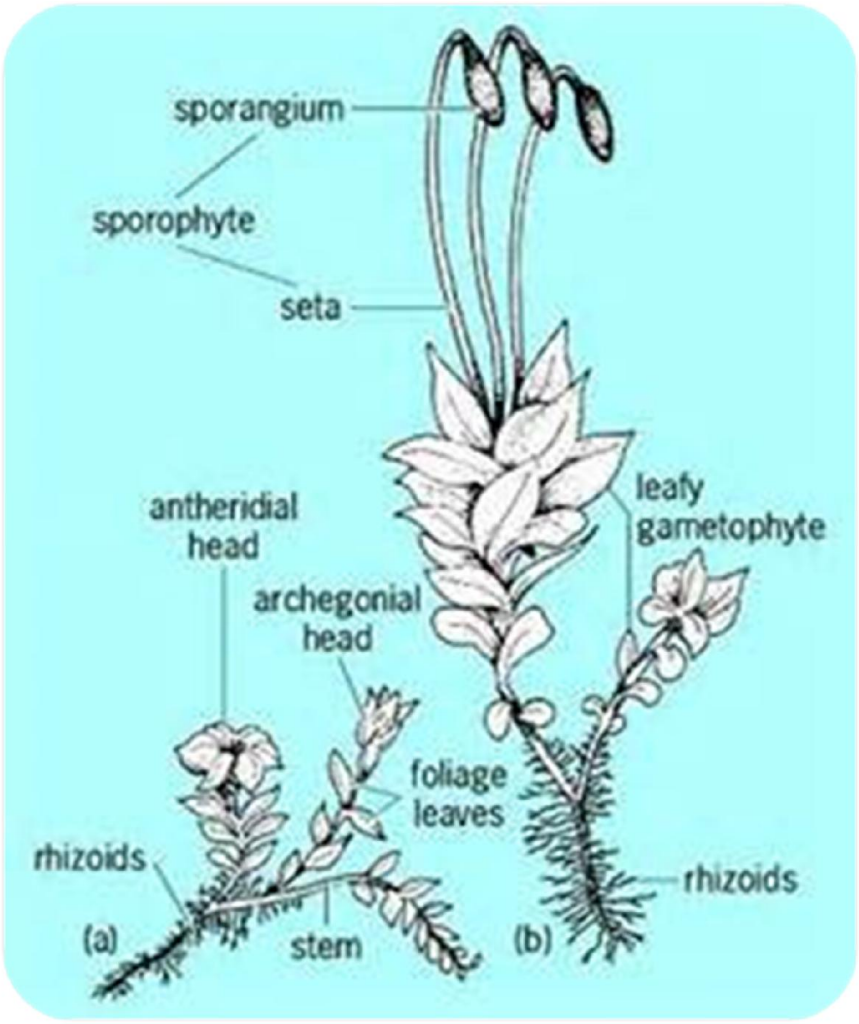
Introduction

- **Unlike algae, bryophytes are terrestrial dwellers**
- **Are cosmopolitan (temperate, tropical & arctic regions of the world)**
- **Mosses are the most dominant of all plants in the Arctic Circle**
- **Bryophytes**
    - **transitional forms of plants**
    - **are placed between algae & vascular plants (ferns & seed plants)**
- **Majority of bryophytes are amphibian forms in the Plant Kingdom**
- **Bryophytes are also known as the *non-vascular plants***
- **Best term is non-tracheophytes**
- **Bryophytes are more advanced than algae because they are adapted to life on land**
- **Are extremely dependent on water for survival & reproduction, hence are typically found:**
    - **in moist habitats such as creeks & forests**
    - **some species can survive in arid areas with little or no rainfall**

General Features of Bryophytes

- **Bryophytes *lack roots* but possess rhizoids**
- **Rhizoids are important for:**
    - **absorption of water & salts**
    - **anchoring plants to substratum (soil)**
- **Epidermis coated with cutin plays the role of protection against dessication**
- **Numerous air pores facilitate gaseous exchange**
- **In their life cycle, gametophyte (gamete-bearing structure) is the most dominant**

- **Gametophytes have structures**
    - **Resemble stems & leaves**
        - **Without internal 'veins'**
    - **Hydroids: conduct H_2O**
    - **Leptoids: conduct food**
    - **Thallus: body of a bryophyte**
    - **Rhizoid: anchors bryophyte to substrate**
        - **Absorption occurs through contact**


sporangium
sporophyte
seta
antheridial head
archegonial head
leafy gametophyte
foliage leaves
rhizoids
rhizoids
(a)
stem
(b)

sporophytes

gametophyte

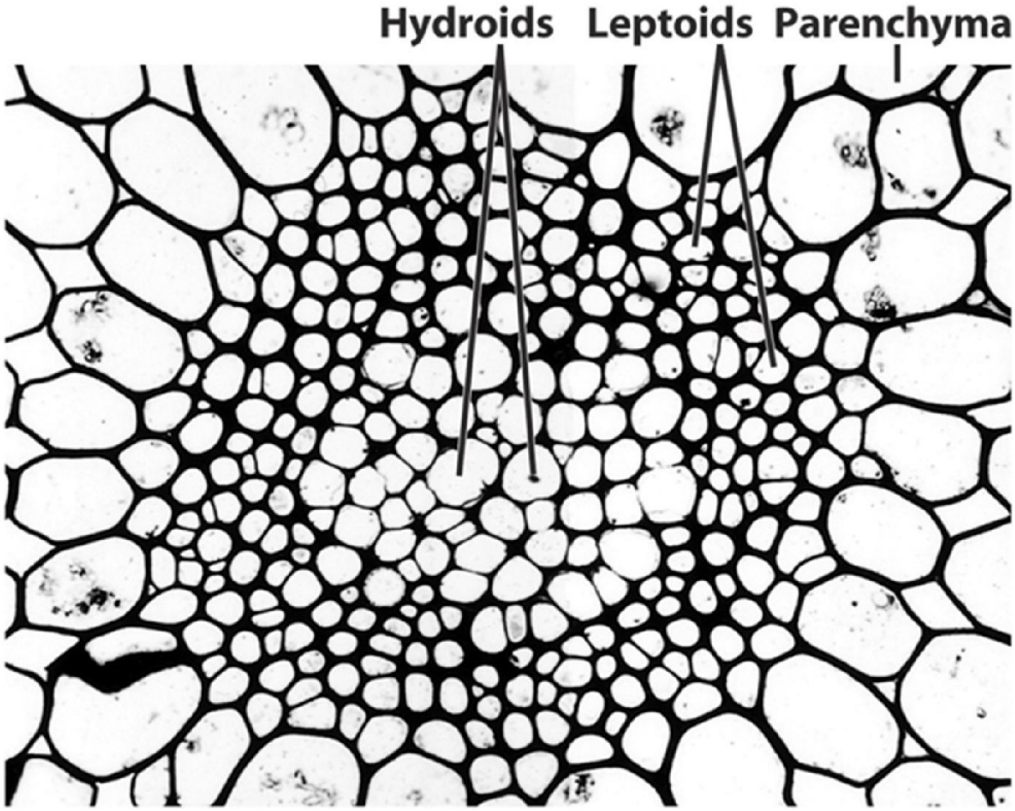


Figure 16-24b
Biology of Plants, Seventh Edition

figure 16-24c
Biology of Plants, Seventh Edition

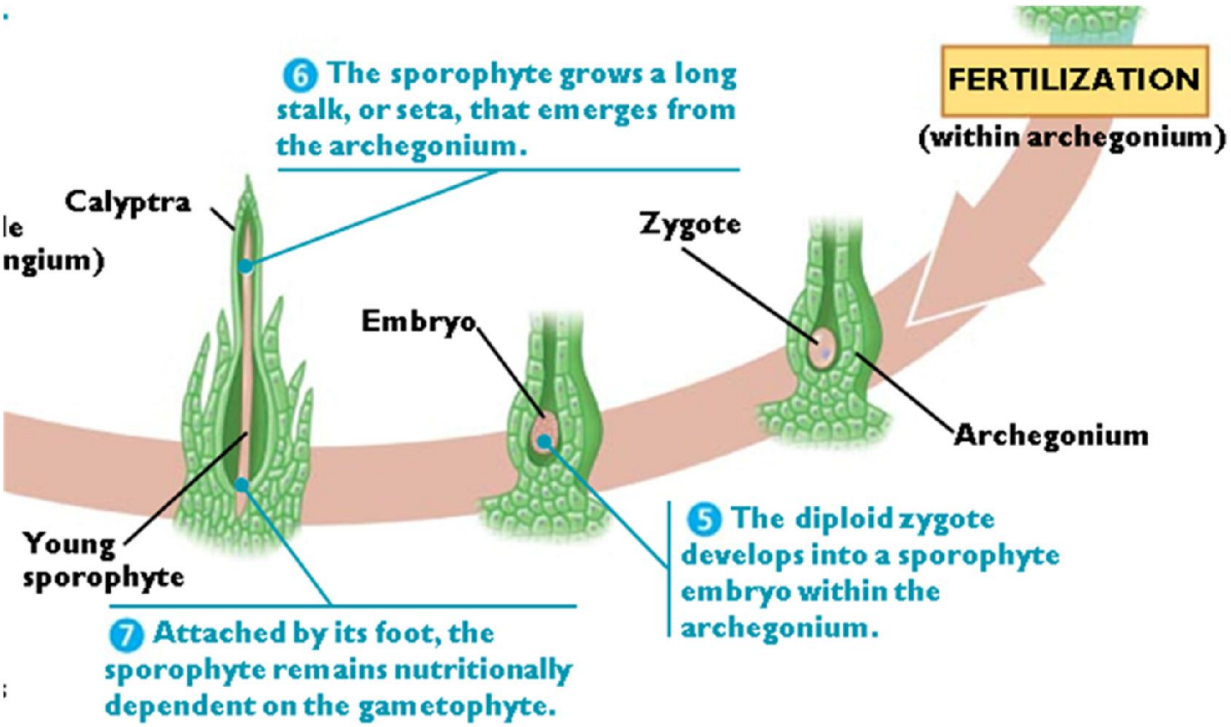
Reproduction in Bryophytes

- **Require abundant water for growth & reproduction**
- **Reproduce by means of spores, hence are known as the cryptogams**
- **The sporophyte which bears the spores is ephemeral in majority of species**
- **Sexual reproduction involves the development of sexual structures called antheridia & the archegonia**
- **The antheridium is the male sexual organ – is either ellipsoidal or spherical**
- **Antheridium contains numerous sperm cells with a single layer of sterile cells**

- **The sperms are *spirally curved cells* bearing a pair of long flagella**
- **The archegonium is a flask-shaped female sexual organ which consists of a neck & the venter**
- **The neck is freely projected so as to be accessible to the sperm cells**
- **The venter encloses the *egg cell***
- **Bryophytes are oogamous because they bear two types of gametes:**
    - **The egg (large and non-motile)**
    - **Sperm (small and motile)**
- **Fusion of sperm cell & egg give rise to zygote which develops into a sporophyte**
- **Gametophytes are nutritionally independent of sporophytes**
- **However, sporophytes are attached to the gametophytes and thus nutritionally dependent on them (gametophytes)**

Bryophyte Sporophytes

- **Bryophyte sporophytes**
    - **Grow out of archegonia**
    - **Consist of a foot, a seta, and a sporangium (capsule)**
- **Hornwort and moss sporophytes have stomata**



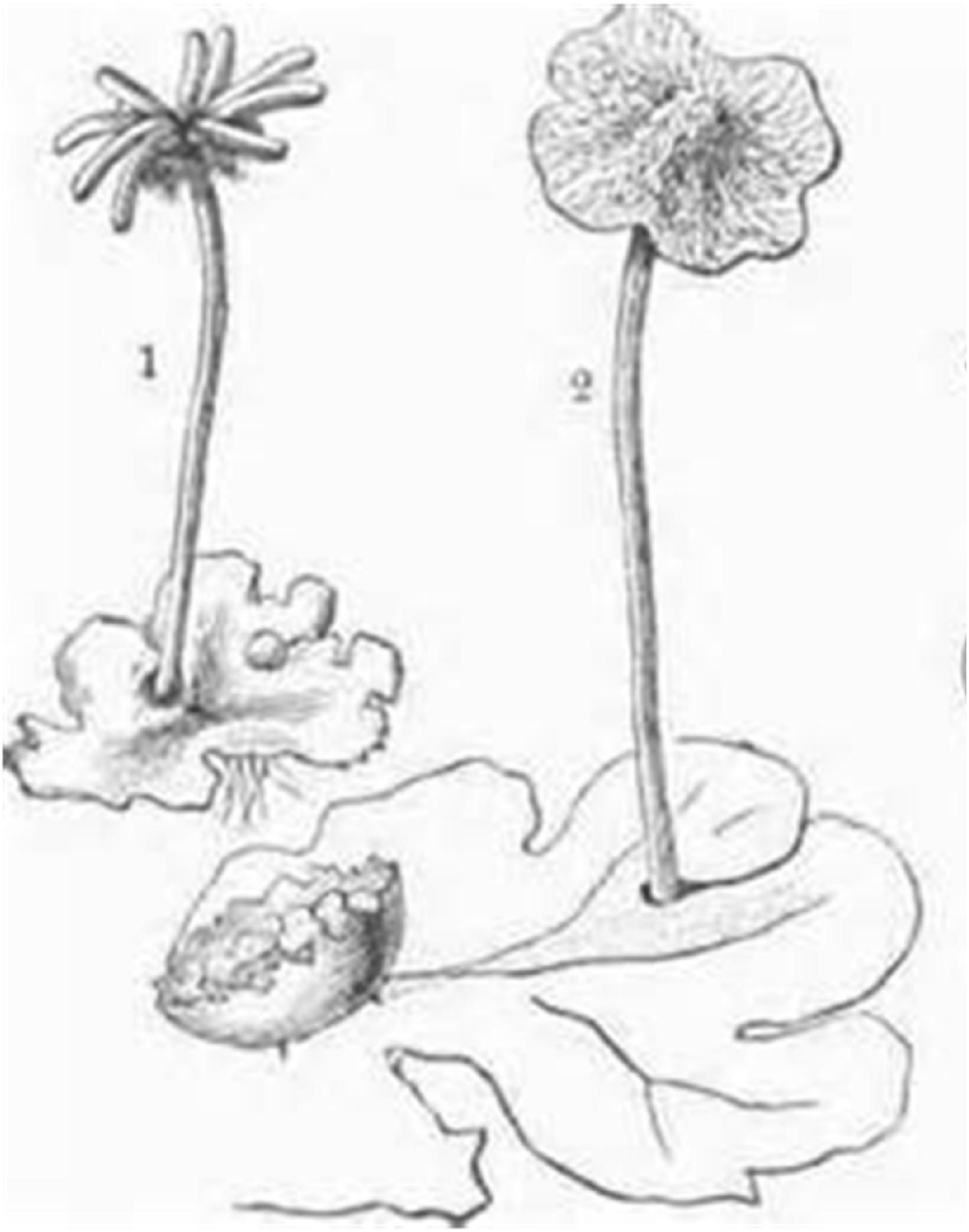
Classification

	Common Name	Approximate Number of Extant Species
Bryophytes (nonvascular plants)		
Phylum Hepatophyta	Liverworts	9,000
Phylum Anthocerophyta	Hornworts	100
Phylum Bryophyta	Mosses	15,000

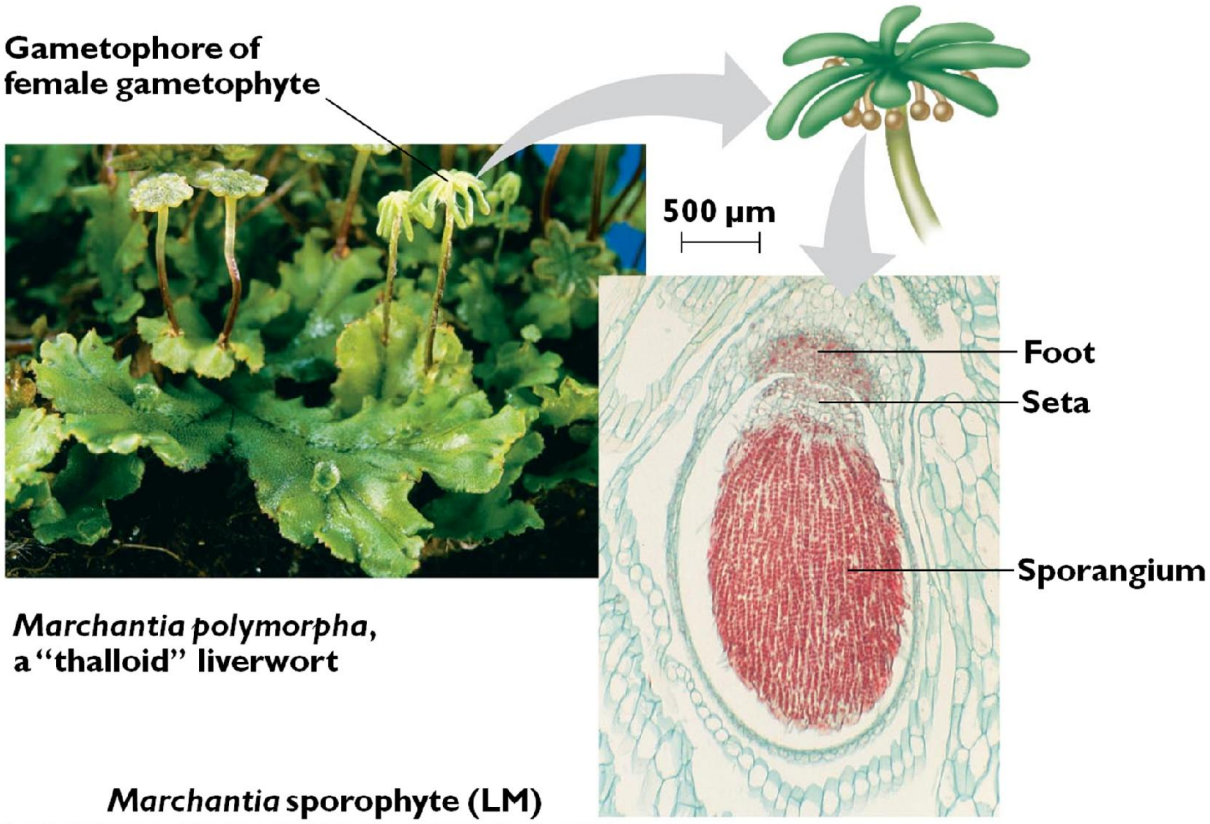
The Liverworts

- **Are classified under division Hepatophyta**

- **Commonly referred to as hepatics**
- **The division Hepatophyta contains one class called Hepatopsida**
- **These plants are characterized by a thalloid plant body**
- **A thallus is defined as a plant body not differentiated into roots, stems and leaves**
- **The most common liverwort in Zambia is *Marchantia polymorpha***
- **This species is dioecious**
    - **Male & Female gametes occur on separate male and female plants**
- **In species of *Marchantia* - asexual (vegetative) reproduction is achieved by means of gemma located in gemma cups**



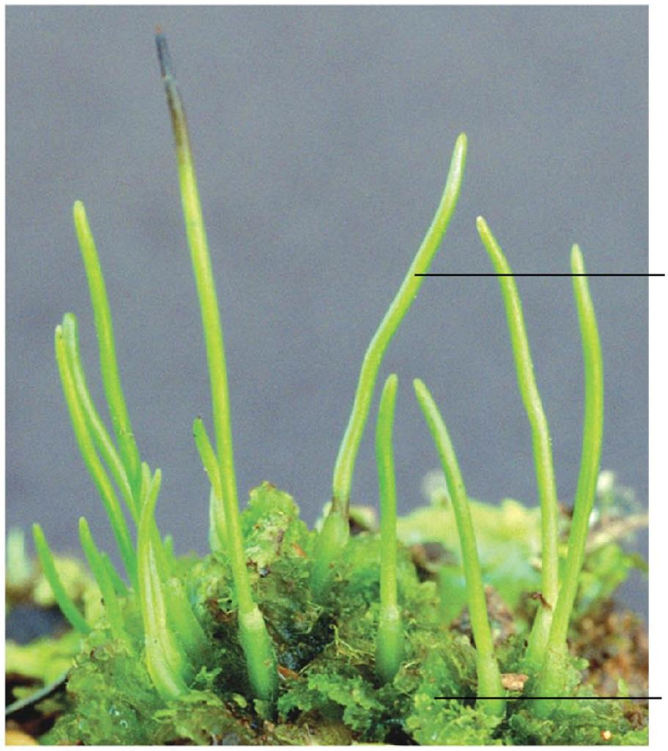
- **The gemma are dispersed around the environment by splashes of rain drops**

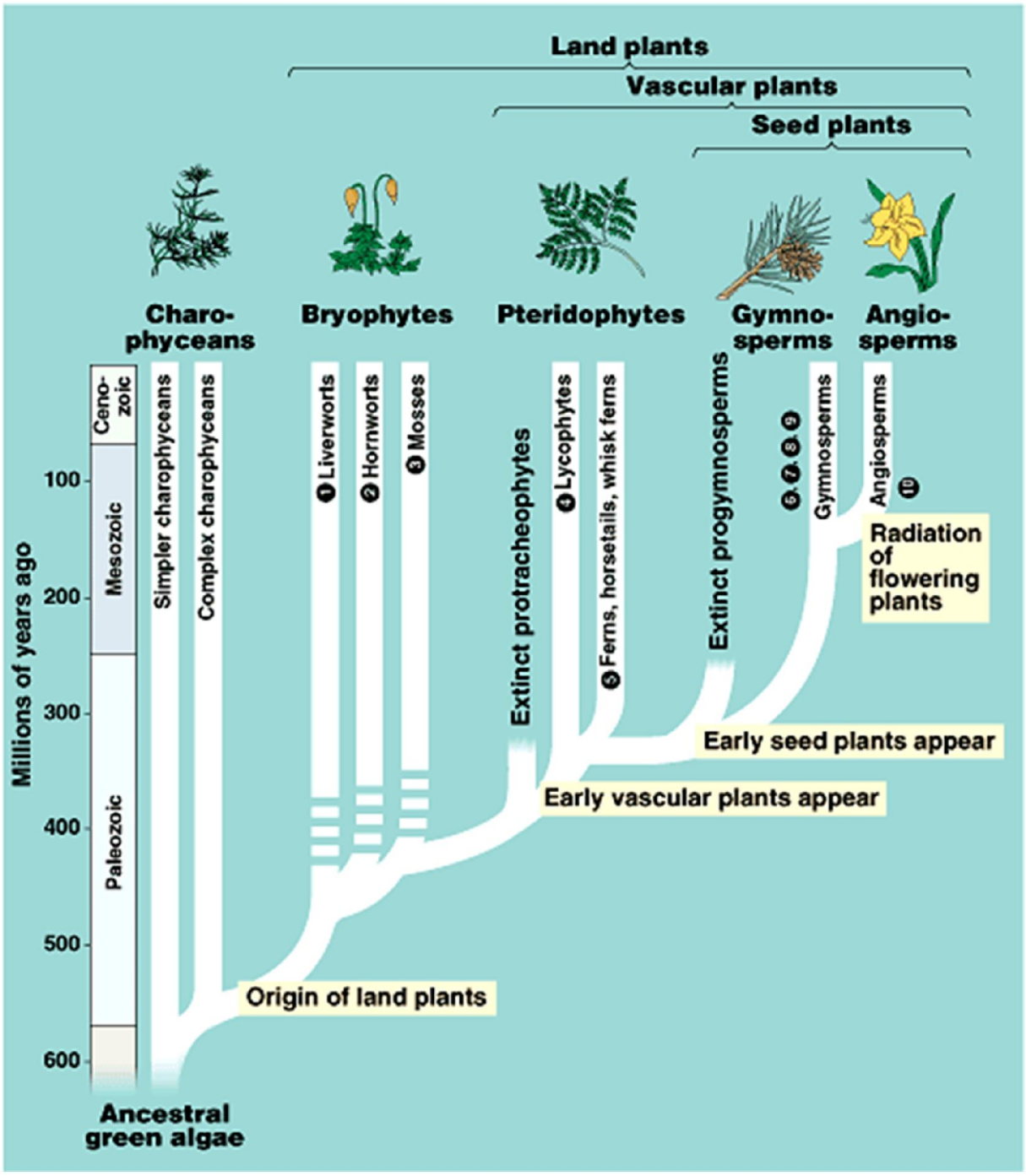


The Hornworts

- **Are classified under division Anthocerotophyta in the Class Anthocerotopsida**
- **Are morphologically different from liverworts**
- **Plants have a thallus bearing a horn-like structure**
- **Are commonly referred to as hornworts**
- **Consists of ~100 species**
- **Haploid *chromosome number* is usually n=5**
- ***Anthoceros* is the most common & widespread genus in Zambia and some parts of Central Africa**
- **The thallus is more or less circular and about 1-2cm across**
- ***Anthoceros* has extensive internal cavities inhabited by the blue-green algae *Nostoc***
- **The horn-like structure bearing the spores is called the sporophyte**
- **The sporophyte consists of the: foot and capsule**

An *Anthroceros* hornwort species

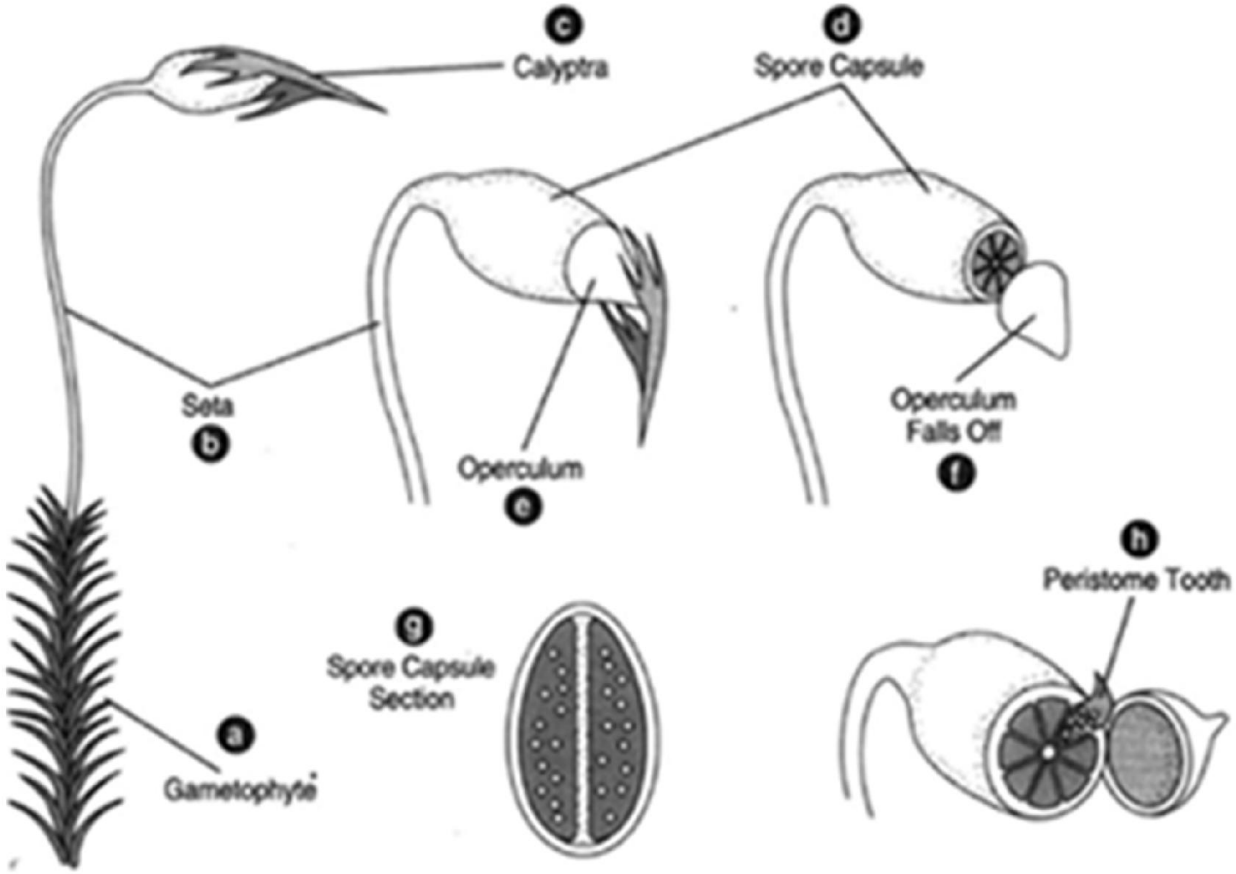




Division Bryophyta

- This is the most advanced group of bryophytes
- Are well adapted to terrestrial ecosystems

- A few species, such as members of the genus *Fissidens* are aquatic
- The plants are differentiated into rhizoids, stems and leaves
- Fertile (mature) plants bear a sporophyte consisting of the seta and capsule
- The capsule contains numerous spores and structures like:
    - Operculum
    - Circular structure called peristome (bears teeth)



Division Bryophyta

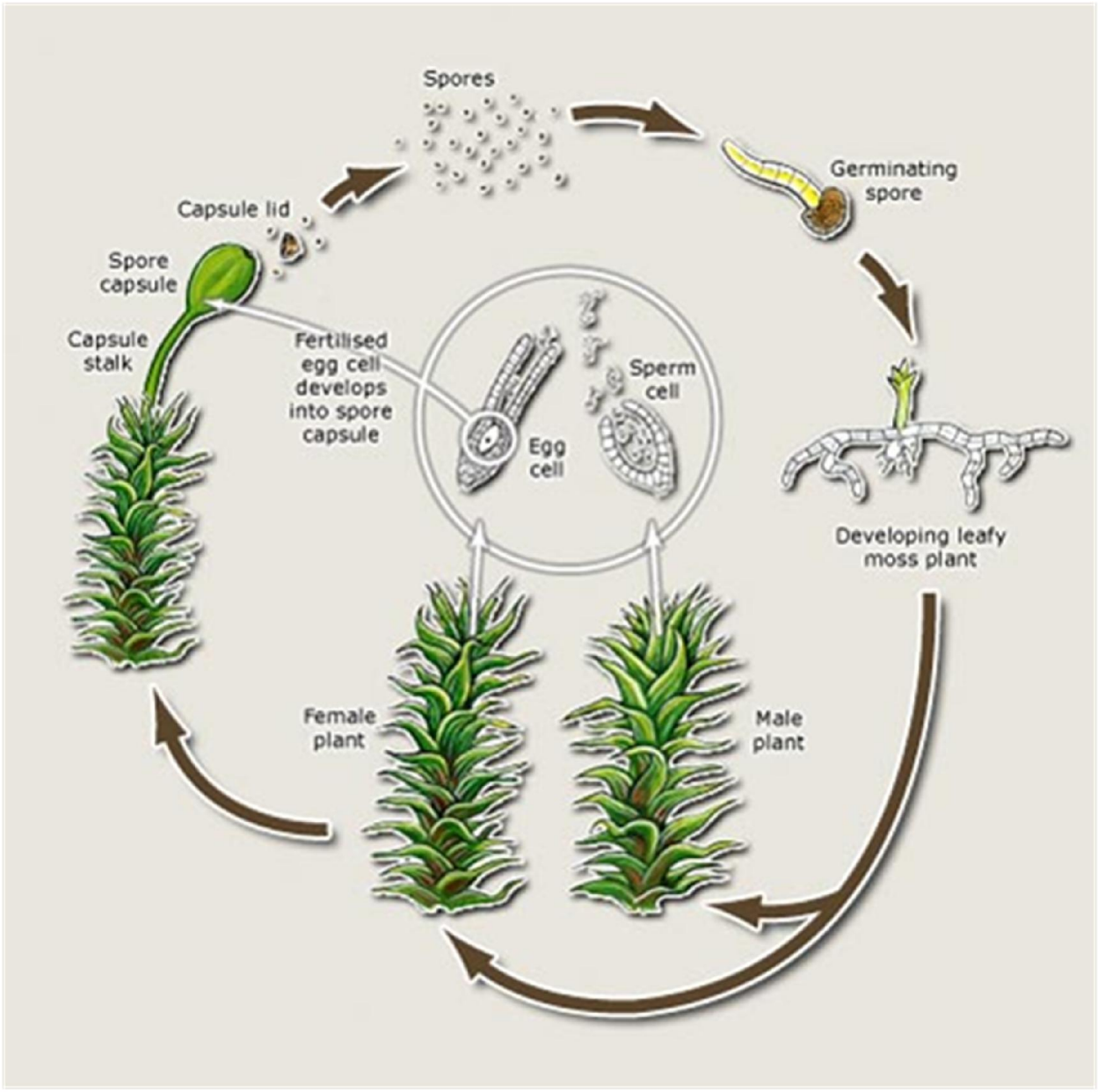
- Number of teeth is a taxonomic character for the identification of moss species
- Mosses – made up of 3 classes:

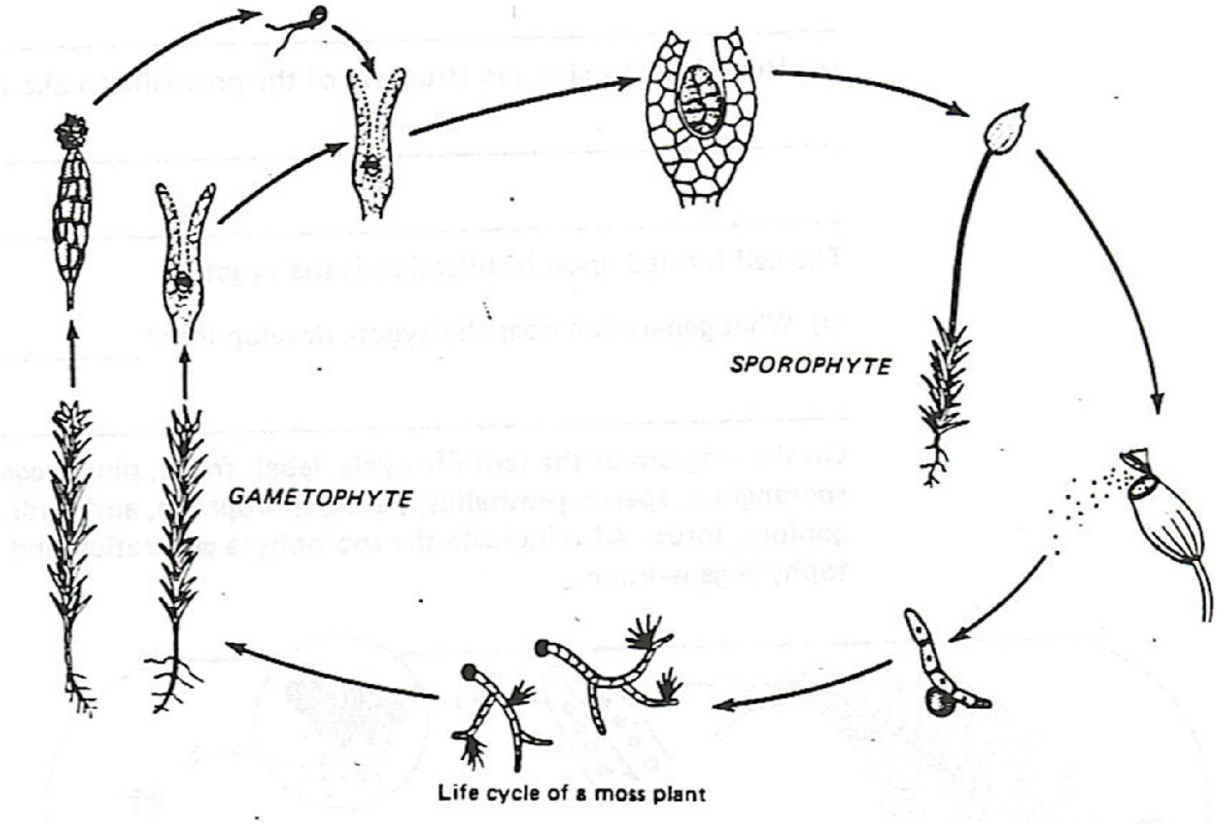
(*Sphagnum*) (*Andreaea*) (*Funaria hygrometrica*)

- Occurs in dambos & occupies ~ 1% of Earth's surface (most abundant)

Life Cycle of Mosses

- The gametophyte of a moss consists of rhizoids, stems and leaves
- A fertile moss bears a sporophyte comprised:
  - **seta**
  - **capsule**
- When spores are released from the capsule, they germinate into protonemata (protonema)
- Protonema develop nodes to give rise to young moss plants
- Both antheridia and archegonia develop at the apex of the moss stems
- Antheridia contain sperm cells while archegonia contain egg cells
- Water facilitates the movement of sperm cells towards the archegonia to effect fertilization
- The resultant zygote develops into a sporophyte that ultimately bears spores


Spores
Germinating spore
Capsule lid
Spore capsule
Capsule stalk
Fertilised egg cell develops into spore capsule
Sperm cell
Egg cell
Developing leafy moss plant
Female plant
Male plant



Life cycle of a moss plant

Importance and Ecology of Bryophytes

- An important component of plants which serve as the carbon sink. Thus play an important role in the carbon cycle
- Biondicators of pollution – some species are very sensitive to pollution & are absent from highly polluted areas
- *Funaria* grows well on burnt areas especially where charcoal has been harvested
- *Campylopus savanarium* forms extensive carpets in miombo woodland
- *Tortula porphyroneura* is a calcium lover. It inhabits areas underlain by limestone rock

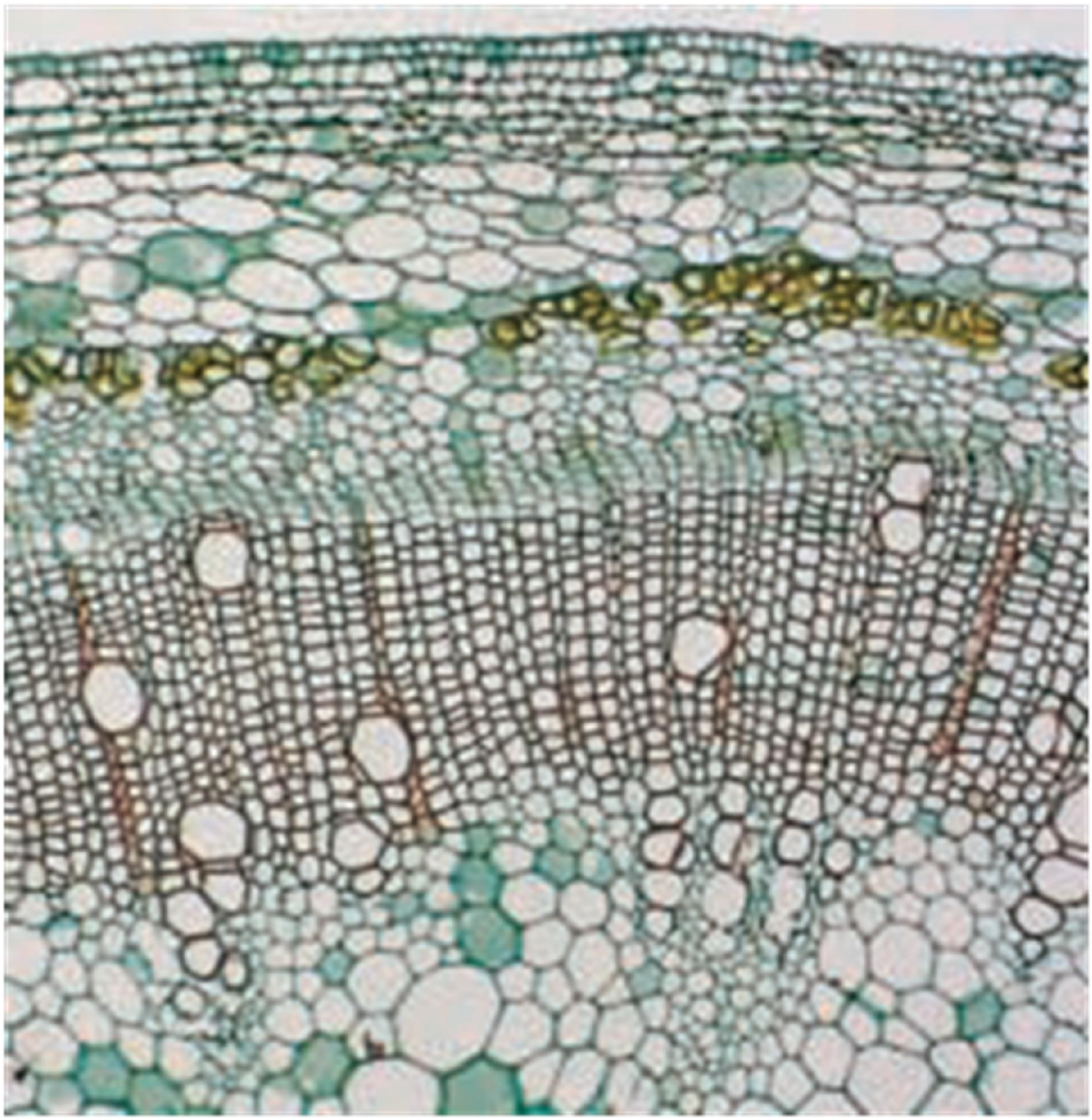
The Pteridophytes

Introduction

- Plants are composed of different types of tissue:

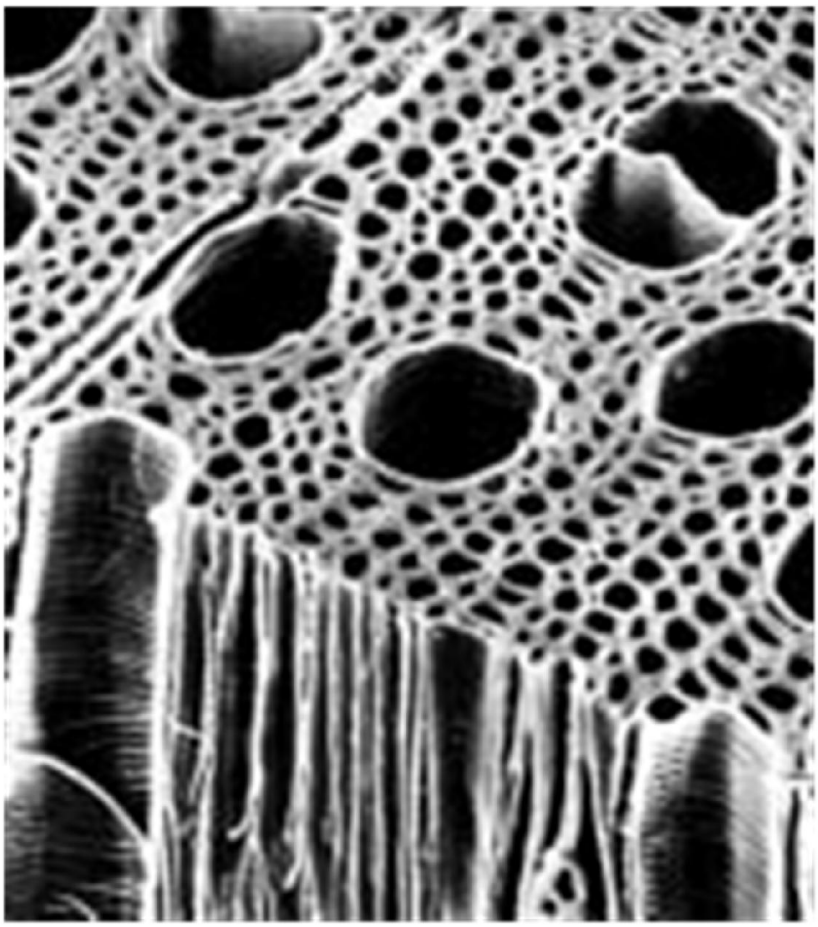
- **the epidermis**
- **parenchyma**
- **xylem**
- **phloem**

- A tissue is a group of cells of the same kind and are known to perform the specific function



- The epidermis is the outermost protective layer of cells found on leaves, young stems and young roots

- Parenchyma is a soft tissue composed of thin-walled cells which often referred to as a ground tissue
- Xylem is a complex vascular tissue whose main function is to transport water and solutes
- The complexity of xylem is based on the understanding that it is comprised of two major types of cells called vessels and tracheids
- Vessels are tube-like cells of xylem which are connected by perforations and are only found in angiosperms & some members of division Gnetophyta



- Tracheids are the elongate cells of xylem characterized by their tapered ends and are found in all vascular plants
- Phloem is a vascular tissue in the transport of photosynthetic products such as sugars and amino acids
- Phloem is mainly composed of sieve elements and companion cells

Plant Diversity and Tissue Types

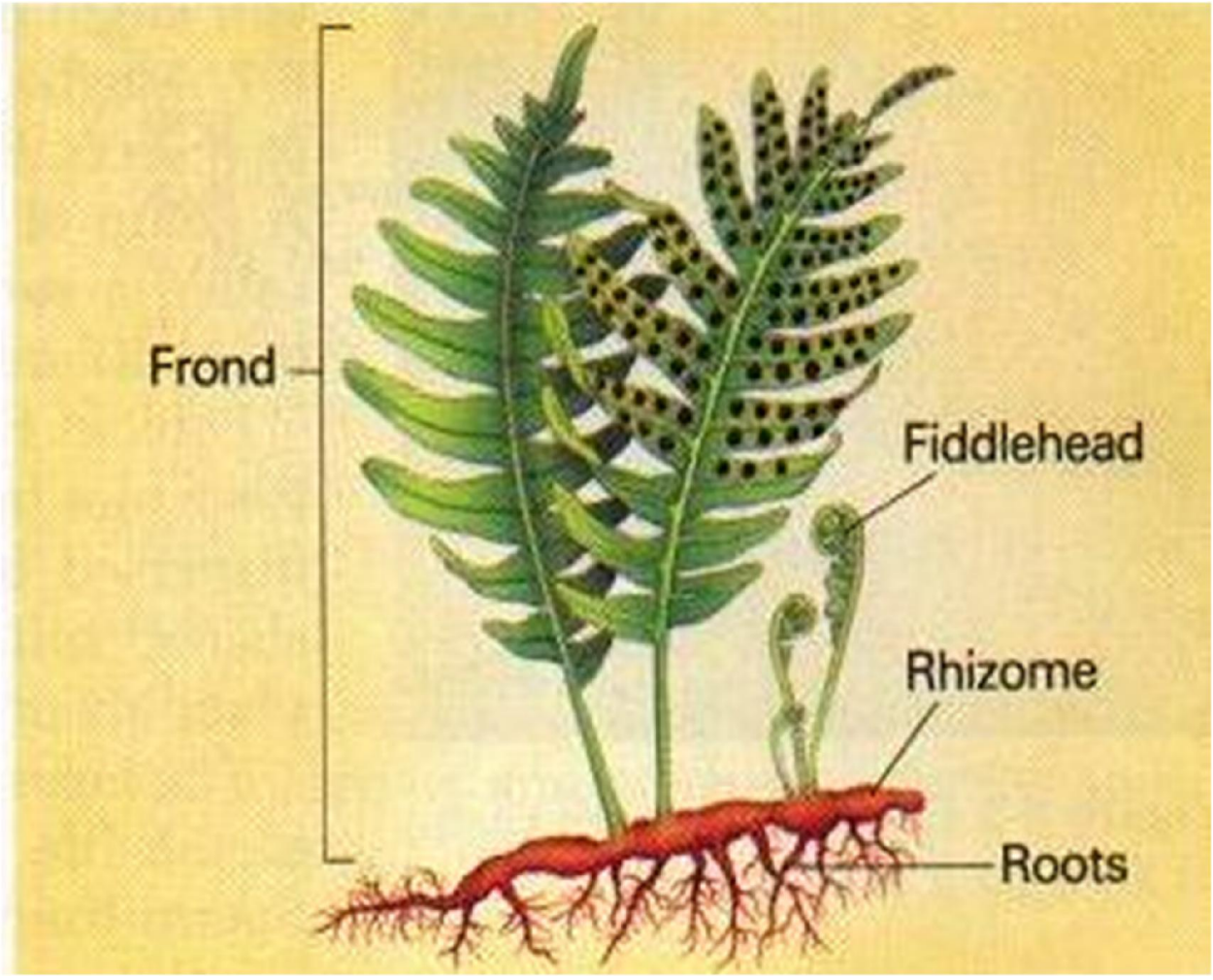
- The algae are the simplest plants in that some species exist as unicellular forms whose cells individually perform the vital physiological roles of photosynthesis and respiration
- The tissue that constitutes the multicelluar(filamentous and thalloid) algae are typically those of parenchyma
- **The bryophytes (liverworts, hornworts mosses) exhibit complex organization; but the parenchyma tissue they possess is externally bounded by the epidermis**

- **Vascular plants, such as the pteridophytes, gymnosperms and angiosperms are more complex than the algae and the bryophytes because these three vascular plant groups contain xylem and phloem in addition parenchyma and the epidermis**

- Vascular plants are dominant in terrestrial habitats
- They are comprised of two major groups: the seedless plants and the seed plants
- The seedless plants are called the vascular cryptogams, but technically referred to as pteridophytes that also constitute the lower vascular plants
- Vascular plants consist of three vegetative organs: roots, stems and leaves
- However, there are some exceptions to this generalization
- So far, there about 12000 species of pteridophytes documented globally and just over two thirds (75%) of the species occur in the tropical regions of the world
- In 1979 Jan Kornas documented a total of 146 pteridophytes occurring in Zambia; but he never explored for ferns on the Nyika plateau
- After publication of the book (*A checklist of Zambian vascular plants*)", the floristic status of the pteridophytes has now been updated to 157 species in Zambia

General Features

- Stems are basically two kinds:
    - (a) The aerial stems typically seen in many plants
    - (b) The subterranean stems, which are often referred to as rhizomes
- Stems of most herbaceous ferns are underground forms; but in tree ferns the stems are erect and thick trunks
- The roots, which arise adventitiously from the rhizome near the base of fronds, are simple

- 

  Leaves of ferns exhibit a circinate vernation - a condition in which the developing young leaves are coiled; but the leaves uncoil when they become mature
- Pteridophytes are the spore-bearing vascular plants, and the sporangia are located on the abaxial side of the leaves
- The mode of reproduction by means of spores rather than seeds has earned such plants the category referred to as the lower vascular plants

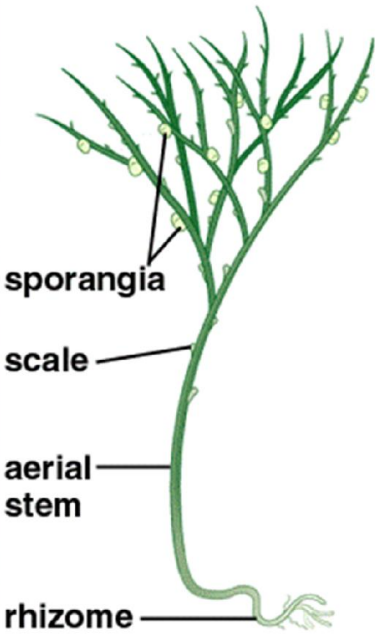
Classification

- Pteridophytes can proudly be classified into two groups: the fern allies and the true ferns

The fern allies include such genera as *Equisetum*, *Isoetes*, *Lycopodiella*, *Lycopodium*, *Psilotum* and *Selaginella*

- Fern allies usually bear relatively small leaves which are termed microphylls because they have a single unbranched strand of vascular tissues

Whisk fern, *Psilotum*



***Equisetum arvense*, field horsetail**

Vegetative stem

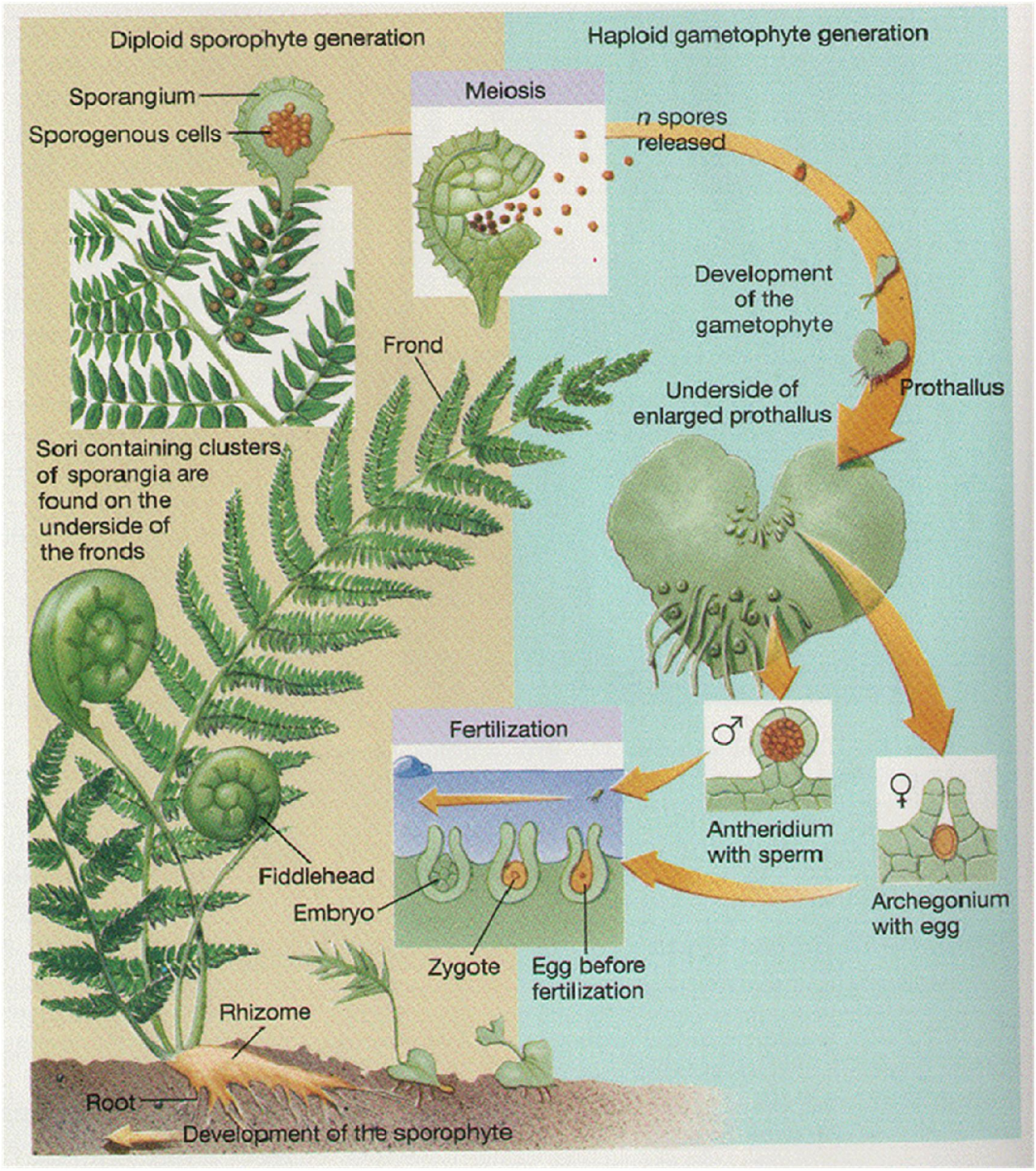
Strobilus on fertile stem

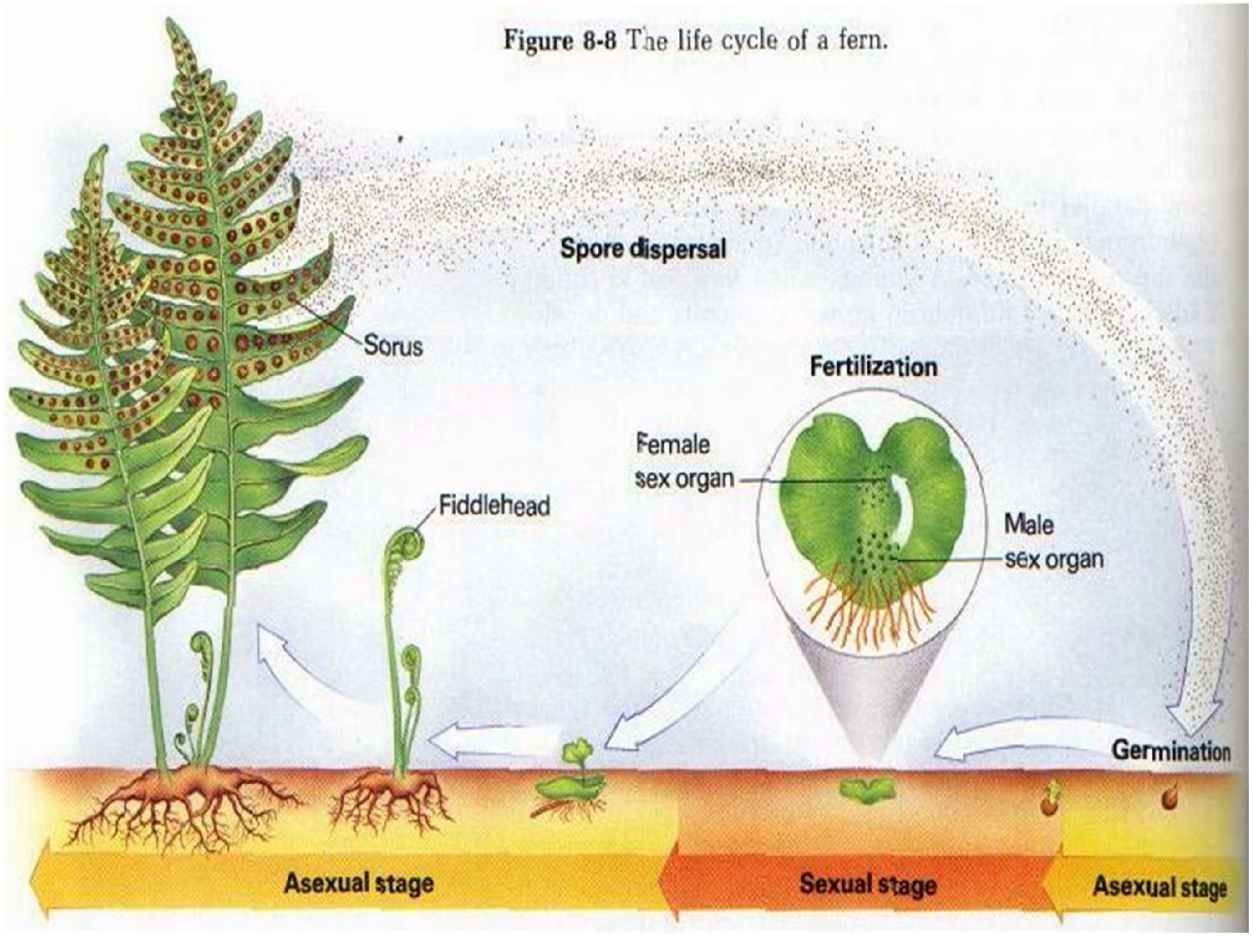
1.5 cm

- The true ferns include such genera as *Adiantum*, *Azolla*, *Dryopteris*, *Marsilea*, *Nephrolepis*, *Ophioglossum*, *Pteridium* and *Salvinia*
- The true ferns are characterized by comparatively large leaves that are termed megaphylls because they contain a complex system (network) of veins

The True Fern Life Cycle

- The veins conspicuously seen in the field are in the sporophyte phase as they are involved in the production of spores
- Each will germinate to give rise to a gametophyte called the prothallus
- The gametophyte bears male gametes in the antheridia and female gametes in the archegonia
- The fusion of the sperm and the egg cells gives rise to a zygote which develops into a young sporophyte plant


Diploid sporophyte generation
Haploid gametophyte generation
Sporangium
Sporogenous cells
Meiosis
n spores released
Development of the gametophyte
Frond
Underside of enlarged prothallus
Prothallus
Sori containing clusters of sporangia are found on the underside of the fronds
Fertilization
Antheridium with sperm
Archegonium with egg
Fiddlehead
Embryo
Zygote
Egg before fertilization
Rhizome
Root
Development of the sporophyte



Biology of Seed Plants

Gymnosperms

Introduction

- The study of pteridophytes has revealed that vascular plants may be either homosporous or heterosporous
- Homosporous plants produce *one type of spores* which germinate to give rise to the development of the *bisexual gametophyte*
- Heterosporous vascular plants produce microspores and megaspores which germinate to give rise and develop into male & female gametophytes
- Most seedless vascular plants are homosporous but heterospory is exhibited in such fern genera as ***Selaginella***, ***Marsilea*** & ***Salvinia***
- The seedless vascular plants have archegonia and antheridia

- The phenomenon of heterospory is also reflected in seed plants
- The pteridophytes are often known as the vascular cryptogams
- The production of seeds is the essence in the biology of seed plants
- A seed is a mature ovule consisting of an embryo, the endosperm that contains food reserve in and the seed coat
- Seed plants include plant groups called gymnosperms and angiosperms
- Also referred to as spermatophytes (reproduce by means of seeds)

The Gymnosperms

- Gymnosperms means “naked seeds”
- The ovules and resultant seeds are exposed on the surface of the sporophylls
- A sporophyll is a modified leaf or leaf-like organ that bears sporangia
- Sporophyll applies to the fertile leaves of ferns and also stamens & carpels borne by angiosperms
- Examples of cycads are the genera *Cycas* and *Encephalartos*
- *Podocarpus & Encephalartos,* only gymnosperms found in Zambia

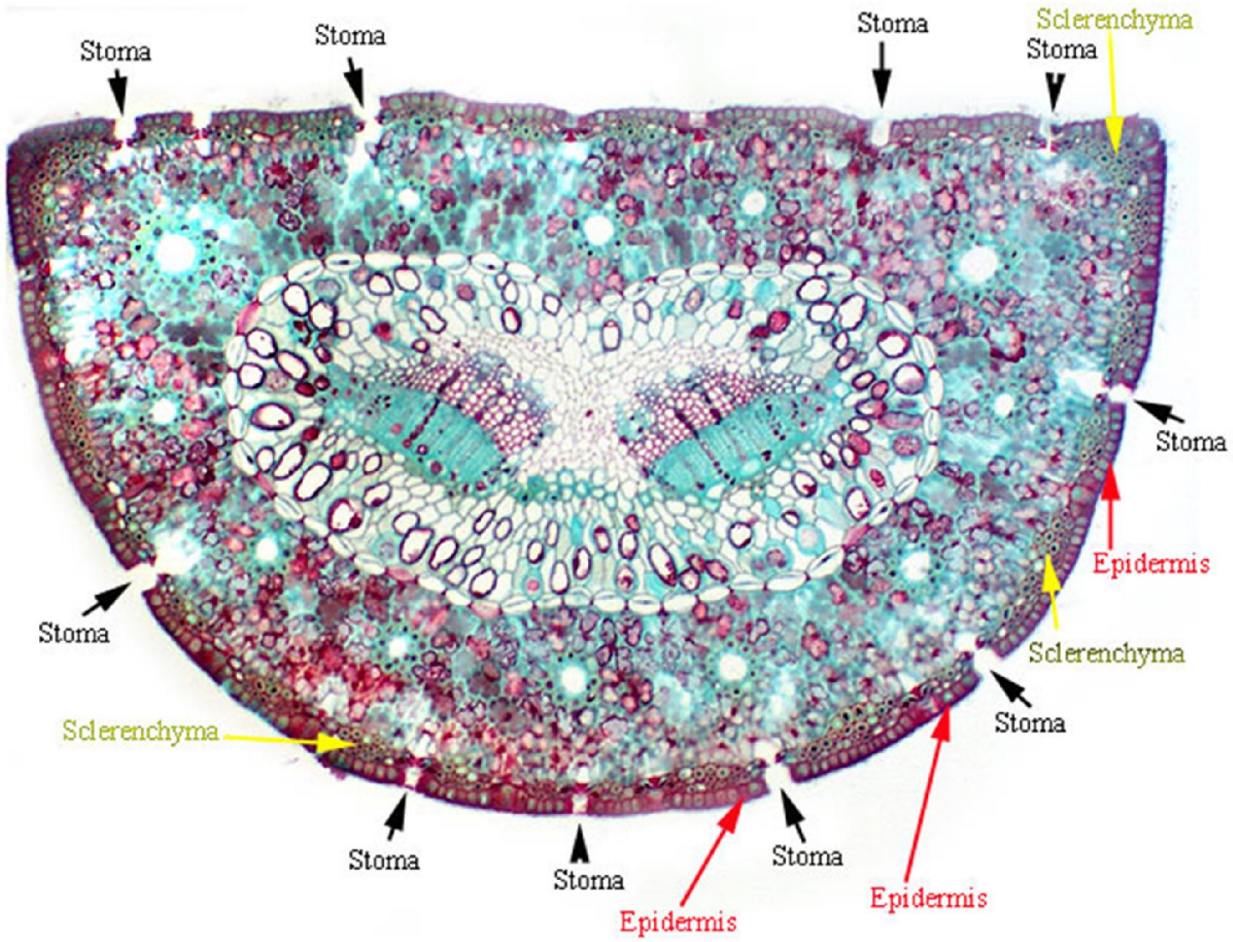
The Division Coniferophyta

- A group commonly called pines
- The most common genus in Zambia is known as *Pinus*
- The only indigenous pine *is Podocarpus latifolius* locally called Mulushi (Bemba, Bisa), Mweye (Tumbuka)

Structure of Pines

- Most pines are trees (woody), rarely shrubs
- Xylem is comprised of tracheid cells only
- Thus their xylem tissue is said to be homogenous (one kind of xylem cells)
- Stems bear two types of leaves:

    - Non-photosynthetic scale leaves
    - Photosynthetic foliage leaves
- Photosynthetic leaves are acicular (needle-shaped)
- The anatomy of *Pinus* leaves reveals such tissues:
    - Xylem
    - Phloem
    - Transfusion tissue
    - The endodermis
    - Mesophyll
    - hypodermis


Stoma
Stoma
Stoma
Sclerenchyma
Stoma
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Epidermis
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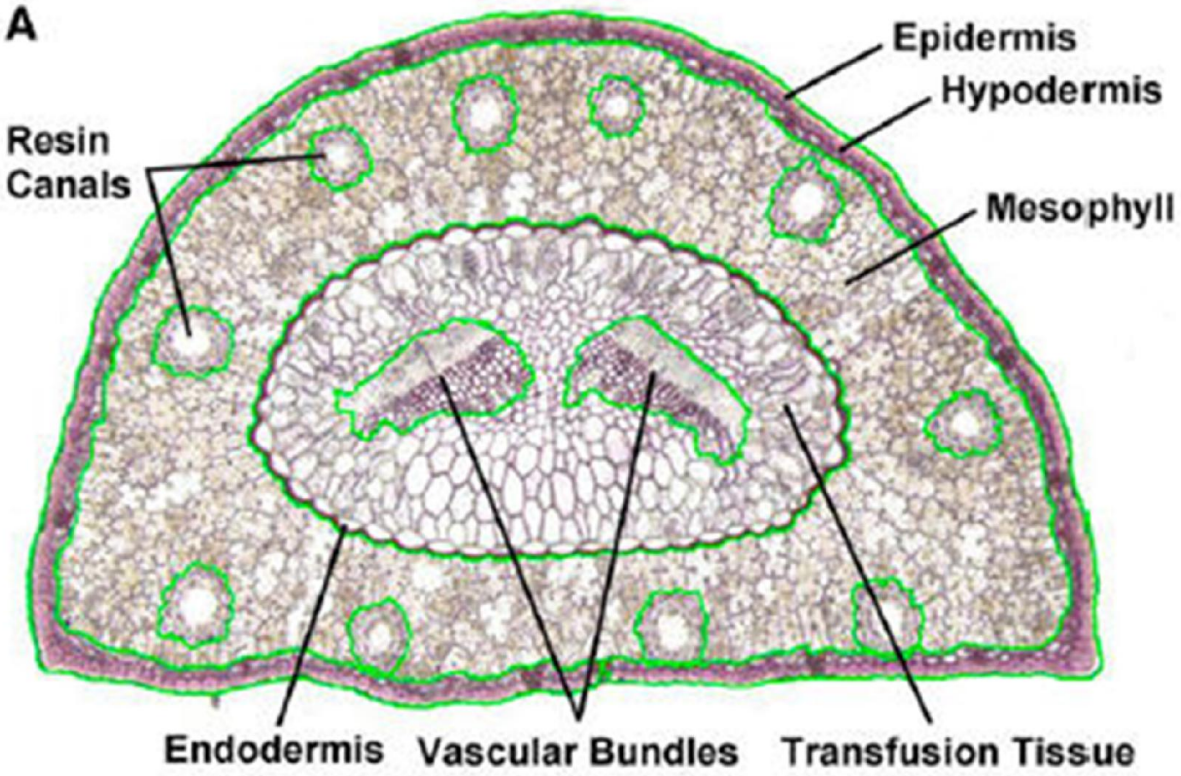
Stoma
Epidermis
Epidermis



- The presence of *sunken stomata*, *thick cuticle* and *hypodermis* is an adaptation to dry environments
- However, since pines occur in temperate climates that are characterized by precipitation in the form of rain (summer) and in the form of snow (in winter), species of Pinus exhibit a phenomenon of a “physiological drought”

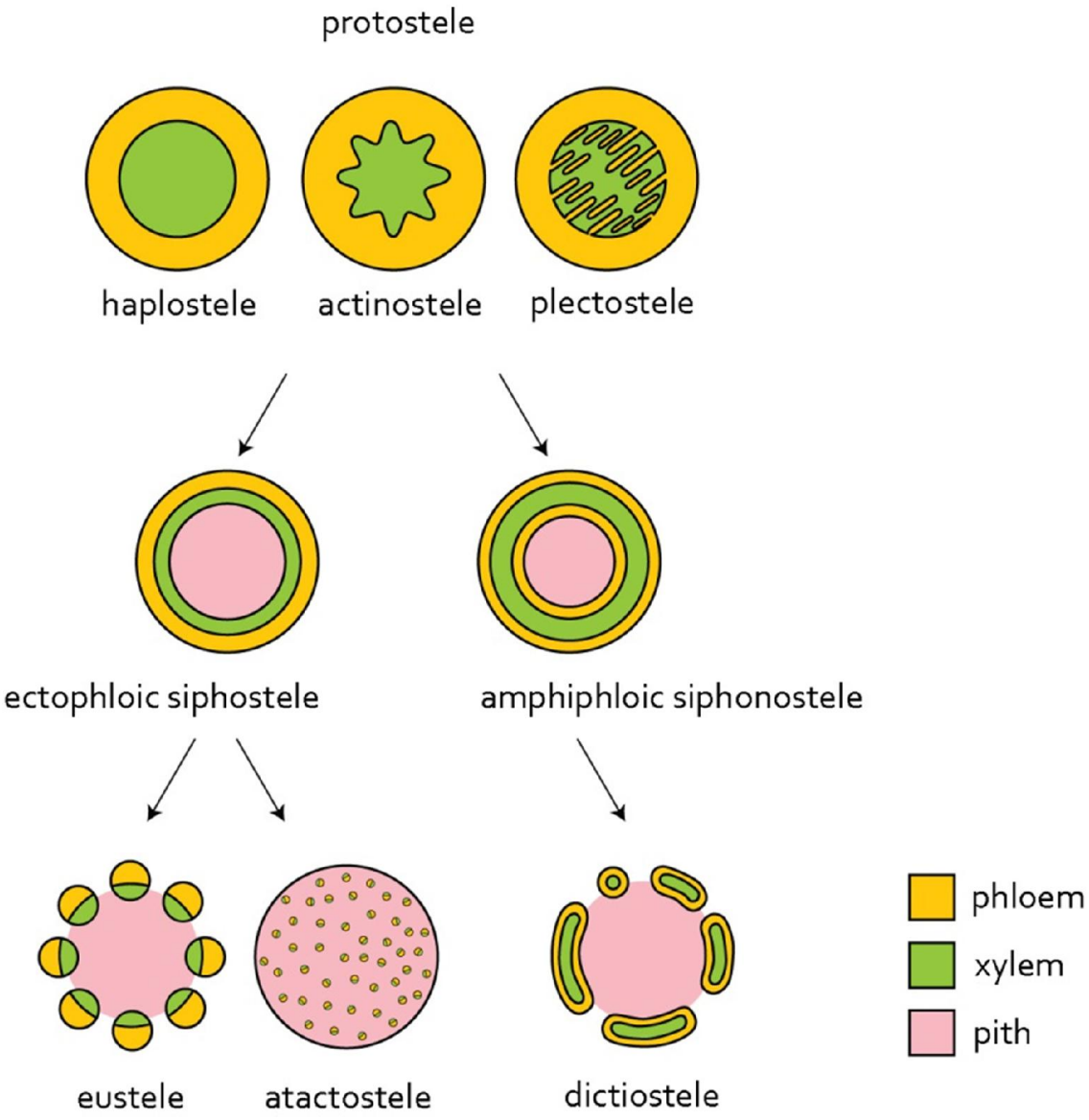
The Genus *Pinus*

- In the family Pinaceae, the genus *Pinus* is the largest taxon comprised of about 100 species of which 27 were introduced to Zambia
- Pinus is a genus of the temperate countries but 8 species have been naturalized in Africa
- The most commonly cultivated species in Zambia is *Pinus insularis*

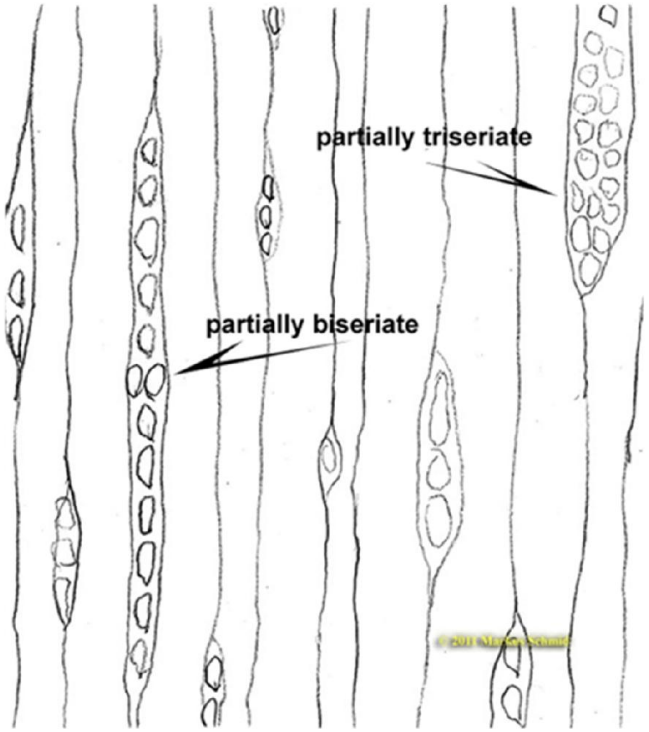
Vegetative Features

- Majority of species are trees, a few are shrubs
- The aerial part of the plant is highly resinous
- Branch roots have an ectophloic symbiotic fungus giving rise to a mutual relationship (mycorrhiza)
- Most exotic species cannot grow in the absence of the mycorrhizal fungus
- Stem branches are of two kinds:
    - Long shoots: bear non-photosynthetic scale leaves
    - Spur shoots: bear photosynthetic needle-like leaves
- The vascular system in young stems is eustele whereas it is ectophloic siphonostele in older stems

- 
long shoot
short shoot leaf
short shoot
long shoot leaf
C
2 mm



Xylem is homogenous – composed of elongate tracheids with prominent pits on radial walls



- Medullary rays are uniseriate
- Resin canals occur in both xylem and cortex regions

Leaves

- Leaves of *Pinus* persist for 2–14 years on the tree. Hence their evergreen state.
- *Pinus longaeva* is a long – living species found on mountains in southwest of the USA
- The number of leaves per fascicle is characteristic of the species & thus used in identification of *Pinus* species
- For instance:
    - *Pinus monophylla* is unifoliate
    - *Pinus sylvestris* is bifoliate
    - *Pinus insularis* is trifoliate

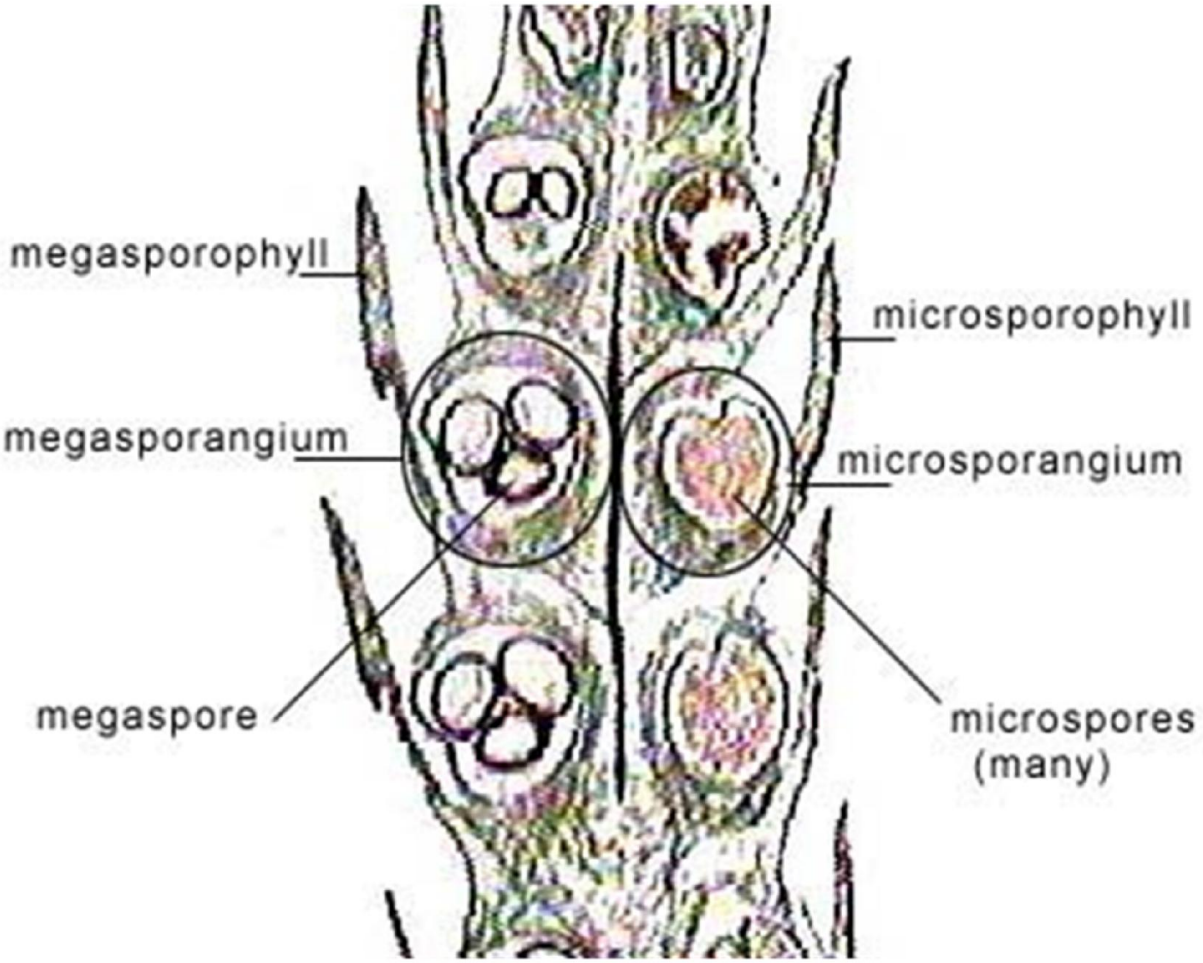
Anatomy of the *Pinus* Leaf

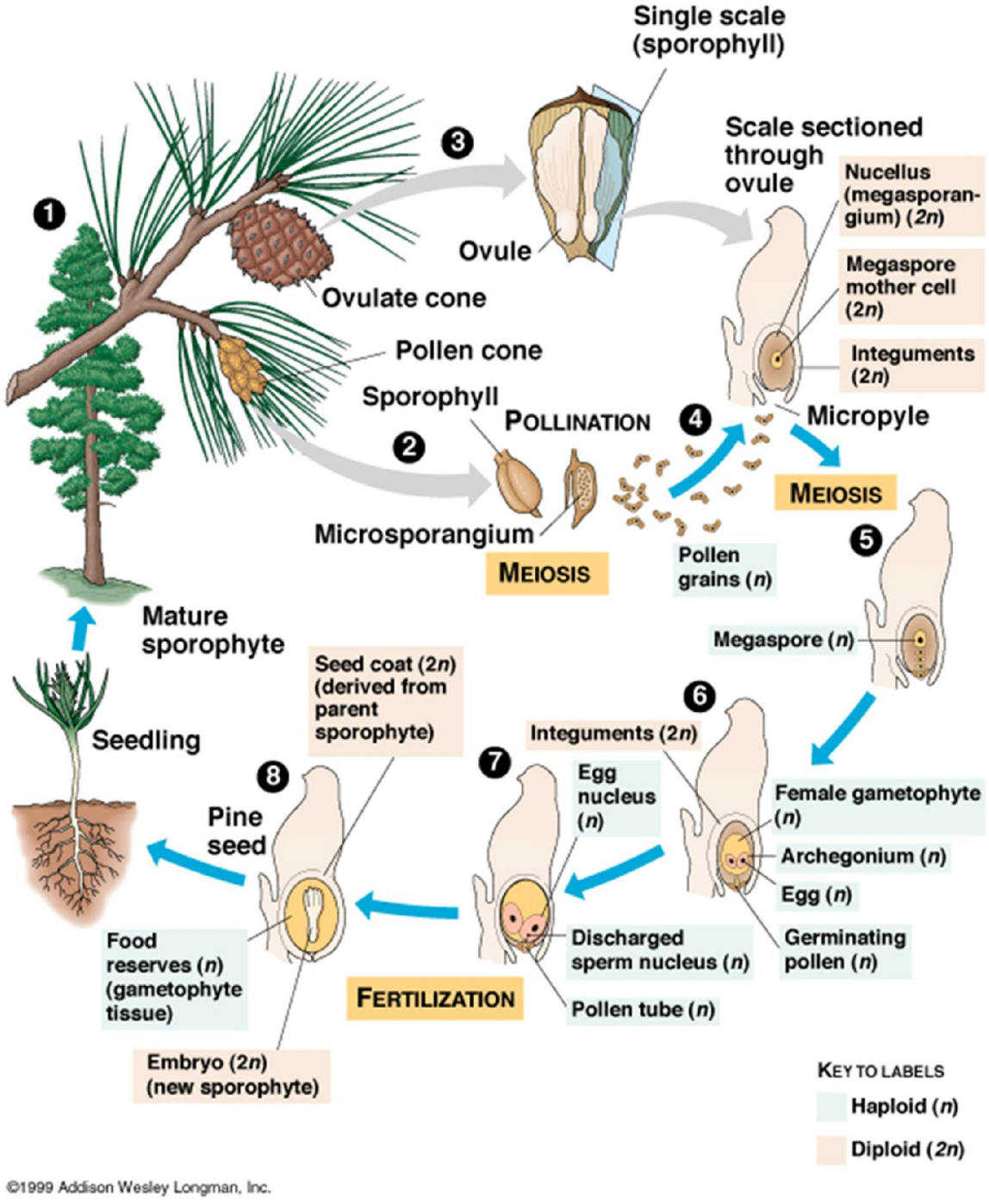
- The important anatomical features associated with leaves of *Pinus* are:
    1. Presence of resin canals in the mesophyll

2. Presence of the endodermis surrounding the vascular system
3. Presence of tranfusion tissue between the vascular system & endodermis
4. The tranfusion tissue is a mixture of dead tracheids and living parenchyma
5. Presence of the hypodermis
6. The characteristic sunken stomata

Reproduction

- The seeds and pollen are produced in structures called cones
- Female cones bear ovules on the adaxial side of the sporophylls
- male cones bear sporangia on the abaxial side of the sporophylls
- The male cones bear winged pollen grains
- All species of *Pinus* are monoecious
- Microsporangia develop on the abaxial side of the sporophylls
- Megasporangia (ovules) develop on the adaxial side of the megasporophyll
- Ovulate strobili take up to 5 years to develop into maturity
- Staminate strobili develop annually on pine trees
- Fertilisation gives rise to the formation of the zygote
- Each mature seed may contain as many as 4 embryos of decreasing size
- Later the developmental process finally leads to the formation of the embryo proper
- Finally only one embryo matures into a viable seed


megasporophyll
microsporophyll
megasporangium
microsporangium
megaspore
microspores
(many)



Biology of Angiosperm Plants

Roots and Stems

Introduction

- Angiosperms are commonly called flowering plants
- Flowering plants dominate the green vegetable matter found on the planet Earth
- Since the first embryonic leaves contained in the seedlings are called the cotyledons, they are conveniently classified into two main classes termed Dicotyledoneae (dicots) and Monocotyledoneae (monocots)
- The dicots are characterized by their seedlings that bear two cotyledons
- Examples of dicot plants include: the groundnuts (*Arachis hypogea*); Tomato plants (*Lycopersicon esculentum*); beans (*Phaseolus vulgaris*); Blackjack, Kanunka or Kasokopyo (*Bidens pilosa*)
- Monocot plants are characterised by a seedling with a single cotyledon
- Examples of monocot plants are:
    - Maize (*Zea mays*)
    - Sorghum (*Sorghum bicolor*)
    - Finger millet (*Eleusine coracana*)

The Plant Body

- The principal vegetative organs of the angiosperm plant are:
    - Roots
    - Stems
    - Leaves

- The development of the flowers occurs near the end of the plant's life cycle, particularly in annual plants

Plant Habits

- Theophrastos is known to have divided plants into growth habits commonly referred to as the herbs, shrubs and trees
- Herbs are plants with stems which contain a much higher proportion of parenchyma tissue compared to xylem tissue
- Examples of herbaceous plants are: sunflower (*Helianthus annus*), Tithonis diversifolia, beans, maize and the majority of grasses
- Shrubs are the woody plants that develop several stems arising from the ground level and sharing a single rootstock
- Examples of shrubs are: *Lantara camara*; *Hibiscus* spp; Cassava plant (*Manihot esculenta*)
- Trees are a form of woody plants which develop a single main trunk arising from the soil level and a single rootstock
- Examples of plants known to be trees are:
    - Mango (*Mangifera indica*)
    - Avocado (*Persea americana*)
    - Pawpaw (*Carica papaya*)

Plant Life Forms

- *Theophrastos* is credited for having classified plants according to their life spans or life forms known as annuals, biennials and perennials

- Annuals are plants which complete their life cycle from germination to the seed within a single growing season
- Examples of annual plants are: maize, groundnuts and sunflower
- Biennials are plants which complete their life span in two years
- Biennials such as Spinach plants remain vegetative for two years and only die after producing flowers and seeds at the end of the second year
- Perennials are plants whose life span extends for more than one two years
- Examples of perennials are: Cassava, Mango, Guava (*Psidium guajava*)

The Roots

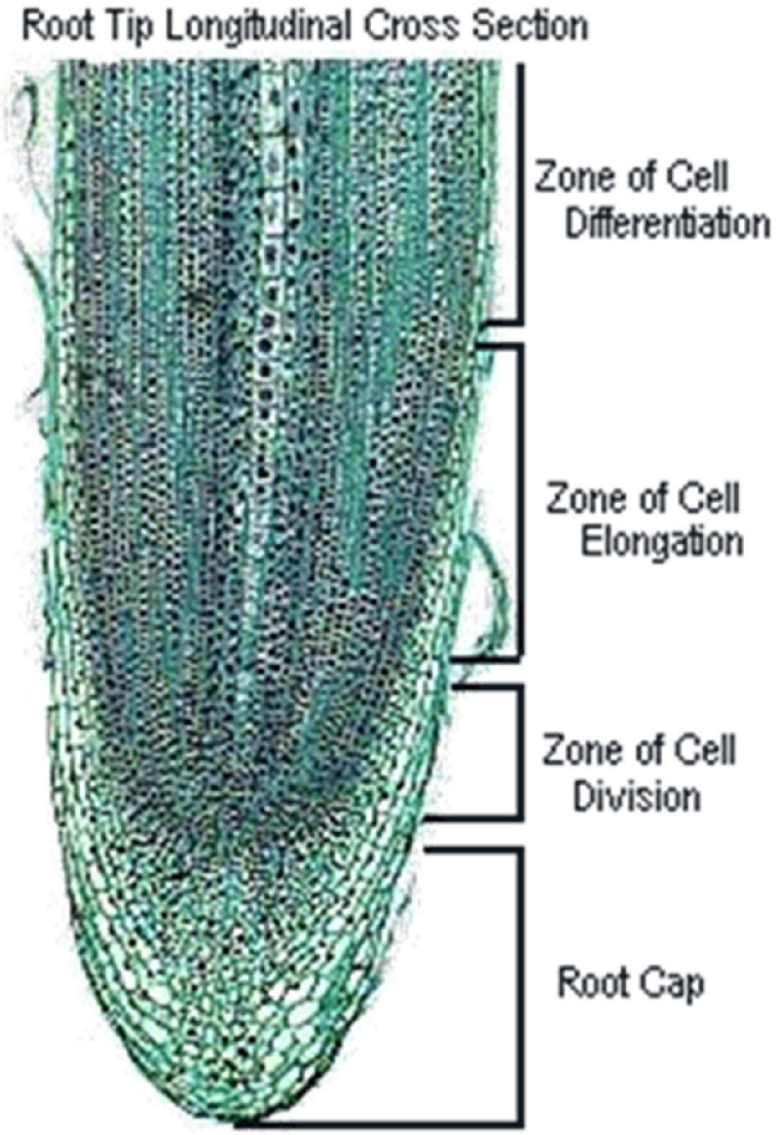
- The most important features of the flowering plants is their possession of vegetative organs called roots, the stems and the leaves
- The main plant axis is differentiated into root system and a shoot system
- The root is the lowermost *underground organs* portion of the plant axis which is usually located below the soil surface
- Typically, roots grow in the direction of gravity – hence such organs are said to be positively geotropic
- Roots are rarely as straight as the stems because they meet obstacles as they penetrate the soil in search of moisture
- The best development of roots and giving rise to the most extensive branching of these organs, is found in well drained moist soils
- The roots do not possess chloroplasts and sunlight has no effect on development of the roots
- In roots the epidermis which usually lacks the cuticle, contains root hairs as the modified epidermal cells involved in the absorption of water and mineral elements

Function of Roots

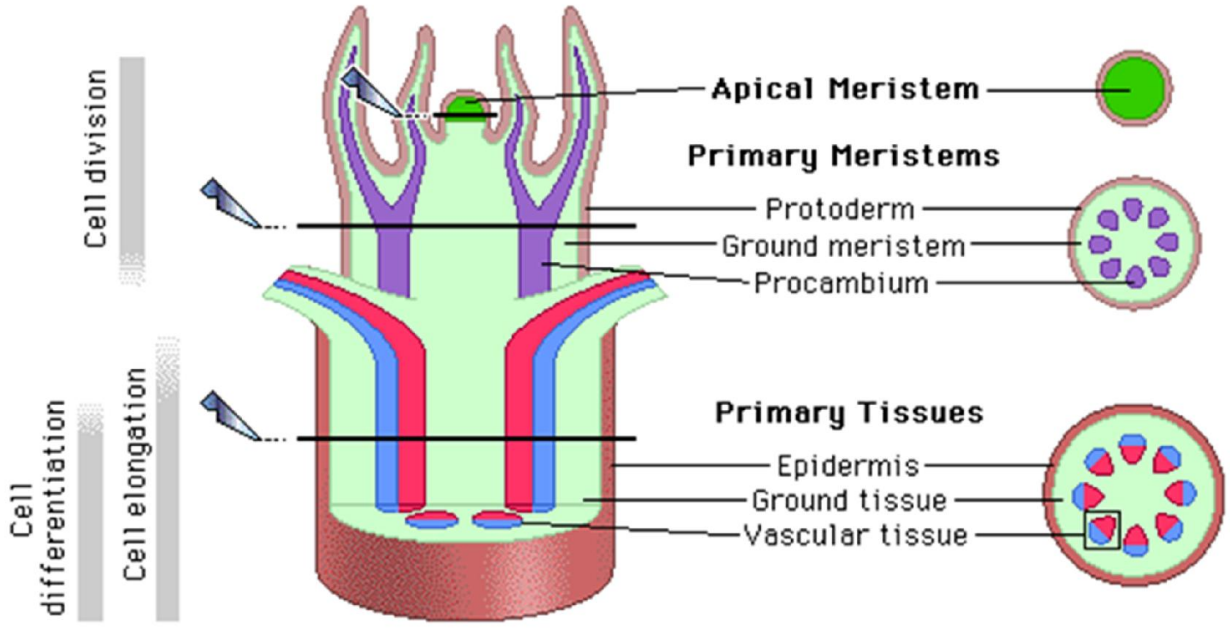
- The roots provide the anchorage of plants to their growth medium
- Roots are involved in the absorption of water and mineral solutes
- Other roles of the roots embrace the storage of synthesized compounds such as the starch in root tubers of sweet potatoes and cassava as well as in the storage of the alkaloids which are sources of medicines
- Roots are also involved in the synthesis of other compounds such as the cytokinins, gibberellins, nicotine (in tobacco plants)

Primary Tissues in Roots

- Growth in roots is governed by the apical meristem
- Prominent tissues found in the region of the meristem are the root cap, the quiescent centre, the procambium, the protoderm, the ground meristem and lateral meristem
- The root cap consists of parenchyma cells that are specialized in the secretion of a slimy polysaccharide called mucigel
- The *mucigel* is a form of *lubricant* rich in carbohydrates and amino acids
- The root cap is also the site of perception of gravity and thus involved in the control of *geotropic growth* of the roots
- Quiescent center (zone) is a hemispherical shaped tissue were cells exhibit low mitosis and even a complete lack of mitotic cell division



- Procambium is a juvenile tissue that gives rise to the development of the vascular cambium
- The protoderm is the juvenile tissue that develops to give rise to the outermost protective tissue called epidermis
- Ground meristem is the portion of apical juvenile tissue that develops into the cortex or pith

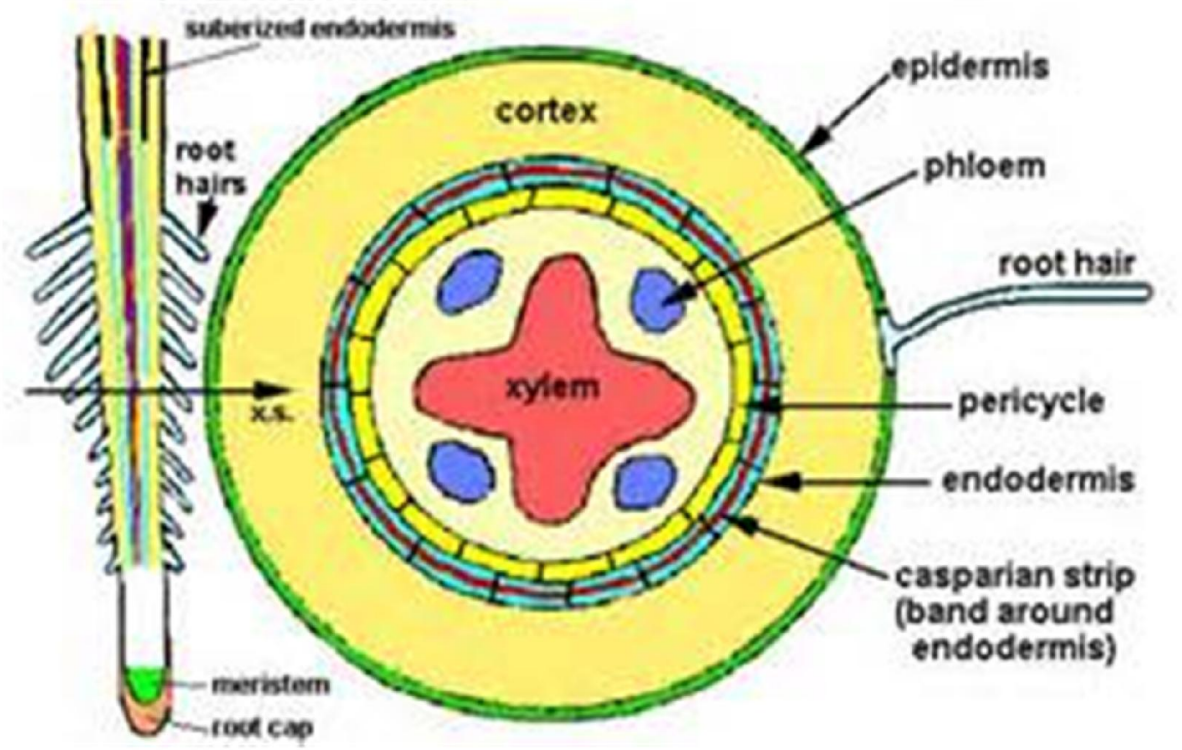


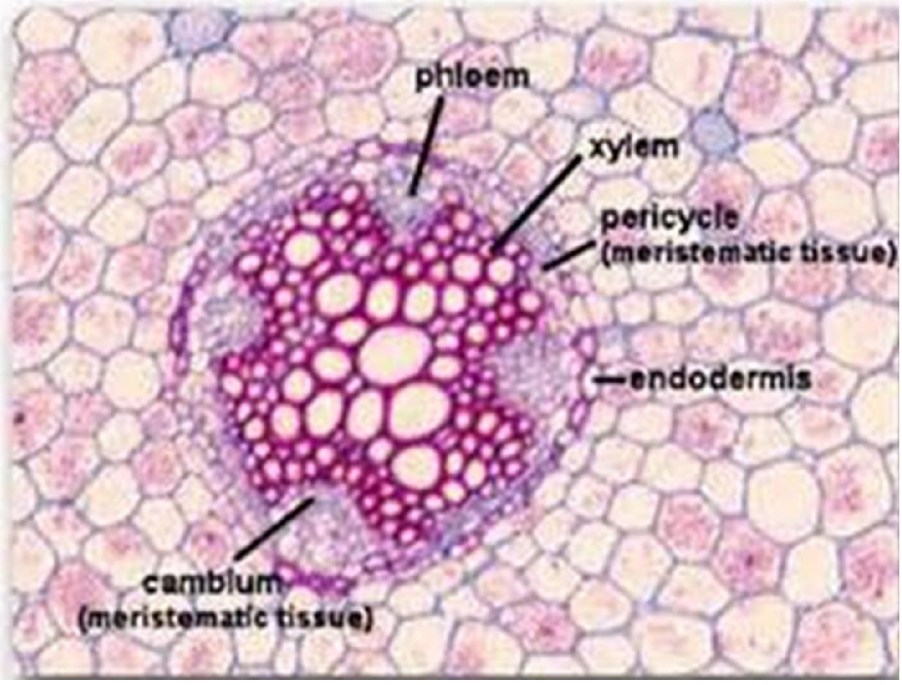
Morphology of Roots

- In dicot plants the initial root which develops at the onset of germination is usually persistent
- This initial root becomes the tap root and this kind of root development in dicot plants is known as the tap root system
- In monocot plants the initial root formed at the onset of germination tends to degenerate and this condition later gives rise to numerous roots of the same diameter to replace the embryonic root
- The embryonic root degenerates at an early stage and is consequently replaced by the proliferation of numerous roots of the same diameter
- Development of numerous roots in monocots constitutes the fibrous root system

Anatomy of Roots

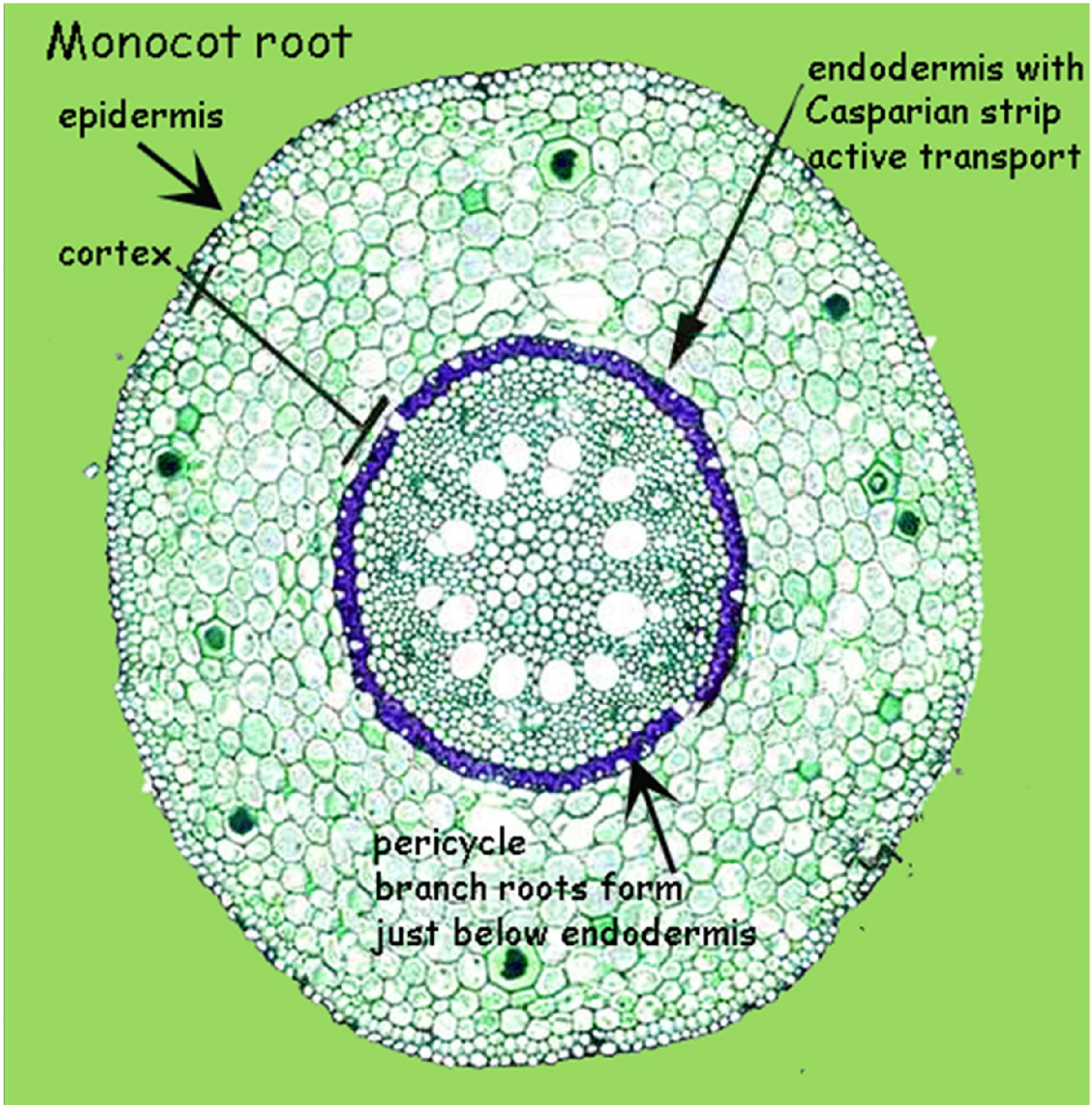
- In roots of *Ranunculus* which is a dicot, the xylem tissue exhibits four arms radiating from the centre – a condition said to be tetrach
- The xylem tissue is surrounded by the cambium which is externally bounded by the phloem
- The phloem tissue is externally surrounded by a meristematic tissue called pericycle which is the origin of lateral roots





- External to the pericycle lies the uniseriate tissue called the endodermis which is strapped by a band of *suberin* called the Casparian strip
- The tissue located between the endodermis and the epidermis is called the cortex

- Some cells of the epidermis are modified into root hairs
- In monocot roots the xylem tissues exhibit numerous arms (bundles) giving rise to a polyarch condition



- In monocot roots the cambium is absent & hence there is no secondary growth in such roots
- Roots of many plants become modified into tubers to serve for the storage of food reserves

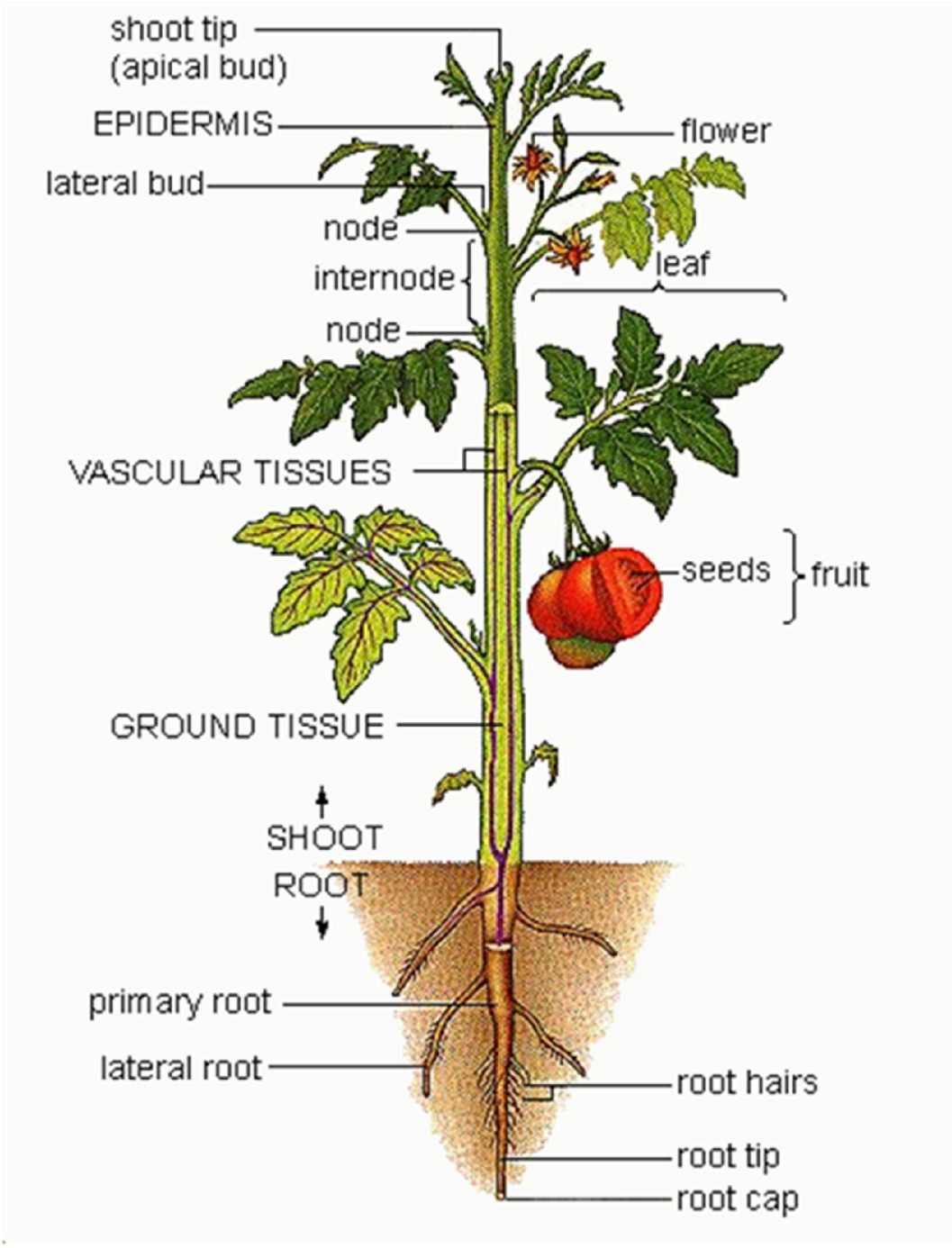
- Plants whose roots swell up to form tubers include cassava, sweet potato (*Ipomoea batatas*) & *ground orchids (Chikanda)*
- The tap root of carrots (*Daucus carota*) is modified into a fleshy structure consisting of storage parenchyma

The Stems

- The shoot is comprised of the stem which ultimately bears the leaves
- However, the stem is ether an aerial or underground organ which is termed the rhizome
- The main role of the stem is to bear the leaves and ensures that the leaves are elevated above the ground
- In physiological terms, the stems are involved in the *transport of water & mineral salts* and the conduction of organic compounds through the phloem tissue
- They are also involved in the *storage of water, food reserves* and secondary compounds such as the alkaloids
- In some plants such as cassava and sweet potatoes, stems serve as a *means of plant dispersal*

Parts of the Stem

- In vascular plants the stem is comprised of the nodes and internodes
- The stem apex has a terminal bud which produces the auxin called indole acetic acid (IAA) which is a derivative of the amino acid tryptophan

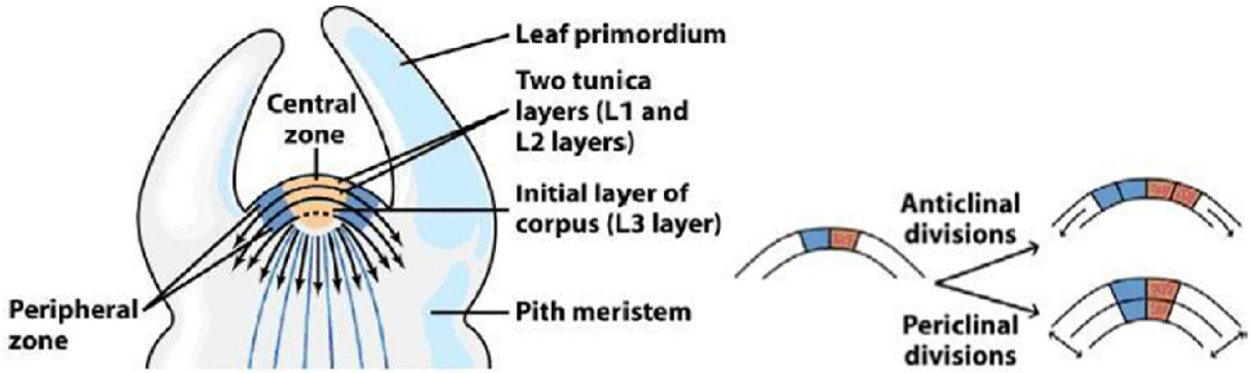


- The IAA promotes apical dominance by inhibiting the development of lateral buds
- This explains why the action of pruning shoot tips promotes the development of lateral branches

- Both the bud and leaf *primordia* are the precursor (meristematic) tissues which give rise to the formation of the bud and leaves respectively

The Tunica-Corpus Theory

- The *tunica-corpus theory* was developed by the German scientist called Schmidt in 1924
- The tunica-corpus theory explains the phenomenon that the stem apex exhibits two distinct zones called the tunica and the corpus
- This entails that the vegetative stem apex of most flowering plants has the *tunica-corpus* type of organization
- The *tunica is the outermost layer or layer of cells* arising from the anticlinal division of cells
- The anticlinal division is the condition when the dividing line is perpendicular to the surface of the stem
- This mode of division (anticlinal division) gives rise to a plate of cells that constitute the epidermis
- When the line of division of the cells is parallel to the surface of the tissue, this variant of cell division is described as being periclinal division of cells
- The *corpus* is the product of both *anticlinal and periclinal divisions* of cells which give rise to a *volume of tissues*
- In the corpus the cells divide in various planes to produce the bulk of the developing stem
- This means that the corpus consists of a body of cells that is located beneath the tunicad

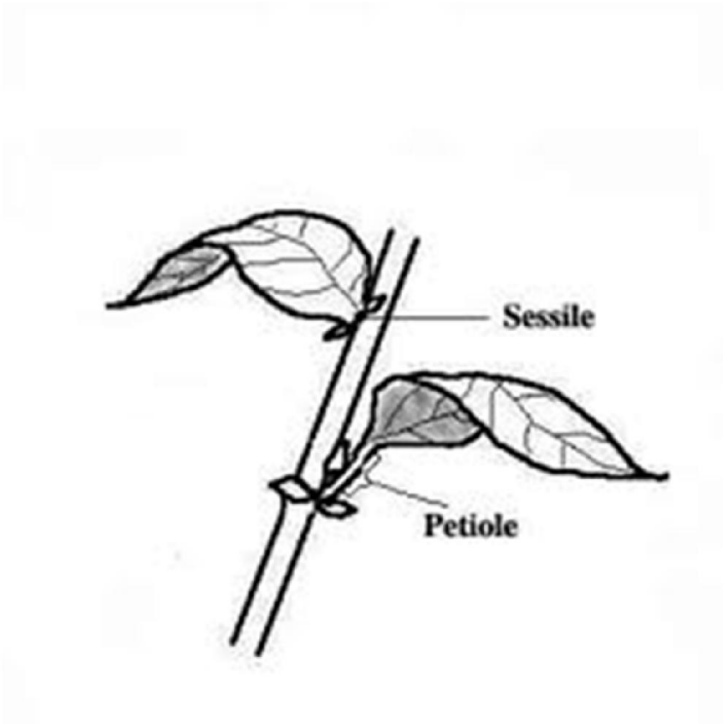


Angiosperm Plants

Leaves, Inflorescences & Flowers

Introduction

- **The leaf is one of the vegetative organs of the plant**
- **The leaves *retain the primary features* throughout their life span**
- **The meristematic tissue (cambium) that brings about the development of seconadry features in perennial plants is absent in the leaves**
- **This entails that the vascular bundles in leaves are *devoid of cambium* – hence leaves do not grow in girth**
- **The leaves are either simple or compound**
- **The main parts of the leaf the petiole and the blade**
- **Leaves without the petioles are said to be sessile**



- **Leaves of some species (*Mimosa pigra* and *Neptunia oleracea*) are sensitive to touch and this phenomenon is described as being seismonastic response**
- **However, plants such as the cacti, don't bear leaves**

Functions of Leaves

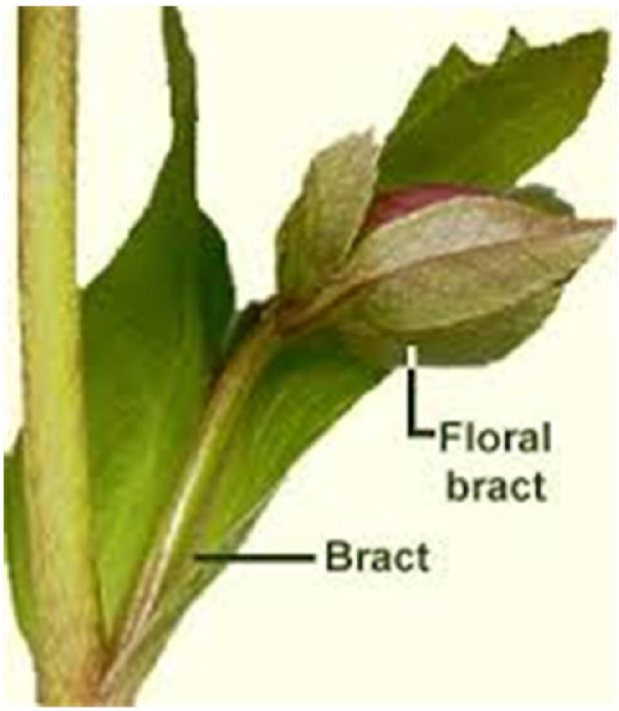
- **Leaves are involved in the process of photosynthesis which in turn brings about the manufacture of food molecules**
- **Plants are ecologically described as primary producers because they produce food molecules**
- **Leaves provide a large surface area to allow for the processes of gaseous exchange & transpiration through the stomata**
- **Leaves provide shade and shelter to the stem and root system below**

- **Leaves are sources of vegetables for many animals (herbivorous vertebrates & invertebrates**
- **In some species of the family Crassulaceae, leaves are involved in the vegetative propagation of new plants**

Types of Leaves

- **Cataphylls: are the scale-like structures that appear on buds and the underground stems (rhizomes whose main function is the protection of the stem apices)**

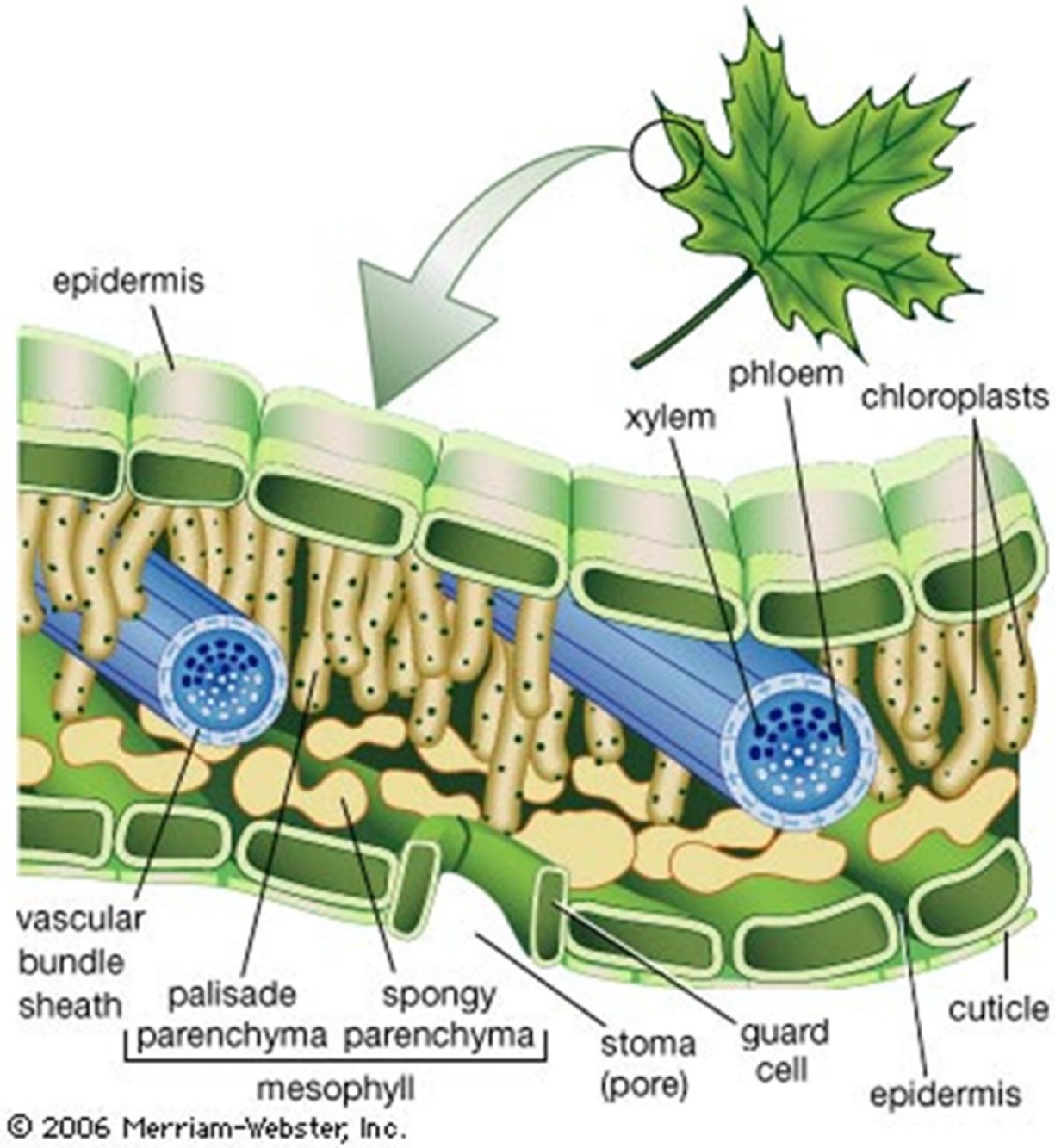
- **Hypophylls are the various types of bracts that are linked to the flowers and commonly referred to as the floral bracts**



- **Cotyledons are the first leaves of the plant that are prominent on seedlings**
- **Foliage leaves – are principal photosynthetic organs**

Anatomy of Dicot and Monocot Leaves

- **The leaf is composed of three main types of tissues known as the epidermis, mesophyll and vascular tissues**
- **The role of the epidermis is to protect internal tissues of the leaves**
- **The mesophyll is a photosynthetic parenchyma tissue comprised of palisade and spongy cells containing chloroplasts**
- **Palisade cells are elongate cells of the mesophyll located below the epidermis whereas spongy cells are variable in shape located internal to the palisade layer**
- **The vascular bundle has xylem located on the adaxial side of the leaf whereas the phloem is located on the abaxial side of the leaf**


epidermis
phloem
xylem
chloroplasts
vascular bundle sheath
palisade parenchyma
spongy parenchyma
mesophyll
stoma (pore)
guard cell
cuticle
epidermis
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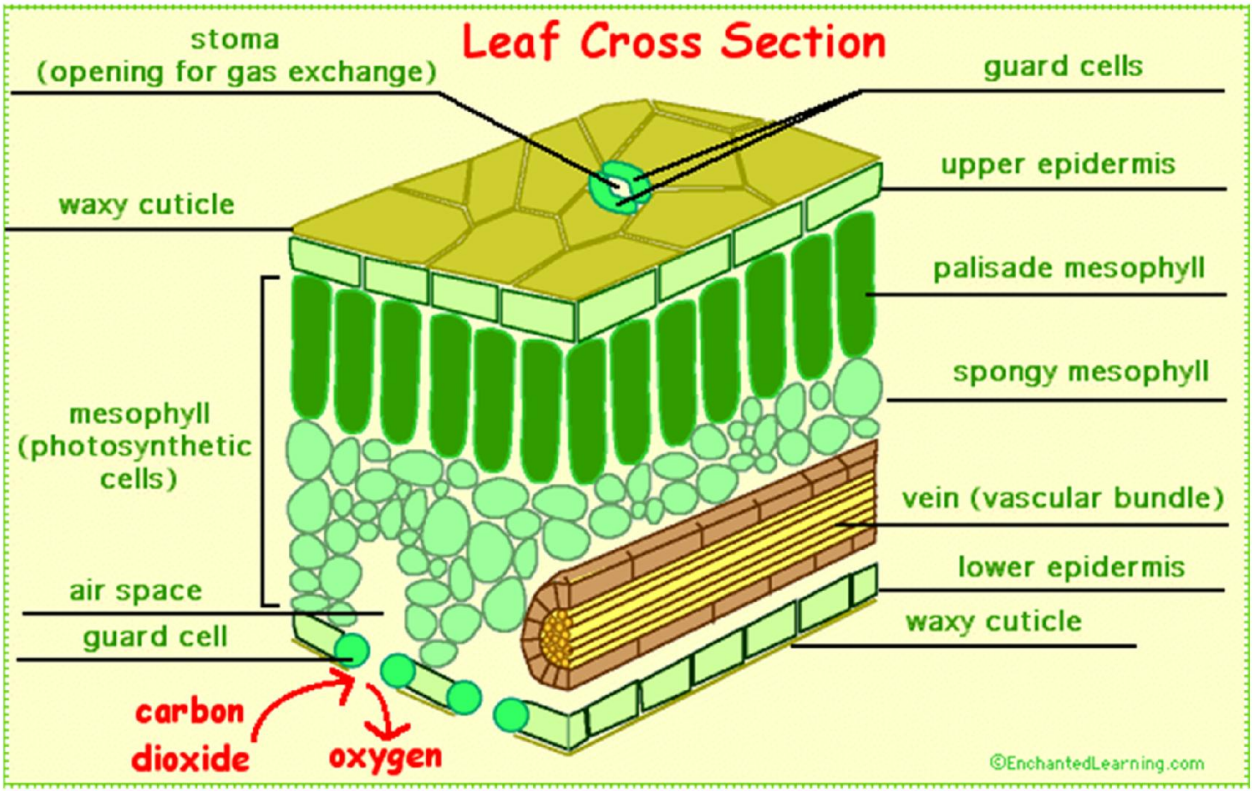
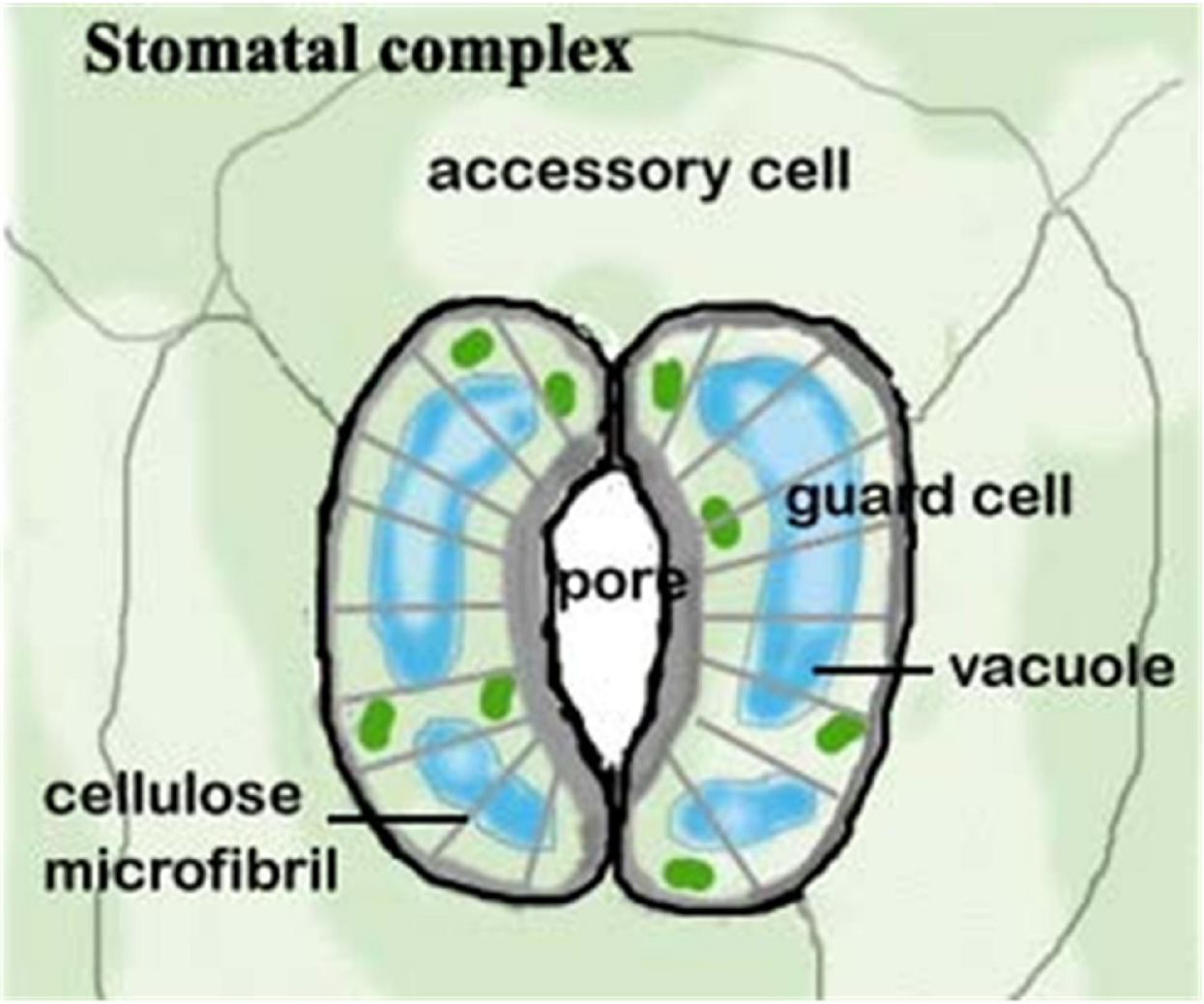


Structure of Stomata

- **Some epidermal cells are modified into stomata**
- **The stomata consists of the pore, guard cells and subsidiary cells**
- **The pore and the guard cells constitute the stoma**
- **The pore, guard cells and the surrounding subsidiary cells constitute the structure referred to as the stomatal complex**

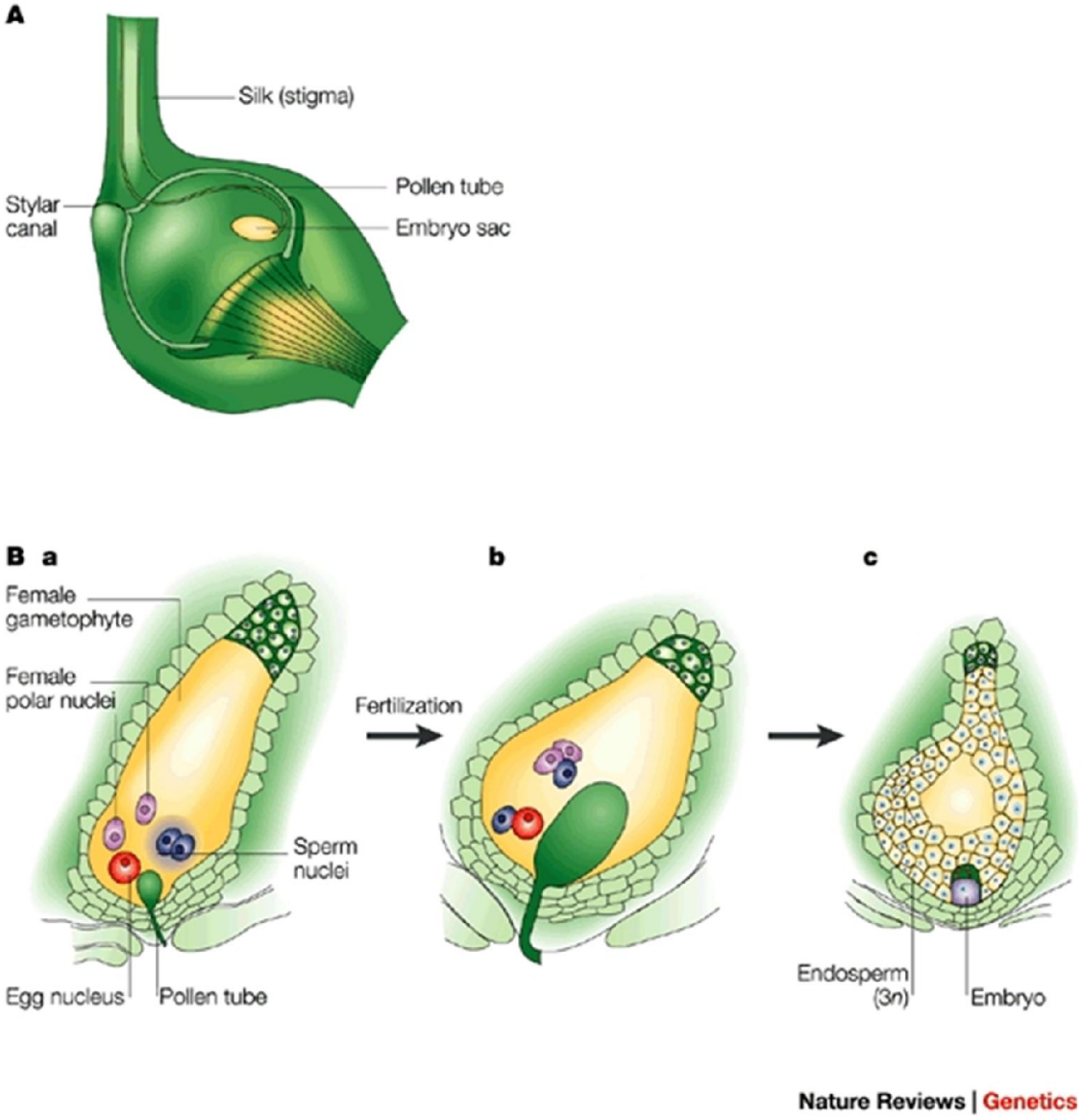


Reproduction in Agiosperms

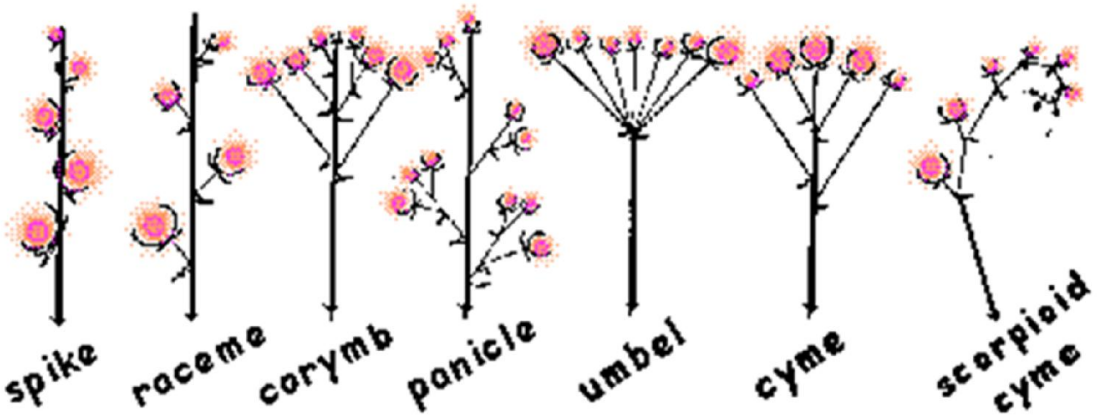
- **Reproduction is a process resulting in an increase in the number of individuals**
- **Reproduction can be achieved by <u>sexual</u> or <u>asexual</u> means**
- **Juvenility is a phase of plant growth during which flowering cannot be induced by any form of treatment**
- **The duration of juvenility varies in different species of plants**
- In annual plants juvenility lasts for a few days, weeks or months

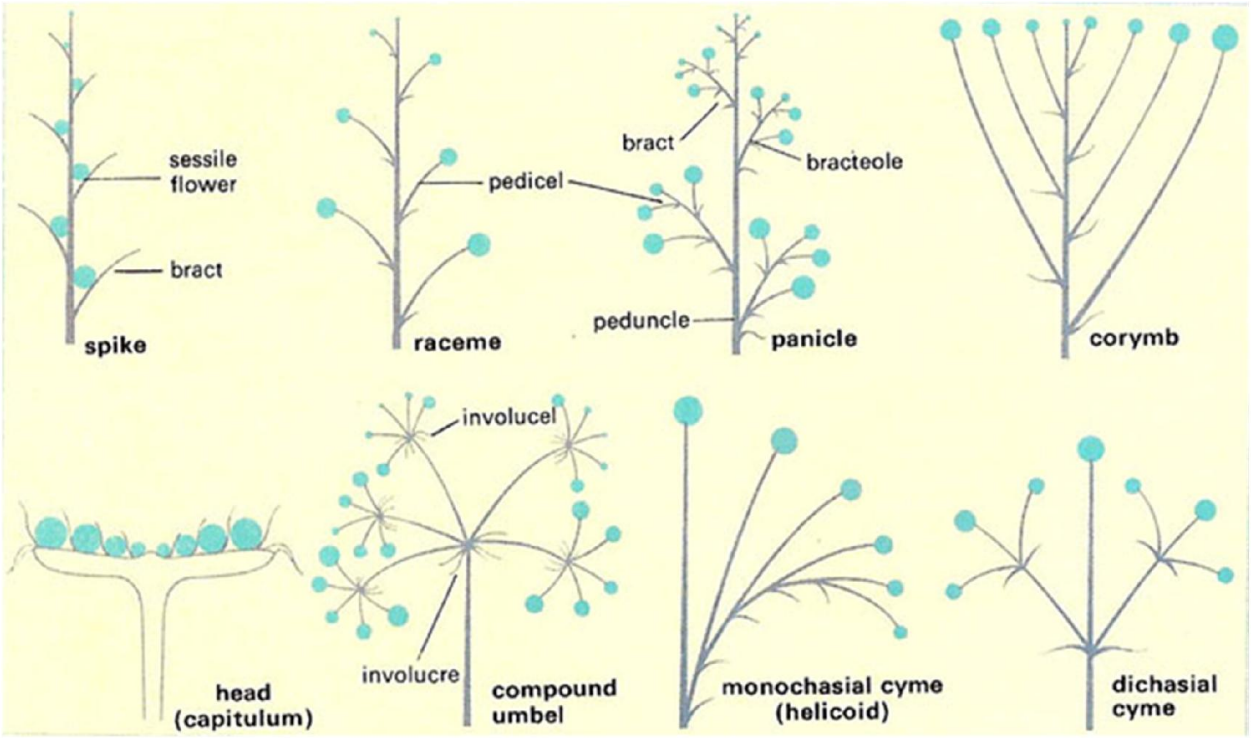
- In woody plants the juvenile period lasts for several years (30–40 years in the some forest species)
- The criterion for the juvenile state is that the plant does not have the ability to form flowers
- The phase of reproduction sets in after the juvenile phase has been completed
- In the life of the plant, the vegetative apex promotes longitudinal growth of the plant axis
- The transition from juvenile (vegetative) to adult (flowering) phase is accompanied by a general increase in the concentration of cytoplasmic proteins, RNA and DNA
- A reproductive shoot of the angiosperm plants is the inflorescence which is a fertile shoot that bears a cluster of flowers
- The inflorescence stalk is called the peduncle whereas the floral stalk is termed the pedicel
- Plants exhibit a diversity of inflorescence types and these include the raceme, spike, panicle, umbel, corymb and capitulum
- A raceme is a kind of inflorescence in which a central axis bears stalked flowers
- A spike is a type of inflorescence with a long central axis but bearing sessile flowers
- A panicle is a much branded inflorescence each branch terminates into a flower and it can be viewed strictly as a form of a branched raceme
- A corymb is a variant of a raceme in which the lower pedicels are longer than those of the upper pedicels resulting in a flat-topped inflorescence
- An umbel is an umbrella shaped inflorescence in which all the pedicels arise from the same point
- A capitulum is a type of inflorescence in which a receptacle is flattened circular head bearing numerous closely packed sessile flowers

Double Fertilization



Inflorescence Types

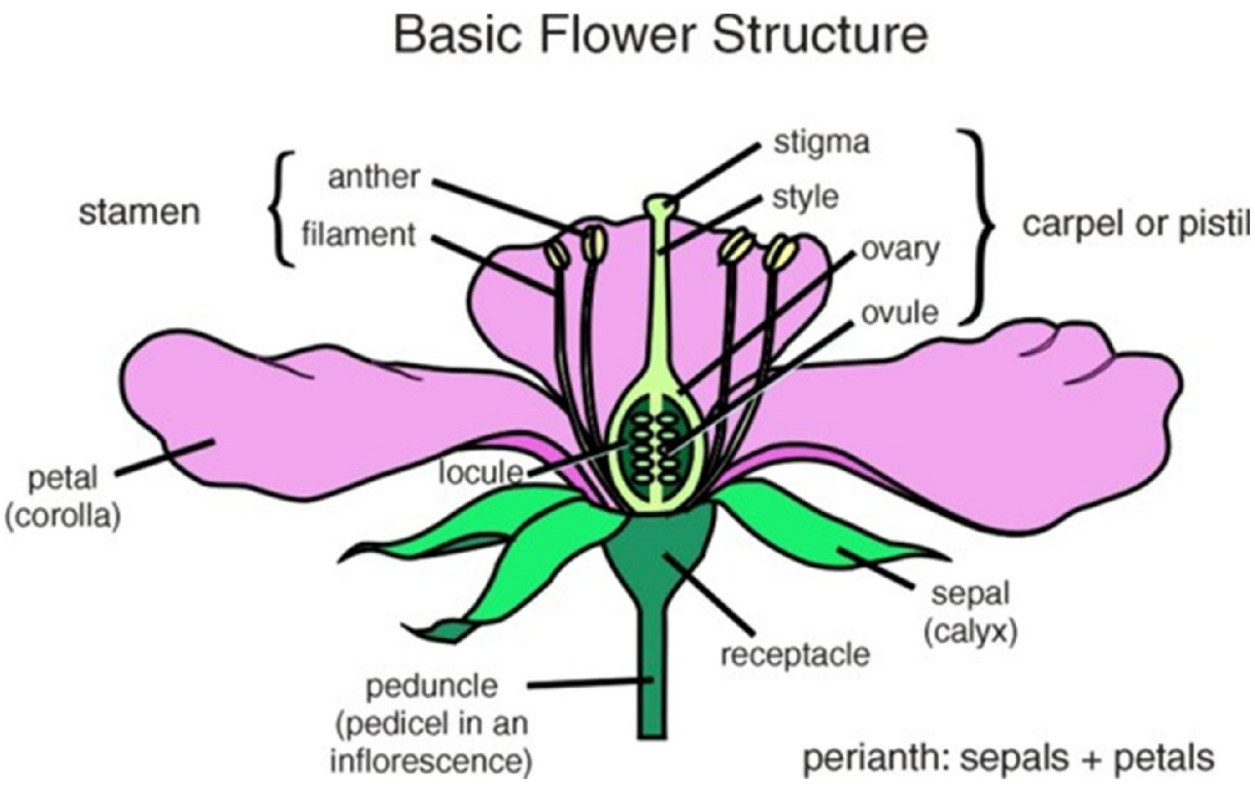




The Flower

- This is the reproductive organ comprised of four kinds of floral parts:
- Sepals – constitute a set of leaf-like structures

- The function of sepals is to protect the flower in the bud form
- Depending on the nature of the species,the number of sepals is variable
- A collective term for a whorl of sepals is the calyx
- Petals are a set of floral parts located internal to the calyx
- Petals are usually brightly coloured due to the presence of organic pigments known as the anthocyanins
- Flowers with free petals form a condition known to be polypetalous; those with fused petals form gamopetalous (or sympetalous) flowers and those flowers without petals are said to be apetalous
- A collective term for a set of petals is the corolla
- A stamen is a male organ of the flower which is comprised of the filament and the anther which contains the pollen grains
- The collective term for a set of stamens is the androecium but stamens which lack a functional anther are called the staminodes
- Carpels are the female organs of the flower and each carpel consists of the ovary, style and stigma
- The alternative term for the carpel is the pistil
- A single pistil or a set of several pistils constitute the gynoecium
- The ovary is the basal portion of the carpel; the stigma is the pollen receptor whereas the style is an elongate structure that connects the stigma to the ovary



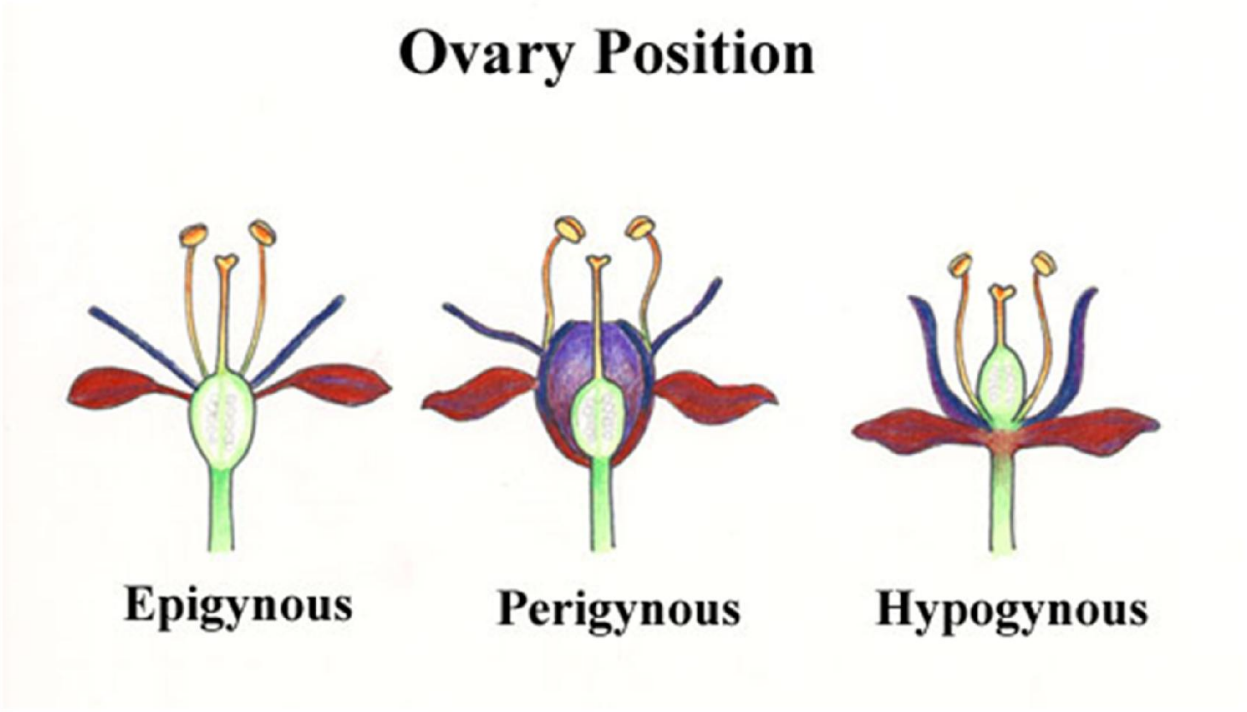
Floral Symmetry

- When petals are arranged radially symmetrical in all directions, the flower is said to be actinomorphic (regular) e.g. flowers of cotton, *Hibiscus*, *Ipomoea*
- When the arrangement of petals is symmetrical in one direction only, then the flowers are said to be zygomorphic (irregular) e.g. a condition found in flowers of legumes and orchids

Position of Floral Parts

- A hypogynous flower is one in which the perianth (calyx and corolla) and stamens are inserted below the ovary
- An epigynous flower is one where the perianth and stamens inserted above the ovary giving rise to an inferior ovary

- A perigynous flower is one in which the perianth and stamens arise from a cup-shaped outgrwth of receptacle called the hypanthium goiving rise to a condition when the ovary is neither inferior nor superior

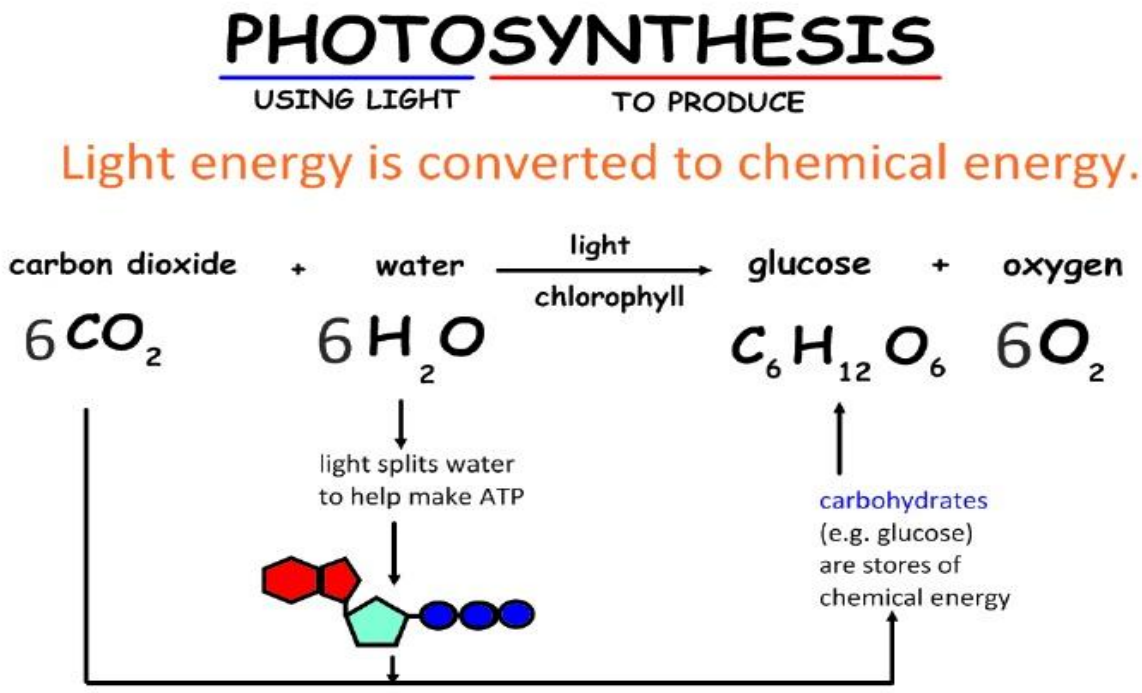


PHOTOSYNTHESIS

- Plants share the property of carrying out the process of respiration.
- They are morphologically and physiologically different - photosynthesis.
- Photosynthesis is explained as: the building of material by light energy.
- **Photosynthesis is a physiological** process that involves the absorption of light energy and its subsequent conversion into stable chemical compounds.

Photosynthetic summary:

- $6CO_2 + 6H_2O$ + Light Energy ---------- $C_6H_{12}O_6 + 6O_2$
- The photosynthetic process is a reverse of respiration summarized as follows:
- $C_6H_{12}O_6 + 6O_2$ ---------- $6CO_2 + 6H_2O$ + Heat Energy



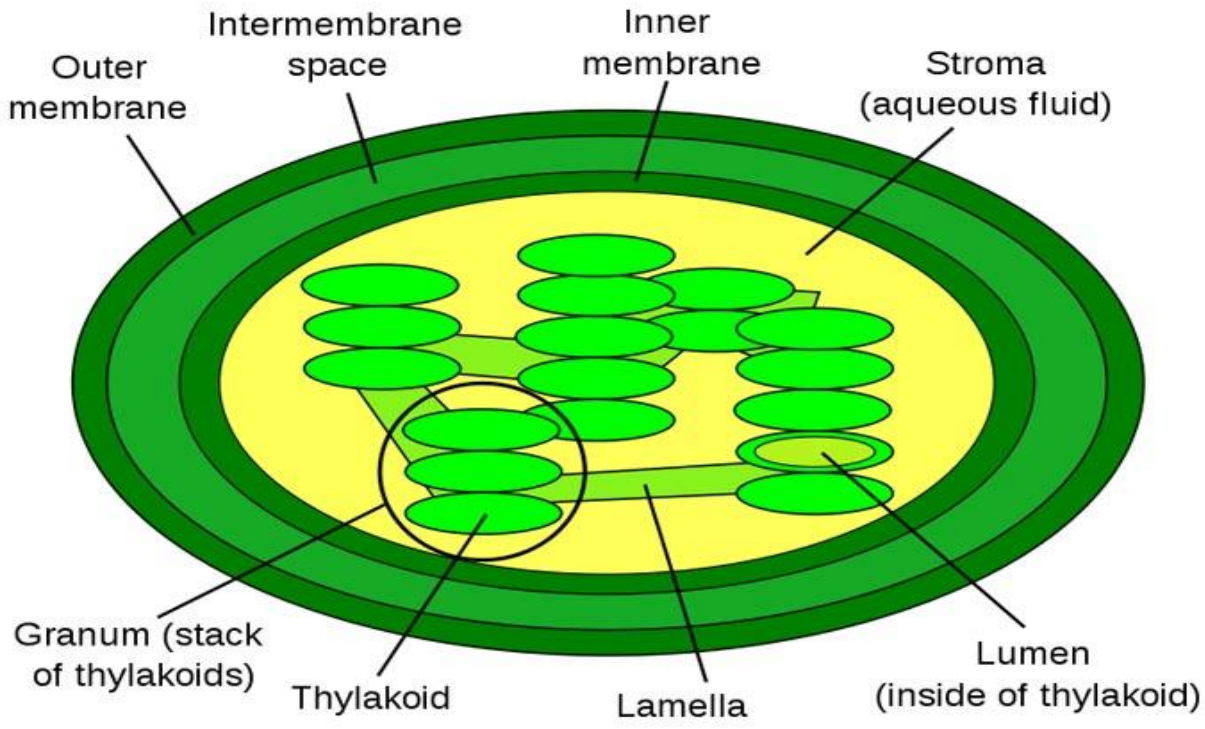
- The process of respiration entails the oxidation of such substrates as carbohydrates to produce usable energy.
- uptake of O_2 and the production of CO_2.
- photosynthesis is a process that is restricted to the green plants and some few micro-organisms such as blue green algae (or the cyanobacteria).
- The photosynthetic process - light reaction and the dark reaction.
- Light reaction in the thylakoid
- Dark reaction in the stroma

Chloroplasts

The Chloroplast Structure

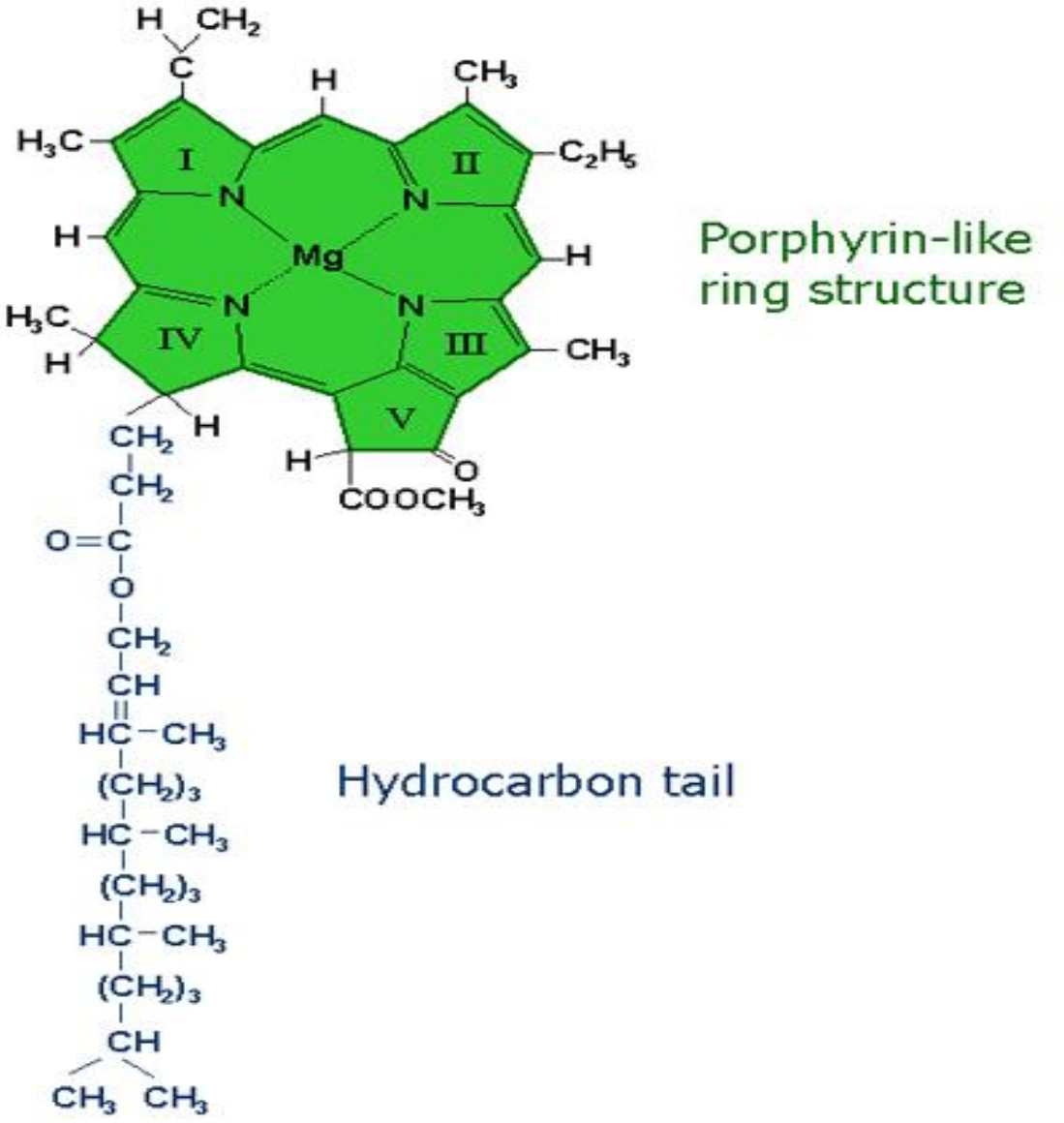
- The chloroplast structure is the essential catalyst of the photosynthetic process
- Chloroplasts are the green plastids located within the cytoplasm of photosynthetic plant cells.
- Chloroplast are more prevalent in leaf tissues and green part of stems; and they contain their own DNA.
- These organelles can be considered as primary biological transducers.
- The chloroplast is a complex organelle contained within the plant cells

CHLOROPHYLL STRUCTURE



- The outermost structure is a double membrane.
- The colorless ground substance that contains enzymes is termed the stroma.

- The chloroplast contains the grana (singular: granum) each consisting of flattened structures called thylakoids, onto which the chlorophyll pigments are attached.
- Chlorophylls are the organic pigments which absorb light energy - conjugated structure.
- A conjugated molecular structure is one in which the single bonds alternate with double bonds, as in the case of B-carotene.
- Molecules with a conjugated structure absorb light energy and reflect a color effect to the observer.
- Chlorophyll a absorbs light more strongly at such wavelength as 430nm and 660nm whereas chlorophyll b absorbs light at 450nm 640nm.



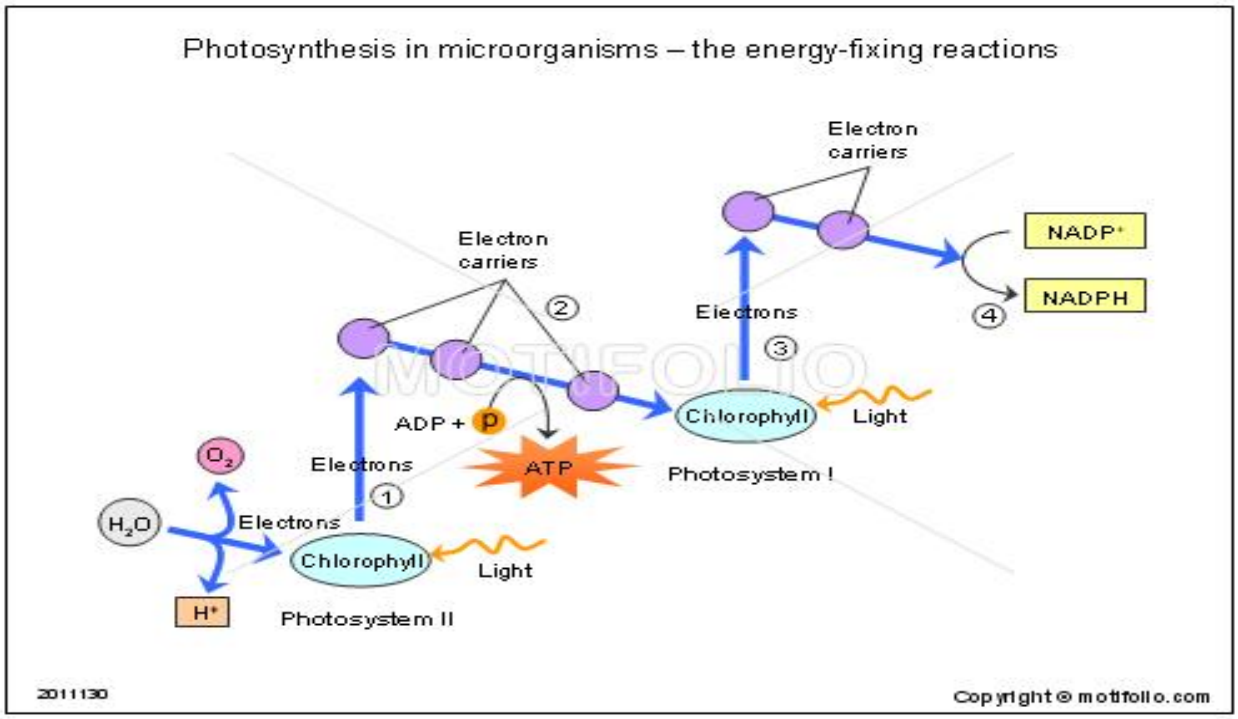
The Light Reaction

:

- 1 Initially light excites a pair of electrons within the chlorophyll molecule.
- 2 The pair of electrons rise above the ground state and get trapped by Ferredoxin Reducing Substances (FRS) – a form of protein containing iron.
- 3 The electrons are transferred to Nicotinamide Adenine Dinucleotide Phosphate ($NADP^+$).

- 4 $NADP^+$ is later reduced and transformed into $NADPH_2$.
- 5 The loss of 2e- creates an “electron hole” within the chlorophyll molecule.
- 6 The electron supply hole is subsequently filled- up by electrons derived from the water molecule.
- 7 The supply from the water molecules is a functions of photolysis.
- 8 The movement of electrons from the water molecule ending up to $NADPH^2$ is known as the “electrons transport”.
- **Summary of Light Reaction**
- The light reaction results in the production of the following products:
- A stable chemical compound called $NADPH_2$.
- The evolution of oxygen which is released to the atmosphere.

PRODUCTS OF LIGHT REACTIONS



The Dark Reaction in C_3 Plants

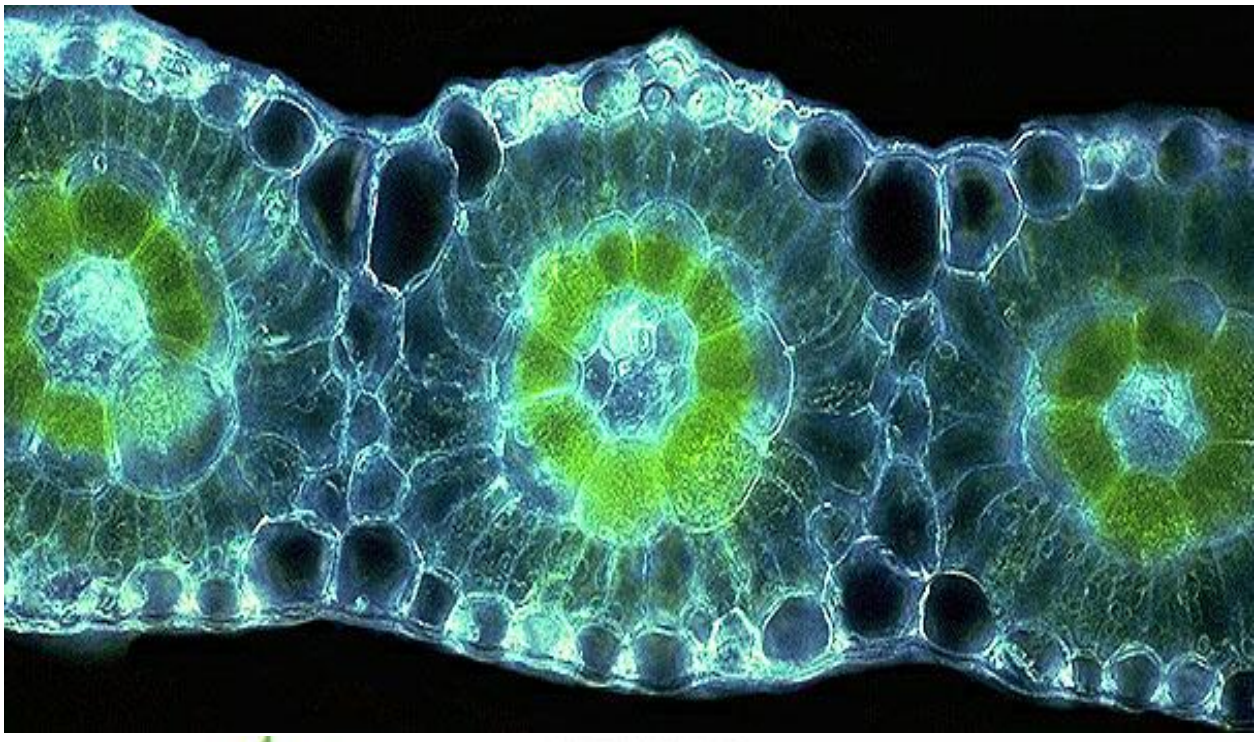
- In plants the dark reaction is mediated (or facilitated) by enzymes.
- Enzymes are known to function (or operate) at specific optimum temperatures.
- Since enzymes are involved, then it follows that the dark reaction is prone to be sensitive to any changes in temperature conditions.
- Light is not required -the dark reaction can be said to be a light – independent process.
- In the process of photosynthesis carbon is available to in the form of carbon dioxide.
- However, the aquatic plants, including the algae and the blue-green algae (cyanobacteria) obtain CO_2 that has been dissolved in water in the form of bicarbonate (HCO_3^-) ions.
- The dark reaction is a phase of photosynthesis in which Co_2 is assimilated by plants to form organic compounds.
- As mentioned earlier, the skeleton structure of all organic compounds is made up of carbon atoms.
- The assimilation of CO_2 in plants that are adapted to different ecological habitats follows three main biochemical pathways: the C_3 pathway; the **C_4** pathway; and the **CAM** pathway.
- The C_4 pathway occurs in tropical grasses whereas the CAM pathways occurs in succulent plants.
- The C_3 pathway is a biochemical process that is universal as it occurs in different types of plants (i.e. algae, bryophytes, ferns, gymnosperms and angiosperms).

The C_3 Photosynthetic Pathway

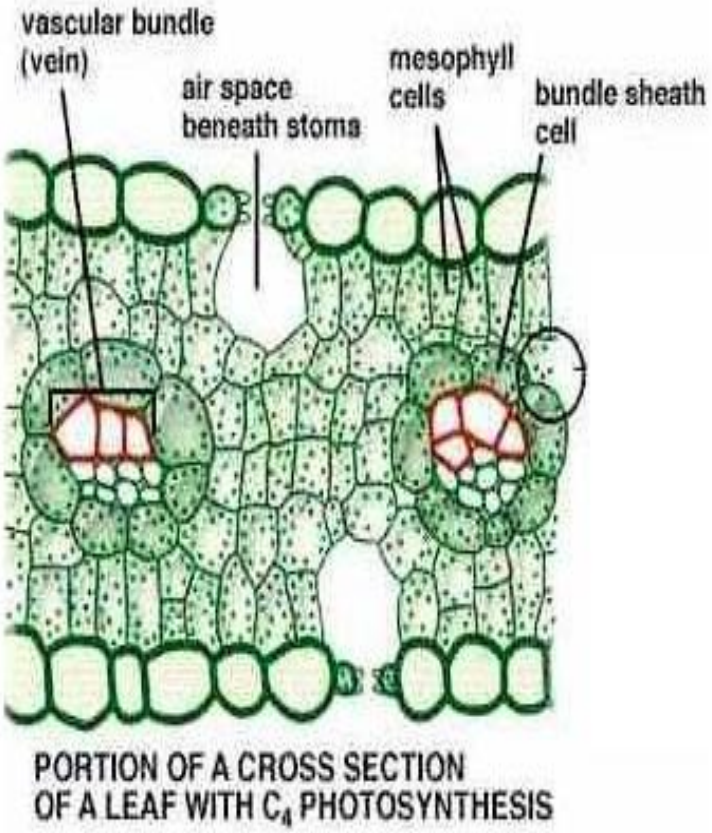
- This variant of photosynthetic pathway operates universally in such plant groups as the algae, bryophytes, pteridophytes, gymnosperms and the majority of angiosperms.

- In flowering plants this biochemical pathway is associated with plants whose leaves exhibit a non-kranz anatomy.

KRANZY ANATOMY

- 

kranz flower arrangement



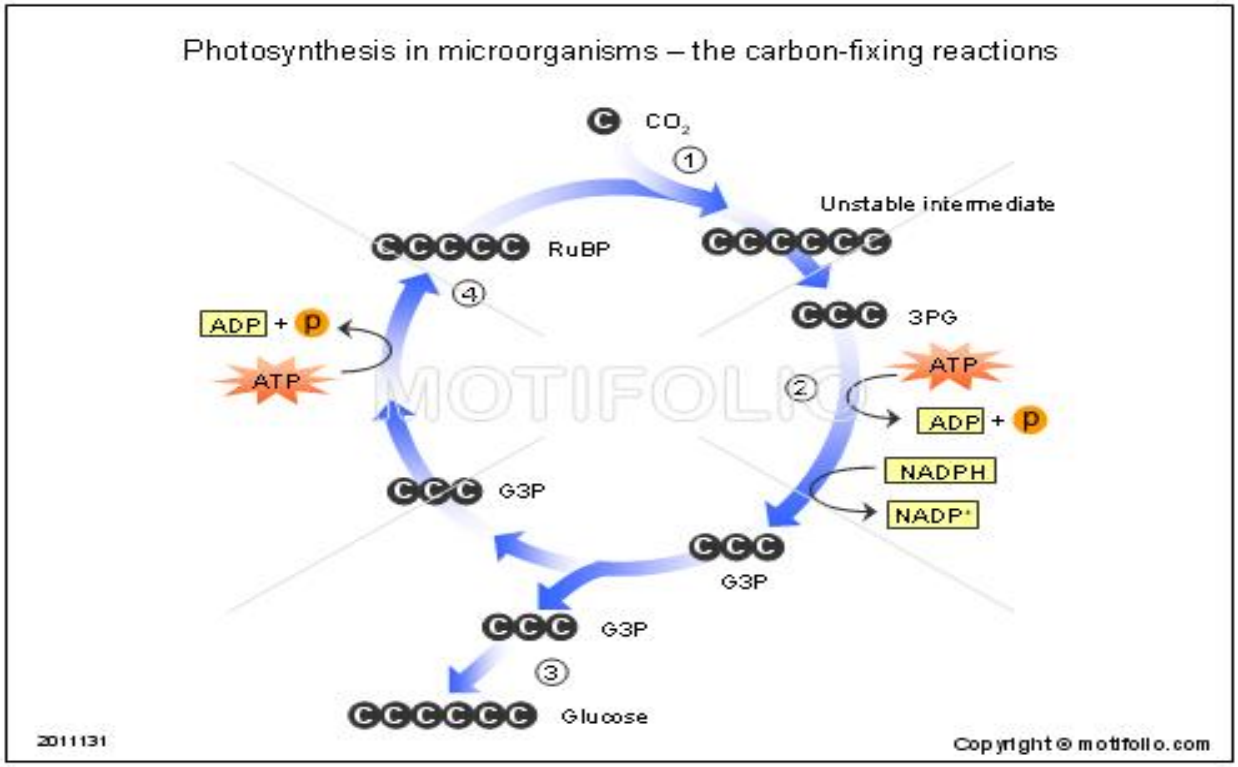
PORTION OF A CROSS SECTION OF A LEAF WITH C_4 PHOTOSYNTHESIS

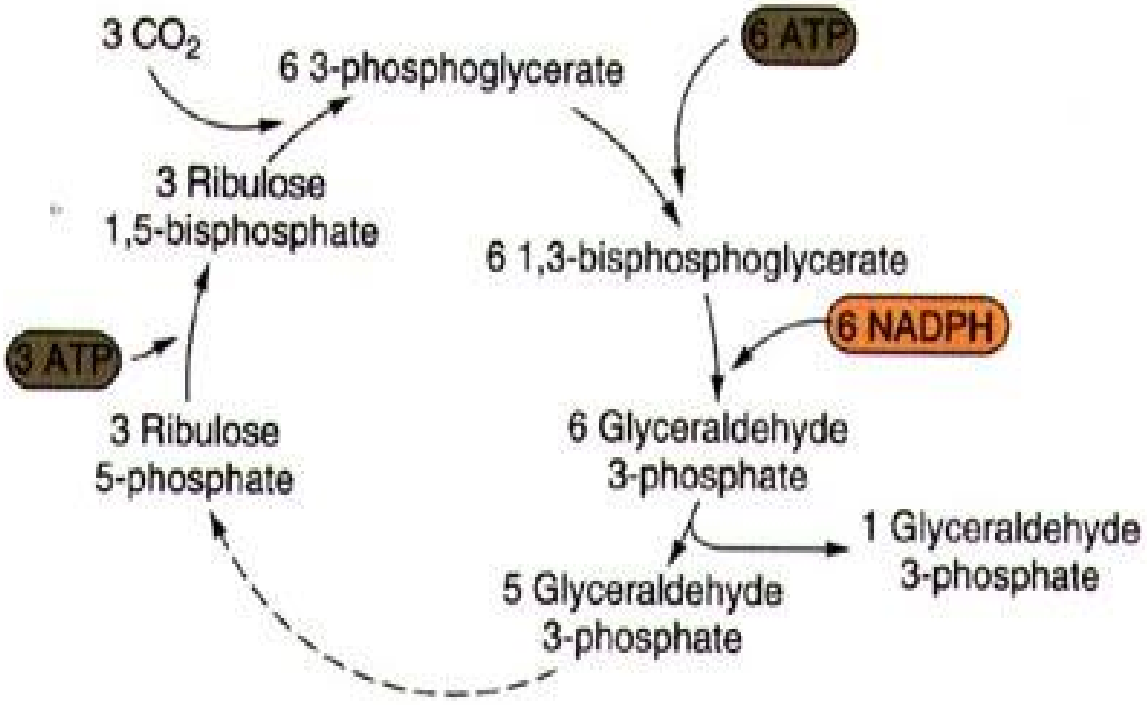
The sources of CO_2 are known as: the atmosphere, soil; and water

- In aquatic habitats CO_2 is available to submerged aquatic plants in the form of bicarbonate ($-HCO_3^-$) ions.

- The initial CO_2 accepter, which is located in the mesophyll cells of the leaves, is known as Ribulose 1,5-diphosphate (RuDP or RuBP).
- Molecules of CO_2 combine with RuDP to form a 6-carbon compound, which is known to be chemically unstable.
- The unstable 6-carbon compound immediately breaks up to form two molecules of a 3-carbon compound called 3-Phosphoglyceric Acid (i.e. 3-PGA).
- 3-Phosphoglyceric acid (3-PGA) is then reduced to form an aldehyde which is known as 3-Phosphoglyceraldehyde (i.e. 3-PGA);
- This reduction process is facilitated by the product of the light reaction earlier identified as Nicotinamide adenine dinucleotide phosphate ($NADPH_2$).
- This $NADPH_2$ is in turn oxidized to $NADP^+$ so as to accept more of the electrons released by the chlorophyll molecules in the dark reaction.
- The 3-PAG molecules are condensed to form a hexose (6-carbon) sugar and later stored in the form of starch.
- Some molecules of 3-PAG are used to regenerate RuDP to sustain the continuous fixation CO_2.
- This biochemical cycle was worked out (elucidated) by Melvin Calvin in the period 1940-1950.
- Hence this biochemical cycle is called the CALVIN CYCLE.
- Since the initial substance formed is a 3-carbon compound and therefore, this form of assimilating CO_2 is referred to as the C_3 pathway.
- Higher plants that exhibit this pathway are known as the C_3 grasses the leaves do not exhibit a Kranz anatomy.

Calvin cycle





Significance of Photosynthesis

- Plants are vital in all ecosystems of the world because the process of photosynthesis that operates in plants supplies oxygen to the atmosphere and the aquatic systems.
- Photosynthesis is a process that maintains the equilibrium of oxygen in the atmosphere.
- This physiological process provides food for a diversity of animals.
- Herbivores and humans directly obtain food in the form of vegetables and fruits.
- Carnivorous animals indirectly obtain their food in the form of protein (flesh) as predators of herbivorous animals.
- Photosynthesis has also provided vast reserves of energy to humans in the form of coal, petroleum oils, peat, wood and dung that are used as various sources of fuel.
- Photosynthesis facilitates in the removal of excess CO_2 arising from processes of industrialization (exhaust emissions)
- That have brought about the phenomenon of global warming to this planet EARTH.
- CARBON SINKS.

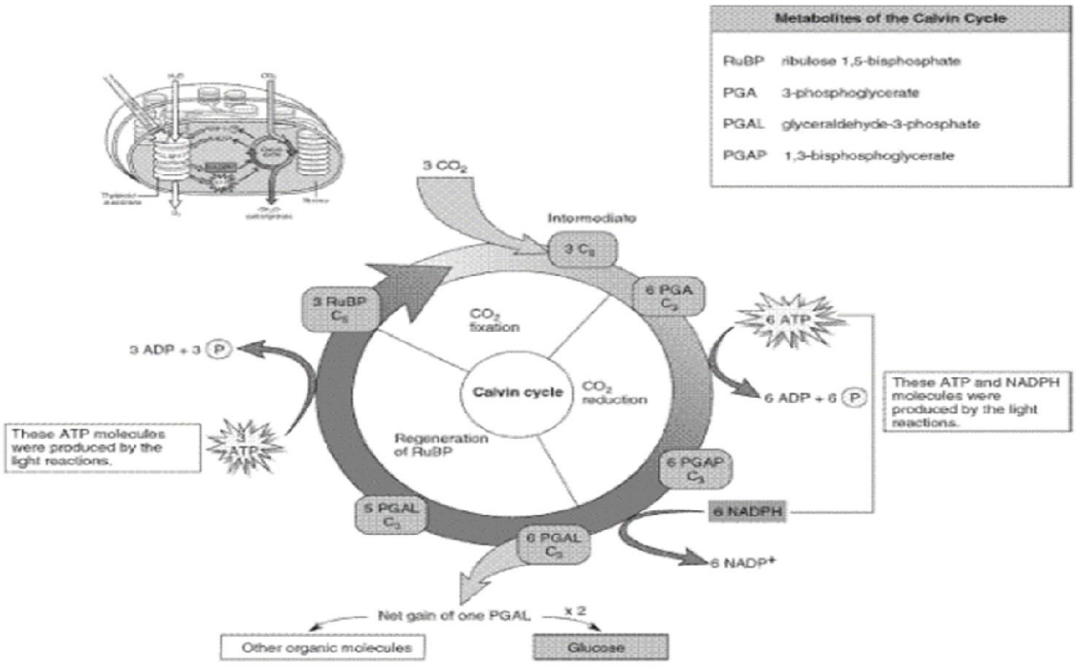


Figure 8.4 The Calvin cycle. *(From* Biology, *8th ed., by Sylvia S Mader, © 1985, 1987, 1990, 1993, 1996, 1998, 2001, 2004 by the McGraw Hill Companies, Inc. Reproduced with permission of The McGraw-Hill Companies.)*

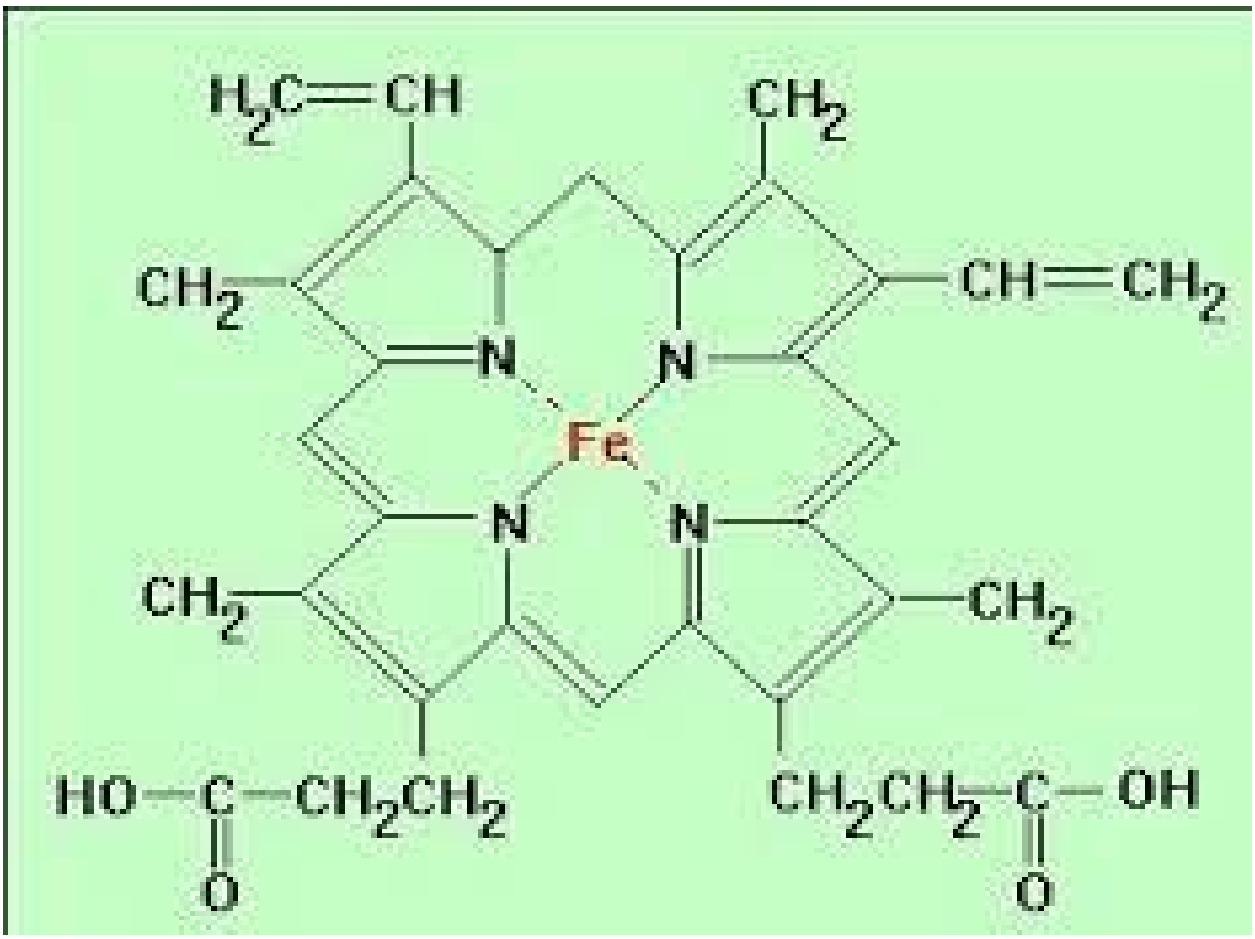
Respiration process

- **The macromolecules - carbohydrates, proteins and fat are vital to all living organisms.**
- **Both prokaryotic and eukaryotic organisms use them in a physiological or metabolic process known as respiration.**
- **starch, lactose, sucrose and cellulose are broken down**
- **Monosaccharides released are later used in respiration.**
- **Proteins are hydrolyzed to amino acids, whereas fats are hydrolyzed to glycerol and fatty acids.**
- **Most foods containing carbohydrates, proteins and fats are rich in chemical bonds that are loaded with energy.**
- **carbohydrates and fats possess many carbon- hydrogen (C-H) bonds and carbon- oxygen bonds.**
- **The process of extracting energy usually occurs in stages.**
- **In the initial stage enzymes break down complex molecules, digestion.**
- **The process of digestion is followed later by action of other enzymes that further break down these simpler compounds to extract energy from C-H and C-O bonds.**
- **Respiration is, therefore, a process in which organisms use organic compounds to extract the energy stored in carbohydrates.**
- **RESPIRATORY PROCESS. When an animal consumes complex of carbohydrates (starch), the initial step that leads to respiration to form monosaccharides.**
- **E.g the end product of starch is glucose; sucrose are glucose and fructose.**
- **Glucose is used by many organisms as a source of energy under aerobic and anaerobic conditions.**

- **In both animals and plants respiration involves the uptake of oxygen and the subsequent release of carbon dioxide.**
- **Respiration is usually reflected in two forms: external respiration; and internal respiration.**
- **External respiration involves the exchange of oxygen and CO_2 between the body tissues and the environment.**
- **External respiration is- ventilation, which is usually achieved by respiratory movements seen in vertebrate animals –**
- **A process known as breathing movements.**
- **This movement of gases into and out of the lungs is a form of ventilation.**
- **In plants oxygen enters through stomatal pores**
- **It diffuse through the tissues via the intercellular spaces, or oxygen dissolves in tissues fluids.**
- **Internal respiration, occurs at cellular levels.**

RESPIRATORY PIGMENTS

- **In animals the circulatory systems, such the circulation of blood in vertebrate animals, facilitate in gaseous exchange.**
- **Blood contains a respiratory pigment which has a high affinity for oxygen.**
- **Haemoglobin, which consists of a pigment called the haem that is combined with protein called globin.**
- **The structure of the heam is similar to that of chlorophyll, based on a porphyrin ring in which the nitrogen atoms of the four pyrrole rings are linked to the ferrous iron.**
-



- **The ferrous iron is attached to a protein component.**
- **The haem component of haemoglobin is responsible for the red color in red blood cells.**
- **Haemoglobin is capable of taking up one molecule of oxygen for each atom of iron in its molecoule.**
- **The combined form of haemoglobin and oxhaemoglobin (HbO).**

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- **The human body requires 250cm of oxygen per minute at rest, and 1000cm of oxygen per minute under strenuous exercises.**
- **Therefore, haemoglobin serves as a reservoir of oxygen.**
- **This property enables blood to supply blood's oxygen needs during time of rest and exercise.**
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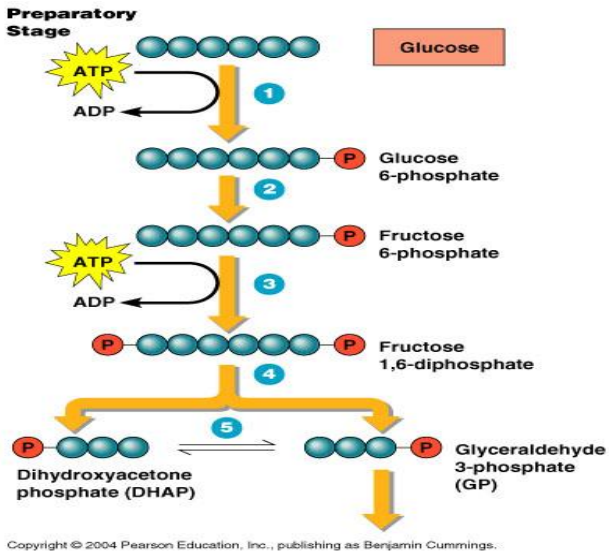
- **This oxygen reserve property of haemoglobin also ensures that**
- **The blood contains enough oxygen to maintain life for 4-5 minutes if the breathing process is interrupted, or in cases when the heart stops pumping blood.**
- **In times of exercise muscles produces high levels of CO which dissolves in water to form carbonic acid (H CO_2).**
- **The production of carbonic acid which results in lowering the pH value tends to reduce haemoglobin'affinity for oxygen –or acidity reduces haemoglobin's power to attract oxygen.**
- **It is also known that oxygen can be easily displaced from oxyhaemoglobin by other gases that form stable compounds with oxygen.**

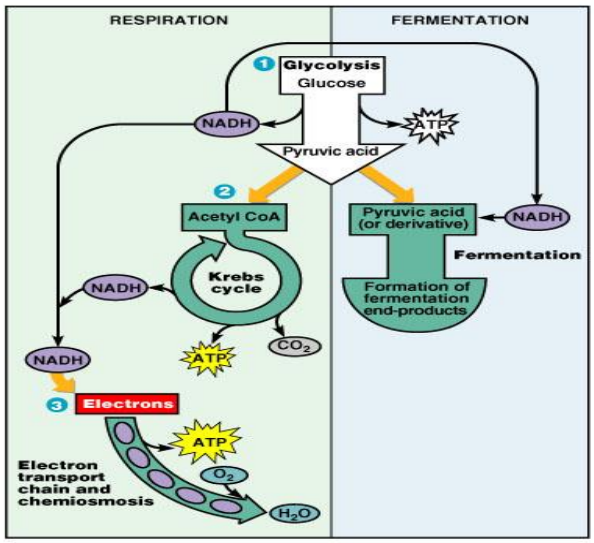
- **This is one reason why carbon monoxide, is considered lethal to humans if it accumulates in indoors when doors and windows are closed.**
- **Carbon monoxide will chemically combine with haemoglobin thereby preventing it from being available as an O-carrier.**
- **However, respiration releases CO which is transported by blood in form of a bicarbonate.**

  [CO_2+H_2 O----- H^+ +H_2CO].

- **people who live at higher altitudes, Such people have a higher concentration of haemoglobin in their blood that allows for the uptake of more oxygen.**

Overall reaction of glycolysis





Glycolysis

- **One of the vital processes of respiration is known as glycolysis.**
- **The term glycolysis is derived from the words glycol meaning "sugar" and lysis meaning "splitting".**

- **Glycolysis is a process that takes place in the cytosol.**
- **The cytosol is the ground substance of the cytoplasm in the organelles are embedded.**
- **Glycolysis is thus a process in which glucose is broken down to form pyruvic acid (pyruvate) and accompanied by the release metabolic energy.**

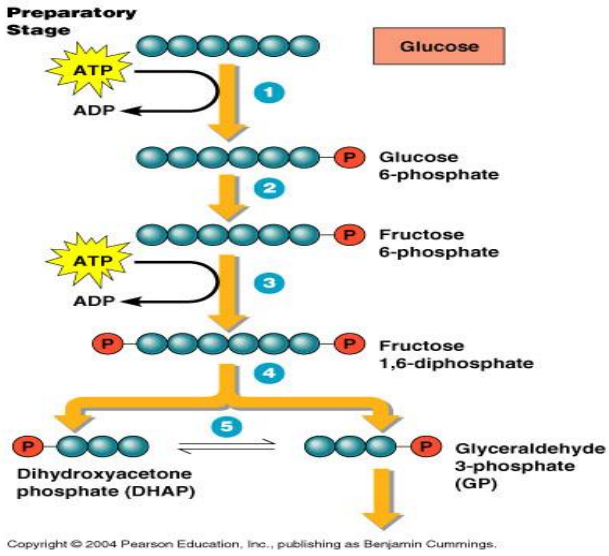
- The glucose molecule is first phosphorylated by ATP to form glucose 6-phosphate.
- Phosphorylation of glucose is merely a process in a phosphate group derived from ATP is added to glucose
- Then glucose 6-phosphote is further phosphorylated by another molecule of ATP to form fructose 1,6-phosphate.
- Fructose 1,6-phosphate is split to form two molecules of the 3-carbon sugars- known as the triose sugars.
- These two triose sugars are oxidized to form molecules of pyruvic acid (pyruvate).
- In this process one molecule of glucose undergoes two phosphorylation reactions and thus split to form two triose molecules each of which is converted to pyruvate.
- The pyruvate molecules are oxidized to form a 2-carbon compound called acetyl-CoA and also resulting the release of CO_2.
- The oxidation process is a stage at which two hydrogen ions [2H+] are released.
- A pair of hydrogen atoms released during the oxidation of triose sugars results in the formation of water.
- The cycle is fundamental to the metabolism of aerobic organisms.
- Summary
- During the process when glucose is being oxidized, the molecule loses electrons and hydrogen ions which are gained by oxygen to form water.
- The overall reaction of glycolysis:
- General Comments
- In plants and herbivorous animals the carbohydrates are the main sources or substrates for the respiratory process.

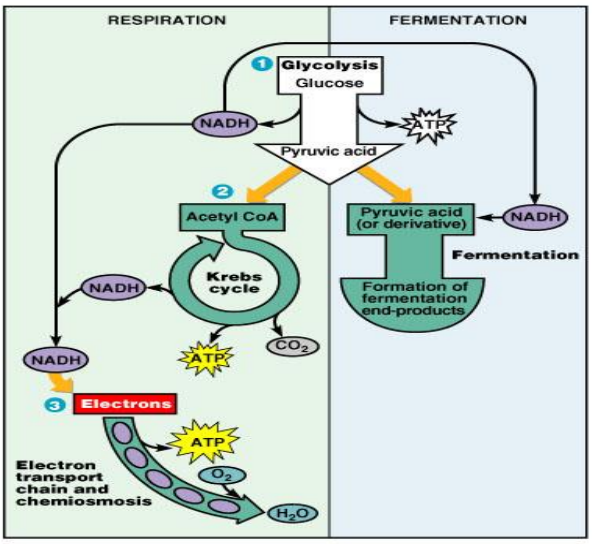
- In carnivorous animals proteins are the main sources or substrates for respiration.
- In this regard protein are hydrolyzed to release amino acids.
- Later the amino acids are de-aminated to release ammonia/urea/uric acid.
- The residual carbon compound then enters the respiratory pathway as pyruvate.
- On the other hand fats are hydrolyzed to glycerol and fatty acids.
- The glycerol is then phosphorylated to form the triose phosphate compounds.
- The resultant triose phosphate is channeled into the respiratory pathways for conversion to acetyl-CoA and release of CO_2.

Phenomenon of Anaemia

- This is a condition which entails a decrease in number of the red blood cells (RBCs).
- Anaemia is actually a reflection of a deficiency in the quantity of haemoglobin, which carries oxygen in to the blood.

Overall reaction of glycolysis





- Anaemia is the most common disorder of the blood.
- All cells depend on oxygen for their survival.

- The main symptom of anaemia include:
- Feeling of weakness or fatigue,
- General malaise (feeling of discomfort or sickness), associated with poor concentration.
- Pale skin

Causes of Anaemia

- Poor nutrition
- Iron deficiency
- In addition to iron deficiency, there may be a deficiency of Vitamin B12 and Folic acid (variant of Vit.B) that are also required for proper production of haemoglobin.

Prevention of Anaemia

- **Provision of a health diet**
- **Reduction of alcohol intake, as alcohol is toxic to bone marrow and is also known to slowdown the formation of red blood cells.**
- **There is need for regular medical check-up of blood tests through blood tests.**