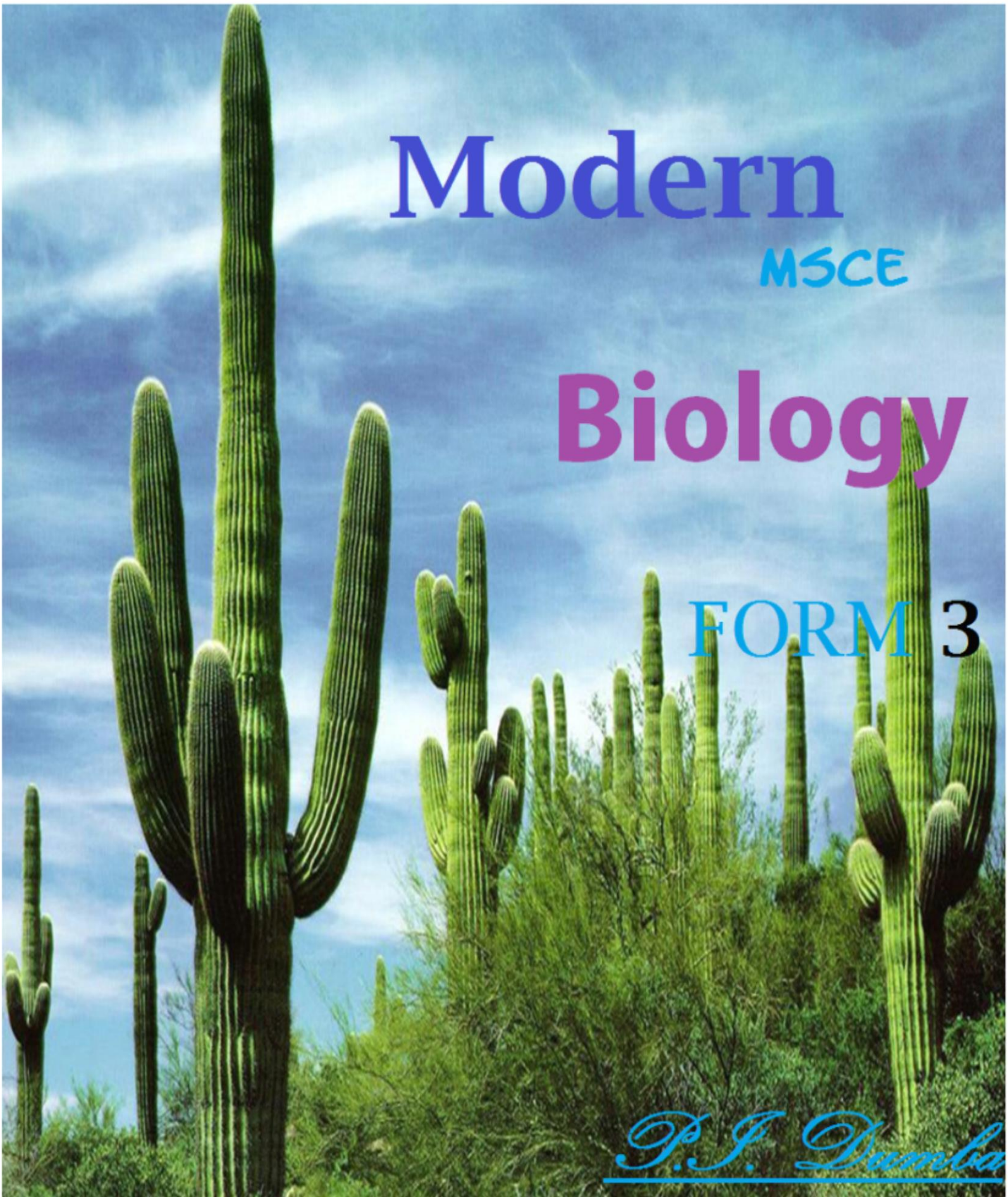
Modern
MSCE
Biology
FORM 3
P. F. Dumba

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TOPIC 1 : LIVINGTHINGS AND THEIR ENVIRONMENT

Living things do not live in isolation. They are always surrounded by other living things and non-living things. The natural surrounding of the living things is known as environment. So to say, all living things within an environment depend on each other for survival. On the other hand, activities of an organisms have an impact on its environment. This implies that there is a relationship between organisms and their environment.

ECOLOGY

Ecology is the study of interactions among organisms in an environment. **Ecosystems** on the other hand refers to a natural self-sustaining ecological unit in which living organisms interact and influence one another. Examples of ecosystems include forests, lakes, grasslands etc. Ecosystem is made up of biotic (living) and abiotic (non living) factors. People who study ecology are known as **ecologists**.

Ecologists study interactions among organisms in order to understand why there are so many plants and animals (abundance), and why there are so many different types of plants and animals (diversity). In other words, ecologists study ecosystems to understand abundance and diversity of living things. Applied ecology uses information about these relationships to address issues such as developing effective vaccination strategies, managing fisheries without over-harvesting, designing land and marine conservation reserves for threatened species, and modeling how natural ecosystems may respond to global climate change.

ECOLOGICAL TERMS

HABITAT

This is a place where living things are found. For example, water is a habitat for fish and other aquatic animals.

ENVIRONMENT

Environment refers to the total surrounding of an organism. For instance, environment of a student in a classroom will comprise of fellow students, teachers, desks, books, air, school blocks, trees, lizards and many more. The environment comprises both living and nonliving things. The living environment) of an organism and animals surrounding is referred to as **community**. It includes all the **flora** (plants) and **fauna** (animals) of the particular environment.

NICHE

This refers to the role that an organism plays in an ecosystem.

In order to understand clearly the dynamics of an ecosystem, ecologists observe behavior of species in their habitats, in additional to studying their population.

POPULATION

This is the term used to describe the number of organisms of the same species found in an area at the same period of time.

POPULATION DENSITY

This refers to the number of organism in a population per unit area for example per square kilometers. It usually tells us the way population has been distributed in a given area. Since organism do not spread evenly, then the population density differs from one area to another. Thus, the organism can have high density in one side of area and low density in other side of the same area.

DERTERMINING THE POPULATION SIZE OF ORGANISMS

While it is quite easy to determine the population size of other organism like in human beings, it is not easy to establish population of other organisms like birds, fish, plants in a garden etc. because they are too mobile or too numerous.

In order to determine the population of large slow moving animals for instance human beings or small populations of scattered plants, a direct counting method for example census or physical counting is used.

However, census or direct counting cannot be feasible in establishing population of organisms which are too numerous or too mobile, rather the following techniques are used to estimate population of such organisms.

a) **Quadrat method –** in ecology, quadrats are used to estimate populations of organisms that are too numerous for example plant populations or slow moving animals such as snails and millipedes. In fact, a quadrat is a light wooden or metal square frames used to get a representative sample of organisms over a large area being studied. The quadrat is placed at random over the areas of study and the individual organisms within the quadrat are calculated to obtain sample counts. Then the average is calculated and then the total calculation is estimated. In so doing, population frequency and distribution are determined. Generally, this method is very easy to apply and the quadrat themselves are easy to make. However, quadrats are limited as they cannot be used in animals which are too mobile.

b) **Transect Method**

A transect is a path along which one counts and records occurrences of the species under study.

There are two types of transect and these are:

- Line transect
- Belt transect

(i). Line transect method

This method involves the use of a straight line cutting across an area in which the organisms to be sampled are found. A transect line can be made using a nylon rope marked and numbered at 0.5m or 1 m

interval, all the way along its length. A line transect is carried out by unrolling the transect line along the gradient identified. The position of the transect line is very important and it depends on the direction of the environmental gradient you wish to study. The species touching the line are recorded along the whole length of the line. Alternatively, the presence or absence of species at each marked point is recorded. The results obtained from a number of such transects made through the study area, are then combined to obtain the distribution pattern and relative density of the different plant species. From the results, it is easy to tell the dominant species or rare species. All in all, this method can be used to estimate the distribution pattern and relative population density of different species in an area.

(ii). Belt transect

This method involves the use of two parallel lines or a narrow strip, one meter apart. The lines or the strip cut across an area in which the organisms to be studied are found. The length of the belt transect is measured. The whole area where the organisms being counted are found, is determined. Organisms found between the two lines are counted and recorded.

For instance, if you counted 100 organisms and the length of the belt is 10 m by 1 m wide then the area of study is $10m^2$.

If the number of organisms in $10m^2$ = 100

Then the number of organism in $1m^2$ = $\frac{100 \times 1}{10} = 10$

This method is suitable for estimating population of trees such as those in forest or woodland.

c) **Mark, Release ,Recapture Technique** - This is a method commonly used in ecology to estimate population size of very active or mobile animals such as birds, grasshoppers, fish, etc. As the name implies, it involves capturing a portion of organisms for example grasshopper then mark them and then release them back to their habitat to mix freely with the unmarked ones. Later another portion comprising both marked and unmarked organisms is captured and the number of marked organisms within this sample is counted. A formula is then used to calculate the estimated population in the selected areas as shown below.

Estimated number of organisms =

$$\frac{\text{No,of animals in 1st capture} \times \text{Total no of animals in 2nd capt}}{\text{No. of marked animals in second capture}}$$

Although this method is very convenient in estimating population size of animals which move frequently, it is limited as it cannot be used to estimate plant populations. Furthermore, some methods of trapping can cause harm to organisms thereby causing them to escape. The painting itself can render the organisms more prone to their predators.

INTERACTIONS AMONG ORGANISM IN AN ECOSYSTEM

Living organism depend on each other on several factors. for example: food, protection, shelter, reproduction etc. hence, interaction among these organisms is inevitable. There are different interactions that take place among these organisms. These include: mutualism, parasitism, commensalism, epiphytism, and predation.

- **Mutualism** - This is an interaction in which both parties benefit. it is also known as **symbiosis. (**a Greek word meaning living together). For example, interaction between useful bacteria in man and man himself. The bacteria gets food and shelter while man benefits from bacteria as it helps in digesting food particles. under this type of interaction, no organism is harmed or injured. Another example is the interaction between beans and rhizobium bacteria which lives in the nodules of beans and also the lichens which consist of algae and fungi living together.

- **Parasitism-** under this relation, one organism benefits at the expense of the other. The organism that benefits is called **parasite** while the one that suffers is called the **host**. Example is man and HIV.

- **Predation -** This refers to an interaction in which one organism kills the other organism. The killer is called the predator while the killed one is called the **prey**. For example, interaction between cat and rat.

COMMENSALISM

Under this interaction, one organism benefits but the other one is not affected in any way. A very good example of commensalism is **epiphytism.** This is a relation in plants where by one plants (epiphyte) grow on the other plant so that it should be exposed to sunlight and air.

ENERGY FLOW IN AN ECOSYSTEM

The **sun** is the principal source of energy input to ecosystems. Energy flow is NOT a cycle. It starts from the sun (and obviously doesn't go back there) and then that energy is harnessed by plants which are eaten by animals which are eaten by other animals. At each step, energy is lost to the environment (for example by heat loss).

The energy flow can be presented in four different ways namely

(i) food chains
(ii) food webs
(iii) pyramid of numbers
(iv) pyramid of biomas

Trophic level: The position of an organism in a food chain, food web or pyramid of biomass, numbers. The trophic levels include producers, primary consumers, secondary and tertiary consumers.

- **Producers-** are basically plants which convert simple inorganic substances into organic substances using sunlight as a source of energy. These producers are also called **autotrophs.** Organisms that

feed on autotrophs are called heterotrophs.

- **Primary consumers** – Are organisms that feed on producers. This trophic level encompasses all herbivores for example goats, cattle, grasshoppers etc.
- **Secondary Consumers** – Are organisms that feed on primary producers. They encompass all carnivores for example lion, hawks, playing mantis etc
- **Tertiary Consumers** – Are organisms that feed on secondary consumers. Most of them have a mixed diet, thus they may feed on both primary and secondary consumers. Example includes man.
- **Decomposers** – organisms that get their energy from dead or waste organic matter. They break down organic compounds, releasing the minerals they contain back to the soil or into the water.

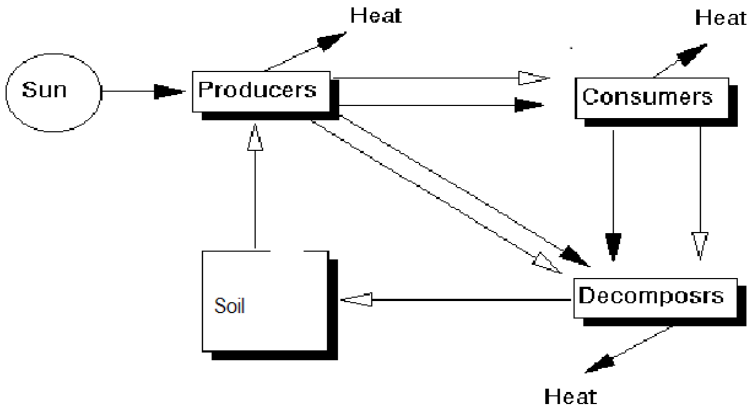
Food chain

This refers to an arrow diagram which shows the energy flow from one organism to another.

mahogany tree → caterpillar → song bird → hawk

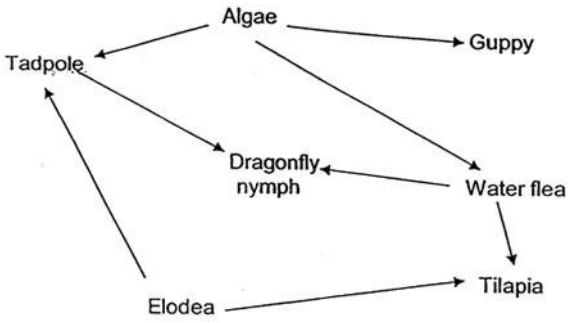
Food chains usually have fewer than five trophic levels, because energy transfer is inefficient:

- Sun produces light, less than 1% of the energy falls onto leaves.
- Producers 'fix' (trap) only about 5-8% of that energy, because of: transmission (passing through), reflection and incorrect wavelength.
- Primary consumer only gets between 5-10% because some parts are indigestible (e.g. cellulose) and not eating the whole plant.
- Secondary consumer gets between 10-20% because animal matter is more digestible and has a higher energy value.
- At each level heat is lost by respiration.



Food web

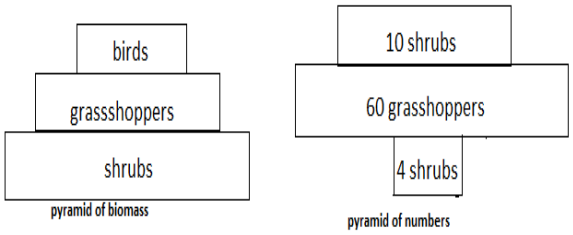
This refers to a network of interconnected food chains showing the energy flow through part of an ecosystem. The following is an example of a food web representing flow of energy in an aquatic ecosystem



Pyramid of numbers: Shows the number of each organism in a food chain. When moving up the pyramid, the number of individuals' decreases but their size usually increases (except when it starts from a large plant like

an oak tree). The problem is that there might be thousands or more producers feeding one single tertiary or quaternary consumer so this cannot be shown to scale without using a massive piece of paper, and if there is one large producer (e.g. an oak tree) and many if parasites feed on the consumers, the pyramid will be inverted.

Pyramid of biomass: a pyramid which shows the biomass (number of individuals × their individual mass). As already stated, energy is lost between each trophic level in a food chain. This means that there is not much energy to support the animals towards the end of the chain, so their populations tend to be lower. We can show this by drawing a pyramid of biomass. For example, if a certain ecosystem has 4 shrubs, 60 grasshoppers and 10 birds, the following pyramids can be constructed



The amounts of material and energy contained in the biomass of organisms is reduced at each successive stage in a food chain because:
– some materials and energy are always lost in the organisms' waste materials
– respiration supplies all the energy needs for living processes, including movement.

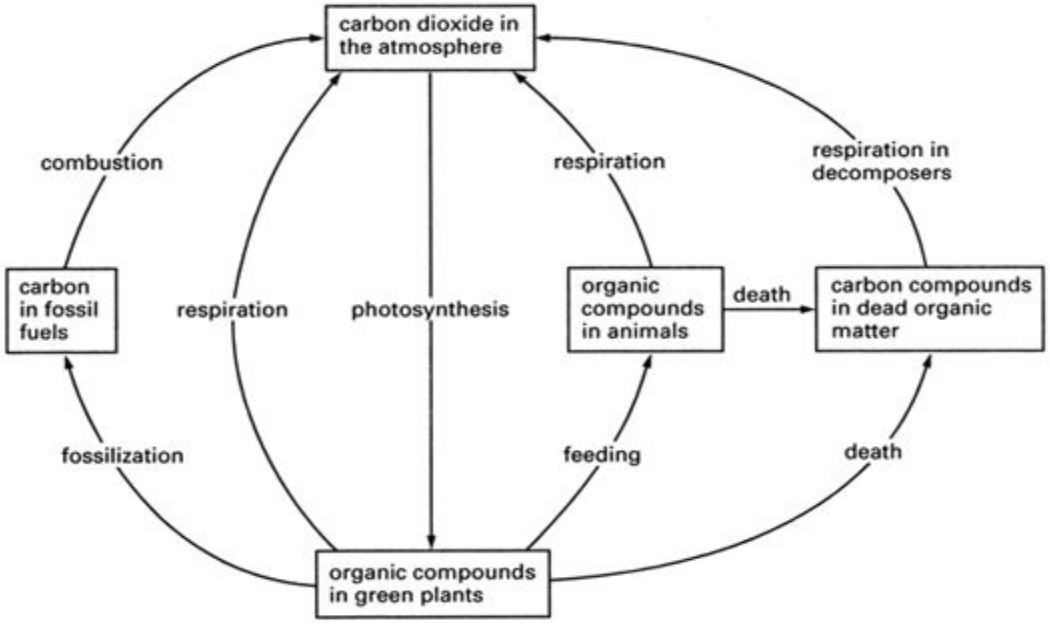
- Much of this energy is eventually lost as heat to the surroundings.

RECYCLING OF MATERIALS IN AN ECOSYSTEM

Living things remove materials from the environment for growth and other processes. These materials are returned to the environment either in waste materials or when living things die and decay. Materials decay because they are broken down (digested) by microorganisms (decomposers). Microorganisms digest materials faster in warm, moist conditions.

Many microorganisms are also more active when there is plenty of oxygen – aerobic conditions. The decay process releases substances which plants need to grow. In a stable community, the processes which remove materials are balanced by processes which return materials. The materials are constantly cycled. The figure below summarizes the recycling of materials in an ecosystem.

THE CARBON CYCLE

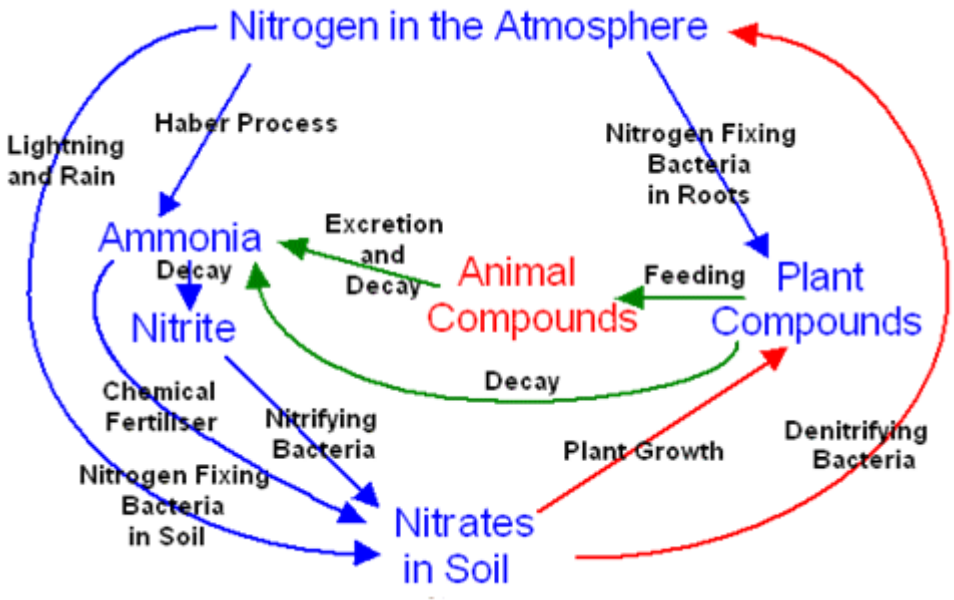


Carbon dioxide is removed from the environment by green plants for photosynthesis. The carbon from the carbon dioxide is used to make carbohydrates, fats and proteins which make up the body of plants. Some of the carbon dioxide is returned to the atmosphere when green plants respire. When green plants and algae are eaten by animals and these animals are eaten by other animals, some of the carbon becomes part of the fats and proteins which make up their bodies. When animals respire some of this carbon becomes carbon dioxide and is released into the atmosphere. When plants, algae and animals die, some animals (detritus feeders) and microorganisms (decomposers) feed on their bodies. Carbon is released into the atmosphere as carbon dioxide when these organisms respire. By the time the microorganisms and detritus feeders have broken down the waste products and dead bodies of organisms in ecosystems and cycled the materials as plant nutrients, all the energy originally captured by green plants has been transferred. Combustion of wood and fossil fuels release carbon dioxide into the atmosphere.

THE NITROGEN CYCLE

1) **Nitrogen-fixing bacteria** provide usable nitrogen for plants, these may exist in the root nodules where they live in symbiosis with the plants (**nitrogen fixation**), or this can happen because of **lightning**, or **microorganisms** provide them through decomposition.
2) **Nitrifying bacteria** convert nitrogen-containing substances into better nitrogen-containing substances for the plants (**nitrification**).

3) plants absorb these substances and convert them into proteins
4) Primary consumers eat the plants and can make their own proteins; secondary consumers eat primary consumers and so on.
5) Death and decay happens at each trophic level leading to stage one (the decomposers bit)
6) **Denitrifying bacteria** carry out **denitrification**: they convert nitrogen-containing substances into atmospheric Nitrogen


Nitrogen in the Atmosphere
Lightning and Rain
Haber Process
Nitrogen Fixing Bacteria in Roots
Ammonia
Excretion and Decay
Animal Compounds
Feeding
Plant Compounds
Decay
Nitrite
Decay
Chemical Fertiliser
Nitrifying Bacteria
Plant Growth
Denitrifying Bacteria
Nitrogen Fixing Bacteria in Soil
Nitrates in Soil

TOPIC 2. PLANT STRUCTURE AND THEIR FUNCTION

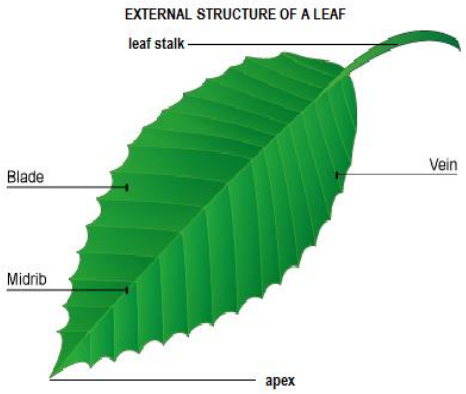
Plants, like animals, are made up of tissues that form organs. These organs include roots, stems, leaves and reproductive structures like flowers, fruits, seeds and many more. One of the major interests among biologists is to understand the structures of these organs as well as the functions of these structures as they relate to the general survival of the plants. This chapter will discuss the structure and functions of the plants.

THE LEAF

Leaves are one of the most important organs of a plant as they are the site for photosynthesis. Generally, leaves come in huge variety of sizes and shapes. Despite these varieties, all leaves share some commonalities.

External structure of a leaf

Generally, the external parts of a leaf include leaf blade (lamina), leaf stalk (petiole), main vein (mid rib), leaf veins, apex and leaf margin. The figure below shows some of the external parts of a leaf.



The internal structure of a leaf

the following are the internal structures of the leaf and their functions.

1 Cuticle

This is waxy substance secreted by the epidermal cells. It is thin and forms the outermost layer found on the upper part and lower part. It is water proof and covers the epidermal cells of the leaf. Its functions are:

- **a)** **To pre**vent the water loss through the leaf surface.
- **b)** To protect the inner part of the leaf for example mesophyll cells from physical forces.
- **c)** To prevent unnecessary entry of water through the leaf surface.
- **d)** Hairy cuticle protects the leaf from predators.
- **e)** It allows light to enter the mesophyll cells as it Is transparent.

2 Epidermal layers

There are two layers of epidermal cells, namely: the upper epidermis and the lower epidermis. The epidermal cells and the cuticle together form a water proof barrier that protects delicate tissues inside the leaf by slowing down water loss through transpiration. Since epidermal cells do not contain chloroplasts, they allow light to pass through them to reach the mesophyll layers.

3 Mesophyll layers

There two types of mesophyll layers and these are spongy and palisade mesophyll layers.

- **a)** **Palisade Mesophyll Layer-** This is a layer of cells below the upper epidermal cells, thus,

it is found on the upper part of the leaf. It contains palisade cells which are the main site of photosynthesis. As a matter of fact, The palisade mesophyll layers are adapted for photosynthesis in the following ways:

(i) They contain numerous chloroplasts.

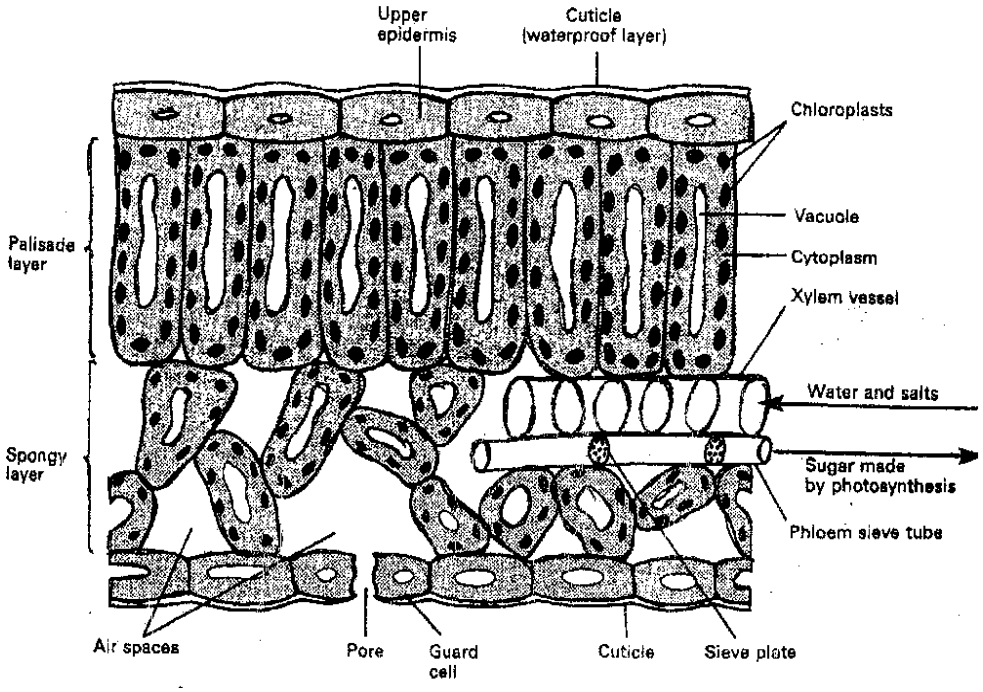
(ii) They are arranged in a single layer so that sunlight can pass through them without passing through other palisade cells.

(iii) Their cylindrical shape enables them to be packed together thereby creating a large surface area for absorption of sunlight.

(iv) They are found on the upper part of the leaf hence light does not pass long distance.

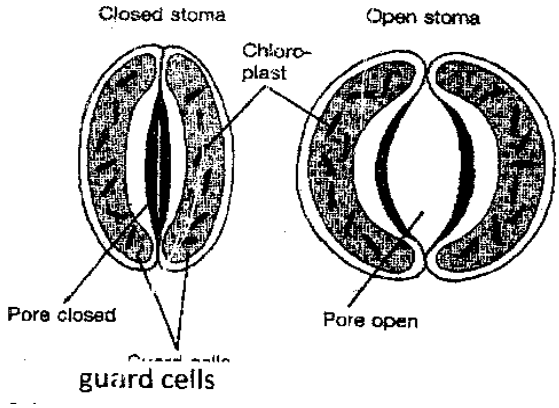
Spongy Mesophyll Layer

This layer is below the palisade mesophyll layer. It has irregular shaped cells which are loosely packed with air spaces in between them and have fewer chloroplasts so that less photosynthesis occurs in these cells. Its porous nature allows easy movement of air.



4 Stomata(Singular Stoma)

These are pores on the surface of the leaf especially in the lower epidermis. They are used for transpiration as well as gaseous exchange . carbon dioxide enters the leaf through these pores passing through the air spaces of the spongy mesophyll to the palisade mesophyll where it is used for photosynthesis. On the other hand, the oxygen produced during photosynthesis leaves the leaf through these stomata. Each stomata is surrounded by two bean shaped cells called **guard cells.**

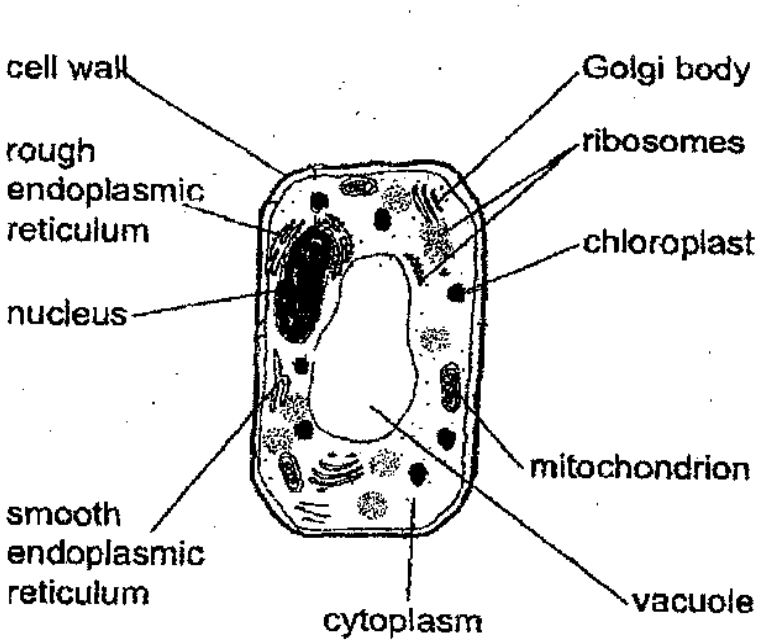


The guard cells have a potential of opening and closing the stomata thereby regulating the rate of water loss through transpiration. In fact ,when the guard cells gain water, they bend into a half moon shape thereby opening the stomata and when they lose water, they become more limp and straightens hence the stoma closes . Guard cells are different from the epidermal cells in

such way that the guard cells are bean shaped and they do contain chloroplasts.

5Veins

These contain vascular tissues namely the xylem and the phloem which transport water plus minerals and manufactured food respectively.



A mesophyll cell as seen under an electron microscope

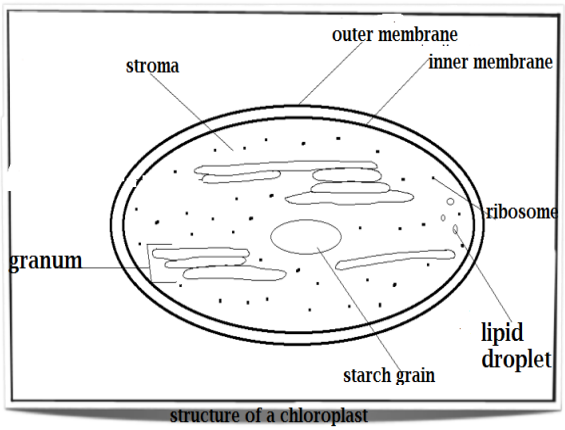
The above diagram shows a mesophyll cell as seen under the electron microscope. The cell comprises of protoplasm which include all the cell contents apart from the vacuoles.

1. **Nucleus** – it controls the activities of a cell for example cell division. It also carries hereditary information. In addition, it produces information required to manufacture proteins. However, this structure is absent in some cells for example red blood cells, xylem cells, as well as unicellular organisms. The nucleolus found in this structure is made up of Ribonucleic acid (RNA) which is responsible for synthesis of ribosomes.
2. **Cell membrane** – this is a thin layer made of proteins and fats. It is semi permeable, thus it allows other substances to pass through depending on their sizes. It separates cells from one another and also aids in the protection and support of the cell.
3. **Cell wall** – this organelle is found in plant cells only. It is made up of carbohydrate called cellulose and it is fully permeable. It allows water and other dissolved substances to pass through. It also protects and supports the cell.
4. **Mitochondrion-** this is a sausage shaped organelle responsible for respiration. Its inner surface is highly folded thereby increasing surface area on which the chemical processes take place.
5. **Vacuole** – mainly found in in plant cells and contains a solution called cell sap which dissolves sugar substances and salts. It gives shape to plant cells through its outward pressure.

6. **Ribosomes** – these are attached to rough endoplasmic reticulum and they are sites for protein synthesis. However, some ribosomes are suspended freely in the cytoplasm

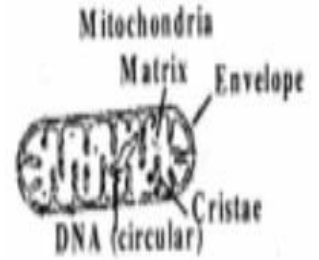
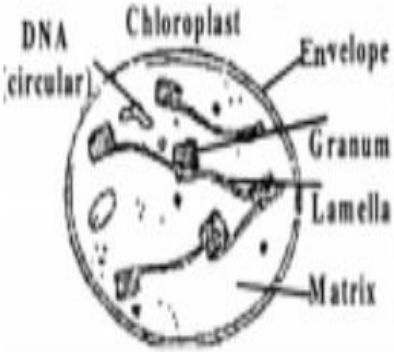
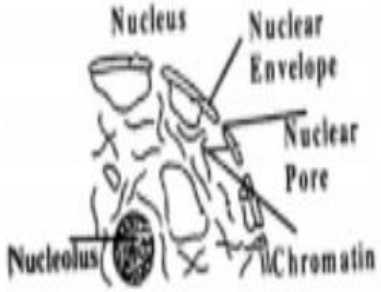
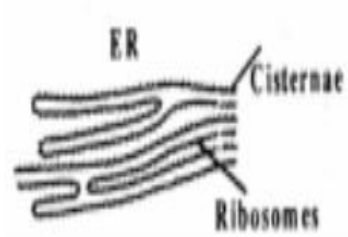
7. **Endoplasmic reticulum** – it is divided into two thus rough and smooth endoplasmic reticulum.
   (a) **Rough endoplasmic reticulum** – this is called rough endoplasmic reticulum because of the ribosomes which are attached to it and makes it look rough. It manufactures membranes and some proteins.
   (b) Smooth Endoplasmic Reticulum
   This is responsible for manufacturing of lipids and detoxification of poisonus substance.

8. Lysozome – these are also referred to as clean up crews of the cell. They eliminate unwanted substances in the cell and also digest dead cells. They are found mainly in animals.
9. **CHLOROPLASTS -** This is an organelle in a plant cell where photosynthesis takes place due to the presence of green pigment called **chlorophyll.** Chloroplasts are found in a cytoplasm of cells of palisade mesophyll, spongy mesophyll and guard cells. These three structures are called photosynthetic cells. Each chloroplast is surrounded by two membranes. Inside each chloroplast are small units called grana (singular: granum). A granum consists of a number of discs placed on each other like a pile of coins. Each disc in a pile is a flat sac with a single membrane. One granum is connected to another by the interregnal lamellae. The remaining part of the chloroplast is filled with a fluid and is called stroma. The stroma contains enzymes involved in photosynthesis.



structure of a chloroplast

Structure and functions of various cell organelles and parts

Diagram	Structure	Functions
	It has an envelope made up of two membranes, the inner is folded to form cristae. Matrix with ribosomes is present. A circular DNA is also there.	ICristae are the sties of oxidative phosphorylation and electron transport. Matrix is the site of Krebs' cycle reactions.
	It has an envelope made up of two membranes. Contains gel like stroma and a system of membranes called grana. Ribosomes and a circular DNA are present in the stroma	Photosynthesis takes place here. It is a process in which light energy is converted into chemical energy.
	It has an envelope made up of two membranes. They have nuclear pores. It contains nucleolus and chromatin.	Nuclear division is the basis of cell replication and thus reproduction. Chromosomes contain DNA, the molecule responsible for inheritance.
	Structure : Consists of membrane - bounded sacs called cisterae.	Smooth ER, (no ribosomes) is the site of lipid synthesis. Rough ER (with ribosomes) transports proteins made by the ribosomes through the cisterae.

A LEAF AS AN ORGAN FOR PHOTOSYNTHESIS.

The process of photosynthesis in green plants takes place to a large extent in leaves. This is due to the fact that the leaves have several structures that enable them to carry out this process efficiently. However, it should be noted that photosynthesis is not limited to these leaves alone, rather, it also takes place in other green parts of the plant for instance some parts of the stem, shoots etc.

In the leaves, the process of photosynthesis takes place in the chloroplasts which are found in palisade mesophyll cells. The following figures show the external and internal structures of a leaf.

ADAPTATIONS OF A LEAF FOR PHOTOSYNTHESIS

Leaves are adapted to photosynthesis in the following ways;

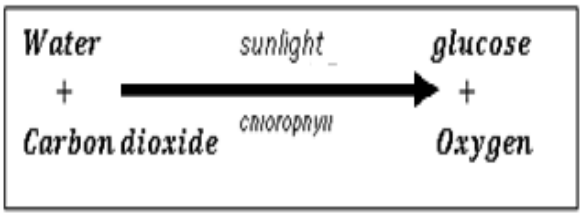
- Their broad, flat shape offers a large surface area for absorption of sunlight and carbon dioxide.
- Most leaves bare thin, hence, the distance across which carbon dioxide has to diffuse to reach the mesophyll cells from the stomata are very short.
- The large intercellular spaces in the mesophyll provide easy passage through which carbon dioxide can diffuse.
- Numerous stomata on one or both surfaces allow the exchange of carbon dioxide and oxygen with the atmosphere .
- In palisade cells the chloroplasts are more numerous than in the spongy mesophyll cell. The palisade cells being on the upper surface will receive most sunlight and this will be available to the chloroplasts without being absorbed by many intervening cell walls. The elongated shape of many palisade cells may confer the same advantage.
- The branching network of veins provides a ready water supply to the photosynthesizing cells.

PHOTOSYNTHESIS

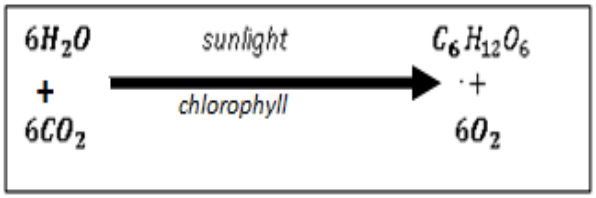
This refers to a process by which green plants manufacture their own food using simple inorganic substances in the presence of sunlight. During the process of photosynthesis, plants combine simple inorganic substances namely water and carbon dioxide using energy derived from sunlight to make their food in form of glucose. This means that photosynthesis is a type of autotrophic nutrition. The water used for photosynthesis is absorbed from the soil by the root system. On the other hand, the carbon dioxide diffuses into plants from the atmosphere through the stomata. The sunlight energy is absorbed by the green pigment known as chlorophyll which is found in plant cells. Apart from glucose, oxygen is also produced during this process. However, the oxygen is given off as a by product.

The process of photosynthesis can be summarized as follows;

(i) Word Equation



(ii) Chemical Equation



This shows that the **raw materials** for photosynthesis are *water* and *carbon dioxide* while the **products** of the process are *glucose* (a carbohydrate) and *oxygen*. Glucose is the main product while oxygen is the by product. A by product is a substance produced besides the main product during a chemical process. In addition, the equation also indicates that *sunlight* and *chlorophyll* are the **necessary conditions** for the process of photosynthesis.

REQUIREMENTS FOR THE PROCESS OF PHOTOSYNTHESIS

The process of photosynthesis requires the following factors for its occurrence;

a. **Sunlight**

It is absorbed by chlorophyll found in chloroplasts. Its major role during photosynthesis is to provide energy which is used to split water molecules into Hydrogen and oxygen. The energy is also used to combine hydrogen and carbon dioxide in order to form glucose.

b. **Chlorophyll**

This is the green pigment found in the chloroplasts in plant cells. Its major role is to absorb sunlight energy.

c. **Carbon dioxide**

It combines with hydrogen molecules in a reduction process to form glucose

d. **Water-** it provides hydrogen required for the formation of glucose.

STAGES OF PHOTOSYNTHESIS

The process of photosynthesis occurs in two stages, these are ;

a. **LIGHT STAGE (PHOTO CHEMICAL)**

During this first stage sunlight energy is absorbed by chlorophyll found in the chloroplast of plant cells. This energy is used to split water molecules into hydrogen and oxygen atoms in the process called **photolysis**. The oxygen atoms are released as a byproduct and on the other hand, the hydrogen atoms are carried over to the next stage. Some sunlight energy is converted

into adenosine triphosphate (ATP). The ATP is a compound by which energy can be stored and easily accessed by every living thing.

b. **DARK STAGE (CARBON STAGE)**

The carbon dioxide from the atmosphere diffuses into the leaf through the stomata up to the chloroplasts of the leaf cell , during this stage hydrogen reduces carbon dioxide to form glucose using energy from ATP. However even though it is called dark stage, it does not occur during the night but the fact is that it does not require sunlight.

THE FATE OF GLUCOSE PRODUCED DURING PHOTOSYNTHESIS

The glucose which is produced during photosynthesis is used in different ways some of them include;

(a) It is used for respiration thereby enabling the plant to reduce energy required for its everyday activities for example cell division , growth , active transport etc.
(b) it is stored in organs like roots , stems and leaves for future in form of starch.
(c) it is used for formation of lipids
(d) it is used for the formation of lipids
(e) it is used for the formation of cellulose which is an integral part of cell walls
(f) it combines with mineral elements like nitrogen to form proteins
(g) it is also used to form lignin which hardens the plant cell
(h) it combines with nitrogen and other minerals to form amino acids and proteins

MINERAL REQUIREMENTS DURING PHOTOSYNTHESIS

The glucose compound comprises hydrogen, carbon and oxygen atoms which are assimilated during the process of photosynthesis. However, this process of photosynthesis also requires other elements which are derived from the soil. Some of them include

- **Potassium** - controls opening and closing of stomata. It also controls the rate of photosynthesis and respiration
- **Magnesium** - for formation of chlorophyll
- **Iron** - facilitates the process of chrolophyll formation
- **Nitrogen and sulphur –** for formation of amino acids (proteins)
- **Phosphorus –** for energy changes and formation of amino acids, nucleic acids, ATP, etc
- **Calcium –** for making chemicals which cement cell walls and formation of some enzymes

LIMITING FACTORS OF PHOTOSYNTHESIS

The rate of photosynthesis is affected by the following factors

- **Temperature -** when temperature is high, the rate of photosynthesis is also high. Similarly, when the temperature is low, the rate of photosynthesis is also low. However, the rate of photosynthesis decreases when temperature goes beyond 40^{o} C.
- **Light intensity –** as light intensity increases, the rate of photosynthesis also increases until the plant carry out photosynthesis to the maximum level.
- **Carbon dioxide –** the concentration of carbon dioxide also determines the rate of photosynthesis as Co_2 is the raw material for this process.
- **Water –** the speed at which photosynthesis occur also depends on the availability of water.

PIGMENTS IN THE LEAVES

There are three types of pigments found in plant leaves and other parts. These are

a) Chlorophyll - green in color
b) Carotene – orange in colour
c) Xanthophylls – yellow in colour

These three pigments co exist. The orange carotene is responsible for orange colour of carrot. The yellow color of xanthophylls is responsible for the yellow color in many flowers and fruits. The green color of chlorophyll is responsible for green colour of leaves and other parts of the plants.

EXPERIMENT TO SHOW THAT GREEN LEAVES CONTAIN THTREE TYPES OF PIGMENTS

Materials

- Fresh leaves , Mortar, Pestal, Beakers, Ethanol or Acetone, Filter paper, Razor blade

Procedure

1) cut the fresh green leaves using the razor blade and put them in the mortar.
2) Add small amount of ethanol and /acetone and grind the small pieces thoroughly.
3) Squeeze the green extracts into a beaker
4) Cut the filter paper into a rectangular shape and mark on one side
5) Put a drop of the green extract on the green spot and immediately put it on the beaker with ethanol.

*Ensure that the green extracts does not come in contact with ethanol in the beaker.

RESULTS

The ethanol will rise through the filter paper and separates the pigments. In fact, the initial green colour will separate into yellow, orange and green

CONCLUSSION

Green leaves contain three types of pigments

IMPORTANCE OF PHOTOSYNTHESIS

The process of photosynthesis is very important as it results into

a) Food production
b) Oxygen production
c) Reduction of carbon dioxide
d) Various plant products eg medicines and industrial products like timber.

TRANSPORT SYTEMS IN PLANTS

Plants like other living organisms need food which they use for growth and maintenance. Unlike animals which depend on already made food, plants manufacture their foods in their leaves using carbon dioxide and water. However, the distance from the roots where water and mineral absorption takes place to the photosynthesis sites is very great and similarly, the distance from the sites of photosynthesis to some parts of the plant where the manufactured food is to be used for various activities is again very great. This necessitates the presence of transport systems to ferry different substances in plants body. The movement of substances from the regions where they are produced to the region where they are used or stored in plants is called **translocation**.

The transport system in plants is made up of two tissues namely; the xylem vessels and the phloem tubes.

THE XYLEM VESSELS

Xylem vessels are tissues in plants which run from the roots up to the stem and every leaf of the plant. They are responsible for transportation of water and minerals from roots to leaves and other parts where photosynthesis takes place. They consist of dead cylindrical cells which lost their cross walls and fit together like a series of pipe. They lack cytoplasm and nucleus. Their elements are shorter, fatter and more specialized for transport. The cell walls of xylem vessels are thickened and hardened by a tough water proof substance called **lignin**. As the vessels get order, lignin is laid down on the original cell wall. This makes them stronger but less flexible. Finally the xylem vessel s can become filled with lignin forming the woody centre of tree trunk or stem. Movement in xylem is restricted to one direction only, thus from the roots to up to the stem and leaves.

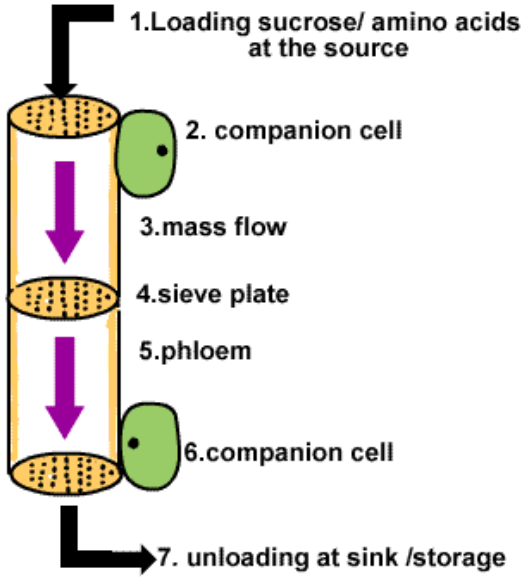
THE PHLOEM TUBES.

These are structures in plants responsible for transportation of manufactured food from the site of photosynthesis to all parts of the plant body. They are made up of **sieve tube cells** and **companion cells**. The sieve tube elements are living individual cells arranged end to end so that they form long tubes. The cross walls between these cells have tiny holes called sieve pores. the sieve tube contains cytoplasm, however they lack nuclei. On the other hand, the companion cells are found alongside the sieve tube. They contain both cytoplasm and nuclei. They are thought to serve their adjacent sieve elements.

Both the sieve tube cells and companion are not lignified hence they are soft and do not live long as they may be crushed easily by the growth of other cells.

	XYLEM	PHLOEM
STRUCTURAL	Made up of dead cells.	Made up of living cells
	No companion cells	Companion cells available
	Lignified (hardened by lignin)	Not lignified
	Cytoplasm absent	Cytoplasm present
	Nuclei absent	Nuclei present
FUNCTIONAL	Transport water and minerals from roots to sites of photosynthesis eg leaves	Transport manufactured food from site of photosynthesis to all parts of the plant.
	Support for woody plants	Little or no support

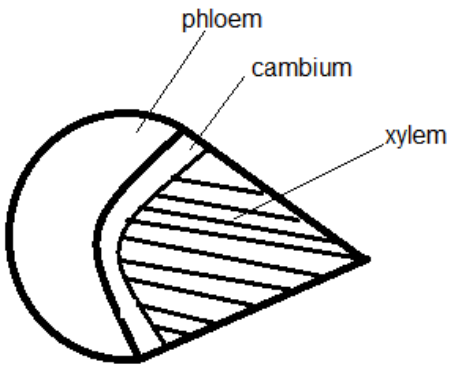
FLOW OF MANUFACTURED FOOD IN A PHLOEM.



THE XYLEM AND PHLOEM COMPARISON

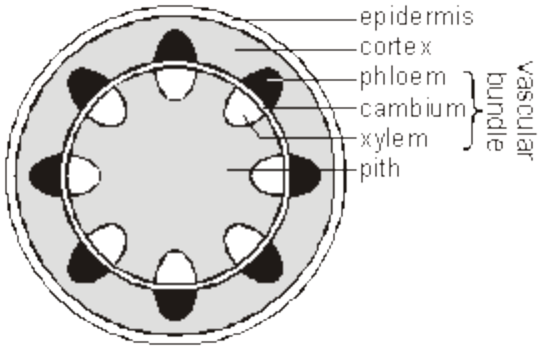
The xylem, phloem and cambium together form a **vascular bundle**. The cambium separates the xylem and phloem tube and further more it provide new cells to these two tubes as the cambium is a region of active cell division.

THE STRUCTURE OF A VASCULAR BUNDLE



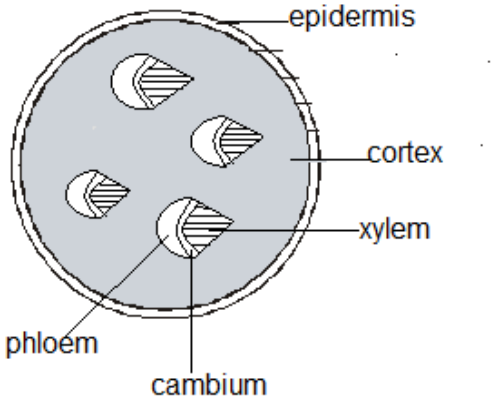
in dicotyledonous plants for instance beans, the vascular bundles are arranged in a pattern as shown in the figure below

A cross section of a dicotyledonous plant stem



In monocotyledous plants for example maize plant the vascular bundles are just scattered without forming a definite pattern as illustrated in the figure below.

- the xylem transports water and minerals. It also provides support to the plant.
- The phloem transports manufactured foods.
- The cambium separates xylem and phloem. It also provides new cells to xylem and phloem as it is a meristem (region of active cell growth.
- The cortex and pith stores food and also provide support to the plant.
- Epidermis- the outer part of the stem responsible for shape of the stem and also for gaseous exchange as it contains stomates.



DIFFUSION, OSMOSIS AND ACTIVE TRANSPORT

DIFFUSION

This refers to the net movement of substances from the region of high concentration to a region of low concentration.

Molecules, atoms and ions of a fluid or a solute like sugar, salt etc are always moving about. This results into particles spreading apart evenly to fill up available space. Therefore diffusion may also defined as the movement of particles along their concentration gradient

A concentration gradient is the difference in concentration between two regions.

FACTORS THAT AFFECT THE RATE OF DIFUSION

- **Size of particle**-the smaller the particle the faster the rate of diffusion. For example, table salt diffuse quickly than kitchen salt.

- **Temperature**-high temperature makes particles in a solution or a gas to move faster than in low temperature solution and gases thereby increasing the rate of diffusion
- **Surface area**-the bigger the area of diffusion the faster the rate of diffusion
- **Concentration gradient**-if the difference between the concentration is bigger, the rate of diffusion will be high and vice versa.

SIGNIFICANCE OF DIFFUSION

- Oxygen and carbon dioxide move in and out of the plant leaves.
- Plant roots take up minerals from the soil.
- Gaseous exchange in the lungs of some large animals.
- Excretion of waste substances in animals.
- Digested food enter in the blood stream from the gut.
- Unicellular animals take in oxygen and get rid of carbon dioxide.

OSMOSIS

This refers to the movement of water from region of high concentration to the region of low concentration across semi permeable membrane

When two solution have the same water concentration they said to be **isotonic solution**

SIGNIFICANCE OF OSMOSIS

1. It helps in distributing water evenly throughout the organism because every organism is surrounded by semi permeable membrane.
2. It controls movement of water into and out of cells
3. It helps in absorption of water from the roots by root hairs

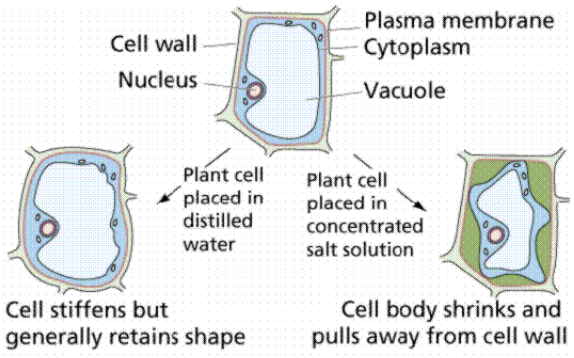
EXPERIMENT: Osmosis in plants

Procedure

Cut 3 stripes of fresh potatoes each of mass 3g and length of 7cm and test the flexibility of each stripe by trying to bend it. Collect 3 test tubes and label them. Pour sugar solution in one test tube and distilled water in another then put the stripes in each test tube. Leave the apparatus for 20 minutes and test the flexibility, mass and length of each stripe and record. Observe the changes in the flexibility, mass and length of strips.

Osmosis in body cells.

Since cells are surrounded by a membrane which is semi permeable, it is inevitable that osmosis takes place in these cells. The figure below summarizes the osmosis in plant cells.



- **Turgidity** – this refers the stiffening of cells. It takes place when a cell has been surrounded by pure water
- **Flaccidity –** this refers to shrinking of a cell especially when it has been put in a concentrated solution.
- **Plasmolysis –** this refers to a condition where the cytoplasms pulls away from the cell resulting into damaging of cell membrane and eventually death of the cell

ACTIVE TRANSPORT

This is the movement of soluble substances from region of low concentration to the region of high concentration. Thus in this, process substances move against the concentration gradient. Active transport uses a lot of energy unlike osmosis and diffusion.

SIGNIFICANCE OF ACTIVE TRANSPORT

1. It helps in transportation manufactured food and ions.
2. It helps the food to be always available since it is faster than diffusion.

TRANSPORT OF WATER IN THE XYLEM

Water is absorbed from root hair through diffusion and it passes from cell to cell by osmosis through **vacuolar pathway** or **apoplast pathway** until water molecules reach the xylem tissues where it moves against against the gravitational force by

- Transpiration pull - a pulling force generated by evaporation of water from the plant.
- Root pressure- a push force generated by the roots. It is developed by osmosis
- Capillarity which is the ability of water to move along a fine tube

Mineral salts are absorbed by diffusion through **symplast pathway** until it reaches the xylem where it is carried along with water in the transpiration stream to leaves or various growing points.

TRANSPORT OF ORGANIC SUBSTANCES IN THE PHLOEM

Food substances in form sucrose and amino acids enter the sieve tube and it is believed that movement of the substances in the phloem is facilitated by turgor pressure gradient. The direction of substance movement may at times change for instance when plants shed their leaves, substances move from roots upwards.

Experiments to show that the phloem transports manufactured food (organic) substances.

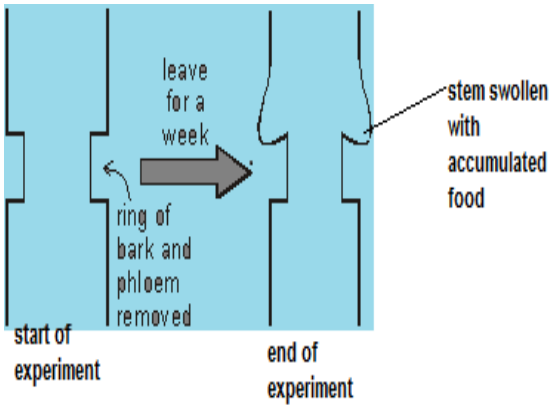
(a) RINGING OR GIRDLING EXPERIMENTS

Procedure

Cut off a complete ring of bark including the phloem and cambium from the main stem of a woody twig so that the xylem is exposed.

Leave it for some days and observe the results.

RESULTS



- Girdling just above the soil level causes reduced root growth and swelling of the tissues above the girdle as the products of photosynthesis destined for the roots accumulate.
- Girdling just below developing buds or fruits prevents the development of the fruits or the buds.

The results show that food is transported in phloem tubes.

(b) EXPERIMENTS WITH APHIDS.

Aphids feed on the phloem. If an aphid is allowed to pierce the phloem of a plant and its body is then removed . The analysis of the contents that will drip out of the stylets of aphids will show the presence of organic food substances. Hence, it can be concluded against this background that the phloem transports food substances.

TRANSPIRATION

This refers to the loss of water in form of water vapour from the leaves and other aerial organs through the stomata. Small amount of water is lost to the atmosphere through the stem which has tiny poles called **lenticles**. The movement of water within the plant is called transpiration stream while the movement of dissolved substances within the plant is called **translocation**

Water is removed from the xylem vessel and tracheoids in the leaves by transpiration. This water is replaced by water moving up the xylem vessels from the roots. The process of respiration is regulated by the opening and closing of stomata.

IMPORTANCE OF TRANSPIRATION

1. It helps to cool the leaves when it is exposed to intense sunlight.
2. It provides a mechanism of transporting mineral salts upwards.
3. It helps in the uptake of water from the roots to the leaves.

FACTORS THAT AFFECT THE RATE OF TRANSPIRATION

TEMPERATURE. On a hot day the rate of transpiration is high as a lot of water evaporates quickly from plants. On the other hand, during the cold days, the rate of transpiration is reduced as minimal amount of water evaporate from the plant to atmosphere.

HUMIDITY- this refers to the amount of water vapour in the atmosphere. When humidity is high, transpiration is low and when humidity is low the rate of

transpiration is high. This is due to the fact that when humidity is high the concentration of water molecules in the atmosphere decreases, thereby decreasing the diffusion gradient and when humidity is low the concentration of water vapour in the atmosphere decreases thereby increasing the diffusion gradient.

WIND SPEED- on a windy day the rate of transpiration is higher than on the calm day. This is because in a strong wind ,a layer of humid air that surrounds the leaf becomes very thin.

LIGHT INTENSITY

In a bright sunlight a plant may open its stomata to supply plenty of carbon dioxide for photosynthesis. Therefore, more water can evaporate from the leaves. Thus, the rate of transpiration increases as light intensity increases.

WATER SUPPLY- if water is in the short supply , the plant will close its stomata. This will cut out the rate of photosynthesis. Hence, the rate of transpiration decreases when water supply decreases.

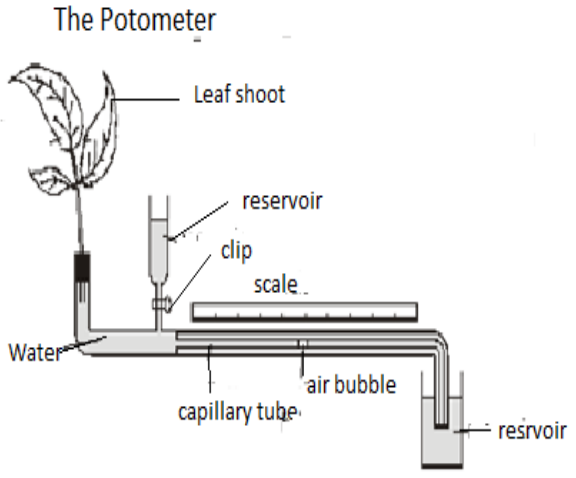
ATMOSPHERIC PRESURE- the lower the atmospheric pressure, the greater the rate of transpiration

MEASURING THE RATE OF TRANSPIRATION

An instrument called **potometer** is used to to measure the rate of absorption of water by plant and the assumption is that the rate of absorption is equal to the rate of transpiration hence the potometer is used to measure the rate of transpiration.

To measure the rate of transpiration in a shoot; firstly, cut the shoot under water then follow the following steps.

1. Insert the shoot through the hole in the cork of the photometer.
2. Open the tap of the reservoir to fill the graduated capillary tube with water. Close the tube when the water is full. As the shoot transpires it absorbs water from the potometer to replace that is lost during transpiration. This causes the water column in the capillary tube to move from one side A to another B.
3. Record the time taken for end of water column from A to B. a reading is taken from the air bubble which moves with the water column



TOPIC 3 : VERTEBRATES AND INVERTABRATES

Living things are divided into two kingdoms namely plant and animal kingdom. As a matter of fact, there are many types of plants and animals and this is called biodiversity. Generally, all animals share many similarities as well as differences. One of the major differences is that some have backbone while others do not have backbone. This enables classification of animals into two main groups namely vertebrates and invertebrate.

Invertebrates

Invertebrates are the most abundant animals on earth. They are generally small in size, they include animals like: insects, annelids, crustaceans, arachnids, Mollusca among others.

Invertebrates are animals that do not have a backbone. This group is made up of several phyla (singular-phylum). A phylum is a group of organisms that have some common characteristics. The phyla for invertebrates include:

- **Arthropods**: these are invertebrates with jointed legs, a hard exoskeleton (carapace), body divided into segments. As a matter of fact, there are different types of arthropods and these are:
    a. **Insects**: 6 legs, 3 body parts (head, thorax and abdomen), made of many segments, and two antennae e.g. bees.
    b. **Crustaceans**: many legs, 4 antennae, 2 body parts (head-thorax and abdomen), made of many segments e.g. crabs.
    c. **Arachnids**: 8 legs, no antennae, 2 body parts (head-thorax and abdomen) e.g. spiders, scorpions, mites and ticks
    d. **Myriapods**: many legs, many segments, 2 antennae e.g. centipede
- **Annelids** - these include ringed worms without legs, for instance earthworms.
- **Nematodes -** these include un-segmented worms which have no legs for instance
- **Molluscs**: these include un-segmented animals with gills and one muscular foot for example snails.

Vertebrates

Vertebrates are larger animals and less numerous compared to the invertebrates. They include animals like: fish, amphibians, reptiles, birds and mammals

CHARACTERISTICS OF VERTEBRATES

Vertebrates are animals with backbones. They have a common body structure modified for life in water, on land and in air. Vertebrates are divided into the following groups. Fish, amphibians, reptiles, aves (birds) and mammals.

FISH

These are vertebrates that live in water and have streamlined bodies covered with scales. Other characteristics of fish include

- Presence of gills for gaseous exchange.
- Presence of fins for locomotion.

BIRDS

These are warm blooded (endothermic) vertebrates with feathers, wings and beaks. They

reproduce by laying eggs. Their bodies are hollow and have scales on their feet.

AMPHIBIANS

These incudes animals like frogs, toads and many others. They have four limbs and smooth moist skins without scales. Have moist skin. They breed in water and fertilization is external. They have three chambered heart. Their gaseous exchange is through the skin, gills and lungs. On land they breath with lungs while in water they can breathe with their skin or gills. They are cold blooded.

REPTILES

These vertebrates live on land and their skins are dry covered with scales. Their fertilization is external. They are cold blooded animals. They have well developed lungs for gaseous exchange.

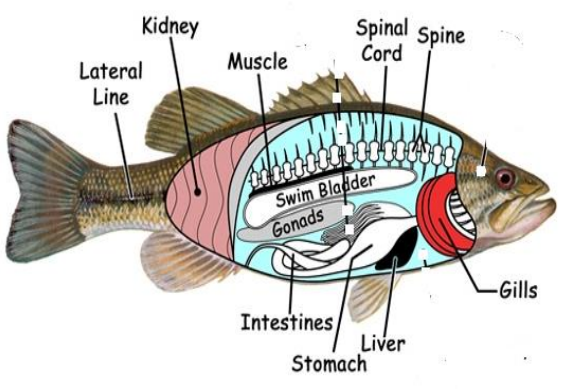
MAMMALS

Animals in this group are warm blooded and are also covered with hair in their bodiesThey Have hammary glands. Furthermore, they have teeth of different types and sizes. Their gaseous exchange is through lungs and have highly developed brain.

INTERNAL STRUCTURES OF VERTEBRATES

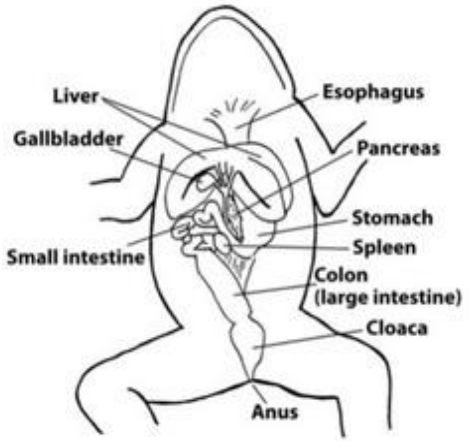
(a) INTERNAL STRUCTURE OF A FISH

If a fish is dissected, some of the organs that can be observed include: the liver, alimentary canal, testis or ovaries, kidneys, spines, gills as well as urinary tract as shown in the figure below.



(b) Internal structure of a frog

When a frog is dissected some of the structures that are observed include the heart, the spleen, the kidneys, the lungs and the alimentary canal as shown in the figure below



LOCOMOTION IN VERTEBRATES

Locomotion is the ability of an organism to move from one place to another. It can be also defined as a change in position of an organism from one place to another. Movement is the change in position of part of the body of an organism. Generally, locomotion is very important in living organisms in the following ways;

- It helps organisms to search for food.
- It helps animals to escape from danger.

- It helps animal to find mates for reproduction.
- It allows young animals to disperse thereby preventing overcrowding.

Locomotion is brought about by the action of muscles and bones of the skeleton.

LOCOMOTORY STRUCTURES IN FISH

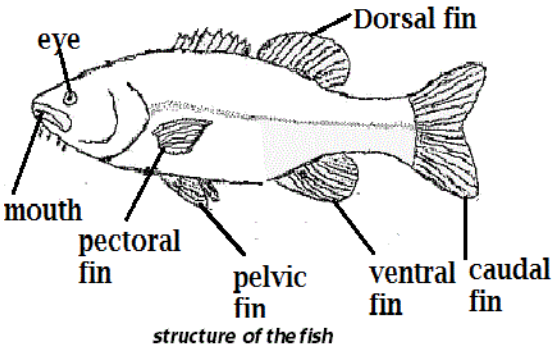
The fish has fins; the fins help in controlling movements of fish in water. There are several types of fins some of these fins are found singly (unpaired) and others are found in pairs (paired). Fish use fins as structures of locomotion.

(a) Unpaired fins

- **Tail fin** – it is also known as caudal fin. This fin is located at the end of the tail.
- **Dorsal fin** – it is found along the back or the dorsal part of the fish.
- **Ventral fin** – it is also known as **anal fin**. It is found on the lower part of the fish. This side is also known as the ventral side.

(b) Paired fins

- **Pectoral fins** – are found on the sides of the near the operculum.
- **Pelvis fins** – are found on the sides of the body below the pectoral fin near the ventral edge.



structure of the fish

The fish also has other features that enable them to move in water. They have air filled sacs called **swim bladder** for buoyancy. Tail fin is long to increase tail power to displace more water. They have strong tail muscles to create more force in movement.

The vertebral column is flexible to allow efficient movement.

LOMOTION IN FISH

Fish move through water which is more resistant than air. This resistance is called drag. However, fish overcome this drag by the following adaptations;

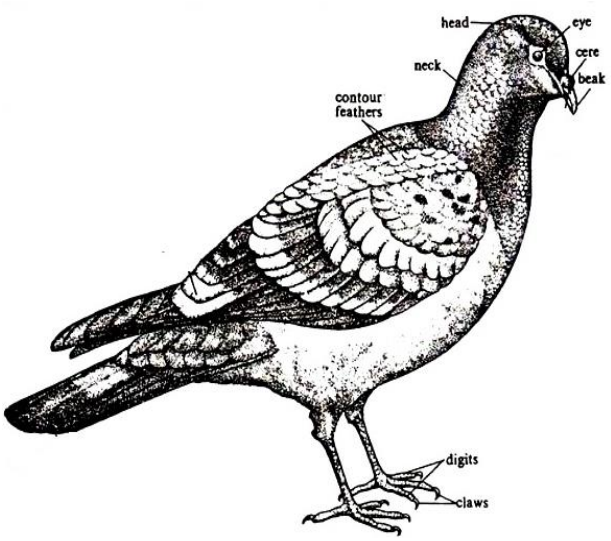
- They have stream lined body shape
- The backward pointing scales and the covering of mucus over the scales also reduce friction.

During slow movements the fish uses all of its fins. The paired fin e.g. pectoral and pelvis fins are like the paddles. The caudal fin is used for forward or backward movement while the dorsal fin and anal fin are for mobility ie. Control rolling of the fish and yawning (side to side movement). Bony fish has air bladders which are used to control its buoyancy. Fast forward movement is

brought about by the side to side action of the tail and is caused by alternate contraction of powerful muscles arranged down the side of the fish.

LOCOMOTION IN BIRDS

Birds can run, swim but most of them fly.



ADAPTATIONS OF BIRDS

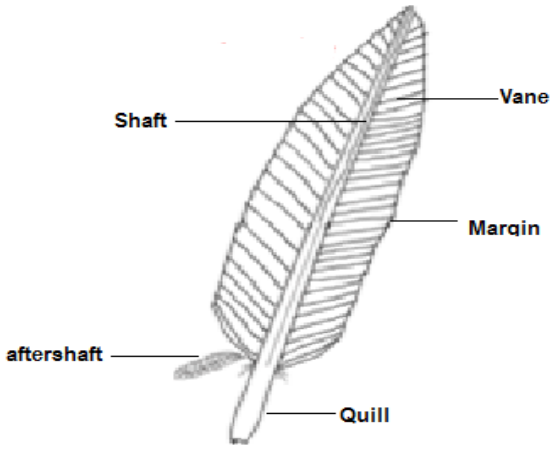
i. Have powerful and large flight muscle which provide the power to flap the wings in flight
ii. Have large sternum which has a deep keel, to which the flight muscles are attached which forms a rigid framework.
iii. Have streamlined shape to reduce air resistance
iv. Have very strong and light bones, in addition they contain air sacs which lighten them even further thereby overcoming gravity.
v. Birds wings acts as an aerofoil which generates lifts
vi. they have feather which provide a large surface area when the wings are flapped to generate lift and also insulate the bird, helping it to stay warm and regulates its body temperature.

TYPES OF FEATHERS

There are four main types of feathers. These are; flight, contour, down and filoprumes.

FLIGHT OR QUILL FEATHERS

They are used for flight. They cover the large wing and the tail. They are made up of a quill which is hallow and light, vane which is flat and made up of shaft and barbs. Barbs have branches called barbules which have hooks.



CONTOUR FEATHER

These are the feathers that cover the body of the birds. Their functions include providing streamlining shape of the bird, camouflage and sexual display.

DOWN FEATHERS

These are feathers whose function is mainly for insulation. The whole vane is loose due to absence of hooks.

FILOPLUMES

These are small hair like feathers which assist in insulation. Down the filoprumes feathers are found between the flight and contour feathers to form a complete insulation. All birds have oil glands on their tails which they obtain oil using their beaks to smear the feathers to ensure that they are water proof. Body temperature of birds is higher than of the human beings as they have high metabolic rate to carter for more energy needed for flight.

MECHANISM OF FLIGHT IN BIRDS

Flight is possible in birds because the birds wings act as an aerofoil (an aerofoil is a structure with curved surface which generates lift in flights) the distance over the top of the wing is greater than the distance over the bottom of the wing thus the air on top moves faster than the air on the bottom. this means that the air molecules becomes more spaced out as they move over the top of the wing compared to those molecules moving over the bottom, this result in air pressure being less above the wing below it and this generate an upward force called lift, in fact the lift is generated on both the down and the upper stroke, quill feather will tilt allowing air to flow between them, while on the down stroke they lock into position, maximizing air resistance. The tail and the wings control steering.

LOCOMOTION IN MAMMALS

Mammals move by creating a propulsion force that moves the body forward. This force is provided by the contraction of muscles of the legs. As the muscles contract they move the bone back and forth. The bones cause movement of the locomotory structures producing a propulsion force that moves the animal forward. The whole mechanism of movement is controlled by the nervous system.

TISSUE OF THE SKELETON

these are tough elastic tissue that join bones together at a joint.

Ligament is a strip of connective tissue which attaches bones to each other. They are made of proteins called collagen which is flexible but resistant to stretching and another protein called elastin which is more elastic.

TENDONS-these are tough inelastic tissue that joins muscles to bones. They are made of collagen, making them elastic. This means that when muscles contract, it will move the bone and not just stretch the tendon.

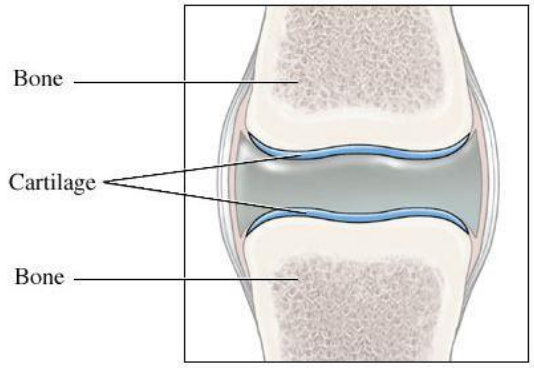
CARTILAGE-this is very flexible. It is a dense fibrous tissue which acts as a shock absorber and also reduces friction. Furthermore, it joins the bones together for instance the vertebral column and also provides support for body parts that do not carry much weight.

BONE-this is a complex tissue in which living cells and long twisted protein called collagen are supported by the crystals of a matrix formed by calcium and phosphate ions. Bones provide support for our bodies and help form shape. The skull protects the brain and forms the shape of our face.

JOINTS

This refers to a place where two or more bones meet. The movement of bones

relative to each other can occur only at a joint.



Cross section of a joint

Joints can be movable or immovable.

- ❖ Immovable joints are found in places like between bones of cranium called sutures, between the sacrum and the pelvic girdle.
- ❖ movable joints include;
  - i. **Hinge joint-** this allows movement of the bones in one plane or one direction only. For example elbow and knee joints.
  - ii. **Ball and socket joints-** these are the joints where the round head of one bone fits into a socket or cavity of another bone, allowing movements in all planes. Example includes hip and shoulder joints.
  - iii. **Gliding joints-**these are type of joints where bones slide over one another. This type of joint is found in the wrist between carpals and in the ankle between the tarsal.
  - iv. **Pivot joints-** these joints are found between the atlas and the axis vertebrae. They permit rotation in all sides for example a head can be moved from side to side and also up and down.

Adaptation of mammals to locomotion

The mammalian body is adapted to locomotion in the following ways.

- **Presence of skeleton** – the bones of the forelimb and those of the hind limb are adapted to locomotion. The bones of the hind limb are always longer than those of the forelimb. This enables creation of greater force to propel the body forward during movement. The bones of the forelimb are shorter to provide stability to the body during movement.
- **Presence of muscles**

The human body has more than 650 muscles, which make up half of the person's body weight. They are connected to the bones by a tough cord like tissue called tendons which allow the muscle to pull on the bones.

TYPES OF MUSCLES

There are three types of muscle. these are skeletal, smooth and cardiac muscles.

a) **Skeletal muscles-** These are also known as voluntary or striated muscles. In fact they are under organism conscious control. They move the bones of the skeleton. They are attached to tondons which join to the bones. They work by contraction only. this implies that to move a bone it requires two sets of muscles, when one set contacts it moves the bone in one direction, and when the other contracts it moves the bone in

opposite direction. These two sets of muscles work in opposite direction. These two muscles work in opposite to each other are called antagonistic muscle, thus pair muscle which on contraction, and produce opposite effects to each other.

b) **Cardiac or heart muscle-** this is a special form of muscle which occurs in the walls of the heart. They are very strong and does not get tire until the organisms die.

- **Presence of movable joints** – Locomotion is enhanced by the presence of hinge joints
- and ball and socket joints. These joints allow the bone to move freely to enhance faster movement. Joints are found where two bones meet. The surface of bones at the joints is covered by a cartilage tissue to absorb shock and reduce friction during movement.
- **Presence of tendons** – These are tough connective tissues that join a muscle to a bone.
- **Presence of ligaments** – Ligaments joins a bone to a bone at the joints. This makes sure that the two bones do not separate even when strong movement activity is taking place.

Some animals such as the carnivore have flexible trunks due to a flexible backbone. This enhances flexibility of the whole body during locomotion.

FUNCTIONS OF THE HUMAN SKELETON

a) Attachment of muscles and movement.

b) Maintenance of the body shape.

c) Storage of calcium and phosphate ions.

d) Production of blood cells.

Protection of vital organs e.g. brain is protected by bones of cranium.

TOPIC 4: THE HUMAN DIGESTIVE SYSTEM

Feeding is one of the basic characteristics of all living things. Both plants and animals need food for their everyday activities. However, most of the foods that are eaten by animals are not in a form that can be readily absorbed and used by the body. As a matter of fact, most foods that animals eat are insoluble and cannot pass through the cell membranes into cells. Furthermore, most foods are chemically different from substances that make up body tissues. Meaning to say, the food has to be processed and rendered into a state that can be readily absorbed by the body. This topic purports to explore how large particles of food are broken down into smaller particles and how these food particles are used by the body.

DIGESTION

This refers to the process by which large particles of food substances are broken down into smaller particles. The process of digestion makes insoluble food particles to be soluble there by maximizing their rate of absorption. The digested food which is in solution form, passes through the walls of intestine and eventually enters the blood stream through the process of absorption. Furthermore, digestion makes food easy to swallow and also increases its surface area so that enzymes can work on it easily.

TYPES OF DIGESTION

There are two types of digestion. These are physical and chemical digestion.

A) PHYSICAL OR MECHANICAL DIGESTION

This refers to the breaking down of large particles of food without changing its chemical or molecular make up. This implies that, when food has been digested physically, it is just reduced in its size without forming any new substances. In the alimentary canal, this type of digestion takes place in the mouth, stomach and duodenum. In the mouth it is accomplished by the action of teeth in a process called mastication (chewing) while in the stomach it is done by the churning movements. In the duodenum it is done by the action of bile which breaks down large particles of fats into smaller molecules in a process called emulsification. Generally, physical digestion renders the food in a state that can subsequently be accessed easily by enzymes during chemical digestion.

IMPORTANCE OF PHYSICAL DIGESTION

- It makes food easy to swallow.
- It increases the surface area of the food thereby enabling digestive enzymes to act or work on it easily.

B) CHEMICAL DIGESTION

This refers to the breakdown of large complex molecules of food into smaller

soluble molecules by the action of chemicals called enzymes.

An enzyme is a protein that works as a biological catalyst. A **catalyst** is a substance that can alter the rate of chemical reaction without itself being altered. Thus enzymes speed up chemical reaction in the alimentary canal without themselves being used up or changed. All enzymes are proteins.

PROPERTIES OF ENZYMES

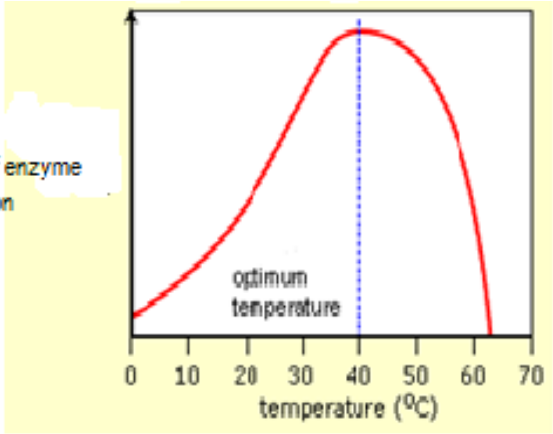
- **Enzymes are specific to the reaction they catalyze.**

The substance on which an enzyme acts is called its substrate. The substrate molecule fits into a cleft in the enzyme molecule, called the active site. They must fit exactly, like a key fitting into a lock. This means that each kind of enzyme can only work on one kind of substrate whose molecules fits and binds.

- **Enzymes are temperature dependent.**

Like most chemical reactions, the rate of enzyme-controlled reactions increases as the temperature increases. The temperature when the enzyme is working fastest is called the **optimum temperature**. In human beings the optimum temperature for enzyme controlled reactions is 37°C – 40°C. However, if temperature is higher than the optimum temperature the structure of the enzyme changes. As a result, the active site becomes a different shape and the substrate no longer fits this process is called **denaturation.** When denaturation occurs, enzymes are destroyed to the extent that they cannot function properly. It should also be noted that when the temperature is very low, the enzymes become inactive. The graph below summarises the effect of temperature on enzymatic reactions.

- **Enzymes are pH dependent.**



The reaction of enzymes also depends on the measure of acidity or alkalinity of its environment. This is due to the fact that pH can also affect the shape of the active site. It does this by affecting the forces that hold the enzyme molecule together. A change in pH can stop the enzyme completely. Different enzymes work best at different pH values. Eg. Stomach enzymes for instance pepsin and rennin work best in acidic conditions. Mouth enzymes like ptyalin work best in neutral conditions. In fact, every enzyme works best at a specific pH.

- **Enzymes are Proteins in nature.**

  Enzymes are protein molecules made up of long chains of amino acids. These long chains are folded to produce a special shape which

enables other molecules to fit into the enzyme.

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However, it should be noted that not all enzymes are digestive enzymes, some enzymes catalyzes other metabolic processes in the body for instance thrombin is used in blood clotting, carbonic anhydrase is used for conversion of carbon dioxide into carbonic acid during respiration.

Digestive enzymes are categorized according to the food substances which they act upon. The main types of these digestive enzymes include proteases which act on protein foods and examples include pepsin, renin, trypsin, and peptidase; lipase which act catalyses the breakdown of lipids into fatty acids and glycerol and finally carbohydrase (amylase) which act on carbohydrates and examples include salivary amylase (ptyalin), pancreatic amylase, maltase, sucrose and lactase.

TYPES OF DIGESTIVE ENZYMES

A summary of enzymes and their functions

Name of enzyme	Digestive juice containing the enzyme	Site for production of juice	Where the enzymes acts	Food acted upon	Product
Ptyalin	Saliva	Salivary glands	Mouth	Cooked starch	Maltose
Pepsin	Gastric	Stomach	Stomach	Proteins	Polypeptides
Lipase	Pancreatic	Pancreas	Duodenum	Fats	Fatty acids and glycerol
Trypsin	Pancreatic	Pancreas	Duodenum	Polypeptides	Peptides
Pancreatic amylase	Pancreatic	Pancreas	Duodenum	Uncooked starch	Maltose
Sucrase	Intestinal	Small intestine	Ileum	Sucrose	Glucose and starch
Maltase	Intestinal	Small intestine	Ileum	Maltose	Glucose
Lactase	Intestinal	Small intestine	Ileum	Lactose	Glucose and galactose

THE HUMAN ALIMENTARY CANAL

Digestion in human beings takes place in a special system called alimentary canal or gut which runs from the mouth to anus. Apart from digestion, the following processes also takes place in alimentary canal

- **Ingestion -** taking in of solid food into the mouth.
- **Absorption -** entering of food into blood stream.
- **Assimilation** - this is the process by which food is made part of the body and used for different activities for example respiration.
- **Egestion –** the removal of indigested food by anus.

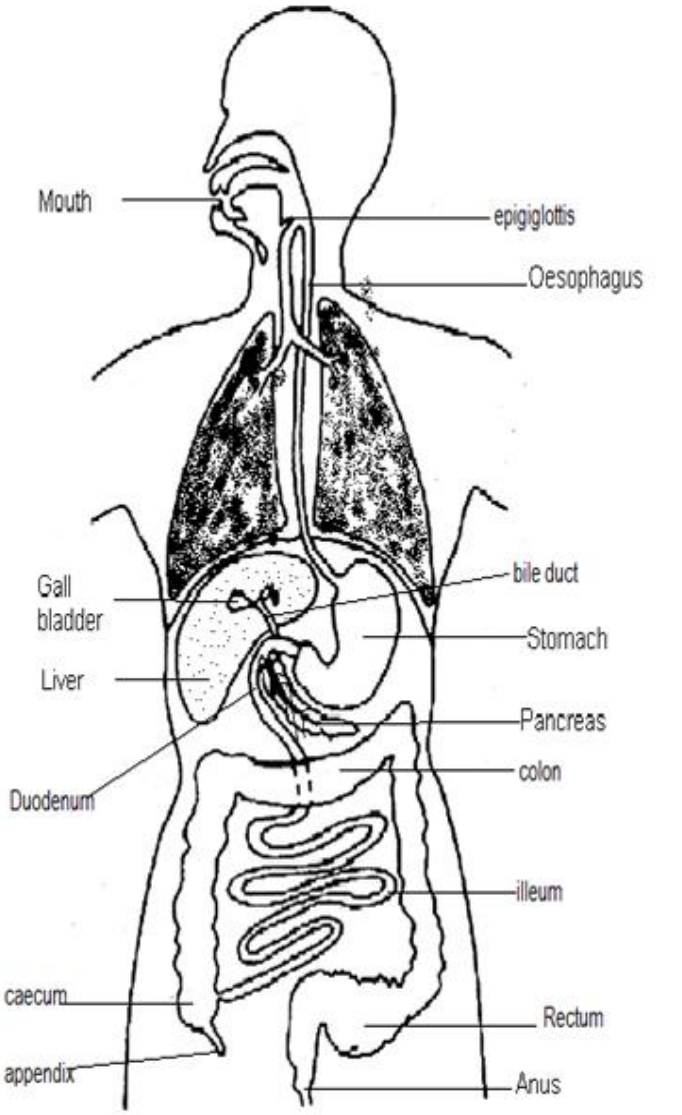
Generally, the human alimentary canal has the following characteristics

(i) It is lubricated with mucus – this helps in easy movement of food during peristalsis and also prevents the lining of the canal from being damaged by the acid found in some parts

(ii) It has a dense network of blood capillaries – this enhances the process of absorption especially in the ileum.

(iii) Numerous digestive glands are present in designated places- these are responsible for production of enzymes

The Structure of Human Alimentary Canal



1. THE MOUTH (BUCCAL CAVITY)

Food enters the mouth in a process called ingestion. After ingestion, it is digested physically by the action of the teeth in a process called mastication (chewing). Generally, there are four different sets of teeth in the mouth responsible for this mastication namely; the incisors, the canines, the premolars and the molars. The incisors bite the food chunk while the canines tear it and the premolars in conjunction with molars grind the food. Furthermore, while the food is still in the mouth, the tongue mixes it with saliva which is produced by three pairs of the salivary glands to form bolus. The saliva contains four substances namely; salivary amylase, mucus, water and salts.

- **The salivary amylase-** this is also called ptyalin. It is an enzyme which starts chemical digestion of cooked starch to disaccharide called maltose
- **The mucus-**is very important in lubricating the food for easy swallowing and formation of a bolus which is a ball like structure formed after food particles have stuck together.
- **Water**-moisten the food and dissolves the soluble food substances for example glucose
- **The salt-** neautrises the PH in the mouth in order for the salivary amylase to act on the cooked starch easily.

In a nutshell, when food enters the mouth, it is digested physically by the action of the teeth and chemically by the action of salivary amylase (ptyalin). It is also lubricated and moistened for easy swallowing by the mucus and saliva respectively.

2. OESOPHAGUS

After chewing, a bolus is formed by the tongue, it is swallowed and enter the oesophagus which is a muscular tissue running from back of the mouth to stomach. Swallowing starts as a voluntary action but later becomes an involuntary action. During swallowing, the epiglottis seals the trachea, preventing food from entering the wind pipe. The oesophagus has two types of smooth muscles namely; the circular and longitudinal muscles. The contraction of these muscles is responsible for movement of food along the alimentary canal. This movement is called peristalisis. Little digestion of cooked starch continues in the oesophagus and sometimes it doesn't occur at all.

3. STOMACH

This is the muscular bag where food is stored for processing later by the rest of the alimentally canal. Apart from storing food temporarily, the stomach wall also produces **hydrochrolic acid** , **gastric juice** and **mucus**. The entry point of the stomach has a ring of muscles called cardiac sphincter which prevents the food from going back into the oesophagus and further allowing gases swallowed with food to escape. When food enters the stomach, starch digestion stops because salivary amylase is not active due to the presence of hydrochloric acid. The

chemical digestion of proteins starts in the stomach due to the presence of proteases like pepsin and rennin.

The gastric juice which is produced by gastric glands in the walls of the stomach contains several substances for instance; pepsin, rennin, hydrochloric acid and water. These substances play the following roles;

- **Pepsin** – a protease secreted in an inactive form pepsinogen and it catalyses the hydrolysis of proteins to peptides.
- **Renin-** another protease mainly found in children in large quantities and it coagulates milk proteins **(casein),** thereby increasing their surface area for pepsin to work on them easily.
- **Hydrochloric Acid –** this substance plays different roles for instance
- Creating acidic environment (pH **1.5 – 4)** in the stomach to ceate optimum PH for pepsin and rennin.
- converting active pepsin from passive pepsinogen.
- dissolving bones that might have been taken together with food.
- -Providing body immunity by killing germs for example bacteria ingested with food.
- **Water-** it continues dissolving the products of digestion.

As food is being churned and mixed by peristalsis, chime is produced . At the exit point of stomach there is another ring of muscles called pyloric sphincter muscles which relaxes at intervals releasing small amount of chime into the duodenum, the first part of the small intestines.

4. The small intestines

This is the longest part of the alimentary canal, almost 7m long. It is where most of chemical digestion and absorption takes place and perhaps completed. The completion of digestion is made possible due to presence of pancreatic juice, bile an intestinal juice. Infact the small intestine comprises duodenum, jejunum and ileum.

i. **Duodenum-** this is the first part of the small intestines, it is the region where food is mixed with **bile** and **pancreatic juices.** Bile is produced by the liver stored by the gall bladder and conducted to duodenum by bile duct while pancreatic juice is produced by the pancreas. The bile is an alkaline green watery fluid which contain inorganic salts and organic salts. The inorganic salts neutralizes the acidic chime coming from stomach while the organic salt emulsify lipids. Emulsification is a process by which large molecules of fats are broken down into smaller molecules. The emulsification increases the surface area on which the lipids digestive enzymes can work on, this is physical digestion as it involves reducing the size of lipids particles without changing their form and also because no enzyme is used. The bile also contains some waste products produced by the liver. the pancreatic juice is also an alkaline fluid

with PH within 7-8. It contains trypsin, lipase, pancreatic amylase and salts. The trypsin catalyses the hydrolysis of proteins to peptides while the lipase catalyses the hydrolysis of lipids to fatty acids and glycerol. The pancreatic amylase catalyses the hydrolysis of starch to maltose while the salts neutralizes the acidic chime from stomach to creatre optimum pH for the action of lipase, trypsin and pancreatic amylase.

ii. **Jejunum-** this is the middle part of the small intestines.

iii. **Ileum-**this is the longest part of the small intestines which is about 6m long. The lining of the ileum contains glands which produces intestinal juice containing the following enzymes.

a) Lipase- responsible for chemical digestion of lipids into fatty acids and glycerol

b) Maltose-responsible for chemical digestion of maltose into glucose.

c) Lactase-responsible for chemical digestion of lactose into glucose and galactose.

d) Sucrose-catalyses the hydrolysis of sucrose to glucose and fructose.

e) Peptidase-catalyses the hydrolysis of peptides into amino acids. It also contain the mucus which prevent the enzymes which digest proteins from digesting the walls of intestines. Digestion is completed in the ileum by the enzymes listed above.

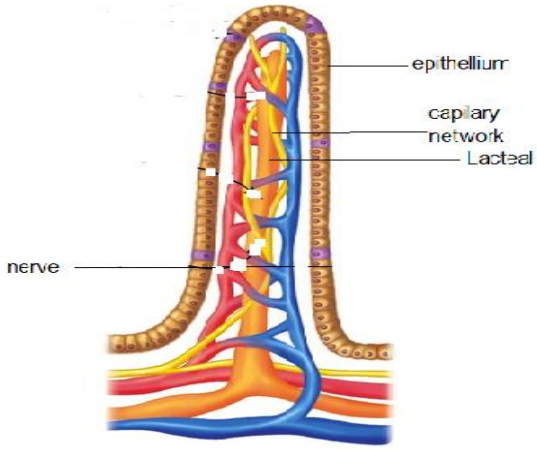
ABSORPTION IN THE ILEUM

Absorption is the process by which the small soluble molecules of food enter the blood and lymph from the lumen of alimentary canal. It mainly takes place in the ileum. the ileum is adapted to this function in the following ways

a) It is the longest part of the alimentary canal, ensuring that most of the soluble food is absorbed, thus providing a large surface area for absorption.

b) It has inner surface highly folded into finger like structures called villi. This produces a very large surface area for absorption of the end products of digestion.

Structure of a Villus



c) The ileum has dense network of blood capillaries called lacteals to pick up molecules produced by digestion and transport them away from the alimentary canal.

Furthermore the ileum is also adapted for completion of digestion by having good PH and production of different enzymes and

presence of epithelium (a single layered membrane) which covers the villi and allows dissolved substances to pass through the blood capillaries and lacteals. Its cell has many mitochondria. Lacteal absorbs the following substances; glycerol, fatty acids, and fat soluble vitamins like vitamin **A,D,E** and **K**. Other food substances like fructose, galactose, amino acids and water soluble vitamins like vitamin **B** and **C** are taken by blood.

The blood capillaries from the ileum join together to form hepatic portal vein which carries glucose and other products to the liver where they are stored temporarily or processed by liver before being transported to other tissues

Glycerol and fatty acids which pass into the lacteals are transported through the lymphatic system. At the end of the ileum there found the appendix and caecum which has no specific role in digestion.

THE LARGE INTESTINES

a) **COLON-** it is wider than ileum and its ridged lining contains many mucus cells. Digestion doesn't take place in the colon, rather the colon play the following roles, absorbing of mineral salts, preparing faeces for egesting

b) **RECTUM-** this part stores faeces for about 24 hours before being egested through the anus during **DEFAECATION.** the anus has anal sphincter which when it relaxes the faeces are released.

ASSIMILATION

Once absorbed into the blood stream, the molecules produced by digestion are taken by the hepatic portal vein to the liver. These end products include glucose, amino acids, fatty acids and glycerol. The liver process these end products in the following ways

i. **Glucose**- Most glucose is transported out the liver through hepatic portal vein to different parts of the body where it is used for respiration. However excess glucose is converted to glycogen for storage by the liver.

ii. **Amino acids-** They are synthesized into blood proteins like prothombin and fibrinogen while some are taken to different glands both endocrine and exocrine gland for synthesis of hormone and enzymes respectively. Excess amino acids are broken down in a process called deamination where the amine group is converted to urea as a waste product and the carboxyl (acid) group is converted into glucose in a process called transmination which is later converted into Glycogen (animal starch) which is stored in the liver and muscles for future use.

iii. **Fatty acids and glycerol**- These are used for respiration and excess are taken out to connective tissues or different vital parts of the body and under the skin for storage as fats.

FUNCTIONS OF THE LIVER IN RELATION TO DIGESTION

The liver is the second largest organ, reddish brown in colour which lies just before the diaphragm in the body. It has several functions. The following are the functions of the liver in digestion;

A. PRODUCTION OF BILE

The liver produces bile by breaking down red blood cells into green and yellow pigments. Bile is passed to the duodenum through the bile duct. Bile is a greenish liquid.it contains bile salts like sodium bicarbonate and bile pigments. Bile salts play a big role in digestion fats. They split up fat in the digestive system into tiny fat droplets in a process called **emulsification.**

B. STORAGE ORGAN

The first function of the liver in related to digestion is this that it acts as a storage organ. As a matter of fact, the liver stores a lot of substances like iron, potassium, vitamins like Vitamin A,B,C,D, E and K

C. **DEAMINATION**

Amino acids are the end products of protein digestion. Because excess amino acids cannot be stored in the body, they are broken down in the liver in a process called **deamination.** From each amino acids, the amino group (NH_2) is changed to ammonia (NH_3). The rest of the amino acid molecule is changed o glycogen or fat for storage. The ammonia produced from the amino group is very quickly converted to a less toxic substance, which is usually urea.

D. TRANSAMINATION

This refers to the transfer of an amino group from one amino acid to another substance so as to form another amino acid. During this process, the liver makes amino acids that are deficient in the diet. It does this by transferring amino groups from one available amino acid to an organic molecule like a sugar or an acid to form the required amino acid. For instance glutamic acid can be made by removing an amino group from alamine and combining it with an organic sugar. Alamine → Amino group + Organic acid → Glutamic acid

E. CONTROL OF LIPIDS

The liver controls the amount of lipids in the blood. One of the lipids that the liver controls is cholesterol which also makes. Cholesterol is necessary for the formation of membranes. It has a very low solubility in body fluids.

Excess cholesterol may form deposits in the arteries leading to heart attack and stroke in severe cases. Gallstones may be formed as a result of accumulation of excess insoluble cholesterol in the gall bladder.

F. CONTROL OF SUGAR

Under the influence of insulin, the liver converts excess glucose and amino acids to glycogen for storage when are above their normal content. Glycogen I an insoluble carbohydrate. Under the influence of glucagon, it converts the stored glycogen to glucose when blood sugar levels are below normal.

MAIN FOOD SUBSTANCES (FOOD NUTRIENTS)

Food nutrients are chemical substances that are found in food and have a specific

function. As a matter of fact, there are six food nutrients namely carbohydrates, proteins, fats/lipids, vitamins, minerals and water.

A. CARBOHYDRATES

These are organic compounds made of **carbon, hydrogen and oxygen**. The proportion of hydrogen to oxygen atoms is always two to one as in water as shown in the general formula for carbohydrates which is $(CH_2O)_n$ where **n** is a number between 3 and several thousands. Carbohydrates are further categorized into three classes. These are **monosaccharides, disaccharides and polysaccharides**

I. MONOSACCHARIDES

These are simple sugars which consist of single molecule. Generally, monosaccharides have the following properties

- They are faintly sweet
- They are soluble in water
- They are crystalline solids
- They are found in many edible fruits and honey
- They have a general formula of $C_6H_{12}O_6$

Examples of monosaccharides include

(i) Glucose - Common sugar common sugar used by animals and plants for respiration

(ii) Fructose fruit sugar which is fairly sweet

(iii) Galactose – single sugar found in milk

II. DISACCHARIDES

These are sugars consisting of two monosaccharides molecules. Generally, disaccharides have the following properties

- They are sweeter than monosaccharides
- They are soluble in water
- They are white crystalline solids
- They have general $C_{12}H_{22}O_{11}$

Examples of disaccharides include

(i) Maltose – this is a double sugar made up of two glucose molecules. it is produced from the breakdown of starch in animals

(ii) Sucrose – this is a double sugar made up of glucose and fruictose. It is found in plants especially sugar cane and sugar beets

(iii) Lactose – this is a double sugar made of glucose and galactose. It is also called milk sugar as it is common found in milk of mammals

III. POLYSACCHARIDES

These are sugars made up of thousands of monosaccharides. The following are their general properties

- They are insoluble in water
- They are tasteless
- They are not crystalline solids

Examples of polysaccharides include

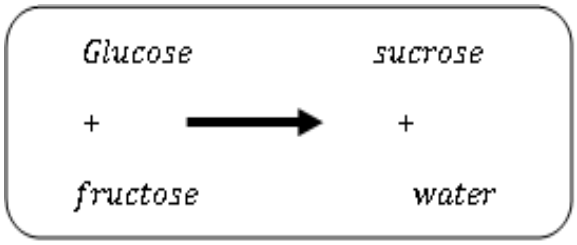
(i) Starch –this is the form by which all glucose is stored in plants
(ii) Glycogen – this is the storage form of glucose in animals
(iii) Cellulose – the carbohydrate which form the cell wall in plant cells
(iv) Chitin – this is the material that makes up the exoskeleton of insects.

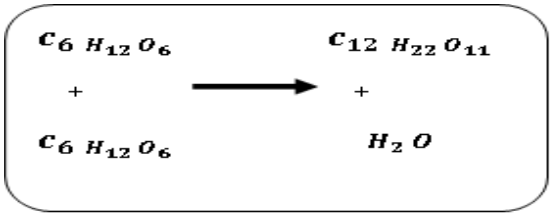
REACTIONS IN CARBOHYDRATES

Carbohydrates undergo two main reactions namely condensation and hydrolysis.

(a) CONDENSATION

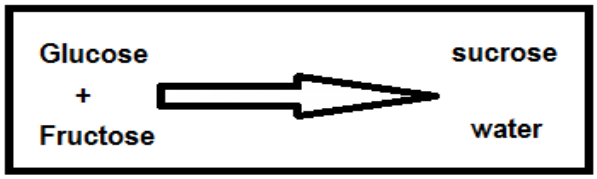
This refers to a condition whereby two or more molecules combine to produce a large molecule plus water. For example, monosaccharides can build up to form disaccharides and polysaccharides by condensation reaction.





(b) HYDROLYSIS

This is one of the most important reactions in digestion. Large molecules are broken down by adding water molecule to them. For instance



B. PROTEINS

These are complex organic molecules and there are millions of different sorts each adapted to carry a specific function, for example

(i) Catalysts for example enzymes
(ii) Transport proteins like haemoglobin
(iii) Antibodies which fight diseases
(iv) Contractile proteins found in muscles
(v) Hormones

CHEMICAL COMPOSITION OF PROTEINS

Proteins are made up four elements namely carbon, hydrogen, oxygen and nitrogen. However, Sulphur and phosphorus are also commonly found in some protein molecules. Virtually, proteins are built from smaller molecules called amino acids. Naturally, there about twenty types of amino acids of which any type can combine together to form different protein molecules. Other amino acids can be made by our bodies while others cannot be made by our bodies. Those that cannot be made by our bodies are called essential amino acids. These essential amino acids are supplied to the body by protein

foods that are consumed. Some protein giving foods contains all ten essential amino acids for example animal proteins while others do not contain all the essential amino acids for example most plant proteins.

In view of this, the former are called first class proteins or proteins of high biological value (HBV) while the latter are called second class proteins or proteins of low biological value (LBV). The main functions of proteins include

- Growth of new cells
- Replacement of dead cells and lost cells
- Repair of dead cells due to accidents or illness
- Provision of energy when there are not enough fats or carbohydrates in the diet

When the proteins are digested, the end products are amino acids. However, excess amino acids are not stored in the body; rather, they are broken down by the liver into amine group and carboxyl group in a process called deamination. The carboxyl group which is made up of carbon, hydrogen and oxygen is converted into glycogen which is stored in the liver for future use, while the amine group which is made up of nitrogeneous compounds is excreted after it is converted into ammonia then urea.

C. LIPIDS

The most common lipids are fats and oils. Like carbohydrates, they are made up of carbon, hydrogen and oxygen. However, the ratio of hydrogen to oxygen is much greater than that of carbohydrates which is 2:1. For example a beef fat molecule is $C_{57}\ H_{110}\ O_7$. Fats and oils are important sources of energy; in fact, they contain relatively more energy than carbohydrates. Fats are solid at room temperature while oils are liquid at room temperature. Generally, lipids molecules are made up of two basic elements which are, glycerol and fat acids. Lipids are broken down into glycerol and fatty acids during digestion in a process called hydrolysis.

PROPERTIES OF LIPIDS

- All lipids are insoluble in water but soluble in organic solvents for example ethanol.
- Fats are solid at room temperature but melt easily with high temperatures while oils are liquid at room temperature

FUNCTIONS OF LIPIDS

(a) They provide energy to the body
(b) Some lipids are used in formation of cell membrane
(c) Fats stored under the skin are used for insulation
(d) They are used for oxidation

D. VITAMINS

Vitamins are organic substances needed in small amounts in the diet. Vitamin C is found in fresh fruit and vegetables. It is needed to make the protein collagen, which is essential for the formation of skin. A shortage

of vitamin C causes scurvy. Vitamin D is found in many plant foods and is made in the skin when sunlight falls onto it. It is needed to help calcium be absorbed and used in the body. A shortage of vitamin D causes rickets.

E. MINERALS

Minerals are inorganic ions needed by the body. Iron is needed for the formation of haemoglobin, and a shortage causes anaemia. Calcium is needed for the formation of teeth and bones, as well as for blood clotting.

F. WATER

Water is needed as a solvent for metabolic reactions, as a transport medium in blood, for cooling when it evaporates from the body and as a reactant in several metabolic reactions

PROBLEMS ASSOCIATED WITH THE DIGESTIVE SYSTEM

- **CONSTIPATION**

  This refers to the retention of the contents of the lower alimentary canal (large intestine with undigested foods) for long periods. The urge to defecate is depressed and it becomes difficult to expel faeces. This can be prevented by the inclusion of roughages in the diet.

- **DIARRHOEA**

  This is a condition in which large intestines fail to absorb water thereby producing large quantities of watery fluids. This is caused mainly by infection and indigestion

- **ULCERS**

  This occur either in the stomach or small intestine due to either little production of mucus or too much hydrochloric acid.

- **HEARTBURN**

  This is caused by acidic foods from the stomach when it goes into the oesophagus.

- **INDIGESTION**

  This applies in general to all sensations of discomfort in the stomach or duodenum. It is caused by eating too much food or accumulation of gases in the stomach.

- **NAUSEA**

  Is either a sign of infection or allergy substances where one feels like vomiting.

TOPIC 5: THE HUMAN CIRCULATORY SYTEM

Living organisms need constant supply of different useful substances for example food nutrients, oxygen. These substances are supposed to be transported throughout the body of an organism. In addition, the waste products that are produced during metabolic processes for example urea, carbon dioxide and sweat are also supposed to be removed from the body before they accumulate to harmful levels. As such, there is a need for transport system in all organism.

In human beings, there are two main transport systems namely the circulatory system which is also known as blood system and the lymphatic system.

THE HUMAN CIRCULATORY SYTEM

The circulatory system is an organ system responsible for transportation of different substances for instances food nutrients, gases, and waste substances within the cells of mammalian animals. In human beings and other vertebrates, the circulatory system is closed. This means that the blood circulates in specialized tubes known as blood vessels hence there is no direct contact between blood and cells. However, some animals for example insects, have open circulatory system whereby the blood and the cells have direct contact. Furthermore, human circulatory system is an example of a double circulatory system as it involves two distinct circulations namely the pulmonary circulation and the systematic circulation. In pulmonary circulation, blood is pumped from the heart to the lungs for purification and back to the heart. On the hand, in systematic circulation, blood is pumped from the heart to all parts of the body and from all parts of the body back to the heart. This implies that in double circulation, blood passes through the heart twice in each circuit around the body and the heart is a double pump. Other animals, for example fish have a single circulatory system in which blood is pumped from the heart to the gills then to all parts of the body and thereafter back to the heart. Human circulatory system comprises the heart, blood vessels and blood

FUNCTIONS OF THE CIRCULATORY SYSTEM

The function of circulatory system can be divided into three main categories.

a) **Transportation of different substances for instance**
   -food nutrients from ileum to all parts of the body
   - oxygen from the lungs to respiratory tissues
   - waste products from tissues to excretory organs
   - hormones from endocrine glands to target organs
   - antibodies and white blood cells to sites of infection.
   - Distribution of heat in the body.

b) **Defense of the body against infections by**
   - Blood clotting

- Action of phagocytes
- Action of antibodies

c) Regulation of

-body temperature

-water levels

-nutrient levels in the body

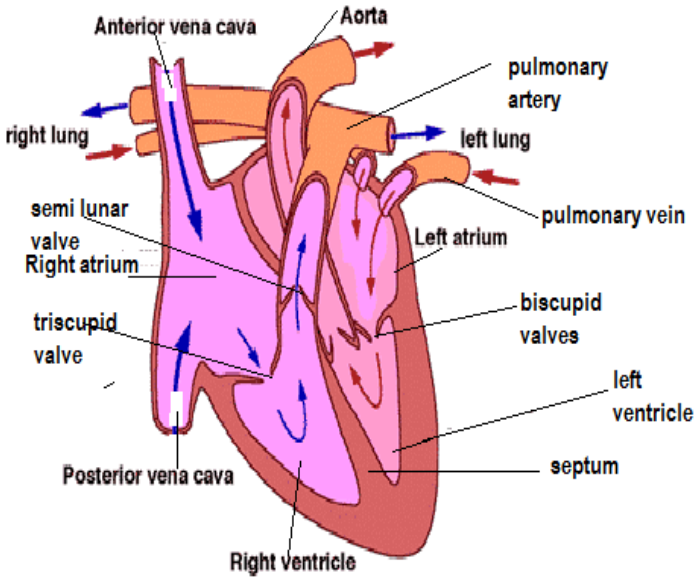
PARTS OF THE CIRCULATORY SYSTEM

(A) THE HEART

The heart is surrounded by a double layered membrane which forms a pericardial cavity which is filled with a fluid called **pericardial fluid.** This fluid prevents friction between the heart and the chest cavity. The function of the heart is to pump blood around the body. It is made up of special type of muscles called **cardiac muscles.** These muscles are very strong and never tires. They contract and relax throughout life. They are supplied by necessary substances like glucose and oxygen by coronary artery.

The human heart is made up of four chambers. The two upper chambers are called the **atria** or **auricles.** The remaining two down chambers are called **ventricles.** Ventricles and auricles are separated by a structure called **septum.**

THE STRUCTURE OF THE HEART



THE FLOW OF BLOOD IN THE HEART

Deoxygenated blood from different parts of the body enters the heart through the **venacava** to the right auricles then thereafter to the **right ventricles** before they flow to the lungs through **pulmonary artery.** Between the right atrium and the right ventricles there found a structure called **triscupid valve** which prevents the back flow of blood. Further the **semi lunar** valves found in the pulmonary arteries and veins also prevents backflow of blood. In the lungs blood is oxygenated. The oxygenated blood coming from the lungs enter the heart through the **pulmonary vein** into the **left auricle** then to the **left ventricles** which pump the blood to the different parts of the body through **aorta.** Generally, the function of auricles is to receive blood, hence their walls are thin since they don't need to exert force on the blood as it enters the ventricles.

The ventricles on other hand are responsible for the pumping of blood. Hence they have thick walls so that they can exert enough pressure on the blood when they contract. However, the left ventricles are thicker than the right ventricles as the left ventricles pump blood over a long distance. In fact the right ventricles, pump blood from the heart to the lungs while the left ventricles pump blood from the heart to all parts of the body.

HOW DOES THE HEART WORKS?

This is quite complex because several things happen at the same time. Each heart beat involves a series of events occurring in different parts of the heart and occurs in two major phases known as systole and diastole.

SYSTOLE

During systole the following things occur at a time

- Ventricles muscle contract at a time, thereby reducing volume of the heart.
- The increase of blood pressure in the ventricles closes tricuspid and bicuspid valves, preventing blood from flowing back into the auricles.
- The semi lunar valves open and blood enter aorta and pulmonary artery.

DIASTOLE

During diastole, the following things occur at a time

- The ventricle muscles relax, thereby increasing the volume of the ventricles
- The bicuspid and tricuspid valves open to fill the ventricles
- At the same time, the semi lunar valves close to prevent blood from flowing back into the ventricles

The pressure exerted during systole is called ***systolic pressure*** while that exerted during diastole is called ***diastolic pressure.*** The rate of heart beat or pulse rate varies with age, size, health and physical activity. A typical resting pulse for an adult is 84 beats per minute for females and 70 beats per minute for males. This increase to 200 beats per minute during physical exercise.

BLOOD VESSELS

There are three types of blood vessels namely

- Arteries
- Veins
- Capillaries

ARTERIES

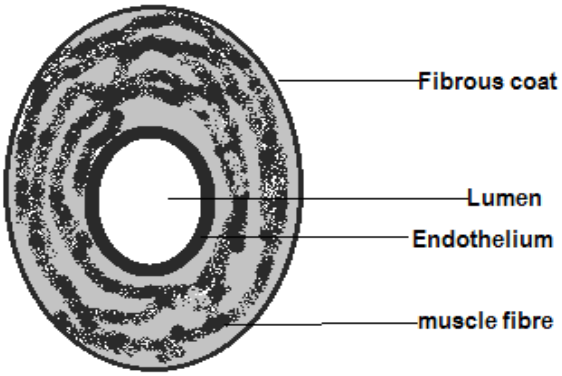
These are blood vessels that carry oxygenated blood away from the heart to the body tissue where they are used for respiration. They have thick walls and narrow lumen (cavities) which enable them to withstand pressure exerted by the pumping force of blood. Arteries have no valves along their length. The largest artery is called aorta and it divides into many arteries which further divide into several

arterioles and the capillaries are joined to these arterioles.

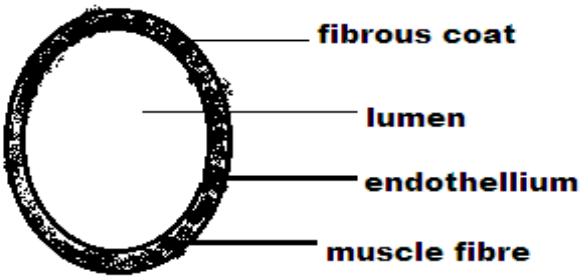
VEINS

These are blood vessels that carry deoxygenated blood to the heart from body tissues. They have thin walls and wide lumen and blood flows in them without pressure. However, veins have valves at intervals which prevent back flow of blood. Furthermore, blood in veins flow due to movement of skeletal muscle around them.

A cross section of an artery



a cross section of a vein



The largest vein is called VENACAVA

CAPILLARIES

These are the smallest blood vessels which have the following properties.

(i) They have narrow lumen which allow red blood cells to flow in a single file. This narrowness makes the volume of blood in them to be the smallest although there are millions of them. The advantage of this narrowness is that it increases the rate of absorption of oxygen in the lungs, release of oxygen and glucose in the respiring cells and rate of blood flow is reduced giving more time for material exchange.

(ii) They have very thin walls consisting of single layer of flattened cells . This allows useful substances like oxygen and glucose and metabolic wastes such as carbon dioxide to diffuse through easily, hence capillaries are centre for exchange.

(iii) Capillaries form a dense network so much that every cell is very close to the capillary. Capillaries form a bridge between arteries and veins. Infact, the capillaries join up to form smaller veins called venules which join to form veins and finally join to the largest vein called venacava.

(B) BLOOD

Blood is made up of liquid and solid substances. The solid part of blood comprises blood cells and platelets while the liquid part of blood is made up of plasma.

PLASMA

It is a straw coloured liquid which transports dissolved substances and blood cells. Almost 90% of blood plasma is water which serves as the solvent for the other 10% of dissolved substances which include.

- Mineral ions
- End products of digestion like glucose , amino acids, fatty acids and glycerols
- Water products like uric acid and carbon dioxide
- Blood proteins for example fibrinogen, prothrombin, antigens and antibodies

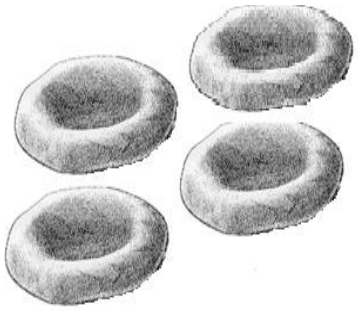
BLOOD CELLS

There are two main types of blood cells. These include; Red blood cells and white blood cells

(a) THE RED BLOOD CELLS (erythrocytes)

These cells do not have nuclei. They are about **0.008mm** in diameter and have a biconcave disc shape which increases the volume of each cell in order to accommodate more red pigments called haemoglobin . They are made in the bone marrows of flat bones and at the end of long bones. **RBCs** are elastic , which means that they can squeeze through capillaries which have a diameter smaller than of red blood cells. The cytoplasm of **RBC** is full of haemoglobin , which is a protein which contains iron and has high affirnity for oxygen. haemoglobin readily combines with oxygen in oxygen in high oxygen concentration region like lungs forming a bright red compound called **OXYHAEMOGLOBIN.** Oxygen is carried by red blood cells to areas where the cells are respiring, releasing oxygen for use by respiring cells. Red blood cells live for about 120 days in the circulation there after it is broken down by the liver into iron and other toxic substances. The iron is stored in the liver for future use while the toxic substances are converted into bile pigment before and they are then excreted.

STRUCTURE OF THE RED BLOOD CELLS



THE WHITE BLOOD CELLS

(LEUKOCYTES)

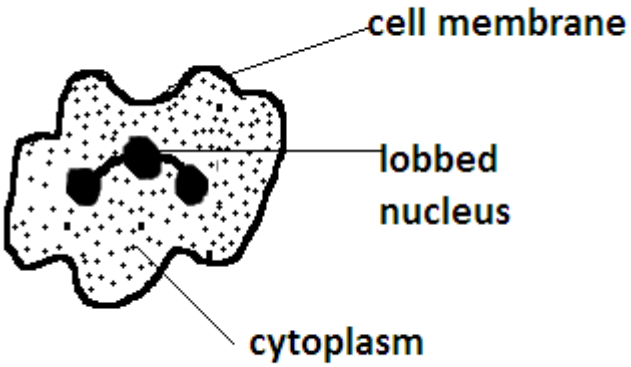
The white blood cells are large and fewer than the red blood cells. Furthermore, white blood cells have nuclei unlike the **RBC** . The **WBC,** especially the phagocytes are irregular in shape.

TYPES OF WHITE BLOOD CELLS

(a)THE PHAGOCYTES

They are made in the bone marrows of short bones and at centre of lower bones. They can be identified by their distinct nuclei which are lobbed. Their function is to engulf and digest foreign particles like bacteria. They are capable of moving like amoeba and can pass out of capillaries into the spaces between the spaces of cells where they engulf bacteria and other pathogens

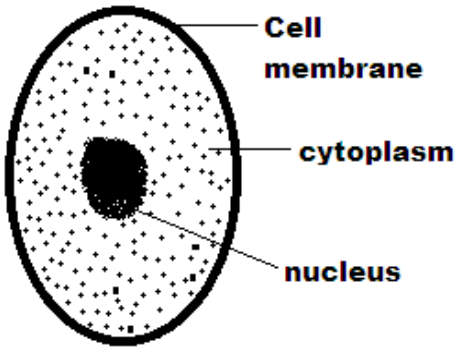
STRUCTURE OF A PHAGOCYTE



(c) The lymphocytes

These cells are identified by their large nuclei which are either oval or spherical. These cells are mostly produced in the lymph nodes and spleen .

STRUCTURE OF A LYMPHOCYTE



Lymphocytes are classified into two groups namely the B- lymphocytes and the T-lymphocytes

(i) The B- Lymphocytes

These lymphocytes produce and secretes special proteins called antibodies into

blood. These antibodies attack invading foreign organisms

(ii) The T-Lymphocytes

These lymphocytes are further categorized into two groups namely the **helper T cells** and the **killer** T cells. The helper T cells produce chemical substances which provide communication among the cells of the immune system. The killer T cells produce chemical substances which kill directly the foreign organisms. White blood cells have a very short life span. HIV Attacks the helper T cells hence AIDS patients have damaged immune system which make them prone to different infections.

PLATELETS

These are fragments formed by the disintegration of large cells in the bone marrow. Like WBC, platelets are irregular in shape and have no nuclei. Their main function is to help in **blood clotting**. Blood clotting simply means hardening of the wound at the site of cut. For this process to occur, the following substances are required; **platelets, prothrombin, fibrinogen, calcium ions** and **vitamin K**. When blood vessel is cut, blood comes out. When platelets come in contact with atmospheric air, they disintegrate producing an enzyme called **prothrombokinase** or **prombroplastin**. This enzyme converts passive enzymes prothrombin into an active enzyme called thrombin. In the presence of calcium ions and vitamins, thrombin converts the soluble fibrinogen into an insoluble fibrin. Fibrin form a meshwork of fibers which traps blood cells there by forming a blood clot. The blood clot is important because it prevents further loss of blood and also prevents the entry of foreign particles into the body.

If blood clot forms inside the blood vessel it can cause a heart attack or stroke. During blood transfusion, the blood is prevented from clotting by adding an anticoagulant called sodium citrate. Sucking insects of blood like mosquitoes also produce anticoagulants which prevent the blood from clotting.

THE LYMPHATIC SYSTEM

As blood enters capillaries from the arterioles, it enters with high pressure which is created by the pumping action of the heart and reduction in the lumen from arteries to capillaries. This pressure forces a fluid out of the capillary between the cells that make up the cell wall of the capillaries. This fluid is called tissue fluid and it contains plasma without fibrinogen and red blood cells and white blood cells can squeeze through the small gaps in the capillary wall and integrates with the fluid. This means that the blood remaining behind in the capillary lumen becomes concentrated. As a result, the fluid starts to move back into the capillary towards the venous ends of the capillary where the blood pressure is lower. Water moves back into capillaries by osmosis. This tissue fluid bathes the cells in the tissue surrounding the capillaries. However, not all the tissue fluid is reabsorbed back into the capillaries because the pressure of fluid in

the capillary is too high. This fluid turns to the blood by another route called the lymphatic system. Some tissue fluid drains into another set of vessels called lymph capillaries to form lymph. Lymph capillaries gradually join up to form large lymph. There is no pumping action in the lymphatic system. Lymph moves along the lymph vessels because of the following factors

i. The presence of valves in the lymph vessels which prevents the backflow of lymph
ii. Movement of the skeletal muscles
iii. The lymph in the other part of the body like arms and the head is moved along the vessel by gravity.

Along the lymph vessels, there are lymph nodes which have tiny spaces in which lymph is filtered before it goes to the blood stream. Lymph nodes produce lymphocytes and traps phagocytes which engulf and digest foreign particles in the lymph. The largest lymph node is the spleen and other lymph nodes are located in many areas like the groin, neck and armpits. Lymphatic vessels from all parts of the body join together to form two large lymphatic vessels which drain their contents into subclavian veins. Lymph is also found in the pleural cavity and pericardial cavity where it

(a) Supplies oxygen to the organs it surrounds
(b) Supplies food to organs it surrounds or encloses
(c) Acts as a lubricant preventing friction between surfaces

PROBLEMS ASSOCIATED WITH THE CIRCULATORY SYSTEM

A number of diseases can affect blood vessels. Blocking of blood vessels by blood clots can cause major problems with the circulation of the blood. Some of these problems are

- **Heart failure**
  This a condition whereby the cardiac muscles are unable to pump enough blood for the requirements of the body. As such, blood vessels narrow to keep blood pressure up and divert blood away from less important tissues and organs to maintain flow to the most vital organs, the heart and the brain. During this time the patient does not know that he has a heart failure problem. When the heart can no longer adapt to the problem the symptoms like fatigue and shortness of breath may occur. This is due to the fact that the body depends on the pumping action to deliver oxygen and nutrient to body cells. When the cells are nourished properly, the body can function normally. With heart failure, the weakened heart cannot supply the cells with enough blood. This has an impact on the routine activities like walking, running and doing other physical exercises.
- **Cardiac arrest**
  This is the sudden loss of heart functionality in a person. it occurs when the heart stops pumping blood around the body. It is a sudden or abrupt loss of heart function in a person. The person may have or may have no history of heart diseases.
  Cardiac arrest occurs when the heart's electrical system malfunctions. Death results when the heart suddenly stops

working completely. It occurs when the heart's lower chambers suddenly start beating chaotically without pumping blood. Death occurs within minutes after the heart stops.

a) Varicose veins

These are enlarged veins and their branches found near the surface of the skin in the lower parts of the leg. The valves in these veins do not work properly. Their walls become stretched, lose their elasticity and are unable to regain their normal size. They become blocked due to retention of tissue fluid which causes swelling.

b) Fainting

This is the temporary loss of consciousness and posture due to temporary insufficient blood flow to the brain. It most often occurs when the blood pressure is too low and the heart doesn't pump a normal supply of oxygen to the brain.

- **Arteriosclerosis**

  Arteries can thicken, harden and lose their elasticity of their walls. This may occur due to accumulation of fat or cholesterol and other substances along the arterial walls. This forms a substance called **plaque**, which can block the arteries making it harder for blood to flow through them. If the coronary artery is affected, the heart lacks enough oxygen that can lead to a heart attack. A condition known as **coronary thrombosis**.

PREVENTING PROBLEMS ASSOCIATED WITH THE CIRCULATORY SYSTEM

Most of the problems associated with circulatory system are attributed to the lifestyles one chooses. To maintain a healthy life, you have to:

1) Doing physical exercises regularly to strengthen the heart and improve the circulation of the blood
2) Avoid smoking because cigarettes contain nicotine which makes arteries to constrict. Constriction of the arteries raises blood pressure causing the heart to beat faster.
3) Reducing the amount of high cholesterol foods by eating less fatty or red meat, instead one should eat white meat such as fish that has no cholesterol and eat more fresh fruits and vegetables.
4) Reduce salt intake to prevent high blood pressure.
5) Exercise your body to burn out excess calories or eat only recommended diet. Obesity causes the heart to overwork leading high blood pressure.
6) Learn to be organized to avoid stress.
7) Avoid alcohol consumption.
8) Avoid drugs that have no medicinal value.

CHAPTER 6: THE HUMAN REPRODUCTIVE SYSTEM

REPRODUCTION

This is a process by which new organisms are formed from the already existing ones. The newly formed organism are called **off springs** while the old ones are called **parents.** This process is very important as it ensures maintenance of species in an ecosystem and also give rise to new organisms.

TYPES OF REPRODUCTION

There are two types of reproduction. These are;

A) ASEXUAL REPRODUCTION

This refers to the process by which offsprings are formed by a single parent. An organism can produce asexually by

- **Budding** – for example in hydra.
- **Binary fission**- for example in amoeba.
- **Regeneration** – for example in worms.

B) SEXUAL REPRODUCTION

This refers to a process by which offsprings are formed by two parents. These parents produce reproductive cells called **gametes**. The male gamete is called a **sperm** while the female gamete is called an **ovum**(ova for many) or eggs. The organs that are responsible for production of these gametes are called **gonads** or **genitals**. The male gonads are called **testis** while the female gonads are called **ovaries.**

THE MALE REPRODUCTIVE SYSTEM

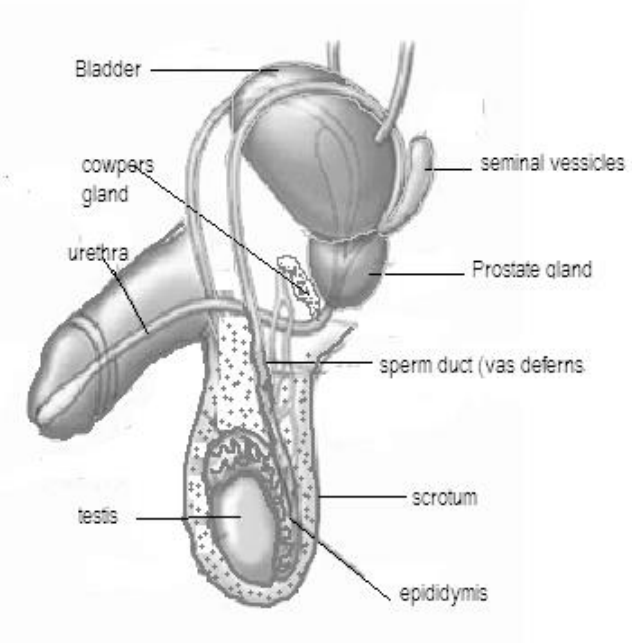
The organs of the male reproductive system are specialized for the following functions:

- To produce sperms.
- To discharge and transport sperm.
- To produce and secrete male sex hormones**.**

The male reproductive system includes internal and external structures.

Structure of the Male Reproductive System

THE EXTERNAL REPRODUCTIVE STRUCTURES



Most of the male reproductive system is located outside of the man's body. The

external structure of the male reproductive parts are the penis and scrotum.

The Penis

The penis is the male organ for sexual intercourse. It has three parts namely **the root** which attaches to the walls of abdomen, the **body or shaft** and the **glans,** which is the cone-shaped end of a penis. The glans which is also called the head of the penis, is covered with loose layer of a skin called **foreskin.** The skin is sometimes removed in a procedure called **circumcision**. Inside the penis, there is a tube that transport urine and semen. This tube is called **urethra**. The penis also contains a number of sensitive nerve endings.

The body of penis is cylindrical in shape and consists of three internal chambers. These chambers are made up of special sponge-like erectile tissue. This tissue contains thousands of large spaces that fill with blood when the man is sexually aroused. As the penis is filled with blood, it becomes rigid and erect which allow penetration during sexual intercourse. The skin of the penis is loose and elastic to accommodate changes in penis during erection.

Semen, a fluid containing sperms, is expelled (ejaculated) through the end of the penis when man reaches sexual climax(**orgasm**). When the penis is erect, the flow of urine is blocked from the urethra, allowing only semen to be ejaculated at orgasm.

The Scrotum

The scrotum is the loose pouch-like sac of skin which hangs behind the penis. It contains the testicles also called testes) as well as many nerves and blood vessels. The scrotum has a protective function and act as a climate control system for the testes. For normal sperm development, the testis must be at a temperature slightly cooler than the body temperature. Special muscles in the wall of scrotum allow it to contract and relax, moving the testicles closer to the body for warmth and protection or farther away from the body to cool the temperature.

THE INTERNAL PARTS OF THE MALE REPRODUCTIVE SYSTEM.

Testes - The testes are oval organs about the size of the large olives that lie in the scrotum secured at either end by a structure called the **spermatic cord**. Normally, a man is supposed to have two testes. The testes are responsible for formation of testosterone, the primary male sex hormone and for generating sperm. Within the testes are the coiled masses of tubes called **seminiferous tubes.** These tubes are responsible for producing the sperm cells through the process called **spermatogenesis.**

Epididymis - This is a long, coiled tube that rest on the back side of each testicle. it functions in the transport and storage of sperm cells that are produced in the testes. The job of epididymis is also to bring the sperm to maturity, since the sperm that emerge from the testes are immature and incapable of fertilization. During sexual

arousal, contraction force the sperms into vas deferens

Vas deferens- This is the long, muscular tube that travels from the epididymis into the pelvic cavity, to just behind the bladder. It transports mature sperms to urethra in preparation for ejaculation.

Ejaculatory ducts - these are formed by the fusion of the vas deferens and the seminal vesicles, the ejaculatory ducts empty into the urethra

Urethra- this is a tube that caries urine from the bladder to the outside of the body. In males it has an additional function of ejaculating semen when man reaches orgasm. When the penis is erect during sex, the flow of urine is blocked from the urethra, allowing only semen to be ejaculated during orgasm.

THE EJACULATORY GLANDS.

There are three main glands that secrete useful substances during the process of ejaculation. These three glands are; the seminal vesicles, the prostate gland and the cowpers gland.

Seminal vesicles - These are sac-like pouches that attach to the vas deferens near the base of the bladder. The seminal vesicles produce a sugar rich fluid (fructose) that provide sperm with energy and helps with sperm motility(ability to move). The fluid of the seminal vesicles makes up most of the volume of man's ejaculation fluid or ejaculate.

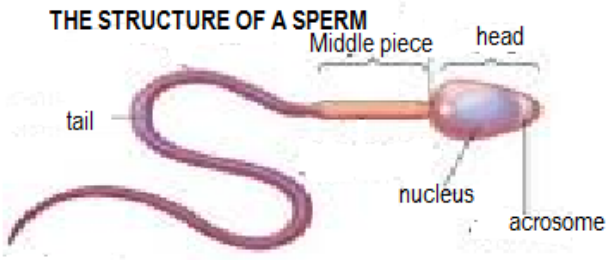
Prostate gland- this is the walnut –sized structure that is located below the urinary bladder in front of the rectum. The prostate gland contributes additional fluid to the ejaculate. Prostate fluid also helps to nourish the sperm. The urethra which carries the ejaculate to be expelled during orgasm, runs through the center of the prostate gland.

Cowper's gland -also known as **bulbourethral glands** are pea sized structure located on the sides of the urethra just below the prostate gland. This gland produces a clear slippery fluid that empty directly into the urethra. This fluid serves to lubricate the urethra and neutralize any acidity that may be present due to residual drops of urine in the urethra.

The sperm

Sperms are the male gametes; thus they are reproductive cells of men. Basically, each sperm is made up of the head, neck and tail.

The structure of a sperm



G

boy reaches puberty(attainment of sexual maturity)during the adolescent stage of life.

Structurally, the sperm consist of a head, neck and tail.

- **The head:** The sperm has a head which contains **nucleus** and **acrosome**. The nucleus is the structure that fuses with the female gamete during fertilization. In fact, carries hereditary information. On the other hand, the acrosome is the sac containing enzymes which dissolves the egg membrane for easy penetration of sperm.
- **The neck** (middle piece) contains a lot of mitochondria which provide energy for activity of the sperm.
- **The tail** (flagellum) helps the sperm to swim.

ADAPTATION OF A SPERM FOR MOBILITY

- ❖ They have tail that propel them
- ❖ They have a lot of mitochondria in the middle piece hence a lot of energy is produced for movement.
- ❖ They have streamlined bodies that minimizes drag during motion.

FORMATION AND TRANSPORTATION OF SPERMS

The male gonads consist of highly coiled tubes called **seminiferous tubules**. Sperms are formed in these tubules. The testes are held outside the abdominal cavity in fold skin called **scrotum**. Actually the temperature in the scrotum is 2^0C lower than the normal body temperature. This forms the best temperature for the sperm production. From the seminiferous tubules of testis, sperms pass into coiled tube of the epididymis. This stores sperms and enable them to gain motility and ability to fertilize. The sperms are released in the process called ejaculation. During this process, the sperms are propelled from the epididymis through the vas deferens which is muscular. The seminal vesicles secrete a thick yellow alkaline substance which nourishes the sperms and activate them by secreting enzymes. They also provide a medium in which sperms swim. The prostate gland helps to push semen out powerfully during ejaculation. Further, the cowpers gland neautrises any activity left by urine and provide a more suitable environment for the passage of sperms.

The penis is normally soft because it contains little blood. During periods of sexual activity the blood vessels in the penis are filled with blood hence the penis expand and becomes firm and erect, thereby being capable of ejaculating sperms. The secretion from the accessory glands and sperms together form a substance called **semen**.

THE FEMALE REPRODUCTIVE SYSTEM AND ITS STRUCTURE

The female reproductive system has much more complex structure and so are its functions. Sperms are delivered into the vagina that get transported through the uterus, and finally they penetrate the egg for fertilization .fallopian tube is the site of fertilization and is the one of the most important of all internal reproductive components. The external components of the female reproductive system help in achieving orgasm and secretion of fluid that lubricates the vagina. The external organs that arouses stimulation are often compared

with male reproductive structures. Here is the division of the external and internal organs.

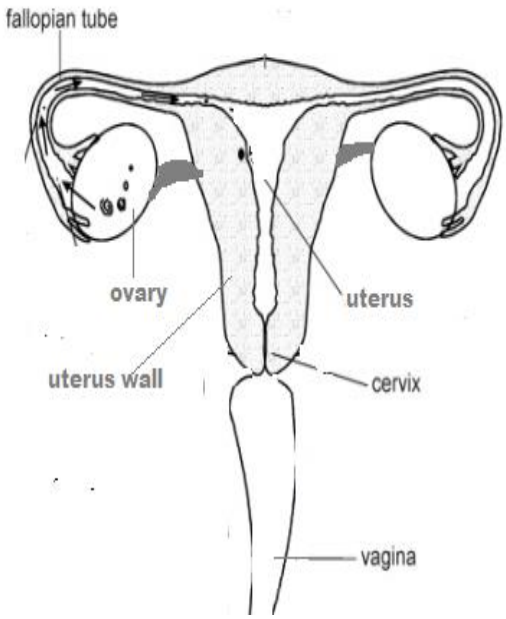
Internal organs include; vagina uterus, ovaries, fallopian tube and external organs include labia majora, labia minora and clitoris.

Labia majora- This encloses and protects the internal organs as well as other external reproductive organs. Literally, it is translated as 'large lips. The labia majora are relatively large and fleshy and are comparable to the scrotum in males. They contain sweat and oil-secreting glands. After puberty the labia majora are covered with hair.

Labia minora- also translated as small lips. The labia minora can be very small up to 2 inches wide. They lie just inside j the labia majora, and surround the opening to the vagina(the part that join the lower part of the uterus to the outside of the body)and urethra (the tube that caries urine from the bladder to the outside body)

Clitoris-the two labia minora meet at the clitoris, a small sensitive protrusion that is comparable to the penis in males. It is covered by the fold of skin ,called prepuce, which is similarly to a fore skin at the end of penis. Like the penis, the clitoris is very sensitive to stimulation and can become erect.

INTERNAL REPRODUCTIVE PARTS



The ovaries- these structures are found in a pair in a female body especially at the back of the pelvis. Its function is to produce, store, and release female garments. They secrete female sexual hormone namely progesterone and oestrogen.

The oviducts - also known as fallopian tube leading from the ovaries to uterus. They are the site for fertilization(union of male and female gametes). They are ciliated and their muscles contract rhythmically hence they are able to push the fertilized egg to the uterus.

The uterus - also known as womb. Its main function is to facilitate the process of implantation (settlement of the foetus). It has thick walls and dense network of blood capillaries as an adaptation implantation. The foetus(embryo) stays in the womb for

almost nine months i.e. from conception to birth.

The cervix- also known as neck of the uterus. It separates the uterus from the vagina. Furthermore, it is always closed except during birth and menstrual periods.

The vagina - this is a tubular tract leading from the uterus to the exterior of the body. It receives male copulatory organ and male gametes contained in garments during sexual intercourse. it also acts as a birth canal during delivery. It is lubricated by vaginal fluid which prevents friction during sexual intercourse and birth.

CHARACTERISTICS OF OVA

- They are non motile.
- They are relatively large as compared to sperms.
- They store food in their yolk which is used to nourish the embryo after fertilization.

THE ROLE OF HORMONES ON MENSTRUAL CYCLE AND HORMONES

The first sign in puberty in girls is menstruation, which refers to a discharge of blood from the reproductive system via vagina. This process repeat itself every 28 days during the fertility age of a woman and it is called menstrual cycle. The cycle begin with the follicle phase. During this follicle phase, the gonadotrophin hormone is released by the hypothalamus. This hormone stimulate pituitary gland to secret follicle stimulating hormone (FSH)that causes a graafian follicle to develop in the ovary. They also stimulate the follicle cells surrounding developing egg to stimulate another hormone called oestrogen. As graafian follicle grows, more oestrogen is produced. High concentration of oestrogen stimulate the pituitary gland to stimulate another hormone called Lieutinizing Hormone. This hormone bring about ovulation(releasing of the ovum into the oviduct)and causes graafian follicle to change into corpus luteum. The corpus luteum produces a hormone called progesterone which causes the thickening of uterus wall in prepation for implantation. It further inhibits production of FSH and reduces oestrogen levels. if fertilization fails ,corpus luteum degenerate leading to low concentration of progesterone and this inhibits production of LH from the pituitary gland. This in turn causes the corpus to stop secreting progesterone and hence start stimulating follicle stimulating hormone (FSH) again. The immediate effect oestrogen is to bring about healing and repair of the uterine wall, following menstruation and the cycle is repeated. if fertilization has occurred, the corpus continues producing progesterone and little amount of oestrogen continue developing the uterine wall and also preventing menstruation. The progesterone prevents further follicles from developing by inhibiting the production of

FSH. The progesterone and oestrogen are also responsible for the growth of mammary glands during pregnancy hence their sudden drop brings about lactation.

A SUMMARY OF FUNCTIONS OF FEMALE SEX HORMONES.

Follicle stimulating hormones-stimulate the formation graafian follicle in the ovary at the beginning of menstrual cycle.

Oestrogen-causes the repair and growth of the uterine wall lining after menstruation - inhibits FSH production if it is in high amount

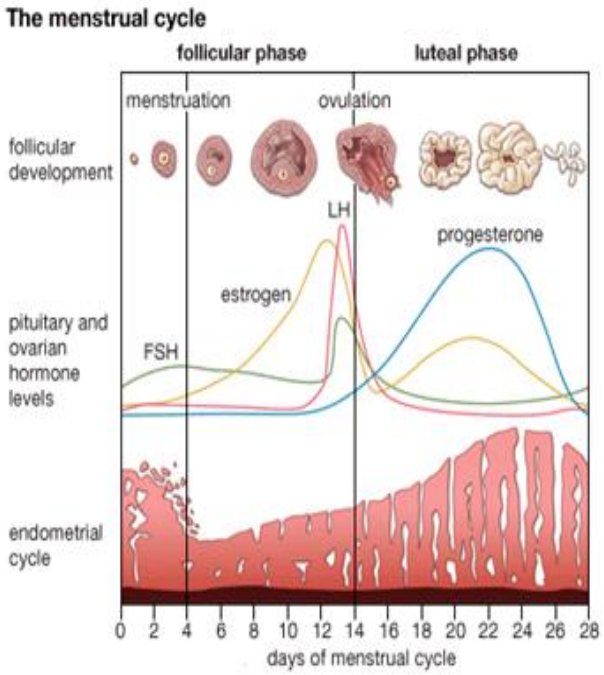
- Stimulate the pituitary gland to secrete Lieutinising Hormone

Progesterone- makes the uterine wall to thicken further and prevent it from breakdown

- Inhibits production of FSH
- Inhibits ovulation

Lieutinising hormone

- Stimulates ovulation
- Stimulates the follicle cells which remain after ovulation to multiply further ,forming a yellowish structure called corpus luteum.



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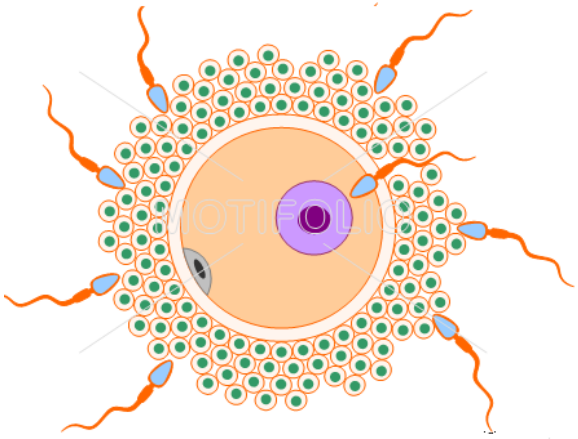
HUMAN DEVELOPMENT

Human development begins with conception. This is the union of the male garments and female gametes which takes place in the oviduct in order to form a zygote. Conception is also known as fertilization. when sperms are deposited in the vagina during sexual intercourse, they swim upwards to the uterus up to oviduct. Their movement is also helped by rhythmic contraction of cervical muscles during orgasm i.e. the most exciting moments of sexual intercourse. When one sperm meet an ovum in the oviducts it unite to form one cell called zygote.

THE PROCESS OF FERTILIZATION



The zygote undergoes rapid cell division and it is pushed towards the uterus where it settles. When it reaches the uterus it is called the embryo and after two months it is now called foetus. After three months of conception, corpus luteum degenerates. By this time another structure called placenta develop and continue secreting progesterone. When the female conceives, the embryo is implanted in the early two to three weeks of pregnancy. At this time the embryo has been produced. The blood vessels and the heart are the first features to rise, including the umbilical cord, amniotic fluid and amnion

FUNCTIONS OF AMNIOTIC FLUID

- Insulate the body
- Allow freedom of movement of the baby during growth
- Protect the baby from any physical harm as it acts as a shock absorber
- The amnion fluid lubricates vagina during birth

FUNCTION OF PLACENTA

- Act as a centre for exchange of different substances for example food nutrients and waste products.
- Produces progesterone which stimulates further growth of the uterus and stimulate milk producing glands in the breast.
- Prevent direct contact between the foetus and the wall of the mother. This prevents damages of delicate organs of the foetus by blood pressure of the mother .and also prevent agglutination and easy contamination of diseases

FUNCTIONS OF THE UMBILICAL CORD

- It carries blood vessels thus arteries and veins thereby ensuring transportation of different substances eg food nutrients from mother to the foetus and waste products from the foetus to the mother

THE PROCES OF BIRTH

When the foetus is about 250 days old (about 9 months)the process of birth starts. This process is called labour. in fact it occurs in three stages. These include :breaking of waters, contraction of muscles and a show

TWINS

Sometimes the ovary may release more than one ovum or both ovaries ovulate silmutaneously. If both ova are fertilized ovum divides into two, they develop into separate embryo, thus the **identical twins**. **siamese twins** are produced when the fertilized ovum divides but fails to separate

completely. the Siamese twins will be joined together and share other vital organ.

CONTRACEPTION

This refers to the deliberate prevention of conception [pregnancy] while sexual intercourse is still taking place. it is also called birth control.

METHODS OF CONTRANCEPTION

These are divided into natural and artificial methods

I. NATURAL METHOD

[a] RHYTHM OR CALENDAR METHOD

This involves having sexual intercourse during safe periods. It is based on the fact that during the menstrual cycle, there is a fertile period of which ovulation is likely to take place. Sexual intercourse is avoided during this time to prevent pregnancy.

(b) Withdraw Method

This is a contraceptive method where a by a man removes his penis just before he releases sperms during sexual intercourse.

II. ARTIFICIAL METHODS

- **SPERMICIDES**

These are chemicals smeared on the male reproductive organ to kill sperms

- **INTRA UTERINE DEVICE**

It is a small metal or plastic strip bent into a loop or coil and it inserted and retained in the uterus where it prevents implantation of the embryo

- **NORPLANT IMPLANT**

These are tiny capsules which contain chemicals which inhibits ovulation. They are inserted under the skin and they can be effective for almost five years. When the couple want to conceive, this can be removed and fertilization can be possible.

- **THE CONDOM OR SHEATH METHOD**

A thin rubber sheath which is placed on the erect penis or in the vagina before sexual intercourse. It traps sperms thereby preventing them from fertilizing the ova. Further it prevents contraction of STIs.

- **THE DIAPHRAGM**

This is a thin rubber laced in the vagina before intercourse, covering the cervix there by preventing entry of the sperms into the uterus. It is removed 8 hours after intercourse.

- **STERILIZATION**

This encompasses all the methods that prevent pregnancy permanently. Examples include **vasecetomy** which involves a surgical operation in which man's sperm duct are cut or tied. This implies that the man will be releasing semen without sperms. The testes are not affected, hence sexual desires, feelings and ejaculations will continue as before. Another example is **tubaligation**. This method involves the cutting and tying of the woman's oviduct.

The ovaries are not affected, hence sexual desires and menstruation continues as before but the sperms can not fertilize the egg.

CHROMOSOMES

Chromosomes are thread like structures found in the nucleus and containing a linear sequence of genes. They are made up of protein called HISTONES which support the complex DEOXY RIBONUCLEIC ACID (DNA) strands where the genes are located. Genes are structures that carry actual information for a character in an organism. This implies that genes are responsible for inheritance; or in short, they are units of inheritance.

DNA contains all the information necessary to produce all the enzymes which direct all the metabolic reactions in the body of any organism such as protein synthesis, respiration, photosynthesis in plants and production of all chemicals in the cells.

Each chromosome is made up of two parallel strands called chromatids which are joined to a point called centromere. The two strands of a sister chromatids are identical in size, shape, sequence of genes and types of genes.

CELL DIVISION

This is a process by which a cell splits to form new cells. The cell which splits during this process is called the **parent cell** while the newly formed cells are called **daughter cells.** Cell division result into multiplication of cells thereby ensuring increase of the number of cells in an organism. This increase of the number of cells and the increase in size of the cells result s into growth. In an organism, cell division occurs rapidly during the early stages of growth and development in order to produce new cells and tissues. Later, when the cells become specialized, the power of cell division is lost and only a limited number of unspecialized retain this power of division for example in meristems like root tips, shoot tips, young leaves, bases of internodes, cambium and all malphighian layer in the skin which produce new epidermis.

TYPES OF CELL DIVISION

Basically, there are two types of cell division. These includes,

i. Mitosis
ii. Meosis

MITOSIS

This is a process by which a cell divides into two daughter cells which are identical to the parent cell. It is also known as somatic cell division because it takes place in somatic (body) cells. In sexual reproduction, a new organism starts life as a single cell called zygote. A zygote results from the process of fertilization. In the first place, the zygote gets its nourishment from the egg embryo and later after implantation in the uterus. The nourishment is provided by the uterus of the

mother through the placenta. The zygote (single cell) starts to divide and produce an embryo consisting of thousand cells. This type of cell division is called mitosis.

During mitosis, the nucleus divide into two; one chromatid from each chromosome goes into each daughter nucleus. The chromatids now become chromosomes and later they make copies of themselves ready for the next cell division. The process of copying is called replication because each chromatid make a replica (an exact copy of itself) to form a complete chromosomes. Therefore, in both plants and animals, the chromosomes are found in pairs. The two chromosomes belonging to a pair look exactly alike and are called homologous chromosomes

Homologous chromosomes are chromosomes which have the same shape, size and sequence of genes, but the genes might have different effects. Remember the cell have different homologous chromosomes. Each species have specific number of chromosomes. For example humans have 46 chromosomes, maize cell have 20 chromosomes, mice have 40 while garden peas has 14. The total number of chromosomes in each cell is called **DIPLOID NUMBER** (2n). Every cell in the body of an organism contains the same number of chromosomes. When a cell divides, it is very important that genes should be shared equally between the two daughter cells, and this means that chromosomes must behave in an orderly way during the cell division.

NUMBER OF CHROMOSOMES

- There are fixed number of chromosomes in each species. Man's body cell contains 46 chromosomes, mouse cell contains 40 chromosomes and garden peas contain 14 chromosomes.
- The number of chromosomes in each of your liver cells, in every nerve cells, skin cell, muscle cell and so on.
- The chromosomes are always in pairs. This is because when the zygote is formed, one of each pair comes from the male one from the female. Your 46 chromosomes consists of 23 from your father. the number of chromosomes in each body cell of a plant or animal is called **DIPLOID NUMBER (2n)** because of chromosomes are in pairs; it is always an even number.

It the division of the nucleus into two daughter nuclei that are genetically identical to one another and to their parent nucleus. Since the DNA contains the genes which control all the metabolic pathways in the cell, mitosis ensures that a new cell in a chicken egg develops into a chicken cell and not into a potato cell. There for mitosis is very process that ensures that every cell in an organism has the same DNA, in short, the DNA is in the chromosomes, and mitosis ensures that every cell receives the same chromosomes.

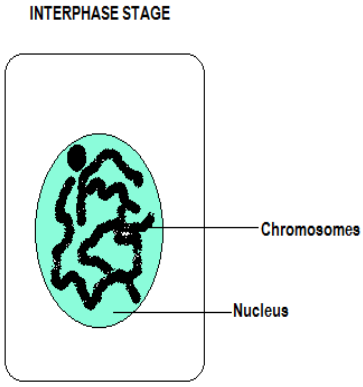
The function of mitosis include growth, and replacement or repair of tissues. The

importance and significance of mitosis is to ensure that the number of chromosomes within the species and within the individual is maintained.

Mitosis is roughly divided into four main phases; namely: prophase, metaphase, anaphase, and telophase. The phase between prophase and telophase called interphase is not considered part of cell sio; however, it is very important phase much of cells life is spent in this period

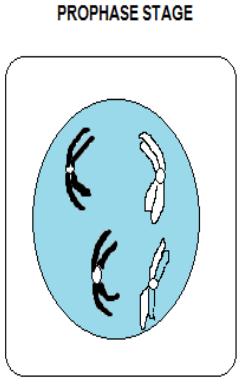
PHASE OF MITOSIS

INTERPHASE



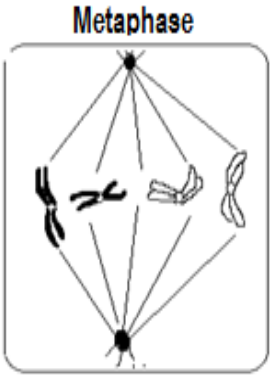
Although this interphase is called a resting stage; the cell does not rest completely, the cell does prepare for the next cell division, replication of chromosomes, division of organelles and production of enough energy before the cell division starts.

PROPHASE



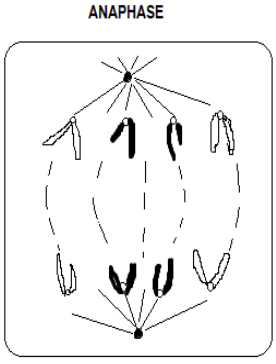
This is the in which chromosomes could be seen, initially as a single stands, but as time progresses; the chromosomes continue to coil thereby getting shorter and thicker. The chromatids could be seen. This phase comes to an end by the disappearance of nuclear membrane and the nucleolus.

METAPHASE



Once the nuclear membrane breaks down, the chromosomes are scattered in the cytoplasm. A spindle is formed which is attached to tiny bodies called centrioles on opposite poles of each cell. The spindle pulls the chromosomes towards the **equator** of the cell. Note that homologous chromosomes do not associate. The chromatids are seen clearly as they become shorter and thicker and being separate. This process ends as the chromosomes are fully aligned at the equator.

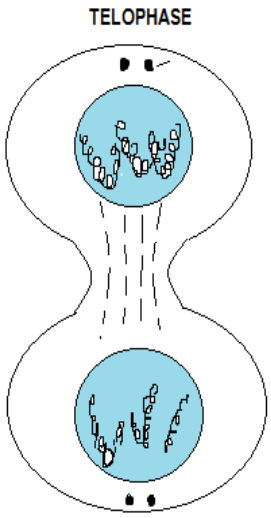
ANAPHASE



The chromosomes separate completely and migrate (are pulled) to opposite poles of the cell, the centromere leading. This

phase vcomes to an end when the chromatids reach the poles.

TELOPHASE



Two new cells are formed with the same number of chromosomes as the original cell. Nuclear membrane and nucleolus are formed in each daughter cell. Spindle generates (disappear). The cytoplasm divides into two thereby producing two separate daughter cells.

Then the cell returns to **interphase (**resting condition) whereby the chromatids seem to disappear as they uncoil and replicate to produce full chromosomes again.

MEOSIS (REDUCTIVE DIVISION) this is a type of cell division by which cells divide and to form four daughter cells. In occurs mainly in reproductive organs for example testes, ovary, anther and stigma. This process is very significant as it result into formation of reproductive cells for example sperms and ova. During this cell division , the number of chromosomes is reduced by half, hence is called **reductive division**. The reduced number is called **haploid number (n)**

STAGES OF MEOSIS

The first four stages of meosis are similar to those of mitosis. However, after telophase stage, the cell indulges in metaphase ii, then anaphase ii and finally telophase ii, during anaphase ii, the chromatids separates and go to opposite poles, the two cell star splitting. During the telophase ii, four daughter cells are produced each containing half the number of chromosomes as of the parent cell.

COMPARISON BETWEEN MITOSIS AND MEOSIS

MITOSIS	MEOSIS
Two daughter cells are formed	Four daughter cells are formed
Daughter cells have equal number of chromosomes to their parents	The number of chromosomes of the daughter cell is half to that of the parent
Occur in body cells	Occur in reproductive cells

CHAPTER 7: GENETICS AND EVOLUTION

Genetics is the scientific study of heredity and variation among organisms.

- **Heredity** refers to the process by which off springs acquire characters or traits from their parents. Heredity can also be defined as transmission of traits from parents to offsprings. Examples of traits include skin color, height, ability to roll a tongue etc.
- **Variation** refers to difference that can easily be observed in organisms.

This implies that genetics can also be defined as the study of things or activities that cause resemblance and difference among organisms.

GENES

Genes are structures found on a DNA molecule of chromosomes and they are responsible for inheritance. DNA contains all the information necessary to produce all the enzymes which direct all the metabolic reactions in the body of organisms such as proteins synthesis, respiration, photosynthesis in plants and production of all the chemicals in the cell. Genes are contained in chromosomes of cells. These chromosomes are made up of two protein strands called **chromatids** which are attached together at a point called **centromere.**

Genes are always found in pairs and are named after alphabetical letters. Capital letters are used to denote **dominant genes** while small letters are used to denote **recessive genes.**

Alleles are genes that control the same characteristic. These genes are located on the same loci or positions

Genotype: is the genetic composition of an organism in terms of the alleles present (e.g. **Tt or GG**)
Phenotype: the physical or other features of an organism due to both its genotype and its environment (e.g. tall plant or green seed blood type)
Homozygous: having two identical alleles of a particular gene (e.g. TT or gg). Two identical homozygous individuals that breed together will be pure-breeding

Heterozygous: having two different alleles of a particular gene (e.g. Tt or Gg), not pure-breeding.

Genotype	**Phenotype**
TT (homozygous dominant)	Tall
Tt (heterozygous)	Tall
Tt (homozygous recessive)	Short

VARIATION

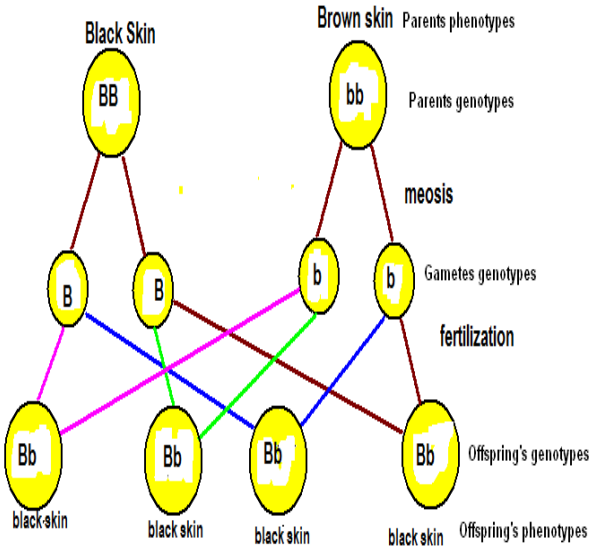
This refers to observable differences among organisms. The observable differences among organisms of the same species are

called **intra specific variation** while observable differences among organisms of different species are called **inter specific variation.** Intra specific variations can be continuous (intermediate variables present) or discontinuous (intermediate variables absent). Generally, organisms of the same species can vary due to

- Genetic factors
- Age
- Environment

THE GENETIC CROSS DIAGRAM

The way off springs acquire genes from their parents can be shown using across diagram. A cross diagram comprises the **genotype** of the parents, **gametes** which are produced after meiosis and **off springs** which are produced after fertilization. For example, if a gene (B) for a black skin in human is dominant over the gene(b) for brown skin the cross of two monohybrids of this trait can be shown using the cross diagram below



This can also be shown by a punnet square as shown in the figure below.

female gamete / male gamete	b	b
B	Bb	Bb
B	Bb	Bb

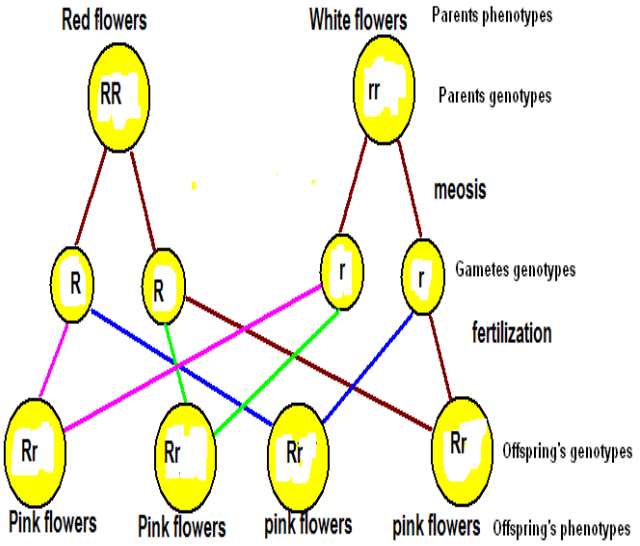
PRINCIPLES OF MENDELIAN GENETICS

The earliest recorded investigations on heredity was conducted by Gregory Mendel, an Australian monk. In his experiments, Mendel grew garden peas. The garden peas were selected for this purpose due to the presence of several traits such as purple or white colored flowers, tall or dwarf plants, green or yellow pods, brown or white seeds, peas with wrinkled or smooth seed coats and peas with green or yellow cotyledon. Secondly, the peas were selected for this purpose due to their ability to self-pollinate.

In his experiment, Mendel cultivated tall peas and then allowed to self pollinate. In so doing, Mendel obtained pure breeds of this trait. These pure breeds were allowed to self-pollinate again and another generation called **first filial generation** (F1 generation) was obtained. In simple terms, filial means offsprings. He followed the same procedure and obtained the pure breeds for the trait of dwarf. He then manually crossed a pure breed tall plant and a pure breed short plants (dwarf). This procedure is called hybridization or cross breeding. All off springs from this cross were tall as shown in

the cross diagram below. He then selfed this F1 generation and some of the f2 offsprings were tall while some were short in the ratio 1: 3.

From this experiments, Mendel arrived at his first law called law of segregation. As a matter of fact, the law of segregation states that an organism's characteristics are determined by internal factors that occur in pairs. Only one of a pair of such factors can be represented in a single gamete. In other words, Mendel was referring to acquisition of traits in diploid organisms by alleles occurring in pairs.



CODOMINANCE

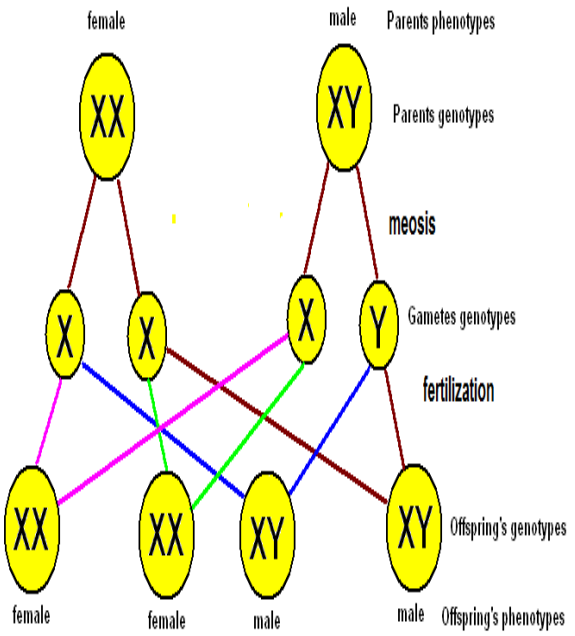
This is a condition where by a character is produced by both genes in allele, thus a condition whereby no gene is recessive nor dominant to the other. For example, genes responsible for blood groups are: **A, B**, and **O** and the first two are dominant genes while the last one is recessive. When allele is made up of gene **A** and **B** thus forming genotype **AB**, the offspring will have the phenotype of blood group **AB**.

INCOMPLETE DOMINANCE

This is a condition whereby characters of recessive genes are not completely hidden by the dominant gene; thus the dominant gene is in full of control. For example, in balsam plants a gene for red flower **(R)** is dominant over the gene for white flower **(r)**. However, the heterozygous genotype **Rr** produces pink flowers. The other example of incomplete dominance is the acquisition of sickle cell anemia in human beings. Genes that are involved in incomplete dominance are called **ADDITIVES GENES**

THE SEX CHROMOSOMES

The sex of an organism is determined by its genes located in the special chromosome called sex chromosomes. In humans, females have a pair of identical chromosomes, hence the genotype of human female **XX**. On the other hand, a human males have a single **X** chromosome and a **Y** chromosome, hence the genotype of a human male has **XY** genotype. The **X** chromosome is larger than the **Y** chromosome. The cross diagram below shows how the sex is determined in human beings.



MUTATION

This refers to sudden change in a chromosome or a gene that alters the way they function. Organisms that have acquired this wrong information are called **mutants**. Example of mutation include: **Down's syndrome**, where a parent's chromosomes are unevenly distributed in meiosis (e.g. one chromosome has 22 and the other has 24). In fertilization, a zygote with a number of chromosomes that is not 46 is created (e.g. 23 + 24 gives 47 chromosomes). This causes a variation in characteristics: broad forehead, short neck, fold in eyelid, spots in iris, downward-sloping eyes, short nose, protruding tongue, congenital heart defects and mental retardation.

Sickle cell anaemia: is a disease in which the red blood cell has a sickle shape instead of a round biconcave shape, controlled by a recessive allele, which causes weakness, aching joints and poor circulation. The fact that it is recessive means that a heterozygous person can be a **carrier**: they have the allele but it is not expressed. Being a carrier of sickle cell anaemia makes you resistant to malaria (WIN!). In equatorial Africa, being sickle cell anaemic causes death, malaria causes death, but the carriers have immunity to have some symptoms of anaemia, in severe cases they are very weak (but do not die).

hemophilia (condition where by blood cannot clot easily, Hemophiliacs are usually male as the condition is inherited through a gene carried on the X chromosome (chapter 30). Hemophiliacs may require blood transfusions for fairly minor injuries to replace lost blood and may need to inject themselves with the missing blood clotting factor) and mongolism. Factors that increase the risk of mutation include radiation (exposure to radiant light e.g. gamma rays , alpha rays, and x-rays) rise in temperature, as well as other chemicals.

These factors are called **mutagens**.

Sex linked characteristics

These is a condition whereby the characteristics is controlled by a gene found on the x or y chromosomes. Examples of sex linked characteristics include Red green colour blindness, haemophillia, hairy eyes, etc.