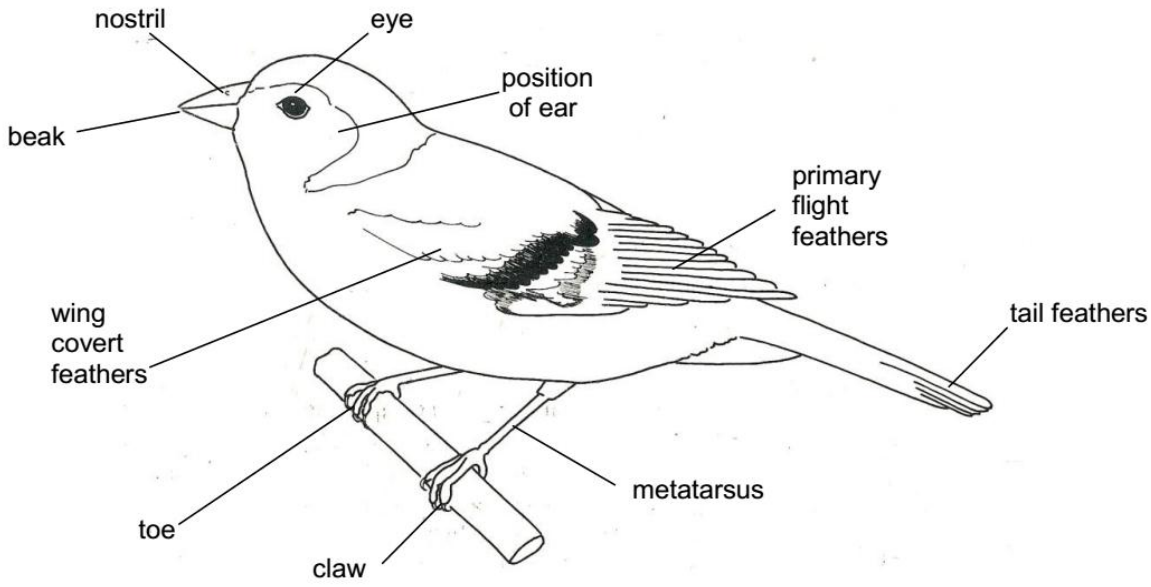
S.1 BIOLOGY CLASS NOTES

By Kugonza H Arthur



BIOLOGY

Biology is a word derived from **two Greek** words i.e. **"*Bios*"** and **"*logos*"** where ***Bios*** means **life** and ***logos*** means **knowledge**.

Therefore *Biology is the study of life or living things*. All living things are called organisms.

Branches of biology

1. **Botany**, the study of plants.
2. **Zoology**, the study of animals.
3. **Anatomy**, the study of the structure of living things.
4. **Nutrition**, the study of food and how living things feed.
5. **Ecology**, the study of how organisms are related to their environment / surrounding.
6. **Mycology**, the study of fungi.
7. **Virology,** the study of virus.
8. **Bacteriology**, the study of bacteria.
9. **Entomology**, the study of insects.
10. **Microbiology**, the study of microorganisms.
11. **Physiology**, the study of process and functioning of the body parts.
12. **Genetics,** the study of inheritance.
13. **Taxonomy**, the study of classification of organisms
14. **Ornithology**, the study of birds.
15. **Ichthyology,** the study of fish.

Why do we study biology?

- To get knowledge on how to treat the sick
- To get knowledge needed to become doctors, and nurses
- To get knowledge on how to manufacture drugs
- To get knowledge on how to conserve the environment
- To know how our body functions.

Characteristics of living things

1. Nutrition/feeding

It's a process by which living things obtain.

Green plants make their own food while the rest obtain already made food from the environment.

2. Respiration

This is the breakdown of food to release energy in the body.

3. Excretion

Is the process by which waste products are removed from the body e.g. urea in urine, carbon dioxide, etc.

4. Reproduction

This is the ability of an organism to give rise to new organisms/off springs.

5. Movement

This is the ability of an organism to transfer its body from one place to another. They move in search for food, water, shelter, mates, and run away from predators.

6. Growth

Growth is a permanent increase in size of an organism. It is followed by development.

7. Irritability / sensitivity

It is the ability of an organism to respond to changes in its environment

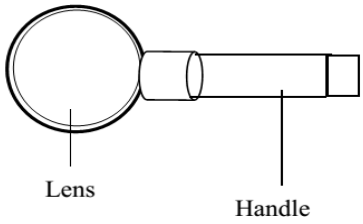
Differences between plants and animals

Plants	Animals
i) Have cell wall.	Lack cell wall.
ii) Have chlorophyll.	Lack chlorophyll.
iii) Movement is by growth of plant parts.	Movement involves the whole organism.
iv) They make their own food by photosynthesis.	Feed on already made food.
v) Respond to stimulus slowly since it involves growth.	Quick / immediate response to stimulus.

TOOLS USED TO STUDY BIOLOGY

1. Hand lens:

A normal hand lens is a convex lens mounted in a frame. It is placed a shorter distance of about 5cm from the eye and the object.



Determination of magnification using a hand lens

Magnification refers to how much larger the object appears compared to its real size.

Magnification = $\frac{size\ of\ the\ image/drawing}{size\ of\ the\ object}$

Example

Calculate the magnification of an object, which is 10cm tall whose image appears to be 20cm tall.

Solution

Using the formula

Magnification $= \frac{size\ of\ the\ image/drawing}{size\ of\ the\ object}$

$= \frac{20\ cm}{10\ cm}$

$= \times 2$

2. Microscopes

It is an instrument used to view objects that are too small to be seen by an unaided eye.

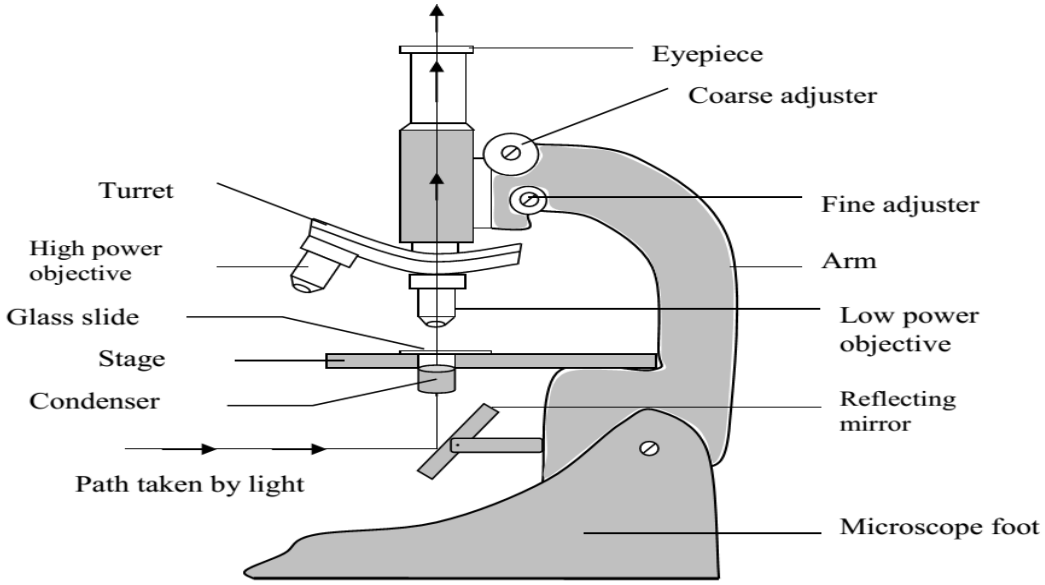
Types of microscopes

- The electron microscope which uses a beam of electrons.
- The compound light microscope.

THE COMPOUND LIGHT MICROSCOPE

It is called so because it uses a beam of light to view objects and has more than one convex lens. It is used in hospitals, schools and some industries.

Structure of a compound light microscope



FUNCTIONS OF THE DIFFERENT PARTS

1. **Eye Piece:**
   - It is where the eye is placed while viewing the specimen
   - Enables one to view the specimen
   - It magnifies the image from the objective lens.
2. **Barrel:**
   - Provides support for the eye piece and objective lens.
3. **Nose piece/ turret/:**
   - It holds the objective lenses in position
   - Can be rotated to position a particular lens required for a particular magnification.
4. **Stage:**
   - It is where a prepared slide is placed for observation.
5. **Mirror:**
   - It reflects light from external source through the specimen.
6. **Stand / Base:**
   - Supports instrument in on a flat surface.
7. **Diaphragm:**
   - Regulates the amount of light passing through the specimen.
8. **Condenser:**
   - Concentrates the light reflected by the mirror through the object / specimen on the stage.
9. **Arm:**
   - Used for carrying the instrument.
10. **Clip:**
    - Keeps the slide firmly on the stage.
11. **Coarse adjustment knob:**
    - Used for focusing of the object under study.
12. **Fine adjustment knob:**
    - Brings specimen into a sharp clearer focus (final focusing).
13. **Objective lens:**
    - Magnifies the specimen under study. They are normally two or three. Low power (shortest), medium power and high power (longest).

Care of a microscope

The microscope is very delicate, expensive instrument which is very useful in the study of biology. Thus it should be handled carefully doing the following;

- It should be carried with both hands.
- Should never be dropped.
- Always kept in an upright position
- Only wipe the lens with soft lens tissue.
- It should always be kept in its special designed box.

Determination of magnification of a microscope

Magnification refers to how much larger the object appears compared to its real size.
Magnification = magnification of the eye piece lens X magnification of the objective lens.

Example:
If the eye piece is marked **x10** and the magnification of the objective lens is **x40**, what is the total magnification of a microscope?
Magnification = magnification of the eye piece lens x magnification of the objective lens.
=10 x 40=400
The specimen was magnified *x*400

Let magnifying objective lens. (x4)

Complete the table below

Eye piece lens	Objective lens	Magnification
X15	X7	
X60		X240
	X17	X340
X25	X8	

THE CELL

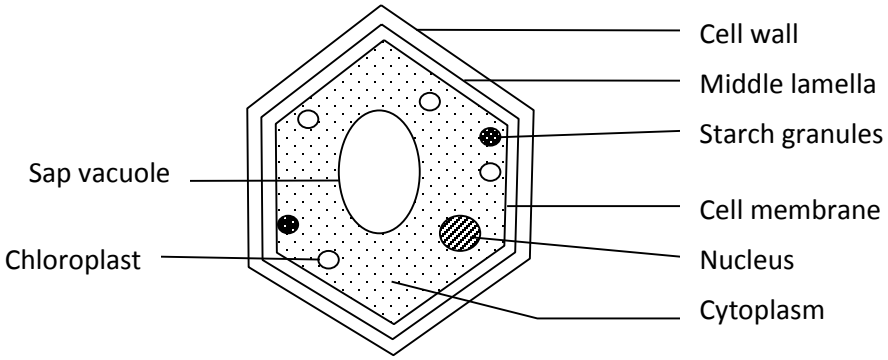
The cell is the smallest basic unit of life.
Unicellular organisms are only made up of a single cell e.g. amoeba, paramecium.
Multicellular organisms are made up of many cells e.g. man, cows, bean plant, etc.

The origin of new cells

New cells are formed from already existing cells by a process called cell division. The already existing cell is called a parent/ mother cell; and the new cells formed are called daughter cells.

Structure of an animal cell

Structure of a plant cell



Cell organelles and their functions

1. Cell Membrane

Is the outer living part of a cell and it is found in all cells.

Its semi permeable i.e. has tiny holes through which only very small molecules like water can pass through.

Functions

- It allows movement of materials in and out of the cell.
- It regulates the shape and strength of a cell.
- Offers protection to the inner parts of the cell.
- Binds protoplasm/ cytoplasm.

2. Cell Walls

It is found in plant cells and it is made up of cellulose (a nonliving substance) which gives it its rigid tough nature.

Functions

- It gives the plant cell its shape.
- Protects the inner parts of the cell.
- Allows movement of materials in and out of the cell.
- It offers mechanical strength to the cell.

3. Nucleus

It is surrounded by double membrane called the nuclear membrane.

Functions of a nucleus

- Controls cell activities.
- Controls cell division
- Stores the genetic material of a cell
- Plays an active role in protein synthesis.

Functions of the nuclear membrane

- Binds the nucleus
- Separates the nucleus plasma from the cytoplasm.
- Allows for the exchange of materials between the nucleus and the cytoplasm.

4. Cell Vacuole

Contains a watery substance called cell sap and is surrounded by a single membrane called the ***tonoplast.***

Each Plant cell possesses one large permanent central vacuole while each animal cell has many temporary vacuoles.

Functions

- Stores waste materials before they are expelled.
- It is a temporary food store.
- Gives shape to the cell.

5. Cytoplasm

It is a fluid material that contains many organelles e.g. mitochondria, nucleus etc.

Functions

- Site for cell activities i.e. metabolic reactions.
- Site for storage of energy producing materials e.g. starch and glycogen.

6. Mitochondria

- It is the cell power house and its function is to release energy through respiration.

7. Chloroplast

- Found in only plant cells
- Contains a green pigment called chlorophyll that traps sunlight for photosynthesis.

8. Golgi body

- Involved in cell secretions i.e. secretes enzymes.
- It transports materials in cells.

9. Lysosome

- It secretes hydrolytic enzymes i.e. breaking down enzymes e.g. help in destruction of old or worn out cells.

Comparing a plant and animal cell

Differences:

Plant cell	Animal cell
i) Regular in shape	Irregular in shape
ii) Has a cellulose cell wall.	Lacks a cellulose call wall.
iii) Has chloroplast.	Lacks chloroplast.
iv) Large vacuole centrally located.	Cell vacuole very small and positioned at the side.
v) Has a middle lamella.	Lacks a middle lamella.
vi) Nucleus is positioned at one side.	Nucleus centrally located.
vii) Store food as starch granules.	Store food as glycogen granules.
viii) Has a tonoplast around the vacuole	Has no tonoplast
ix) Has a Thin layer of cytoplasm	Has a thick layer of cytoplasm
x) Has a permanent vacuole	Has a temporary vacuole

Similarities

- Both have a nucleus.
- Both have mitochondria.
- Both have a vacuole.
- Both have a cytoplasm.
- Both have a cell membrane.

SPECIALISED CELLS

These are cells modified to perform a particular function.

Examples of specialized cells in animals

i) Red blood cells in blood: These transport oxygen in our bodies.

ii) **Sperm cells:** These fuses with the ovum to form a zygote during fertilization
iii) **Ovum or egg:** This is the female reproductive cell that fuses with a sperm to form a zygote.
iv) **White blood cells:** This defends the body against infections and diseases
v) **Platelets:** These are used for blood clotting.

Examples of specialized cells in plants

i) **Root hair cells**

They are found in plant roots
They absorb water and mineral salts from the soil

ii) **Palisade cells**

These are found in leaves of green plants**.** They carry out the process of photosynthesis

iii) **Guard cells**

They are found in green leaves
They control the opening and closing of stomata in leaves

LEVELS OF ORGANISATION

Cell ⟶ tissue ⟶ organ ⟶ organ system⟶organism

Tissue

A tissue is a group of similar cells linked together to perform a particular function.
A tissue may be made up of single type of cell or may comprise of different types of cells. E.g.

i) Blood tissue made up of red blood cells, white blood cells and platelets. Blood transports materials in the body and offers protection.
ii) Nervous tissue made up of nerve cells. It transmits impulses in the body.
iii) Muscular tissue made up of muscle cells which cause movement of body parts
iv) Photosynthetic tissue made of palisade cells for photosynthesis.

Organ

An organ is a collection of tissues specialized in carrying out a specific function. An organ is made up of different types of cells grouped together as a unit e.g.

i) Eye for sight
ii) Heart for pumping blood
iii) Ear for hearing
iv) Kidney for purifying blood
v) Leaves for photosynthesis
vi) Roots for absorbing water and mineral salts

Organ system

An organ system is a collection of different organs performing a specific function(s) e.g.

i) Nervous system (Brain, Spinal cord),
ii) Circulatory system (Heart, Lungs and Blood vessels),
iii) Digestive system (gullet, stomach, small intestines).
iv) Shoot system (leaves stems. flowers)
v) Root system (roots)

Organism

This is a collection of organ systems working together efficiently as a unit. E.g. man, cow, banana plant, etc.

TOPIC ONE:

CLASSIFICATION OF LIVING ORGANISMS

Classification is the process of placing animals and plants into groups according to their similarities in structure, physiological processes and behavioral.
This involves collecting organisms, observing their structural characteristics and sorting them into groups known as ***taxa.***
The branch of biology concerned with classification is called ***taxonomy.***
The word taxonomy is derived from a Greek word taxis- meaning arrangement and nomia-meaning distribution.

Level of classification

The level of classification is called taxon. Plural –taxa. A taxon is a unit of classification made of similar organisms. The largest taxon is the kingdom and the smallest taxon is the species. All organisms have been put in seven major taxa and these include:

1. Kingdom
2. Phylum (phyla)
3. Class
4. Order
5. Family
6. Genus (genera)
7. Species

Easy formula for seven taxa from highest to lowest

Kings	Play	Cards	On	Fat	Green	Stools
K	P	C	O	F	G	S
(Kingdom)	*(Phylum)*	*(Class)*	(*Order*)	*(Family)*	*(Genus)*	*(Species)*

Kingdom:
A kingdom is the largest taxon, and all the other taxa (groups of living organisms) are placed in one the kingdoms. In modern classification system, there are 5 kingdoms:

1. Monera (bacteria)
2. Protoctista
3. Fungi (Mycota)
4. Plantae
5. Animalia

Note:
Viruses are not classified in any of the five kingdoms because they do not have all the characteristics of all living things. For example;

- ✓ They do not have cellular structures like cytoplasm, organelles.
- ✓ They use nuclear material and organelles of other living organisms to carry out their metabolic processes.
- ✓ They can survive out their host's cell as inert organic crystals.

Species:
A species is the smallest taxon which is made up of individuals that have almost the same characteristic features and can interbreed freely to produce viable off springs i.e. reproductively fertile off springs

Examples of hierarchy system of classification

	Human	**Honeybee**	**Maize**	**Meadow mushroom**
Kingdom	Animalia	Animalia	Plantae	Fungi
Phylum	Chordata	Arthropoda	Angiospermophyta	Basidiomycota
Class	Mammalia	Insect	Monocotyledoneae	Basidiomcetes
Order	primates	Hymenoptera	Commelinales	Agaricales
Family	Hominidae	Apidae	Poaceae	Agaricaceae
Genus	*Homo*	*Apis*	*Zea*	*Agaricus*
Species	*sapiens*	*mellifera*	*mays*	*campestris*

Binomial system of nomenclature:
Binomial nomenclature is the system of giving a scientific name to an organism.
The word binomial comes from two words bi- meaning *two* and nomio meaning *name*.
The first accepted classification and nomenclature was introduced by a Swedish scientist called **Carl Linnaeus (1707 - 1778).**

Rules of binomial system of nomenclature

- ✓ Each organism should be given two Latin or Greek names which include generic (genus) name followed by specific (species) name.
- ✓ The generic name should start with a capital letter and a specific name starts with the small letter
- ✓ When written both names should be **underlined** **separately** or ***printed in italics***

Examples of some scientific name for common organisms

Human – scientific name is *Homo sapiens* (Homo sapiens – when hand written)
Maize – scientific name is *Zea mays*
Assignment: write the scientific names of the following; honey bee, meadow mushroom and house fly.

Importance of classification

- ✓ It is easy to study organism in a group since the members of a specific group resemble.
- ✓ It helps new organisms to be easily classified since they share certain characteristics with those in existence.
- ✓ It helps the scientist to easily identify organisms belonging to the same group.
- ✓ The use of scientific names enables to prevent confusion that would arise if the organism had different names used in different places.

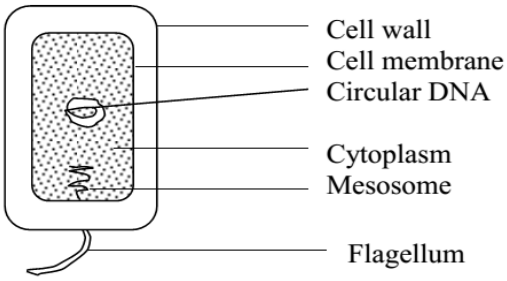
KINGDOM: MONERA

This basically comprises of bacteria which are prokaryotes

General characteristics

- ✓ They are unicellular with cells occurring either alone or in colonies.
- ✓ The cells lack membrane bound organelles.
- ✓ Some are parasitic and others are saprophytic
- ✓ They reproduce asexually by means of spores or binary fission.

General structure of bacterium



Bacteria are grouped according to their shapes. There are four groups of bacteria

Shape	Type	Structure
Coccus Single spherical cells ○	**Diplococcus:** These occur as a pair of spherical cells.	○○
	Staphylococcus: Spherical shaped occurring in a bunch or group	○○ ○○
	Streptococcus: Spherical cells in a chain	○○○○○○
Bacilli: These are rod shaped.	**Bacillus:** Single rod shaped bacterium.	▭
	Diplobacilli: A pair of rod shaped bacteria.	

	Streptobacilli: Rod shaped bacteria existing in a chain.	
	Spherical spore bacilli: These have spherical spore at the head e.g. clostridium tetani which causes tetanus	
Vibrio: Coma shaped	*Vibrio cholera* which causes cholera	
Spirillus	These are spiral shaped bacteria	

Economic importance of bacteria

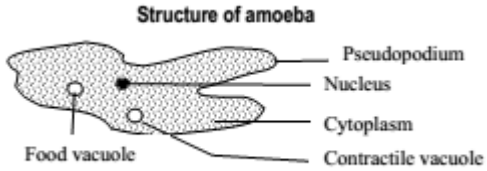
i) Bacteria causes decay of dead plants and animals thus releasing nutrients for use by green plants
ii) Rhizobium converts the nitrogen into nitrates in the soils
iii) Bacteria manufacture vitamin B12 and k
iv) Used in curing tea and tobacco, making silage /retting flax. Curing is process of treating and preserving tea / tobacco
v) Bacteria destroys harmful organisms in sewage in the sewage treatment
vi) Used in industrial processing of food like vinegar, cheese, and yoghurt
vii) Symbiotic bacteria in ruminants help in digesting cellulose by secreting enzymes cellulose
viii) Bacteria cause decay and food spoilage
ix) Denitrifying bacteria converts nitrates in to free nitrogen in the soil.
x) Some bacteria cause harmful diseases to man like anthrax.

KINGDOM: PROTOCTISTA

Protoctista are referred to as protozoans.
They are unicellular organisms. I.e. single celled organisms.
They have a true nucleus with a nuclear membrane.
Examples of protozoa include ***Amoeba, Paramecium, Euglena, Trypanosome and plasmodium***.

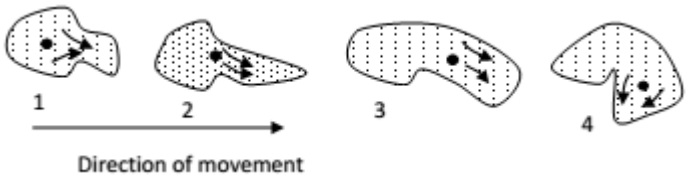
Amoeba

Amoeba is a free-living protozoa found at the bottom of ponds. It has temporary extensions called *pseudopodia used for locomotion*. The pseudopodia are also used for enclosing food particles which form food vacuoles. The food in vacuole is digested by phagocytosis.
The excess amount of water can be regulated and removed by contractile vacuole.



Locomotion in amoeba

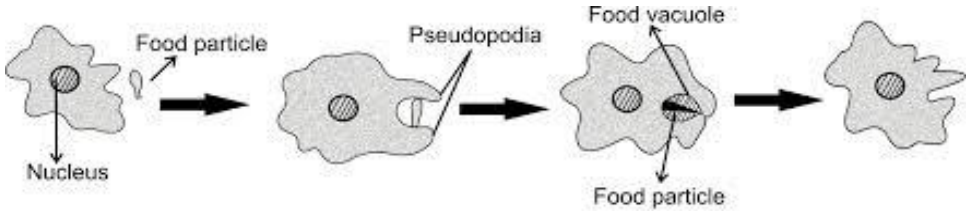
Amoeba ***moves by means of pseudopodia*** (false legs) that are formed by the flow of cytoplasm (plasmosol and plasmogel) in the direction of movement but this is followed by the flow of other protoplasm in the same direction, as shown below:



Excretion in amoeba

Excess water is eliminated from its body by contractile vacuole. This collects the water and moves to the cell membrane where it discharges its contents. The process is repeated and hence it is the means of osmoregulation (control of water amount inside the body) by amoeba. Other by-products diffuse out of the cytoplasm through the cell membrane e.g. CO_2.

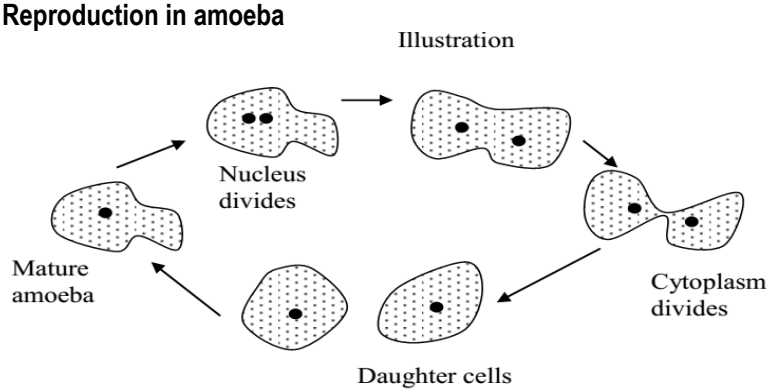
Feeding in amoeba



Amoeba feeds on microscopic algae and bacteria. It captures the food by developing pseudopodia around the food and it engulfs it. The cytoplasm flows around the food. This one now forms the food vacuole.
Digestive enzymes are produced which break the food particles into soluble food substances. The products are utilized and amoeba moves away from undigested food remains. This is called **egestion.**

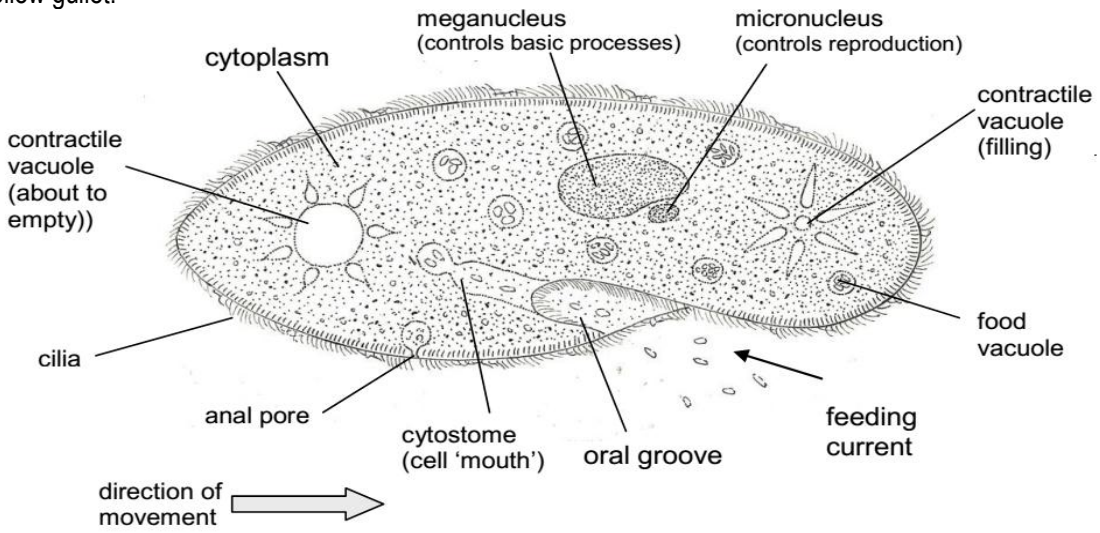
Reproduction in amoeba

- Amoeba reproduces by binary fission.
- An amoeba ready to reproduce stops moving and rounds off.
- The nucleus then constricts and divides into two identical parts.
- The cytoplasm begins to constrict so that the separation of the remaining parts into 2 can occur.
- Two identical daughter amoebae forms and move apart to feed and grow into mature amoebae before they divide again.



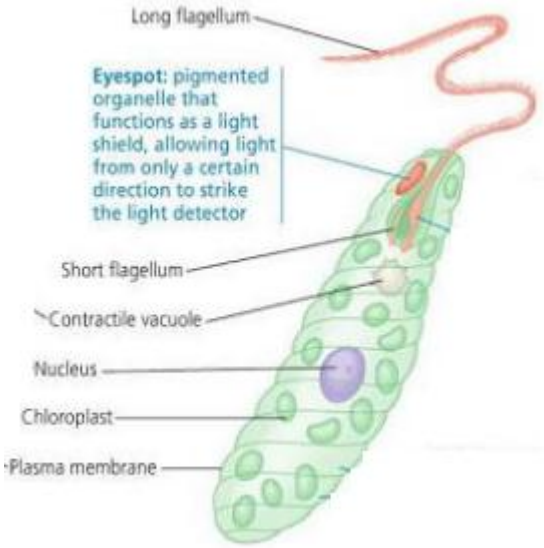
Paramecium

Paramecium uses ***cilia for movement*** and collection of food. It has special row of cilia that waft food particles into the hollow gullet.



Euglena

This is commonly found in water and in soil. It is photosynthetic and moves by means of flagellum.



KINGDOM: FUNGI

Kingdom fungi mostly have multicellular eukaryotic organisms such as mushroom and mould. Some are unicellular like yeast.

Other examples include toad stool, smuts, penicilium, mucor (grows on soil and dead plants), rhizopus (common bread mould).

Rhizopus is saprophytic fungus which grows on decaying food like bread and fruits.

General characteristics

- ✓ Fungi inhabit damp moist places.
- ✓ They reproduce by means of spores.
- ✓ They have saprophytic or parasitic mode of nutrition.
- ✓ Have vegetative body called mycelium which consists of a network of hyphae.
- ✓ They have cell walls which consist of a material called chitin.
- ✓ They lack chlorophyll though majorities are plant-like.

Diagram of common bread mould (Rhizopus)

Economic importance of fungi

- ✓ Fungi decay dead organic materials to release materials needed by green plants
- ✓ Yeast respiring anaerobically, provides alcohol for brewers and wine makers.
- ✓ Fungi produce antibiotics e.g. penicillum.
- ✓ Fungi provide food e.g. mushroom also used in making cheese.

- ✓ Fungi can spoil food e.g. Rhizopus and penicillum on the bread, cakes, fruits and jam.
- ✓ Fungi causes plant disease e.g. rust, white bright and smut.
- ✓ Fungi causes diseases to man e.g. ringworm, athlete's foot.

KINGDOM ANIMALIA

Kingdom Animalia has several phyla each of which consists of a variety of organisms.
The phyla include

1. Porifera e.g. sponges
2. Coelenterata e.g. hydra
3. Platyhelminthes e.g. flat worms
4. Nematoda e.g. round worms
5. Annelida e.g. ringed worms
6. Mollusca e.g. snails
7. Echinodermata e.g. star fish
8. Arthropoda e.g. cockroach
9. Chordata e.g. man

1. Phylum: Porifera – the sponges

The phylum is made of many types of ***sponges***. They have the following characteristics:

- Possess simple bodies which are hollow and sac-like.
- They are marine dwellers
- They have only one opening in their bodies.

2. Phylum: Coelenterata (Cnidarians)

They include the following; the ***jelly fish, sea anemones, hydra and corals***. They have the following characteristics:

- They are aquatic or marine organisms.
- They have soft bodies which are sac-like with body cavity called enteron.

3. Phylum: Platyhelminthes (flat worms)

The phylum consists of organisms like ***flukes*** and ***tape worms***. They have the following characteristics:

- They have dorso-ventrally flattened body
- They have bilateral body symmetry.
- They are damp, moist or aquatic dwellers.
- They are parasitic organisms.

The phylum has 3 main classes;

i) Turbellaria e.g. Planarians

- They are free living flat worms that live in wet soils, fresh water and seas.
- They have many simple eyes and cilia on the under surface of the body used for movement over stones and weeds.

ii) Trematoda e.g. Liver fluke

- They live as endo parasites in cattle, goats and man.
- They have suckers used for attachment on to the host.
- They suck digested food from the host.

iii) Cestoda e.g Tape worm

- They live as endo-parasites in the gut of man, muscles of goats, cows and pigs.
- They have suckers and hooks for feeding and attachment on to the host.
- They have elongated bodies consisting of segments called proglotids.
- They absorb digested food directly from the host.

4. Phylum: Nematoda (round worms)

The phylum has the examples like hookworms, pin worms, guinea worms, whip worms and ascaris lumbricoides. They have the following characteristics:

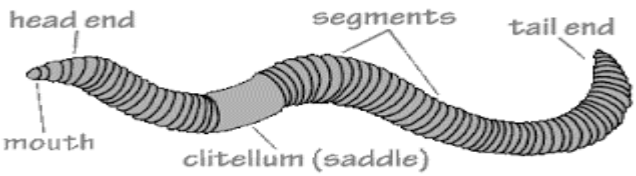
- They have segmented bodies.
- They have elongated and cylindrical bodies pointed at both ends.
- Some are parasitic and others are free living.

5. Phylum: Annelida (ringed worm)

These are the ringed or segmented worms e.g. earthworms, leeches, rag worms, lugworms, etc. They have the following characteristics:

- The body wall has three body layers of cells (triploblastic) i.e. ectoderm (outer), mesoderm (middle) and endoderm (inner).
- They are hermaphrodites and reproduce sexually but they often promote cross fertilization.
- They have bodies divided into section called septae.
- Externally the body shows ring- like segments.

The earthworm

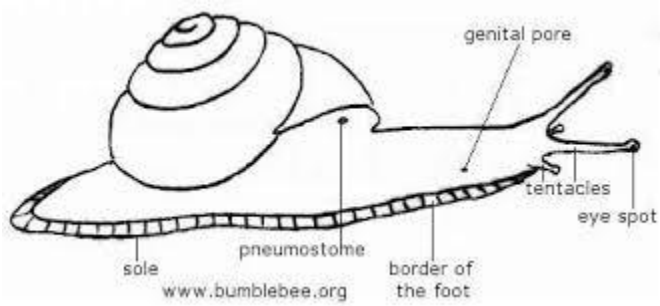


6. phylum: Mollusca

The organisms are generally aquatic and live both on fresh water and marine. Examples include snails, slugs, octopus, squids, mussels and oysters. They have the following characteristics:

- ✓ They have soft and un segmented bodies.
- ✓ Nearly all have shells with exception of octopus and squids.
- ✓ The foot is used for locomotion and attachment to the substratum.

Garden snail

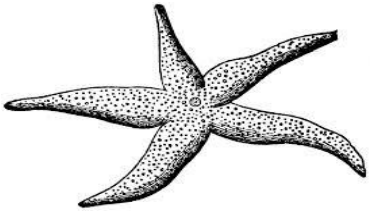


7. Phylum: Echinodermata

The organisms are sea dwellers. Examples are bristles star, sea urchin, sea lilies, sea star, star fish, sea cucumber. They have the following characteristics:

- ✓ The body wall has three body layers of cells (triploblastic) i.e. ectoderm (outer), mesoderm (middle) and endoderm (inner).
- ✓ They have feet for locomotion and capturing the food (feeding).
- ✓ They have spiny skin which is a hard plate.

Star fish



PHYLUM ARTHROPODA

Arthropoda has a wide variety of animals. These animals occupy a wide variety of habitats on land, sea and fresh water.

Main characteristics

i) They have a segmented body.
ii) They have an exoskeleton.
iii) They have jointed limbs and appendages for feeding, locomotion, and irritability.

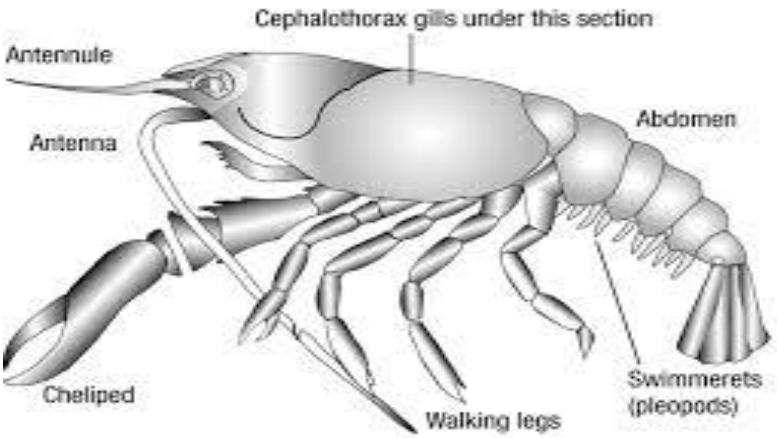
The exoskeleton is made up of chitin which is fairly hard but flexible. ***The exoskeleton has the following functions:***

- It provides support to terrestrial arthropods.
- It provides points of attachment for the muscles.
- It prevents the body from drying by secreting wax.
- It protects the organism from mechanical injury.

The phylum comprises of classes **Crustacea, Chilopoda, Diplopoda, Insecta and Arachnida.**

1. Class: Crustacea

Crustacea are organisms whose body is covered by a carapace. A carapace is a hard shell. Examples of members of the class Crustacea include crabs, crayfish, lobsters, prawns, woodlice and shrimps.



Distinguishing characteristics

- Crustacea are mainly found in both marine and fresh water.
- Their body is divided into two parts. Their head and thorax are fused to form a ***cephalothorax***. The second division is the abdomen.
- They have a pair of compound eyes each on a raised stalk.

2. Class: Chilopoda

Chilopoda is made up of centipedes. The centipedes are mainly found on land.

Centipede

Distinguishing characteristics

- ✓ Centipedes have a clearly defined head while the rest of the segments are similar.
- ✓ They have a pair of antenna
- ✓ They have one pair of mouthparts known as mandibles.
- ✓ They have simple and compound eyes, although some lack compound eyes.
- ✓ They have one pair of legs on each body segment.

3. Class: Diplopoda

Class Diplopoda is made up of millipedes. Millipedes are common in damp places.

Distinguishing characteristics

- ✓ Millipedes have a clearly defined head. All the other body segments are basically similar.
- ✓ They have one pair of antenna
- ✓ They have one pair of mouthparts, namely the mandibles.
- ✓ They have two pairs of legs on each body segment.

4. Class: Arachnida

Arachnida are terrestrial arthropods. Members of this class all have 8 legs. Examples of arachnids include spiders, ticks, scorpions and mites

Distinguishing characteristics

- ✓ Arachnida have two body parts. The head and thorax are fused to form the cephalothorax or prosoma (cephalothorax). The abdomen is referred to as opisthosoma.
- ✓ They have simple eyes.
- ✓ They have four pairs of walking legs.
- ✓ They carry out gaseous exchange by the lung book or trachea. A lung book consists of folds of ectoderm with slit-like openings on the surface of the abdomen
- ✓ Arachnids do not have wings.

5. Class: Insecta

Insects are the most successful animals on earth since they possess an exoskeleton which reduces water loss from the body.
Insects are the largest group of arthropods.
They occupy every habitat on earth in such places as air, soil and water. However, they mainly inhabit terrestrial habitats.
Examples of insects include grasshoppers, houseflies, butterflies, bees, and termites.

The main characteristics of class Insecta

i) Insects have three body parts, namely: the head, thorax, and abdomen.
ii) They have three pairs of walking legs on the thorax. One pair of walking legs per segment of the thorax.
iii) They have a thorax divided into three segments i.e. prothorax, mesothorax and metathorax.

They exhibit the longest level of organization in animals, i.e. social organization especially in bees, wasps and ants. They are the only invertebrates which can fly.

Their success on land is attributed to:

i) Evolution of special organs for flight. The wings which enable them to diverse and colonize new areas.
ii) Impervious exoskeleton made of chitin which has protected them from drying up in the terrestrial environment.
iii) The small size has enabled them to tackle every place.
iv) Excretion of toxic products as uric acid has enabled them to conserve water
v) Tracheal system has enabled them to carry efficient gaseous exchange.
vi) Disposition of legs enables them to maintain swift locomotion.
vii) The compound eyes that provide wide field of view for food and enemies.
viii) The modified mouth parts that suit a variety of food materials.
ix) The high reproductive rate that ensures enormous number of offsprings is produced.

Some insects are directly beneficial to man these include pollinators like butterfly, moth and bees others are beneficial indirectly such as parasitic pest species.
Harmful insects include those that directly live on man as parasite like lice, flies, mosquitoes, tsetse flies.

Some common orders of insects

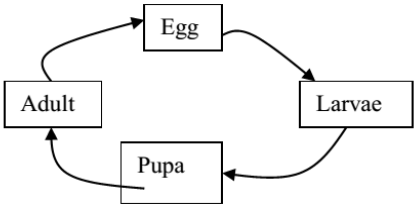
Order	Characteristic feather of the order (***The word ptera means wing***).	Examples
Dictyoptera	Has hard outer wings	Cockroach, beetles, weevils.
Hymenoptera	Has membranous wings	Wasps, bees
Isoptera	Has similar wings	Termites
Lepidoptera	Has scale wings	Moths, butterflies
Diptera	Have two pairs of wings. The second pair is reduced into halteres for balancing.	Mosquitoes, houseflies
Orthoptera	Has long straight wings	Grasshopper, locusts, Preying mantis

INSECT METAMORPHOSIS

Metamorphosis is the gradual developmental change from the eggs to the adult stage. It occurs in insects and amphibians. Insect metamorphosis is divided into two types.

Complete metamorphosis (holometabolous)

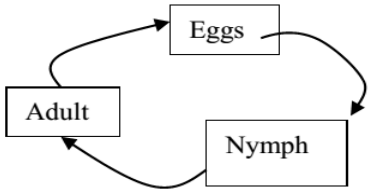
This is a gradual development change where the eggs hatch into larvae and the larvae change into pupa and finally the pupa change into an adult. It involves four stages.



Insects, which undergo complete metamorphosis, include butterflies, mosquitoes, houseflies, tsetse flies, bees, wasps, and beetles.

Incomplete metamorphosis (hemimetabolous)

This is the gradual developmental change where an insect undergoes only 3 stages, when eggs hatch, they give rise to adult-like nymphs which latter change into adults. Insects showing this include locusts, grasshoppers, bedbugs, cockroaches, and termites.



SOME INSECTS OF IMPORTANCE

CITRUS BUTTERFLY *(Papilio demodocus)*

The citrus butterfly is also referred to as lime butterfly because it feeds on lime and citrus.

Classification

Kingdom: Animalia
Phylum : Arthropoda
Class : Insecta
Order : Lepidoptera

Habitat

Butterflies live in gardens and forests and where they can feed on nectar from flowers. They are active during day.

Butterflies and moths

Butterflies and moths are both members of the Lepidoptera. Although they appear very similar, there are differences in their bodies and behaviour.

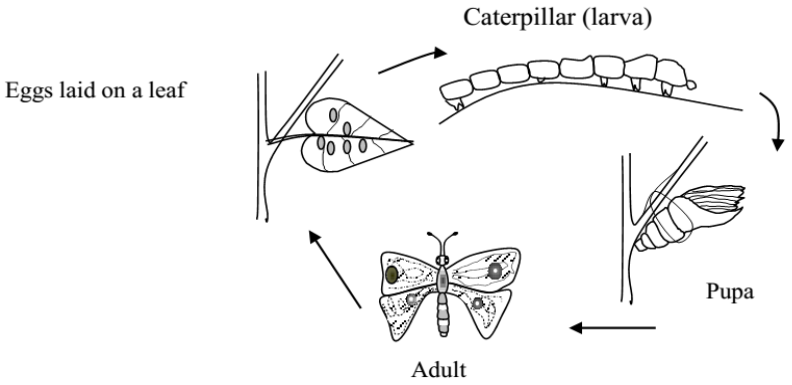
Differences between a butterfly and a moth

Butterfly	Moth
It is diurnal i.e. active during day time	Nocturnal i.e. active during night
Wings are held upright at rest.	Wings are held horizontally at rest.
Small body	Fatter body
Body brightly colored	The body is dull
Antennae are clubbed or knobbed at the tip	Antennae are pointed at the tip and feathery
Pupate above the ground	Pupate in cocoons or in the soil

The life cycle of a butterfly

A butterfly undergoes complete metamorphosis.
A fertilized female butterfly lays eggs.
The eggs hatch into larvae (caterpillars) after about 3 days. The thoracic segments of the larvae bear each a pair of true walking legs and abdomen bearing a pair of claspers on the last segment.
After three weeks of feeding on leaves, **the caterpillar develops to pupa**. The pupa is inactive i.e. it does not feed nor move.

During pupa stage, there is internal reorganization of tissues involving the formation of wing, compound eyes, proboscis and reproductive organs. This lasts for about 7-10 days after which the pupa case split along the dorsal region. After about 1 hour while the wings expand and dry, the adult butterfly emerges ready to fly away, feed, mate and lay more eggs.



Economic importance of citrus butterfly

i) From the cocoons of butterfly, silk threads are obtained for making silk clothes.
ii) The larvae spoil the leafy vegetable with fecal drops such as dodo.
iii) The scales may be respiratory hazards when inhaled.
iv) The caterpillar stage of a butterfly is significantly destructive on vegetables including crops such as cabbages, maize, millet sorghum etc. . . .
v) Some caterpillars feed on insects thus help in destroying insect pests.
vi) The butterflies also are of much importance to the farmers in pollinating flowers of the crops.

Control measures against butterflies

i) Apply environmental friendly insecticides
ii) Use of biological control methods
iii) By hand picking of the infected leaves and burning or burying them. This destroys the eggs and some leaves.

COCKROACH *(Periplaneta americana*)

Classification

Kingdom : Animalia
Phylum : Arthropoda
Class : Insecta
Order : Dictyoptera

Habitat:

Cockroaches live in dark, dirty and dump warm places e.g. pipes that carry sewage. During day they live in crevices of walls, cupboards, underneath drawers and in boxes.
They are active at night thus referred to as nocturnal.

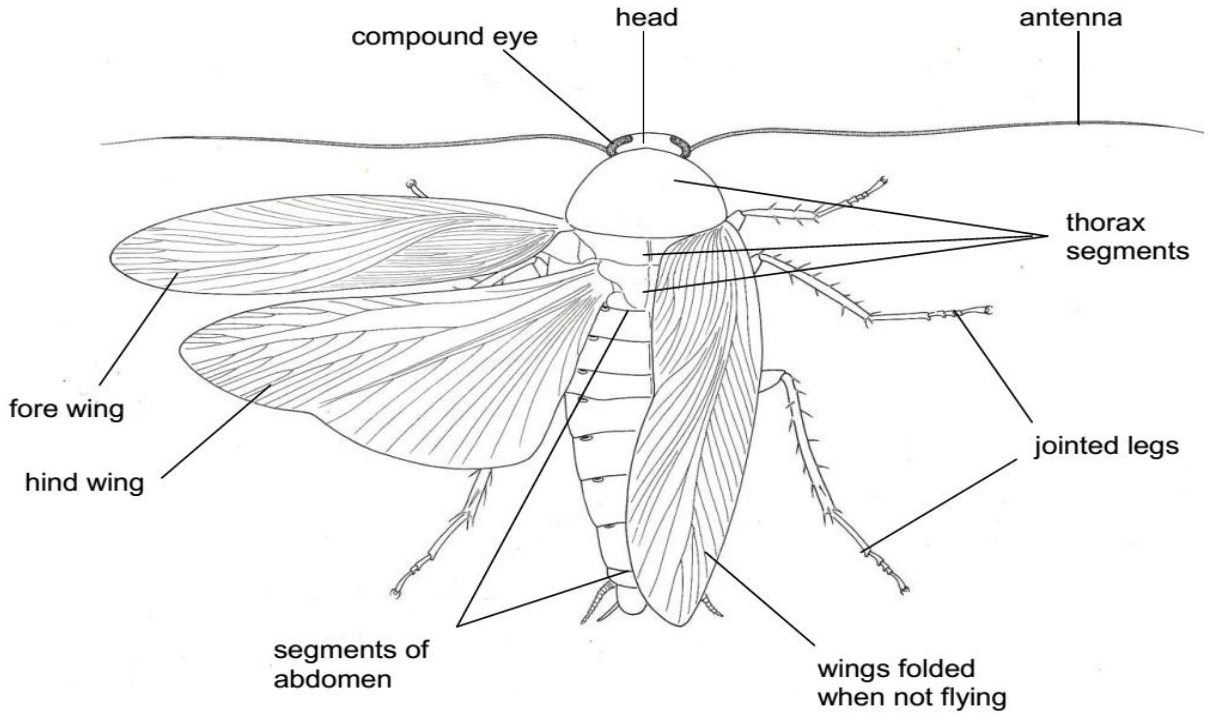
Adaptation of a cockroach to its environment

i) Cockroaches have dorso-ventrally flattened bodies to fit in narrow places.
ii) Its body is dark brown to camouflage well against a dark background.
iii) They are smooth and greasy to escape easily from predators.
iv) It has one pair of long antennae for feeling and smelling the area around their body.
v) Since they are omnivorous, they survive on a wide variety of food materials.
vi) Their nocturnal emergence renders them less liable to capture.
vii) They have spines on their legs for defense.

NB: Other insects belonging to the order Dictyoptera include locusts, crickets, praying mantis and grass hoppers etc.

External features:
It is dorsal- ventrally flattened body with brown colour.
It has a hard thick exoskeleton made of chitin.
The body is made up of three main divisions, each segment of thorax and abdomen consists of dorsal plate tegmen (plu:- terga) a ventral plate, sternum (plu-sterna) and two internal plates, pleura.

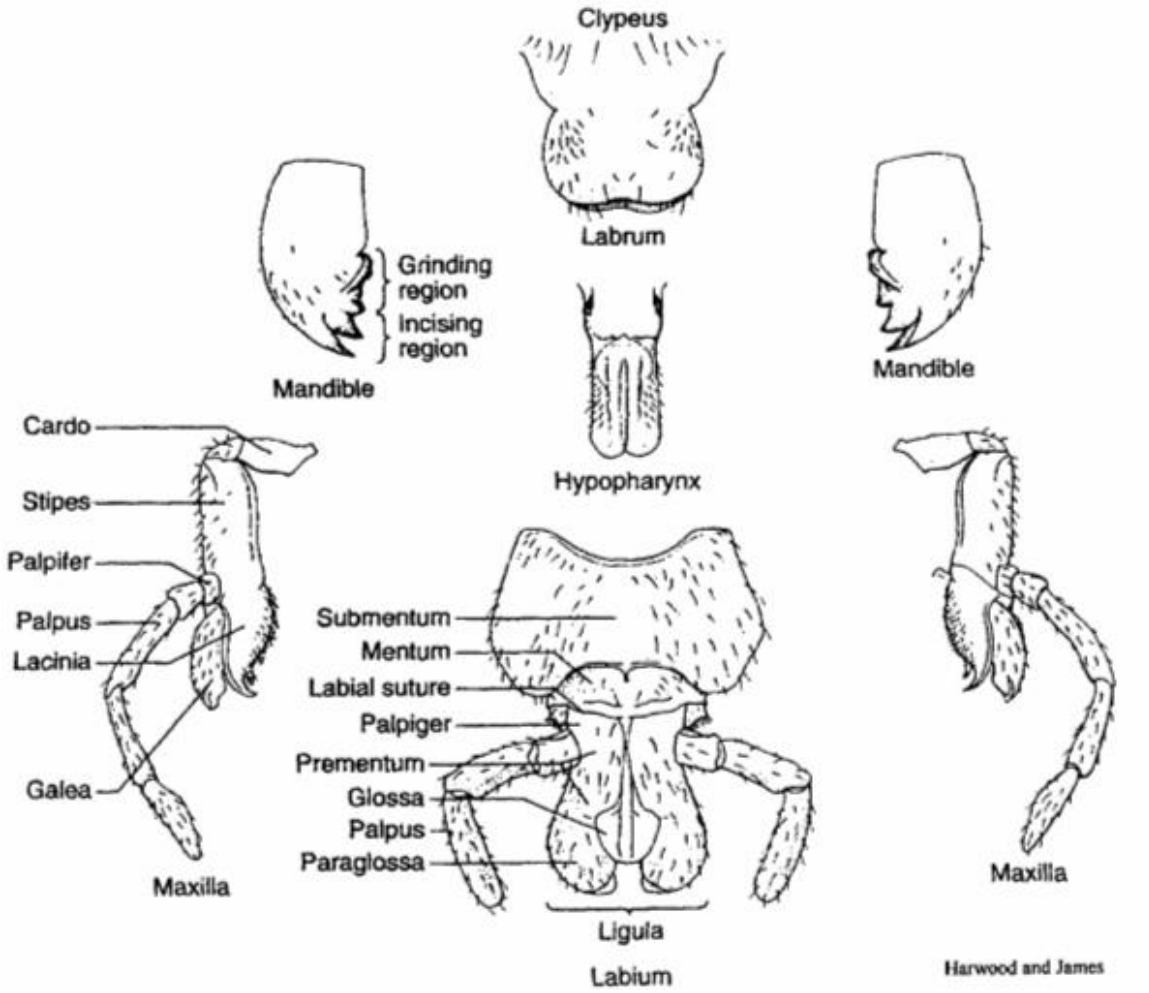
Dorsal view of the cockroach with the left wings spread



The head

- The head is small and pear-shaped.
- It bears a large kidney- shaped pair of compound eyes.
- In front of each compound eye lies a long thread- like segmented antennae (feelers). These are sensitive to touch, smell and vibrations.
- The head has biting and chewing mouth parts – mandibles for cutting and crushing food, maxillary palps for holding food, a labrum (upper lip) and labium (lower lip).
- The head is connected to the thorax by short neck.

Mouth parts of a cockroach



The thorax

- The thorax consists of three segments: the prothorax, the mesothorax and the metathorax.
- Each of the segments bears a pair of jointed legs on its ventral surface. They end in a pair of sharp claws with a soft hairy pad, the arolium (plural: arolia) between them
- The prothorax is the largest of the thoracic segment
- The paired wings are attached to dorsal surface of mesothorax and metathorax.
- The anterior (fore) wings are narrow, brown leathery and still and are called elytra or tegmina. They are not used for flight but for covering and protection of broad, membranous posterior (hind) wings when at rest.

Drawing of the fore wing **Drawing of the hind wing**

Drawing of the hind leg

The abdomen

This is made up of 10 segments. Only seven are easily seen because tergum of seventh segment covers the 8th and 9th segment

The flat, broad tergum of the 10th segment bears a pair of jointed sensory structures, the cerci in males, another additional pair of short structures styles.

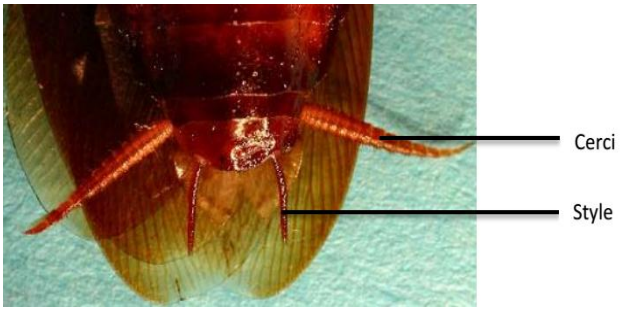
Identification of a cockroach's sex

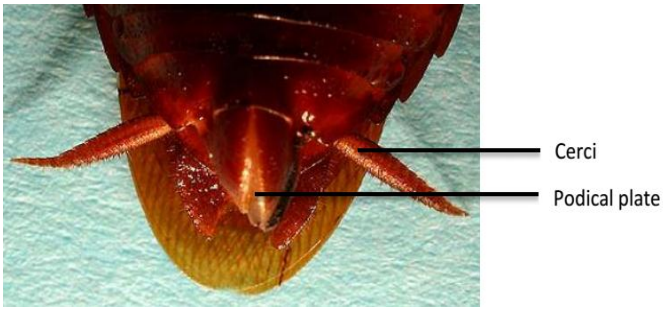
In males, there is a pair of slender **styles** that are used to hold and manipulate the female during copulation.

In females, there is a pair of boat shaped structures called the **podical plates** used for holding eggs.

Differences between a male and female cockroach:

Male	Female
Has a narrow abdomen	Has a broader abdomen
Lack ootheca	Has ootheca which develops after fertilization.
Has rod-shaped structures called styles on the 9th abdominal segments.	No styles on the 9th abdominal segment.
No podical plates.	Has podical plate for carrying eggs.





The life cycle of a cockroach

A cock roach undergoes incomplete metamorphosis.

After mating, the fertilized eggs are stored in an egg-case called ootheca.

This is hard, chitinous structure 1cm long containing eggs in rows of eight

The female carries ootheca for a number of days before depositing them in dark obscure places. Within a week, it turns dark brown.

After six weeks, the eggs hatch out into young, wingless and colorless cockroaches called nymphs. After 2 weeks they turn brown like adult but wingless.

The nymph grows and undergoes ecdysis, about 7 times and every two ecdysis, the nymphs are called instars. After the last ecdysis, the nymph becomes adult cockroach which has a life span of about 2 months.

Economic importance of cockroaches

- They destroy clothes, books, shoes, furniture and spoil food.
- They spread disease causing germs such as cholera, dysentery etc. especially those in latrines
- They contaminate food if not properly covered.
- They are food to some organisms like birds.
- They are used in biological studies as specimens.

Control of cockroaches

- Improve personal and public hygiene.
- Use of environmentally friendly insecticides like doom, etc.
- Use of biological control methods.
- Polish the walls of the house to close the small crevices.

THE HOUSE FLY *(Musca domestica)*

Classification

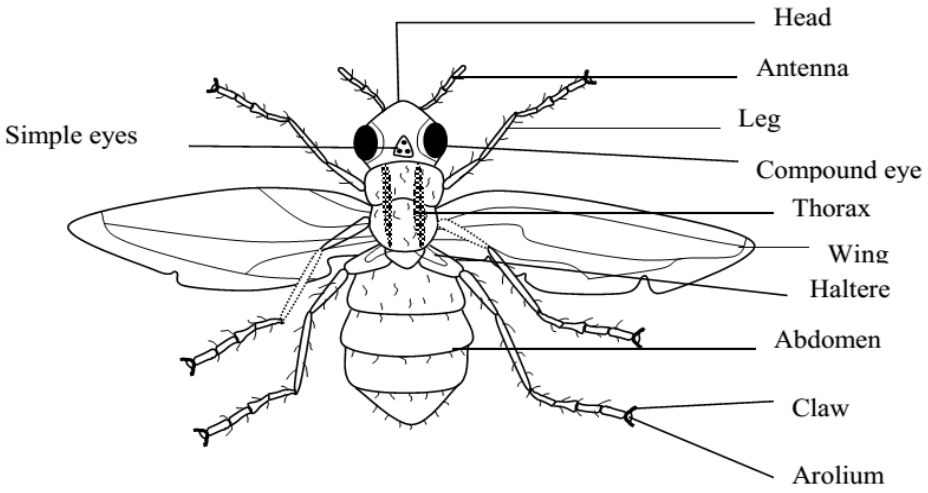
Kingdom: Animalia
Phylum : Arthropoda
Class : Insecta
Order : Diptera

Examples of members in the order include mosquitoes, housefly, tsetse fly etc.

Habitat: House flies live in filthy or dirty places such as toilets, dust bins, and manure heaps, etc.

The body of the housefly is divided into three main parts, head, thorax and abdomen.

General structure



Life cycle of a housefly

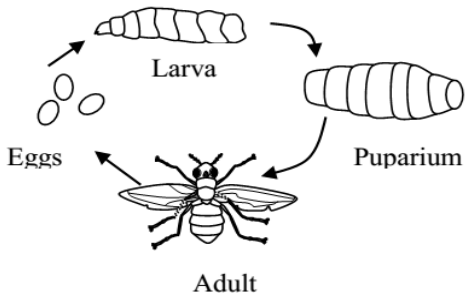
The housefly undergoes complete metamorphosis.

After mating, the female housefly lays eggs in batches. The eggs are laid on rotting matter such as meat or faeces, where it is warm and moist.

After about 8-24 hours, the eggs hatch into larvae. The larvae (maggots) are white and conical shaped.

After 5 days and shading its cuticle twice. It then moves to a drier region of the meat or faeces and pupates.

The cuticle hardens, darkens and becomes brown to form the pupa case. This forms a protective covering as internal reorganization of tissues takes place inside. After the pupa case bursts open, the adult fly emerges. The wings expand and harden and after a few hours, the fly flies away.



Economic importance of house flies

i) They feed on faeces and manure heaps, hence help in garbage disposal.
ii) They are vectors of diseases i.e. spread or transmit diseases such as dysentery, cholera, red eyes & trachoma.
iii) It is a source of food for some organisms such as chameleons.
iv) They are specimens for study purposes.

Control of house flies and prevention of diseases they spread

i) Spraying with an insecticide such as pyrethrum to kill the adult.
ii) Proper disposal of faeces in latrines with covers, so that flies cannot get to the waste to lay eggs.
iii) Washing hands with soap and clean water after visiting the latrine and before eating or preparing food.
iv) Disposing of wastes in such a way that flies cannot reach them. E.g. burning or burying them.
v) Covering or storing food properly so that flies cannot settle on it.

THE MOSQUITO

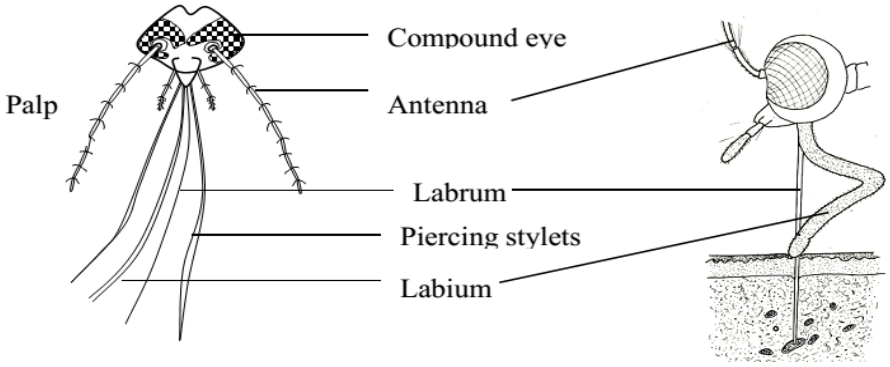
The mosquitoes are majorly found in the tropics and are best known for carrying disease germs
They belong to the order Diptera and the important three genera are:

1. Anopheles that are vectors of malaria.
2. Aedes which are vectors of yellow fever and dengue fever.
3. Culex, the vector of elephantiasis.

Classification

Kingdom : Animalia
Phylum : Arthropoda
Class : Insecta
Order : Diptera

The head of a mosquito

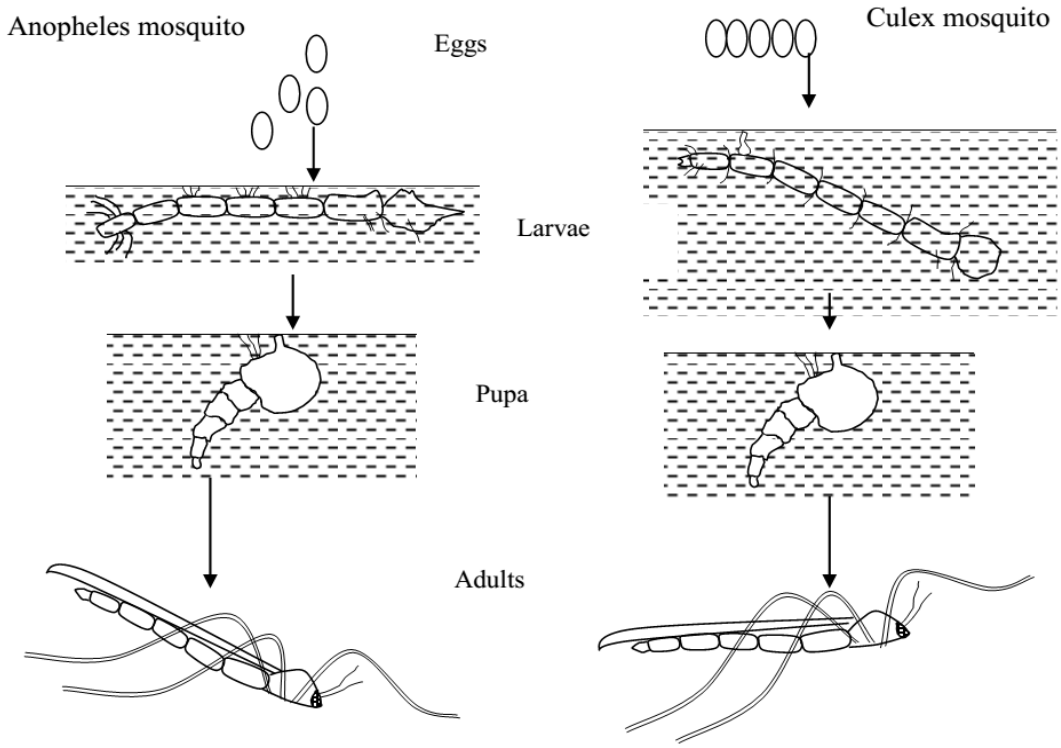


Mode of life of a mosquito

- Hates light and like resting in dark places during day and comes out to feed at night
- They feed mainly within late evening and early morning (day and dawn)
- Male mosquitoes feed on plant juices and nectar while the female feed on blood.

Life cycle of a Mosquito

It begins with mating and internal fertilization and is a complete metamorphosis. The difference however are observed for both anopheles and culex mosquitoes



Economic importance of mosquitoes

They carry malarial parasites which cause malaria. These germs are carried by a female anopheles. The disease causing parasite is referred to as ***plasmodium***. The four types of plasmodia are;

1. Plasmodium malariae *2. Plasmodium vivax*
3. Plasmodium ovale *4. Plasmodium falciparum*

Symptoms of malaria

- ✓ A Person with malaria has very high fever.
- ✓ Headaches.
- ✓ Sometimes vomiting.
- ✓ Pain in the joints and sometimes the general body.
- ✓ There is alternate cold and shivering spells as well as hot sweating.
- ✓ Loss of appetite.
- ✓ Anemia.
- ✓ Enlarged liver and spleen.

Malaria may cause convulsions and sometimes death in children and abortions in pregnant women due to destruction of red blood cells by the parasites.

Control of spread of malaria

Of these diseases malaria is probably becoming the most serious and is increasingly becoming a killer of such great as AIDS. This is mainly because the parasites causing it are becoming resistant to drugs like chloroquine which in the past have been very effective at old malaria.

As things stand now, effective control of the mosquito is as much prerequisite to control malaria as it is to combat the disease.

Appropriate measures include;

- ✓ Destroying the breeding places where larvae develop from by draining or applying a film of oil over the water surface to prevent oxygen reaching the mosquito larva.
- ✓ Burning or burying all empty containers to prevent water from collecting during the rainy season.
- ✓ Clearing bushes around homestead. Mosquitoes like to rest and breed on them during the rainy season.
- ✓ Biological control which involves the introduction of fish into water bodies which feed on the larvae and pupa.
- ✓ Mosquitoes can be killed by spraying with insecticides using special sprayers.
- ✓ Removal of small water containers such as old tins, bottles, and drainage channels, so as to reduce on breeding sites.

- ✓ protecting our bodies from mosquito bites by using mosquito nets at night as well as wearing clothes which cover both legs and arms in the evening
- ✓ Applying mosquito repellant cream to the body.

Aedes species carry a virus which causes Dengue. It also carries germs which cause yellow fever.
*The Culex species carry **filarial worms which cause elephantiasis**. It is not a killing disease but causes discomfort due to large swelling of the legs and/ arm.*

Differences between anopheles and culex

Anopheles	Culex
i) Eggs are laid singly	Eggs are in rafts
ii) Eggs have air floats to keep buoyant	Eggs have air float
iii) Eggs are boat shaped	Eggs are cigar shapes
iv) Larva lies parallel to the water surface	Lies at an angle to the water surface
v) Larva has a pair of spiracles for breathing	Larva has siphon for breathing
vi) Adult at rest lies at an angle to the object	At rest lies parallel to the object

THE HONEY BEE (*Apis mellifera*)

Classification

Kingdom : Animalia
Phylum : Arthropoda
Class : Insecta
Family : Hymenoptera

Other examples of insects under hymenoptera include bee swamps, ants, gull wasps, etc.
Generally, bees are social insects and live in colonies (large numbers) in bee hives. They show division of labor among the castes for instance;

The queen produces other bees.
The drone fertilizes the queen.
The workers have a number of duties among which include collecting food and cleaning the hive.

External features on the honey bee especially worker include:

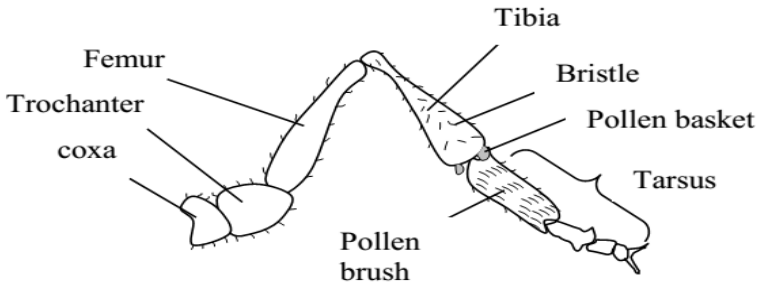
- ✓ The head is not fixed on the thorax and therefore it is free to move (mobile).
- ✓ The compound eyes are prominent. In addition to these are simple eyes which are three in number.
- ✓ The antennae are short and segmented.
- ✓ The mouth parts are a modified proboscis which is curved at the distal end. It is used for lapping during feeding and also used for construction, the glossa also modified for sucking.

The features on the thorax include pairs of legs which differ in various aspects as shown below.

The fore leg	The middle leg
The fore leg has a pollen comb located at the end of the tibia. This is used for cleaning pollen off the head.	These legs possess a hair like structure, prong at the distal end of the tibia. The prong is used for scooping pollen grains out of the pollen basket on the hind leg.

Hind leg

The leg is hairy with pollen baskets, which are responsible for carrying pollen grains.



These have pollen baskets on their tibia which are used for carrying the collected pollen grain to the hive. They also possess tufts of hairs on the tarsus called **pollen brush** which are used for cleaning pollen off the body into the basket on the other leg.

1. The Worker bees:

The workers do not lay eggs because they are infertile females. They are the smallest in size among the bees. They perform the following duties among others:

i) Cleaning the bee hive by eating away dirt and rubbish.
ii) Feeding the old grubs (larva) on honey and pollen.
iii) Packing and storing honey and pollen in the cells of the honey comb.
iv) Feeding the young grubs on their milk produced by their own salivary glands.
v) Producing wax from their wax glands.
vi) Field work to collect food and pollen.
vii) Guarding the bee hive.

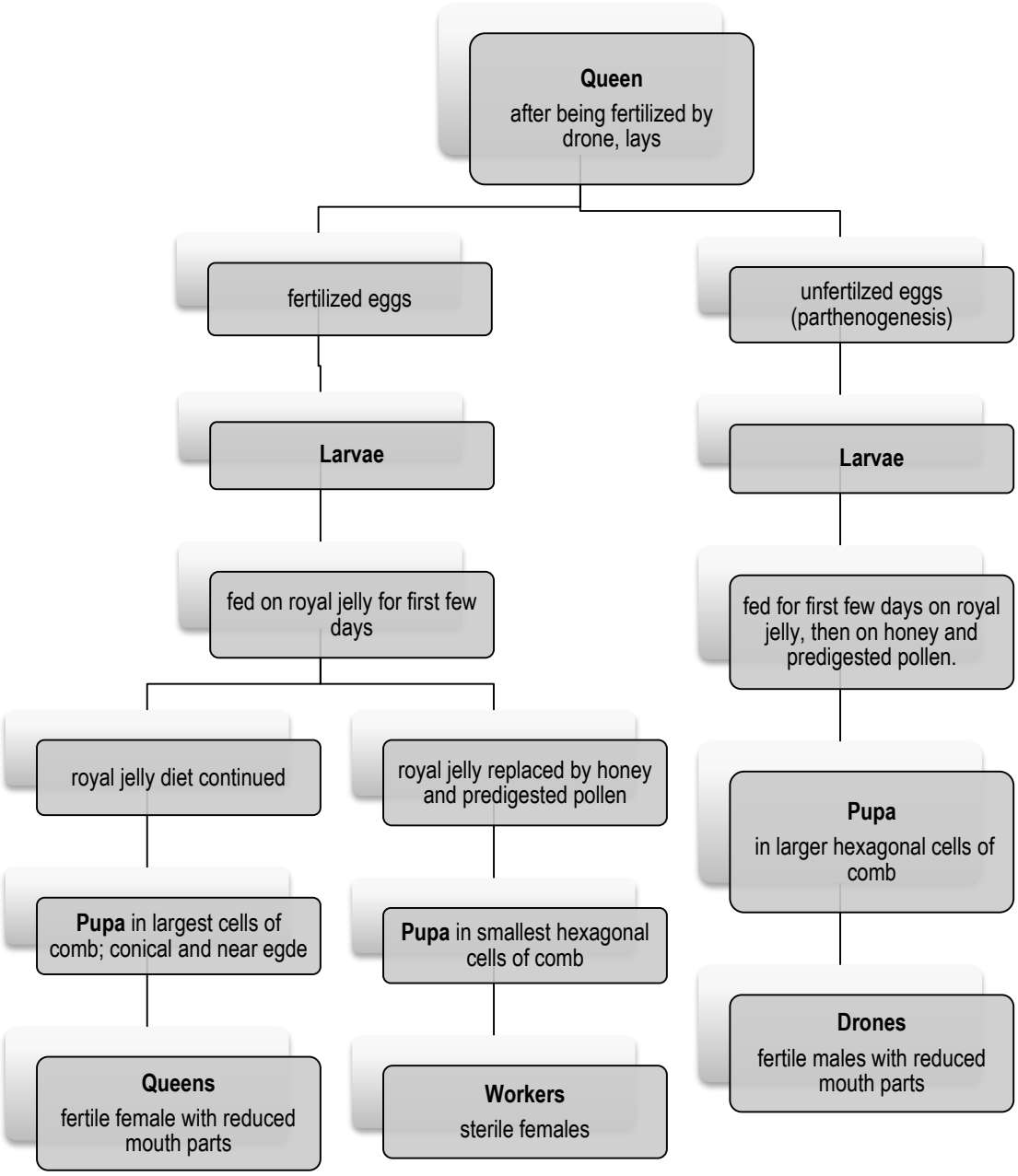
2. The drone bees:

These are male bees. They are larger than workers and are usually very few in the hive. Their role is to fertilize the queen after which they are stung to death by workers.

3. The queen.

This is the fertile female bee. It is usually one in the hive. Its work is to produce all the other bees in the hive.

Life cycle of a bee



Economic importance of bees

- ✓ Source of honey which is a rich food (carbohydrate)
- ✓ Pollinate plants most of which provide food for man.
- ✓ Provide wax used in industry to make candles, varnish, shoe polish etc.
- ✓ Their honey is a drug for many diseases like cough.
- ✓ They are useful specimen for biological studies.
- ✓ The worker bee-stings inflict irritation on our bodies.

PHYLUM: CHORDATA

Chordate refers to animals which possess a notochord.

Main characteristics

- ✓ The presence of a notochord during the early stages of development.

- ✓ They have bilateral symmetry.
- ✓ The body is composed of head, trunk and usually a tail at some stage of development.
- ✓ Possess a hollow dorsal nerve cord.

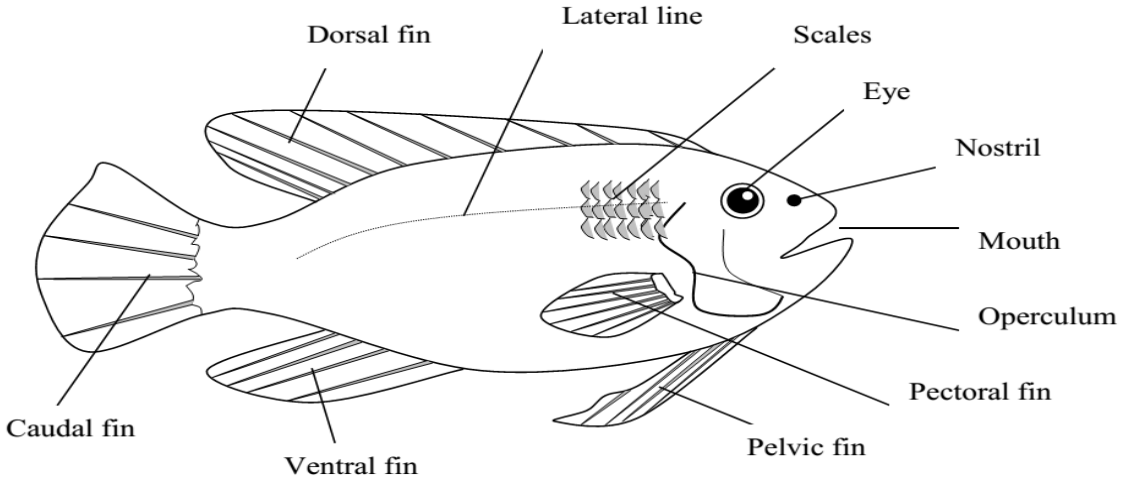
This phylum mainly consists of the vertebrates and they are divided into 5 classes. The 5 classes include the following;

1) **Pisces (**fishes**)** e.g. tilapia and the Nile perch**,**
2) **Amphibia,** e.g. frogs and toads
3) **Reptilia** e.g. snakes, lizards, crocodiles
4) **Aves** - birds
5) **Mammalia** e.g. man and whale

CLASS: PISCES

This class contains fish. Organisms have the following characteristics:

- ✓ They have a streamlined body
- ✓ They scales on their skin
- ✓ They breathe using gills
- ✓ They have fins for swimming.
- ✓ They have eggs that are fertilized outside the body (externally)
- ✓

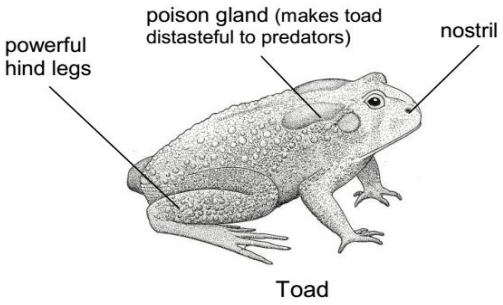


CLASS: AMPHIBIA

This class includes the newt, salamander, toad and frog. The word amphibian comes from two greek words: amphi- (both) and bios (life). This means that amphibians spend part of their life (as larvae or tadpoles) in water, and part of their life as adults on land. Amphibians live on land but require water for breeding.

Characteristics

- ✓ Amphibians have a soft moist skin without scales.
- ✓ They have visceral clefts at the larval stages which are used as gills for gaseous exchange. Adult amphibians use lungs for gaseous exchange.
- ✓ Amphibians have middle and an inner ear but no external ear. However, they have a tympanic membrane also called the ear drum
- ✓ An amphibian has a three-chambered heart with two auricles and a ventricle.



Toad

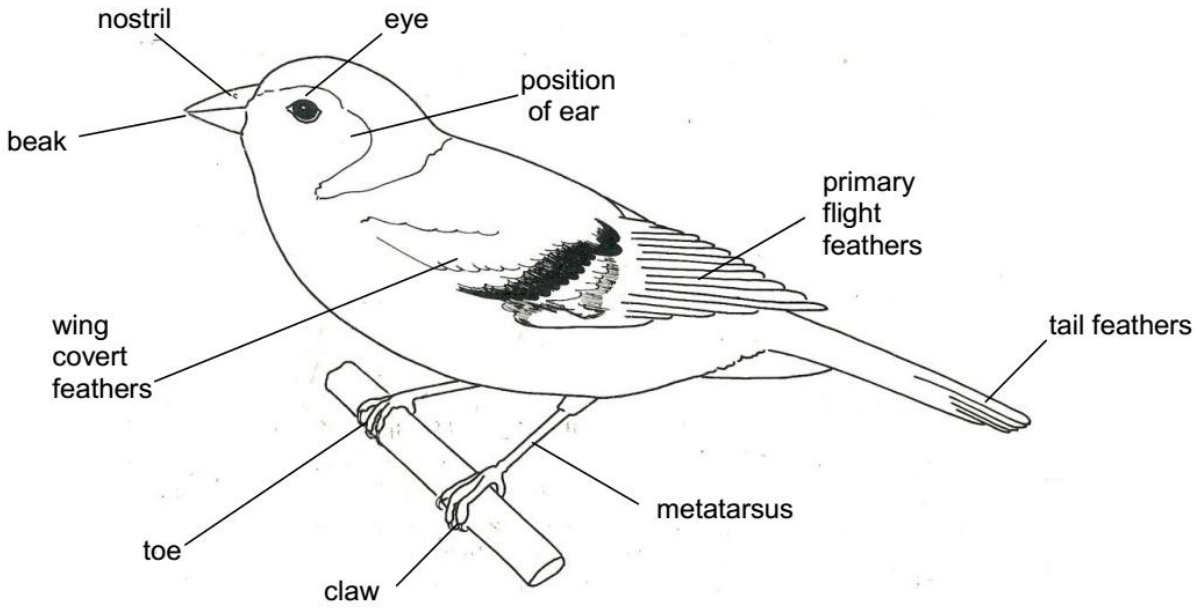
CLASS: REPTILIA

Reptiles are mainly terrestrial with the exception of the turtle which lives in water.
Examples of reptiles include the lizard, snake, crocodile, tortoise and turtle.

- ✓ Reptiles have dry skin with horny scales
- ✓ Most reptiles have pentadactyl limbs
- ✓ Some reptiles have a three-chambered heart; two auricles and one ventricle. Others have four chambered heart for example crocodile.

CLASS: AVES

Aves refer to birds. There exists a wide variety of birds. Examples of birds include eagle, ducks, flamingo, heron, dove etc.



Characteristics

- ✓ The skin of birds is covered by feathers, except the legs which are covered by horny scales. The feathers keep the bird warm and also used for flight.
- ✓ They have skeleton is made of hollow bones. The hollow and light bones reduce weight and enable flight.
- ✓ They have two pairs of pentadactyl limbs. The fore limbs modified into wings for flight while the hind are feet for walking or swimming.
- ✓ They have internal fertilization. They lay eggs in calcareous shells.

CLASS: MAMMALIA

Mammals comprise a wide variety of animals. They mostly occupy terrestrial habitats except few which occupy aquatic habitats. Examples of terrestrial mammals are cows pigs, goats, monkeys, rats, lions etc. and the aquatic mammals are seals, dolphins and whales.

Distinguishing characteristics

- ✓ The skins of mammals are covered by hairs or fur.
- ✓ The skin has sweat glands called sebaceous glands.
- ✓ They have an endoskeleton made up of bones.
- ✓ They have four types of teeth for feeding.
- ✓ They have muscular diaphragm which separates the thoracic organs from the abdominal organs.
- ✓ They have mammary glands.

KINGDOM PLANTAE

The kingdom Plantae comprises a variety of plants.

General characteristics

- ✓ They are mostly green in colour thus carry out photosynthesis
- ✓ They are multicellular.
- ✓ They exhibit; limited movements such as opening and closing of petals etc.
- ✓ Their cells are surrounded by cellulose cell wall.
- ✓ They respond slowly to external stimuli and do not move from one place to another.

The kingdom is sub divided into three divisions, Bryophyta, Pteridophyta, spermatophyta and the algae.

Spirogyra

Characteristics of spirogyra

- ✓ It is filamentous green algae found in fresh water of slow flowing water in ponds, streams, and lakes
- ✓ It grows in length and its always one cell thick.
- ✓ Each cell is capable of living an independent life
- ✓ Each cell has one spiral chloroplast from one end to another
- ✓ Small protein bodies called pyrenoids are present on each ribbon like chloroplast and are used to store starch
- ✓ The nucleus is in the center to control the activities of the cell

Economic importance

- ✓ Algae are used in the manufacture of agar which is used in laboratory experiments.
- ✓ They provide food for humans and fish.
- ✓ When they die, they sink at the bottom of the sea bed on which they can turn into oil.
- ✓ During photosynthesis, they release oxygen that is necessary for the respiration of animals that live in water.
- ✓ They are used in the manufacture ice cream, cosmetics, and plants.
- ✓ They pollute water, i.e. producing foul smell.
- ✓ They clog water pipes hindering the flow of water

DIVISION: BRYOPHYTA

The division is comprised of liverworts and moss plants.

Main characteristics

- ✓ They have simple leaves and rhizoids that are root-like structures. They are used mainly for anchorage.
- ✓ Plants lack vascular bundles thus depend on diffusion for movement of materials.
- ✓ They are found in sheltered and wet areas.
- ✓ Their life cycle consists of the two generations which alternate a gametophyte and sporophyte generation

Examples are mosses and liverworts which belong to 2 classes; musci and hepatica respectively.

DIVISION: TRACHEOPHYTA

These show alternation of generations. The sporophytes differentiate into roots, stems and leaves with lignified vascular tissues that are used for conducting water and food. This division is divided into 2 sub-phyla: Pteridophyta and Spermatophyta.

Pteridophyta:

This is made up of ferns. Ferns are commonly found in shaded places which are damp with cool temperature. Some ferns grow on trees as epiphytes.

The body of a sporophyte fern is divided into leaves, stems and roots. The leaves are called fronds while the stems are rhizomes. The spore forming structures are called sporophyta which occur on the underneath (side) of a frond in clusters called sori.

Main characteristics

- ✓ The sporophyte is the dominant generation while gametophyte generation is short lived.
- ✓ The rhizomes grow horizontally below the soil surface.
- ✓ Ferns have well-delivered conducting tissues i.e. vascular bundles. The xylem also supports the plants.
- ✓ They have the adventitious roots which anchor the plants into the soil and absorb materials.

Spermatophyta

The spermatophyta comprises of well-developed plants which are adapted to a variety of habitats. The habitats include terrestrial and aquatic. The seed are either contained inside the ovary wall or exposed.

General characteristics

- ✓ The body is divided into leaves, stem and root system
- ✓ Plants have complex and well developed vascular tissues.
- ✓ The supporting tissues like xylem, sclerenchyma and collenchyma, are found in leaves, stem and roots. Turgid parenchyma cells also provide support.
- ✓ Reproduce sexually.
- ✓ Sporophyte generation is greatly reduced and short-lived(flower)

The sub-division spermatophyta is subdivided into two sub divisions ie gymnospermae and angiospermae:

Gymnospermae (cone bearing plants)

These are commonly found in high lands/ altitudes areas. They show xerophytic characteristics such as sunken stomata, needle-like leaves, thick waxy cuticle to prevent or reduce rate of transpiration.

Examples include pines, cypress, cedar tree, cycads, jacaranda, and bougainvillea.

Gymnospermae refers to plants whose seeds are not enclosed.

Main characteristics

- ✓ They are non-flowering plants.
- ✓ Their seeds are found in the cone scale.
- ✓ Have needle like leaves which reduce the rate of transpiration.
- ✓ Found in high altitudes and can carry out photosynthesis at low temperatures.

Angiospermae (flowering plants)

These are flowering plants where seeds are enclosed in the ovary of the fruits.

General characteristics

- ✓ They are flowering plants
- ✓ Their seeds are enclosed in the ovary from where the fruits develop
- ✓ The reproductive organs are found within the flower

These are sub divided into two classes. Monocotyledonae and dicotyledonae.

Monocotyledonae

These are mainly grass family. Examples include wheat, rice, barley, star grass, sorghum, maize, millet sugarcane etc.

Distinguishing characteristics

- ✓ Seeds have one cotyledon
- ✓ Have fibrous root system
- ✓ Have parallel veins in their leaves
- ✓ Vascular bundles are scattered in the stem cross section
- ✓ Flowers are held on an inflorescence.

Dicotyledonae

These include herbs, shrubs and trees. Shrubs and trees have stems with supporting tissues such as xylem.

Examples include beans, jacaranda, hibiscus, etc.

Distinguishing characteristics

- ✓ Have seeds with two cotyledons
- ✓ They have tap root system.
- ✓ Have network (reticulate) venation.
- ✓ Leaves are generally broad and short.
- ✓ Vascular bundles are radially arranged in the stem cross section.
- ✓ Have vascular cambium for secondary thickening.
- ✓ The floral parts are in fours or fives or in their multiples.

TOPIC TWO:

FLOWERING PLANTS

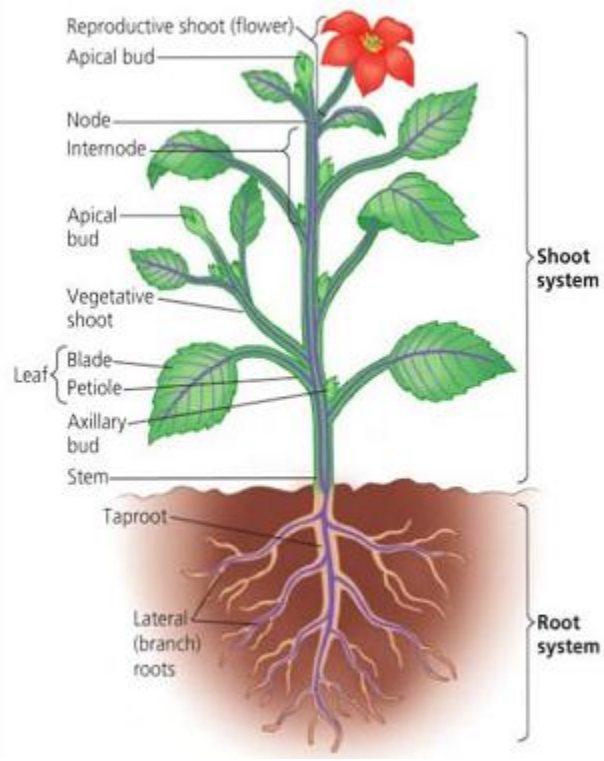
These are plants that bear flowers. A typical flowering plant is composed of 2 systems i.e: Root system and Shoot system

The two systems are made up of two categories of organs i.e.

Reproductive organs: these produce fruits and seeds. They are directly involved in the reproduction of the plant.

Vegetative organs: these are not directly involved in the reproduction. They include roots, stems and leaves.

Structure of a flowering plant



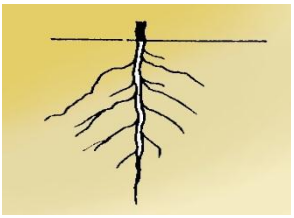
ROOTS

A root is a descending portion of the axis of the plant and develops from the radical of the embryo during germination.

Types of roots

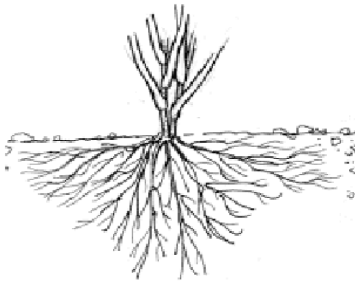
1. Tap root system

This consists of a main root growing straight down wards from the radicle. It gives rise to side roots called lateral roots. Tap root system is a characteristic of dicotyledonous plants.



2. Fibrous root system

This is the root system without a main root and all roots arise from the same point of the base of the stem. The roots are almost of the same size and a characteristic of monocotyledonous plants.



Functions of roots

i) They anchor the plant firmly in the soil.
ii) They absorb water and mineral salts from the ground to the plant.
iii) They conduct the absorbed water and mineral salts up to the stems and leaves.
iv) In some plants, roots are modified into root tubers which store food e.g. cassava.
v) Some roots are modified for breathing e.g. white mangrove.

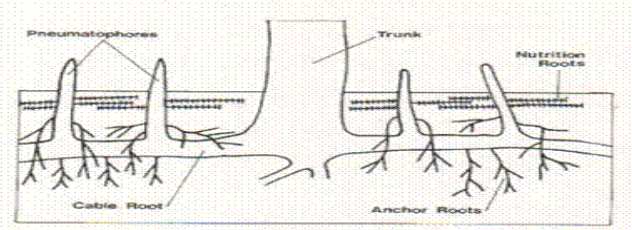
MODIFIED ROOTS

1. Storage roots

These are thick fleshly and succulent roots. ***They contain stored food like sugar and starch. The roots are modified as root tubers*** e.g. ***carrots, cassava and sweet potato roots*.**

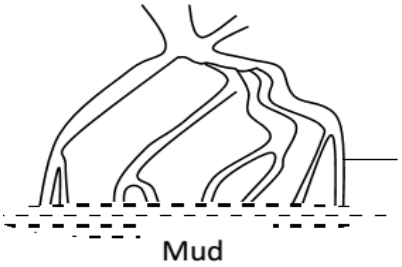
2. Breathing roots

These are found on some plants growing in swampy areas e.g**. *white mangrove***. Its roots grow up through the mud to the air. The root parts above the mud are spongy ***and absorb air from the atmosphere.*** The main root of such plants bears branch roots.



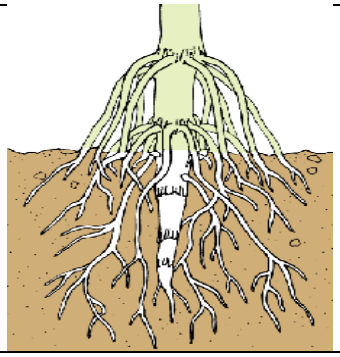
3. Stilt roots

These roots develop from the main stem in certain plants such as ***red mangrove*** which grow in muddy areas. ***Stilt roots provide additional support to the plant.***



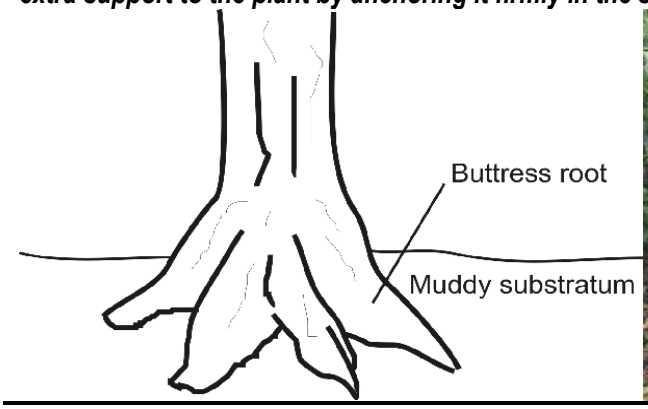
4. Prop roots:

These are found growing on plants such as ***maize, sorghum and sugar canes***. They develop from the nodes of the stem close to the soil surface. ***They provide extra support by holding the plant firmly to the soil surface.***



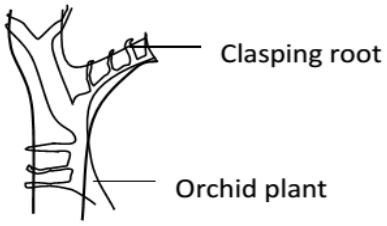
5. Buttress roots

These are large thick roots growing from the base of certain stems e.g. ***Mvule trees, silk cotton***, etc. ***They provide extra support to the plant by anchoring it firmly in the soil.***



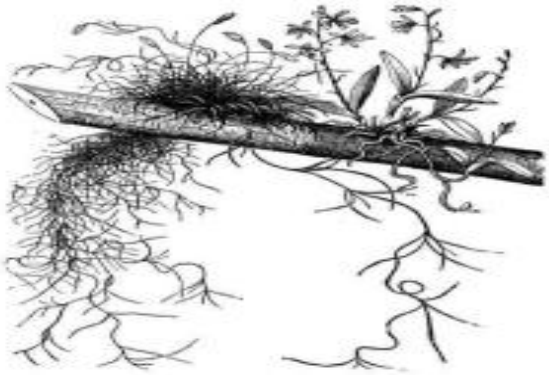
6. Clasping roots

These are roots growing from the nodes of climbing stems such as ***figs (mituba trees), vanilla and orchids.*** They secret a sticky substance which dries up in air. ***<u>This helps such plants to cling on to other plants for support.</u>***



7. Epiphytic roots

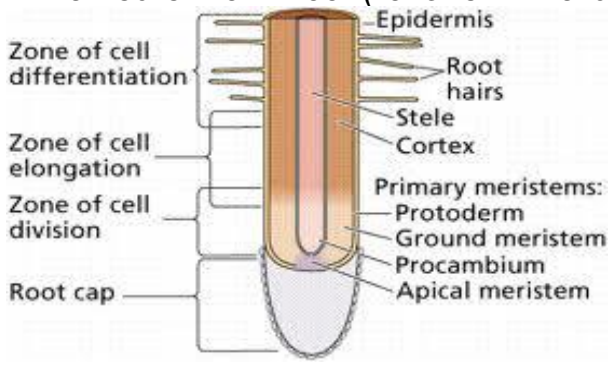
These grow on certain plants called epiphytes. Epiphytes are plants which grow and get support from other plants. These roots hang freely in the atmosphere. ***They absorb moisture from the atmosphere.***



8. Sucking roots

These are roots found growing on certain parasitic plants e.g. ***figs (mituba).*** They grow from the stem and penetrate the host plant. ***These roots absorb water, mineral salts and organic food compounds from the host plant.***

INTERNAL STRUCTURE OF A ROOT (LONGITUDINAL SECTION)



In a longitudinal section through the growing end of a root, its parts are divided into 4 main zone or regions:

1) Root cap
2) Region of cell division (meristematic region)
3) Region of cell elongation
4) Region of cell differentiation (maturation)

1) Root cap

This is found at the tip of the root and is made up of loosely arranged cells. It protects the tender apex of a root from mechanical damage as it makes its way through the soil. It's absent in aquatic plants.

2) Region of cell division

This is the growing apex of the root lying just behind the root cap. The ***cells in this region undergo repeated divisions*** to form new root cap and new cells that increase the length of the root.

3) Region of cell elongation

This is the region lying just above the region of cell division. The cells in this region absorb water and develop vacuoles, the cells being elastic, elongated and enlarged. This causes an overall growth in the length of the root.

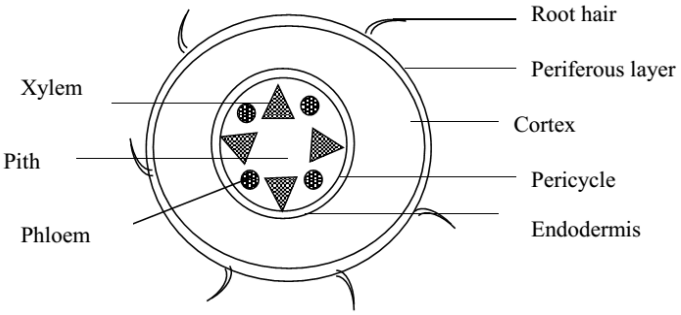
4) Region of cell differentiation

This is also called the region of absorption. The characteristic feature of this region is the development of root hairs; these are fine, delicate, unicellular hair like extensions of epidermal cells (periferous layer). They absorb soil water and dissolved mineral salts from the soil. The cells in this region acquire specific shapes and functions thus they are said to be differentiated or specialized.

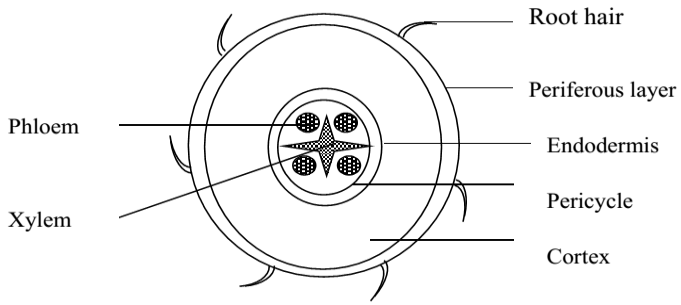
NB: the region behind the zone of differentiation is the oldest part of the root. It has permanent tissues and is covered by a layer of cork which prevents the evaporation of water from the roots.

Transverse section of a root

Monocot root



Dicot root



The transverse or cross section of most young roots has two regions

- The outer cylinder (cortex)
- The central cylinder (stele)

The vascular tissues are composed of xylem and phloem and may contain cambium and pith tissues.

Xylem *is the water conducting tissue through which water and mineral salts pass from the soil upwards to the stem and leaves.*

Phloem *is the food conducting tissue that carries manufactured food from the upper parts of the plant mainly leaves and distributes it to various parts of the root.*

Cambium: *causes secondary thickening of the root.* It adds all secondary xylem cells on its inner side and secondary phloem cells on its outer side by continuous cell division during growing season.

Pith: *is a small area in the centre of the monocot root. It is composed of parenchyma cells for strengthening the root.* It's normally absent in most roots because the centre is normally occupied by the xylem. It also stores food and water for the plant.

Differences between transverse section of monocot and dicot roots

Dicot root	Monocot
1. Has no pith.	Has pith.
2. Can form a ring of cambium.	Cannot form a ring of cambium.
3. The xylem is star-shaped occupying the central part.	The xylem and phloem alternates forming a ring.

STEMS

This is the ascending portion of the plant axis that develops from the plumule of the embryo. It has the following characteristic features;

i) It bears leaves at the nodes.
ii) It has nodes and internodes.
iii) It has buds in the axills called axillary buds.
iv) It has flowers or fruits.
v) Its terminal bud is located at the tip of the stem.

NB: the axill is the angle between the leaf and the stem.

Functions of stems

a) **Primary functions**

i) They hold leaves in the best position for receiving enough sun light needed in the process of photosynthesis.
ii) They conduct water and mineral salts from roots to leaves and manufactured food from leaves to other parts.
iii) They hold flowers and fruits in good position so that they can be easily pollinated or dispersed.
iv) When stems are young, they carry out photosynthesis thus making food for the plant.
v) Stems have lenticels (pores) that facilitate gaseous exchange.

b) Secondary functions

i) Some stems may specialize in storing food and water e.g. stem tubers like corms, Irish potatoes, rhizomes and sugar cane.
ii) Protect a plant against browsers by forming thorns, spines or prickles.
iii) Vegetative reproduction or propagation through the stem cuttings e.g. cassava and sweet potatoes.
iv) They support the plant by climbing stem tendrils e.g. *pasum* pea (wild pea).

TYPES OF STEMS

1) Erect stems

These can support themselves in an upright position. They may be woody or herbaceous.

Woody stems: These have a high content of lignin and are hard. They are found in shrubs and trees.

Herbaceous stems: These contain no or less woody materials e.g. tomatoes, rice. The herbs are shorter than grass.

2) Weak stems

These can't support themselves upright but either creep or climb for support.

3) Underground stems

These are modified stems which remain permanently underground. They are often swollen and serve as food storage organs.

NB:

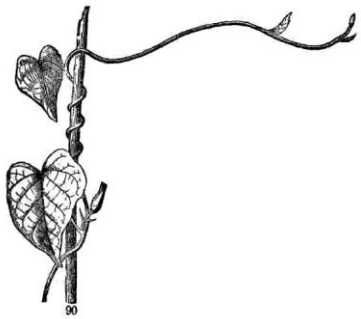
- Annual herbs only live for one year
- Bi – annual herbs live for two years
- Perennial herbs live for many years

MODIFICATION OF STEMS

Weak stems

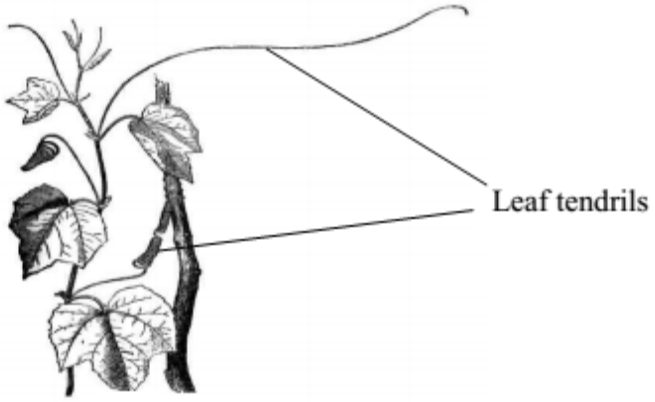
1. Twinning stems (twinners)

These are stems that grow ascending spirally around a support. They are usually long and slender e.g. Dutch man's pipe and lianas.



2. Climbing stems

These are stems that grow clinging to the support of other plants by means of tendrils. Tendrils are thin wire-like spirally coiled branches of certain stems. They may be modified at axillary buds e.g. in passion fruit plants or terminal buds



3. Creeping stems (creepers)

These are long thin stems which grow along the surface of the ground, giving off roots at certain intervals of the nodes. Four types of creeping stems are;

a) **Runners**

This is a slender trailing stem lying flat on the ground possessing long internodes. A runner arises as an axillary bud and creeps some distance away from the mother plant and grow into another plant e.g. oxalis.

b) Offset stems

This is a horizontal thickened short stem. It originates from the axil of the leaf and grows flat on the ground. It produces many leaves above and a cluster of roots below e.g. water hyacinth and water lettuce.

4. Sucker

A sucker is a creeping stem that grows obliquely upwards, directly giving rise to a leafy shoot. E.g. banana, pineapple, sisal plant, etc.

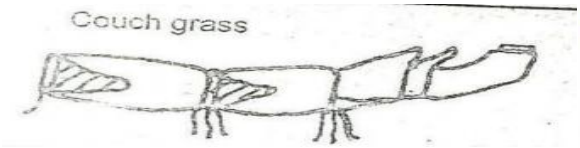
Underground stems

There are four types of underground stems namely: Rhizome, Corm, Stem tuber and Bulb.

1. Rhizomes

This is a horizontal thick underground stem having adventitious roots growing from the lower side of the nodes. It has terminal buds which develop into aerial shoots. It bears buds in axils of the reduced brown leaves called scale leaves.

Rhizomes store a lot food for the plant. Some also act as organs for vegetative propagation e.g ginger, canalily, couch grass and Solomon's seal.

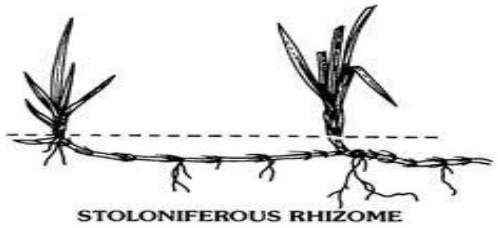


2. Stem tuber

This is a short, fleshy underground stem swollen with large amounts of stored food. It has scale leaves and axillary buds which form the "eyes" e.g Irish potato, yams.

3. Stolon

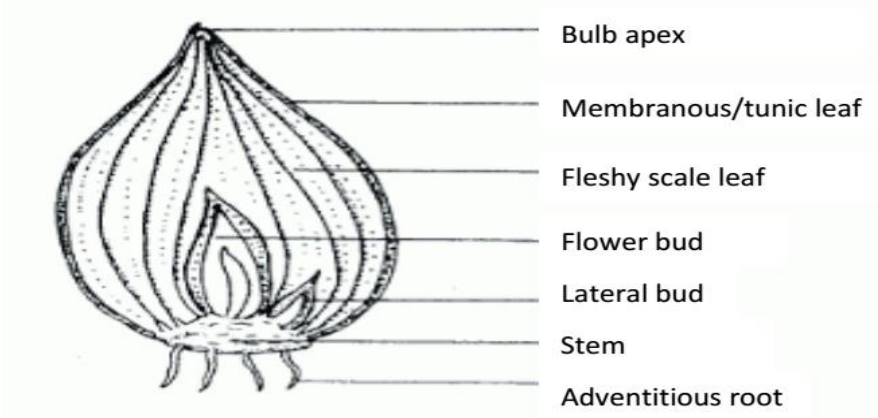
A stolon is a horizontally growing stem that roots at the nodes and develops buds that grow into new plants. E.g. straw berry.



4. Bulb

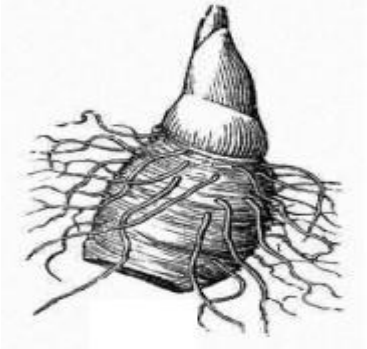
A bulb is short conical-shaped underground stem comprising of thick fleshy leaves arranged in concentric circles. The thick fleshy leaves store food for the plant and are protected by outer dry brown leaves called scale leaves.
A terminal bud lies at the top of the stem and give rise to the aerial shoot. Axillary buds are situated between the leaf bases. Onions, garlic, tuberose, etc. are bulbs.

Structure of a bulb (onion)



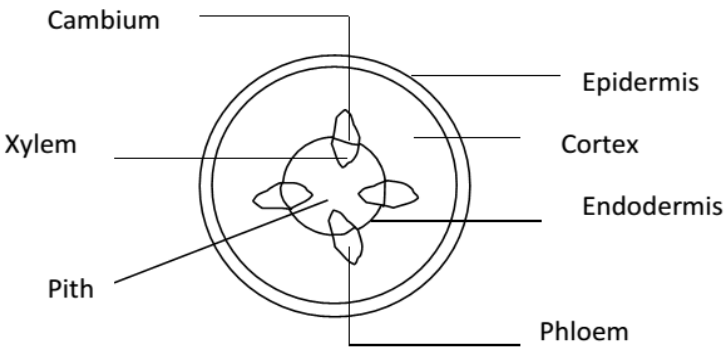
5. Corm

A corm is a swollen fleshy underground stem that grows in a vertical direction. It is round-shaped and somehow flattened from the top to bottom. It has a terminal bud lying at the top of the stem and has scale leaves a rising from the nodes. Its roots grow randomly from the stem. Examples of corms are coco yams and yams.

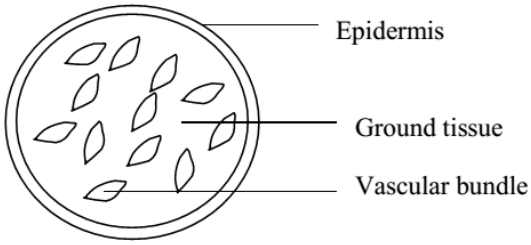


INTERNAL STRUCTURE OF STEMS

Transverse section of a dicot stem



Transverse section of a monocot stem



Internally stems have 3 main tissues;

1. Epidermis

It comprises of a single layer of cells which are brick-shaped. The outer wall of these cells is thickened by cutin, a waxy material which forms the outside skin of a stem called cuticle.

- ❖ It protects the stem against water loss.
- ❖ It also protects the inner tissues of the stem from mechanical injury.
- ❖ It prevents entry of bacteria and germs into stem.

2. Cortex

This is the part of the stem between the epidermis and the vascular bundles. It's made up of collenchyma, parenchyma and endodermis.

i) Collenchyma

This is the outer tissue of the cortex. It's 3 or more cells thick. The cells are small, tightly packed and thickened at their corners. They offer mechanical support, hence strengthening and giving rigidity to the stem.

ii) Parenchyma

This is made up of large thin walled cells. These cells have air spaces between them called intercellular spaces. The spaces provide passage for water vapour and gases in the stem. Parenchyma cells offer support to the stem when filled with water and store some food.

iii) Endodermis

This is a single layer of rectangular shaped cells. It contains starch usually, and its main function is storage of food.

3. Vascular bundles

These are conducting or transporting tissues of a plant. They consist of xylem and phloem. The phloem lies externally and the xylem lies internally in each bundle.

Phloem:

The phloem conducts and transports manufactured food. It is made up of three main cells:

i) **Sieve tubes**
These are cylindrical tubes arranged end to end in long rows. Their cross-walls have many fine pores forming a sieve plate. They conduct manufactured food in the stem.

ii) **Companion cells**
These are smaller than the sieve tubes. They are filled with a dense cytoplasm and have nucleus. They control the activities of the sieve tubes.

iii) **Phloem parenchyma**
It stores some food in the stem. They are the first to be formed in the vascular bundle.

Xylem:
Xylem is water and mineral salts conducting tissue. It comprises of 2 types of cells i.e. vessels and tracheids. These cells have their walls thickened with a substance called lignin.
The xylem also provides mechanical strength to the stem due to the presence of lignified dead cells.
The lignified dead cells formed between the endodermis and phloem is termed as sclerenchyma.

Differences between dicot and monocot stems

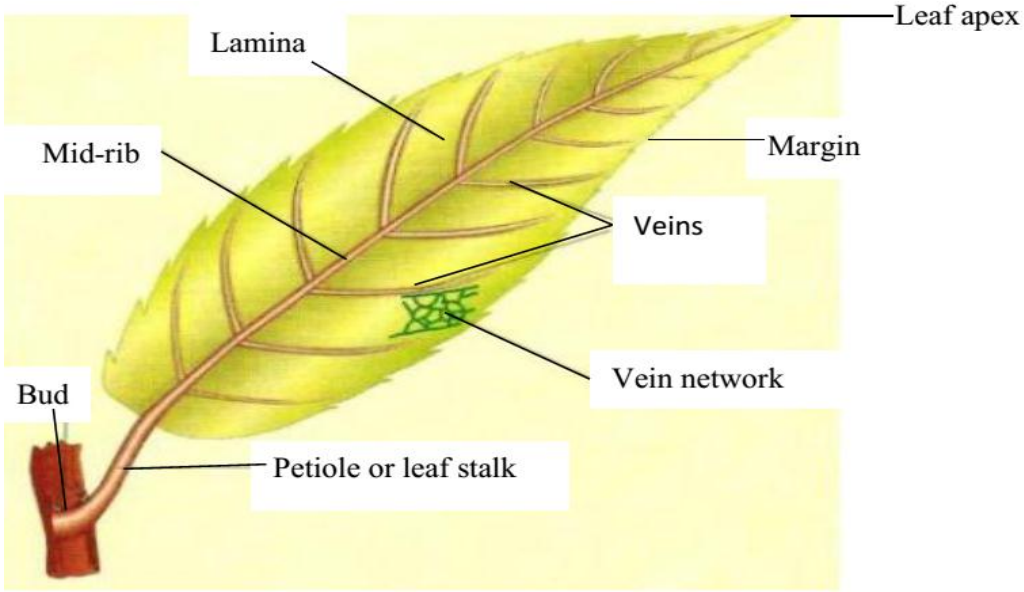
Monocot stem	Dicot stem
Lack cambium	Has cambium. The cambium is responsible for secondary growth or thickening of the stem.
The vascular bundles are scattered within the stem.	The vascular bundles are arranged in form of a ring.
Lack a distinct cortex and pith.	Has a distinct cortex and pith. The pith is wide.
Its cortex has several layers of parenchyma cells.	Its cortex has a few layers of parenchyma cells.

LEAVES

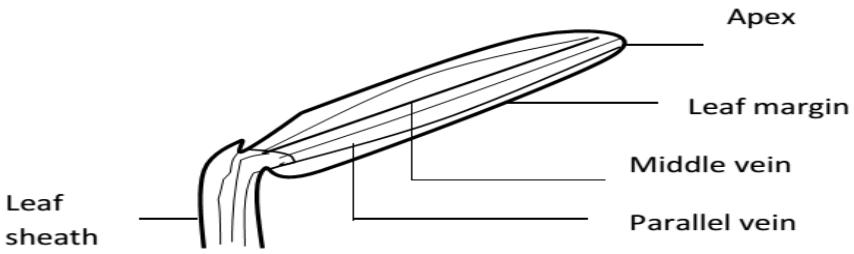
A leaf is a thin flattened structure which grows from the nodes of a stem or its branches and has a bud in its axil. Leaves are generally green although some are red or brown. The leaf is made up of 3 main parts;

External structure of a leaf

Dicot leaf



The monocot leaf



Leaf base; this is the part which attaches the leaf to the stem.
Petiole; this is the part which connects the leaf base to the leaf blade. Leaves with a petiole are called ***petiolate*** and those without are called ***sessile.***
The ***leaf stalk*** is a characteristic of dicots while a ***leaf sheath*** is found in monocots. The leaf stalk/sheath can be hairy or smooth.
Lamina; this is the expanded and flattened portion of the leaf consisting of veins and midrib.
Texture of lamina; the lamina may be hairy or smooth. It may be hard or soft.

Venation

The arrangement of veins in the lamina of a leaf is called venation. Two broad types of venation are;

1. **Network venation/reticulate venation**

In network venation, the veins in the lamina branch while intersecting to form a network. It's a characteristic of dicots.

2. **Parallel venation**

In this venation, the veins run side by side without branching. This is a characteristic of monocotyledonous plants.

Leaf complexity

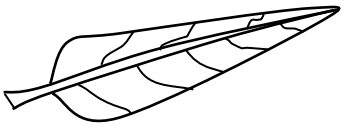
Leaves can be classified according to whether the leaf lamina is completely divided or not divided. Two broad types are:

- Simple leaves
- Compound leaves

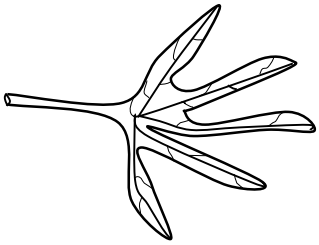
1. **Simple leaves**

A simple leaf has a single lamina which isn't divided up into leaflets e.g. Avocado, mango, orange, hibiscus, pawpaw, cassava, etc. Cassava and pawpaw leaves are partly divided. The lobes are not considered to be leaflets because the divisions do not reach down the midrib. They are simple digitate i.e.

Simple leaf of a mango



Simple leaf of cassava



A swelling at the base of the leaf stalk is called ***pulvinus*** e.g. beans and cassava. Some leaves have it while others do not have it.

2. **Compound leaves**

A compound leaf has a lamina which is completely divided into leaflets. They resemble leaves but are not leaves because the axillary buds are absent in the axis of leaflets e.g. beans, oxalis, cassia, etc.

Types of compound leaves

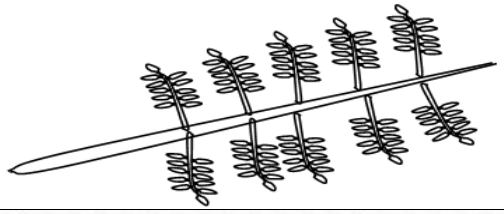
i) Compound pinnate leaves

These are compound leaves with leaflets arranged either in pairs opposite one another or alternately along the midrib called rachis of the leaf. If the terminal leaflet is present, the leaf is said to be ***imparipinnate*** and if the terminal leaflet is absent, the leaf is said to be ***paripinnate.***

Imparipinnate **Paripinnate**

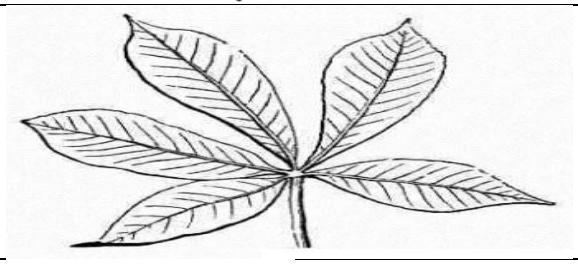
ii) Compound bipinnate leaves

These are compound leaves with 2 orders of leaflets. Leaflets are further divided up to form leaf-like structures called pinnules e.g. jacaranda.



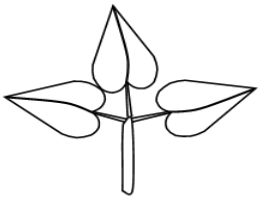
iii) Compound digitate leaves

These are compound leaves with leaflets radiating out from the end of the petiole-like fingers of the hand.



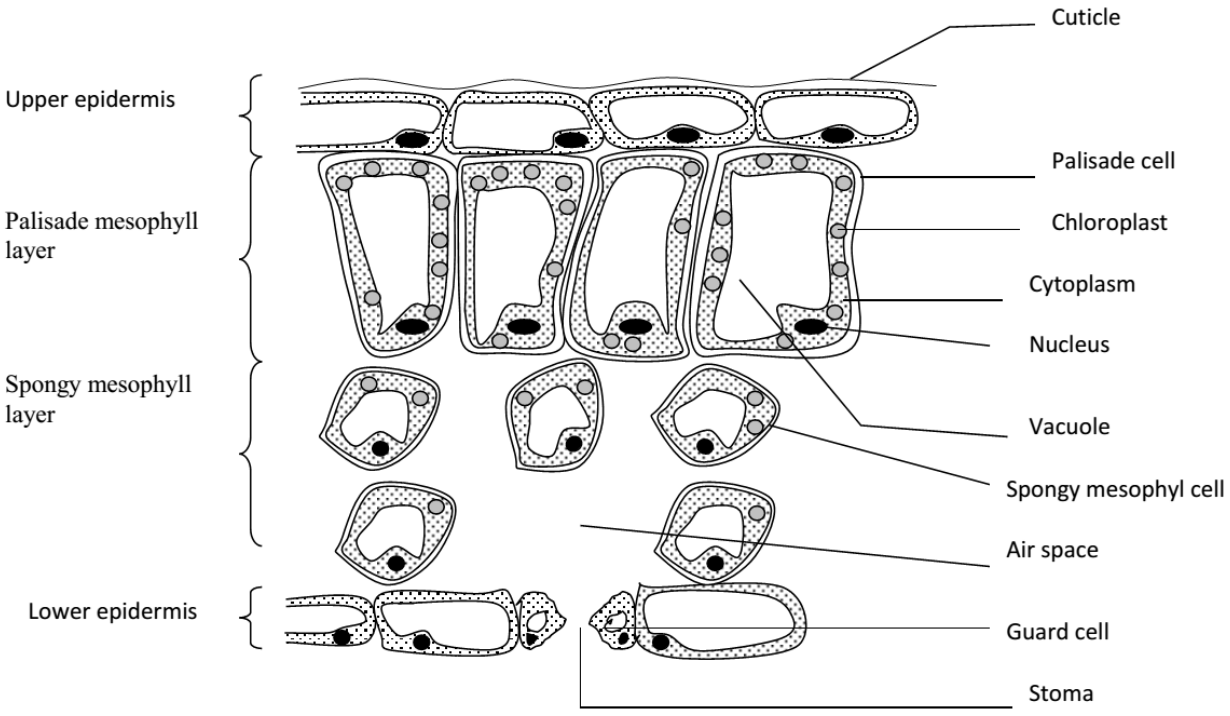
iv) Compound trifoliate leaves

These are compound leaves with only 3 leaflets. They include soya beans, oxalis and straw berry.



NB: stipules (foliar appendages) are attached to the leaf base or petiole e.g. in beans, hibiscus and cassia.

INTERNAL STRUCTURE OF A LEAF



1. Epidermis:

This is the outer most layer of a leaf. It acts as a skin covering the whole leaf surface. It's covered by a transparent water porous layer of cutin called cuticle. This cuticle allows light penetration into the leaf and prevents excess water loss from the leaf surface.

The epidermal tissue is divided into 2 according to the location on a leaf i.e. upper and lower epidermis. The upper epidermis is a single layer of brick-shaped cells covered by a thick cutin in case of terrestrial plants or land plants.

In most plants, it does not possess stomata and if present are few. This is so as to control the amount of water loss during transpiration process.

The major function of this epidermis is to prevent evaporation of water from the leaf cells and protection of the inner cells.

The lower epidermis is usually made up of one layer of cells and contains numerous openings called stomata.

These stomata are protected by 2 guard cells. In water plant e.g. water lily or hyacinths, stomata are few on this side of the leaf. Some chloroplasts are present in this layer of cells.

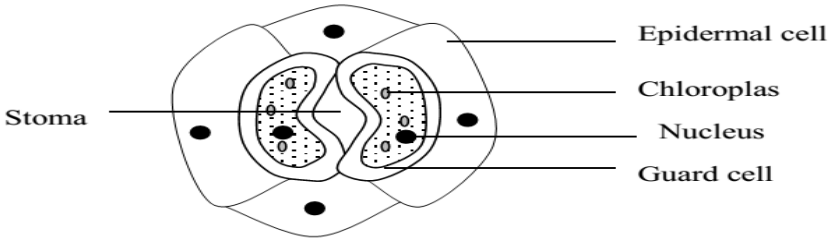
Stomata

These are small openings found in the epidermis of a leaf. They are surrounded by 2 guard cells. Plants growing on land have more stomata located in the lower epidermis than in the upper epidermis. (The reverse is true for aquatic plants)

The function of the stomata is to allow entry and exit of important gases like O_2 and CO_2 into the leaf.

The stomata also regulate the loss of water vapour from the plant i.e. they control transpiration.

Structure of the stomata



2. Mesophyll:

This is located between the upper and the lower epidermis. It's differentiated into two layers. i.e.

i) Palisade layer

It's found just below the upper epidermis. It's made up of cylindrical shaped cells. The cells are closely packed together without air spaces. The palisade cells contain many chloroplasts which are the major sites for photosynthesis.

Chloroplasts are small and made up of proteins. They contain chlorophyll which gives green plants their colour. The chlorophyll absorbs sun light energy that is used in the process of food manufacture (photosynthesis).

ii) Spongy mesophyll layer

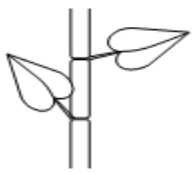
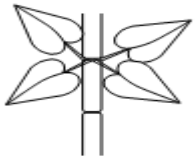
It's found under the palisade layer. It consists of cell called spongy cells which are irregularly arranged. These cells are not closely arranged, and therefore have large intercellular air spaces between them. The air spaces are connected with each. There is also the sub-stomatal air chamber where the gases collect before moving out of a leaf. Spongy cells contain fewer chloroplasts than the palisade cells hence they manufacture food.

3. Vascular tissue

These are vascular bundles consisting of veins. Each vein has a phloem for transporting manufactured food and the xylem for conducting and distributing water and mineral salts. The veins also provide mechanical support to the leaf lamina.

Arrangement of leaves on a stem

Arrangement is the insertion of leaves on the stem. Leaves develop at the nodes in the stem and are arranged in different ways.

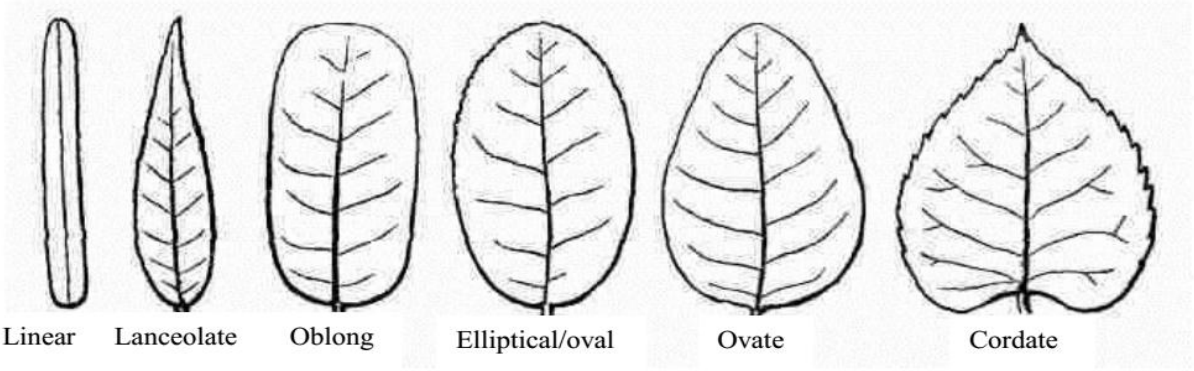
Alternate leaf arrangement	Opposite leaf arrangement	Whorl leaf arrangement
		

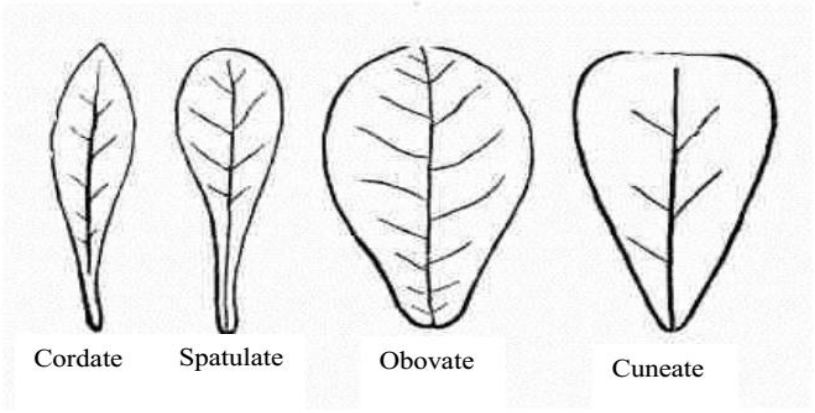
Types of leaf margins

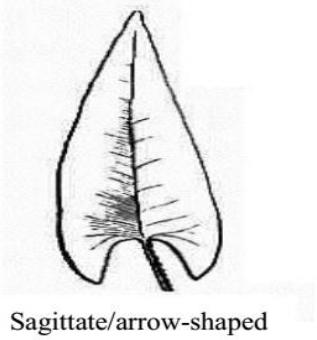
Leaves can be classified according to the leaf margins.

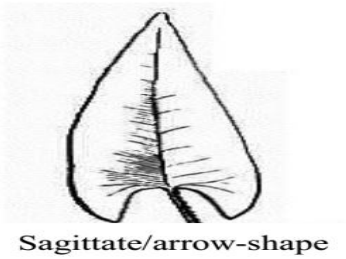
1. **Entire margin**
   The margin is smooth and without indentation of any kind. E.g. mango leaves.
2. **Serrate margin**
   The margin is with indentations pointing towards the apex.
3. **Crenate margin**
   The margin has round indentations.
4. **Dentate margin**
   The margin has indentations pointing towards the petiole.
5. **Lobed margin**
   The margin has relatively few and shallow indentations.

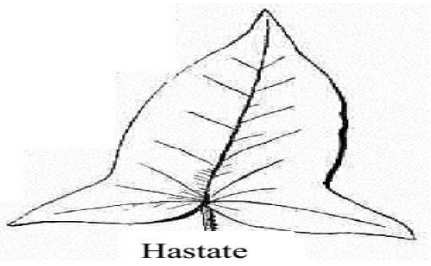
Types of leaf shapes

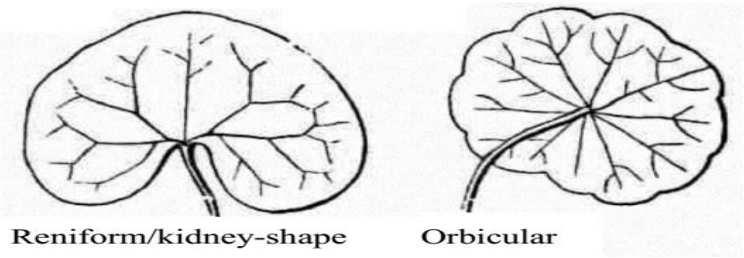












Functions of leaves to plants

a) Primary functions

- The major function is to manufacture food for the plant during photosynthesis.
- Leaves have stomata which allow exchange of gases i.e. O_2 and CO_2.
- Leaves facilitate transpiration which sometimes helps the removal of excess water within the plant.

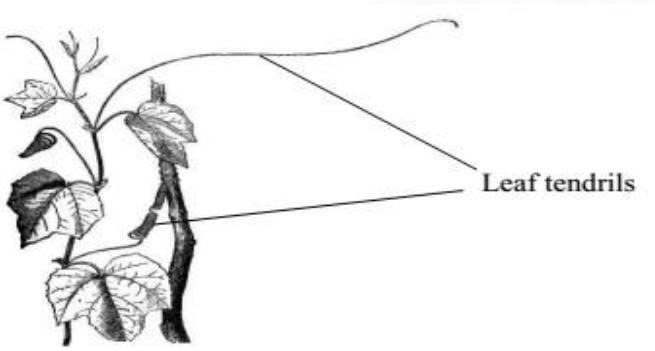
b) Modified or secondary functions

- They store food and water for the plant e.g. the thick fleshy leaves of onions.
- Some plant leaves are useful in vegetative reproduction e.g. bryophytes.

Modification of leaves

Leaves of some plants have become modified to perform other functions other than photosynthesis.

1. Leaf tendrils



These are slender wire like coil structures used as climbing organs in climbers for support. The leaf may be partly modified into a tendril.

2. Leaf spines

These are sharp pointed structures of certain plants modified for defense.

3. Scale leaves

These are thin, dry membranous structures usually brown in colour and sometimes colourless. Their main function is to protect the axillary bud from mechanical injury and drying out. They are commonly found on underground stems. E.g. scale leaves of onions, rhizome and garlic.

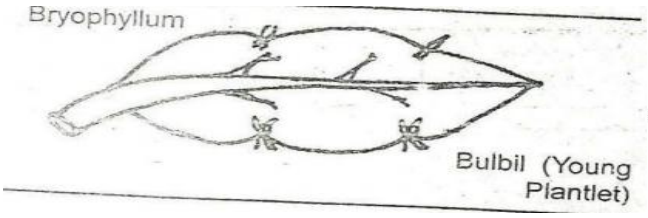
4. Insectivorous leaves

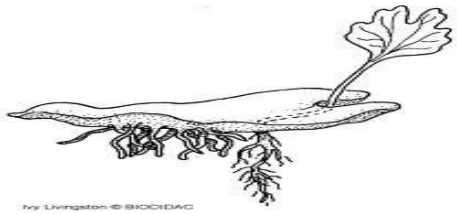
These are modified leaves whose function is to capture and digest insects. Such plants are called insectivorous plants.

Pitcher plants grow in soil with a deficiency of nitrogen/nitrates. They obtain nitrogen from insects. E.g. Venus fly trap, butter wort, sundew, bladder wort, nepenthes, and the pitcher.

5. Bryophyllum leaves

Leaves have series of buds at the end of vein. These buds grow into new plants (plantlet) when the leaf is mature.

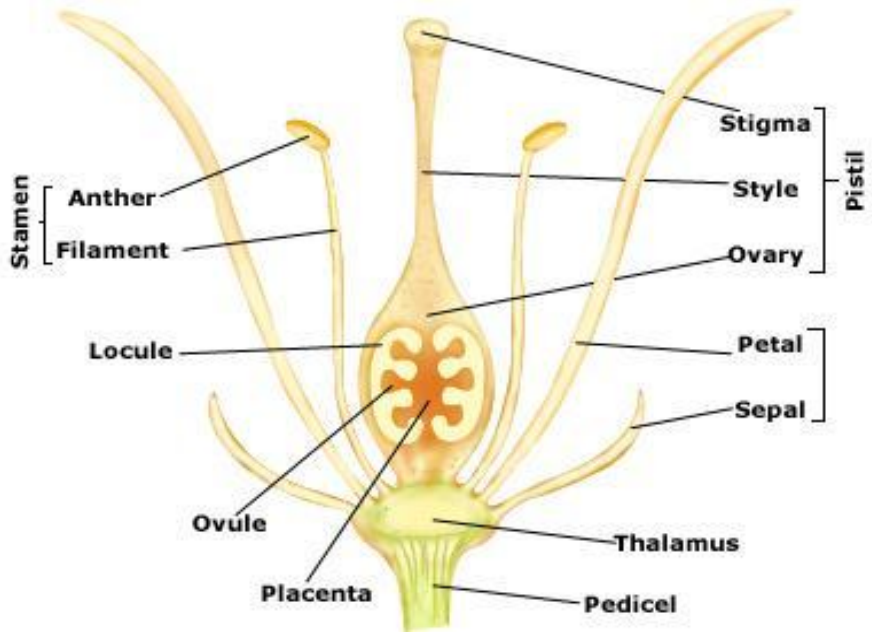




THE FLOWER

The flower is part of the shoot specialized for reproduction. Most flowers have male and female reproductive organs though some are of a single sex. A group of flowers is called an ***inflorescence*** e.g. maize flower.

General structure of a flower



When petals, calyx, epicalyx and the sheath of the staminal tube have been removed, this is shown in the diagram

Parts of a flower

The floral parts are arranged in rings, spirals or whorls with short internodes. The end of a flower stalk may be expanded to form a receptacle. The stalk of the flower where floral parts grow is called pedicel.

The four floral whorls are ***Calyx, Corolla, Gynoecium and Androecium.***

The calyx is the outer most floral whorls of the flower made up of sepals. The calyx protects the inner whorls of a flower during the bad stage.

The corolla is the second floral whorl of a flower made up of petals. Most flowers have scented petals to attract insects for pollination e.g. hibiscus, crotalaria, coffee, morning glory, etc. the calyx and corolla are collectively known as Perianth.

Androecium is the male part of the flower consisting of stamen. Each stamen is made up of filament and head called anther. Anthers contain pollen grains which develop to form male reproductive cells called gametes.

N.B: an infertile or sterile stamen is called staminode.

Gynoecium (pistil) is made up of female reproductive parts called carpels. The pistil occupies a central position in the flower. Each carpel is made up of;

- ✓ Ovary which contains ovules or female gametes.
- ✓ Style which connects the ovary to the stigma
- ✓ Stigma which receives the pollen grains

The wall of the ovary develops into the pericarp of the fruit. Nectaries are swellings often at the base of the ovary or on the receptacle which produce a sugary solution called nectar.

Types of pistils

Three main types of pistils are:

1. **Monocarpous:** This is a pistil with only one carpel e.g. morning glory and cow pea.
2. **Syncarpous pistil:** This is a pistil with carpels fused together e.g. hibiscus and isolanum.
3. **Apocarpous pistil:** This is a pistil with several carpels which are not fused i.e. as distinct carpels e.g butter cap and Bryophyllum.

Types of ovaries

The two types of ovaries include the following

1. **Superior ovary:** Is the one that arises above the other floral parts e.g. hibiscus, cassia, commelina, mimosa pudica, etc.
2. **Inferior ovary:** Is the one which arises below the rest of the floral parts e.g. morning glory.

Hypogenous: The gynoecium is situated at the apex of the receptacle and other whorls arise below it. The sepals and petals are inserted independently below gynoecium. Hypogenous flower has superior ovary.

Terms used

Complete flower: A flower having all the four whorls or floral parts i.e. calyx, corolla, stamen and pistil.
Incomplete flower: A flower lacking one or more of the four floral parts.
Perfect flower: Is a flower with both male (stamen) and female (pistil) parts.
Imperfect flower: A flower lacking either stamen or pistil.
Unisexual flower: Has only one of the sexual parts i.e. staminate; when the flower has stamens only. Pistillate (carpellary) when it has carpels only.
Staminode: sterile stamen.
Bisexual (hermaphrodite) flower: is one that contains both male and female organs and parts.
Monoecious plant: Is one that has the pistillate and staminate that are born on the same plant but at different points on the plant e.g. maize and castor oil plants.
Dioecious plant: is one that bears either pistillate or staminate flower only e.g. pawpaw.
Dichogamy: Is a condition in which the male and female parts of a flower mature at different times. There are 2 types;

- **Protandry:** when the anthers mature before the stigma.
- **Protogyny:** where by the stigma matures before the anthers.

Regular (actinomorphic) flower: a flower which can be divided symmetrically (equally) in different planes.
Irregular (zygomorphic) flower: is one which can be divided into 2 similar halves in only one plane.
Polysepalous: is when the sepals are borne free or are separate and are distinct from each other.
Gamosepalous: is when the sepals are fused or joined together.
Petaloid: Sepals resembling petals and have the same colour.
Gamopetalous: Are petals which are wholly joined or fused together e.g. morning glory, sweet potatoes.
Sepaloid: They are petals which resemble sepals and are green in colour.
Septum: Is an internal dividing wall or partition with in a syncarpous ovary.
Locules: Is an internal compartment of an ovary of fruits.
Simple flowers may be borne on a common flower stalk called peduncle while individual flowers may be borne on a pedicel.

POLLINATION

Pollination is the transfer of pollen grains from the anther to the stigma of a flower. There are two types of pollination.

1. **Self-pollination**. This is the transfer of pollen grains from the anther to the stigma of the same flower or between two flowers on the same plant.
2. **Cross-pollination**. This is the transfer of pollen grains from the anthers of one flower to the stigma of another flower on a different plant but of the same species.

Agents of pollination

These are things that aid the process of pollination. The agents of pollination include.
Animals, Water, Wind and Artificial pollination
There are however two major agents that is wind and insects. Pollination can therefore be described as wind pollination and insect pollination.

Characteristics of insect pollinated flowers

i) They have brightly coloured petals to attract insects.
ii) They have a scent to attract insects

iii) They have large conspicuous petals, which act as landing sites for insects.
iv) They have sticky pollen grains, which stick to the insects' body.
v) They have sticky stigmas, which hold pollen grains.
vi) They produce few sticky pollen grains.
vii) They produce heavy pollen grains.
viii) They produce nectar from nectarines to attract insects.

Characteristics of wind pollinated flowers.

i) They have dull coloured petals.
ii) They have small petals.
iii) They produce light pollen grains, which can easily be carried by wind.
iv) They do not produce nectar
v) They have feathery stigmas to trap pollen grains carried by wind.
vi) They produce a lot of pollen grains.
vii) They have no scent
viii) They have long stamens and pistils hanging outside the petals to release and receive respectively pollen grains easily.

Differences between insect and wind pollinated flowers.

Insect pollinated flower	Wind pollinated flower
Have brightly coloured petals	Have dull coloured petals
Have a scent	Have no scent
Produce nectar from nectarines	Produce no nectar
Have large petals	Have small petals
Produce few pollen grains	Produce a lot of pollen grains
Have sticky stigmas	Have feathery stigmas
Produce heavy pollen grains	Produce light pollen grains
Have short pistils	Have long pistils
Have short stamens	Have long stamens

Characteristics of flowers pollinated by nocturnal insects

Nocturnal insects are those insects, which are active at night. Flowers pollinated by such insects have the following characteristics.

1. They have light coloured petals mainly white and pink.
2. They produce a strong scent.
3. They open their petals at night and close them during daytime.

Modifications of flowers to prevent self-pollination

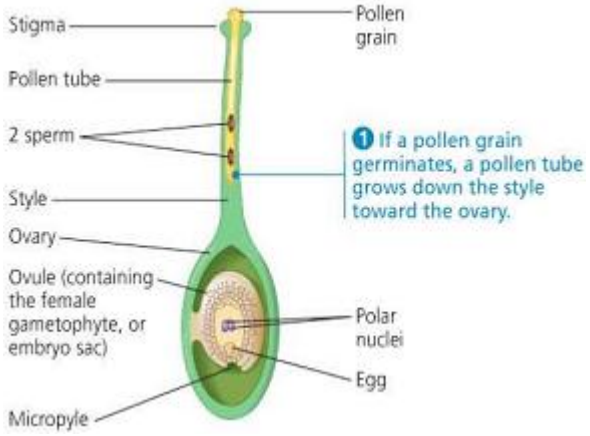
1. **Protandry**. This is a situation where stamens ripen before the stigma such that when pollination occurs, the pollen grains cannot germinate on the immature stigma.
2. **Protogyny.** This is a condition where the stigma ripens before the anthers.
3. **Dioecious condition**. This is a condition where a plant bears either pistillate or staminate flowers but not both.
4. **Self-incompatibility**. This is where pollen grains from the same flower fail to fertilize the stigma of that flower.
5. **Structure of the flower**. Sometimes the carpel is taller than the stamens of the same flower and in some flowers the corolla covers the stamens preventing self-pollination.

FERTILIZATION IN PLANTS

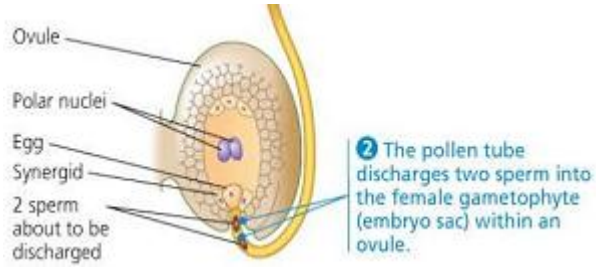
This is the fusion of male and female gamete to form a zygote. Fertilization in plants is internal taking place inside the ovary in the structure called embryo sac.

The process of fertilization in plants

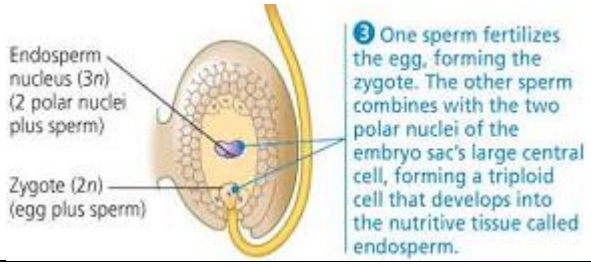
1. Pollen grain lands on the stigma of a flower of the same species.
2. On the stigma, pollen grain absorbs water, nutrients and then germinates to form a pollen tube which grows through the style under the control of the tube nucleus at the tip.
3. Pollen grain has two nuclei i.e. generative nucleus and pollen tube nucleus. The generative nucleus divides mitotically to form two male nuclei which lie behind the pollen tube nucleus.



4. The pollen tube enters the ovary and the tip of the pollen tube breaks. The pollen tube nucleus disappears.



5. One of the male nucleus fuse with the egg nucleus to form a zygote which divides mitotically to form embryo.
6. The other male nucleus fuses with two polar nuclei to form a triploid endosperm which develops into endosperm. This is called double fertilization.



Events after fertilization

- The zygote divides mitotically followed by growth and development resulting into an embryo.
- The triploid endosperm divides mitotically to form good solid organs called endosperm.
- The ovules develop into seeds.
- The integuments become the seed coat.
- The ovary develops into a fruit and ovary wall develops into a fruit wall which protects the seeds.
- Petals, stigma, style and stamen wither and fall off while the calyx may wither and fall off or may remain in shriveled form.

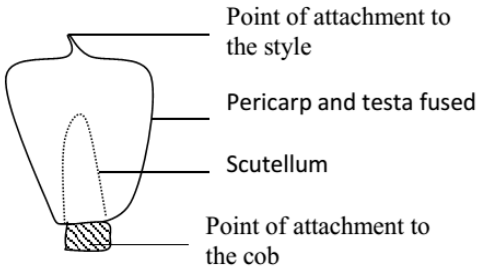
SEEDS

A seed is a fertilized mature ovule. It has one scar called hilium which is a spot where it was attached to the pod inside a fruit.

Types of seeds

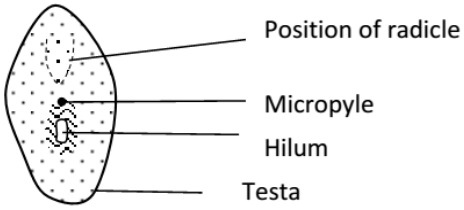
Monocotyledonous seeds: These contain only one seed leaf or cotyledon. E.g. cereals like maize.

External structure of a monocot seed

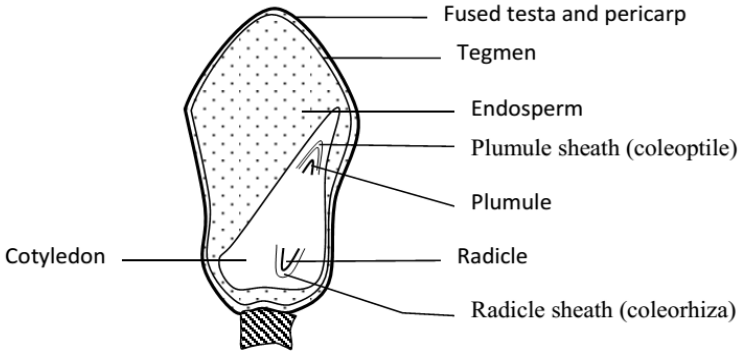


Dicotyledonous seeds: These contain 2 cotyledons e.g. legumes like beans, peas and G. nuts.

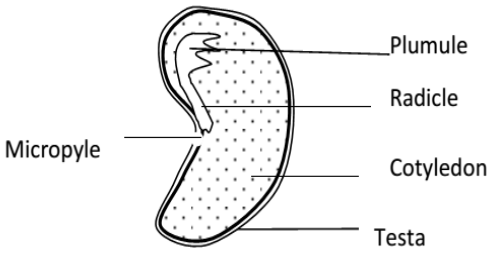
External structure of a seed (dicot seed)



Internal structure of a monocot seed (maize seed)



Internal structure of a dicot seed



i) Testa

It is a protective -covering of the embryo of the seed formed from the integuments. It is usually hard and dry. It protects it from fungi, bacteria and insects.

ii) Tegmen

It is the inner membrane of the seed coat and it's also used for protection.

iii) Micropyle

It is a narrow opening into the seed through which water, mineral salts and oxygen enter during germination.

iv) Radicle

It is a seed root (embryo root) which develops into primary root of the plant. A developing root has a root cap which bores through the soil particles and protects the newly formed cells at the root tip from mechanical damage.

v) Hilium

It's a scar of attachment left by the stalk of the ovule to the ovary wall.

vi) Endosperm

Stores food especially starch for the embryo.

vii) Scutellum or cotyledon

Digests and absorbs food stored in the endosperm. It provides food to the whole seed.

viii) Coleorhiza

It is the radicle sheath that offers protection to the radicle.

ix) Coleoptile

It is the plumule sheath that offers protection to the plumule.

x) Cotyledon

These contain stored food like starch, proteins and liquids for the initial growth of the embryo during germination.

FRUITS

A fruit is a fully grown fertilized ovary containing one or more seeds. A fruit has 2 scars, one where it was attached to the receptacle and the other, the remains of the style or stigma.

During a fruit formation, the wall of the ovary becomes a fruit wall called pericarp. In some fruits such as banana and pine apple, the fruits develop without fertilization. Such fruit are said to be ***parthenocarpic*** fruits. Therefore ***parthenocarpy is the development of fruits without fertilization.***

CLASSES OF FRUITS

True fruits: develop only from the ovaries of a flower e.g. beans, tomatoes, etc.

False fruits: develop from the association of ovaries and other floral parts such as receptacle. Examples include; pineapples and apples.

Classification of fruits

There are 3 groups of fruits namely;

i) Simple fruits

These are formed from one flower in which the pistil consists of either one carpel (monocarpic) or of several fused together (syncarpous) e.g. legumes, g, nuts, peas, tomatoes, mango, beans, etc.

ii) Aggregate fruits

These are formed from one flower in which the pistil consists of several free carpels (apocarpous) e.g. apples and rose.

iii) Multiple fruits

These are formed from several flowers and the ovaries become fused after fertilization e.g. jackfruit and pineapple.

SIMPLE FRUITS

There are either dry or succulent according to whether the pericarp becomes dry or juicy as the fruit ripens.

Types of simple fruits

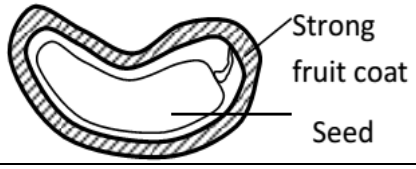
Simple fruits are further divided into three categories.

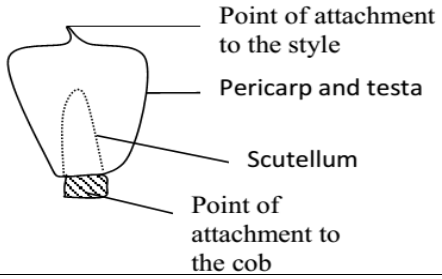
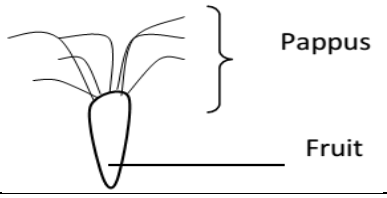
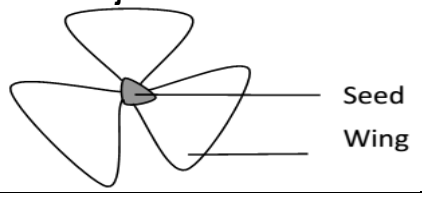
1. Dry indehiscent fruits
2. Dry dehiscent fruits
3. Succulent fruits.

Dry indehiscent fruits

These are fruits with a dry pericarp that does not split up (dehisce) to release seeds. This category contains five types of fruits. These are Achene, Nut, Caryopsis, Cypsela and Samara.

The table below shows the different types of dry indehiscent fruits.

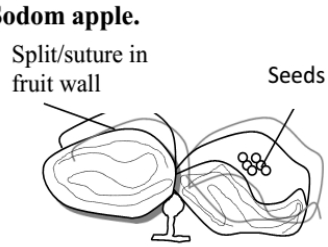
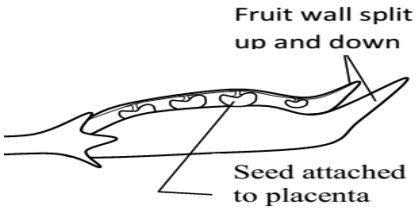
Type of dry indehiscent fruit	Description	Illustrative diagram
Achene	This is a one seeded fruit covered by a dry pericarp, which does not split open, e.g. sunflower. The achene is the simplest fruit.	**An achene of sunflower.** 
Nut.	This is similar to an achene but the pericarp is hard and tough, e.g. cashew nut. Note; coconuts and groundnuts are biologically not nuts.	**Section through a cashew nut** 

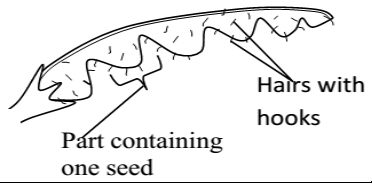
Caryopsis.	This is an achene-like fruit in which the testa and pericarp are fused. These are mainly found in grasses and maize.	**Caryopsis of maize.** 
Cypsela	This is a fruit similar to an achene in which the inferior ovary has a pappus of persistent calyx. It is common in composite fruits, e.g. tridax and *bidens pilosa*	**Cypsela of tridax.** 
Samara.	This is a fruit similar to an achene in which the pericarp is extended to form one or more wings, e.g. in jacaranda and African rose wood.	**Samara of jacaranda.** 

Dry dehiscent fruits

These are fruits with a dry pericarp that splits (dehisces) to release seeds. The fruits split at particular lines of weakness known as sutures. These fruits are categorized into the following different groups depending on the number of splits that occur on the pericarp. These fruits include, Follicles, Legume, Capsule and Schizocarp.

The table below shows the different types of dry dehiscent fruits

Type of dehiscent fruit	Description	Illustrative diagram
Follicle	This is a dry fruit with many seeds and splits open along one suture, e.g. Sodom apple	**Sodom apple.** 
Legume.	This is a dry fruit with many seeds and splits open along two sutures, e.g. beans, peas, flamboyant and Barbados pride.	**Legume of a bean** 

Capsule	This is a dry fruit with many seeds and splits open along many vertical slits. It is formed from an apocarpous flower, e.g. Dutchman's pipe, balsam, cotton, etc.	
Schizocarp.	This is a dry several seeded fruit, which breaks up into Separate parts each containing one seed, e.g. desmodium, sweet hearts and some cassia.	**Schizocarp of desmodium.** 

Succulent fruits

These are fleshy fruits. They are either entirely fleshy or have part of it fleshy. They are further divided into 2 types.

1. Drupes.

These are fruits with only one seed and only part of it fleshy (epicarp and mesocarp). The endocarp is fibrous and hard, e.g. mango and avocado.

Longitudinal section through a mango.

2. Berry.

This is a fruit with many seeds and the whole of it fleshy, e.g. tomatoes, guavas, oranges, bananas etc.

A transverse section through a berry (orange)

3. Pome

This is a succulent fruit in which the outer fleshy (normally edible) part develops from the calyx and receptacle. The ovary forms a papery cover containing seeds e.g. apple and pears.

PLACENTATION

This is the distribution of the placentae in the ovary or the arrangement of the seeds on the placenta within the ovary. There are five types of placentation as shown in the table below.

Type of Placentation	Description	Example
Marginal	Ovules are situated at or near the margin of the ovary	Beans, peas, cassia
Axile	Ovules centrally located in the ovary with ovary divided into many chambers.	Orange and tomato
Central	Ovary is one chambered and ovules centrally located	Soap wort,
Parietal	Placenta is found on the inner wall of the fruit and the ovules are attached on the inner wall	Passion fruits pawpaw, cocoa
Free central	Ovules located on the projection from the base of a one chambered fruit	Green pepper
Basal	Ovule found on a placenta that arises from the base of the ovary, fruit usually single seeded	Mango, avocado.

FRUIT/SEED DISPERSAL

This is the scattering or spreading/displacement of fruits and seeds from their parent plants. In some plants, only seeds are dispersed while in others, fruits are dispersed with seeds.

Importance of dispersal

i) It helps to prevent overcrowding among plants of the same species.
ii) It reduces competition between member plants of the same species.
iii) It helps to minimize the spread of epidemic diseases especially in seedlings if they are crowded.
iv) It helps plants to colonize new areas which may even be better for the species survival.
v) It enhances the chances of survival and continuity of the plant species.

Agents of dispersal include the following:

1) Water,
2) Wind
3) Animals
4) Self-dispersal/ explosive mechanism

Fruits and seeds possess specialized structure to aid their dispersal and are adopted to specific mode of dispersal.

Characteristics of fruits/seeds dispersed by wind

i) They are usually small, light and dry which enables them to easily be carried or flown by wind.
ii) Some fruits like elm and tecoma have wing like structures that increase their surface area. This helps in delaying the fall of seeds and fruits and increases chances of being blown away.
iii) Some fruits like tridax and clancletion have parachute-like hairs called pappus which enables them to fleet and fly by wind.
iv) Some seeds like silk cotton possess thread-like structures called floss which increase surface area enabling the seeds to float in air.

Characteristics of fruits/seeds dispersed by water

i) They are usually light and contain air space inside which reduces their relative density that enable them float on water easily like the coconut.

Characteristics of fruits/seeds dispersed by animals

i) Some fruits such as tomatoes, oranges and mangoes are usually large and brightly coloured especially when ripe. This helps to attract animals.
ii) Some fruits when ripe are scented e.g. jack fruit. This helps to lure/attract animals.
iii) Some usually possess edible parts which are succulent / juicy and the only part of the fruit that is eaten and the rest containing the seeds is thrown away e.g. mango and avocado.

iv) In some fruits, such as guavas, tomatoes, pepper and pawpaw. The whole fruit is eaten and the seed passed out in the faeces because of their resistance to digesting i.e. are indigestible.
v) Some fruits e.g. Biden pilosa and desmodium possess hooks and sticks in the hair of passing animals. They stick in the fur of animals or on clothing of people.

Self-dispersal

a) explosive mechanism

This happens with dry dehiscent fruits. The pericarp splits open along the sutures to release the seeds. This is made possible due to the tension that is built during the process of dying. E.g. legumes, capsule or follicles

b) ribbon fruits

These are succulent, may drop freely from the parent plant. The pericarp then rots, bearing the seeds that are enclosed within a hard protective testa so that it can begin germinating.

SEED GERMINATION

This is the growth and development of an embryo of a seed into a seedling or a young plant under favorable conditions.

Types of germination

1. Epigeal germination

This is where the cotyledons appear above the ground due to the rapid elongation of the hypocotyl e.g. beans, cotton, sun flower, etc.

2. Hypogeal germination

Is where the cotyledons remain below the ground and the radicle emerges due to elongation of the epicotyl e.g. maize, mango and black jack.

NB: During germination, the seed absorbs water mainly through the micropyle which makes the cotyledon swell and split the testa. This process is called imbibition. The radicle comes out of the testa faster followed by the plumule.

Conditions necessary for germination to occur

a) Environmental or external factors

i) Water
ii) Oxygen
iii) Suitable temperature

b) Internal conditions

i) Viability of the seeds
ii) Amount of food in the seeds
iii) Enzymes
iv) Absence of germination inhibitors e.g. poison

1. Water

Water is needed for the following:

- It activates the enzymes within the seed to hydrolyze the stored food.
- It makes the seed swell, soft and the testa to bursts.
- It dissolves the stored food.
- It is a medium in which all the chemical and enzymatic reactions proceed.
- It is a medium of transport of the dissolved food substances to the developing shoot and root of the new plant.
- Water is needed for the development of cell vacuoles. Large cell vacuoles contribute to increase in size of cells.

2. Oxygen

Oxygen is necessary for the process of respiration, the oxidation of food to provide energy required for growth.

3. Warmth

Suitable temperature is important for the enzyme controlled reactions in the cotyledon of the germinating seed. At low temperatures, the enzymes are inactive and at high temperatures, they are denatured hence no germination. Germination will require an optimum temperature which varies from 10℃-50℃ for most tropical seeds.

An experiment to demonstrate the conditions necessary for germination

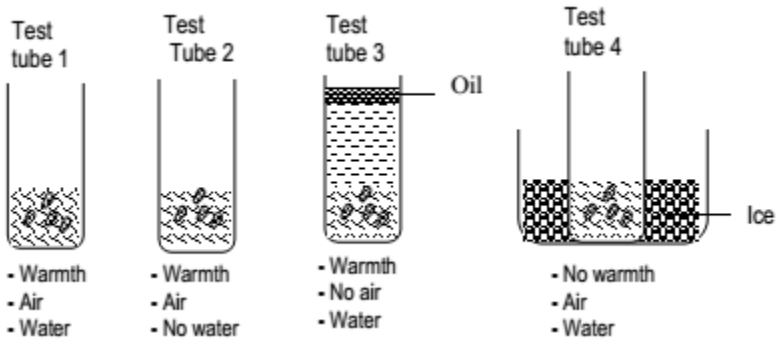
Apparatus:

4 test tubes, Cotton wool, Seeds, Oil and Water.

Procedure:

a) Arrange four test tubes labeled 1-4
b) To test tube 1 add moist cotton wool, seeds and leave test tube open.
c) To test tube 2 add dry cotton wool, seeds and leave test tube open.
d) To test tube 3 add seeds, boiled cooled water and a layer of oil.
e) To 4 add seeds, moist cotton wool, and ice and leave test tube open. Leave all test tubes for 3 days.

Setup:



Observations

Seeds germinated in only test tube ***1*** and those in ***2***, ***3*** and ***4*** did not germinate.

Conclusion:

Air, water and warmth are necessary for germination.

Experiment to show that oxygen is necessary for germination

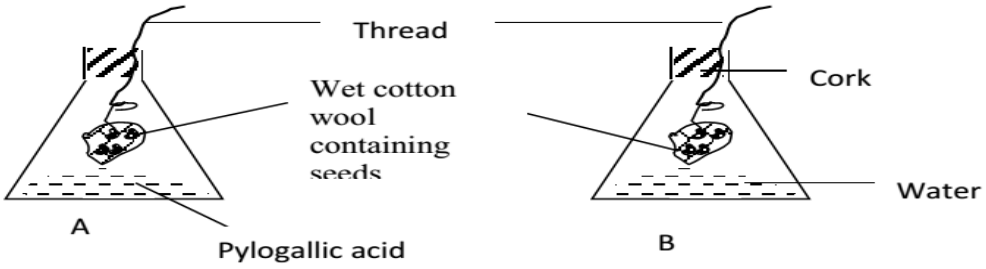
Apparatus:

2 conical flasks, 2 corks, Water, Cotton wool, Seeds and Pyrogallic acid.

Procedure:

- ✓ 1. Pour some water in one conical flask and some alkaline pyrogallol in another conical flask.
- ✓ Tie some seeds in wet cotton wool and suspend the cotton wool in the flasks using a thread.
- ✓ Fix the threads using a cork.
- ✓ Leave the set up for three days

Set up:



Observation:

After a few days the seeds in ***B*** germinated while those in ***A*** did not germinate.

Conclusion:

Oxygen is necessary for germination.

Explanation:

Alkaline pyrogallol absorbs oxygen from air in flask ***A*** thereby preventing germination.

SEED DORMANCY

Seed dormancy is the condition where by viable seeds fails to germinate under certain conditions or resting stage.

Causes of seed dormancy

1. **Immature embryo of the seed**

This may cause dormancy in seed germination since the embryo may undergo development before germination occurs.

2. **Presence of germination inhibitors**

Some chemical substances like acids do not promote germination of seeds when present. They destroy the enzymes.

3. **Extreme temperatures**

These greatly affect the working of enzymes in the seed. High temperatures denature enzymes while low temperatures inactivate them.

4. **Presence of hard impermeable seed coat**

Some seeds have a strong seed coat that does not allow water and gases to enter the seeds. Without water and gases, germination will not take place.

5. **Dryness of soil and lack of sufficient oxygen enough for seeds.**

If oxygen is absent, seed respire anaerobically and obtain less energy. This will not allow seeds to germinate.

Ways of breaking seed dormancy

1. Harvesting mature seeds. This involves allowing embryos in seeds to develop up to maturity for certain period called ***after-ripening period.*** This allows the seed to develop fully.
2. By providing growth promoters which deactivate germination inhibitors. These are chemical substances that can make inhibitors less active. They contain nutrients or hormones for proper growth.
3. By exposing seeds to a cool period or chilling to initiate germination. This is common method of breaking seed dormancy in cereals.
4. By providing suitable conditions of oxygen, temperature and moisture which favour germination.
5. Removing the hard seed coat by:
    - Soaking seeds in water to soften it.
    - Action of fire to burn away the seed coat.
    - Passing seeds through animal gut.
    - Churning seed coat in concentrated acids.
    - Physical removal of the seed coat by using the hand or pricking or by action of bacteria in the soil.

Importance of seed dormancy

- It promotes germination of seeds during favourable conditions e.g. seeds dispersed in winter remain dormant in summer.
- It improves the chances of seedling to grow to maturity during favourable conditions.
- Dormant seeds can be stored for a long time and the seed dormancy can be broken by giving artificial conditions. This helps in their transportation.
- It reduces the risk of seeds being frozen to death during unfavorable conditions.

END OF S.1 WORK- CONGRATULATIONS