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The author and publisher have done everything possible to make this book accurate, up to date, and in accord with new syllabus for biology.

Basic Biology for form 3 and 4
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Discover Success Criteria series **Basic MSCE Biology**

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PREFACE

This textbook aims to provide a comprehensive set of elementary notes in Basic biology, which will be suitable for students taking biology. The book concentrates on core topics which are most likely to be common to those biology courses which follow on from a foundation. Biology is a subject which can lead some students to the heights of ecstasy.

The concepts of system and reaction mechanisms are often the most difficult to master. These difficulties are often compounded by the fact that current textbooks in biology are normally long and can be quite expensive to buy. However, this book attempts to condense the essentials of biology into a manageable text which is student friendly and which does not cost an arm and a leg.

Furthermore, the notes on each topic summarize the essential facts covered and help focus the mind on the essentials. Biology is a peculiar subject in that it becomes easier as you go along! Understanding biology leads to a better understanding of life chemistry and how the body works at the molecular level.

The order in which the topics of this book are presented is important as it follows the syllabus. It is hoped that students will find this textbook useful in their studies and that once they have grasped what biology is all about they will read more widely and enter a truly exciting world of life science.

Contents

Topic 1 Ecosystem

In a community, living things interact with members of their own species and other species. They also interact with the environment. These form an ecological system called **ecosystem**.

Ecosystem

This is a natural unit consisting of all animals and plants in an area considered together with nonliving of the environment.

The interactions of organism and their environment are **give** and **take** relationship.

Living things **take** materials and energy from the environment for life. As these materials and energy are used up, the organisms **give** materials and energy back to the environment.

Estimating plant population

It is very difficult to count all the Tridax Procumbens plant in the garden. In this case you can only calculate an approximate size of the population of the Tridax Procumbens by using a **quadrat method**.

A quadrat is a square box chosen randomly on the ground.

A sample is a part of something intended as representative of the whole.

Procedures

- Take a sample of the garden.
- A quadrat is used to sample the plant cover on the ground.
- Choose a quadrat of sides 2m so that its area is $4m^2$. Throw it on the garden.
- Count the number of the Tridax Procumbens in the quadrat.
- Measure the dimensions of the gardens and calculate its area.
- Carry out simple proportion to find the approximate population of the plant on the ground.

The formula will support in the calculation.

> Number of plants in quadrat should be multiplied by area of garden then divide by area of quadrat

The same method can be used to estimate the population of a particular animal in the soil like earthworm.

Advantage: A quadrat method is used in estimating the populations of only those organisms which stay in one place.

Estimating animal populations

The population of animals is estimated by using a sampling method called mark – recapture method.

This method is used to estimate the population size of the organisms that

move around a lot such as grasshoppers and fish.

Procedures

- Capture the sample of the animals on the habitat.
- Count the number of captured animals.
- Mark each of the captured animals with ink or paint which is harmless.
- Release the animals on the same habitat.
- Wait for a day to give the marked ones a chance to become mixed up with any unmarked ones.
- Capture the second sample of many animals as you can.
- Count the total number and the number of marked ones.

Use the following formula which will give you estimated size of the population of the animals in the habitat.

> The number of organisms caught the first time and marked should be multiplied by total number of organisms caught second time then divided by number of organisms caught second time

AP = S1 X S2/S3

This is *Lincoln index* formula. Lincoln is the one who devised this formula used to estimate the population of mobile organisms.

Energy transfer in aquatic and terrestrial ecosystems

By studying the interactions of organisms, we can understand how they are affected by changes in their animal and plant communities within a particular habitat which are linked through their feeding habits.

To understand these ideas, you first need to know about different ways of feeding.

Trophic levels

These are the main levels that the energy must pass through in a food chain.

Organisms in ecosystem may be grouped into trophic or feeding levels depending on they feed.

Producers

These are autotrophs, such as green plants, photosynthetic bacteria, algae and phytoplankton which convert water and carbon dioxide into organic molecules using sunlight as a source of energy.

Consumers

These are organisms that feed on producers. They depend on the producers for their food, directly or indirectly.

1. Primary consumers
   These are organisms that eat the producers and they include the herbivores such as cattle, zebras, grasshoppers etc.

These are plant – eating organisms such that they depend on plant materials.

2. Secondary consumers

These are organisms that eat primary consumers and they include small carnivores such as spider, chameleon and praying mantis.

3. Tertiary consumers

These are organisms that feed on secondary consumers and most of these tertiary consumers have mixed diet, that is, they may feed on both primary and secondary consumers.

These include large carnivores such as lions, leopards, cheetah, and hyena among others.

Omnivores

These include animals which eat both producers and primary consumers.

Decomposers

These are organisms that break down organic compounds, releasing the minerals then contain back into the soil or into the water of aquatic ecosystem.

All are saprophytic such as fungi and bacteria. They can only get food from dead and decaying materials.

Parasites

These are organisms that feed on the living bodies of either producers or consumers and they include plasmodium the parasite that causes malaria.

How energy flows in an ecosystem

The energy from the sun flows through producers to the consumers. Therefore, not all energy from the producers is transferred to the consumer.

The flow of energy from producers to consumers in an ecosystem is known as a **food chain**.

Eventually, all energy is lost as heat energy and is **reused once lost**.

Energy transfer from the producer to the primary consumer is about 10% efficient. This becomes food is not even eaten, e.g. roots – not eaten by grazing cattle. Some of it is not digested by the consumer is again 10% efficient.

Therefore, less energy is transferred from one feeding level to the other as you move towards the higher consumer levels.

Ways in which energy is lost

i. Respiration

ii. Storage

iii. Excretion

iv. Defaecation

v. Decomposition

Ways of expressing relationships (interaction)

Food chain

It is a sequence of organisms which represents the way in which energy is

transferred from one organism to another in a community.

Grass	grasshopper	mongoose	hawk

Food chain traces the transfer of energy from one organism to another organism. This energy originates from sunlight and is incorporated by green plants into organic compounds by the process of photosynthesis.

Producers form the base (starting point) of all food chains.

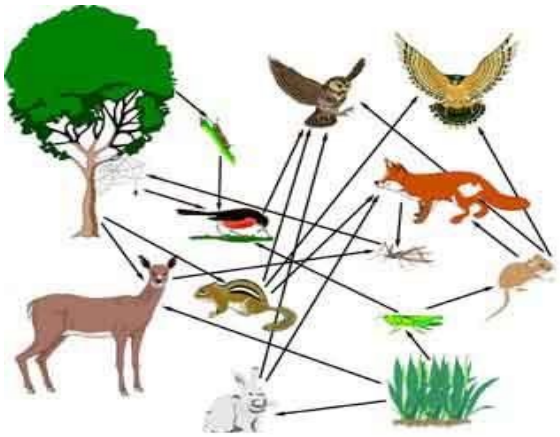
Producer → primary consumer → secondary consumer → tertiary consumer

These arrows indicate the direction of energy flow. This means ''is eaten by''.

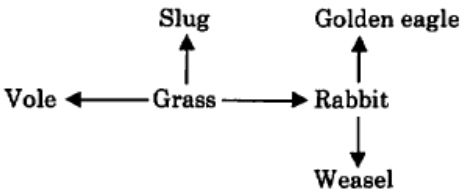
Food web

This is a series of interconnected food chains showing various species of organisms in a given community.

A food web is made up of many interconnected food chains in a given ecosystem.



Vital group of organisms that are not always mentioned in food chains but food webs are the absorbing simple food materials. They are important in returning essential nutrients locked up inorganic compounds back to the soil. These essential nutrients are reabsorbed by roots of green plants. Therefore, mineral elements are recycled.

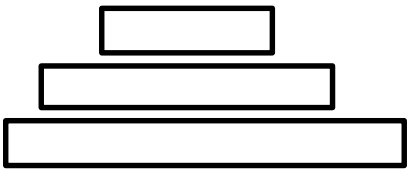


Pyramid of numbers

It is illustration of the numbers of organisms at different trophic levels in a food chain.

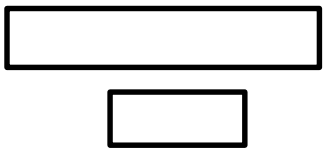
In most food chains the number of individuals in each link decreases as you progress through the food chain.

This can be represented diagrammatically as a pyramid of numbers having the producers at the base and the tertiary consumers at the apex.



It must be noted however, that although the number of individuals decrease, sizes of the individuals generally increases.

One occurrence where this is not the case is when the producer is very large and supports a large community of consumers.



50 aphids

1 Cabbage

Although easily constructed, a pyramid of numbers has some disadvantages:-

i. Each individual is regarded as one regardless of size. One grass plant is therefore equal to one elephant in a pyramid of number.

ii. Single individuals are often difficult to distinguish, especially when several are massed together, e.g. moss

iii. It is difficult to choose a proper scale because of the great differences in the numbers at each trophic level.

Pyramid of biomass

It is a way of expressing biomass at each trophic level. **Biomass** is the living or dry weight of an organism.

In an attempt to give a more accurate representation of a food chain, a more time consuming method involves using biomass obtained to construct pyramid of biomass.

A more accurate result can achieve the dry mass, but this approach is rather **destructive**, since all the organisms have to be killed in order to get a pyramid of biomass.

Pyramid of energy

Pyramids of energy provide the most accurate picture of feeding relationships in a community. They give information about the amount of new tissue at each trophic level over a certain period of time.

Nutrient cycles in an ecosystem

The bacteria and fungi which found in soil are called decomposers because they break down the dead remains and release chemicals for the plants to use again.

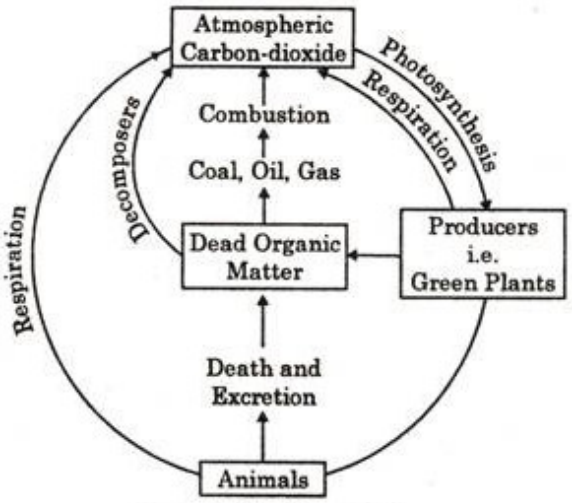
Importance of decomposition

a. Maintains soil fertility through humus.

b. Reduces the bulk or amount of dead plant or animal remains in nature – important in waste disposal.

The carbon cycle

Carbon is an element which occurs in all compounds which make up living organism. Plants get carbon from carbon dioxide and animals get carbon from plants.



Carbon-Cycle.

Removal of carbon dioxide from the atmosphere

Photosynthesis

Green plants remove carbon dioxide from the atmosphere as a result of photosynthesis. This carbon dioxide is

built into carbohydrate (sugar) and some of it is changed into starch, cellulose and proteins and pigment which are digested by animals, absorbed and built into compounds making up the animals' tissue.

Addition of carbon dioxide to the atmosphere

Respiration

Plants and animals obtain energy by oxidizing carbohydrates in their cells to carbon dioxide and water.

Carbon dioxide and water are excreted and so carbon dioxide diffuses into atmosphere.

Decay

The organic matter of dead animals and plants is used by saprotrophs especially bacteria and fungus as source of energy. This micro – organisms decompose the plant and animal remains and turns the carbon into carbon dioxide.

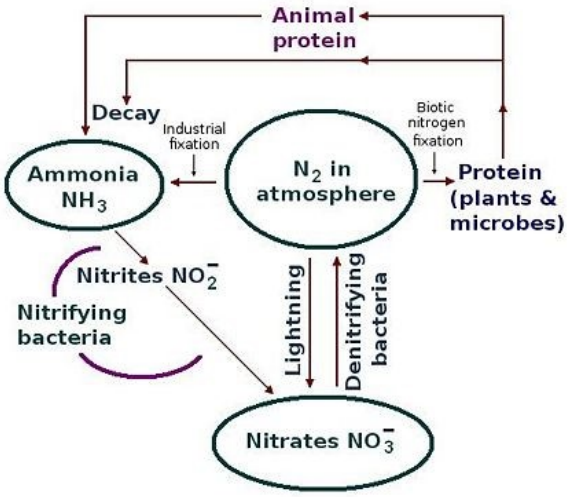
Combustion

When carbon – containing fuels (i.e. wood, coal, petroleum and natural gas) are burned, the carbon is oxidized to carbon dioxide.

$$C + O_2 \longrightarrow CO_2$$

Nitrogen cycle

When a plant or animal dies, its tissues decompose partly as a result of the action of saprotrophic bacteria. One of the important products of this decay is ammonia (NH_3) which is washed into the soil.



Processes which add nitrates to the soil

Nitrifying bacteria

These are bacteria living in the soil which uses the ammonia from the excretory products and decaying organisms as a source of energy.

In the process of getting energy from ammonia, the bacteria produce nitrates.

Nitrogen – fixing bacteria

This is a special group of nitrifying nitrogen as a gas from the air spaces in the soil and built it into compounds of ammonia. The process of building nitrogen into compounds of ammonia is called **Nitrogen fixation**.

Some of the nitrogen – fixing bacteria lives freely in the soil. Others live in the roots of leguminous plants, where they cause swelling called **Root Nodules**, which increases the nitrate content of the soil.

Lightning

The high temperature of lightning discharge causes some of the nitrogen and oxygen in the air to combine and form nitrogen oxides.

These dissolve in the rain and are washed into the soil where they form nitrates.

Processes which remove nitrates from the soil

Uptake by plants

Plants use their roots to absorb nitrates from the soil and combine them with carbohydrates to make proteins.

Leaching

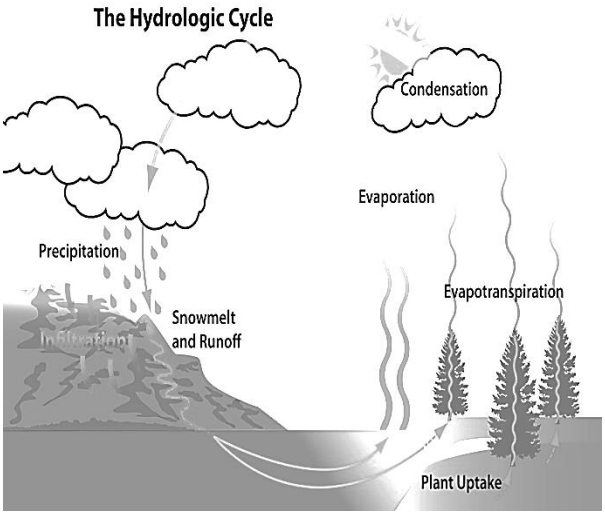
Nitrogen are very soluble and as rain water passes through the soil it dissolves the nitrate and carries them away in the run – off or to deep layer of the soil. This is called **leaching**.

Denitrifying bacteria

These are bacteria which obtain their energy by breaking down nitrates to nitrogen gas which then escapes from the soil into the atmosphere.

Water cycle

About 70% of the earth's surface is covered by water bodies such oceans, lakes among others. Water circulates from one place to another and from one form to another.



Processes involved in water cycle

Evaporation (into clouds)

Heat from the sun makes water become a gas. As water warms, currents carry the water vapour into the sky. The water vapour gets cooler as it rises and condenses into tiny droplets that form clouds.

Precipitation

These tiny droplets stick together to form larger drops and when get too heavy to stay in the cloud, gravity pulls them back to the earth as rain, snow or hail.

Surface run off

This rainfall can run directly off the land into water bodies as well as wetlands.

Infiltration

Rainfall can also soak deeply into the ground and add to the groundwater where it is stored in rock.

Transpiration

Water is absorbed by roots of plant and expired as water vapour by the leaves of plants back into the air.

Components of an ecosystem

Physical factors

These factors are called abiotic factors and they include; light, temperature, water, air and temperature.

Plant communities

These are different species or populations of plants

Animal communities

These are different species or populations of animals.

Note

Plants and animals are simply called **biotic factors**.

Effects of physical factors on organisms in an ecosystem

Soil

The soil forms an ecosystem in which a large number of organisms live. In addition, soil is an essential medium for most land plants. Plant roots anchor the plant in the soil and help to hold the plant upright. It is from the soil that land plants obtain the water and mineral salts they need for photosynthesis and production of food

Light intensity

The surface water receives a high light intensity. The small particles suspended in the water absorb the light so that a depth may not be enough light to allow plants to photosynthesize and grow.

Water

The distribution of rainfall throughout the year determines the amount of water available. No organism can live without water. This influences the distribution of plants and animals.

P^H (Hydrogen ion concentration)

This is a measure of concentration of hydrogen of water molecule in an aquatic habitat or soil solution.

It affects the way proteins work in the body of an organism.

The number of earthworms and bacteria that cause decay are normally reduced in acidic soils; this means the rate of decay is slowed down.

P^H of the soil also affects the availability of nutrient.

Temperature

Water can absorb a good deal of heat from the sun with its temperature going up much and similarly when water loses heat.

When temperature of the water rises, it can hold less dissolved oxygen. Thus rise in temperature well below the lethal level might damage the breathing system of some aquatic animals.

Humidity

This is a measure of water vapour there is in the air.

Humidity directly affects the rate of water loss by transpiration from plant leaves and from the body of animals by evaporation.

Mineral salts

The salinity of the water is an important factor for aquatic organism.

The salt concentration of the cytoplasmic contents of fresh water organisms is usually higher than that of the surrounding water so that water tends to enter these organisms by **osmosis**.

The cells of the fresh water plant are prevented from bursting by their rigid cell walls.

Amount of oxygen

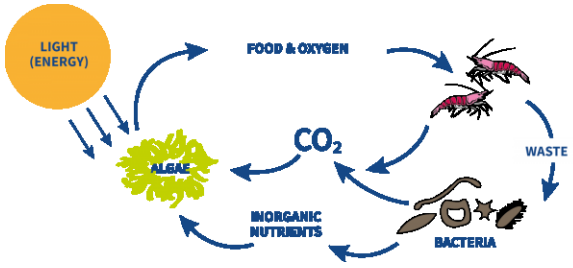
The oxygen in the water molecules is not available for respiration. The oxygen that plants and animals use for respiration is dissolved in the water.

The oxygen comes from photosynthesis of plants during the day and also diffuses continuously through the water surface from the air.

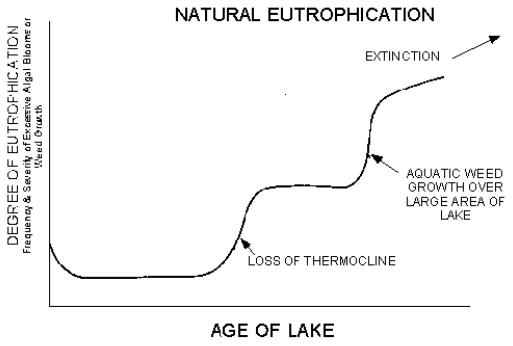
The stationary animal or plant in still water use quickly all the oxygen from the water. Anything such as **eutrophication** reduces this small oxygen concentration in fresh water and puts the animals at risk of suffocation.

Eutrophication

It is the enrichment of natural waters with nutrients which allow the water to support an increasing amount of plant life.



The excessive enrichment which results from human activities leads to overgrowth of microscopic algae. The extra nitrates and phosphate enable them to increase so rapidly which are eaten up by microscopic animals. They die and fall to the bottom of river and their bodies are broken by bacteria and however, bacteria need oxygen which is taken from the water to carry out this breakdown. So the oxygen in that water becomes deoxygenated and cannot support animal life. Fish and other animals die due to suffocation.



Adaptations

These are characteristics possessed by organisms to survive in their habitats. Organisms are distributed according to their adaptations.

Adaptations are traits that enhance an organism's ability to survive in a particular environment. They may be structural, physiological, behavioral, or a combination of all three.

Every biologically successful organism is a complex collection of coordinated

adaptations produced through evolutionary processes.

Characteristics that enable fresh water plants to survive in their habitat

i. Their roots and lower parts of the leaves contain air spaces.
This enables the plants to float and allow diffusion of oxygen.
ii. The waxy cuticle on the leaves repels water if the leaves are temporarily submerged by waves.
iii. The leaves of plants have stomata on the upper surface in order to exchange gases directly with atmosphere rather than water.
iv. Their epidermal cells contain chloroplasts unlike in land plants, in order to speed up the absorption of light and increases photosynthesis.
v. Their rigid cell walls are to prevent their cells from bursting as water tends to enter by osmosis.
vi. They are lighter than water hence they float.

Characteristics of plants in tropical savanna woodland ecosystem

i. Shedding of leaves by some plants during the dry season to reduce the rate of transpiration.
ii. Presence of swollen trunks of stems of some plants in order to store water.
iii. Some plants have thorns to reduce the rate of transpiration and for protection.
iv. Some plants have deep and long roots in order to absorb water and mineral salts.

Adaptations of animal communities in fresh water ecosystem

i. They have streamlined shape to reduce drag.
ii. They have gills for breathing by using dissolved oxygen.
iii. They make themselves buoyant *e.g* presence of swim bladders in fish to float on surface of water.
iv. The abundant bristles on the antennae of some animals like water like water flea to offer resistance and helps to swim.
v. Some aquatic animals have suckers which attack firmly and prevent them being carried off in the water currents.

Adaptations of animals in tropical savanna woodland ecosystem

i. Lion – has sharp claws that it uses to catch and hold its prey and has long and pointed teeth for tearing flesh from bones.
ii. Antelope – its limbs are adapted for swift movement and increases speed. Its teeth are flat-topped and ridged for grinding plants.
iii. Giraffe – has long neck to reach the higher plant in order to feed on leaves.
iv. Birds – storks have long beaks suitable for catching small aquatic animals. Hornbill has strong beak for eating fruits. Other birds have long sharp beaks and strong hooked beak.
v. Birds feet – the feet have sharp claws which are curved and strong.

vi. Chameleon – camouflage helps to catch other animals or avoid being caught.

Population density

This is the number of distinct organisms in a population per unit area.

It is generally expressed as the number of individuals per square metre.

It tells how close to each other organisms are in a population.

$$\text{Population density} = \frac{\text{total population}}{\text{Area}}$$

Activity

Students caught 64 grasshoppers in a school garden of area 32 m^2 and marked them with nail varnish. They released them into the same garden. After two hours the students captured 60 grasshoppers in the same area of which 12 had marks of nail varnish.

Calculate the population density of the grasshopper.

Identification of organisms

Phylum: a kingdom can be divided into smaller groups called phyla (singular, phylum). Members of a phylum have some major features in common.

Class: the phylum can be further divided into classes. The vertebrate phylum includes all the animals with vertebral columns, and is divided into 5 classes: fishes, amphibian, reptiles, birds and mammals.

Order: within each class there are groups called orders. Some of the orders in the Class mammals are the rodents (e.g. rats and mice), the carnivores (e.g. lions, wolves), insectivores (e.g. shrews, moles, hedgehogs) and the primates (lemurs, monkeys, apes and humans).

Genus: when organisms within an order share many features in common they are classified into a genus. For example, in the carnivore order the genus Mustelus includes stoats, weasels and polecats.

Species: the smallest natural group of organisms is the species. Robins, blackbirds and sparrows are three different species of bird. Apart from small variations, members of a species are almost identical in their anatomy, physiology and behaviour.
Members of a species also often resemble each other very closely in appearance. One of the main features which determine whether organisms belong to the same species is whether they can successfully breed together.

Binomial nomenclature

Species must be named in such a way that the name is recognized all over the world. The Latin form of the name allows it to be used in all the countries of the world irrespective of language barriers.

Binomial means two names; the first name gives the genus and the second gives the species. For example, the scientific names of selected organisms are as follow;

- Lion – *Panthera leo*
- Leopard – *Panthera pardus*
- Dog - *Canis lupus (formerly Canis familiaris)*
- Maize – *Zea mays*

The effects of human activities on the environment

Deforestation

Deforestation involves the loss of trees from the environment due to human activities such as opening farms, using trees for timber or firewood and making charcoal.

As trees are cut carelessly, this leads to;

- Reduction of forests causing the changes in weather patterns.
- Exposure of water catchment area thus destruction of water sources
- Pollution with burning charcoal

Soil *erosion*

Soil erosion is the removal of the top fertile soil by agents such as wind, water and animals. This mainly occurs when land is left bare by the removal of trees and other vegetation.

Soil erosion reduces soil fertility.

Over – fishing

Over – fishing occurs when harvesting of fish is greater than the rate at which fish are producing in a water body due to increase in human population.

Over – fishing has reduced the number of fish that can breed to produce new offspring.

Pollution

Pollution is the addition of substances or energy forms to the environment in quantities that are harmful to organisms and destructive to an ecosystem.

The substances that cause pollution are called pollutants. These pollutants are released to the environment as a result of human activities such as combustion of fuels, use of pesticides and disposal of domestic sewage and industrial wastes.

Pollution causes

- Acid rain
- Global warming and depletion of ozone layer.
- Eutrophication etc.

Impacts of human activities on the environment and climate change

Drought

The absence of rain due to deforestation and fuels which are burned emit gases that may disturb hydrological cycle.

Floods

Forests and woodland are cut down and the soil is ploughed up. The land is left bare and as such, this may leads to floods.

Soil degradation

The loss in value and quality of soil due to several human activities on environment such as bad farming practices, deforestation, overgrazing and use of heavy machines.

Diseases

The sewage and domestic waste can cause diseases because of pollution in the absence of effective disposal.

Introduction of alien species

This is the introduction of strange species of organisms in an environment. This may occur when controlling pests biologically using drugs hence they become resistance to the drugs (insecticides and pesticides). As a result, they are naturally selected and introduce strange offspring to the environment. The pests may therefore damage crops and plants in the environment and disturb ecosystem.

Global warming

This is the rise in temperature. An increasing concentration of atmospheric carbon dioxide may have the effect of 'trapping' the sun's radiant energy in a similar way to a greenhouse. This could result in a warming of the Earth's atmosphere, the melting of the polar ice-caps and arise in sea level.
There could also be climatic changes which would affect the important food-growing areas of the world.

Causes of land degradation

i. Poverty
ii. Illiteracy
iii. Overpopulation
iv. Attitude

Ways of mitigating the impact of climate change

- Using **better farming practices** such as crop rotation, afforestation and others.
- **Preservation** – keeping and maintaining the ecosystem include perfect condition.
- **Restoration** of damaged habitats such as creation of game reserve and avoid encroachment.
- **Conservation** thus careful management of natural resources so that they will continue benefits this generation and succeeding generations.
- **Civic education** on reduction of pollution

Topic 2 plant structure and function

All green parts of plant carry out photosynthesis in day light hours only, but the leaves are the principal photosynthetic organs. The leaf is the plant structure where the process of photosynthesis takes place. Gas exchange between the leaf cells and the atmosphere occurs here.

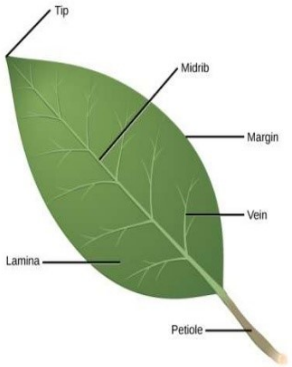
Leaf structure in relation to photosynthesis

A leaf is a green lamina or blade made from soft tissue of thin walled cells supported by stronger network of veins.

Leaves serve as a site for photosynthesis.

Parts of typical leaf:

- Blade or lamila
- Petiole or leaf stalk
  - Petiolated leaf
  - Sessile leaf
- Midrib
- Stipule
  - Stipulated leaf
  - Ex-stipulated leaf
- Veins



External features of a leaf

Petiole

The petiole is the narrow stalk of a leaf by which it is attached to the stem.

Lamina

It is the photosynthetic part of a leaf. It is usually thin and flat and its shape allows a large surface area of chlorophyll to be exposed to the light.

Midrib

This is the thick bundle down the leaf centre. It contains vascular bundles surrounded by other fibrous and strengthens cells.

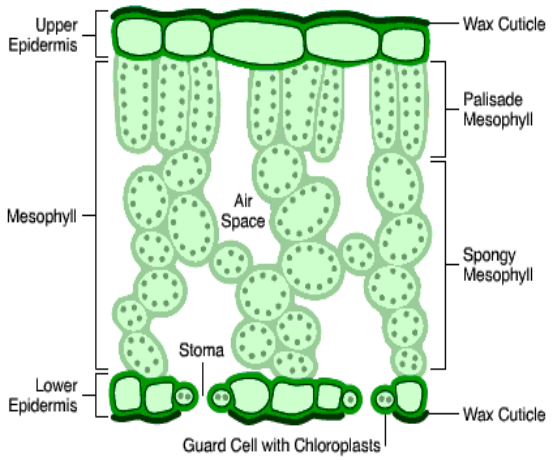
Function – the midrib performs the following functions;

- **Support** the leaf
- **Conduct** water into the leaf and food away from it.

Veins

These are smaller bundles spread out from the mid-rib to all parts of the leaf giving the net veined appearance typical of dicotyledons. They provide good water supply to the leaf cells.

Parts of a cross section of a leaf



Internal structure of a leaf

Cuticle

This is a thin water proof covering the upper epidermis.

Cuticle is also defined as continuous layer of waxy.

Function of cuticle

i. **Limits** the loss of water from the leaf by evaporation.

ii. **Protection**

- The internal organs of the leaf from any physical forces.
- The plant against disease organism such as parasitic fungi.

iii. **Prevents** unnecessary entry of water through the leaf surface.

Epidermis

It is the outermost layer of cells of a plant. This layer is one cell thick, and consists of flattened cells which cover the leaf. There is upper and lower epidermis.

The lower epidermis is characterized by the presence of pores called **stomata** at regular distance over its surface.

Function of epidermis

i. Protect the inner cells of the leaf

ii. Maintain the shape of the leaf

iii. Reduces the rate of transpiration

Mesophyll tissues

These are the ones that contain chlorophyll hence they are photosynthetic tissue. They are found in between the upper and lower epidermis.

There are two types of mesophyll:

a. Palisade mesophyll

b. Spongy mesophyll

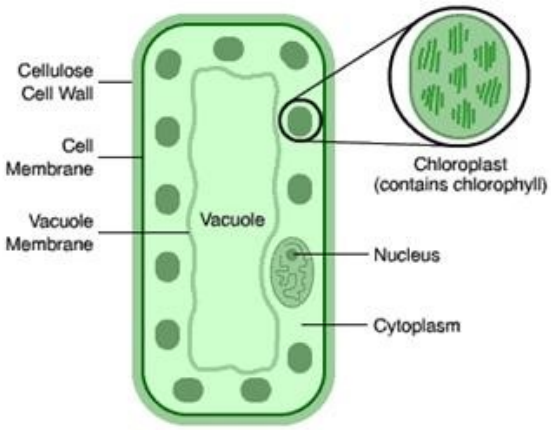
Palisade mesophyll

The palisade layer of a leaf consists of cylindrical cells which are situated below the upper epidermis. The cells are tightly packed close to each other.

The palisade cells contain more chlorophyll than any other cells. Chlorophyll is contained within organelles called **chloroplasts**.

The important adaptations of the palisade mesophyll for photosynthesis are;

- Close-fitting packing of its cells
- Presence of numerous number of chloroplasts in each palisade cell
- The cell wall and other parts of cytoplasm are transparent to allow light to pass through the leaf.
- Presence of oblong shape

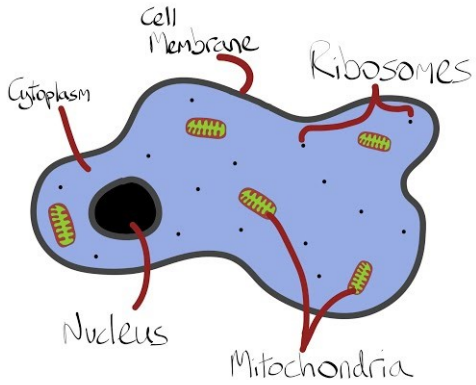


Spongy mesophyll

Spongy mesophyll consists of uneven shaped cells with large air space between them. These cells have fewer chloroplasts than palisade. It has sponge appearance when viewed under the microscope hence their name *spongy cells*.

The spongy cell provides small surface area for photosynthesis due to;

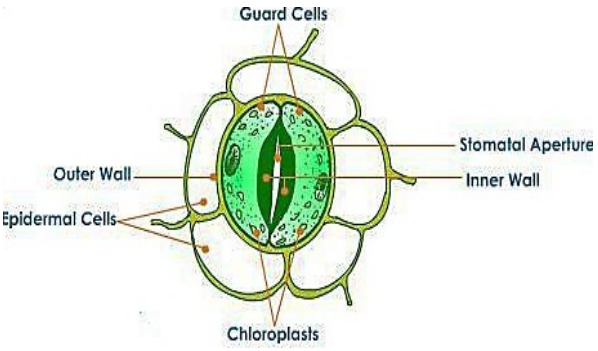
- free packing cells
- Presence of fewer chloroplasts



Stomata

These are the openings of an extensive system of air spaces between the cells of the leaf. These spaces allow gases to diffuse in and out of the leaf.

The stomata are found on the surface of the leaf. Each stoma (**singular*) is made up of a pair of bean – shaped **guard cells** which can change shape, thereby opening and closing the pore.



Functions of stomata

Gas exchange

During day, some of the oxygen produced within the plant diffuses from the leaf into the atmosphere through the stomata. At the same time carbon dioxide diffuses from the atmosphere into the leaf through the stomata.

During night, carbon dioxide produced during respiration diffuses from the leaf into atmosphere through the stomata, since there is no photosynthesis to use the carbon dioxide. Oxygen diffuses from the atmosphere into the leaf through the stomata to be used in respiration.

Transpiration

Excess water evaporates from the leaf into the atmosphere. The rate of transpiration is controlled by the guard cells.

Differences between guard cell and epidermal cell

i. **Bean shaped**; guard cell is bean shaped while epidermal cell is not bean shaped.

ii. **Chloroplasts**; guard cell has chloroplasts while epidermal has no chloroplasts.

Vascular bundles

Xylem vessel transports water and mineral salts absorbed from the soil.

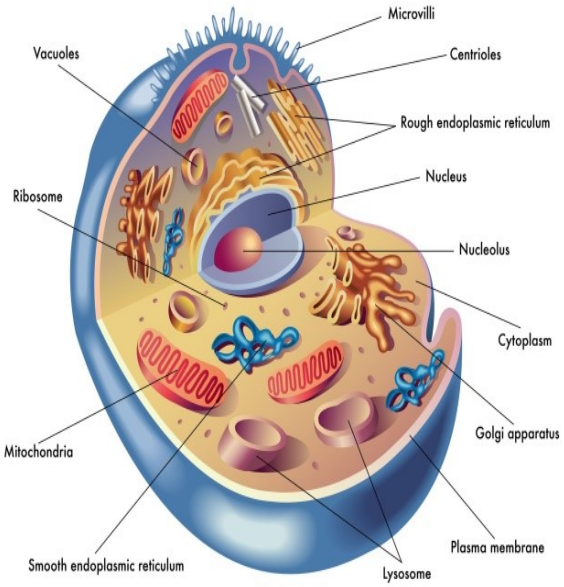
Phloem tube transports manufactured food within the plant.

Cell structure and functions

Cell is a basic functional unit of the organism. The cell is therefore a building block of which living things are made.

The cells are microscopic in size and electron microscope is used to see the structures found in cells. However, ordinary microscope is not powerful enough to show all the organelles present in the cell.

Organelles are small structures which carry out specific functions in the cell.

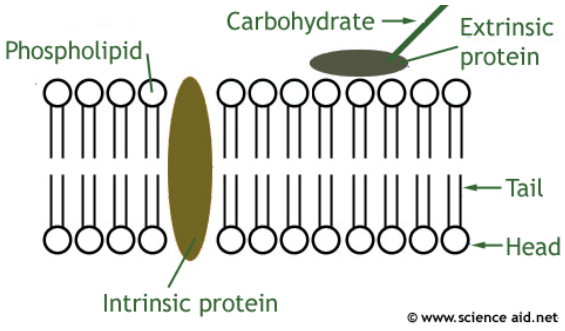


Functions of parts of the cell

Cell membrane

This is a thin flexible layer of protein and fats molecules. The cell membrane is dark line around the outside of the cell.

The cell membrane is **semi – permeable**, that is, membrane that allows some particles to pass across it but not others depending on their sizes. It is protein molecules which act as the gate to allow this to happen in that way. Protein molecules also float in the lipids' molecules.



Note

All membranes of some organelles such as nucleus, mitochondrion, chloroplasts and endoplasmic reticulum have the same as of that cell membrane.

Nucleus

The nucleus is surrounded by two membranes called the **nuclear envelope.** The outer membrane is part of the endoplasmic reticulum. The nuclear envelope is full of small holes or nuclear pores through which large molecules pass.

Inside the nucleus consists of **nucleoplasm** in which the nucleolus is suspended. Ribosomes are made in nucleolus.

Functions of nucleus

i. Contains the *genetic material* of a cell in form of chromosome.

ii. Acts as *control centre*.

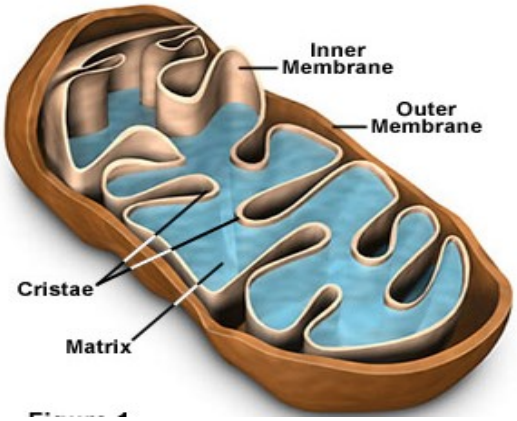
iii. Produces the *information* needed to synthesize proteins.

iv. Essential for *cell division*.

Mitochondrion

There are lots of mitochondria in the cell structure. The mitochondrion has two membranes a smooth outer membrane and highly folded inner membrane.

The folds of the inner membrane are called **Cristae** and they increase the surface area on which part of the process of respiration occurs.



Adaptations of mitochondria to its function

i. **Presence of cristae** which provide large surface area on which the process of respiration occurs.

ii. **Thin walls** – allow oxygen to diffuse into the mitochondria and carbon dioxide and water to diffuse out of the mitochondria.

iii. **Surrounded by cytoplasm** which is a medium in chemical processes occur such as respiration.

Function of mitochondria

Energy production; they turn the chemical energy in food into energy used in series of chemical reaction called respiration.

Endoplasmic reticulum

This is a network of tubes surrounded by membrane which spread throughout the cytoplasm.

There are two types of endoplasmic reticulum

- ## Rough endoplasmic reticulum

  It is so called because it is bumpy under a microscope. The bumps are thousands of ribosomes attached to it.

  The rough endoplasmic reticulum is covered with tiny structures called ribosomes where proteins are made.

- ## Smooth endoplasmic reticulum

  It does not contain ribosomes. However, it contains enzymes needed for the formation of molecules such as carbohydrates and lipids.

  It is involved in the uptake and release of calcium to transfer some types of cellular activity.

  It helps in detoxification of poisonous substances entering the cell.

Functions of endoplasmic reticulum

- **Surface area for chemical reaction** provides a large surface area of membrane inside the cell on which chemical reaction can occur.
- **Transport** provides pathways for transporting materials through the cell.
- **Synthesis** produces protein and lipids.
- **Storage** collects and stores synthesized substances.
- **Skeletal part** provides part of the skeleton of a cell which helps maintain the shape of the cell.

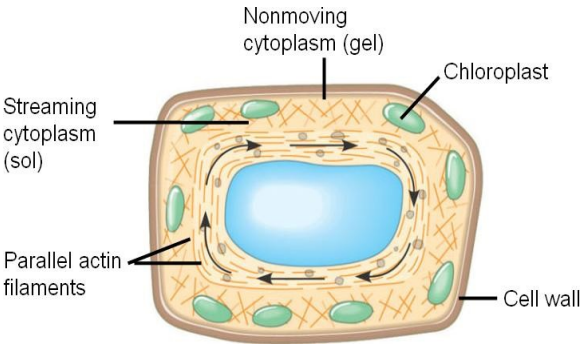
> Note
>
> Endoplasmic reticulum is part of the cell's transport system carrying substances such as proteins and lipids.

Cytoplasm

This is an aqueous solution of many dissolved substances such as proteins, vesicles, organelles except nucleus.

The movement of cytoplasm around the cell is called **Cytoplasmic streaming**.

Cytoplasmic streaming is the movement of cytoplasm within living cell resulting in transport of nutrients and enzymes.



The arrows show the movement of cytoplasm.

Cytoplasmic streaming

i. Transport substances from one part of the cell to another many times faster than simple diffusion.

ii. Involves use of energy in the movement of materials, hence it is important part of **active transport**.

Functions of cytoplasm

i. Link the organelles

ii. Medium in which chemical processes occur.

Vacuole – is membrane bound – cavities filled with cell sap which is made up mostly of water containing various dissolved sugar, salt and other chemicals.

Ribosomes

Ribosomes are small spherical structures which make proteins. They are found in the cytoplasm and they are attached to the membrane of the rough endoplasmic reticulum.

Ribosomes use genetic instructions transported in ribonucleic acid (RNA) to link specific sequence of amino acids into chains to form protein.

Golgi bodies

They consist of flattened tube – like surrounded by membranes from which small vesicles are made. They are often found near the surface of a cell and are involved in packaging molecules such as protein.

Golgi bodies are also called Golgi apparatus.

Functions of Golgi bodies

- **Synthesis**, Golgi bodies produce substances such as *enzymes* and *carbohydrates*. They manufacture long chained sugars including *cellulose* and *pectin*.

  They are responsible for formation of *lysosomes*

- **Transport and storage** of lipids. Golgi bodies have vesicles (known as '*Golgi vesicles'*) which are used for transport.

- **Sorting and packaging** macromolecules.

Lysosomes[1]

This is the membrane bound sac found in the cell that contains digestive enzymes that breaks down ('*degrading'*) complex molecules in the body.

When a cell dies, and indeed millions of cells die every day in the body, then lysosomes release their enzymes to digest the dead cell.

Due to their autolysis, they are nicknamed '**suicide bags**' or '**suicide sacs**'

Functions of lysosomes

- **Removal** of the unwanted substances produced by cells.
- **Digestion** of the dead cells by releasing their enzymes.
- **Engulfing** bacteria and virus**.**

The small molecules produced by lysosomes are then used by other cells.

Centrioles

[1] Lysosomes are recycling organelles; they degrade and recycle complex molecules.

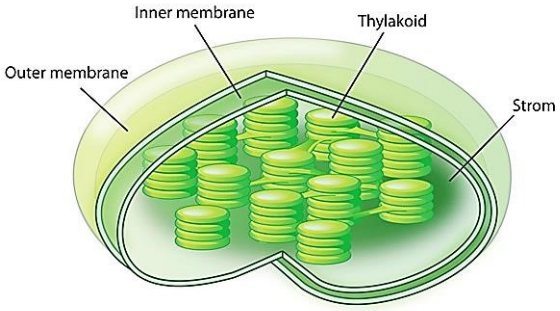
These are rod – shaped bodies lying outside the nuclear envelope. The centrioles aid in cell division, when new cells are made, existing cell divides into two.

Importance: The centrioles aid in cell division, when new cells are made, they grow into maturity and divide into two, a process called '*mitosis*[2]' and/or '*meiosis*'

Chloroplasts

These are organelles that are found in plant cell joined by complex network as discs called **thylakoid.** They are enclosed in the double membrane around its outside and surrounded by a viscous fluid called **stroma** and system of membrane.

The system of membrane is seen as sets of layers within chloroplast. The set of layers is called **granum**. It is the thylakoid membranes which contain the chlorophyll that traps the light energy used during photosynthesis.



Chloroplast contains starch grains that temporarily store the product of photosynthesis.

[2] Mitosis: cell division where nuclei divides into two – each having same number of chromosomes as original; Meiosis, cell division where nuclei divides into four – each containing half number of chromosomes

Cell wall

This is a tough layer around the cell membrane made of chemical substance called **cellulose**. It is fully permeable, that is, allows all substances to pass across it.

It is also involved in transport, absorption and secretion.

Function

- **Protection and support** the cellular contents.
- **Storage**, in some plant cell walls act as storage depots for carbohydrates that can be broken down and resorbed to supply the metabolic and growth needs of the plant
- **Control,** limits the cell size.

Autotrophic nutrition

Green plants make their own food from simple inorganic substances. Organisms that make their own food from simple inorganic substances are called **Autotrophs**.

On the other hand, organisms that do not make their own food but depend on ready-made complex organic compounds are called **heterotrophs**.

Green plants are autotrophs while animals are heterotrophs because plant cells of green plants contain chloroplasts in which chlorophyll is found. Animal cells do not contain chloroplasts so that do not have chlorophyll.

Chlorophyll is the green pigment that enables plants to make their own food in the process of photosynthesis.

The process of photosynthesis

Photosynthesis is a chemical process in which green plants make their own complex organic food from water and carbon dioxide in the presence of sunlight.

You can also define photosynthesis as a process by which green plants use energy of light to convert carbon dioxide and water into the simple sugar glucose.

The water which plants absorb from the soil through the roots and carbon dioxide which diffuses from the atmosphere into the leaf through the stomata are combined to produce complex organic food.

Necessary conditions for photosynthesis

For photosynthesis to occur, plants require the following materials;

1. Light

Provides the energy needed to combine carbon dioxide and water molecules. This energy is used to split water molecules, a process known as **photolysis** into hydrogen and oxygen atoms. The hydrogen atom is used to reduce carbon dioxide to produce carbohydrate. Oxygen is produced as waste product.

Energy from sunlight is also used to produce ATP – adenosine Triphosphate which is used in the synthesis of carbohydrate.

2. Carbon dioxide

Is used in the presence of the hydrogen atoms released from water, using ATP to produce carbohydrate.

3. Water

Provides the raw materials which are split to form hydrogen and oxygen atoms.

4. Chlorophyll

It is the green pigment found in chloroplasts in leaf cells. It is used to trap light.

Adaptations of leaves for photosynthesis

1. Supported by stem and petiole

   Expose the leaf to necessary sunlight and air.

2. Large surface area; broad and flat

   Expose the leaf to necessary sunlight and carbon dioxide.

3. Thin lamina

   Allows sunlight to penetrate to all cells and allows gas exchange, that is, carbon dioxide and oxygen to diffuse in and out respectively since the distances across it are very short.

4. Presence of stomata on the leaf surface

   Allow diffusion of carbon dioxide in and oxygen out.

5. Branching network of veins

   Provide good water supply to the mesophyll cells.

6. Presence of chloroplasts

They contain chlorophyll that absorbs sunlight.

7. Absence of chloroplasts in the epidermal layers

Allow sunlight to penetrate to mesophyll layers.

Factors that affect the rate of photosynthesis

1. Sunlight

In the dark photosynthesis does not take place at all. In dim light the plant photosynthesizes slowly.

As light intensity increases the rate of photosynthesis increases until plant photosynthesizes as much as it can.

2. Carbon dioxide

The more carbon dioxide a green plant is given, the faster it can make food up to a certain point but then the maximum is reached. The amount of carbon dioxide in the atmosphere is about 0.03% and it does not differ much.

3. Temperature

The process of photosynthesis occurs very slowly at low temperature. It increases when temperature is increased.

Experimental observation show that if temperature goes beyond 40 ^{0}C photosynthesis slows down and stops altogether because the enzymes involved in the process of photosynthesis are denatured by the heat.

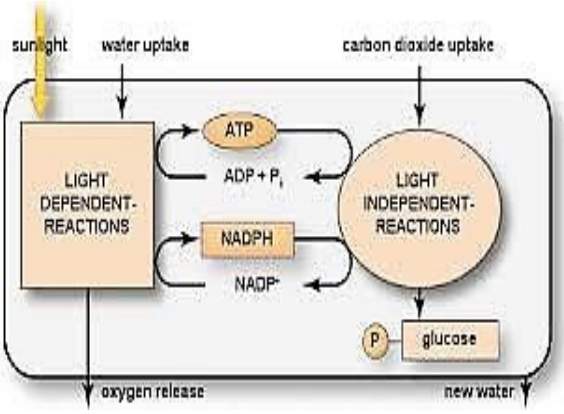
Stages of photosynthesis

The process of photosynthesis occurs in two stages namely;

a. **Light stage** (photochemical stage)

b. **Dark stage** (carbon stage)

Figure below illustrate the process of photosynthesis.



Light stage

This stage requires light. Thus, this stage is called light dependent stage. The light originates from sunlight where is absorbed by the chlorophyll in form of ADP – (Adenosine Diphosphate). Chlorophyll allows ADP to combine with phosphate electrons to form ATP (Adenosine Triphosphate) in the process called **photophosphorytion.**

The energy ATP is used to split water molecules into hydrogen and oxygen atoms, a process called **photolysis.** The oxygen atoms rearrange to form oxygen molecule which diffuses out of the leaf through the stomata as a waste product. The hydrogen is used in the dark stage.

Dark stage

Light is not needed at this stage and as such it is called light independent stage. Carbon dioxide gas from the air diffuses into the leaf through the stomata into palisade cells which contain chloroplasts.

Once inside the cell, carbon dioxide diffuses into chloroplasts.

The hydrogen using energy from ATP reduces the carbon dioxide to form glucose. The process whereby glucose is produced is called **reduction reaction**. The glucose is then converted into other forms of organic molecules such as starch and, lipids and vitamins through **condensation reaction**.

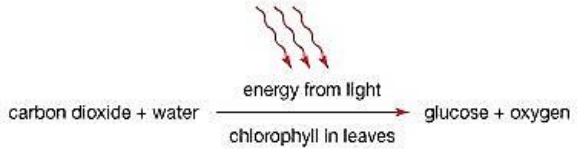
Dark stage occurs during day only that it does not require sunlight.

Summary of photosynthesis

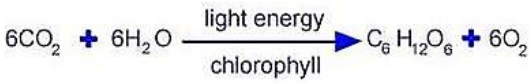
The complex organic food which is produced during photosynthesis is **glucose,** this is the main product. Besides it, oxygen is produced as a by – product.

A by – product is a useful product produced in addition to a main product during the chemical process.

Word equation



Chemical equation



What happens to glucose after photosynthesis

1. **Respiration** within the plant. Thus enables plant to produce energy essential by plant for a number of processes such as growth.
2. **Cell wall formation** when it is converted to cellulose or lignin.
3. **As raw material** combine with nitrogen and other mineral elements to make proteins. These mineral elements include phosphorus and sulphur.
4. **Converted** to lipids and vitamins.
5. **Transported** to storage organs, where it is converted into *starch*[3] and stored for future use.

Presence of starch in plant leaf is an indication that photosynthesis takes place within the plant, producing excess glucose from which the starch is formed.

Therefore, **starch** is a long chain of glucose molecules. Starch, being insoluble, can accumulate without causing osmotic disturbances.

Testing for starch in a plant leaf

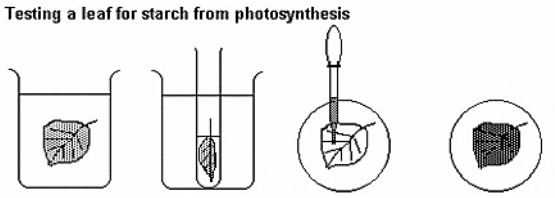
Starch in plant leaf is tested to show the occurrence of photosynthesis within the plant from which the leaf has been taken. The test for starch in a plant leaf is therefore done by adding iodine solution to the plant leaf to see whether a blue – black colour forms on the leaf.

It is however not possible to get positive results if the test is done on a living cell because:

- **Permeability**; the living plant leaf is not all permeable for iodine solution so that it is hard for iodine solution to penetrate inside the leaf cells and mix with starch.

[3] Starch is the storage form of glucose in plants. In animals, glucose is converted to glycogen (hence glycogen also called '*animal starch*')

- **Colour**; the green colour of the leaf would mask any blue black colour that might form on the leaf.



The procedures followed when plant leaf is tested for a starch in order to get successful results.

1. Dip the leaf in boiling water to boil it for about 2 minutes.
   - To kill the leaf so that this prevents any further chemical reactions.
   - To make leaf more permeable to iodine solution because the boiling of the leaf breaks the cuticle of the leaf.
2. Boil the leaf in alcohol such as ethanol.
   - To dissolve chlorophyll so that the leaf turns whitish to make any colour changes easily.
3. Dip the leaf in warm water for about 2 minutes.
   - To soften the leaf so that it can be easily spread out. The alcohol makes the leaf hard and brittle.
   - To rinse the alcohol from the leaf.
4. Spread the leaf on a white tile and add few drops of iodine solution on the leaf.
   - The white tile enables any colour change on the leaf to be efficient.
   - The drops of iodine solution are added on the leaf in order to find out whether there is starch or not in the leaf.

Expected results

A blue black colour forms on the leaf if there is starch in the leaf. If there is no starch in the leaf, the leaf is simply stained brown by the iodine solution, that is, the leaf looks brown.

Functions of mineral elements in photosynthesis

1. ***Nitrogen***
   - Formation of amino acids, protein and other complex nitrogen compounds like chlorophyll.
2. ***Phosphorus***
   - Formation of nucleic acid and high energy phosphate compound such as ATP.
   - Activation of certain enzymes.
3. ***Magnesium***
   - Formation of chlorophyll
4. ***Potassium***
   - Activates enzymes in photosynthesis and respiration.
   - Stored in the cell sap to increase sap concentration.
   - Opening and closing of stomata thereby allowing osmotic uptake of water.
5. ***Calcium***

- Building the cell wall in particular of the lamella.

6. ***Sulphur***
   - Formation of amino acids and protein.
7. ***Iron***
   - Formation of chlorophyll
   - Formation of components of the electron carrier system in the light reaction in photosynthesis.
8. ***Boron***
   - It helps in absorption of calcium ions and cell division of shoot tips.
9. ***Manganese***
   - activates some enzymes
10. ***Zinc***
    - Auxin production and activation of some enzymes.
11. ***Copper***
    - Constituent of certain oxidizing and reducing enzymes.

Experiments on photosynthesis

Any experiment that involves finding out if a specific condition is necessary for photosynthesis, the plant is given everything it needs except for the condition being tested. Another plant especially part of plant is used at the same time, this is control.

The control is given everything it needs including the condition being tested.

Since the presence of starch is regarded as an evidence of photosynthesis, the experimental plant must have no starch in their leaves at the beginning of the experiment. As such, the leaf must be destarched.

Destarching is placing the leaves in the darkness for 24 hours or leaving them in a card cup board for 2 – 3 days.

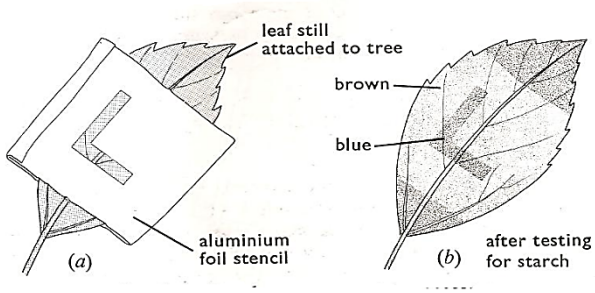
The plant cannot carry out photosynthesis while it is in the darkness since there is no light.

Experiment 1: necessity of light to photosynthesis.

Is light necessary for photosynthesis?

Procedures

- Take a potted green plant and put it in the darkness for 24 hours.
- Pluck the leaf and test for starch to make sure there is no starch.
- Cover part of both sides of the leaf with aluminium foil.
- Leave the plant in the sun for about 5 hours.
- Remove the aluminium foil and test for starch.



Results – only areas which received light turn into blue black with iodine solution.

Conclusion

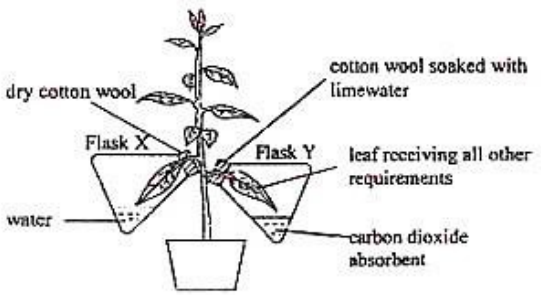
Light plays an important part in starch formation and hence in photosynthesis.

Experiment 2: necessity of CO_2 to photosynthesis.

Is carbon dioxide necessary for photosynthesis?

Procedures

- Take a potted plant and put it in the darkness for 24 hours to destarch it.
- Pluck the leaf and test for starch to make sure that plant has been destarched.
- Put potassium hydroxide/sodium hydroxide solution in transparent plastic bag and cover the leaf. This solution absorbs carbon dioxide.
- Put sodium hydrogen carbonate or soda lime in another transparent plastic bag and cover another leaf. This compound releases carbon dioxide.
- Leave the plant in the sun for about 5 hours.
- Remove the plastic bag and test for starch.



Results

The leaf deprived of carbon dioxide will not turn blue – black, while the leaf that receives carbon dioxide will turn blue – black.

Note: *Potted plant is a plant grown in a container.*

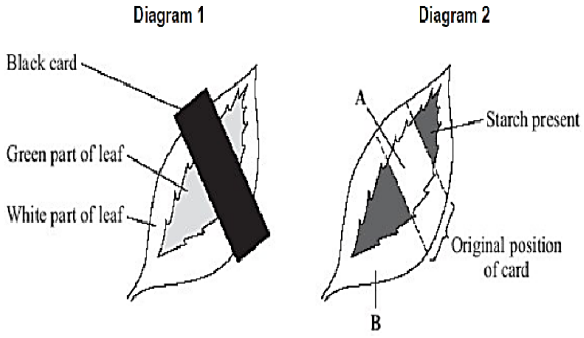
Experiment 3: necessity of chlorophyll to photosynthesis.

Is chlorophyll necessary for photosynthesis?

In order to carry out this experiment, a **variegated leaf** is used. This is a leaf that contains green and non – green parts on it.

Procedures

- Pluck a variegated leaf from a plant and destarch the leaf.
- Test for starch for both parts of the leaf.



Results

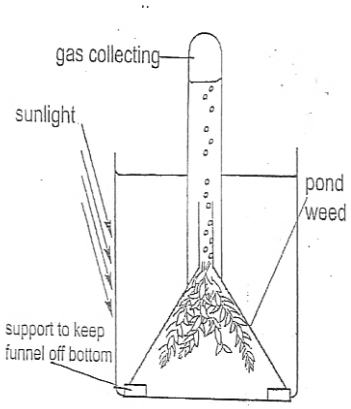
Only parts that were previously green turn blue – black with iodine. The parts that were white stain brown. Bear in mind that the variegated leaf has both experimental part and control part.

Oxygen production

Experiment: **To show that oxygen is produced during photosynthesis.**

Procedures

- Set up the apparatus as follow.



- Add sodium hydrogen carbonate in the water to release carbon dioxide.
- Leave the apparatus in the sun for a few days.
- Carefully remove the tube from the top of the funnel, allowing the water to run out, but not allowing the gas to escape.
- Carefully lower a glowing into the gas in the test tube.

Results

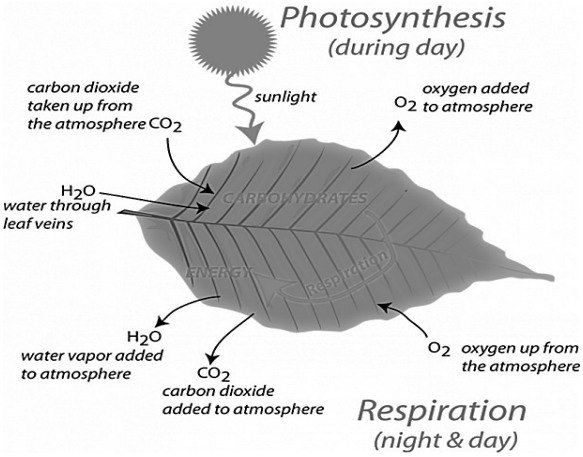
The glowing burns into flames.

Interpretation

The relighting of a glowing splint does not prove that the gas collected is pure oxygen but it does show that plant has given off a gas which is richer in oxygen.

Observation on photosynthesis and respiration in plant leaf

It is aerobic respiration that occurs in the green plant. Therefore, in a green plant both aerobic respiration and photosynthesis occur simultaneously during day time only.



Observations show that the products of photosynthesis are the raw materials for aerobic respiration. The products of aerobic respiration are the raw materials for photosynthesis. As such, this observation gives similarity between photosynthesis and aerobic respiration.

Respiration takes place in mitochondrion of the green plant all the time, that is, day and night and photosynthesis takes place in the chloroplasts of the green plant only during day time.

Evidences that show that the process of photosynthesis is faster than respiration

The process of photosynthesis is faster than respiration in green plant during day time.

1. Additional glucose is produced by photosynthesis than used for respiration. Therefore there is surplus glucose which is converted to starch for storage.
2. Additional oxygen is produced by photosynthesis than is used for respiration. There is excess oxygen inside the leaf. However, there is higher concentration of oxygen in

the plant leaf than in the atmosphere so that this excess oxygen diffuses from the leaf into the atmosphere through the stomata.

3. A reduced amount of carbon dioxide is produced by respiration than required for photosynthesis. Then, there is shortfall of carbon dioxide in the plant that creates a lower concentration of carbon dioxide in the leaf than in the atmosphere. Hence, carbon dioxide diffuses from the atmosphere into the leaf through the stomata.

Compensation point

This is the point when the rate of photosynthesis is equal to the rate of respiration in a green plant so that there is no gas exchange between the leaf and atmosphere.

This happens especially during light of low intensity.

Investigations on types of pigments in leaves

In plant cells there are a number of pigments that account for different colours in fresh leaves. Thylakoid membrane in chloroplast contains several kinds of pigments, which are substances that trap visible light. The kinds of pigments in plant leaves are;

- **Chlorophyll** has green colour, however, there are chlorophyll *a* which accounts for bright green colour and chlorophyll *b* which accounts for dark green.
- **Carotene** has orange colour in carrots and many flowers.
- **Xanthophyll** has a yellow colour in many flowers and fruits.
- **Anthocyanin** has red and purple colours found in red cabbage.
- **Tannin** has golden yellow in autumn.

Some leaves do not look green but have chlorophyll only that it is found in relatively small amount. The chlorophyll in such leaves is concealed by the colours formed due to mixing of other pigments in them.

Experiment

An experiment that could be carried out to show that fresh leaves contain three types of pigments.

Materials

- Two beakers, ethanol, fresh leaves, chromatography paper/ white piece of chalk and crushers.

Procedures

- Crush the fresh leaves into small pieces.
- Collect the small pieces and put them into a beaker.
- Add ethanol into the beaker to dissolve the crushed pieces.
- Decant
- Filter the dissolved substance and pour into another beaker.
- Put the white piece of chalk/chromatography paper upright
- Wait for 1 – 2 hours, then observe.

Results

The white piece of chalk will show different colours, that is, green, yellow and orange.

Conclusion

Green accounts for chlorophyll, yellow colour accounts for xanthophyll and orange colour accounts for carotene.

Importance of photosynthesis

1. **Food production** for both plants and animals.
2. **Oxygen production** which is used by animals and same plants for the process of respiration.
3. **Reduction of amount of carbon dioxide** in the atmosphere since carbon dioxide is used as a raw material for the process of photosynthesis. Hence minimize global warming.
4. **Plant products** bring items obtained from plants such as;
   - Medicine e.g. aloe Vera, molinga etc.
   - Raw materials for the use of industrial products

Revision questions

1. Describe an experiment that could be carried out to show that fresh leaves contain three types of pigments. Your answer should include procedures, expected results and conclusion. (**2008 Maneb**)
2. Mention any **two** uses of glucose after photosynthesis.
3. Explain how photosynthesis helps minimize global warming (**2011 Maneb**)

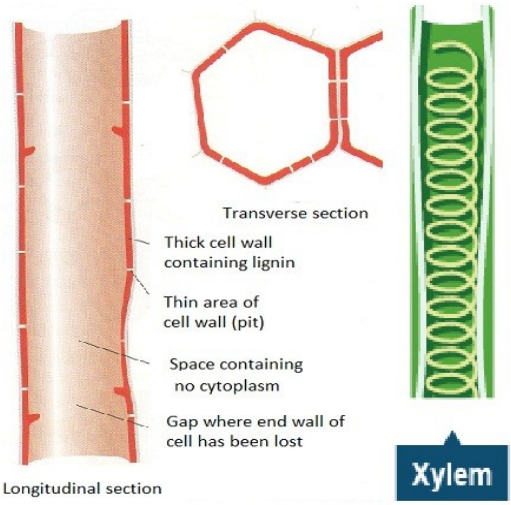
Topic 3 transport in plant

Vascular tissue

The **vascular tissue system** transports needed materials throughout the plant through two complex tissues, thus forming transport systems in plants.

Plants have two transport systems namely;

a. **Xylem tube**
b. **Phloem tube**



The structural differences between xylem and phloem tubes

Xylem tube

A xylem tube is a long drawn tube. It is made of long *hollow cells* joined end to end.

Xylem tube in veins is made up of several types namely:

1. Conducting cells
2. Spiral thickening cells
3. Packing cells

Xylem tube consists of two types of conducting cells;

- **Tracheids**
- **Vessels**

Vessels usually are shorter and broader than tracheids. The vessels run from the roots of the plant up through the stem.

Facts about the xylem tubes

- They *do not* contain cytoplasm
- *Do not* have nuclei
- Their walls are made of **cellulose** and **lignin**.

  The lignin is very strong so the xylem vessels help to keep plant upright. Wood is made almost completely of lignified xylem vessels.
- They consist of dead cells

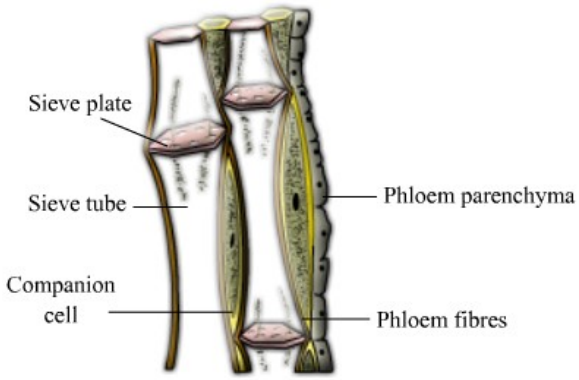
Phloem tube

Phloem tube is a **food conducting tissue** consists of cells that are living at maturity. It contains **sieve elements**.

Two types of sieve elements occur;

- **Sieve cell** with a narrow pores.
- **Sieve tube** with larger pore

Associated with the sieve elements are **companion cells** that contain nuclei and are responsible for manufacturing and secreting substances into sieve element.



Facts about phloem tube

- They have cytoplasm
- Do not contain nuclei
- Their walls are not lignified
- They are made of living cells called **sieve elements**.
- They have ends not completely broken down. As such, they form **sieve plates** which have small holes in them.
- Each sieve tube element has a companion cell next to it.

  The companion cell has nucleus and many other organelles.

In brief, xylem and phloem tube differ in the following ways:

- **Nature of cells**; xylem tube has dead cells and phloem tube has living cells.
- **Nuclei**; xylem tube does not contain nucleus and phloem tube contains nucleus in its companion cells.
- **Walls**; xylem tube has lignified walls and phloem tube has no lignified walls.

Functional differences between xylem tube and phloem tube

Xylem tubes;

i. Conduct water and mineral salts absorbed from the soil.

ii. Store food

iii. Help support the plant

Phloem tubes conduct materials manufactured by plants.

Vascular tissues

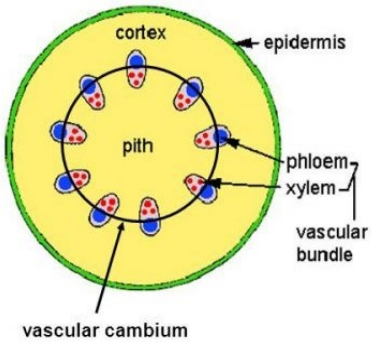
These are groups of xylem tubes and phloem tubes. These tubes are simply called vascular bundles. In between the xylem and phloem is **cambium**.

Cambium is a region of active cell division, that is, meristem where new xylem and phloem are formed.

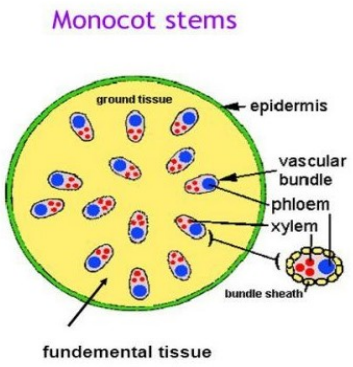
Arrangements of vascular bundles in dicots and monocots.

In a stem of a dicotyledonous plant such as bean seed the vascular bundles are arranged in a **ring** near outside the edge.

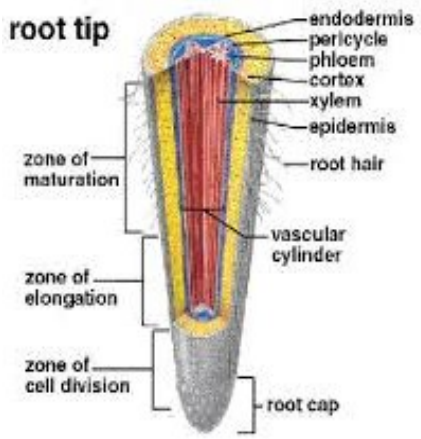
Dicot stems



In a monocotyledonous plant such as maize, sugar cane the vascular bundles are **scattered** in no pattern.



The structure of a plant root



Root cap

This is a mass of loose unspecialized cells fitting over the region of active division. It is found at the very tip of a root. This cap is protective in function, which protects the root as it grows through the soil.

Meristem

This is a region of active cell division from which permanent tissue is derived. Apical meristems occur at tips of stems and roots. Meristem also occurs between the xylem and phloem in cambium (veins).

Region of elongation

Lies behind the apical meristem. Here the root is actively lengthening mainly by the enlargement of its cells.

Region of differentiation

As the cells get order they become specialized to carry out different functions. Some become vascular cells, some protective cells, etc. They thus come to differ in size and shape.

Root hair

- Absorption of mineral salts and water since they provide large surface area.
- Stick to the soil particle, anchor the plant in the soil

Adaptations of root hairs to their function

1. **Long and narrow**

   Increases the surface area which in turn increases the rate of absorption of water and salts.

2. **Contain many mitochondria** where respiration occurs in the presence of oxygen to produce ATP. This ATP is needed for active transport.

3. At the centre of the root is the **vascular tissue** which transports water and mineral salts to the rest of the plant.

4. The **cell sap** in it contains sugar, amino acids and salts so that it is more concentrated than the soil solution. Water is in high concentration in soil so they diffuse into the root hairs.

Diffusion

Diffusion is the net movement of particles from a region of high concentration to a region of lower

concentration. This is also movement of particles along their concentration.

Factors that affect the rate of diffusion

1. Size of particles

Small particles move faster than large ones. So small particles will diffuse faster than large ones.

2. Temperature

Increasing the temperature makes the particles in a solution or gas move faster. So increasing the temperature will increase the rate of diffusion.

3. Difference in concentration

The bigger the difference in concentration between two points the steeper the concentration gradient and the faster the rate of diffusion.

4. Surface area

For a molecule to get into an organism's body it has to pass through a cell membrane. The bigger the area of the cell membrane available for diffusion the faster is the rate of diffusion.

5. Density of the medium

The density of the medium through which diffusion takes place determines flow of substances. In gases, there is a great deal of fast diffusion. Accordingly, gas molecules occupy a space that becomes available to diffusion relatively rapidly, while liquids do so more slowly.

Significance of diffusion

i. Helps in the movement of manufactured food within the plant.

ii. Uptake and removal of oxygen and carbon dioxide by plants.

Osmosis

Osmosis is the net movement of water from a region of higher water concentration to a region of lower water concentration across *semi – permeable membrane*.

A semi – **permeable** membrane is the one that allows small particles to pass through it.

Conditions of osmosis in solution

1. Turgidity

As the plant cell is placed in pure water, the concentration of water around the cell is much high than in the cytoplasm and the vacuole of the cell.

As a result, a lot of water moves from the pure water around the cell into the cytoplasm and vacuole by **osmosis.** As more and more water enters the cytoplasm and the vacuole, they swell. However, the plant cell has very strong cell wall around it, so that it cell wall around it, so that it prevents the cell from bursting.

Turgor pressure is the outward pressure that the cytoplasm exerts on to the cell wall in a plant cell.

The cell is said to be turgid. Turgidity is a condition when cell is in state of blown up, tight and firm.

The turgidity of the plant cells – helps a plant that has no wood in it to stay upright and keeps the leaves firm.

2. Flaccidity

This is when a plant cell is put in concentrated solution; the concentration of water in the cytoplasm of the cell is higher than in the concentrated solution around the cell. Hence, water moves from the cytoplasm into the solution around the cell across the cell membrane by **osmosis.**

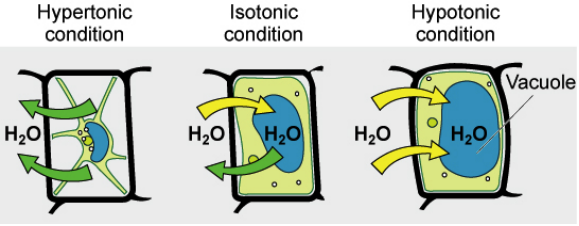
The cytoplasm shrinks, as a result it stops exerting the turgor pressure on the cell wall and the cell becomes floppy. The two solutions now have the same concentration of water molecules. They are called **isotonic solutions.**

Flaccidity is a condition in which the cytoplasm of the cell shrinks. The cell is said to be flaccid. If the cell in a plant becomes flaccid then the plant loses its firmness and begins to wilt.

3. Plasmolysis

This is the condition in which the cytoplasm of a plant cell shrinks to the centre of the cell so much that the cell membrane tears away from the cell wall.

Plasmolysis occurs if the solution in the plant cell is **hypertonic** and solution around the cell is very concentrated, that is, **hypotonic**, then a lot of water will diffuse out of the cell and the cytoplasm goes on shrinking.



Changes that occur in the plant cell during plasmolysis are;

i. Shrinking of cytoplasm

ii. Shrinking of vacuole

iii. Tearing away of cell membrane

Plasmolysis kills a plant cell because the cell membrane is damaged as it tears away from the cell wall.

Significance of osmosis

i. Helps in the absorption of water from the soil into the root.

ii. Helps in the absorption of mineral salts from the soil into the root.

Experiment on osmosis

You are provided with the following materials:

- Specimen **X**
- Salt solutions of the following concentration: 0%, 25% and 50.
- Razor blade or knife
- Ruler

a. Using a scalpel or razor blade

- Peel the specimen
- Cut three small pieces that are 2 cm long, 1cm wide and 0.5cm thick.

b. Place one piece in 0% salt solution, the other piece in 25% salt solution and the third piece in 50% salt solution. Leave to stand for 10 minutes.

c. Remove the pieces

(1) Measure the length of each piece.

(2) Try to bend each piece to test its flexibility.

d. Record your results in the form of table
e. From the table, state the relationship between salt concentration and length of potato pieces.
f. Explain the results observed in flexibility of the potato pieces in 0% salt concentration and 50% salt concentration.

Active transport

Active transport is the movement of particles from low concentration to high concentration.

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

Examples of active transport

a. Phloem translocation
b. Cytoplasmic streaming
c. Absorption of ions by roots.

The concentration of mineral nutrients required by the plant is always greater in the roots than in the surrounding solution. Thus ions move into the root against a concentration gradient. The movement of ions into the root must therefore use energy, hence active transport.

Nitrates and magnesium ions are readily absorbed by active transport. This process uses a lot of energy. The energy is supplied by the process of respiration.

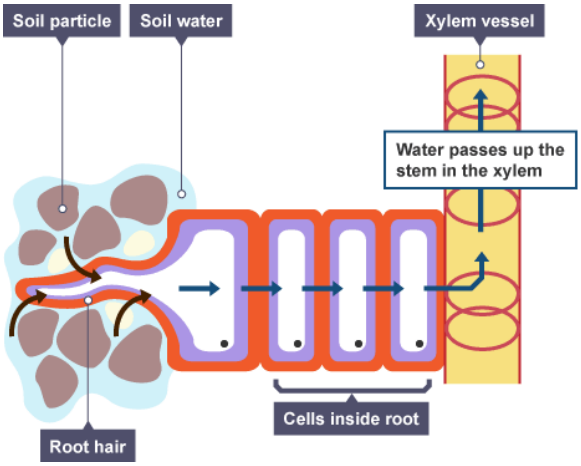
Significance of active transport

- Helps in the movement of manufactured food within plant.
- Helps in the movement of ions by root hairs.

How water and mineral salts are transported in xylem vessels

1. Through osmosis

The soil remains a region of high water concentration at all the times than the root hairs. Water therefore, moves from the soil into the root hair cells by osmosis. This increases the concentration of water in the root hair cell than the root.



2. Through root pressure

From behind, water in the preceding cell pushes the water on the adjacent cell, creating what is called **Root pressure**. Root pressure continues to push the water in each cell behind right up the stem to the leaves.

3. Through suction

Water that transpires from the leaf surface into the atmosphere leaves a **Suction force** that pulls more water from below the xylem cell. This suction force continues pulling water from below the xylem cell. Again, the suction force continues pulling the water from the soil into the root, right up the stem and out into the atmosphere.

This brings about the continuous flow of water from the soil into root to the leaves. This is called **Transpiration stream.**

How manufactured food are transported in phloem tube

From the chloroplasts, manufactured food (glucose) moves into the phloem cell by diffusion. This happens because there is more food in the chloroplasts than the phloem cell. From one phloem cell to the other glucose continues to move by diffusion.

However, from a phloem cell into storage organs, for example, fruit, glucose moves by active transport since there is more food in the storage organ than phloem.

Evidence that phloem transports organic food

Organic food produced in the leaves is transported to the rest of the plant through the phloem.

Experiments with aphids

Aphids are small insects that feed by pushing their piercing mouthparts into phloem tubes. The contents of the phloem are under pressure so that they flow along the stylets into the aphid.

If an aphid is allowed to pierce the phloem of the plant and its body is then removed, the contents drip out of the stylets.

Ringing (girdling) experiment

The active phloem tube lies just below the bark of a stem. If a complete ring of a bark is removed from the stem of a plant, a process called girdling; this removes the phloem tubes and leads to reduced root growth and swelling of tissues above the girdle.

Heat and cold treatment

Heating and cooling affect the living cytoplasm of cells. This affects the translocation of materials in the phloem. Heating a leaf petiole with steam stops the movement of food in the petiole. Cooling a petiole also reduces the rate of translocation of organic molecules.

Radioactive isotopes

If a leaf is provided with radioactive carbon dioxide it uses this carbon dioxide during photosynthesis to produce sugar. The movement of this radioactive sugar can be followed and it can be shown that the sugar molecules move through phloem.

Transpiration

This is a process by which water is lost from the plant surface into the atmosphere.

Plant leaves have the openings called **stomata** while plants have the opening called **Lenticles.** Water is lost through these openings. However, more water is lost through stomata on the leaf surface than through lenticles.

A thin firm moisture on which gas such as carbon dioxide dissolve, gases diffuse faster across the cell in a solution form. It is the thin layer of moisture that lost into the atmosphere.

How does transpiration occur

There are two forms that bring about transpiration

i. Evaporation
ii. Suction

Evaporation

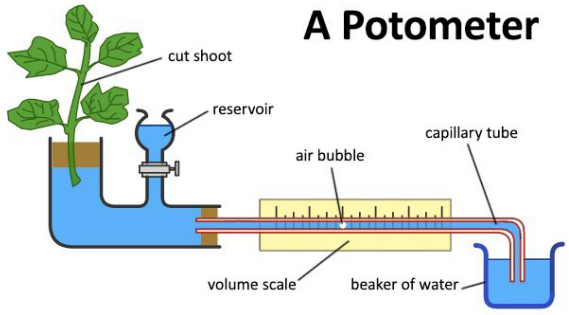
This is the loss of water molecules in form of water vapour into the atmosphere. This occurs to only those water molecules with high latent heat energy, they jump up into the atmosphere leaving the water molecules with less heat energy.

Suction

Evaporation of water molecules leaves a suction force that pulls more and more water from down the root right up the stem into the leaves. This brings about the stream.

Measuring the rate of transpiration

A potometer is an instrument used to measure the rate of absorption of water by a plant and not the rate of transpiration. However, the rate at which a plant takes up water equals the rate of transpiration. The faster it takes up water, the faster the plant transpires.



As water evaporates from the leaves, more is drawn from the stem which in turn draws it from the potometer tube. The tap below the funnel is closed so that water will be withdrawn from the capillary tube. Here, the meniscus at the air water boundary can be seen moving quite rapidly as water is withdrawn and air is drawn in behind the retreating water column.

By timing this water column movement over a fixed distance on the scale, the rate of water uptake can be calculated. It must be noted that the potometer does not measure water lost by transpiration but only water taken up as a result of it. Not all the water taken up will escape into the atmosphere. Some of it will be absorbed by those plant tissues whose turgidity is low.

Importance of transpiration

1. **Helps in the uptake of water by plant from the soil.**

   As more water is evaporating into the atmosphere this helps the plant to absorb more water from the soil.

2. **Transportation of mineral salts from the soil.**

   As water moves up into the leaves for transpiration they carry some of dissolved mineral salts together with it which are used up by the plant.

3. **Cooling of the plant**

   Water that has high heat latent energy evaporate quickly from the leaf surface leaving those which has low heat latent energy, therefore, these help to cool down the plant.

Factors that affect the rate of transpiration

1. Temperature

   On a hot day a lot of water evaporates quickly from leaves of plants. Transpiration rate increases as temperature increases.

2. Humidity

   The higher the humidity the less water will evaporate from leaves. The rate of transpiration decreases as humidity increases.

3. Air movement (wind speed)

On windy day water evaporates more quickly than on still day. Transpiration rate increases as wind speed increases.

4. Light intensity

In bright sunlight a plant may open its stomata to supply plenty of carbon dioxide for photosynthesis. More water can therefore evaporate from the leaves. Transpiration rate increases as light intensity increases.

5. Water supply

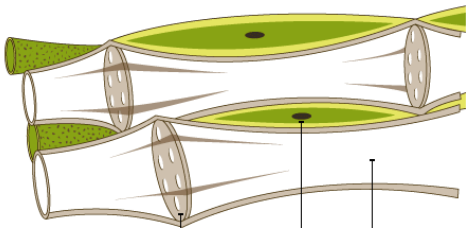
If water is in short supply, then the plant will close its stomata. This will cut down the rate of transpiration. Transpiration rate decreases when water supply decreases below the certain level.

Adaptations in plants that tend to reduce transpiration rate

1. **Closing stomata**; plants lose water through their stomata. If they close their stomata, then transpiration will slow down.
2. **Waxy cuticle**; many leaves are covered with a waxy cuticle, made by cells in the epidermis. The wax waterproofs the leaf.
3. **Hairy leaves**; some plants have hairs on their leaves. These hairs trap a layer of moist air close the leaf.
4. **Cutting down the surface area**; the smaller the surface area of the leaf, the less water will evaporate from it.

Revision questions

1. Define transpiration stream
2. Of what value is transpiration? Outline three points.
3. Describe five factors that affect the rate of diffusion.
4. State the function of cambium.
5. What is the difference between hypotonic and hypertonic solution?
6. Figure 1 is a diagram of plant tissue.



a. Name the tissue

b. Give two reasons for your answer.

Topic 4 Animal structure and function

Main groups of animals

There are two main groups of animals namely

- Invertebrates
- Vertebrates

Invertebrates

Insects

The insects form a very large class of arthropods. Examples include bees, butterflies, mosquitoes, houseflies, earwigs, greenfly and beetles
Insects have segmented bodies with a firm exoskeleton, three pairs of jointed legs, compound eyes and, typically two pairs of wings. The segments are grouped into distinct head, thorax and abdomen regions. Insects differ from crustacean in having wings, only one pair of antennae and only three pairs of legs. There are no limbs on the abdominal segments the insects have very successfully colonized the land.
Insects such as dragonflies, butterflies, bees and beetles have two pairs of wings on their thoracic segments. In the beetles, the first pair of wings is modified, forming hard wing-cases. Flies and mosquitoes have only one pair of wings, and some insects have no wings at all.
The appendages on the head segments form antennae and mouth parts. The mouth parts vary widely according to the feeding habits of the species.

Nematodes

They are commonly called roundworms. Roundworms are extremely abundant and diverse in the soil and in aquatic habitats; many species parasitize plants and animals while others are free living. The most distinctive feature of roundworms is a tough cuticle that coats the body. They are dioecious that is, have separate male and female parts. They reproduce sexually.

Annelids

Annelids are worms. Most of them have elongated, cylindrical bodies which are divided into segments. All the segments have identical sets of organs, though those at the front end may have specialized structures. Some organs, e.g. the alimentary canal, the nerve cord and the main blood vessels run the whole length of the body. Earthworms are annelids, but there are many more annelid species living in fresh water and the sea. Lugworms, bristle-worms and rag worms, are annelids which burrow in the sand on the sea shore. Tubifex is a freshwater annelid living in the mud at the bottom of ponds.

Crustaceans

Examples of crustacean are crabs, prawns, lobsters, shrimps and barnacles.
Freshwater crustacean are water fleas, Cyclops, the freshwater shrimp and the water louse. Woodlice are land dwelling crustacean. Compound eyes are made up of tens or hundreds of separate lenses with light-sensitive cells beneath. They are able to form a crude image and are very sensitive to movement. Naturally, crustacean have a pail of jointed limbs on each segment of the body, but those on the head segments are modified to form antennae are specialized mouth parts for feeding.

Arachnids

Arachnids are spiders, mites and scorpions. A spider's body is not clearly segmented but is divided into two regions, a cephalothorax and an abdomen. The cephalothorax carries four pairs of walking legs and two pairs of appendages for feeding. There are no antennae and, although there are eight eyes, they are not compound eyes like those of insects but they can detect movement.
The first pair of appendages on the cephalothorax are the chelicerae. These carry poison fangs which seize the prey and inject poison, followed by digestive enzymes.
There are over 70 000 species of spiders and many of them produce silk threads which they use to make webs and trap prey.

Molluscs

Molluscs include snails, whelks, slugs, mussels, oysters, squids and octopuses. Many of the molluscs have a shell. In snails, the shell is usually a coiled, tubular structure. In mussels and clams (the bivalves), the shell consists of two halves which can be partial1y open or tightly closed. In squids the shell is a plate-like structure enclosed in the body. In other molluscs, the shell is reduced or absent, e.g. slugs, octopuses.
All molluscs have a muscular foot. In the snails and slugs it forms a battened structure which protrudes from the shell during locomotion. In bivalves, the foot can protrude from between the halves of the shell and burrow in the sand (e.g. cockles). In the squids and octopuses, the foot has become the array of tentacles.

Vertebrates

Fish

Fish are 'cold-blooded' (poikilothermic) vertebrates. Many of them have streamlined bodies, which make it possible to move rapidly in water. The bodies of fish are covered with overlapping scales which themselves are covered by a thin layer of skin. The fins are either median, e.g. dorsal or ventral, or paired, e.g. pectoral and pelvic. In the backside, the pelvic fins have become spines. The fins are formed from skin supported by bony fin rays.

The tail fin is important in propelling the fish through the water. The median fins help to reduce rolling and assist in turning movements. The paired fins help to steer the fish up or down.
The lateral line is a sensory organ. It consists of a fine tube with sensory nerve endings and runs just beneath the skin. It is sensitive to movements and vibrations in the water. The operculum is a bony plate which covers and protects the gills and also acts as a valve in the breathing movements.

Amphibian

Amphibia are 'cold-blooded' vertebrates with four limbs and no scales. The class includes frogs, toads and newts. The name, amphibian, means double life and refers to the fact that the organism spends part of its life in water and part on the land. In fact, most frogs, toads and newts spend much of their time on the land, although in moist situations, and return to ponds only to lay eggs.
The toad's skin is drier than that of the frog and it has glands which can exude an unpleasant-tasting chemical which discourages predators. Newts differ from frogs and toads in having a tail. All three groups are carnivorous. Amphibians have four limbs. In frogs and toads, the hind feet have a web of skin between the toes. This offers a large surface area to thrust against the water when the animal is swimming. Newts swim by a wriggling,

fish-like movement of their bodies and make less use of their limbs for swimming. Amphibia have moist skins with a good supply of capillaries which can exchange oxygen and carbon dioxide with the air or water. They also have lungs which can be inflated by a kind of swallowing action. They do not have a diaphragm or ribs.

Reptiles

The reptiles include lizards, snakes, turtles, tortoises and crocodiles. Reptiles are land-living vertebrates. Their skins are dry and the outer layer of epidermis forms a pattern of scales. This dry, scaly skin resists water loss. Also the eggs of most species have a tough, parchment-like shell. Reptiles, therefore, are not restricted to damp habitats, nor do they need water in which to breed.
The reptiles are cold-blooded but they can regulate their temperature to some extent. They do this by basking in the sun until their bodies warm up. This enables them to move about rapidly in search of insects and other prey.
Reproduction; Fertilization of the eggs takes place internally. There is a behaviour pattern which leads to copulation during which the male introduces sperms into the female's reproductive tracts.

Birds

Birds are warm-blooded (homoiothermic) vertebrates: that is, they keep their body temperature more or less constant. The vertebral column in the neck is flexible but the rest of the vertebrae are fused to form a rigid structure. This is probably an adaptation to flight, as the powerful wing muscles need a rigid air-frame to work against. The epidermis over most of the body, produces a covering of feathers but, on the legs and toes, the epidermis forms scales. The feathers are of several kinds. The soft down feathers form an insulating layer close to the skin; the contour feathers cover the body and give the bird its shape and coloration; the large quill feathers on the wing are essential for flight.
Birds have four limbs, but the forelimbs are modified to form wings. The feet have four toes with claws which help the bird to perch, scratch for seeds or capture prey, according to the species.
The upper and lower jaws are extended to form a beak which is used for feeding in various ways.
Reproduction; birds lay eggs with hard shells. Fertilization is internal. The male mates with the female and passes sperms into her oviducts to fertilize the eggs before the shell is formed. The female lays the eggs in a nest and then incubates them, that is, keeps them at body temperature by sitting on them.

Mammals

Mammals are warm-blooded vertebrates with four limbs.
They differ from birds in having hair rather than feathers.
Unlike the other vertebrates they have a diaphragm which plays a part in breathing. They also have mammary glands and suckle their young on milk.
They have internal fertilization and reproduce sexually. The eggs are fertilized internally and undergo a period of development in the uterus. They give birth to fully young ones.
They have some degree of parental care.
Respiration: they use lungs for breathing.

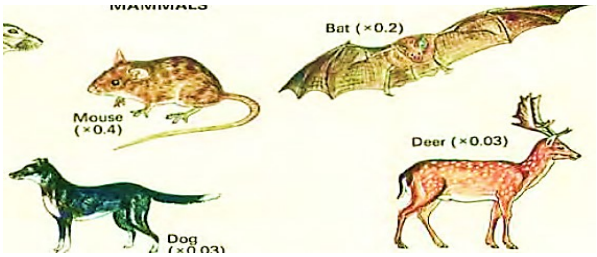
Classification

The information used to classify organisms can be put into a key called dichotomous key. Each stage or branch in the key has two parts to help identify the organism.

Dichotomous key groups similar organisms together. When designing dichotomous key we use characteristics that reflect their overall similarity.

Facts about dichotomous key

a. Each step has a pair of statements which describe organisms.
b. Each pair of statement divides the organisms into two groups.
c. The permanent features or characteristics are used to describe animals in each step.



Sample question

Figure below shows different animals. Use them to construct a dichotomous key that can be used to identify them.

1. Animal with wings …….Bat
   Animals without wings …. See 2

2. Animal with horns ……..Deer
   Animals without ……See 3

3. Animal with long legs ….. Dog
   Animal with short legs ….. Mouse

Note

You should be able to

- Draw and label the structures of these selected vertebrates.
- Compare and contrast the systems such as Locomotory, reproductive, respiratory and circulatory systems in the selected vertebrates.

Topic 5 locomotion in vertebrates

Locomotion

Energy released during respiration is used to bring about movement in living things. The movement of the whole organism from one point to another point is called locomotion. Locomotion enables an organism to look for food, seek mates and avoid danger and overcrowding.

Locomotion is made possible through collective team work of;

a. Skeleton

b. Joints

c. Muscles

Skeleton

This is framework of the body of an organism. It is important in producing locomotion in animals because it provides rigid places against which muscles pull.

Types of skeleton

Endoskeleton

This is hard material found inside the body of an organism. It is present in both plants and animals such as vertebrates and plants with wood. Endoskeleton in animals is made of bones and cartilage.

Advantage of endoskeleton is to allow free growth of an organism.

Disadvantage of endoskeleton provides less protection to the body of an organism from external physical forces.

Exoskeleton

This is hard material covering the body of an organism, that is, external cover. Chitin form exoskeleton in insects.

Advantage of exoskeleton – provides a lot of protection to the organism against external physical forces.

Disadvantage of exoskeleton – limits the growth of an organism hence organisms are small in size.

However, exoskeleton organisms grow through moulting (ecdysis). Moulting is the shedding off of exoskeleton animals, thus promotes growth.

Hydro skeleton

This consists of fluid contained inside cells and closed cavity of soft bodied animals. Examples include earthworm and caterpillar. A worm has a body cavity (coelom) containing a liquid called coelomic[4] fluid. The worms have muscles that relax and contract thereby causing movement.

Relaxation and contraction of the muscles squeeze the coelomic fluid. Contraction of the muscles send pressure waves through the fluid thereby causing changes in the shape of the body.

Bones

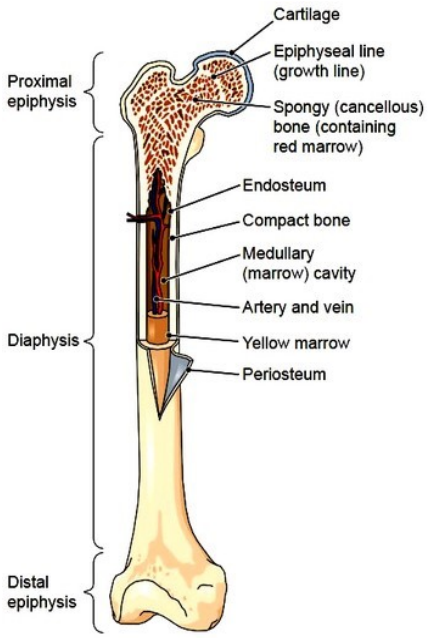
Bones are living organs that actively contribute to the maintenance of the

[4] Pronounced as ''see-lo-mic''

internal environment of the body. The bones are supplied with oxygen and food.

Bones are hollow rods with the centre filled with bone marrow. In human, there are 206 bones.

Structure of a bone



Cartilage

This is the soft tissue at the end of the bone. It contains less mineral salts hence it is smooth than the bone. It prevents the bones from jarring during movement.

Spongy bone

Has air spaces to make the bones lighter. Has blood capillaries that bring food substances and oxygen for the bone.

Marrow cavity

This is where red blood cells, white blood cells and platelets are made.

Compact bone

This is the hardest part of the bone. It is fused to the periosteum. Periosteum anchors structures of the bone and contains blood vessels.

Note

The types of bone tissues are compact bone and spongy bone.

Functions of bones

1. **Storage**
   Bones store calcium and phosphate ions. These ions are important in the physiology of the body. The release of these ions from bones to the blood is regulated by hormones of the parathyroid glands.

2. **Movement**
   Many bones act as levers. When muscles pull on these levers they produce movement.

3. **Protection**
   Provide protection for all the delicate organs in the body. For example, skull protects the eyes, brain, nasal organs and ears. The ribcage protects the liver, lungs and the heart. The vertebral column protects the spinal cord.

4. **Support**
   The bones support the body and give the body shape and form. The short skeletal parts support the greater mass than long skeletal parts.

5. **Production of blood cells**
   Red blood cells, white blood cells and platelets are produced in bone marrow.

6. **Help in breathing**
   The ribs help in breathing as they move inwards and outwards or upwards and downwards due to contraction of intercostal muscles.

Chemical composition of a bone

A bone is made up of two major components;

a. The organic component

b. The inorganic component

The organic component

This is made up of a protein called collagen. Collagen makes the bone to be flexible or rubbery or elastic.

The inorganic component

These comprise

i. Calcium phosphate
ii. Calcium carbonate

Calcium in bones makes the bones to be hard. The bone with inorganic component only (calcium) without collagen becomes brittle hence easily breaks. The bone with the organic component only (collagen) becomes more elastic and rubbery.

Experiment

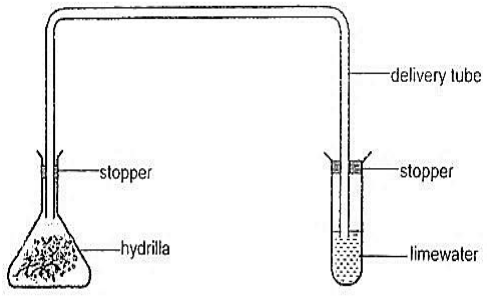
Describe an experiment that could be carried out to show composition of a bone.

Materials

4 large test tubes, 2 glass delivery tubes, dilute hydrochloric acid, lime water, triple beam balance and fresh bones.

Procedures

- Take some pieces of fresh bones and weigh them. Record the results.
- Now place the bones in a test tube and cover them with dilute hydrochloric acid.
- Fix the delivery tube to another test tube containing limewater as shown below



- Set up a control apparatus without the bones.
- Leave the experiment for two days.
- After two days, observe and record any changes in the limewater both in the experimental tube and control tube.
- Rinse the bones and try to bend them.
- Dry the bones in the sun. When they are dry and cool, weigh them again and record the results.

Expected results

After two days the limewater turns milky. This means the mixture of hydrochloric acid and the bones in the test tubes produce carbon dioxide. The mass of the bones decreases showing that part of the bones dissolves in the hydrochloric acid.

The bones are hard before soaking in the acid. But after soaking in the acid for two days they become rubbery because the hard inorganic component dissolves in the hydrochloric acid.

Conclusion

From the experiment we may conclude that the bones consist of two parts; hard substance and soft spongy substance. The hard substance consists of calcium which has reacted with the acid thereby producing Carbon dioxide while leaving soft spongy substance which consists of collagen to become rubbery.

Classification of bones

1. **Long bones** – such as bones of the arms, legs, hands and feet.
2. **Short bones** – such as bones of wrist and ankle.
3. **Flat bones** – these include the ribs, shoulder blades, hip bones and cranial bones.
4. **Irregular bones** – these include the vertebrae and facial bones.

The human skeleton

The main divisions of human skeleton are;

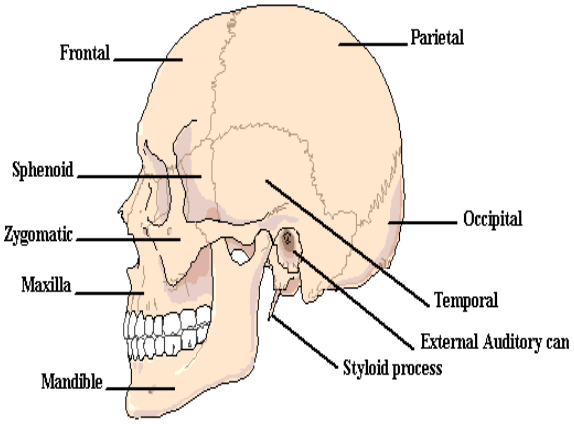
a. Axial skeleton
b. Appendicular skeleton

Axial skeleton

This region is made of the skull, ribcage and vertebral column. These structures form the main centre of the body.

Skull

The skull consists of 8 cranial bones and 14 facial bones. The cranial bones form the brain case – lined with meninges that encloses and protects the brain, eyes and ears. The bones are fused together at lines (joints) called **sutures**.



Rib cage

The rib cage consists of 12 pairs of ribs and sternum. The ribs form a curved bony cage around the heart and lungs. At the front they are attached by the costal cartilages to a bone called sternum. All the ribs join with the thoracic vertebrae.

Each rib ridges to which the intercostal muscles are attached. The costal cartilage allows the rib cage to expand and contract without causing friction between the ribs and sternum during breathing.

Vertebral column

The vertebral column (spinal column or backbone) is made of individual bones called **vertebrae** arranged as a curved rod.

There are thirty three (33) vertebrae in total.

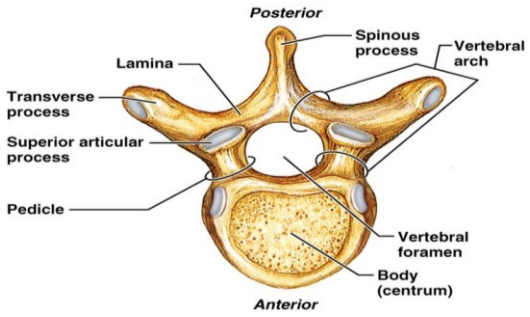
- Cervical – 7 vertebrae
- Thoracic – 12 vertebrae
- Lumbar – 5 vertebrae
- Sacral – 5 vertebrae
- Coccygeal – 4 vertebrae

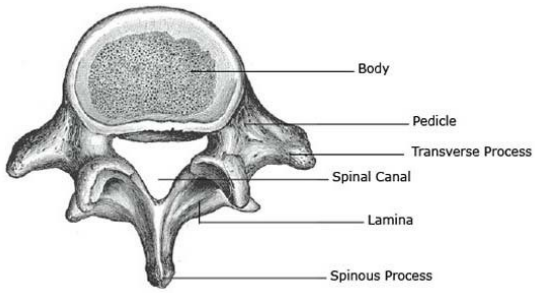
The vertebral column supports the skull and limb girdles. Neural canal is a cavity that runs through the centre of each vertebra forming a space in the vertebral column through which the spinal cord runs.

Functions of vertebral column

i. Provides centre of attachment for pelvis and rib cage.
ii. Support the head.
iii. Protects the spinal cord from external physical forces.

Structure of vertebra





Functions of parts of vertebra

1. **Neural spine**
   Used for ligament and muscle attachment.
2. **Transverse process**
   Used for ligament and muscle attachment.
3. **Centrum**
   This structure resists compression and produces red blood cells.
4. **Neural canal**
   Passage of the spinal cord.

Appendicular skeleton

It consists of bones of the pectoral and pelvis girdle. The girdles form a rigid system of attachment of the limbs. These girdles absorb any stress that the limbs may experience.
The limbs are arms and legs. The arms are attached to the pectoral girdles. The legs are attached to the pelvic girdles.

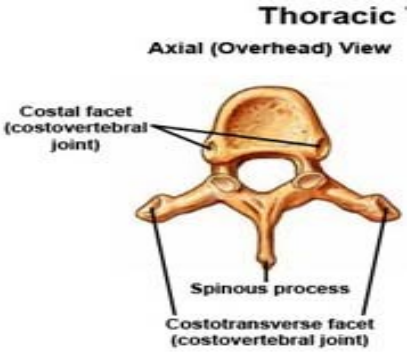
Groups of vertebrae and their functions

Cervical vertebra

Form the neck by small vertebrae, very small neural spines and absence of transverse process.
Have atlas that allows nodding of the head since there is hollow onto which fit the two swelling of the head.
Have axis that allows lateral movement of the head because of presence of odontoid peg.

Thoracic vertebrae

Hold the ribs by their long transverse process, long neural spine which point backwards.

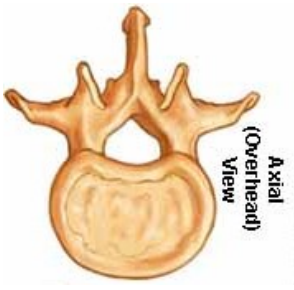


Lumbar vertebrae

- Provide points for muscle and ligament attachment.
- Support the body mass.
- Withstand external physical forces.

Have the following adaptations

i. Broad and thick invertebral discs.
ii. Broad and thick transverse process.
iii. Their neural spines are broad and thick.
iv. Has greatest curvature.



Sacral vertebrae

Anchors the vertebral column firmly within the pelvic girdle.

Adaptation: the vertebrae are fused and flared out to firmly fit into the pelvic girdle.

Coccygeal vertebrae

Are non – functional in human beings. They form a tail in other animals as such it is tail bones. The vertebrae are fused together.

Joints

The place where two or more bones are attached to each other is called a joint. Thus joint is the meeting of bones.

Groups of joints

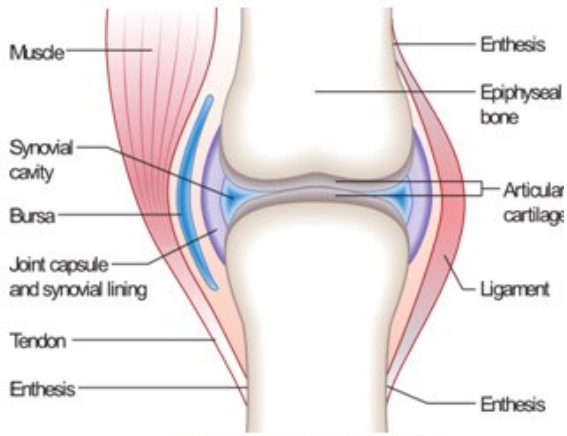
Movable (synovial) joints

These allow some movement of the bones.

Immovable (fixed) joints

These joints do not allow movement of the bones. Immovable joints are found in the skull and in the pelvic girdle.

Structure of a typical movable joint



Functions of parts of movable joint

1. **Capsule**
   Binds the whole joint and keeps it intact.

2. **Synovial membrane**
   Secretes the synovial fluid that lubricates the joints thereby preventing friction during movement.

3. **Cartilage**
   Reduces friction between the ends of bones during movement.

4. **Ligament**
   Hold the bones at a joint firmly together.

Types of joints

There are four types of joints.

1. **Hinge joints**
   These are joints that allow movement in one plane only. Hinge joints are found in elbow, fingers and knees.

2. **Ball and socket joints**
   These joints have greatest flexibility, allowing movement in all direction. They are formed where the upper long bones of the arms and legs meet their respective girdles.
   Their rounded end of the femur fits into a cup – shaped socket in the pelvic girdle.

3. **Fixed joints (sutures)**
   These are joints where bones are fused together by collagen. The bones of skull meet at fixed joints called sutures.

4. **Gliding joints**

These are joints that occur where bones meet at a flat surface and glide over each other, such as ankle and wrist.

Muscles

Muscle tissue is specialized for contraction. Thus muscle is a flesh part of the body. All muscles contain microscopic fibres called fibrils. Fibrils are made of two kinds of proteins. Such proteins are **actin** and **myosin**.
The muscles are attached to the bones by tough, inelastic fibres called tendons. Tendons are made of collagen fibres. Tendons are very strong and do not stretch.

Characteristics of muscles

i. The ability to contract very rapidly.
ii. The ability to contract without receiving impulses from the nervous system.

Functions of muscles

1. **Movement**
   Body movements such as walking, breathing as well as movements associated with digestion and flow of fluids.
2. **Production of heat**
   The heat is produced to maintain normal body temperature.
3. **Body support and posture.**

How actin and myosin make muscle contract

The actin and myosin molecules can slide past each other which make the muscle contract. This uses energy which comes from ATP made in respiration.

Types of muscles

Smooth muscle

Smooth muscle is also called involuntary or visceral muscle. Contractions of smooth muscle therefore occur involuntary. The term visceral refers to internal organs, many of which contain smooth muscle.
In mammals, smooth muscle is found in the walls of intestine, blood vessels, air passages and bladders.

Characteristics of smooth muscle

i. Contracts and relaxes slowly and steadily does not become tired.
ii. Ideal for the continuous movement of substances through the organs of the body.
iii. Has a single nucleus.

Skeletal muscle

Skeletal muscle is also called striated or voluntary muscle. Skeletal cells are cylindrical and have many nuclei.

Characteristics of skeletal muscle

i. Consists of fibres which are crossed with alternate light and dark bands.
ii. Becomes tired. Its contractions are quick, strong and usually voluntary.
iii. Its fibres receive branches from axon of motor neurons.

Cardiac muscle

Cardiac (heart) muscle is striated[5].

Characteristics of cardiac muscle

i. Its fibres are branched and connect with one another.
ii. Has structure that allows nerve impulses spread throughout.
iii. The whole tissue coordinates its contractions.
iv. It never becomes tired and is involuntary.

[5] Having long thin lines i.e. strips of colour

How muscles and bones bring about movement

a. **Attachment of muscles to bones.**
Skeletal muscle is attached to the bones by tendons. When the skeletal muscle contracts it pulls bone towards it, the muscle in the other side of the bone contracts to return the bone to its position.

b. **Antagonistic muscle** is the skeletal muscle that contracts on one side of the bone while causing relaxation of another muscle called agonistic muscle.
The skeletal muscle that is relaxed on one side of bone due to contraction of another skeletal muscle on other side is called antagonistic muscles.
The pairs of the muscles that relax and contract are antagonistic muscles.

Examples of skeletal muscles (antagonistic muscles) are; biceps and triceps muscles of the upper arm and leg. These muscles are called antagonistic muscles because *they are found in pairs and work in opposition to each other.*

When the biceps muscle contracts, it causes relaxation of the triceps muscle. When the triceps muscle contracts, it causes relaxation of the biceps muscle.

How is the arm raised?
The biceps contract to pull the arm up while the triceps relax thereby raising the arm.

How is the arm lowered?
The triceps contract to pull the arm down while the biceps relax thereby lowering the arm.

Experiment

Design an experiment to find out how antagonistic muscles work to help you move your limbs.

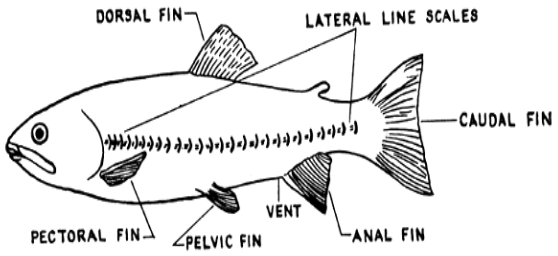
You will need; an object weighing 2 kg and material for taking notes.

Procedures
- Work with a partner to design a simple investigation.
- Put your two hands on the front and back of your upper leg either standing or sitting.
- Then how the muscles contract and relax as you swing your lower leg.

Expected results
You should observe if the muscles on both sides contract at the same time. You realize that they are not.

Conclusion
When you move your lower leg forward, it is the muscles in the front of the thigh and hip contract. As you move your leg back, the muscles at the back of the thigh and hip contract, while those on the front part relax.
Why is this so? Question for you! You can discuss with your colleague.

Locomotory structures in fish
Locomotory structures in fish are fins that enable locomotion.



Locomotion in fish

Water is much denser therefore more difficult to move through. However, water provides better support for locomotion structures to push against. When a fish moves in water, it is slowed down by:

- Water resistance (friction) between its surface and water.
- Turbulence – formation of eddies and irregular pattern of flow in the water.

Water resistance and turbulence create slowing down called **drag**.

Movement of fish through water is brought about mainly by the powerful muscles of the tail. In most fish over 50% of the total body mass is made up of the tail. The powerful muscles on either side of the vertebrae of the tail contract alternatively making the body move from side to side.

1. **Propelling**
   This is movement that pushes water backwards and in so doing pushes the fish forward. This is done by powerful muscles of tail and all other fins.

2. **Rolling**
   The fish is kept stable and upright by the paired fins and median fins such as dorsal and ventral, which prevent the fish from rolling.

3. **Pitching**
   This is the change of an angle in fish. It is done by median fins (dorsal and ventral fins).

4. **Yawing**
   It is jumped movement of fish. It is controlled by the paired fins.

Most fish are also assisted in changing depth by the presence of a swim bladder which, when full with air allows the fish to rise and when less full allows the fish to sink. In general the fins control stability and direction of the fish.

How fish is adapted for locomotion

i. **Streamlined in shape** that help reduce resistance of their body through the water and overcomes weight.

ii. **Presence of scales**

- Smeared with layers of mucus to overcome drag.
- which overlap backward to reduce drag during locomotion.

iii. **Light weight** that is, less dense than water.

iv. **Presence of swim bladders in other species**
This makes them buoyancy.

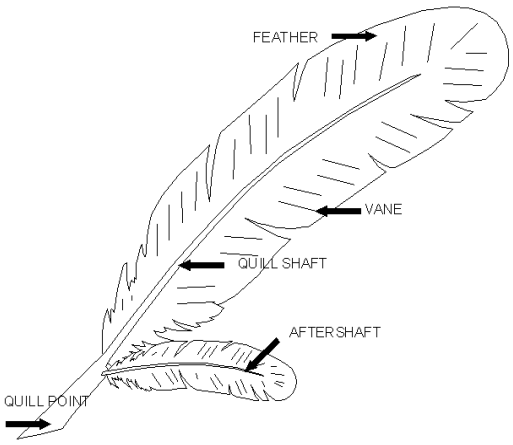
v. **Water – current mechanism**
This mechanism is achieved by the process called osmosis. The water that enters and leaves the inside of fish enables locomotion.

Locomotory structure in bird

The birds use feather for locomotion, thus feathers are locomotory structures in birds.

There are three types of feathers namely;

- flight feathers
- down feathers
- contour feathers



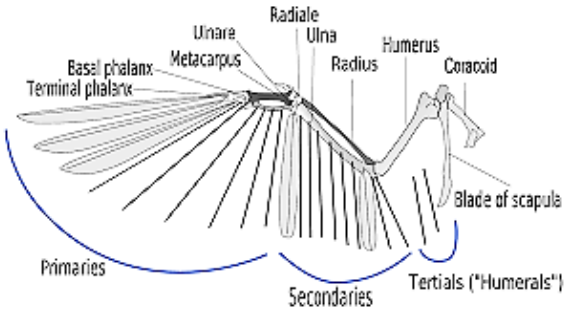
1. **Quill;** attaches muscles to change the angle of the feather.
2. **Shaft** has barbules containing hooks that catch on to the grooves of the barbules.
3. **Vane** consists of outer edges of a feather called **primaries** and inner edges of feather called **secondaries**.
4. **Wing coverts** are rows of smaller feathers that smoothly overlap the flight feather top and underneath the wing.

Functional differences between flight feathers and down feathers

- Flight feathers are used for locomotion in birds since they help in flight of birds while down feathers cover the whole body of the birds.

Structure of a wing of a bird

The wing of the bird is equivalent to the human arm. However, bird's wing forms the bastard wing that attaches out in front.



Locomotion in birds

Flying birds remain airborne only as long as they are lifted by forces a least equal to their body weight. These forces are called lift.

The significance of lift in birds

- Overcome the force of gravity
- Allow the birds to remain afloat in the air.

Birds fly in two ways:

1. Flapping in birds
2. Gliding

Flapping in birds

Birds have two pairs of antagonistic muscles called pectoralis muscles that bring about flapping of the wings in birds. As such pectoralis muscles are flight muscles in birds.

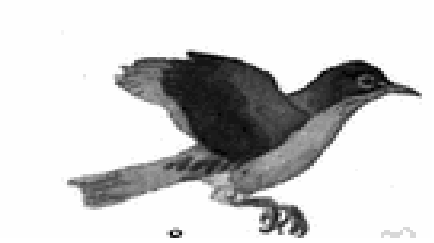
The pairs of pectoralis muscles are;

a. Pectoralis minor – pectoralis elevator muscle.
b. Pectoralis major – pectoralis depressor muscle.

Flapping in birds causes **strokes** in birds.

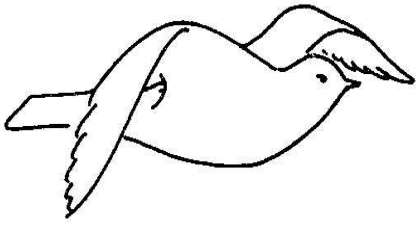
Upstroke

When the pectoralis minor contract the pectoralis major are forced to relax and wings are raised. As a result there is no upthrust below the wings and the force of gravity pulls down the bird so that it loses height.



Down stroke

When pectoralis major contract the pectoralis minor are forced to relax hence the wings are lowered. As such, the air resistance below the wings produces an upthrust on the wings. This force is spread through the coracoid bone to the sternum, thus lifting the birds. The down stroke allows the birds to gain height.

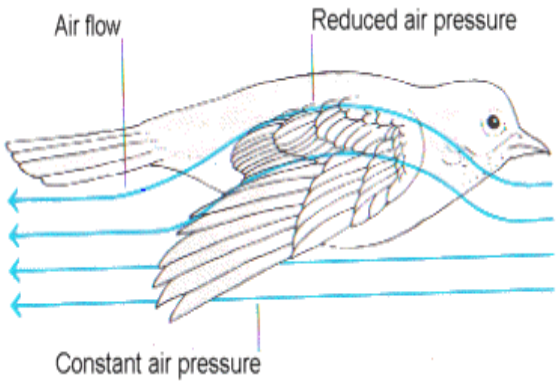


Gliding

During gliding air currents are created either by;

i. Gliding downwards at an angle through the air with wings outstretched.
ii. Or heading into wind currents.

The secret in gliding in birds is the shape of the wing which is streamlined that creates air currents. This streamlined shape of the wing is called **aerofoil**.



The shape of an aerofoil is such that air flow across its upper surface moves faster than air that moves its lower surface. Then, the faster moving air has lower pressure than slower moving air which has high pressure. As a result, the faster moving air creates a zone of low downward air pressure while the slow moving air below aerofoil creates a zone of high upward air pressure in order to overcome force of gravity.

How birds are adapted for locomotion

1. **Streamlined shape**

- Wings have this shape that creates air currents at the surfaces of the wings to provide a lift to the birds to overcome drag. Tips of feathers point backward in the same direction as the flow of air.
- Bodies have this shape that reduces drag caused by the resistance of air.

2. **Presence of hollow in bones and quills** that make them to be lighter in weight as such, they easily overcome gravity.

3. **The flight and down feathers**

- Trap air using their large surface area and air sacs which when filled with air reduce the average density of the birds.
- Provide enough insulation to the bird. At around 41°C the temperature of a

bird is higher than most of warm – bodied animals. The higher temperature means that the flight muscles work more efficiently.

4. **Presence of strong and powerful pectoral muscles** for producing sufficient energy for flight that provides lift to overcome force of gravity.

5. **Good vision of sight;** to detect changes in the environment during locomotion.

Topic 6 digestive system

Principal function of digestive system

Change complex organic nutrient molecules into simple organic and inorganic molecules that can be then be absorbed into the blood or lymph to be transported to cells.

Division of digestive system

1. Alimentary tube (canal)

   It consists of oral cavity, pharynx, oesophagus, stomach, small intestine and large intestine.

2. Accessory organs of digestion

   It consists of teeth, tongue, salivary glands, liver, gall bladder and pancreas. These organs contribute something to the digestion process.

The human alimentary canal

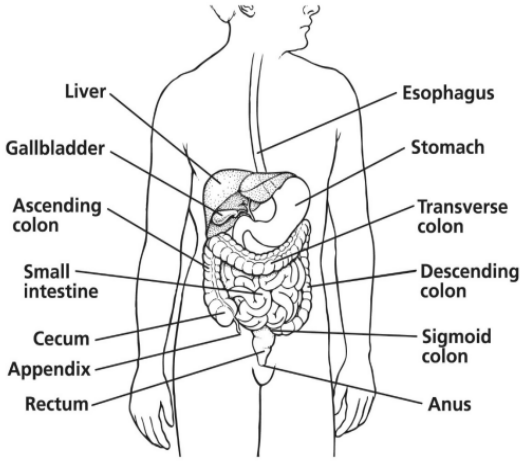
This is a long hollow muscular tube that runs from mouth to anus.

The significant functions of the alimentary canal;

i. Food digestion

ii. Food absorption into bloodstream

Parts of human alimentary canal



Digestion

This is a process by which food is broken down into soluble form for easy diffusion and absorption.

Types of digestion

There are two types of digestion namely;

i. Physical (Mechanical) digestion

ii. Chemical digestion

Physical digestion

This is the breaking down of large pieces of food into smaller pieces by exerting external physical forces onto the food.

Example of physical digestion is chewing.

Regions along the alimentary canal where physical digestion occurs

1. Mouth

   In the mouth food is chewed and mixed with saliva by the action of

teeth. Chewing reduces the food to suitable sizes for swallowing and increases the surface.

2. Duodenum

The bile from the liver is poured into the duodenum that physically breaks down drops of fats into droplets of fats. This process is called **Emulsification**.

Advantages of physical digestion

i. Ease swallowing; makes the food to be in form which can be easily swallowed.

ii. Produce small surface area; smaller pieces of food, it increases the surface area of food on which enzymes act during chemical digestion.

Chemical digestion

This is the breaking down of large molecules of food into new and smaller molecules through action of enzymes.

Advantages of chemical digestion

It makes food to be in such a form of small molecules that can be absorbed into bloodstream for body use.

Digestion in different parts of the alimentary canal

Mouth

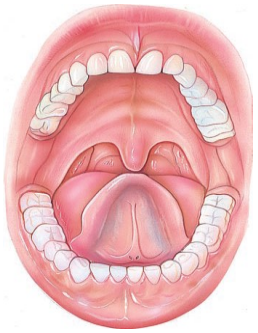
In the mouth there are salivary glands that produce saliva which is secreted into the mouth through salivary duct. The saliva is a mixture of water, mucus and enzyme ptyalin (salivary gland).

When the food is taken into the mouth is mixed with saliva. This saliva;

i. Softens the food so that it is easily digested physically by the teeth and tongue.

ii. Contains an enzyme ptyalin which chemically digests cooked starch into maltose.

iii. Makes food slippery due to the mucus so that it is easily swallowed.



Oesophagus

Behind the trachea is the oesophagus (gullet) which takes food down to the stomach.

As you swallow, a piece of cartilage called **epiglottis** covers the entrance from the mouth into the trachea called **glottis**, this stops the food from going into the trachea. As a result food goes into the oesophagus.

The oesophagus is lubricated with mucus produced by it.

Remember that, there is no digestion of food in the oesophagus.

Stomach

It is an elastic sac with many glands. Its lining has many folds called **rugae** which flatten to let it enlarge. Its walls secrete a digestive juice called **gastric juice** which contains mucus, hydrochloric acid (HCl)

and enzymes including renin, chymotrypsin and pepsin.

Mucus covers the inner walls of the stomach thereby protecting them from being burnt by theHCl.

Hydrochloric acid;

i. **Brings** about the acidic P^H essential for the enzymes working in the stomach.

ii. **Kills** germs that might be eaten together with food

iii. **Softens** hard food particles such as bones for easy digestion.

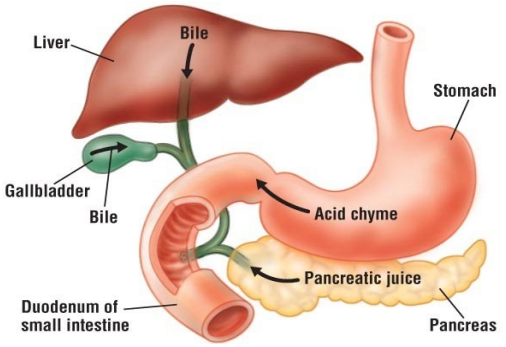
Renin in babies coagulates milk into a semi – solid form. Chymotrypsin breaks down a milk protein in babies called **Caseinogen** into **Casein**. Pepsin chemically digests proteins into polypeptides.

Duodenum

Two secretions are made into the duodenum.

i. Bile

ii. Pancreatic juice

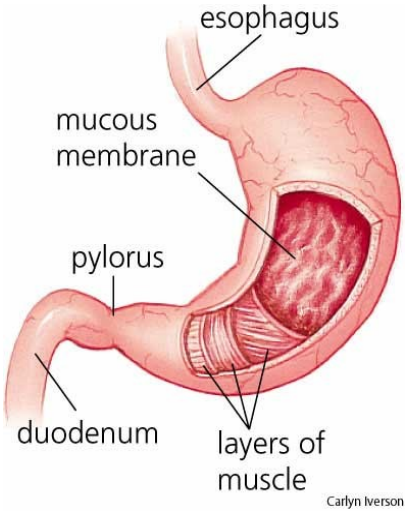


Bile is produced by the liver but stored in the **gall bladder**. Bile consists of iron and salt called sodium bicarbonate. Bile physically breaks down drops of fats into droplets of fats. This process is called Emulsification, as such bile emulsifies fats.

Pancreatic juice is secreted by the **pancreas**. It consists of a salt called Sodium Hydrogen Carbonate and enzymes including lipase, trypsin and pancreatic (ptyalin) amylase.

The salt, sodium hydrogen carbonate brings about the alkaline $\mathbf{P^H}$ essential for the pancreatic enzymes to work properly. The enzyme lipase chemically breaks down emulsified fats into fatty acids and glycerol.

Trypsin chemically digests polypeptides into peptides. Pancreatic amylase chemically breaks uncooked starch (polysaccharides) into **maltose.**



Ileum

Its walls secrete a digestive juice called **intestinal juice** (Succus Intericus) which is composed of enzymes such as maltase, peptidase, sucrase, lactase and cellulase.

- Maltase breaks down maltose into glucose.
- Peptidase breaks down peptides into amino acids.
- Sucrase breaks sucrose into glucose and fructose.

- Lactase breaks lactose milk sugar into galactose.
- Cellulase breaks down cellulose in vegetables into glucose.

Food absorption

Soon after chemical digestion is completed, the small intestines tend to have a higher concentration of food substances than the surrounding blood capillaries. End products of chemical digestion therefore move by Diffusion and Active transport from the small intestine into bloodstream in surrounding blood capillaries. This movement is called Food Absorption.

The end products are then carried away in the capillaries to the liver through **Hepatic Portal** vein. The liver changes any of the digestion products. The digested food then reaches the general circulation.

Functions of the small intestine

There are two functions of small intestine:

i. Digestion of food

ii. Absorption of food substances

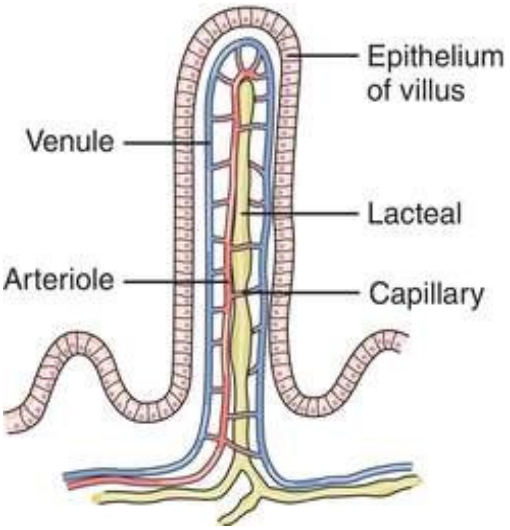
Adaptations of small intestines to the function of digestion

1. Length; is very long to increase the surface area for food digestion.
2. Highly folded to increase the surface area for food digestion.
3. Have an alkaline P^H, essential for proper functioning of the intestinal enzymes.
4. Have enzymes that chemically break down large food molecules into simple food molecules.

Adaptations of small intestines to the function of food absorption

1. Length; is very long to increase the surface area for food absorption.
2. Highly folded to increase the surface area for food absorption.
3. Have finger – like projection called **villi** that increase the surface area for food absorption. The villi are the actual sites on which food absorption takes place.

The structure of the villi



Adaptations of villi to their function

i. **Thin walls**; have extremely thin walls, only one cell thick to make diffusion of food substance faster.

ii. **Presence of mitochondria**; their cells have mitochondria that provide energy for food absorption that is, active transport.

iii. **Dense network of blood capillaries** that bring more blood into which more food substances diffuse.

iv. **Permeability;** have a more permeable lacteal into which fatty acids and glycerol diffuse.

Large intestine (colon)

i. Absorption of water

ii. Absorption of mineral salts

Fate of food substances after absorption

Assimilation

That is, glucose, amino acids, fatty acids and glycerol, vitamins, mineral salts and water are used up in the body in various metabolic processes in the body.

Liver related functions to digestion

i. **Control of protein level** through Deamination and Transamination.
Transamination is a process by which the liver converts one form of amino acid into another form of amino acid.

ii. **Control of carbohydrate level**, the liver removes excess glucose from the blood and stores it as glycogen. When glucose concentration falls, the liver converts some of its stored glycogen into glucose and releases it into the bloodstream.

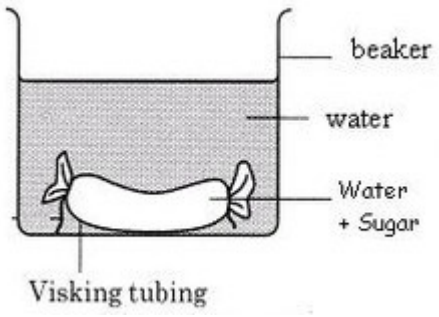
iii. **Control of lipid level** in the body, the liver chemically changes excess fatty acids and glycerol and is either sent to connective tissues or under the skin for storage.

iv. **Bile production**, cells in the liver make bile and stored in the gall bladder. The green colour of the bile results from a pigment bilirubin from the breakdown of haemoglobin of worn out red blood cells.

v. **Stores iron** as red blood cells break the iron from their haemoglobin is stored in the liver.

vi. **Formation and excretion of bilirubin** the liver contains macrophages that engulf and digest old red blood cells. Bilirubin is then formed from the haemo portion of the haemoglobin. The liver also removes bilirubin in blood formed in spleen and red bone marrow and excretes it into bile to be eliminated in faeces.

Figure below shows an experimental set up to relate permeability of visking to small intestines.



Observation

The visking tube has semi – permeable membrane. After some time visking tube will inflate. This happens because water diffuses into visking tube across semi – permeable membrane. Water has small particles than water solution hence moves

into visking tube. The level of water in the beaker will decrease.

Enzymes

Enzymes are biological catalysts. Enzymes are categorized as **intracellular** and **extracellular** enzymes. *Digestive* enzymes are called extracellular enzymes because they work outside the site of their secretion.

Properties of enzymes

i. Protein in nature

All enzymes are proteins in nature since they have long polypeptide chains folded and curled into 3-D shape with its active shape fits the specific substrate[6].

ii. Catalyst

All enzymes are catalyst. A catalyst is a substance that speeds up a chemical reaction without itself becoming part and parcel of the reaction.

iii. Specificity

Enzymes are specific in function because one enzyme will act only on one substrate that is, has one function only.

iv. Affected by temperature

Enzymes are affected by temperature. The temperature at which an enzyme works best is called *optimum temperature*. For example, the optimum temperature for enzymes to work properly in a human being is 37 ± 1^0C. Higher temperature **denatures** enzymes.

v. Affected by P^H

Enzymes are affected by P^H. The P^H at which an enzyme works best is called Optimum P^H.

Enzymes are denatured outside their range.

Factors that affect enzyme activity

1. **Enzyme concentration**
   Supply of enzymes that is, less enzyme – less activity.
2. **Substrate concentration**
   Supply of substrate that is, less substrate – less activity.
3. **Removal of end products**
   A buildup of end product will slow the reaction.
4. **Presence or absence of co-factor or co-enzymes and enzyme inhibitor** such as toxins which are *natural inhibitor*. They are important in controlling enzyme action.
5. **Abiotic condition** whether they are available for example, temperature, P^H and salinity.

Investigations on enzymes

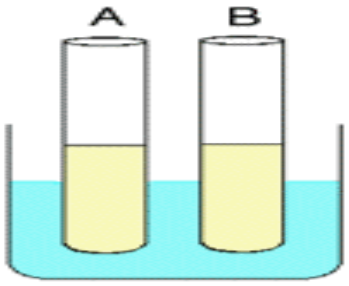
[6] Substrate is a substance on which an enzyme acts on during chemical digestion.

1. The effect of enzymes on food substances
2. The effect of temperature on enzymes
3. The effect of P^H on enzymes
4. Presence of enzymes in food sample e.g
    - Germinating seed
    - Pineapples
5. Presence of enzymes in the liver

Experiments on enzymes

Experiment 1:

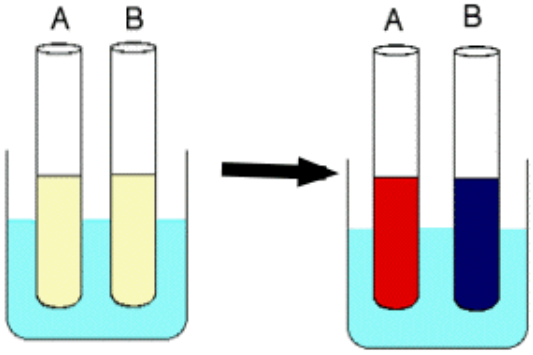
To investigate the property of enzyme



Tube A contains unboiled saliva and starch solution. Tube B contains boiled saliva and starch solution.

The property being investigated in the experiment is **temperature.** Enzymes are affected by temperature.

After 10 minutes the contents were tested for starch, the colour changes would be observed;



(i) Tube A

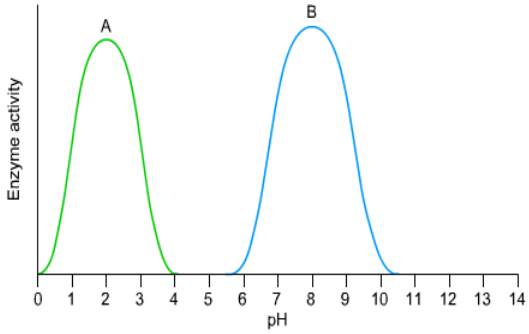
Turns into brown colour since there is unboiled saliva in which salivary amylase is not denatured, hence, breaks starch into glucose.

(ii) Tube B

Turns into blue black since there is boiled saliva. The enzyme in saliva is denatured by boiling it.

Experiment 2:

Optimum P^H for enzymes



Enzyme **A** is most likely to be secreted by the stomach. Enzyme **B** is secreted by pancreas. The activity of enzyme B at P^H 2 fails because it is denatured. This enzyme **B** works best in alkaline P^H only.

This graph tells that enzymes are affected by P^H.

Experiment 3:

Describe an experiment that could be conducted to show that germinating bean seeds contain enzyme that digests starch.

Materials

- 2 test tubes, water, germinating bean seeds, iodine solution and benedict's solution.

Water is used to activate enzyme in germinating seeds in order to convert stored starch into glucose for growth of shoots and radicle.

Procedures

- Soak the germinating bean seeds in water about 2 – 3 days.
- Crush the bean seeds and put them into different test tubes that is tube A and tube B.
- Add few water to both test tubes.
- Test both tubes for starch and reducing sugar using other test tubes.

Results

When testing for starch the extract will stain brown colour but when testing for reducing sugar the extract will turn into brick red, orange colour.

Conclusion

Enzyme in germinating bean seeds break starch into glucose. Thus, one test tube stains brown colour showing absence of starch.

Experiment 4:

Extracting and testing for the presence of enzymes in living cells (tissues)

Procedures

- Crush the liver tissue into small pieces
- Add small amount of water
- Decant
- Collect the extract
- Add Hydrogen Peroxide (H_2O_2)
- Use glowing splint to test for the presence of oxygen.

Results

The enzymes in liver will break the hydrogen peroxide into hydrogen and oxygen molecules. The glowing splint bursts into flames.

Conclusion

The glowing splint relight proves that gas produced is oxygen from hydrogen peroxide has been broken down by enzymes in liver cells.

Abnormal conditions associated with the digestive system

1. Diarrhoea

This is a condition in which an individual passes watery faeces. It is caused by virus or bacteria. When the virus or bacteria attacks the inner lining of the digestive tract, its walls become irritated. This forces the inner walls to secrete more mucus as well as contract and relax more frequently and vigorously.

The more frequent and vigorous contraction forces the food to move fast along the digestive tract so much that the large intestine has no time to absorb the water. The faeces therefore become watery.

Signs and symptoms

- Vomiting
- Fever
- Blood in stools
- Watery faeces

Treatment

- **Oral Rehydration formula** e.g. Thanzi ORS to replace the water and mineral salts in the body.
- **Antibiotics** e.g. Tetracycline and deoxycline to kill the virus and bacteria.

2. Constipation

This is a condition in which the faeces become too hard.

Causes

- Suppressing the reflex defaecation for too long so much so that more water is absorbed from the faeces by the large intestine.
- Eating too much over refined food. This food has little or no dietary fibre which stimulates digestion.

3. Indigestion

This is a condition in which too much hydrochloric acid is produced in the stomach due to eating the food too fast. Some of this hydrochloric acid is belched up into the oesophagus where it causes a burning sensation called **heart burn**.

Treatment

Use antacid such as Drews to neutralize the acidity.

4. Ulcers

This is a condition in which hydrochloric acid (burns) eats up the tissues of the inner walls of the stomach thereby creating painful wounds. These wounds are called Ulcers.

The condition arises as a result of either

- Failure to produce mucus an adequate quantities to cover all parts of the stomach in order to effectively protect them from HCl.
- Producing too much hydrochloric acid so much that mucus fails to withstand its effect.

5. Nausea

This is a general condition in which the alimentary canal is upset so much that an individual loses appetite and feels to eat. It is a psychological problem.

Revision questions

1. State two adaptations of a villus to its functions.
2. Explain why small intestines are long?
3. In which part of alimentary does physical digestion end and why?
4. Describe the process of diffusion in relation to digestion.
5. Digestive enzymes are called extracellular enzymes. Why is it so by justifying your answer with examples?

Topic 7 human circulatory system

Human circulatory system

The function of the circulatory system is to link the exchange surface such as lungs, guts and kidney to the tissues so that both essential and metabolic wastes are transported faster between the two surfaces.

The circulatory system is, therefore, a transport system.

Types of transport system

There are two types, namely;

i. Blood system

ii. Lymphatic system

Blood system

General functions of blood

1. **Transportation**

- Food substances from the guts to the respiring tissues.
- Oxygen from lungs to the respiring cells.
- Hormones from the endocrine glands to the target organs.

2. **Removal;** metabolic wastes such as carbon dioxide and urea are removed from the respiring cells to the excretory organs such as lungs and kidneys respectively.
3. **Protection** body defence against infection.
4. **Regulates** body temperature.

Components of blood system

There are **three** components of blood system namely;

a. Blood vessels

b. Heart

c. Blood

Blood vessels

These are pathways of blood round the body.

Types of blood vessels

There are **three** types of blood vessels namely;

i. Arteries

ii. Veins

iii. Capillaries

Arteries

The function of arteries is *to carry blood from the heart to all parts of the body*.

Facts about arteries

i. Have thick elastic walls to withstand great pressure of blood since it is under the pumping force of the heart.

ii. All arteries carry oxygenated blood except pulmonary artery which carries deoxygenated blood.

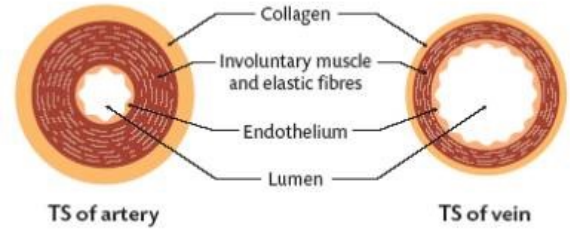
iii. The blood is bright red in colour due to the presence of oxygen.

iv. Blood flows in spurts

v. Have narrow lumens.

vi. The largest artery is **aorta**.

vii. Have no valves at intervals.



Veins

The function of veins is to *carry blood from all parts of the body to the heart.*

Facts about veins

i. Have thin walls with less elastic in them since the blood has low pressure as the pumping force is not felt in veins.

ii. All veins carry deoxygenated blood except pulmonary vein which carries oxygenated blood.

iii. The blood is dark red in colour due to the presence of carbon dioxide.

iv. Blood flows smoothly.

v. The largest vein is called **vena cava**.

vi. Have wider lumens.

vii. Have valves at intervals that stop blood from going back since the flows on its own in veins.

Capillaries

They form bridge between arteries and veins.

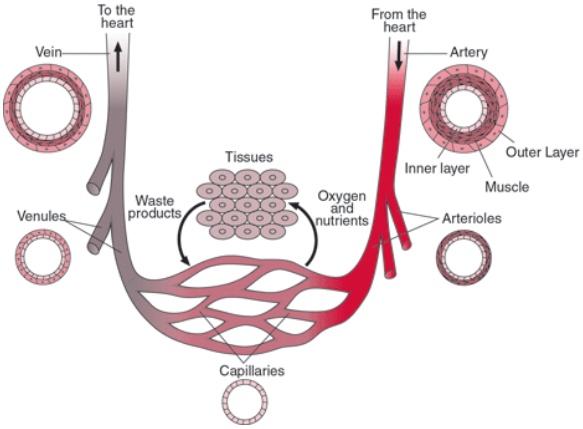
Characteristics of capillaries

i. Have narrowest lumens

ii. Are the smallest

iii. Are the shortest

iv. Have extremely thin walls – only one cell thick.



Above characteristics of capillaries enable them have large surface area on which more substances are exchanged between them and the tissues. Being one cell thick makes diffusion of the substances to be faster.

Heart

Heart is made up of a special type of muscle called the **Cardiac muscle** which never tires throughout one's life.

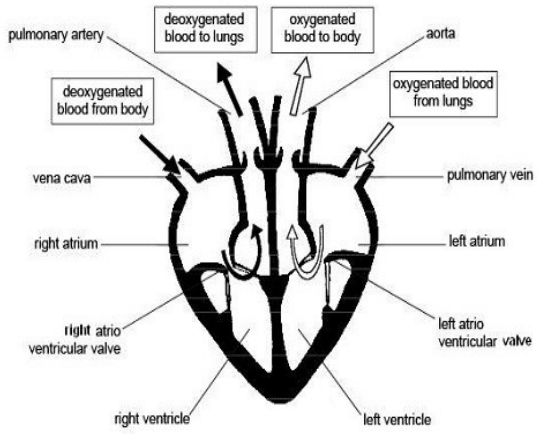
The heart has its own system of blood supply called the **Coronary (system) arteries.** They bring food and oxygen for the heart.

Function of the heart

The primary function of the heart is to pump the blood through arteries, capillaries and veins. The heart is therefore a pump that keeps blood circulating properly.

Location of the heart

The heart is located in the thoracic cavity between the lungs. It is enclosed in the pericardial membranes. However, outside the heart are fluid – filled cavities called pericardial cavities that are filled with pericardial fluid which cushions the heart thereby minimizing friction between the heart and thoracic (chest) cavity.



Structure of the heart

1. Chambers

There are two upper chambers called **Atria** (**Auricles**). There are also two lower chambers called **Ventricles**.

2. Septum

One atrium and one ventricle on the right hand side of the heart are separated from one atrium and one ventricle on the left hand side of the heart by a muscle called **Septum.**

3. Atria

The function of atria is to receive blood. The atria are less than ventricles, that is, ventricles are thicker than atria.

The other function of atria is the production of a hormone involved in blood pressure maintenance.

4. Left ventricle

Pumps blood a longer distance to all parts of the body. For this reason, left ventricle is thicker than right ventricle in order to be able to force the blood through a longer distance.

5. Right ventricle

Pumps blood a shorter distance to the lungs. It has less thick walls.

Note

The left hand side of the heart carries oxygenated blood while the right hand side carries deoxygenated blood.

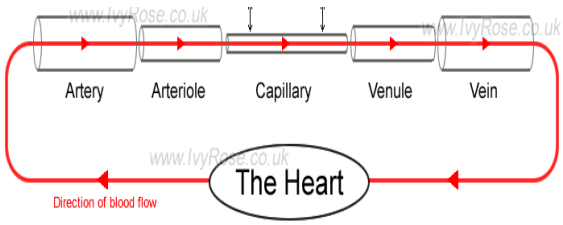
6. Valves

The valves found in the heart are;

a. Tricuspid valve – found between the right atrium and right ventricle.

b. Bicuspid (mitral) valve – found between the left atrium and left ventricle.

c. Semi – lunar valves are found in pulmonary vessels between right and left hand side of the heart. They are also called aortic valves.



How the heart works

Ventricles contract that is, shorten. This is called a **systole**. The systole creates high pressure called systolic pressure. It is this systolic pressure that forces (pumps) blood out of the heart to all parts of the body.

The next thing that happens is that the ventricles relax. This is called **diastole**. Diastole exerts a low pressure called diastolic pressure. It is diastolic pressure

that sucks blood from atria into the ventricles.

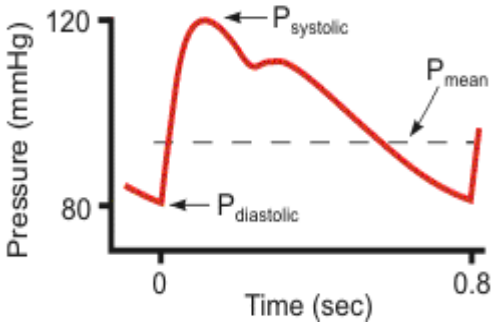
During the diastole, blood may also be sucked from the aorta and pulmonary artery just outside the heart and back to ventricles. This is however prevented by the presence of the **semi – lunar valves** inside the heart within both aorta and pulmonary artery. The semi – lunar valves stop the blood from going back into the heart due to the diastolic pressure.

Blood pressure

One's blood pressure is determined by the ratio of the systolic pressure to diastolic pressure, that is,

$$\text{Blood pressure} = \frac{systolic pressure}{diastolic pressure}$$

Blood pressure is the force per unit area exerted by the blood against the inner walls of blood vessels due to the action of the heart. Blood pressure is measured in millimeters of mercury.



Factors that affect blood pressure

i. **Heart rate** – increased rate increases the blood pressure.

ii. **Blood volume** – increased volume increases blood pressure.

iii. **Peripheral resistance** – decreases vessels diameter increases resistance.

Blood circulation in the human heart

Blood flows from the head, arms and the rest of the body into the right atrium through the anterior and posterior vena cava. The blood is deoxygenated since it is dark red in colour.

The tricuspid valve opens when the right atrium is filled with blood and allowing the blood into the right ventricle. This happens because of down wards force of the tricuspid valve. The right ventricle contracts and pushes the blood through pulmonary artery. The blood is oxygenated in the lungs. The contraction of right ventricle pushes the tricuspid valve upwards thereby preventing blood from going back. The tendon controls the flow of blood.

The semi – lunar valves in the pulmonary artery prevents the blood from slipping back. Then the oxygenated blood from the lungs enters the left atrium through pulmonary vein. The blood pressure forces the bicuspid valve to open and allowing blood into left ventricle. The left ventricle contracts and pushes the blood into the aorta. The contraction of left ventricle creates blood pressure that pushes the bicuspid valve upwards that is to prevent blood from going back. The tendon again controls the flow of blood. Semi – lunar valves in this case preventing the slipping back of blood in the aorta.

Heart beat (pulse rate)

This is the number of beats of heart per minute. Heart beat occurs due to contraction and relaxation of ventricles. A healthy adult has a resting heart rate of 60 to 80 beats per minute.

Measuring pulse rate

Pulse rate = systolic pressure – diastolic pressure

Effects of physical exercise on the pulse rate (heart beat)

i. Increases the rate of heart beat

ii. Increases the speed at which blood flows

iii. Increases the breathing rate thereby;

- Increasing the amount of inhaled oxygen
- Increasing the amounts of exhaled carbon dioxide.

Blood

This is a liquid tissue consisting of several types of cells. Blood is a fluid connective tissue that is pumped by the heart throughout the vessels of circulatory system.

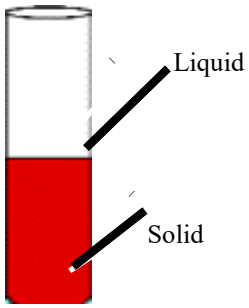
Characteristics of blood

Blood has the following distinctive physical characteristics;

1. **Amount**
   A person has 4 to 6 litres of blood depending on his or her size.
2. **Colour**
   The blood is red in colour, however, the colour varies. Arterial blood is bright red because it contains high levels of oxygen. Venous blood is dark red (dull red).
3. **PH**
   The normal P^H range of blood is 7.35 to 7.45, which is slightly alkaline. Venous blood normally has a lower P^H than arterial blood because of more carbon dioxide.
4. **Viscosity**
   This means thickness or resistance to flow. Blood is about three to five times thicker than water. Viscosity is increased by the presence of blood cells and plasma protein and this contributes to normal blood pressure.

Composition of blood

Blood sample left in a test tube to settle appears as below;



However, the actual components are;

i. Plasma

ii. Cells

iii. Platelets

Plasma forms the liquid part of blood while cells and platelets form the solid part of blood.

Plasma

This is a liquid part of blood. Plasma is an aqueous solution of dissolved food substances (glucose, amino acids, vitamins and excess mineral salts), carbon dioxide, hormones and antibodies.

Functions of plasma

i. Transport *food substances* to the respiring tissues.

ii. Transport *hormones* from the endocrine gland to the target organs.

iii. Transport *antibodies* round the body.

iv. Removes *waste metabolic products* such as carbon dioxide and urea

from the tissues to the excretory organs.

Experiment

Describe an experiment that could be carried out to show that blood contains glucose content. Your answer should include procedures, expected results and conclusion.

You will need: blood sample, 2 test tubes, water, benedicts solution, sodium citrate and heater.

Procedures

- Collect the blood sample and pour them into test tube.
- Add 2 cm^3 of sodium citrate to prevent agglutination of blood.
- Allow the blood to settle for some minutes.
- Pour the liquid part of blood into another test tube.
- Add 2 ml of benedict's solution to that test tube containing liquid part.
- Heat gently and then cool the test tube with cold water.
- Observe the colour change on the blood sample.

Expected results

We expect that the blood sample will turn brick red or yellow colour in the presence of glucose.

Conclusion

The blood sample that was poured in the test tube that is, the liquid part is plasma that contains dissolved food substances including glucose.

Blood cells

There are two types of blood cells;

a. Red blood cells

b. White blood cells

Red blood cells (erythrocytes)

Are produced in red bone marrows of short bones. A bone marrow is a fatty tissue found in the hollows of short bones.

Red blood cells are numerous than white blood cells. They have also short lifespan. As such, they are produced at a faster rate than white blood cells.

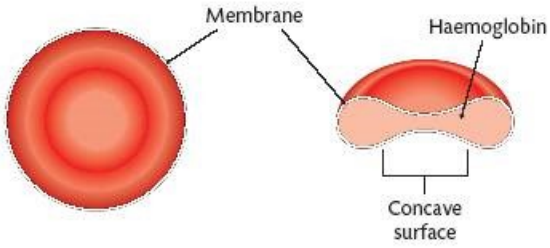
Red blood cells are red because they contain a red pigment called **haemoglobin**. Haemoglobin is made up of iron and protein molecule. '*Haemo'* means iron while '*globin'* means protein.

Old and dead red blood cells are broken in the short bones to release the iron that was part of the haemoglobin while the rest of the remaining iron is excreted through bile formation and then faeces.

Structure of the red blood cells

i. Are disc – shaped that is, **biconcave** in shape.

ii. Have no nuclei



Functions of red blood cells

i. Transport oxygen from the lungs to the respiring tissues.

ii. Transport antigens. Antigens are proteins that are found on the surface of red blood cells.

Adaptations of red blood cells for the transportation of oxygen

Presence of haemoglobin which has high affinity for oxygen, that is, attracts oxygen.

Biconcave shape which increase the surface area on which more oxygen is transported.

Absence of nuclei and this increases the surface area for carrying more oxygen.

Role of haemoglobin in oxygen transportation

Haemoglobin has an affinity for oxygen and readily combines with it in conditions of high oxygen concentration. Such that, oxygen diffuses into the blood from alveoli of the lungs to be attracted and transported by haemoglobin on the red blood cells. It forms an unstable compound called **oxy – haemoglobin** which, however, in conditions of low oxygen concentration readily breaks down and releases the oxygen. This property makes it most efficient in transporting oxygen from lungs to the tissues.

Haemoglobin +oxygen ➔ oxyhaemoglobin

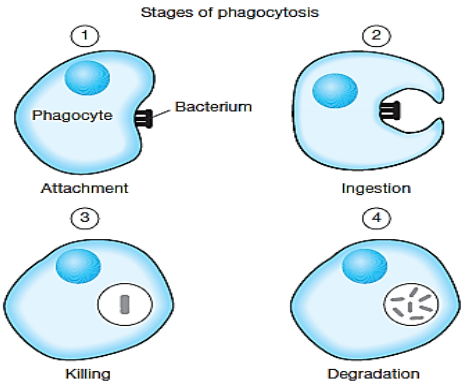
Haemoglobin is a protein with iron found in red blood cells.

White blood cells (leukocytes)

Have irregular shape, that is, can change their shapes depending on the environment. Have nuclei and they work outside the blood stream in the infected tissues.

They provide body defence against infection. Irritated by a chemical substance produced by the infected tissues, the white blood cell squeezes itself through the tiny pole of the blood capillary and out into the tissues. The process by which a white blood cell squeezes itself out of the blood capillary is called **diapedesis**.

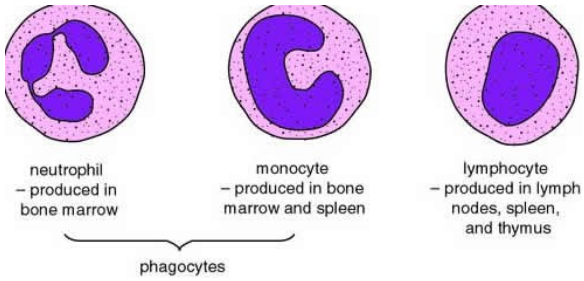
Once outside the blood capillary, the white blood cell moves between cells by using flow of its cytoplasm. This is called **phagocytosis**.



Types of white blood cells

There are two main types of white blood cells namely;

a. Phagocytes
b. Lymphocytes



Phagocytes

They provide body defence by engulfing and digesting the germs (pathogens).

There are two types of phagocytes;

i. Neutrophils
ii. Monocytes

Neutrophils

These are most abundant white blood cells. They arrive at the site (scene) of infection first. They engulf and digest the germs.

Monocytes

Arrive at the site of infection later after the fighting between neutrophils and pathogens. They engulf and digest dead germs, dead neutrophils and dead cells. They also engulf and digest any living

pathogen that might have remained after the fighting. Thus monocytes, act as ‘‘**Mop up crew**.’’

Some monocytes reside permanently in connective tissues to act as ‘’ **watchful soldiers**,’’ such monocytes are called **macrophages**. Phagocytes are produced in Bone marrow.

Lymphocytes

Are produced in the lymphoid organs such as the lymph nodes and the spleen.

There are two types of lymphocytes namely;

i. B – Lymphocytes
ii. T – Lymphocytes

B – Lymphocytes (b - cells)

Produce antibody mediated immunity. B lymphocytes become sensitive to an antigen.

Types of b – cells

i. Plasma cells
Transform plasma enzymes into **antibodies** that provide body defence against infection.

ii. Memory B – cells
They keep the memory of both the pathogens and antibodies used to kill them so that next time they come again they should easily and timely be controlled.

Types of antibodies

a. Antitoxins
Neutralize poisonous made by pathogens in the body.

b. Lysins
Dissolve the germs on contact.

c. Agglutinins
Clump (stick) the germs together so that they fail to live properly.

d. Opsonis
Weaken the germs so that they are easily engulfed and digested by the phagocytes.

T – Lymphocytes (t - cells)

Produce cell – mediated immunity. Upon interacting with a specific antigen they become sensitive.

Types of t – cells

i. Memory T – Cells
Remain inactive until future exposure to same antigen.

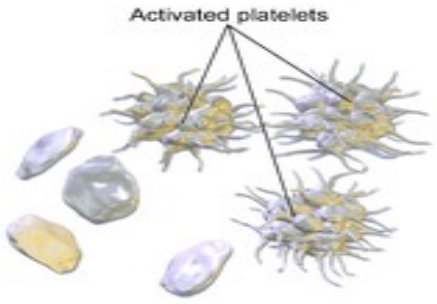
ii. Killer T – cells (Cytotoxic T – cells)
They attack bacteria and tumor (cancer) cells by killing all infected body tissues.

iii. Helper T – Cells (CD4 T – Cells)
They control the proper functioning of all the immune systems including the phagocytes, B – cells and killer T – Cells.

CD4 simply means Cluster Determinate 4.

Platelets (thrombocytes)

These are tiny fragments of cells produced by a large cell called the **megakaryocyte** found in red bone marrow.



Function of platelets

Platelets help in formation of a blood clot. A clot is important in the following ways;

i. Stops bleeding

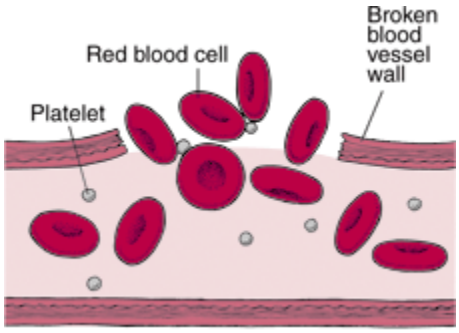
ii. Prevents entry of germs in the body

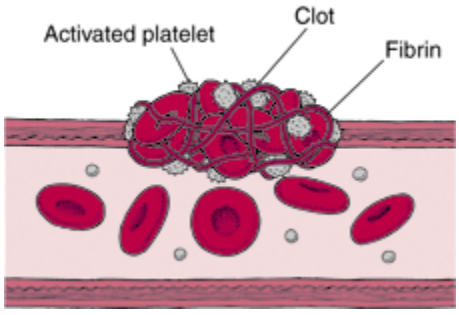
Formation of clot

Damaged tissues and platelets with the help of calcium ions and vitamin K produce a chemical substance called **Thromboplastin.** Thromboplastin is also called **thrombokinase,** which converts a plasma enzyme called **prothrombin** from its inactive form to an active form called **thrombin.** Prothrombin is produced by the liver.

Thrombin in turn converts soluble blood protein called **Fibrinogen** into an insoluble form called **fibrin**. This fibrin forms a network of fibres over the cut or wound. It is this network of fibres which is called the **clot**.

Blood is prevented from clotting as it circulates within the body by an **anti-coagulant**.





Serum

This is a blood without fibrinogens.

Abnormal conditions associated with the circulatory system

1. High blood pressure (HBP)

This is also called hypertension. Some people have high blood pressure all the time. This puts an extra strain on the heart and may lead to heart failure.

High blood pressure pushes the walls of the arteries and may burst them. This leads to stroke when such bursting occurs in the arteries of brain cells hence the spillage of blood kills cells in part of brain.

Factors associated with high blood pressure

- Over – eating.
- Drinking too much alcohol
- Stress and tensions of modern life.
- Smoking.

2. Heart attack

This is the problem in which the heart cannot contract so that it stops beating. This is also called **cardiac arrest**.

Causes

- When a coronary artery is blocked, the part of the heart to which the coronary artery serves is deprived of oxygen and nutrients.
- A clot in the coronary artery.
- A fatty substance called **Cholesterol** being laid down in the walls of the coronary artery also cause coronary artery blockage.

Factors that increase the chances of heart attack

- Eating a lot of saturated fats found in animal foods.
- Inhalation of carbon monoxide through smoking.
- Obesity

These encourage the deposition of cholesterol in the walls of the arteries.

3. Oedema

This is caused due to blockage of lymph vessels which results from an infection of tiny nematode worms called filarial worms.

Oedema is swelling up of lymph because tissue fluid is formed at the rate higher than the lymph vessel drain it away.

4. Fainting

The brain relies on oxygen in the blood to function properly. Fainting can occur when blood flows to the brain is reduced.

It is caused by temporary problem with part of nervous system that regulates blood pressure.

Preventive measures

- Avoid overcrowding conditions
- Lying down to increase blood flow to the brain
- Avoid dehydration by increasing fluid intake
- Avoid over eating and decrease salt intake

Ways of preventing problems associated with the circulatory system

i. Keeping the body fit through physical exercises.

ii. Healthy living e.g. avoids smoking and excessive alcohol.

iii. Keeping the body weight at reasonable levels. Reasonable body weight is between 45 – 84 kgs.

Lymphatic system

This is responsible for returning tissue fluid to the blood and protecting the body against foreign material. It also contributes to homeostasis.

Parts of lymphatic system

a. Lymph

b. Lymph vessels

c. Lymphatic tissues – such as lymph nodes and nodules as well as thymus gland.

Lymph vessels

The system of lymph vessels begins as dead – end lymph capillaries found in most tissue spaces. They return fluids to the blood system that would otherwise collect in the tissues.

Lacteals are specialized lymph capillaries in the villi of the small intestines.

There are two large lymphatic vessels;

1. The right lymph duct

   Empties lymph into the right subclavian vein in the neck.

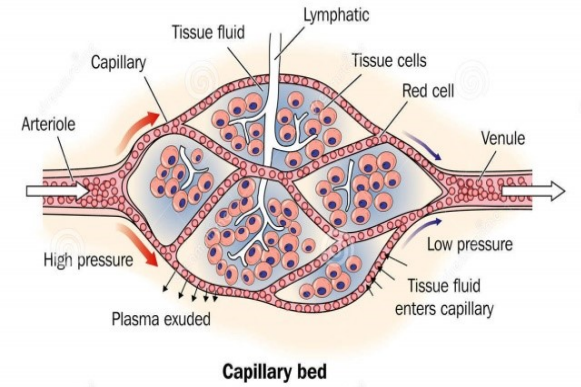
2. The thoracic duct

   Empties into the left subclavian vein in the neck.

The two subclavian veins empty into the vena cava.

Capillary bed

On one side of an artery branches into smaller arteries called **arterioles** that branch further into capillaries. On other side, the capillaries join together to form larger blood vessel called **venules** that further join to form another larger vessel called vein. Such arrangement is called capillary bed.



Capillary bed

Reasons for high blood pressure in arterial side

i. Pumping force of the heart rises the blood pressure on the arterial side

ii. Blood flows from wider lumen into narrower lumen hence its pressure rises.

Reasons for low blood pressure in venous side

i. The pumping force of heart is not felt in veins.

ii. Blood flows from narrower lumen into wider lumens.

Formation of tissue fluid

Blood capillaries leak. They are porous so that small molecules pass across them. On the arterial side of the capillary bed there is high blood pressure. This high pressure forces some blood to seep out (leak) into the tissues, bathing the tissues. This blood becomes **Tissue Fluid**. The formation of tissue fluid occurs through filtration.

On the venous side of the capillary bed some tissue fluid goes back into the blood capillaries.

This happens because of the following factors;

i. There is low pressure of blood on the venous side of capillary bed.

ii. Most tissue fluid is water hence the water moves by **osmosis** from the tissues across semi – permeable walls into the blood capillaries.

Composition of tissue fluid

The composition tissue fluid is as follows; glucose, amino acids, water, oxygen, hormones, white blood cells and antibodies. All these substances are made up of small molecules that can pass across the wall of a blood capillary.

On the other hand, large blood molecules such as red blood cells and fibrinogen remain in the blood capillaries.

Functions of tissue fluid

i. **Provides**
   - Food to the tissues.
   - Oxygen to the tissues.

ii. **Removes** metabolic wastes such as carbon dioxide and urea from the tissues into the blood capillaries.

iii. **Cleanses** *dirt* and *cellular debris*, bacteria and other particulate matter from the cells into the lymph vessels.

For this reason, the lymphatic system is also known as the **Drainage system** of the body.

iv. **Transport** antibodies.

Lymph

Lymph is the tissue fluid that is drained into the lymphatic capillaries.

Lymph is found in **Pleural** membrane and **pericardial** cavities.

Lymph flow

There is no pump to make lymph flow. Lymph flows because of the following factors;

a. Gravity

Pulls lymph from upper parts of the body.

b. Contraction of skeletal muscles

Squeezes onto the lymph vessels, forcing the lymph to flow on.

c. Valves

Presence of valves along the lymph vessels enable lymph to accumulate enough force to let it moves on.

Lymph (nodes) glands

Each lymph node has tiny spaces in which the lymph is filtered before it goes to the bloodstream. The lymphatic tissue consists mainly of lymphocytes that produce antibodies. These antibodies therefore provide immunological defence.

Lymphoid organs

1. **Tonsils**

   These are pharyngeal, palatine and lingual tonsils. They function to fight infection of the nose, ear and throat regions.

2. **Spleen**

   Located in the upper left part of the abdominal cavity. It is not vital organ in the adult but assists other organs in producing lymphocytes.

   Collects damaged and old red blood cells, breaking them down and releasing the haemoglobin in them.

3. **Thymus**

   Found in the anterior thorax. This is the most important gland in children and wastes away as an individual grows through **atrophy**.

Importance of the lymphatic system

i. Provides oxygen to the organs it encloses e.g lungs.

ii. Provides food substances to the organs it encloses.

iii. Acts as a lubricant, preventing friction between surfaces.

iv. Provides immunological defence by producing lymphocytes that produce antibodies.

Topic 8 human reproductive system

Reproduction

Reproduction is one of the most important characteristics in living organisms for example in multicellular organisms. The word reproduction refers to breed another organism. In many multicellular organisms reproduction involves sex[7] – something that is pleasant in feelings.

Reproduction is the formation of new organism from already existing ones.

All living things eventually die, but before dying, some organisms produce new organisms of their own kind.

Importance of reproduction

- Maintains existence of species of organisms on earth.
- Leads to the arising of new species of organism.

The human reproductive system

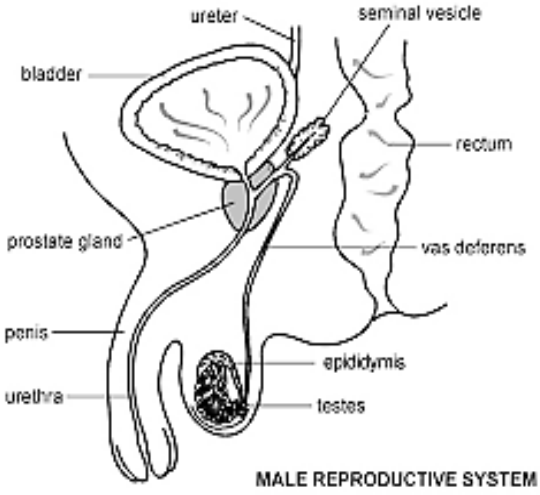
The parts of organs that form reproductive system are called **genitalia**.

[7] You can suggest that sex is engaged for several reasons; some being for fertilization and pleasure.

Male Reproductive organs

The external sex organs of male are the **penis** and the **scrotum**. The scrotum is a pouch that hangs below the penis and contains the two testes which produce sperm – the male sex cell responsible for fertilization. The position in which scrotum lies protect the testes from injury and keeps testes about 3 – 4 ℃ lower than body temperature. Thus, the temperature that enables sperms to develop properly inside the testes.

Parts of male reproductive organs



MALE REPRODUCTIVE SYSTEM

Functions of parts of the male reproductive organs

Penis

The penis is a sensitive organ important to reproduction and

urination as well as to sexual pleasure – copulation.

At the tip of penis is the **glans** which contains the urethral opening through which urine passes. The ridge that separates the glans from the body of the penis is called the **corona**.

The glans and the corona are the most sensitive parts of the penis.

Foreskin

It covers the glans (the head of the penis) thereby;

- Protects the penis
- Keeps the glans moist to prevent it from drying up.

Scrotum

Protects the testes and help to regulate temperature. The testes are also primary producers of testosterone (male sex hormone).

The scrotum can pull up close to the body when surrounding temperature is low and drop farther away when the temperature is high in order to keep testes at optimal, constant temperature somewhat lower than body temperature.

Seminiferous tubules

Inside the testes are about 1 000 seminiferous tubules that manufacture and store sperms, thus, the actual site of sperm production. The tissues in this site undergo the process of meiosis to form spermatozoa.

Epididymis

This is a long tube coiled against the testis, where the sperms are stored and mature. After sperms are produced in the seminiferous tubules, they move out of each testis and into the epididymis.

Sperm duct (vas deferens)

Transport the sperms from the epididymis through the prostate, after which the vas deferens becomes the ejaculatory duct. Here, fluids from the prostate and seminal vesicles combine with the sperms to form **semen** – a thick yellowish white fluid.

The average discharge of semen called ejaculation contains approximately 300 million sperms.

Seminal vesicle

Opens into sperm duct and produce a fluid called seminal fluid which;

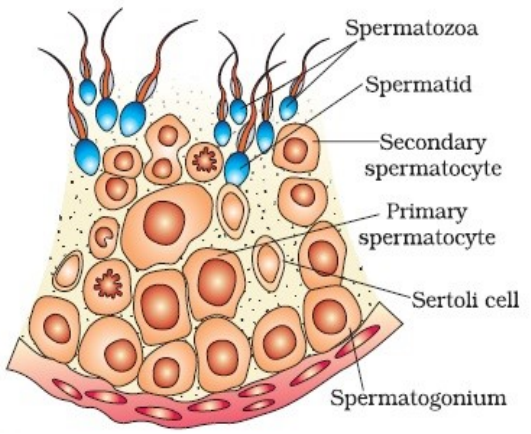
- Dilutes the sperms
- Acts as medium in which sperm swim
- Nourishes the sperms.

Prostate gland

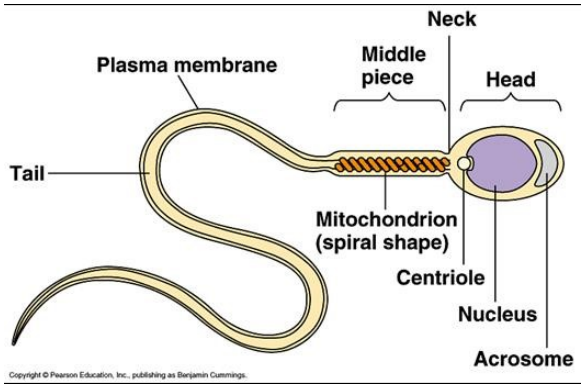
Also opens into urethra and produces an alkaline fluid which neutralizes urine.

Sperm production

The lining of the sperm producing tubules in the testis consists of rapidly dividing cells. After a series of division, that is, meiosis, the cells grow long tails and become sperms which pass into epididymis.



During copulation, the epididymis and vas deferens contract and force the sperms out through urethra.



Adaptations of sperm for movement

- **Presence of tail** used for swimming by flapping it.
- **Presence of a lot of mitochondria** in the middle piece where a lot of energy is produced during respiration and is used for movement.
- **Streamlined shape** that reduces the drag so that the sperm easily swim in the semen.

Note;
The middle piece is referred to as the power house because it produces a lot of energy during respiration in the mitochondria, which the sperm uses for movement.

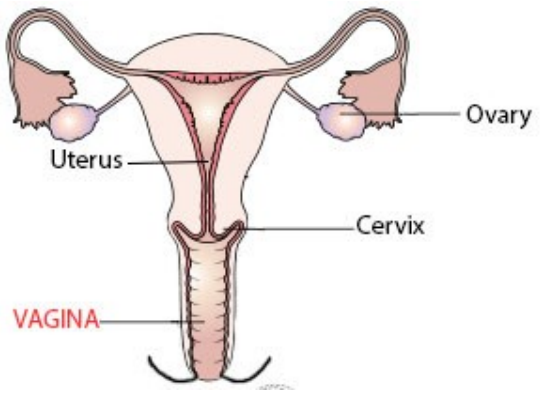
A sperm cell consists of several parts. The **head** contains the 23 chromosomes. On the tip of the head is the **acrosome** which is similar to a lysosome and contains enzymes to digest the membrane of an egg cell. Within the middle piece are mitochondria that produce ATP. The **tail** provides movement, the capability of the sperm cell to move.

Female reproductive organs

Sexual organs of a female include the external genitalia (vulva) and internal organs that make it possible for a woman to produce ova (eggs) and become pregnant. The vulva includes the mons pubis, the most visible part of the female external genitalia, which is layer of fatty tissue that covers the pubic bone and covered by pubic hair and labia.
The inner labia come together in front to form the clitoral hood, which covers the clitoris – a sensitive organ that is very important to the female sexual response.

The internal sex organs of the female consist of the vagina, uterus, fallopian tubes (or oviducts) and ovaries.

Parts of female reproductive organs



Functions of parts of the female reproductive organs

Ovary

- Site for egg development and maturation.

- Produces hormones such as oestrogen and progesterone.

Oviduct (fallopian tube)

This is a tube that transports ovulated egg from ovary through funnel to the uterus. The funnel receives ovulated egg which is then transported by the oviduct.
Oviduct is the actual site of fertilization.

Adaptations of oviduct for egg transportation into the uterus

i. Presence of cilia that pushes the zygote towards the uterus.
ii. Has thick muscular walls that contract to push the zygote to the uterus.
iii. It is extensively folded

Uterus (womb)

It is a hollow muscular organ in the pelvic cavity of the female, in which the embryo develops before birth, thus providing a site for pregnancy. The zygote is attached (implanted) to the uterine wall, as the microscopic ball of cells.
Implantation is the attachment of fertilized egg to the wall of the uterus.

The cells of the zygote divide to produce **embryo** and beginning of umbilical cord and thin membrane called **amnion**.
Remember that, uterus as a muscular organ has an inner lining called **endometrium** richly supplied with blood vessels and glands.

Cervix

The cervix is located at the bottom of the uterus and includes the opening between the vagina and uterus.

Vagina

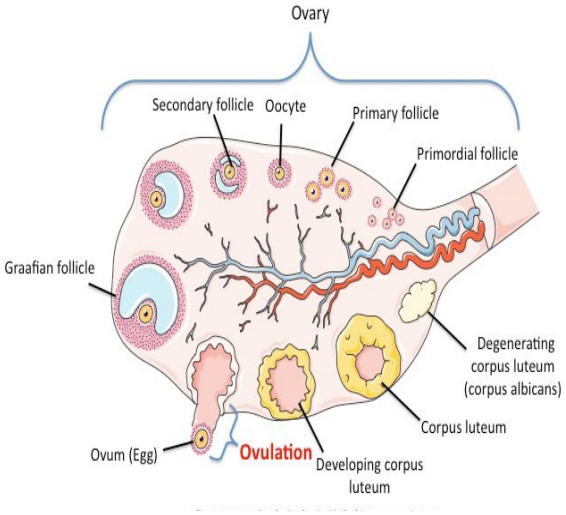
The vagina is a flexible tube shaped organ that is the passageway between the uterus and the opening in the vulva. Because during birth the baby travels from the uterus through the vagina, the vagina is known as the birth canal.

The development of an ovum in the ovary of a woman

Oogenesis is the process of meiosis for egg cell formation. It begins in the ovaries and is also regulated by hormones. Follicle Stimulating Hormones (FSH) initiates the growth of **ovarian follicles (or graafian follicles)**, each of which contains an oogonium, a stem cell for egg cell production. This hormone also stimulates the follicle cells to secrete oestrogen, which promotes the maturation of the ovum. Notice that for each primary oocyte that undergoes meiosis, only one functional egg cell is produced. A mature ovarian follicle actually contains the secondary oocyte; the second meiotic division will take place if and when the egg is fertilized. The production of ova begins at puberty (10 to 14 years of age) and continues until **menopause** (45 to 55 years of age), when the ovaries atrophy and no longer respond to pituitary hormones.

During this 30- to 40- year span, egg production is cyclical, with a mature ovum being produced approximately every 28 days (the menstrual cycle is discussed later in this chapter). Actually, several follicles usually begin to develop during each cycle. The rupture (ovulation) of the first follicle to mature stops the growth of the others.

Ovulation is the release of an ovum by the ovary. The ovum is released with a coating of cells called **zona pellucida** and ovum is received into the funnel of oviduct.



Important

Graafian follicle is a liquid filled sac. The remaining Graafian follicle from which the ovum is released becomes yellow solid called **corpus luteum** that produces hormone progesterone.

Fertilization and conception

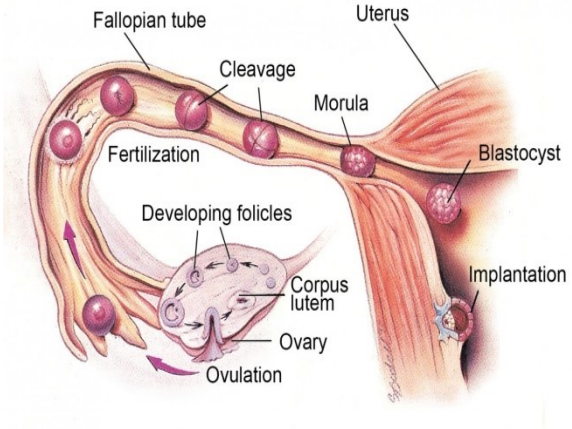
Although millions of sperm are deposited in the vagina during sexual intercourse, only one sperm will fertilize an ovum. As the sperm swim through the fluid of the uterus and fallopian tube they undergo a final metabolic change called **capacitation**. This change involves the **acrosome** which becomes more fragile. When sperm and egg make contact, the acrosomal enzymes will digest the layers of cells and membrane around an ovum.

Once a sperm nucleus enters the ovum, changes in the egg cell membrane block the entry of other sperm. The nucleus of the ovum completes the second meiotic division and the nuclei of ovum and sperm fuse restoring the diploid number of chromosomes in the zygote. The human diploid number of 46 chromosomes is actually 23 pairs of chromosomes; 23 from the sperm and 23 from the egg. By the time the ball of cells reaches the uterus it forms **embryo** and finally becomes firmly implanted in the uterus wall where it undergoes mitotic division.

Note

Fertilization in human beings occurs during sexual intercourse as a man is sexually excited; the penis stiffens and lengthens as the blood fills the spongy tissue of the shaft. In woman, the labia are filled with blood and swell a little. The swollen labia helps guide the erect penis into the vagina. The muscle of the vaginal wall relaxes helping entry. Fluid produced by the vaginal wall lubricates the movement of penis which results into continuous movement from which ejaculation occurs. During ejaculation, the man experiences pleasant feeling called **orgasm**.

The woman's orgasm is usually caused by gentle pressure stimulating the clitoris.



However, when the ovum is not fertilized within three days after ovulation, it dies upon reaching the uterus. Hence, fertilization does not take place in the

uterus because the ovum is dead by the time it reaches the uterus. This is followed by menstruation.

The role of hormones in the menstrual cycle

The **menstrual cycle** includes the activity of the hormones of the ovaries and anterior pituitary gland and the resultant changes in the ovaries and uterus. The four hormones involved: **Follicle Stimulating Hormone (FSH)** and **Luteinizing Hormone (LH)** from the anterior pituitary gland**, oestrogen** from the ovarian follicle, and **progesterone** from the corpus luteum. The fluctuations of these hormones are shown as they would occur in an average 28-day cycle.

*A cycle may be described in terms of three phases: menstrual phase, follicular phase and luteal phase.

Menstrual phase

The loss of the functional layer of the endometrium is called **menstruation**. Although this is actually the end of a menstrual cycle, the onset of menstruation is easily pinpointed and is, therefore, a useful starting point. Menstruation may last 2 to 8 days, with an average of 3 to 6 days. At this time, secretion of Follicle Stimulating Hormone (FSH) is increasing, and several ovarian follicles begin to develop.

Follicular phase

Follicle Stimulating Hormone (FSH) stimulates growth of ovarian follicles and secretion of oestrogen by the follicle cells. The secretion of Luteinizing Hormone (LH) is also increasing, but more slowly that helps in ovulation.

FSH and oestrogen promote the growth and maturation of the ovum.

Oestrogen stimulates the growth of blood vessels in the endometrium to regenerate the functional layer and develop the rapid growth of cells lining the uterus. This phase ends with ovulation, when a sharp increase in LH causes rupture of a mature ovarian follicle.

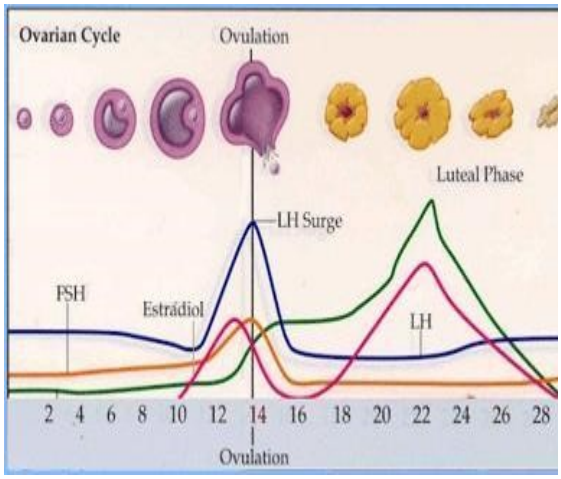
Luteal phase

Under the influence of Luteinizing Hormone (LH), the ruptured follicle becomes the **corpus luteum** and begins to secrete **progesterone** as well as **oestrogen**.

Progesterone stimulates further growth of blood vessels in the functional layer of the endometrium and promotes the storage of nutrients such as glycogen.

As progesterone secretion increases, LH secretion decreases, and if the ovum is not fertilized, the secretion of progesterone also begins to decrease.

Without progesterone, the endometrium cannot be maintained and begins to slough off in menstruation. FSH secretion begins to increase (as oestrogen and progesterone decrease), and the cycle begins again.



Note
Menstruation is simply followed by the release of blood and tissues through the vagina and is meant by a period. Blood released during period can be absorbed by the sanitary towel which the woman wears as lining to her underwear.

Ovulation occurs on day 14 but it may occur either day 13 or 15 from counting day 1 of menstruation. Ovulated egg has lifespan of 3 days. Between ages of 40 and 55 the ovaries lose the ability to release ova. Thus, the woman starts losing fertility. The loss of fertility in a woman is called **menopause**.

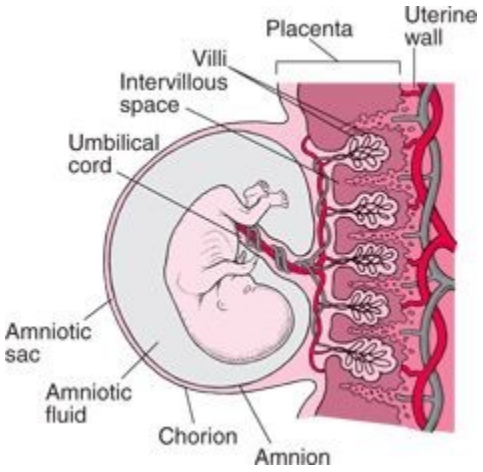
Embryonic development

This refers to the period of pregnancy which is also called **gestation period**. Pregnancy is therefore the time taken for the embryo to develop into foetus from conception then into a baby.
This period begins soon after implantation and ends during the birth of an organism. It usually takes 9 months (38 weeks) in humans.

During the entire time of pregnancy, the part of the ovary which produced the egg continues to control the development of the uterus and produces a progesterone hormone which causes the uterus to grow more muscle and increase in thickness, while **sinuses** – (blood filled spaces) develop to surround the villi of the baby. Progesterone hormone also inhibits any further development of other eggs.

Development of embryo maintains pregnancy as it develops several structures. The embryo grows and produces new cells by mitosis, to form tissues and organs.
The first organ to be formed is heart that pumps embryo's blood through the tiny body out by **umbilical cord** to the villi and back again. The villi increase to form the tissue called **placenta**. Embryo develops into **foetus** when all organs are formed after six weeks.

Notice that, foetus' **kidneys** and **lungs** will not function until it is born. At 7 months and 2 weeks, the couples should stop having intercourse, since there is danger of causing an infection in the uterus and that would harm the baby.
The mother gets tired from the mass of the baby. Although the pelvis bone gives support and protection to the foetus, abdominal muscles are attached to the lumbar vertebrae and mother may have backache. Her legs may swell, especially if she has reduced her activity.



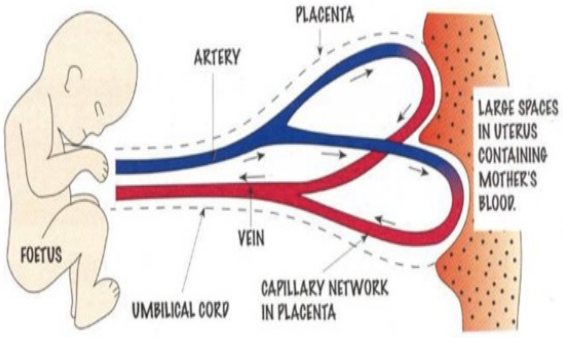
Umbilical cord

i. **Blood vessels**, carries a vein and artery from the embryo to the placenta.
   - Blood in the artery has lower concentration of oxygen, amino acids and glucose, and has high concentration of carbon dioxide and urea. It is dark red in colour.
   - Blood in veins has lower concentration of carbon dioxide and urea, and has high concentration of oxygen, amino acids and glucose. It is bright in colour.

ii. **Diffusion** – forms the passage of materials from the mother's blood to the embryo's blood and vice versa. Glucose, amino acids, vitamins, minerals, water and oxygen diffuse from mother's blood into the embryo's blood.
The waste products such as carbon dioxide and urea of the embryo diffuse from the placenta to the mother's blood.

Placenta

This is the vascular structure in the uterus of the pregnant woman to supply nutrients and oxygen to the foetus through the umbilical cord.
Placenta is responsible for respiration and excretion in the growing foetus. It is expelled after birth.



Functions of placenta

Forms a barrier

Placenta separates the embryo's blood and mother's blood system. The barrier is important in the following ways;
- Prevents mother's high blood pressure from damaging the embryo's delicate blood vessels.
- Reduces the entry of harmful substances into the embryo from mother.
- Prevents agglutination as when the blood groups of the mother and embryo are incompatible.

Diffusion

The process of diffusion exchanges the materials such as glucose, amino acids, oxygen, vitamins and mineral salts to diffuse from mother to embryo. Waste products such as urea and carbon dioxide diffuse from embryo to mother's blood for excretion.

Production of hormone

The placenta produces the hormone progesterone which prevents menstruation and any further ovulation. The hormone also stimulates further thickening of the uterus lining.

Adaptations of placenta to the function of diffusion

i. **Close contact with a dense network of blood capillaries**. This enables good supply of blood to carry away and bring in materials for exchange by diffusion.

ii. **Finger like projection** called villi that increase the surface area of a place for diffusion to occur.

iii. **Highly folded** to increase surface area of the placenta on which a lot of diffusion occurs.

iv. **Thin membrane** for the materials to diffuse faster and easier.

v. **Attachment** to the uterus lining to supply nutrients and oxygen to the foetus through the umbilical cord.

Amnion

This is the thin inner membranous sac that encloses the developing embryo. It has a dense concentration of blood vessels and aids in the formation of the placenta in women.

Amnion is filled with a serous fluid called **amniotic fluid** in which the embryo is suspended inside the amnion.

Functions of amniotic fluid

1. Acts shock absorber

   It cushions the embryo thereby protecting the embryo from external physical forces that may damage the embryo.

2. Insulation

   The amniotic fluid is an insulator that prevents any exchange of energy between the embryo and the mother. This keeps a constant temperature of the surrounding embryo.

3. Assists during birth

   It makes the birth canal slippery so that the baby passes through it easily.

Requirements of pregnant woman

- During pregnancy the woman should eat balanced and enough diet since foetus needs proteins, vitamins and mineral salts such as iron, calcium and phosphorus to grow well. Protein is used for production of tissues, calcium and vitamin D for bone development and iron for formation of haemoglobin in foetus' blood.
- Pregnant woman should visit an antenatal[8] clinic where she is examined by the doctor and if goes for treatment of any sickness, she should tell the doctor that she is pregnant in order not to be given any medicine that will harm the foetus.
- The woman should avoid drinking alcohol or smoking. The harmful chemicals in alcohol or cigarette may diffuse from mother's blood into the embryo's blood through placenta and this can lead to **miscarriage** and sometimes may damage the developing brain of the foetus.
- She should also avoid contracting sexually transmitted diseases. Germs may also diffuse from mother's blood into the embryo's blood through placenta and attacks the embryo before and after birth.

The process of birth

[8] Pre- birth or prenatal.

The month before birth the uterus walls of the mother develop muscle fibres that will be used to expel the baby from the mother's body. A few weeks before birth, the baby turns within the uterus until the head points towards the cervix.

The nature of the initial force of birth is almost certainly controlled by the changes in the amounts of hormones, which are produced by the mother in pituitary gland. Giving birth takes 12 to 18 hours, but the first born may take longer. The hormone called **oxytocin** brings about muscular contraction of the uterus and this occurs in stages.

Stages during birth

Stage 1

- The muscle of the uterine wall begins to contract. The muscular contraction becomes more frequent and powerful. This is called **labour**.
- The cervix dilates to about 10 cm.
- The amniotic fluids flow out. This lubricates the vagina.

Stage 2

- More vigorous contractions of the uterine wall pushes the baby and comes out with the head first. This contraction is helped by the mother's abdominal muscles, slowly push the baby out. The remainder of the body passes easily.
- The umbilical cord is tied close to the baby and cut with a sterile knife or scissors.

Stage 3

- The placenta is still attached to the uterus. Further contractions of the uterus separate the placenta.
- Placenta is expelled through the vagina with the remainder of the umbilical cord. This is called **afterbirth**.

The umbilical cord is damped near to where it joins the baby and is cut; the stump that remains forms the baby's navel.

As soon as the baby is born, it cries to make sure it breathes immediately because even a minute delay in breathing causes brain damage. The baby cries as it experiences sudden change in temperature of its surrounding upon birth.

If the fetus is positioned other than head down, delivery may be difficult. This is called a breech birth and may involve a **cesarean section** which is delivery of the fetus through a surgical incision in the abdominal wall and uterus.

Note

Babies born before nine months of pregnancy are described as premature babies. They are often kept in incubators. Incubator is a cabinet with controlled environment that keeps the baby warm and provides extra oxygen to help in breathing. Occasionally, pregnancy may be disturbed at an early stage and embryo is expelled from the uterus either dead or dies immediately afterwards. This is **miscarriage (or sudden abortion)**.

After delivery, the uterus will return to the size it was before pregnancy in about 6 to 10 weeks. After 8 weeks, the father and mother may resume having intercourse. The ovary stops producing special hormone once the baby is born, and menstrual cycle starts again. However, some women do not resume the menstrual cycle while they nursing their baby.

Twins

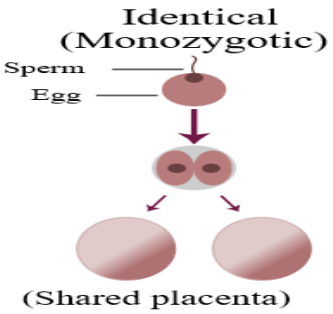
In human pregnancy usually results in the birth of only one baby since one embryo develops in the uterus at a time. However, two embryos may develop at once in the uterus, each with its placenta and umbilical cord. The babies born are called **twins**.

Types of twins

Identical twins

These twins arise as one egg is released from ovary and fertilized by a sperm. The fertilized egg then divides into two cells forming two zygotes. The zygotes develop into two separate embryos.

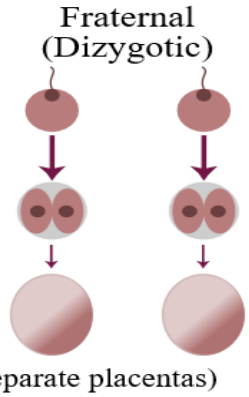
The identical twins have exactly same genes and alike since they are formed from one fertilized ovum. They have same sex either as males or females.



Non – identical twins

These twins are also known as fraternal twins. They arise when two eggs are produced from the ovary and fertilized by different sperms and both develop into embryos.

Non – identical twins are different from one another because they have different genes. However, they may have same or different sex.



Siamese twins

Sometimes in identical twins, the zygotes formed do not completely separate and such embryos are joined at a point. These Siamese twins can be separated through an operation at a hospital after their birth. But in the case on the diagram operation cannot be done.

Milk production

Milk production happens soon after birth and is called **lactation**. **Lactation** is the secretion and ejection of milk from the mammary glands. A principal hormone in promoting milk production and secretion is **prolactin,** which is secreted from the **anterior pituitary gland**.

Even though prolactin levels increase as the pregnancy develops, no milk secretion occurs because **progesterone** inhibits the effects of prolactin. After delivery, the levels of **oestrogen** and **progesterone** in the mother's blood decrease, and the inhibition is removed.

The principal stimulus in maintaining prolactin secretion during lactation is the sucking action of the infant (baby). Suckling initiates nerve impulses from stretch receptors in the nipples to the Hypothalamus and the impulses decrease hypothalamic release of prolactin – inhibiting hormone and increase release of prolactin releasing hormone, so more prolactin is released by the anterior pituitary.

Oxytocin causes release of milk into the mammary ducts through the **milk ejection reflex.** Oxytocin stimulates contraction of epithelial cells in the breasts, which squeezes the glandular and duct cells and causes milk ejection.

Importance of breast feeding over bottled feeding

1. **The colostrum and breast milk** contain antibodies and living cells which help to protect the baby from diseases. The antibodies destroy germs that may enter body of the baby and fight early infections such as diarrhoea and bronchitis.
2. **Pure and fresh;** that its contents are constantly changed to meet the needs of the baby.
3. **Inexpensive**; breast milk is cheap since it is available at the moment it is needed, hence baby sucks it at the time it needs up to the beginning of weaning.
4. **Ease digestion**; breast milk is digested more quickly and more easily than bottled milk. It has right concentration and is naturally diluted.
5. **Normal temperature regulation**; breast milk is regulated at a right temperature, that is, the normal body temperature for the baby which is 37±℃.
6. **Mother** – **child bond**; breast feeding provides emotional and psychological benefits to both the mother and the baby.

The baby within three days receives thick liquid called **colostrum** rich in proteins, vitamins and antibodies. Colostrum helps the baby to be defensive from infections. After six months, the first teeth appear and solid food can now be gradually added to the baby's diet. At this stage the baby's milk intake decreases. This is **weaning**. **Lactation** continues until weaning.

Contraception

This is prevention of fertilization when sexual intercourse takes place, thus prevention of pregnancy from taking place. Contraception as the prevention of pregnancy involves use of artificial methods and birth – control pills or natural methods.

Methods of contraception

1. Sheath/ condom

A thin rubber sheath is placed on erect penis before sexual intercourse. The sheath traps the sperms and prevents them from reaching the uterus. The condom is not expensive, easy to use, and does not require a prescription.

2. The diaphragm

A thin rubber disc placed in the vagina before intercourse which covers cervix and stops from entering the uterus.

3. Spermicides

Spermicides are chemicals which though harmless to tissues, kill or immobilize sperms. The spermicides are in form of cream and are placed in the vagina.

4. Intra – uterine device (IUD)

A small metal or plastic strip bent into a loop or coil is inserted and retained in the uterus, where it prevents implantation of a fertilized egg (ovum). However, this method has some implications.

5. The contraceptive pill

The pill contains chemicals which have the same effects on the body as the **oestrogen** and **progesterone**, when mixed in suitable proportions. These hormones suppress ovulation and prevent conception. The pill should be taken each day for the 21 days between menstrual periods.

6. Vasectomy

This is simple and safe surgical operation in which man's sperm ducts are cut and the ends sealed. This means that semen contains the secretions of prostate gland and seminal vesicle but no sperms and so cannot fertilize an ovum. This method is almost 100 percent effective in preventing pregnancy.

7. Laparotomy (tubal ligation)

A woman is sterilized by an operation in which oviducts are tied, blocked or cut so that sperms can no longer reach the ova. This method is almost 100 percent effective in preventing pregnancy.

8. Abstainance

The woman keeps careful record of her menstrual cycle over several months so that she predicts roughly when an ovum is likely to present in her oviducts. She must abstain from sexual intercourse for several days around ovulation.

> Note

Vasectomy and laparotomy are called **sterilization**. This just involves a minor operation.

Abnormal conditions associated with reproduction

Sterility

This is a state in which an individual is unable to produce the reproductive gametes. Sterility is sometimes caused by presence of acidic secretion particularly lactic acid in the vagina and soon as semen is released all the sperms are killed.

Sterility is also due to failure of the ovaries to yield the ova.

Sexually transmitted diseases

These diseases pass from person to person during sexual activity. These diseases include syphilis, gonorrhea among others.

The sexually transmitted diseases may cause the foetus in the uterus to impairment. Oviduct becomes blocked. The babies are affected in the uterus and may be born blind.

Maternal mortality

This is the death of pregnant woman during the delivery perhaps because of diseases that affect reproductive organs or either early pregnancy.

Fistula

This is abnormal connection between the vagina and rectum or bladder.
It is caused by complication from surgery, heredity, injury, radiation and inflammatory bowel disease including crohn's disease and ulcerative colitis.

Treatment

- Medication
- colostomy

Cervical cancer

It occurs when abnormal cells on the cervix grow out of control. It is caused by Human Papilloma Virus (HPV) through sexual contact.

Symptoms

- bleeding
- pain on the lower belly or pelvis
- pain during sex
- abnormal vaginal discharge

Prevention and treatment

- surgery, chemotherapy and radiotherapy
- vaccination against HPV
- undergo pap test
- limit number of sex partner and use of condom

Revision questions

1. a. State any two things that happen during the first stage of birth.
   b. Mention two advantages of breast feeding. (**2007 Maneb**)
2. State any five contraceptive methods and explain how each one works. Your answer should be in an essay form. (**2009 Maneb**)
3. Name the hormone that promotes thickening of the uterus during ovulation. (**2014 Maneb**)
4. State two roles played by the amniotic fluid during the development of the foetus.
5. Explain why breast feeding is important. Outline five points. (**2012 Maneb**)

Topic 9 Genetics and Evolution I

Genetics

Genetics is the study of inheritance.

This study of inheritance involves **variation** and **heredity** in organisms.

Importance of genetics

i. Helps in understanding of heredity.
- By investigating how offspring inherit characteristics from their parents.

ii. Helps in understanding theory of evolution.

iii. Introduces new techniques such as the use of monoclonal antibodies and genetic engineering.
- Help fight diseases.
- Make new products
- Improve food production and protect environment.

Heredity

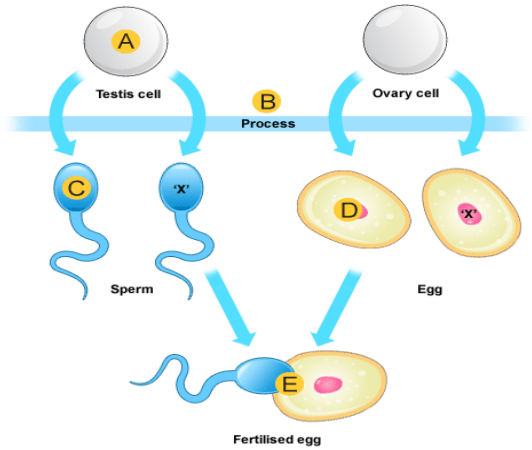
This is a process by which characters are transferred from the parents to the offspring.

Organisms acquire characters from their parents. The characters are also called **traits**.

Characters are body structures that make the phenotype.

Inheritance is the transmission of genetic information from one generation to the next.

Inheritance is about the passing of characteristics or traits from parents to their offspring. This is achieved when genes from the sex cell of each parent combine during *sexual reproduction*. The resulting offspring will be a mixture of the characteristics of the parents.



Exampl es of characters

i. Skin colour
ii. Fatness
iii. Tongue rolling
iv. Blood group
v. Height

Principles underlying Mendelian genetics

The principles underlying Mendelian genetics were written by Gregor Mendel in Australia who taught in a local state school and kept bees and flowers in the monastery garden long before anyone had described DNA to use the word ‘‘gene’’.

He carried out a number of breeding experiments after 1860, pollinating different kinds of peas with pollen from other kinds of peas as well as their own.

These experiments were carefully recorded. He described every **cross**

where pollen came from and which type of flowers and plants, which grew white or purple or brown flowers.

From these experiments, he came up with the following principles:-

1. Characteristics are controlled by pairs of alleles (genes).
2. Alleles of same gene do not blend.
3. Alleles of same gene pass into separate cells during gamete formation.
4. Alleles of the same gene are inherited independently.

Cross

A cross is a genetic diagram that shows a means of inheritance of genes by offspring from their parents.

Genetic terms used to describe crosses

Genotype

This is a term given to a pair of genes controlling a character.

It is, as such called a gene combination for a character,

For example; **BB**, **Bb** and **bb**.

Genes that control a particular character are represented by the same letter. However, when a capital letter and small letter are represented together, it means that the two genes are different that is, **Bb**.

Phenotype

This is the final appearance of an organism due to expression of genes.

Characters always give different phenotypes depending on the gene combination.

For example, grey colour, brown seeds, tall man etc.

Homozygous condition

This is a condition in which a pair of similar genes controls a character. **BB** and **bb** are homozygous condition.

An individual with a pair of similar genes controlling a particular character is called **homozygote** or **pure breed**.

Heterozygous condition

This is a condition in which a pair of different genes controls a character.

Bb is an example of heterozygous condition.

An organism with a pair of different genes regulating a particular character is called heterozygote.

Dominant gene

This is a gene that gives its phenotype in both homozygous and heterozygous condition.

A dominant gene is always denoted by capital letters.

Therefore, **BB**, **GG** and **HH** can be defined as homozygous dominant.

Recessive gene

This is a gene that gives its phenotype in the homozygous condition only. A recessive gene is always denoted by small letters.

Therefore, **bb**, **gg** and **tt** can be defined as homozygous recessive.

Alleles

These are alternative forms of a gene which control the characteristics.

Selfing

This is a process that involves crossing the filial (F1 generation) to produce next generation (F2 generation). Filial are offspring produced after crossing.

F1 generation

The offspring produced by the parental generation.

F2 generation

The offspring of the first filial generation (F1).

Pure line (breed)

An organism with homozygous characteristics.

Codominance

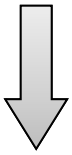
This is the genetics of two or more genes (alleles) that are equally dominant. Such genes are said to be **co-dominant genes**.

Another circumstance where co-dominance is practical is when a recessive gene is not fully masked by dominant gene in a character of an organism (i.e. partial dominance). Such genes are said to be **additive genes**.

Modelling genetic crosses

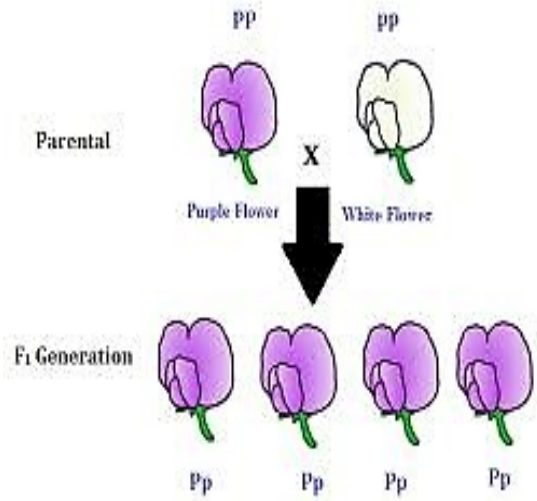
The results recorded by Mendel can be summarized as follows;

Parents: purple flower × white flower

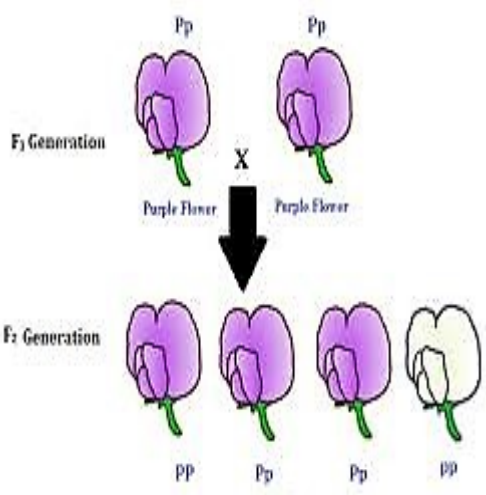


Offspring: all purple flowers

Take **P** to denote a gene for purple flower and **p** to denote a gene for white flower then the following cross can be done to display how offspring inherited these genes from their parents.



The next experiment that was taken by Mendel was to cross (self) the offspring produced during the first experiment.



Note; when parents with same phenotype who are heterozygotes cross, they produce offspring with different phenotypes.

The genetic diagram illustrates the following important points;

- There is a pair of genes for each characteristics, one gene from each parent.
- Although, the gene pairs control the same characters, they may have effects. One gene (allele) is dominant over the other.
- The alleles of each gene are on corresponding positions.

Allelomorphic genes are also called alleles. The word **Allelomorphic** means '*alternative form*'.

The ratio of genotype and phenotype of offspring in monohybrid crosses up to f2 generation

The generations formed as an outcome of a cross are called **Filial**. Hence the first generation is called the first filial generation or F1 generation.

In Mendel's incident the cross produced F1 generation. F1 generation grow into adults and produce second filial generation. F1 generation is **selfed** to produce F2 generation which can again be selfed to produce F3 generation.

Genotypic ratio is determined by the categories of genotypes such as; homozygous dominant, homozygous recessive and heterozygous.

For example, the results of Mendel's second experiment indicate 1 homozygous dominant, 2 heterozygous and 1 homozygous recessive.

i.e. genotypic ratio: 1:2:1 (1RR: 2Rr: 1rr)

Phenotypic ratio: The results of second experiment indicate that 25% or ¼ have white seeds while 75% or ¾ have brown seeds. In other words, there is phenotypic ratio of 1:3

(1white seed: 3brown seeds)

This means that if there are 240 plants in the F2,

(i) ¼ of 240 plants have white seeds

$$\frac{1}{4} \times 240$$

60 plants have white seeds

(ii) ¾ of 240 plants have brown seeds

$$\frac{3}{4} \times 240$$

180 plants have brown seeds

Question

When a grey cock was mate with a grey hen, grey and white chicks were produced.

a. Using **G** for grey colour and **g** for white colour, draw a genetic diagram to determine the genotype of the offspring.
b. Give the genotypic ratio of the chicks.
c. If the parents produced 12 chicks, how many were white? Show your working. (2012 Maneb)

Sex chromosomes

Whether you are a male or female depends on one particular pair of chromosomes on each somatic cell called *sex chromosomes* since they determine the sex of an individual.

In females, the two sex chromosomes called **X** chromosomes are of same size as each other.

In males, the two sex chromosomes are of different sizes. One corresponds to the female sex chromosome which is **X** chromosome and the other one is smaller which is **Y** chromosome.

Hereditary, female genotype is (XX) and the male genotype is (XY). As such, sex is determined by X and Y chromosomes.

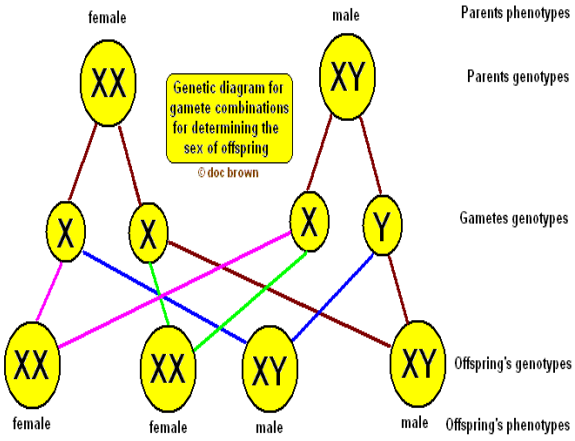
How sex of a baby is determined at fertilization

Once meiosis takes place in the female's ovary, each ovum receives one of the X chromosomes, so all ova are the same. Meiosis in male's testes results in 50% of the sperm attaining an X chromosome and 50% getting a Y chromosome.

If an X sperm fertilizes the ovum, the zygote will be (XX) and will grow into a girl. If a Y sperm fertilizes an ovum, the zygote will (XY) and will develop into a boy.

There is an equal chance of an X or Y chromosome fertilizing an ovum, so the numbers of girl and boy babies are more or less the same.

Using a genetic diagram we can show inheritance of sex in human being.

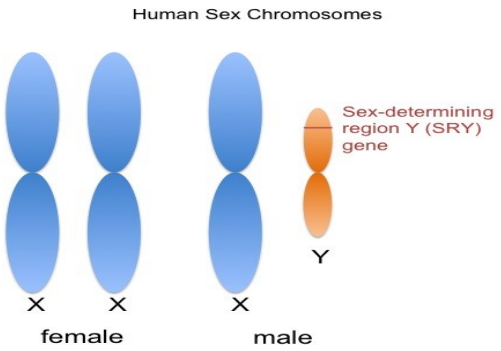


This shows that there are 50:50 chances for any fertilization resulting into production of a male or female offspring.

How sex linked characters are inherited

The X and Y chromosomes have other genes on them that cause sex linked characters to be inherited by the offspring. Some genetic disorders affect many more males than females.

Sex linkage result from the fact the X chromosome is longer than Y chromosome. Thus, there are genes on the X chromosome which have no corresponding alleles on the Y chromosome.



Genes *a*, *b* and *c* are sex – linked to the X chromosome and they are **recessive**, however, they will be expressed in the phenotype.

Examples of sex linked characters

1. Haemophilia

A few of the genes are carried on the X chromosome. One of them is a gene for blood clotting. The dominant allele of this gene H allows the blood to clot normally. But the recessive allele, h, causes haemophilia, a disease where even a bruise or small scratch will go on bleeding for a very long time.

There are three possible genotypes that a woman might have for the haemophilia characteristics.

Genotype	Phenotype
X^HX^H	normal
X^HX^h	carrier
X^hX^h	haemophiliac

There are only two possible genotypes for a man. This is because the Y chromosome does not have a haemophilia or blood clotting gene.

Genotype	Phenotype
X^HY	normal
X^hY	haemophiliac

2. Red – green colour blindness

The alleles for red – green colour blindness are recessive. But since they lie on the section of X chromosome which is not matched by the Y, there is no chance of their effects being suppressed by the dominant allele.

Genotype	Phenotype
X^NX^N	normal female
X^NX^n	carrier female
X^NY	normal male
X^nY	colour blind male

3. Hairy ears

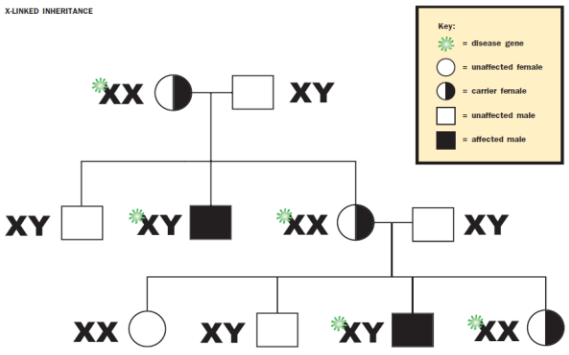
The gene for this character is inherited in Y chromosomes and it is particularly males who have hairy ears. This is so because of Y chromosome.

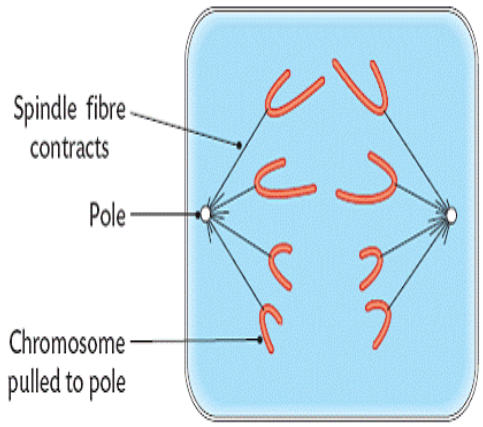
A **carrier** is an organism with a recessive gene in their cells, but has a normal phenotype.

The sex linked characters are represented on a **pedigree** diagram.

Pedigree diagram

This is a family tree diagram in which there is inheritance of sex linked diseases.





Types of cell division

As already stated above, there are two types of cell division, namely;

a. Mitosis
b. Meiosis

Mitosis

This is process by which a cell divides and splits to give rise to two cells. The new cells are formed from parent cells called **somatic cells**.

The significance of mitosis is to bring about growth in multicellular animals, repair and replacement of damaged or worn out cells and for asexual reproduction. Mitosis results into two new cells that are genetically identical to each other.

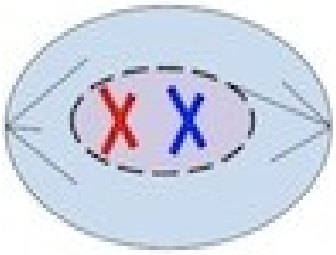
Interphase is the first cycle of cell division before mitosis. Interphase is the preparatory stage of mitosis.

Stages of mitosis

Mitosis occurs in four stages.

Prophase

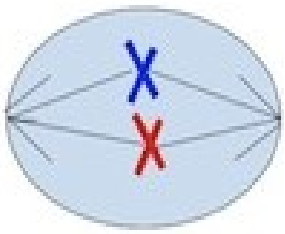
Two bodies called centrioles move to opposite ends of the cell.
Protein fibres form round each other.
Chromosomes become shorter and thicker.



Metaphase

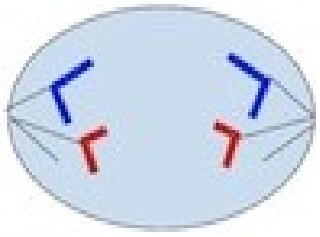
The protein fibres arrange themselves between centrioles into a structure called spindle.
The nuclear membrane disappears.
Pairs of chromatids of chromosomes arrange themselves on the equator of the spindle.

Note; the spindle of a plant cell forms without the help of centrioles.



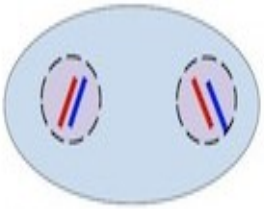
Anaphase

Chromatids separate and move to the opposite ends. The cell starts to split.

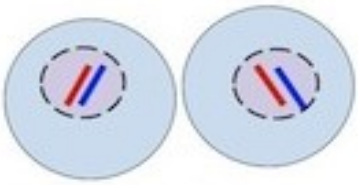


Telophase

The chromatids are now the new chromosomes. They gather into two bunches. A nuclear membrane forms around each bunch.
The two daughter cells are formed. Each cell has the same number of chromosomes as those of parent cell.

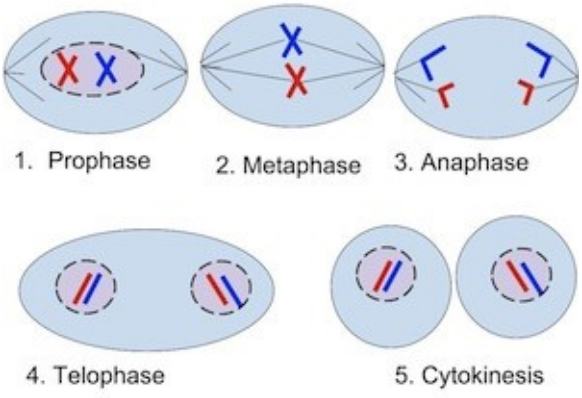


After mitosis the cytokinesis follows to complete cell division.



Summary of mitosis

A cell containing pairs of homologous chromosomes in mitosis is called diploid cell. The total number of chromosomes in a diploid cell is called a diploid number and such condition is known as diploid condition. The parent cell and daughter cell are all diploid cells formed from somatic cells.



Meiosis

This is a process of cell division that gives rise to eggs or sperms. The diploid cell divides and splits into four daughter cells. Thus, production of sperms and ova is the result of a special nuclear division which reduces to half, the number of chromosomes in the cells. This division is therefore described as **reduction division**.

In ovaries and testes, diploid cells undergo meiotic division during which their chromosome pairs recombine and then separate into different new cells. The resulting daughter cells are **haploid**, that is, they contain half the chromosome number. These cells are now gametes.

Stages in meiosis

First reduction division

Prophase

Chromosomes divide into pairs of identical chromatids joined to one another by centromere.
Centrioles move to opposite ends of the cell. Protein fibres form around each of them.

Late prophase

Chromosomes pair up to form two chromosomes of a pair called homologous chromosomes.

Metaphase 1

The nuclear membrane disappears. A spindle forms between the centrioles. Homologous pairs of chromosomes arrange themselves on the equator.

Anaphase 1

Homologous pairs of chromosomes separate, each chromosome of a pair moves to opposite ends of the cell.

Telophase 1

The chromosomes gather into two bunches and the cell begins to divide where new nuclear membrane forms around each bunch. Two daughter cells are formed.

Second reduction division

Metaphase II

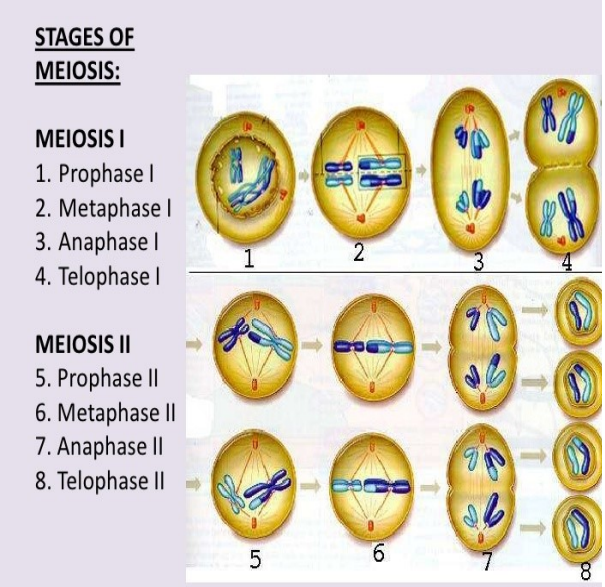
The chromosomes arrange themselves on the equator. The nuclear membrane disappear and new spindles form at right angles.

Anaphase II

The chromatids separate and bunch at opposite ends of each cell that begins to divide. The centromeres divide leading to separation of the chromatids.

Telophase II

The spindle fibres disappear and a new nuclear membrane forms around each new group of chromosomes to form four haploid cells.



Summary on comparison between mitosis and meiosis

- **Nature of cells**; mitosis produces genetically identical cells while meiosis produces genetically different cells.
- **Chromosome number**; in mitosis, chromosome number of parent cell is equal in daughter cells while in meiosis, chromosome number of parent cell is halved in daughter cells.
- **Number of cells**; mitosis produces two daughter cells while meiosis produces four daughter cells.
- **Site of occurrence**; mitosis occurs in ordinary body cells (somatic cells) while meiosis occurs in certain cells in reproductive organs.

Chromosomes

These are threadlike structure of nucleic acids and protein found in the nucleus of the cells.
Chromosomes are further defined as rod shaped structure usually found in pairs in a cell nucleus that carries the genes that determine sex and characteristics of an organism inherited from its parents.

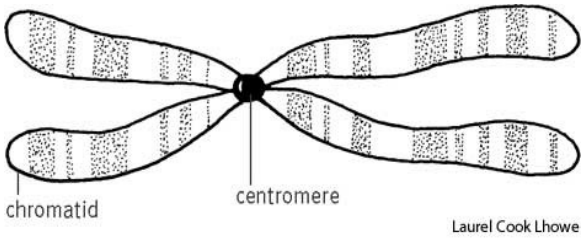
A human body cell usually contains 46 chromosomes arranged in 23 pairs.

Homologous chromosomes

These are identical chromosomes that form pairs. The number of chromosomes in organisms, however, varies from one species to another.

Homologous chromosomes cross over at a point where they exchange genes during fertilization. The crossing over occurs because of synapsis in meiosis when gametes are made.

Structure of a chromosome



A chromosome consists of **DNA** wound round a core of **protein** and folded tightly into compact structure. The protein contains strands called **chromatids**. The pair of chromatids are joined at a point called **centromere**.

A chromosome contains about 10, 000 times its own length of DNA – deoxyribonucleic acid.

Functions of chromosomes

a. **Carry genetic information** in the form of DNA molecules necessary to produce all enzymes which direct all metabolic reactions.
b. **Control activities** of a living cell that is, vital for cell division.

Necessary conditions for chromosomes to be seen on the nucleus under microscope.

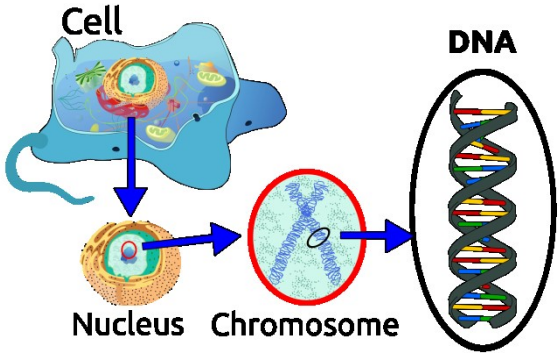
- **Cell division**; at this condition the chromosomes become shorter and thicker easily to be seen.
- **Application of cell with a dye**; this gives colour to the chromosomes for easily be seen.

Genes

A gene is a sequence of chemicals which controls the development of particular characteristics in an organism.

Genes are found on the Deoxyribonucleic Acid – DNA molecule. One gene is a section of DNA which is a part of the chromosome.

According to the location, gene is therefore the portion of DNA that codes for protein or RNA molecule.



Forms of genes

a. **Regulatory** genes
b. **Structural** genes

Facts about genes

- Genes are represented by letters of alphabet. The letters act as symbols for the genes.
- Genes exist in pairs. A pair of genes controls a character.
- Genes are described as hereditary messages.
- Different varieties of genes are called alleles.

Functions of a gene

i. **Controls** characters in an organism. This happens when instructions are sent by RNA to the ribosome which makes a polypeptide chain. These form cell structures and/or enzymes controlling character.
ii. **Transmits** an organism's hereditary materials.
iii. Acts as **switch** in response to local conditions.

iv. **Dictates** how cells specialize that is, how cells develop.

Nucleic acids

There are two categories of nucleic acids namely;

1 DNA (Deoxyribonucleic Acids)

2 RNA (Ribonucleic Acids) molecules.

DNA molecule

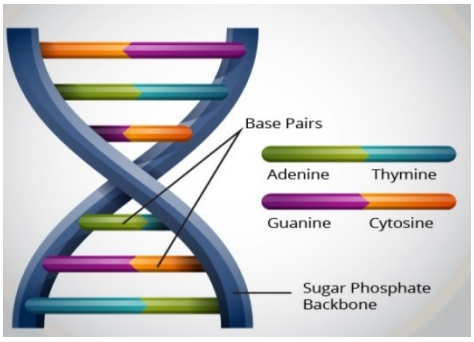
DNA molecule is a long chain of nucleotides.

Deoxyribonucleic Acid (DNA), a genetic material of all cellular organisms and most viruses.

In cells, DNA is a double stranded helical molecule in which the two single stranded chains are joined together by bonds between the bases. DNA molecule is located in chromosome in the part of the cell called **nucleus.**

Structure of DNA molecule

DNA is made of two strands, twisted together into a spiral or helix. The two strands are linked together through bases as shown below.

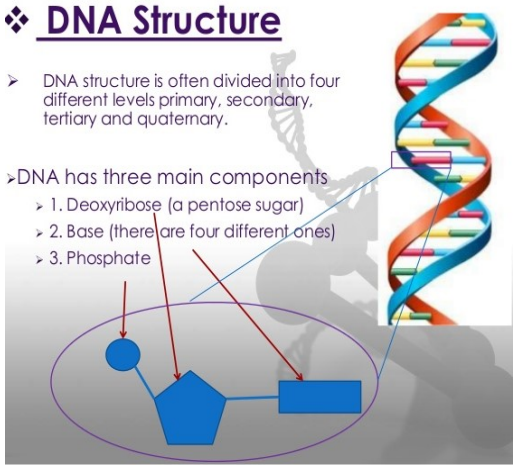


A molecule of DNA consists of two chains, strands composed of a large number of chemical compounds, called **nucleotides**, linked together to form a chain. These chains are arranged like a ladder that has been twisted into the shape of a winding staircase, called a **double helix.**

Components of nucleotides

Each nucleotide consists of three units namely;

1. Deoxyribose – sugar molecule.
2. A phosphate group
3. Bases – this is a nitrogen-containing compound. Each nucleotide contains one of four of these nitrogen containing compounds.



The Deoxyribose molecule occupies the center position in the nucleotide, flanked by a phosphate group on one side and a base on the other.

The phosphate group of each nucleotide is also linked to the Deoxyribose of the adjacent nucleotide in the chain. These linked Deoxyribose – phosphate subunits form the parallel side bars of the ladder. The bases face inward toward each other, forming the rungs of the ladder.

Kinds of bases

There are **four** kinds of bases in DNA molecule namely;

1. Adenine (A)
2. Thymine (T)
3. Cytosine (C)
4. Guanine (G).

The bases have different sizes and shapes, so that **A** will only fit next to **T**, and **C** will only fit next to **G**. The complementary bases are joined to each other by weak chemical bonds called *hydrogen bonds*.

Functions of DNA molecule

- Carries genetic materials from parents to offspring.
- Carries the information needed to direct protein synthesis and replication.
- Storage of genetic information.

DNA then combines with synthesized protein to form long molecule of chromosome.

Protein synthesis is the production of the proteins needed by the cell or virus for its activities and development.

Replication is the process by which DNA copies itself for each descendant cell or virus, passing on the information needed for protein synthesis.

A sequence of three nucleotide bases, called a triplet, is **codon** (the genetic code word), that specifies a particular amino acid.

Topic 10 tropisms

Tropism

Higher plants are rooted in the ground and are unable to move from place to place. However plants move all the time by growing towards or away from a stimulus.

These growth movements are only in a part of certain plants and are so slow that we often cannot see them. Plants move in the response to external stimuli take the form of **tropisms** or **nastic movements**.

A nastic movement is a response by a plant which is independently to the direction of the stimulus, e.g. *Mimosa pudica*

For example, the opening and closing of many flowers in response to changes in light intensity.

A tropism is the plant growth response which is related to the direction of stimulus. Tropism is also called **tropic responses**.

Plants produce hormones that influence their growth responses. The growth hormones in plants are called **auxins**.

The auxins are made in the tips of plant called meristems.

A meristem is a region of active cell division, that is, root tips and shoot tips.

Removal of plant tips therefore prevents auxin production hence there is no growth response.

How tropisms occur

From the meristems the auxins diffuse to other parts of the plant where they affect increase in length and growth of the plant cells. Tropisms are caused due to the difference in concentration of auxin which is brought about by a particular part of plant.

The following are examples of stimuli for plants;

- Light
- Water
- Gravity
- Chemicals
- Touch

Types of tropisms

Phototropism

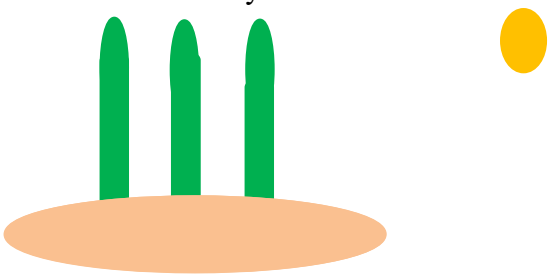
This is a plant growth in relation to the direction of light. Plant shoots grow and so bend towards the stimulus of light. Plant shoots are therefore, positively phototropism.

Plant roots grow and bend away from the source of light. Plant roots are said to be negatively phototropism.

Experiment 1:

Which parts of a shoot of a green plant respond to light?

Figure below shows three seedlings placed in a box. The seedlings are to be treated differently.

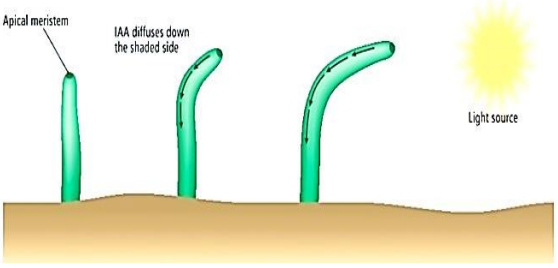


Procedures

- Obtain a box containing three newly germinating seeds as shown above.
- Cut the tip of the first seedling. Cover the tip of one of the seedlings with a transparent material. Leave the other seedling untampered.
- Allow the light from one side and leave the apparatus for several days.

Expected results

After leaving the apparatus for several days, the seedling left untampered will bend much towards the light.



Conclusion

The seedling produced auxins due to the stimulus of light that caused its shoots to bend towards the light.

Clinostat

This is a piece of apparatus with a clock mechanism inside it.

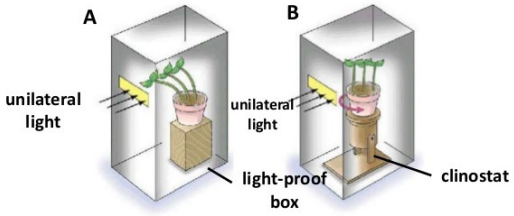
It is adjusted that its cork disc rotates 4 times every one hour. Because of this rotation, any part of a plant that is attached to the disc can be given equal stimulation, by light or gravity.

Experiment 2

The effects of light distribution on a growing shoot.

Procedures

- Select two potted plants of similar size and water them.
- Place one of them under a cardboard box with a window cut on one side so that light reaches the shoots from one direction only as follows.



- Place the other seedling in an identical situation but this time on a rotating clinostat.

Results

The shoot in pot **A** respond by growing towards the light source. The shoot in pot B will grow vertically without any curvature.

Conclusion

Auxin is distributed evenly in pot B. All parts of the shoot are exposed to the light by the clinostat. This will expose each side of the shoot to the light equally.

The mechanism of phototropism

When a shoot is illuminated from above, auxin is made at its tip and passes equally down to the region of the cell extension that grows evenly and upright.

The uniform supply and illumination of light on a shoot results into uniform distribution of auxin, hence uniform vertical growth.

One sided illumination results in unequal distribution of auxin. The light causes the auxins to diffuse from the illuminated side to the dark side of the shoot, that is, increase in auxin concentration on dark side.

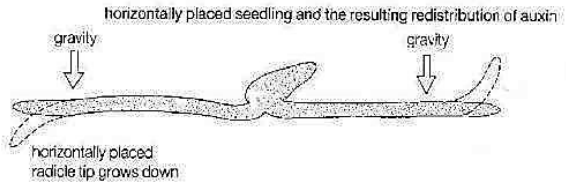
The increased auxin concentration stimulates rapid cell extension on the dark side.

Geotropism (gravitotropism)

This is a plant growth response in relation to the direction of gravity.

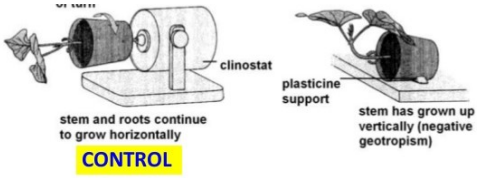
When you place a newly germinated seedling in a horizontal position in the dark, that is, to avoid the effect of light, the shoot bends upwards while roots bend downwards.

The root is said to have positive geotropism since it grows towards gravity and the shoot is said to have negative geotropism since it grows away from gravity.



The mechanism of geotropism

When a seedling is placed in its regular, vertical position with the shoot upwards and the roots downwards, this causes the shoot and the roots to grow uniformly and vertically because there is uniform distribution of auxin.

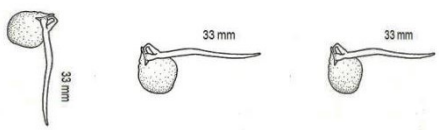


The more auxins are made at the tips of the shoot and root that gather on the lower side of the shoot and the root when the seedling is placed with its shoot and root horizontal.

The higher concentration of auxin on the lower side of the shoot causes the lower side grow longer more quickly since there is quicker growth.

Experiment 3

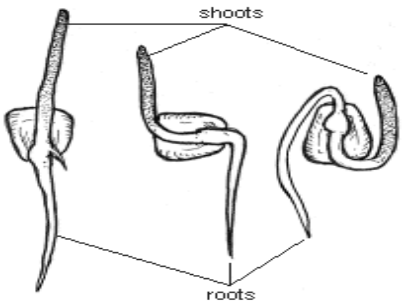
A plant response to gravity.



Procedures

- Obtain three seedlings of beans whose radicles are visible.

- Put bean seedlings in a small aquarium container with slight amount of water at its base.
- Observe the seedlings after some days and draw their appearance.



Conclusion

It is seen that seedlings respond to gravity even though we place the seedlings in any position. The roots grow in the direction of gravity.

Experiment 4

Geotropism in a bean radicle

Procedures

- Obtain germinated bean seedling about 10 mm long.
- Cover the cork on the clinostat with wet cotton.
- Pin seedling onto clinostat.
- Turn clinostat on its side. Switch on clinostat.

Expected results

Observe what happens to the bean seedling after some days.

Conclusion

Base your conclusion on the difference of seedlings before and after experiment. Explain the difference with your colleague.

Hydrotropism

This is the growth response to the stimulus of water. Plant roots grow towards water. They are positively hydrotropic.

Importance of water for the germinated seeds

i. Activate enzyme in the seed to convert starch into glucose for immediate use.

ii. help the conversion of proteins to amino acids

iii. transport the sugar in solution from the cotyledons to the growing regions

iv. expand the vacuoles of newly formed cells and so cause the root and shoot to grow and the leaves to expand

v. maintain the turgor of the cells and thus keep the shoot upright and the leaves expanded

vi. provide the water needed for photosynthesis once the plumule and young leaves are above ground;

vii. Transport salts from the soil to the shoot.

Practical uses of auxin

i. Quick root formation in cuttings

ii. Quick shoot and bud formation.

iii. Stimulates some plants to produce fruits. Plant hormones help the fruits to grow larger and ripen well. For example, many fruits produce the gas ethane when they are ripening. This encourages fruits near them to ripen as well.

iv. Prevent fruits from producing buds and germinate and allow longer storage period of the fruits.

v. Kill the weeds on the ground.

Advantages of tropisms

a. Permit the shoots to take along their leaves into the finest condition for trapping sunlight for photosynthesis.

b. The flowers are visible to condition of the pollination.

c. Facilitates the roots to grow down into the soil to get the necessary water and mineral salts for the plant growth.

Revision questions

1. Design an experiment that you would conduct to find out the region that responds to stimulus of gravity in bean seedling. (**2006 Maneb**)

2. a. Define tropisms

   b. Name the stimulus in geotropism. (**2014 Maneb**)

3. a. What are 'auxins'?

   b. How does high auxin concentration affect growth of the following parts of the plants? (i) shoots (ii) roots.

   (**2005 Maneb**)

Topic 11 respiratory system

Respiratory system

The general term of respiration describes the uptake of oxygen from the environment and disposal of carbon dioxide into the environment at the body system level.

Respiration at the **body system level** involves a number of processes like mechanisms of breathing and exchange of oxygen and carbon dioxide in the capillaries.

All cells require a continuous supply of oxygen and must continuously eliminate a metabolic product, carbon dioxide.

On cellular level, it refers to the processes by which cells utilize oxygen, produce carbon dioxide and convert energy into useful forms in the body.

Types of respiration

There are three types of respiration namely;

i. External respiration
ii. Internal respiration
iii. Tissue (Cellular) respiration

External respiration

This is a process by which air is exchanged between the atmosphere and lungs. This is also known as **Breathing** or **Ventilation**.

Internal respiration

This is a process by which oxygen diffuses from the blood or tissue fluid into tissues (cells). This is a gas exchange between the blood and cells.

Tissue respiration

This is a process by which energy is released from food in living cells. Thus, cell use of oxygen for metabolism, yielding carbon dioxide as waste product.

Types of tissue respiration

There are two types of tissue respiration namely;

a. **Aerobic** respiration
b. **Anaerobic** respiration

Aerobic respiration

This is a process by which oxygen breaks down glucose to release carbon dioxide and water.

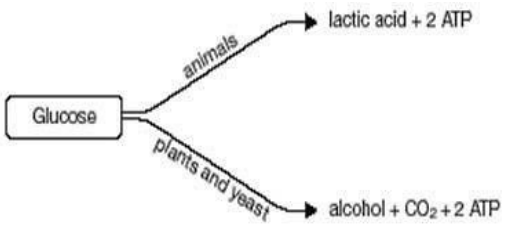
Energy is the main product while both carbon and water are by – products. Aerobic respiration is catalyzed by phosphorus and potassium. Aerobic respiration occurs in the same way in plants and animals.

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6H_20 + 6CO_2 + \text{energy}$$

(glucose + oxygen → water + carbon dioxide + energy)

Anaerobic respiration

This is a process by which glucose is broken down in the absence of oxygen to release energy. Anaerobic respiration occurs differently in plants and animals.



Anaerobic respiration in mammals

Glucose is broken down to release less energy and lactic acid.

Glucose → Energy + Lactic acid

$C_6H_{12}O_6 \rightarrow 210\ Kj + 2C_3H_6O_3$

Anaerobic respiration in plants

Glucose is broken down to release less energy, carbon dioxide and alcohol called **Ethanol**.

$C_6H_{12}O_6 \rightarrow 210Kj + 2CO_2 + 2C_2H_5OH$

Similarities between aerobic and anaerobic respiration

- Use of glucose as a raw material.
- produce energy

Differences between aerobic and anaerobic respiration

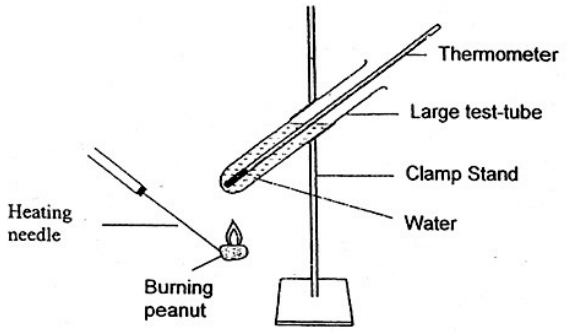
i. **Energy release**; aerobic respiration releases more energy than anaerobic respiration.

ii. **Oxygen use**; aerobic respiration involves use of oxygen while anaerobic respiration does not involve use of oxygen.

iii. **Site of occurrence**; aerobic respiration occurs in mitochondria while anaerobic respiration occurs in cytoplasm.

Experiment

To show that peanuts release energy when they are oxidized.



Procedures

- Set up apparatus as shown above. You also need a thermometer.
- Take the temperature of the water in the test tube and record it.
- Using the mounted needle, hold the peanut in the Bunsen flame. The heat from the flame will give the peanut enough energy for it to begin to combine with oxygen in the air, so it starts to burn. This reaction is called Oxidation or Combustion.
- Hold the burning peanut under the test tube of water until it stops burning.
- Quickly take the temperature of the water again.

Expected results

The water in the test tube will boil because of heat energy from burning of peanut. The thermometer will measure the point at which the water boils.

Conclusion

The heat energy that comes from peanut indicates that some food substances contain energy which is used in the body for various activities like respiration.

Breathing (ventilation)

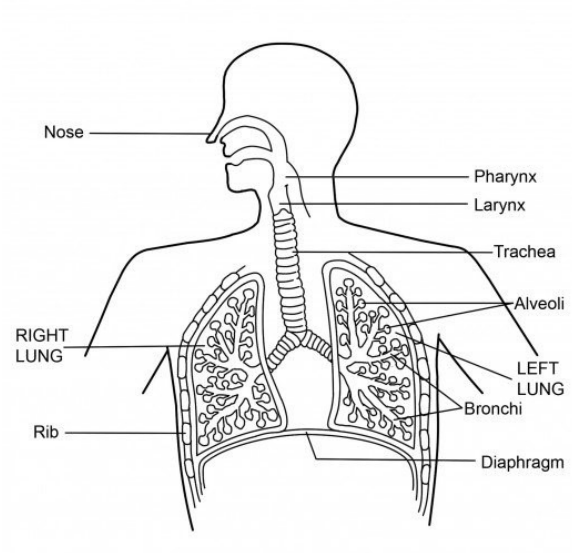
This is the taking of air into and out of the lungs.

Importance of gaseous exchange in organisms

i. **Renewal of oxygen** supply to the lungs which is essential in aerobic respiration. The air is taken into the lungs.

ii. **Removal of carbon dioxide** from the tissues which would otherwise, be harmful to the tissues. The air is taken out of the lungs.

The passage (path) of air into and out of the lungs is called the **respiratory tract**.



Organs of the respiratory tract

Nose

This is the organ that warms, moistens and filters the air as it passes through the nasal cavity. The air is warmed to raise its temperature to body temperature that is, 37 ± 1°C proper metabolic processes.

The air is filtered to trap dirt, dust and germs and thus preventing them from infecting the lungs. The air is moistened to enable it diffuses faster in a solution form.

This organ has thin bones called **turbinal bones** covered by thin layer of cells that produce water and mucus. The cells have cilia that pushes and traps germs and dust particles. The dust and mucus form **catarrh** in the nasal passage that is expelled by blowing.

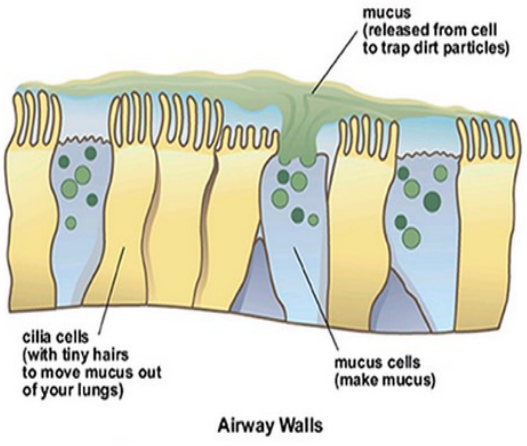
Mouth

The palate separates the nose and mouth. The air also enters the body through the mouth. However, breathing through the mouth is discouraged because it does not filter the air and moisten the air efficiently.

Trachea (wind pipe)

The trachea is made of rings of cartilage that are kept open always to allow free entry of air through it. At the top of trachea is a flap of cartilage called **epiglottis**.

Trachea contains cilia that constantly push and force any dust entering it. The dust and any foreign matter are carried by film of mucus where it forms **phlegm** and is coughed out through the mouth.



Airway Walls

Bronchi

The trachea divides into two branches, the right and left bronchi. The bronchi reach the lungs. They also have cilia and mucus that further filter the air.

They are made of a ring cartilage that keep bronchi open to allow free entry of air.

Bronchioles

These are narrower branches that run from the bronchi. The branches of bronchioles form structure called **Bronchial Tree**.

Alveoli (air sacs)

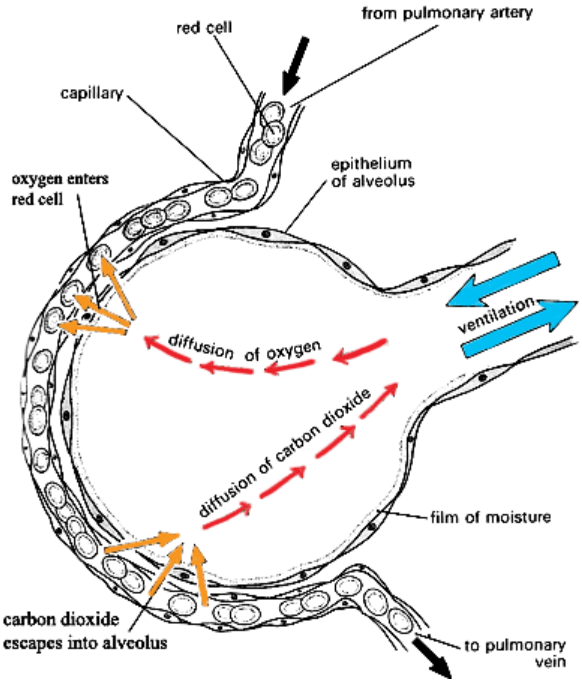
The bronchioles subdivide into smaller tubes which end in groups of small sacs called Alveoli. The walls of the alveoli are very thin and surrounded by lung capillary. This is where gas exchange occurs between the walls of the alveoli and lung capillary in blood vessels.

Gas exchange in the lungs and tissues

When inhaled air reaches the alveoli inside the lungs, oxygen from the inhaled air diffuses into blood and carbon dioxide diffuses from blood in the air in alveoli. The oxygen diffuses from the blood into tissues (cells) for tissue respiration. Carbon dioxide diffuses into alveoli and excreted by lungs into atmosphere during exhalation.

Adaptations of alveoli for gas exchange

1. **Have thin walls**
   It is only one cell thick that ensures faster diffusion of gases.
2. **Have dense network of blood capillaries**
   The blood capillary has close contact with its walls that brings oxygenated blood from alveoli into alveolar air.
3. **Have thin layer of moisture**
   The cells in the alveolus secretes thee watery liquid. Oxygen diffuses in liquid form across the wall of alveoli.
4. **They are numerous in number**
   This increases large surface area for gas exchange.
5. **Have diffusion gradients for oxygen and carbon dioxide.**



How diffusion gradients are maintained?

1. **Inhalation** which increases oxygen concentration in the alveolar air than in the blood capillary hence oxygen diffuses from the alveolar air into the bloodstream.
2. **Exhalation** which lowers the concentration of carbon dioxide in the alveolar air than in the blood capillaries. Carbon dioxide therefore diffuses from the bloodstream into the alveolar air.
3. **Transportation of blood to the alveolus** increases concentration of carbon dioxide in the blood capillaries surrounding the alveolus than in the

alveolar air. Carbon dioxide therefore diffuses into the alveolar air from bloodstream.

4. **Transportation of oxygen away from the blood capillaries** surrounding the alveolus, lowers the concentration of oxygen in the bloodstream than in the alveolar air, oxygen, therefore diffuses into the bloodstream from the alveolar air.
5. **Presence of haemoglobin** in the bloodstream helps to pull oxygen from the alveolar air into the bloodstream since haemoglobin has high affinity for oxygen.

Transportation of carbon dioxide to the alveoli

From the respiring tissues, carbon dioxide is transported in the following ways;

i. Some of it is bound to the haemoglobin.

ii. The bulk of carbon dioxide is transported by blood plasma in form of bicarbonate ions.

From the respiring tissues the carbon dioxide diffuses into the red blood cell where it is dissolved to form carbonic acid. As soon as the carbonic acid is formed, it dissociates into hydrogen ion and bicarbonate ions.

The hydrogen and bicarbonate ions diffuse back into the blood plasma from the red blood cell. Thus the carbon dioxide now is transported by the blood plasma in form of bicarbonate ions. Upon reaching the alveolus the hydrogen ion and bicarbonate ions reacts to reform carbonic acid which eventually dissociates once again into CO_2 and water vapour. The carbon dioxide diffuses into the alveolar air from bloodstream.

Breathing mechanism

Lungs have no muscles of their own to make them move, (expand and contract). However, they are made to expand and contract by the following factors;

a. Movement of the ribs due to contraction of the **intercostal muscles**. This gives rise to **rib breathing.**

b. Movement of the diaphragm due to contraction of its muscles. This gives rise to **diaphragm breathing**.

Breathing mechanism involves inhalation and exhalation.

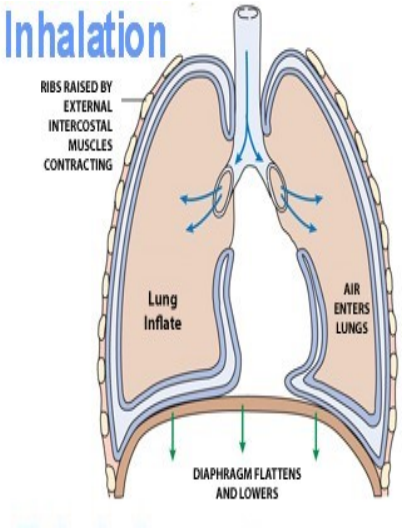
Inhalation

This is the taking of air into the lungs. It renews oxygen supply to the lungs. For this to occur, the following things take place;

i. The external intercostal muscles contract, pulling the rib cage upwards and outwards.

ii. The diaphragm flattens due to the contraction of its muscles.

These two movements outlined above increases the volume of the chest cavity (rib cage). This is turn lowers air pressure within the ribcage. Air therefore flows from the atmosphere where pressure is high to the lungs where pressure is low. This is mechanism of inhalation.



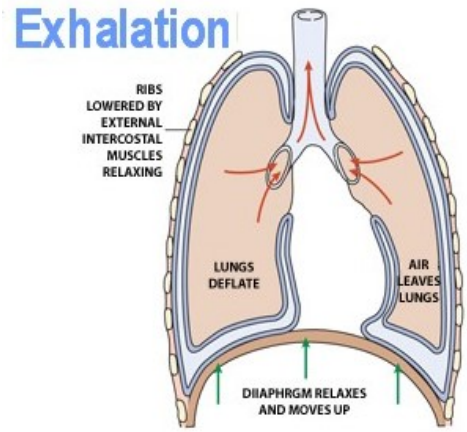
Exhalation

This is the taking of air out of the lungs. It removes carbon dioxide from the lungs. For this to occur, the following things take place;

i. The internal intercostal muscles contract pulling the rib cage downwards and inwards.

ii. The diaphragm domes (arcs upwards) due to the relaxation of its muscles.

These two movements outlined above reduce the volume of the chest cavity. This in turn increases air pressure within the lungs. This in turn increases air pressure within the lungs. Air therefore rushes out from the lungs where pressure is high into atmosphere where pressure is low. This is mechanism of exhalation.



Lung capacity

This is the volume of air when the lungs are inflated. This is 5 litres of air in a normal adult person.

Breathing can be;

a. Normal as when one is sitting still or sleep.

b. Deeper, as when one is voluntarily chooses to stop breathing and then resumes.

c. Breathing during exercise.

During normal breathing, 0.5l of air is exchanged between the lungs and atmosphere. This 0.5l is called **Tidal air**.

During deeper breathing, an additional 1.5l of air to tidal air that is, 2l is exchanged between the atmosphere and the lungs. The additional air to tidal air that is taken into the lungs during deeper breathing is called **Complemental air.**

The additional air to tidal air is taken out of the lungs during deeper breathing is called **Supplemental air**. Complemental air is equal to supplemental air and this is 1.5l.

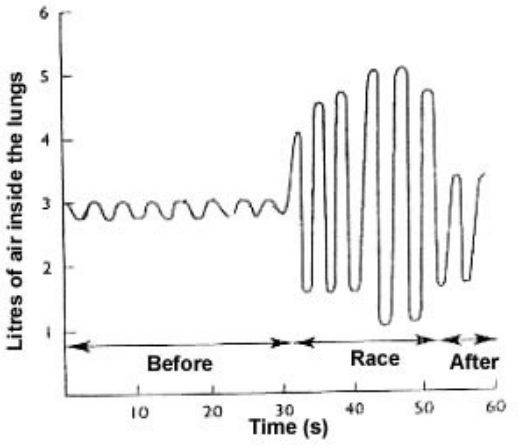
During an exercise, an additional 3l of air to tidal air that is 3.5l is taken into and out of the lungs. This volume of air (3.5l) is called **Vital capacity**.

Therefore, no matter how hard one breaths, there is some air 1.5l that remains in the lungs. This volume of air is called **Residual air.** Residual air prevents the lungs from collapsing thereby preventing their inner walls from sticking together.

Breathing rate

This is the number of complete breaths per minute. A complete breath consists of one inhalation and one exhalation.

The average breathing rate of a normal adult person when at rest is 18 breaths per minute. During an exercise the breathing rate increases to 27 breaths per minute.



To find out the number of breaths per minute we do calculations involving simple proportions.

Regulation of breathing

The medulla oblongata regulates breathing. At the base of the medulla oblongata is centred by the structure called **Hypothalamus** which detects concentrations of carbon dioxide in blood passing through it. When carbon dioxide concentration is high the hypothalamus informs the medulla oblongata which in turn sends off nervous impulses to the intercostal muscles and the diaphragm to contract and relax faster, thereby increasing the rate of breathing. This removes the carbon dioxide faster.

Effects of exercise on breathing

i. Increases the rate of breathing.

ii. Depth of breathing increases causing the carbon dioxide to be removed more quickly from the blood.

iii. Amount of carbon dioxide exhaled increases since concentration of carbon dioxide in the blood increases.

iv. Amount of oxygen taken into the body increases for aerobic respiration.

v. The amount (volume) of residual air decreases during breathing since breathing becomes much deeper.

Experiment

Describe an experiment that could be carried out to investigate the effect of exercise on breathing rate in human beings.

Procedures

- Take the stop watch to record the number of breaths per minute.
- Count the number of breaths per minute of a fellow student at rest.
- Tell your fellow student to jump up and down or run for one minute.
- Then find his/her breathing rate soon after the one – minute exercise.

Expected results

Account for the difference in the two rates, that is, at rest and after exercise.

Conclusion

During exercise breathing becomes deeper and faster since more oxygen is taken in during inhalation and is allowed to dissolve in the blood, which supplies it to the active muscles for production of energy.

Note

each lung is surrounded by a pleural cavity called **a pleural membrane.** This membrane produces fluid called **pleural fluid**. The fluid acts as lubricant that greatly reduces friction between the lung and chest cavity (thoracic wall) during breathing movement.

Carbon monoxide poisoning

Carbon monoxide poisoning occurs due to poor ventilation within an enclosure such as a room with all windows closed with burning fuels, e.g. charcoal or firewood.

Oxygen supply is cut off and this brings about incomplete combustion (burning) which leads to buildup of carbon monoxide. Haemoglobin readily combines with carbon monoxide.

Carbon monoxide is then transported to the brain where it blocks the blood

capillaries thereby cutting off oxygen supply to the tissues. Besides the fact that haemoglobin transports carbon monoxide, less oxygen is carried by it hence the brain is deprived off of oxygen.

The individual eventually falls into a coma from which he never wakes up again.

First aid for carbon monoxide poisoning

- Provide mouth – to – mouth resuscitation in case of mild case.
- Take the patient to the hospital.

Prevention for carbon monoxide poisoning

Ensure that the room is well ventilated whenever fuels are burning that is, always keep the windows open for free flow of air.

Effects of smoking on human health

i. **Respiratory infection**
The upper respiratory tract such as bronchi and bronchioles and lungs become infected by disease causing micro-organisms.

ii. **Lung cancer**
Tar in cigarette contains chemicals which include carcinogens, the substances that cause cancer. Tar collects in the lungs as tobacco smoke cools.

iii. **Harm to foetus**
Pregnant women are always advised not to smoke. The chemicals in cigarette smoke enter the mother's bloodstream and reach the developing baby across the placenta.

iv. **Addiction**
This is when a person is abnormally tolerant to and dependent on smoking that is psychologically or physically habit – forming.

Abnormal conditions associated with respiratory system

Asthma

Asthma is usually caused by an infection or allergic reaction that affects the smooth muscle and glands of the bronchioles. Allergens include foods and inhaled substances such as dust and pollen. Wheezing and dyspnea – difficult breathing) characterize an asthma attack, which may range from mild to fatal.

As part of the allergic response, the smooth muscle of the bronchioles constricts. Because there is no cartilage present in their walls, the bronchioles may close completely. The secretion of mucus increases, so the constricted bronchioles may become clogged or completely obstructed with mucus.

Bronchitis

The smoke stops the cilia in the air passages from beating and so the irritant substances in the smoke and the excess mucus collect in the bronchi. This leads to the inflammation known as bronchitis.

Over 95 per cent of people suffering from bronchitis are smokers and they have a 20 times greater chance of dying from bronchitis than non-smokers.

Pulmonary TB

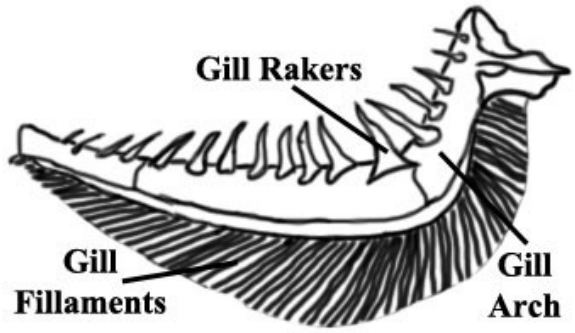
It is contagious bacterial infection that involves the lungs. It may spread to other organs.

It is spread by breathing in air droplets from cough or sneeze of an infected person. The risk of this disease increases with poor nutrition and overcrowding conditions.

Respiratory system of fish

Fish uses gills as the respiratory system, that is, for breathing in fish.

Structure of gills in fish



Gill arch (bar)

This is a thin bar bone of gill that supports the gill.

Lamellae (gill filament)

This is a thin and soft flap of tissue where gas exchange takes place by diffusion.

Gill rakers

These trap dirt particles and stop them from clogging up the lamellae.
They also filter out food particles from the water as it passes over them.

Functions of water that enters the mouth of fish

i. **Renewal of oxygen** to the fish since concentration of oxygen in the water is higher than in the blood in gills. Hence oxygen diffuses from water into the gill lamellae.

ii. **Removes carbon dioxide** away from the fish, since concentration of carbon dioxide in the blood is higher than in water. As such, carbon dioxide diffuses from the gill lamellae into the water.

iii. **Provides food** to the fish. The water contains food particles that are filtered by gill rakers as water passes over them. The food particles move to gullet of fish for digestion.

iv. **Used for drinking** to control all metabolic processes in fish and medium of chemical reactions in fish.

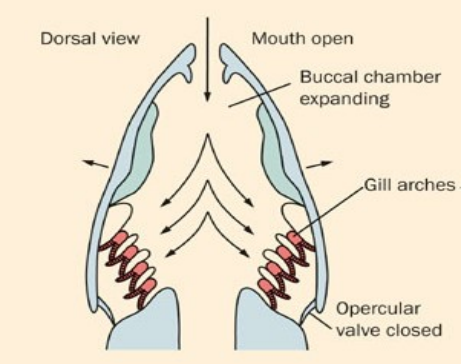
v. **Assists in locomotion** in fish to move forward as water flows out through opercula opening. This produces reaction that provides a push on to the fish.

Breathing mechanism in fish

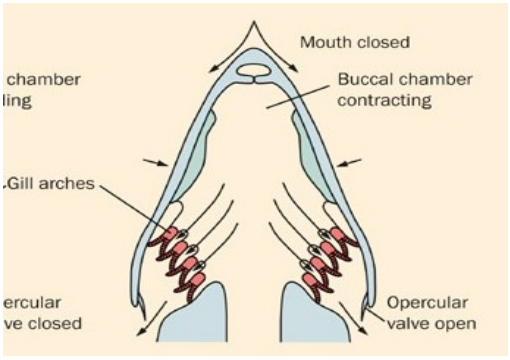
Fish uses gills for breathing. The fish sucks water through its mouth. As water passes over the lamellae, dissolved oxygen diffuses into the blood through the capillary network. At the same time carbon dioxide diffuses out of the blood and is carried away in the water current.

Exchange of gases is achieved because of the opposite flow of blood through lamellae and the flow of water over the lamellae.

Inspiration occurs when fish opens its mouth; this increases volume of buccal cavity and reduces pressure inside it. Water flows in through the open mouth and over the gills.



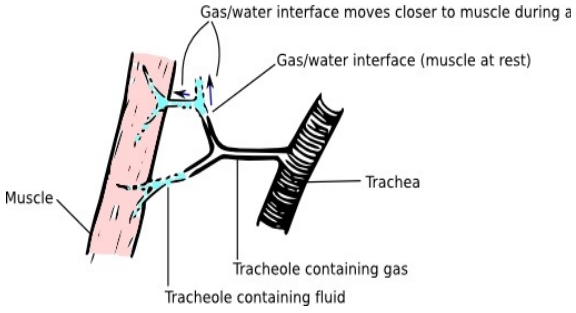
Expiration occurs when fish closes its mouth, this reduces volume of buccal cavity and increases the pressure inside, and then water is forced out through operculum, as it flows over the gills.



Adaptations of gills for diffusion of gases

i. Have dense network of blood capillaries.
ii. Have large surface area.
iii. Their gill lamellae are thin, only one cell thick.
iv. Are moist.

Respiration in insects



Spiracles

These are tiny holes through which air enters the body of an insect. These holes are found in thorax and abdomen of an insect.

Tracheae

The spiracles open into tubes called tracheae. Tracheae are supported by a spiral of chitin that keeps them open to allow free entry of air.

Tracheoles

These are narrower branches that run from trachea. Tracheoles lead the air directly into tissues of the insect. Tracheoles are therefore places of gas exchange in the insects.

Tracheoles do not have chitin in their walls but they have thin walls for easy diffusion of gases. Their ends are filled with fluid – moisture content that dissolves oxygen.

Gas exchange in insects

From thin walls of tracheoles, as oxygen dissolves, it diffuses across the membrane from the air in tracheoles into tissues of insect and carbon dioxide diffuses out of tracheoles into atmosphere.

The blood in insects is colourless and do not have haemoglobin to carry oxygen. However, this blood transports food substances and waste matters.

The structure of respiratory system in insects forms **tracheal system**.

Adaptations of tracheal system to its function

i. Are supported by spiral of chitin.

ii. Have thin walls.

iii. Their ends have fluid filled – moisture content.

Review questions

1. State the role played by each of the following structures during inspiration.

   i. Diaphragm

   ii. Intercostal muscles (**2005 Maneb**)

2. Mention any two effects of smoking on human health. (**2012 Maneb**)
3. State any two effects of exercise on breathing. (**2012 Maneb**)
4. During winter, a farmer decided to light a charcoal burner to warm calves in a modern cattle khola. Before the charcoal completely got burnt, it was taken into the khola which had its windows closed. The following morning the calves were found dead. In an essay form, explain the steps that led to the death of the calves. (**2011 Maneb**)

Topic 12 Excretory system

Excretion

Excretion is the removal of metabolic wastes from the body of an organism.

The system of organs that get rid of the metabolic wastes is known as **excretory system**.

Metabolism

These are cell activities aided by energy produced by oxidation of food substances.

All metabolic wastes are drawn from tissues. For this reason, **defaecation** is not an example of excretion because *faeces are not drawn from the tissues.*

Secretion is also different from excretion because it produces substances from cells and fluids within gland or organs of the body and releases them.

Excretory organs

These are organs that get rid of metabolic wastes (excretory product).

Skin removes water and mineral salts (sweat).

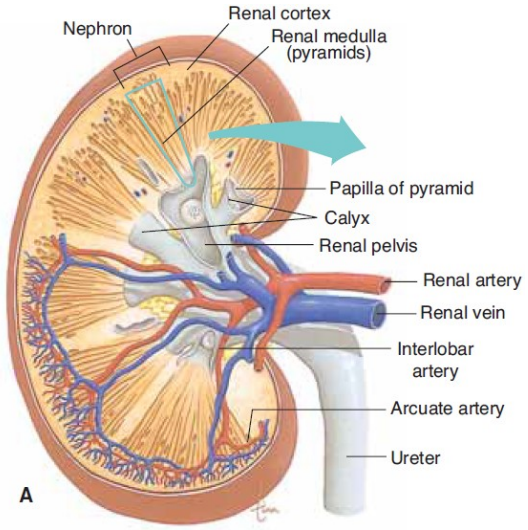
Lungs remove carbon dioxide and water vapour.

Liver removes bile pigment called bilirubin that results from destruction of red blood cells.

Kidneys remove urea, water, uric acid and mineral salts in form of urine.

> **Note**
>
> The kidney is the largest excretory organ.

Parts of a kidney



Cortex

- A lighter outer layer of a kidney.

Medulla

- A dark inner area of a kidney. The medulla is connected to the ureter.

Pelvis

This is the expanded portion of the ureter within a kidney. It is where urine is discharged before passing into the ureter.

Ureter

This is a tube that connects and allows urine to travel from each kidney to the

urinary bladder. Ureter carries urine from the kidney to the urinary bladder.

Renal vessels

- Renal artery carries oxygenated blood and supplies it to each kidney.
- Renal vein carries deoxygenated blood away from the kidneys.

> **Note**
>
> There are two kidneys in human being and many other mammals. These are reddish, bean – shaped organs situated towards the back of abdominal cavity.

Functions of the kidneys

i. Excretes the nitrogenous wastes.
ii. Controls the concentration of mineral salts in the blood.
iii. Controls the amount of water in the blood.
iv. Removes any substances produced in abnormal metabolism.
v. Maintains the alkalinity of the blood at **P^H** 7.4.

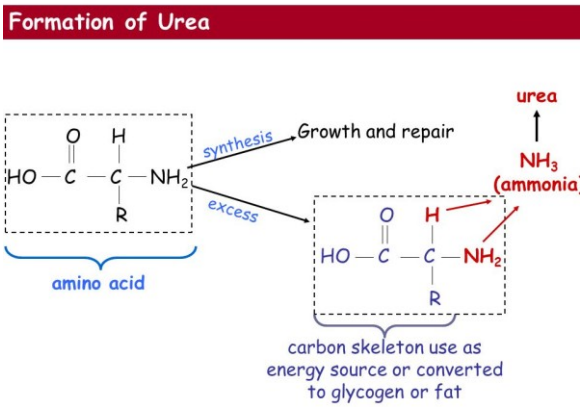
Excretion of urea in human being

When the proteins are eaten, digestive enzymes break them down into amino acids. The amino acids are absorbed into the blood capillaries in the villi in ileum and amino acids are carried by blood through **hepatic portal vein.**

The liver allows some of the amino acids to carry on in the blood to other parts of the body. Any excess amino acids are deaminated into amino group by the liver.

The amino group of each amino acid is converted to ammonia (NH_3) which reacts with carbon dioxide to finally form **urea**. The urea is sent to the kidneys for excretion.

The part of amino group containing the energy is kept and turned into carbohydrates or fat and stored for future use.



Nephron

Nephron is a basic functional and smallest unit that consists of long tubule in the kidney.

Each kidney contains about one million nephrons.

The nephron contains a network of capillaries called a **glomerulus**, enclosed in a cuplike capsule called **Bowman's capsule**. The capsule is linked to a long coiled tubule.

The tubule winds and turns double back. Finally it leads to a collecting duct. About twelve nephrons share one collecting duct that opens into the ureter.

Regions of the tubule of a nephron

The tubule consists of three regions namely;

Proximal convoluted tubule

First convolution after a capsule and it is coiled.

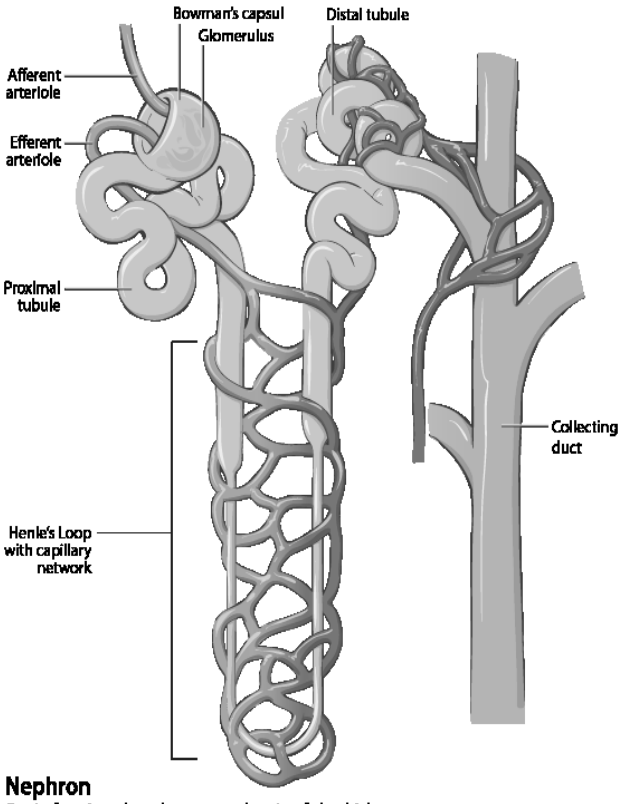
Loop of Henle

It is U – shaped region.

Distal convoluted tubule

Second convolution after the U shaped region.

Structure of a single nephron



Nephron
Basic funtional and structural unit of the kidney

Functions of the nephron

Filtration

The great pressure of blood in the glomerulus forces some substances to diffuse out of blood into Bowman's capsule. These substances include glucose, amino acids, fatty acids and glycerol, mineral salts, hormones, antibodies, water, urea, uric acids and toxins. This stage of the process is called **filtration**.

Selective Reabsorption

As substances in Bowman's capsule flow through the tubule, only important substances such as glucose, amino acids, fatty acids and glycerol, some water, salts, hormones and antibodies are

reabsorbed by **active transport** into the capillaries surrounding the tubule.

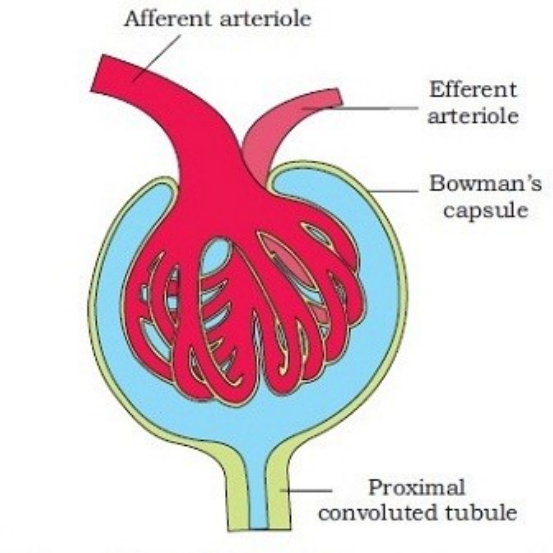
Tubular secretion

Tubular secretion occurs in the second (distal) convoluted tubule. Blood P^H must be between 7.35 and 7.45.

Mineral ions such as K^+, H^+ and HCO_3^- are either reabsorbed or not in this part in order to control the P^H of the blood.

How urine is formed in the kidneys of the human body

Urine formation in the kidney occurs in the nephron. Urine is formed by **filtration** and **selective reabsorption**.



The blood vessel that carries blood to the glomerulus is wider than that carries blood away from the glomerulus.

This creates high blood pressure in the glomerulus which squeezes the blood against the walls of capillaries since they are **semi – permeable**. The great pressure forces small molecules of substances in blood to pass across the walls of Bowman's capsule into the tubule. This is process of filtration.

The filtrate moves along the tubule. The only important substances are selectively reabsorbed into the bloodstream from the tubule. This process takes place in the proximal convoluted tubule and ends in the loop of Henle.

Exactly the right amount of water and salt ions are reabsorbed in the collecting duct to give blood its correct composition. The remaining fluid in the collecting duct is mostly water with some mineral salts, uric acids, toxins and urea dissolved in it, thus forming **urine**.

Percentage composition of human blood and urine

Substance	Blood %	Urine %
Water	90	96
Protein	9	0
Glucose	0.1	0
Urea	0.03	2
Uric acid	0.003	0.05
Creatinine	0.001	0.1
Chloride	0.37	0.6
Sodium	0.35	0.35→0.6
Potassium	0.02	0.15

Urea is an organic chemical and it is excreted in large quantities because it is waste product from amino acids and therefore contains nitrogen atom which is not needed in the human body.

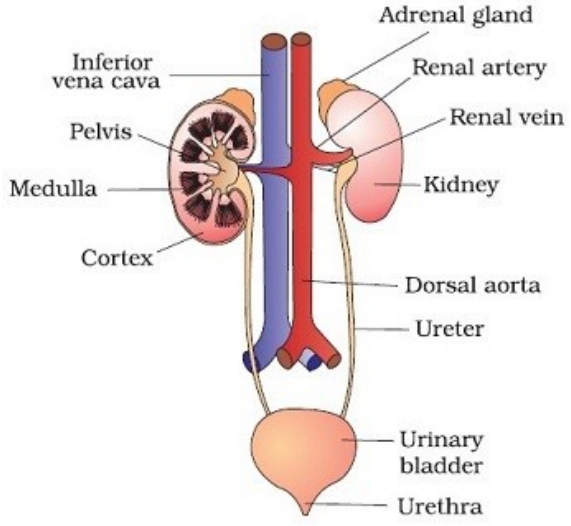
Glucose and **protein** are completely absent in urine of a healthy person.

Differences between the blood flowing in renal artery and renal vein

Renal artery	Renal vein
Contains more urea	Contains less urea
Contains more glucose	Contains less glucose
Contains more oxygen	Contains less oxygen
Contains more water	Contains less water
Contains less carbon dioxide	Contains more carbon dioxide

Micturition

This is process of urination in human beings and other mammals.



The kidneys produce watery liquid called urine which contains other substances such as urea that comes from liver. The urine passes along the collecting ducts of the kidney into the ureters which pass to the urinary bladder.

When the urinary bladder is full of urine, it expands as a balloon. The top of urethra is surrounded by the ring of muscle called **sphincter muscle** which contracts to squeeze the tube to empty the urine.

Normally, the sphincter muscle is tightly contracted, so urine cannot get out of the urinary bladder unless is completely filled with urine.

The role of antidiuretic hormone in osmo – regulation

Osmo – regulation is the vital control of water contents in the blood. The control of water balance occurs in the kidney.

Osmo – regulation is an example of the **homeostasis**. Control of the water content in the blood is maintained by the hypothalamus of the brain, thus continuously detects the concentration of the blood.

Antidiuretic hormone (ADH) is secreted by the pituitary gland. When the blood passing through brain is too concentrated, the hypothalamus causes pituitary gland to secrete the hormone ADH. This hormone dissolves in the blood plasma.

When it reaches the kidneys, this hormone causes the kidney tubule to absorb more water from the glomerular back into the blood. Thus urine becomes more concentrated and little.

When the blood passing through the brain is too diluted, the pituitary gland suppresses the production of ADH and little water is absorbed from the glomerulus. Kidneys keep blood at

constant osmotic pressure to prevent unnecessary movement of water.

Kidney failure

This is a condition in which a kidney of a person fails to function properly.

Causes of kidney failure

1. **Accident:** this involves a drop in blood pressure. Takes more than two weeks, the patient may die as a result of potassium (K^+) ions imbalance in the blood thus also causing heart failure.
2. **Kidney disease:** in case of kidney disease, the patient with one kidney can survive with only that one kidney.

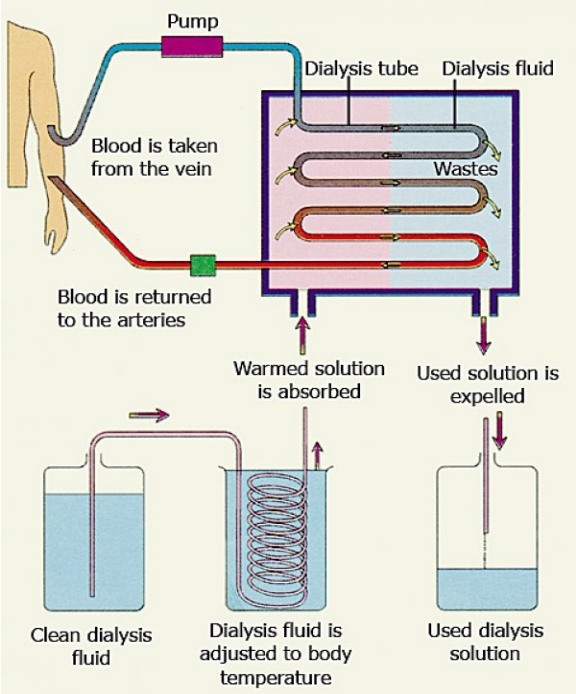
Treatment of kidney failure includes;

a. **Dialysis machine** (artificial kidney)
b. **Kidney transplant**

The dialysis machine

A dialysis machine consists of a long cellulose tube coiled up in the water bath.

The patient's blood is led from an artery in the arm and pumped through the cellulose (dialysis) tubing and then turned to the vein in the arm of the patient.



The patient is hooked up to a dialysis machine every 2 – 3 days. The dialysis machine is similar to the functioning of the kidney.

The dialysis fluid is constantly changed to:

- Prevent the accumulation of unwanted solutes in it.
- Maintain a high diffusion gradient.

The patient's blood and dialysis fluid move to opposite directions in the dialyzer to prevent such accumulation of unwanted solutes.

Adaptations of dialysis machine to its function

1. Long and narrow

It consists of a long cellulose tube coiled up in the water bath. This increases large surface area to a volume ratio to increase the rate of diffusion.

2. Semi – permeable membrane

The submicroscopic pores in the dialysis are semi – permeable to allow small molecules such as salts, glucose, and urea to leak out into the water bath.

3. Contents of sugar and salts

The liquid in the water bath consists of a solution of **sugar** (**glucose**) and **salts** which have **same concentration** to those of blood.

As such, glucose and salts do not diffuse out of the blood because of same concentration in the dialysis fluid and blood.

4. The dialysis fluid is warmed

Close to blood temperature which increases the rate of diffusion.

5. Presence of pump

It has **roller pump** to push blood through the dialyzer.

6. Concentration of waste products in blood

There is **higher concentration of waste products in blood** than in dialysis fluid hence waste products diffuse into dialysis fluid.

Kidney transplant

The kidney transplant requires to find enough suitable donors of healthy kidney and to prevent kidney from being rejected.

Kidney transplant involves surgically removal of diseased kidney and replace it with suitable kidney.

The problem with rejection is that the body reacts to any transplanted cells or tissues as it does to all foreign proteins and produces lymphocytes which attack and destroy them.

The rejection can be overcome by;

1. Choice

Choose a donor whose tissues are similar to those of the patient, e.g. close relative.

2. Immunosuppressive drugs

They suppress the production of lymphocytes and their antibodies against transplanted organ.

Effects of eating and drinking habits on the kidneys

- Excess intake of protein from meat causes kidney stones.
- Excess intake of salts in form of calcium raises blood pressure which may cause damage to nephrons of kidney.
- Excess intake of carbonated beverages increase risk of disease of kidney.
- Eating genetically modified food causes kidney toxicity.
- Excess intake of caffeine in tea, coffee may cause chronic kidney diseases.

Problems associated with excretion in the kidneys

1. **Diabetes Mellitus:** this is the condition in which glucose is present in urine.

2. **Nephritis**: this is a condition in which protein is present in urine. This may lead to blockage of ureters.

Revision questions

1. A dialysis machine is an artificial kidney which is used when a person has kidney failure.
   a. How is the loss of glucose and other important substance from the blood prevented when a patient is on the dialysis machine?
   b. State **one** similarity between the dialysis tube and the tubule of the nephron.
   c. Name **two** substances which diffuse out of the dialysis tube when it is in operation. (**2004 Maneb**)
2. a. (i) Name the main nitrogenous waste excreted by kidneys.
   (ii) Describe how the nitrogenous waste mentioned is formed.
   b. Name **two** substances found in blood plasma that are not found in the urine of a healthy person. (**2012 Maneb**)
3. Describe how nitrogen atoms eaten in a bean meal can eventually be excreted in urine. Write your answer in an essay form. (**2002 Maneb**)
4. Describe how urine is formed in the kidneys of the human body. Write your answer in an essay form.

(2010 Maneb)

Topic 13 Coordination

Co – ordination

The various physiological processes in living animals are all very closely linked and dependent on each other.

Coordination is the linking together in time and space of various physiological processes and activities.

Types of co – ordination

Co – ordination is effected by the;

a. Nervous system
b. Endocrine system

Nervous system

It is a series of conducting tissues running to all parts of the body.

Composition of nervous system

Central nervous system is composed of the brain and the spinal cord.

Peripheral nervous system is branching network of the nerves linking the brain and spinal cord with all parts of the body.

Autonomic nervous system, include nerve centres that control vital processes such as blood circulation and digestion.

Characteristics of nervous system

Composition; is made up of nerve cells

Structure; consists of nerve fibres such as *dendrons* and *axons* which have special property of transmitting electrical impulses very rapidly.

Function; control reflex actions.

Functions of the nervous system

- **detection** of changes and feel sensations
- **response** initiate appropriate responses to changes
- **organization** of information for immediate use and store it for future use

Neurons

Neurons are nerve cells that contain small masses of cytoplasm with a central nucleus.

Thus, a neuron is a basic functional unit of the nervous system.

> The central nervous system and peripheral nervous system are made up of neurons.

How does the neuron function

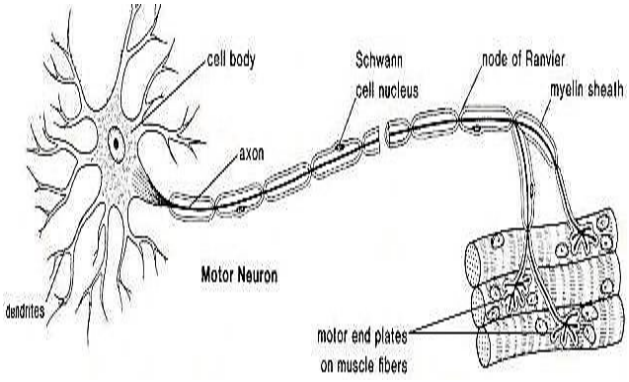
Transmission of nerve impulses is carried from one part of the body to another.

These impulses are **electrical** in nature and are conducted along the neurons.

Neurons usually transmit impulses in one direction only.

Note

The axon builds up within itself an electrical charge which is released when nerve is stimulated and has to be built up again before the next impulses can pass.

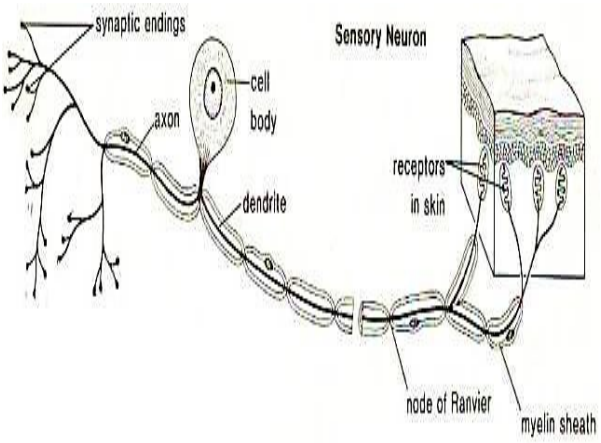


Types of neurons

Sensory neuron;

These are neurons that carry impulses from receptors (sensory organs) to the brain and spinal cord.

Sensory neuron has cell body that lies along its length (fibre).



Motor neuron

These are impulses that carry impulses from the brain and spinal cord to the effectors such as muscles and glands.

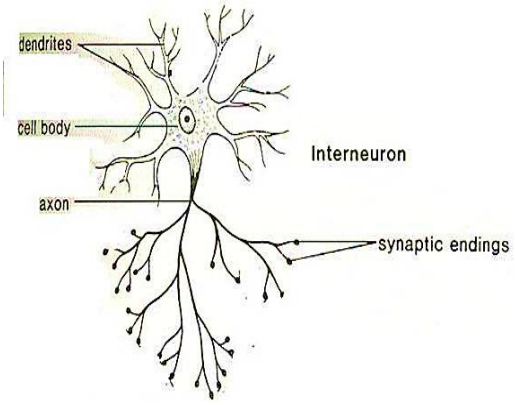
Motor neuron has cell body that lies at the end of its fibre.

Relay neuron

These are neurons that relay impulses from the sensory neurons to the motor neurons. As such, relay neurons are linking neurons which are also called association or multipolar neurons.

They are numerous in the brain and spinal cord.

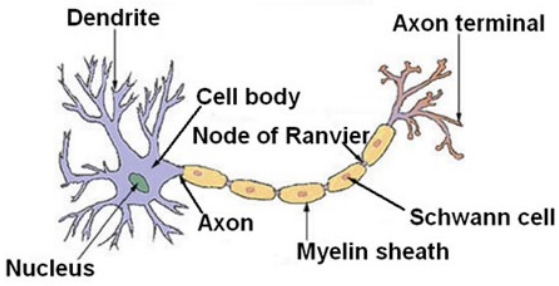
These neurons lack myelin sheath.



Direction of impulses in neurons during movement

Impulses move from dendrites of sensory neurons to the dendrites of relay neurons on the side before the cell body. Then impulses move from the dendrites on the other of the relay neuron after the cell body to the dendrites of the motor neuron.

Structure of a typical neuron



Functions of parts of a neuron

1. Cell body

This is an enlarged portion of the neuron. It controls the metabolism of the nerve cell since it contains organelles.

2. Dendrites

These are thin branched extensions of the cytoplasm of the cell body. They receive information from other cells.

3. Dendron

This is a nerve fibre that conducts impulses towards the cell body.

4. Axon

This is a long fibre which carries information away from the cell body sometimes over long distances.

5. Myelin sheath

This is a fatty layer that encloses many nerve fibres. It is made up of fats.

- It insulates the axon between close cells.
- It speeds up the transmission of impulses.

6. Node of Ranvier

These are small gaps in the myelin sheath of medullated axons.

It allows rapid conduction of impulses by forcing them to jump from one node to the next.

Synapse

The small gap or space between the axon of one neuron and the dendrites of cell body of the next neuron is called the **synapse**.

It is a **microscopic** gap existing between two neurons where terminal branches of the axon of the one neuron lie very close to dendrites of adjacent neurons. Thus, shows the area of junction between two neurons.

Significance of synapses

1. Important in reflex actions

- Effective for other muscles in the body.
- Send impulses to the brain from spinal cord.

2. Pass nerve impulse

- From one neuron to another.

Transmission of impulses across synapse

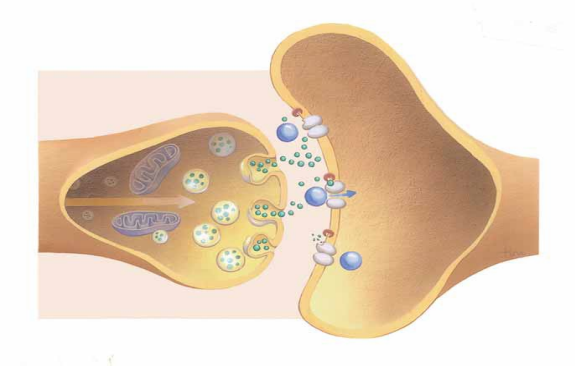
The impulse is transmitted by the secretion of a chemical into a microscopic space which exists between the termination of the fibre and the membrane of the cell body.

Within the synaptic knob (terminal end) of the presynaptic axon is a chemical neurotransmitter such as **acetylcholine** that is released into the synapse by the arrival of an electrical nerve impulse. An influx of Ca^{2+} causes synaptic vesicles

containing neurotransmitter to fuse with presynaptic membrane.

The **neurotransmitter** diffuses across the synapse, combines with specific receptor sites on the cell membrane of the post – synaptic neuron, and there generates an electrical impulse that is, in turn, carried by this neuron's axon to the next synapse, and so forth.

A chemical ***inactivator*** at the cell body or dendrite of the post – synaptic neuron quickly inactivates the neurotransmitter.

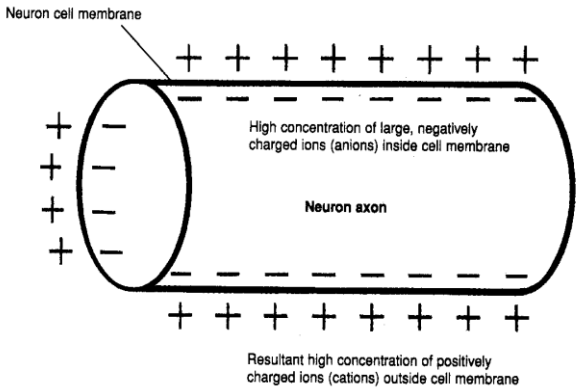


Transmission of nerve impulses along the axon (nerve conduction)

The axon of the neurons in a resting condition has a difference in **electro-charge** between the inside and outside. The outside is positive and the inside is negative.

The cell membrane is **more permeable** to potassium ion than to sodium ion, so that the K^+ which is more concentrated inside the cell diffuses outward faster than Na^+ which is more concentrated outside, diffuses inward. K^+ and Na^+ move through the membrane using different channels.

The **inflow** of sodium ions makes the inside positive and the outside negative. As a result a nerve impulse is generated.



The neurons recover when sodium ions are pumped out so that the charge difference is restored.

Reflex action

It is an automatic rapid and immediate response of the body to a stimulus.

Reflex actions are simply called reflexes.

Categories of reflex action

Brain reflexes

These are reflexes controlled by the brain.

Examples of brain reflexes;

Blinking, coughing, salivation, swallowing and contraction of the pupil of the eye.

Spinal reflexes

These are reflexes controlled by the spinal cord.

Examples of spinal reflexes;

Knee jerk and ankle jerk

Note

Withdrawing a hand from a hot object is reflex action controlled by both brain and spinal reflexes.

Reflex arc

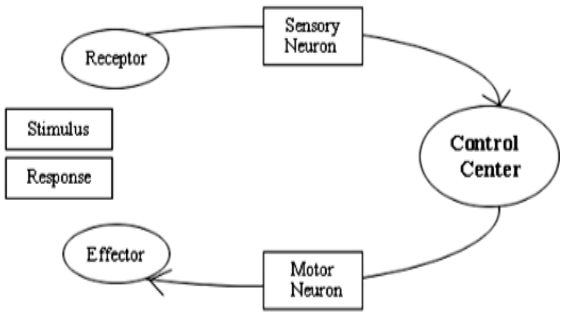
This is the pathway taken by the impulse involved in a reflex action.

The pathway is made up of five parts.

Receptors receive stimulus when one unexpected touches a hot object, the hand is rapidly removed from the source of heat. Heat or pain receptors in the skin are stimulated and fire off impulses which travel along the sensory fibres. The **sensory fibres** enter the **spinal cord** through the dorsal root.

In the grey matter of the spinal cord, the impulses pass from the sensory neuron to a **relay neuron** across a synapse. The relay neuron in turn, makes synapse with motor neurons. The impulses are thus transmitted to the motor fibres which leave the spinal cord through the ventral root and pass in a nerve travelling to a muscle to give response to a stimulus.

Summary diagram



Reflex action takes place when nerve fibres conduct impulses passing in the reflex arc up the spinal cord and brain.

Significance of reflex action

It ***protects*** and ***prevents*** body parts and tissues from damage.

The human brain

The **brain** is an enlarged and specialized front region of the spinal cord.

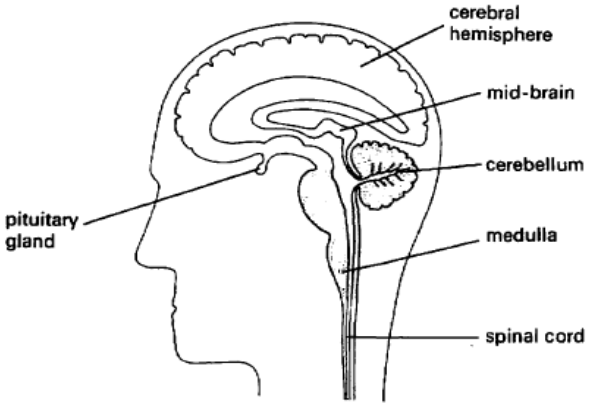
It is an organ that controls most of the body activities.

The human brain is enclosed within part of the skull called **cranium**. It is surrounded by two membranes with a fluid in between them called **cerebral spinal fluid**.

Cranium – protects the brain from external physical forces.

Cerebral spinal fluid – is formed from two masses of fine blood capillaries called plexuses.

The cerebral spinal fluid acts as shock absorber thereby protecting the brain from external physical forces.



Parts of a human brain

Cerebrum

It is the largest and foremost part of the brain.

Cerebrum is composed of two identical halves called cerebral hemisphere that are joined by a band of nerve fibres called corpus callosum.

Cerebrum has two layers;

a. Grey matter – outer layer which is also called cerebral cortex. This layer is highly folded.
b. White matter – inner layer.

Important factors that increase surface area of the cerebrum

- Large size
- High folding of grey matter

Functions of cerebrum

- ***Control*** – speech, emotions, memory and intelligence.
- ***Sensation*** – smell, vision, taste hearing and touch.

Cerebellum

It is mid part of the brain.

Function of this part;

- **Control and coordination** – balancing organs, muscles as well as postures.
- **Maintenance** – muscle tones for balance.

Medulla Oblongata

It is the hind most and smallest part of the brain.

In the medulla oblongata there is a structured located in it called ***hypothalamus***.

Hypothalamus

It is sensitive to;

- Carbon dioxide concentration
- Temperature changes in the blood.

The hypothalamus enables medulla oblongata to control many vital processes such as;

Breathing rate, heartbeat, blood pressure and regulation of body temperature.

Pituitary gland

- Secretes hormones such as Follicle Stimulating hormones (FSH) and Anti – diuretic hormones (ADH).

FSH – regulate development of female gametes.

ADH – control water retention by the kidney.

How do large size and high folding of brain affect complexity and activity of an organism?

- By increasing surface area that accommodates numerous cell bodies.
- The numerous cell bodies increase **complexity** and **activities** possessed by an organism.

People with brain smaller in size and les folded have a fewer cell bodies. Such people are less intelligent and do less complex activities.

Functions of the brain

- **Receiver**: impulses are received from all sensory organs of the body.
- **Sender**: motor impulses are sent to the gland and muscles causing them to function properly.
- **Storage**: stores information so that behaviour can be modified according to past experience.
- **Coordination**: all body activities are coordinated by the brain so that the physical and chemical reactions of the body work efficiently together.
- **Correlation**: the various stimuli are correlated from different sense organs.

The spinal cord

The spinal cord arises from the medulla oblongata and consists of many nerve cells of fibres and cell bodies grouped into cylindrical mass.

The spinal cord is protected external physical forces by

a. Vertebral column (spine)
b. Cerebral spinal fluid

There are 31 pairs of spinal nerve connected to the spinal cord.

Each spinal nerve is made up of two groups of nerve fibres namely;

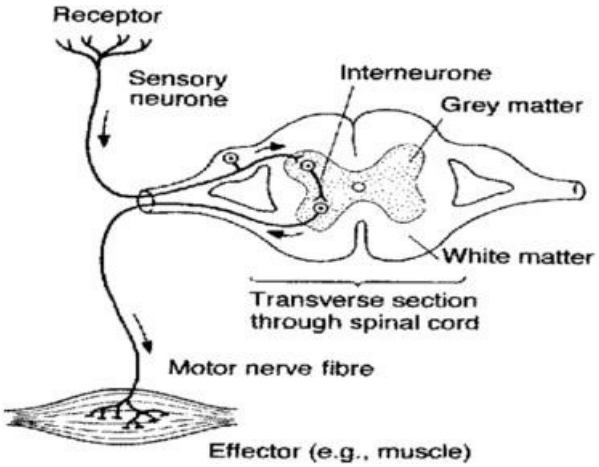
a. Dorsal (sensory) root

   It is made up of sensory neurons that bring impulses in from receptors.

b. Ventral (motor) root

   It carries impulses out of the spinal cord to the effectors.

Parts of a spinal cord



White matter

It is concentrated with nerve fibres and is outer region of the spinal cord.

Grey matter

It is concentrated with cell bodies of neurons.

Ganglion

It is a budge made by the cell bodies of sensory fibres in the dorsal root.

Neural canal

This is a passage of the spinal cord. It is filled with cerebral spinal fluid that brings nutrients to the brain and acts as shock absorber.

Functions of spinal cord

- **Conduction**
  - Sensory impulses are conducted from skin and muscles to the brain.

- Motor impulses are conducted from the brain to the muscles of the trunk and limbs.

- **Control** – reflex action involving body structures below the neck.

Conditioned reflex

It is reflex that is acquired through training and past experience.

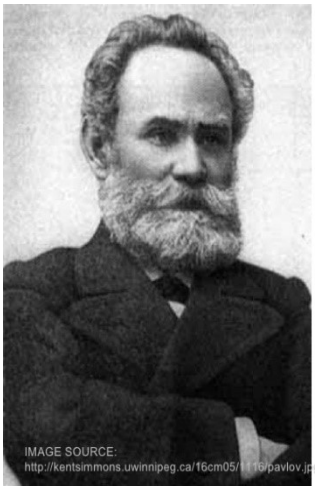
Examples of conditioned reflex

- Salivation of dogs upon food
- Walking
- Riding a bicycle
- Crying
- Fearing from danger
- Speaking different languages
- Hitting a target

Main steps involved in conditioning an organism

i. The original stimulus is presented, the related response is made.
ii. The substitute stimulus is presented together with the original stimulus; the same response as before is made.
iii. The substitute stimulus is now presented alone; the same response as before is still made.

Ivan Pavlov made an illustration on conditioning an organism.



IVAN PAVLOV

- physiologist known for classical conditioning.
- EXPERIMENT: Involves a food, a dog and a bell

How conditioned reflex develops

The conditioned reflex is acquired in the first place by **concentration** and **practice**. Without association centres, conditioned reflex and learning would not be possible.

Conditioned reflex to be made possible, all impulses relay to the **association centres** and according to the strength of stimulation and past experience are ‘‘stored’’ in the brain.

Uses of conditioned reflex

- Protection
- Learning or training as well as for survival.

Investigations on coordination

This involves carrying out experiments on coordination.

Experiment requires procedures, expected results and conclusion.

Procedures – established or correct methods of doing something. Methods are established from the materials required.

Expected results are what observed in an experiment.

A **conclusion** is a summary of what have been observed. It explains what happens in the observation.

Experiment 1

Effects of time of a day on memorizing a list of words

Materials

- Textbook, student, stop watch and experimenter.

Procedures

- Let the student collect the textbook for memorization.
- Tell the student to start studying the list of words for the maximum time of 2 hours.
- The experimenter or supervisor should set questions from the list of words the student has memorized and give them to the student. Observe how he or she performs.
- Repeat the steps but for this time with maximum of 6 hours and observe how he or she performs.

Expected results

The marks that the student will get will be different depending on the time he/she spends on memorizing a list of words.

Conclusion

The more time you spend on memorizing a list of words, the more the brain stores information so that memorization can be modified according to past experience.

Experiment 2

Effects of practice on hitting target

Materials

- Target area, target range, object to be hit, throwing object and experimenter.

Procedures

- Measure the distance of about 5 metres and mark the target area.
- Place an object to be hit on the target area.
- Start throwing object onto the target area to hit the targeted object. Every round of throwing should have maximum time of 10 minutes.
- Repeat step 3 using round 2 up to 4.
- Record the number of times you hit the targeted object against each round.

Expected results

Compare the number of times from round 1 to 4. You expect that fourth round will have highest number of times you hit the targeted object.

Conclusion

This shows that the more you practise hitting the target, the more chances you make.

Drug

It is any substance that changes the normal function of the body. These drugs include alcohol and Indian hemp.

Effects of alcohol on central nervous system

- It leads to loss of self – control and reduction of psychology.
- It reduces one's attention and dulls one's judgement.
- It causes the body to lose heat. A drunken person can freeze to death more quickly from exposure to extreme cold.

- It may lead to dehydration of the body.
- It causes muscular incoordination and general nervousness.

Indian hemp (marijuana)

- It speeds up the action of the brain and makes the person more alert.
- It makes a person become addicted.
- It damages brain cells by killing them.

Problems associated with the nervous system

Polio

The polio virus attacks some of the motor nerve cells in the spinal cord of the patient.

As a result, some impulses do not reach the effector muscles attached to the skeleton. The effector muscles become inactive and prevent proper developments of the bones on which muscles are attached.

Mode of transmission

Through faeces, nose and throat secretions.

Symptoms – Fever, Headache, neck stiffness, muscle and withered legs.

Prevention

- Vaccination (Sabin and Salk vaccine).
- Hygiene.

Meningitis

This is an infection involving the meninges and brain.

Mode of transmission

- Through direct contact including respiratory droplets.

Symptoms – headache, neck stiffness, cough, vomiting and fever.

Prevention

- Reduce direct contact and exposure to droplet infection.
- Reduce overcrowding.
- Isolate the patient
- Treated by using antibiotics.

Leprosy

Leprosy is a chronic infectious disease of a human being.

Leprosy affects the nervous system and bacillus called mycobacterium leprae prefers the cooler parts of the body such as hands and feet are most often affected.

When nerves are destroyed the affected part becomes anaesthetic and the patient does not feel pain when wounded or burned.

Treatment – use of modern drugs usually taken in tablet form.

Tetanus

Tetanus is caused by an anaerobic bacillus bacterium that forms spores which resist boiling.

The tetanus bacillus is present in soil and dust where it reproduces in deep wounds with insufficient oxygen.

Mode of transmission

- Through a wound where a person is cut with a dirty implement.

Symptoms – uncontrolled contraction of muscles and death.

Prevention

- Vaccination
- Avoid making cuts with dirty implements.
- Give anti – tetanus serum and benzyl penicillin to the child.

Stroke

High blood pressure pushes the walls of the arteries in the brain. When the arteries rupture in the brain, the spillage of blood kills cells in that part of the brain leading to stroke. A severe stroke can be fatal.

Stroke is caused by the following factors;

- over – eating
- drinking too much alcohol
- smoking

Symptoms – impaired speech and paralysis.

Endocrine system

This refers to a group of specialized organs and body tissues that produce, store and secrete chemical substance called hormones.

Endocrine system consists of glands that secrete hormones. As such, it is also called **hormonal coordination**.

Glands

These are various organs that form substances needed by the body and release them through ducts or directly into bloodstream.

Types of glands

Exocrine glands

These glands release their secretion into a duct. The duct carries the secretion to where it is needed.

These glands include;

- Sweat gland
- Salivary gland
- Pancreas

Endocrine glands

These glands release their secretion directly into bloodstream. They do not have ducts; hence they are also called ductless glands.

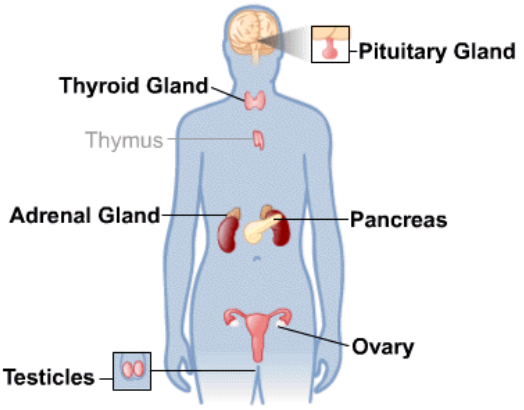
These glands include;

- Pituitary gland
- Thyroid gland
- Adrenal gland
- Ovaries
- Testes
- Pancreas

Note

Pancreas is both exocrine and endocrine gland. Hence it is called **exo- endocrine** gland

Position of glands in human body



Hormones

These are chemicals that transfer information and instructions between cells in an organism.

Since hormones carry information and instructions from endocrine gland to target organs, they are called **chemical messengers.**

Functions of hormones

- **Regulation** of metabolism
- **Control** – growth and development as well as function of various tissues.
- **Support** reproductive function
- **Provision** of resistance to stress.

Types of hormones

With respect to their chemical structure, hormones are classified into three types

Amine hormones

These simple hormones are structural variations of amino acid tyrosine.

Examples

- Thyroxine hormone
- Adrenaline hormone.

Peptide hormone

These hormones are chain of amino acid derivate. They are produced as larger proteins.

Examples

- Growth hormone
- Insulin
- Antidiuretic hormone
- Oxytocin
- Thyroxin

Antidiuretic and oxytocin hormones are synthesized by the hypothalamus.

Steroid hormone

These hormones are synthesized from cholesterol – a fatty substance produced by the body.

These include hormones secreted by adrenal gland, ovaries and testes.

Nature of hormones – water soluble and fat soluble.

How do hormones work?

Endocrine glands secrete hormones as a result of stimulation by changes in the environment of a human being. These changes in the environment are called **stimuli**.

Hormones are secreted directly into blood capillaries. They travel in the bloodstream until they reach their target tissues (organs) where they activate a series of chemical changes.

To achieve this, hormones must be recognized by a specialized protein in the cells of the target organ called **receptor**.

Target organs – are organs affected by particular hormones.

Endocrine glands and their secretions

Pituitary gland

This gland is also called **hypophysis** and is located in the brain near hypothalamus.

Significance of pituitary gland

- It determines the amount of hormone produced by the endocrine glands.
- It stimulates other endocrine glands to produce their own hormones. For this reason, pituitary gland is described as the **master gland** or the **conductor of the endocrine orchestra.**
- It directly influences growth of an individual through its own growth hormone which controls the size of the bones.

Hormones produced by pituitary gland

Growth hormone

- Stimulates the thyroid gland to produce hormone that promotes growth.

  Giantism is abnormal growth when pituitary gland produces too much growth hormone.

  Dwarfism is the permanent retarded growth when pituitary gland secretes too little growth hormones.
- Increases transport of amino acids into cells and increase the rate of protein formation.

Antidiuretic hormone

- Increases the water reabsorption by the kidney tubule into the blood.
- Decreases sweating.

Oxytocin

- Promotes contraction of myometrium of the uterus during labour.
- Promotes release of milk from mammary glands.

Prolactin

- Initiates and maintains milk production by the mammary glands.

Follicle Stimulating hormone

- Stimulate the growth of ovarian follicles i.e. initiates egg development.
- Stimulates secretion of oestrogen by the follicle cells.
- Initiates sperm production within the testes.

Luteinizing hormone

- It is responsible for ovulation.
- Stimulates the follicle to develop into corpus luteum which involves secretion of progesterone.
- Stimulates the cells of the testes to secrete testosterone.

Thyroid gland

The thyroid gland is located on the front and sides of trachea.

Thyroid gland produces thyroxine hormone which controls the rate of metabolism in the body since metabolism uses energy produced by tissue respiration whose rate is controlled by thyroxine hormone.

- Goitre is the swelling up of thyroid gland due to too much secretion of thyroxine hormone. The metabolism speeds up and the person becomes thin.
- Cretinism is a condition which occurs when less thyroxine hormone is secreted.

Adrenal gland

It is found on top of each kidney.

Adrenal gland produces adrenaline hormone that prepares the body for an emergency.

For this reason, adrenaline hormone is described as the **fight** or **fright** hormone.

Adrenaline hormone once secreted has effects on various organs in the body such as heart, liver, muscles of alimentary canal and breathing centre of the brain.

The biological effect of adrenaline hormone is that the whole body tenses up ready for action, i.e.

- Heart beats faster
- Faster and deeper breathing to increase oxygenation of blood and rapid removal of carbon dioxide.
- Muscles of alimentary canal relax to slow down peristalsis and digestion.

Pancreas

Pancreas is an endocrine gland because it secretes two important hormones.

On the pancreas, there are hormone producing cells arranged in small isolated groups called **Islets of Langerhans**. These cells produce insulin and glucagon.

The Islets of Langerhans secretes insulin into the blood, when the glucose (sugar) level in the blood is very high soon after a meal. The insulin stimulates the liver cells to convert glucose in the blood into glycogen and store it for future use. As such, the glucose level is restored.

The Islets of Langerhans secretes glucagon, when blood glucose level falls. Glucagon stimulates the liver cells to convert some of the stored glycogen into glucose for immediate use and so restores the blood glucose level.

> *NOTE*
> Insulin also promotes the conversion of carbohydrates to fats and slows down the conversion of protein to carbohydrates.

Diabetes Mellitus

This is a disease in which an individual passes out sugar in his or her urine.

Causes of Diabetes Mellitus

- Failure of the Islets of Langerhans to produce sufficient insulin.
- Reduced ability of the liver cells to use insulin.

Treatment

Patients with diabetes need regular injection of insulin in order to control blood glucose level.

Problems associated with endocrine system

- Disturbances in production of hormones.
- Inability of tissues to respond to hormones.

Homeostasis is the process that keeps the conditions in the body constant. Homeostasis occurs with influence of endocrine system.

Examples of homeostasis

- Regulation of body temperature
- Regulation of glucose level in blood.
- Osmo – regulation
- Tubular secretion

Differences between nervous and hormonal coordination

- **Composition**
  - Nervous system is made of neurons.
  - Hormonal system is made of secretory cells.
- **Message transmission**
  - Messages in nervous system are transmitted in form of electrical impulse.
  - Messages are transmitted in form of chemicals called hormones.
- **Speed**
  - Messages in nervous system travel quickly.
  - Messages in hormonal system travel slowly.
- **Mode of message transmission**
  - Messages in nervous system are transmitted along nerve fibres.
  - Messages in hormonal system are transmitted through blood system.
- **Duration of effect**
  - Effect of message in nervous system lasts for a short time.
  - Effect of the message in hormonal system lasts longer.

Revision questions

1. Mention three steps involved in conditioning an organism. (**2007 Maneb**)
2. Describe an experiment that could be carried out to show the effects of practice on hitting a target. Your answer should include procedures, expected results and conclusion. (**2014 Maneb**)

Topic 14 Immunity

Immunity

It is the process by which the body provides defense against infection.

How does the body provide defense against infection

i. Prevents entry of germs into it.
ii. Kills pathogens that enter it.
iii. Neutralizes toxins produced by the pathogens.

Types of immunity

1. **Natural** immunity
2. **Artificial** immunity

Natural immunity

The defense against infection is provided by body on its own without being made to do so by man.

There is no influence made by man but the body.

Examples of natural immunity

First line defense

Prevent germs from entering the body.

The first line defense acts as barriers that prevent entry of germs into the body.

The following are the barriers against entry of germs into the body

Skin; the outer surface of the human body is covered with a thin layer of dead cells called cornified layer of the skin.

The cornified or keratinized layer acts as barrier against entry of germs since this layer is deprived of food and oxygen hence germs die. Thus, skin is also called germ proof.

Respiratory tract; has trachea and nasal cavity that have cilia and produce mucus.

The cilia and mucus trap germs and dirt and get rid of the germs.

Tears; contain a substance called lysonzyme that kills germs that might enter the eye.

They sweep away germs as they flow and blink movement until the eye is clean.

Earwax (**cerumen**)**;** the wax kills any organism that might enter the ear. The wax traps dust and germs.

Digestive tract; the walls of stomach contain hydrochloric acid (HCl) which kills germs that might enter together with food.

Symbiotic defence; in the small intestines there are bacteria called E. coli that produce some vitamins which are important for immunity.

Blood clotting; platelets clump together and block smaller capillaries thus forming clot. The clot prevents entry of germs into the body through the wound.

Second line defence

Kills germs that enter the body. This defense involves:

Phagocytes; engulf and digest the germs in the blood and tissues. They are attached to the walls of lymph nodes where they destroy germs in them.

B – Lymphocytes; they have B – plasma cells that transform into antibodies that kill, weaken, neutralize and make pathogens more susceptible to attack by the phagocytes.

Fever; suppresses iron release from the liver, this in turn weakens and inactivates (deactivates) the pathogen thereby killing them.

Third line defence

This defense aims at getting rid of cells that are severely infected.

Killer T – cells (Cytotoxic cells)

Kill human cells that are highly infected by the pathogens. In so doing the pathogens (germs) are also killed.

Note:

Active natural immunity is when antibodies are produced in response to the presence of pathogens in the body.

Antigens actively produce antibodies thus active natural immunity.

Artificial immunity

This is the body defense against infection by the influence of man.

Types of artificial immunity

1. Passive artificial immunity

Under passive immunity an individual receives ready-made antibodies to provide body defense against infection.

The individual's body does not have to produce the antibodies.

Examples of passive artificial immunity

i. Antibodies from colostrum to the baby.
ii. Antibodies against diphtheria and tetanus from horse's serum injected into an individual.
iii. Antitoxins from a recently recovered person from an attack of measles are taken and injected into the body of healthy person.

2. Active acquired artificial immunity

The individual receives killed, weakened or attenuated germs through vaccination so that his or her body responds by producing the antibodies on its own.

Artificial immunity is achieved through a vaccine which is administered in a process called vaccination or inoculation.

Vaccine

A vaccine is a dosage of killed, weakened and toxoids (inactivated toxins) administered through vaccination.

The killed or weakened germs are similar to those which cause a serious disease but are actually harmless.

Vaccination involves oral or injection.

How does an individual acquire immunity through vaccine?

When a vaccine reaches the bloodstream the body responds by producing antibodies as if it were undergoing an attack from actual disease causing organism.

These antibodies once produced remain thereby making the body immune to a disease.

These antibodies react with only the antigens which lead to their production because they are specific.

HIV and the immune system

Virus has specific host cells. The primary host cell for the HIV is Helper T – cells.

How does the HIV affect the helper T – cells?

i. The HIV infects the helper T – cells directly thereby killing them or makes them useless.
ii. The virus also makes the helper T – cells to undergo **apoptosis**.

Apoptosis is a programmed cell death in which cells kill themselves (cell suicide).

The helper T – cells are made to kill themselves prematurely and for no good reason.

Helper T – cells are the ones that control and regulate other immune cells such as B – cells. In view of the HIV, CD4 or helper T – cells become fewer in person such that his or her immune system becomes incapacitated and deficient (immunodeficiency) and therefore person will not be able to respond properly to other infections that one would not succumb to in normal circumstances.

AIDS

AIDS is an acronym for Acquired Immunodeficiency Syndrome. AIDS is the stage of infection with HIV in which an infected person's immune system has become so weak that he or she is at risk of developing other infections or cancers that can potentially lead to death. This is so because the virus damages the ability of body to defend against diseases.

Though all people with AIDS are infected with HIV, not all people with HIV infection have AIDS nor will all of them develop AIDS. However, AIDS is the final life threatening stage of infections due to presence of HIV in the body.

ABO blood systems

Blood groups are determined by antigen. There are antigens on the surface of one's red blood cells.

Antigens[9] are proteins that influence the production of antibodies.

Types of antigens

There are two types of antigens namely:

i. Antigen A
ii. Antigen B

Some individuals have antigen A on their red blood cells. Others have antigen B on their red blood cells. Yet some have both antigens A and B on their red blood cells. Other individuals have neither antigen A nor B on their red blood cells.

Blood groups are named after the type of antigen an individual has on his or her red blood cells.

Antigen on red blood cell	Blood group
A	A
B	B
A and B	AB
None	O

Antigens influence the production of antibodies.

Antibodies are blood proteins that are found in the blood plasma.

Antigen	Antibody
A	anti – b
B	anti – a
A & B	none
None	anti – b & anti – a

[9] See also red blood cells in circulatory system for better understanding of antigens.

Determination of one's blood group

The blood group determination involves the following procedures:

- Put anti – a serum on the slide and should be dried. Anti – a serum contains anti – a antibodies.
- Put anti – b serum on another slide and dry it. It contains anti – b antibodies.
- Then put blood samples of an individual on these anti – sera.

Results

- The blood group is A when agglutination occurs on anti – a serum but not on anti – b serum. This means the blood sample has antigen A that has agglutinated with anti – a antibodies.
- The blood group is B when agglutination occurs on anti – b serum but not on anti – a serum. This means the blood sample has antigen B that has agglutinated with anti – b antibodies.
- The blood group is AB when agglutination occurs on both anti – a serum and anti – b serum. This shows that the blood sample has both antigen A and B.
- The blood group is O when there is no agglutination on both anti – a serum and anti – b serum. This shows that blood sample has neither antigen A nor antigen B.

Blood transfusion

This is the practice of transferring blood from an external source into the patient

who must have lost blood through accident or diseases.

Cross matching

This is the procedure of ensuring safe blood transfusion.

How cross – matching is carried out?

- A blood sample from a patient is put on a slide. A blood sample from a donor is then added to the same slide. Mix the samples.
- Leave the mixture of samples for some time.
- Check if agglutination has or not occurred on the slide.
    - **Clear mixture** indicates that there will be safe blood transfusion.
    - **Clump mixture** indicates that will be unsafe blood transfusion.

Factors to consider before blood transfusion

Blood group

Attention should be observed before conducting blood transfusion because it is factual that the antibodies in the recipient's blood agglutinate (destroy) the antigens in the donor's blood if these antigens do not influence the production of particular antibody.

Rhesus factor

Another group of antigen is Rhesus factor. Rh antigens are present on surface of red blood cells of about 85% of the population. These people are said Rhesus positive (Rh^+). The rest of population is 15% with no Rhesus antigen and are said Rhesus negative Rh- . Giving Rh+ blood to a Rh- person agglutination occurs. Before transfusion, make sure the patient's blood is compatible with donor's blood.

Hepatitis

This is inflammation of the liver caused by any of several viruses. Hepatitis B is contracted by exposure to the body fluids of an infected person. These fluids include blood and semen. Hepatitis B may be severe or even fatal and approximately 10% of those who recover become carriers of the virus. Hepatitis B may lead to cirrhosis or primary liver cancer. However, before blood transfusion hepatitis B should be considered.

Syphilis

This is caused by the bacterium Treponema pallidum. Although syphilis can be cured with penicillin, it is a disease that may be ignored by the person who has it because the symptoms may seem minor and often do not last long. If untreated, however, syphilis may cause severe or even fatal damage to the nervous system and heart.

HIV/AIDS

Since HIV/AIDS is blood borne infection. Therefore, blood must be screened to ensure it is free from the virus before transfusion.

Anaemia

This is a condition in a patient has insufficient red blood cells. For this reason anaemic person cannot donate blood. In

most cases girls, women and older people are prone to anaemia.

Summary of safe blood transfusion

The information below summarizes the pattern from whom or to whom donate or receive blood (thus, safe blood transfusion)

- Blood group A can donate blood to A and AB but can receive from A and O.
- Blood group B can donate blood to B and AB but can receive blood from B and O.
- Blood group AB can donate blood to AB only but can receive blood from A, B, AB and O.
- Blood group O can donate blood to A, B, AB and O but can receive blood from O only.

Universal donor is an individual with blood group O. This is so because individuals with blood group O have no antigens on the surface of red blood cells to agglutinate any recipient's blood.

Universal recipient is an individual with blood group AB. This is so because individuals with blood group AB have no antibodies to agglutinate any donor's antigen.

Organ transplant

It is the surgery that involves tissues replacement to the patient (or victim)

Calcineurin is the target of immunosuppressive drugs used to treat patient following an organ transplant.

Examples of organ transplants

- Kidney
- Cornea
- Heart
- skin

Factors to consider before organ transplant

i. Type of organ
ii. Size of an organ
iii. Age of a person
iv. Blood group
v. Rhesus factor
vi. Syphilis
vii. Hepatitis B
viii. HIV/AIDS

Importance of immunization

Immunization is based on the principle ''prevention is better than cure''. As such immunization provides a resistance of a body to various infections.

Revision questions

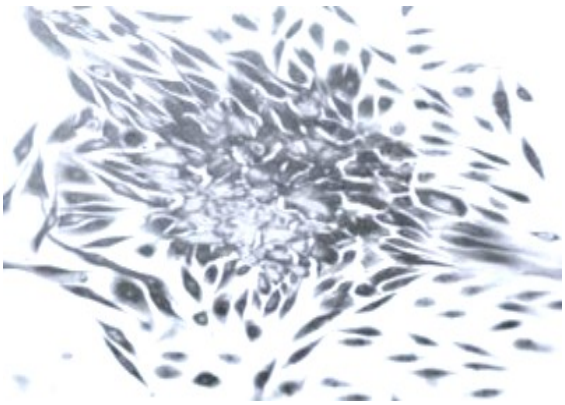
1. State two factors which must be considered before a blood transfusion is done. (**2004 Maneb**)
2. Describe how an individual could acquire natural active immunity. (**2004 Maneb**)

Topic 15 Cancer

Cancer

Cancer occurs when cells grow and multiply in abnormal and uncontrolled manner. Normal tissue development depends on a balance between cell multiplication and cell death. When cells multiply faster than they die, the result is an abnormal tissue growth called a tumor (**neoplasm**).

The study and treatment of tumors is a branch of medicine called ***oncology***.



Note

Tumours are simply clumps of cells.

Forms of tumors

Benign

These are harmless tumors but sometimes can be fatal. Benign tumors are surrounded by a fibrous capsule, grow slowly, and do not spread to other organs; although they are nevertheless sometimes fatal. A wart is a benign tumor.

Malignant

These tumours have no capsule, grow rapidly and shed cells that can "seed" new tumours in other organs, a phenomenon called ***metastasis***.
The word *cancer* refers only to malignant tumours.

Types of cancer

Cancers are classified according to the type of tissues or cells in which they originate.

Carcinoma

Found most frequently in the skin, nose, mouth, throat, stomach, intestinal tract, glands, nerves, breasts, urinary and genital structures, lungs, kidneys and liver.

Sarcoma

It is formed in the connective tissues of the body such as bone, cartilage and tendons.

Melanoma

It arises from the melanin – containing cells of skin.

Found most often in people who have had extensive sun exposure.

Neuroblastoma

It originates in the immature cells found within the central nervous system and usually found in children.

Leukemia

It is found in cells of the blood and blood forming tissues characterized by abnormal, immature white blood cell formation and several forms are found in children and adults.

Lymphoma

It arises in cells of the lymphatic tissues or immune system tissues.

Characterized by abnormal white blood cell production and decreased resistance.

How cancerous cells spread

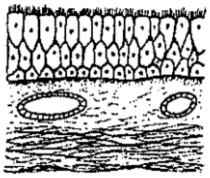
A primary tumour is a tumour in the site of origin, and a secondary (metastatic) tumour is a tumour in a new site resulting from the spread of cells from the original tumour. Thus, spreading of cancerous cells is called ***metastasis***.

Human organs often affected by cancer are as follow; lung, breast, colon, prostate, pancreatic duct, leukemic, ovarian, stomach, nervous system and bladder.

Differences between cancerous cells and normal cells

Cancerous cells have distinct characteristics that make them different from normal cells.

- Abnormal division
- Metastasize
- Do not stick together firmly.
- Differentiate; they look as if they have reverted to an early stage in their development.



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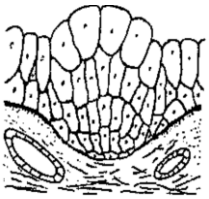

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Causes of cancer

Cancer is caused by abnormal multiplication of cells in the body due to **mutation**.

Factors that increase the risk of cancer

1. Carcinogens

This includes chemicals such as cigarette tar, nitrites (used as food preservatives) and many industrial chemicals.

2. Some viral infections

Viruses such as the hepatitis B and herpes simplex 2 viruses increase the risk of cancer.

3. Ionizing radiation

This includes as X – rays and gamma rays.

4. Smoking and over drinking alcohol

Smoking greatly increases the chances of getting lung cancer. The tar in a tobacco smoke causes some cells to divide abnormally developing into lung cancer. Over drinking alcohol causes cancer of stomach, oesophagus and liver since alcohol kills cells.

5. Hereditary

The risk of cancer is often hereditary and many forms of cancer have been traced to

two types of genes; oncogenes and tumour – suppressor genes.

Note

All of these agents are **mutagens**; that is, they cause mutations, or changes in deoxyribonucleic acid (DNA) and chromosome structure, which in turn result in uncontrolled cell division.

Effects of cancerous cells in the body

Death, by displacing normal tissue, so the function of an organ deteriorates; an example of this is when a lung tumour replaces so much lung tissue so that the blood can no longer get enough oxygen, or a brain tumour compresses and kills brain tissue.

Cancerous cells by invading blood vessels, causes fatal haemorrhages.

Malfunctioning of organs: by compressing vital passages. For example, shutting off air flow into the lung or obstructing blood flow through a major vein or artery.

Competition for nutrients; by competing with healthy tissues for nutrients, often causing the body to break down its own proteins (muscle, for example) to feed the "hungry" tumor, or failing to make enough red blood cells and platelets because stem cells are diverted into producing the abnormal white blood cells of leukemia.

Treatment of cancer

Surgery, remove cancerous mass surgically.

Chemotherapy arrests the cancer with highly toxic drugs.

Radiotherapy, use of radiation such as x – rays from radioactive element like cobalt to destroy tumours.

Immunotherapy, provide antibodies or immune cells to attack cancer cells.

Prevention and control of cancer

Healthy living, avoid smoking, avoid excessive drinking of alcohol and eating proper diet containing vitamin C and vegetables with fibres.

Immunization, for example, liver cancer related to hepatitis B.

Palliative care

Revision questions

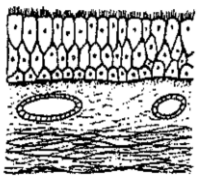
1. Figure 2 is a diagram showing a lymph node which has a tumour beginning to develop. Use it to answer the questions that follow:

   a. Name the type of disease shown.
   b. State two ways in which the cells of the tumour might affect the surrounding it.
   c. Suggest any two factors that would increase the risk of developing the disease named above. (**2004 Maneb**)

2. Figure 7 shows the normal lining of a lung in W and an infected lining in X. use it to answer the questions that follow.

   a. Name the disease that causes the condition in X.
   b. Explain how the disease is caused.

3. State any two ways of preventing the disease. (**2013 maneb)**



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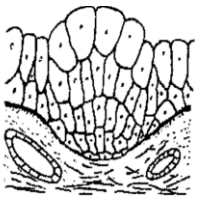

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Topic 16 Genetics and Evolution II

Variation

This refers to observable differences that exist within species of organisms.

Variation among organisms of same species is called **intraspecific variation**.

Causes of variation among organisms of the same species

1. Heredity

These are variations that are inherited by organisms from their parents.

These are called **genetic** or **heritable** variation such as height, nose shape, face shape and others.

2. Age

These are variations that are determined by the age of an organism in a species. Example include skin colour among human beings.

3. Environment

There are several variations which are determined by factors in the environment. Characteristics caused by an organism's environment are sometimes called *acquired characteristics*.

They are not caused by genes as such they cannot be handed on to the next generation. Examples include; height, intelligence, skin colour among others.

Types of variation

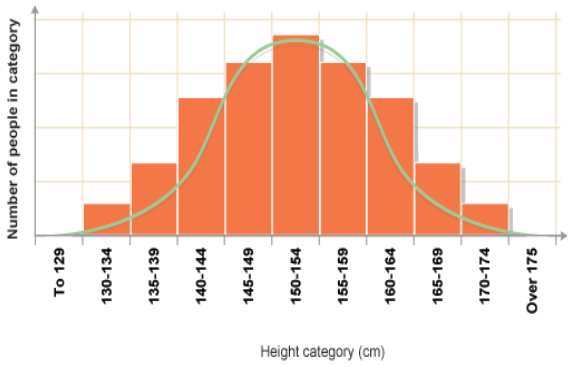
Continuous variation

- Has several middle forms for a character in organisms so that the organisms can be arranged from one extreme to another.
- Usually controlled by several pairs of alleles.
- It is greatly influenced by environment.

Examples of continuous variation

- Height
- Mass
- Intelligence

A graph of students against height character.



Interpretation – most students come in the middle of the range, with fewer at the lower or upper ends.

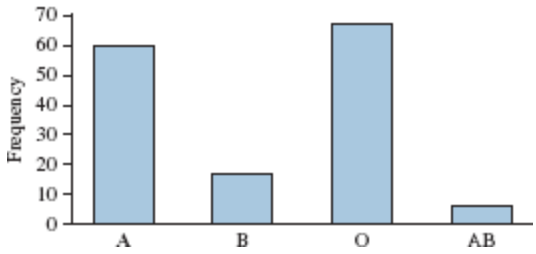
Discontinuous variation

- Has fewer or no middle forms and so organisms cannot be graded into a continuous sequence.
- Usually controlled by a single pair of alleles.
- It cannot be altered by environment.

Examples of discontinuous variation

- Sex
- Tongue rolling
- Blood group

A graph of population in million against frequency of blood group



Blood group A (37%), Blood group B (13%), Blood group AB (6%) and Blood group O (44%).

How does genetic variation arise?

Meiosis

During sexual reproduction, gametes are formed by meiosis. In meiosis,

homologous chromosomes

exchange genes and separate from one another, so the gametes are not all exactly the same.

Fertilization

Any two gametes of opposite type can fuse together at fertilization, so there are many possible combinations of genes which may be produced in the zygote.

In an organism with a large number of genes the possibility of two offspring having identical genotypes is so small that it can be considered almost impossible.

Mutation

Sometimes a gene may suddenly change. This is called **mutation**. Most mutations are harmful, but occasionally one may happen to give mutant organism an advantage in the struggle for existence. It will then survive to pass its new characteristics on to the next generation.

Mathematical skills used to describe variation

You must collect data on the following; students' heights, tongue rolling, among others. Then do the mathematical calculation on statistical terms.

Calculation

- **Frequency;** this is the total number of tallies in each event.
- **Mean;** this is also called average.

$$\text{Mean} = \frac{\text{sum of numbers}}{\text{total frequency}}$$

- **Median;** this is the number which is found exactly in the middle of events.

The numbers are arranged in an order either ascending or descending.

$$\text{Middle number} = \frac{n+1}{2}$$

Where **n** is the total number in the list

Then you count the numbers where middle number is found is the median.

- **Range;** it is the number found when lowest number is subtracted from highest number.

  R = highest value – lowest value

  For example, find the range from data 5, 6, 7, 8, 9

  R= HV – LV R= 9 – 5 = 4

- **Mode;** it is the most frequent number.

Drawing

- **Histogram**

  It has no spaces between the bars and the bars have same width. Histogram uses grouped data.

- **Bar chart**

  It has equal spaces between any bars that have same and equal width.

Activity

Data below are the birth masses of 12 babies in kg. Use it to answer the questions that follow;

3.1, 2.5, 3.0, 3.5, 3.4, 2.5,

2.6, 3.4, 3.0, 3.5, 2.0, 3.5

a. Calculate the average birth mass

b. Draw a histogram to compare the mass and number of babies of each range.

Mutation

This is a sudden change in gene or chromosome.

Any change in a gene or chromosome usually has a harmful effect on the cell in which it occurs.

Inheritable mutation – occurs in the primary sex cells or germ cell of an organism and is inherited by its offspring. It is passed on to future generation.

Non inheritable mutation – occurs in body cell or somatic cell of an organism and spread in that organism if the cell multiplies by **mitosis**. It is not transmitted to the sex cells hence not inherited.

Types of mutation

Chromosome mutation

This involves a change in chromosome number. There are two forms

- Nondisjunction

  Ovum carries an extra chromosome, so that it 24 chromosomes instead of 23 chromosomes. The affected child has 47 chromosomes because the ovum fuses with a sperm that has normal 23 chromosomes.

  Effects – inheritance form of mental and physical retardation called **Down syndrome** or **mongolism**

- ### Polyploidy

  The ovum carries 22 chromosomes instead of 23 chromosomes. The affected child has 45 chromosomes because the ovum fuses with normal 23 chromosomes.

  Effect – monosomy

  Chromosome mutation also involves a change in chromosome structure by the following ways;

  i. Addition of extra nitrogenous base
  ii. Deletion of a base
  iii. Translocation of one base for another.

Gene mutation

This is a change in the sequence of nitrogenous bases in DNA molecule that occur as an error during replication.

Examples of characteristics produced by mutations

i. Albinism
ii. Sickle cell anaemia
iii. Haemophilia
iv. Resistant germs to drugs

Causes of mutation

1. Rise in temperature

In some organisms the mutation rate increases as the temperature increases. The rate appears to twice over with increase of 100 ^{0}C.

2. Chemicals

Numerous chemicals cause rise in mutation rate when applied to organisms.

3. Exposure to high energy radiation

The radiations such as X – rays, beta and gamma rays are the most increasing rate of mutation.

4. Exposure to ultra violet rays

The radiations lying in the ultraviolet range are longer than X –rays. This occurs due to exposure to intense sunlight.

Effects of mutation

i. Cause variations among members of the same species, for example, a person having extra finger or toe.
ii. Make organisms better adapted to its environment for survival. This may be beneficial effect of mutation.
iii. Some mutations are harmful and can cause result in death.

Note
Mutants are homozygous recessive; and therefore are very weak and die before old age.

Evolution

Evolution is *the gradual change in organisms* from common ancestors.

The general accepted ideas today about where all living things came from is that the forms of life that now exist have gradually developed from much simpler ones.

Forms of evolution

Convergent evolution

Produces analogous structures in organisms evolved from different ancestors.

Divergent evolution

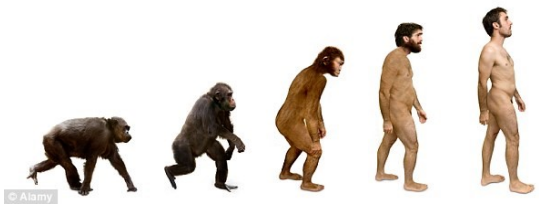
Produces modifications of structures that have evolved from a common ancestor.

Theory of evolution

All living things evolved from common ancestors over a long period of time, thus the theory of evolution.

However, scientists have been puzzled over the origins of forms of life wondering where living organisms came from. At different times, different ideas attempt to explain the problem, but none stood the test.

Many theories were proposed and later were disapproved and only one theory proposed by Charles Darwin was accepted and it is widely applied as the theory of evolution.



Charles Darwin (1809 – 1882) theory of evolution

In 1858, Charles Darwin was the first person (biologist) to theorize the ideas that living things have through **natural selection** or **survival of fittest** acting over a wide range of inheritable variances.

He arrived at this theory after visiting many strange, distant and lonely places such as Galapagos, Chatham Islands, 960 km into the Pacific Ocean from the mainland of South America, a land at the unknown in Europe.

During his voyage, he saw many different forms of life, growth of trees and varieties of beetles and other invertebrates, giant slow moving tortoise and important fossils were just beginning to be accepted by scientist as remain to pass life.

Darwin's theory of Evolution by natural selection is beautifully simple and stated in system.

Variation

The organisms of a given species have variation. Ever, individual differs from all others of the same species. This is not only clearly seen in human beings and other organisms but also true of simple organism, for example, malaria parasite.

The variations are due to mutation and resortment of genetic materials.

Over – production

All organisms can produce more offspring than survive, that is, for example, a fern plant may produce 50 million spores in a year and other spores die. If all species survived fern might cover most of Africa within two generations.

Struggle for existence

Every organism faces a constant struggle to survive. The struggle is worst amongst members of the same species because they compete for the same resources with the struggle to reproduce and leave more

offspring, the others die before they reproduce fewer offspring.

Natural selection (survival of fittest)

Throughout the past deep ocean of time environment has been constantly changing. Some members of any species given population of organisms that adapted change and become best suited to the new environment will survive because their inheritance best suits the environment.

Others will not be suited to the new environment and will die without leaving offspring, hence their genes will not continue in the population. Darwin called this fittest through natural selection.

Advantageous characteristics passed to offspring

The organisms that survive pass their traits hence inheritable characteristics to their offspring. Generally, offspring restore parents that survive because of some useful traits for that on their offspring.

Offspring whose traits appear will also tend to survive and the same will be true in each generation as long as same forces are at work in the environment.

Gradual change

No single person can observe the process taking place, but it can be proved by evidences. In this way, over a period of time the population will lose all poorly adapted individuals. The population will gradually become better adapted to its environment.

Evidence of evolution

Fossil Records

Fossils are the remains of animals and plants preserved in various ways.

Sedimentation; The fossils show how a skeleton of the fish might become embedded in mud was settling down on the bottom of a lake. It may become covered with sediment.

Preservation of whole organisms; any environment that prevents rapid decay may produce fossils. Insects have been found trapped in amber which is formed from resin exuding from trees, pollen grains are preserved in the anaerobic conditions of bogs and their fossils remain are found in peat.

Preservation of hard parts; such as shells and bones, tree trunks and other fossil remains give us some ideas of the animals and plants that were living millions of years ago. Fossil sequence; the deepest layers of rocks are likely to contain the oldest fossils.

Petrifaction; the fossil record appears to support the idea that fish like creatures could have given rise to mammals because 300 million years ago, there were plenty of fish but no mammals. The fossils were washed away and replaced by minerals from the water.

Other tracers such as dinosaurs, worms and other burrowing animals.

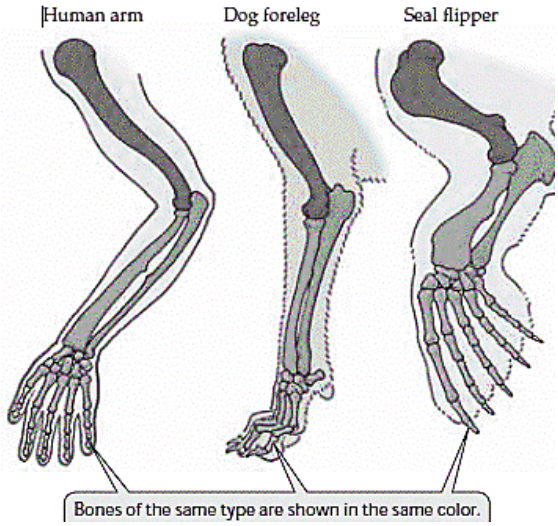
Comparative anatomy

The skeleton of the front limb of five types of vertebrates such as amphibians, reptiles, birds and mammals have arrangement and number of the bones that is almost the same in all five animals. The same design is **pent dactyl limb**.

This suggests that all mammals may have evolved from the same ancestors which lived long time ago. Structures which are found in different animals

but have the same design are called **homologous structures**.

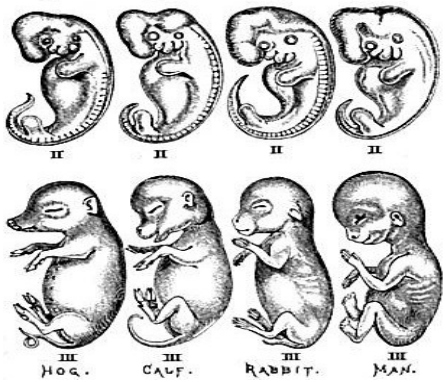
Structures that have no function today but are thought to have been important in the past such as coccygeal vertebrae in human beings and part of skeleton of snake that is thought where the legs were joined are called **vestigial structures**.



Comparative Embryology

The development of the embryo of organisms that are quite different in the mature form often shows a similar early pattern and similar structures in the early stages. All vertebrate embryos, for example, pass through stages that are very similar in structure and organization before differentiating into special structures of the species. This is believed that the vertebrates have development pattern of a common ancestor.

The embryos possess gill slits (gill clefts) in mammals, reptiles and birds in the pharynx. This means vertebrates have aquatic ancestors.



Geographical distribution

Biogeography is the study of the geographical distribution of organisms. Mammals are distributed on all great continents. The mammals are not exactly alike, though they are similar.

The similarity supports the idea that they arose from a common ancestor many millions of years ago and have evolved along their own lines in separate continents.

Comparative Biochemistry

The composition and structure of the biochemical compounds in different species can be compared to be similar such as haemoglobin molecules and amino acid sequences in their proteins and the chlorophyll molecules in plants.

As such, the closer the relationships like chimpanzees and humans in terms of haemoglobin molecules, the closer the similarity.

Comparative Cytology

Cell organelles, such as the cell membrane, ribosomes and mitochondria are very similar in organisms of all kinds.

Natural selection

This is the process in which *nature selects* the fittest individuals and rejects the weak ones.

This natural selection is based on ‘‘the better adapted varieties are selected by the pressure of the environment’’ hence selection pressures.

Examples of natural selection in action

Sickle cell anaemia

A person with sickle – cell disease has inherited both recessive alleles (Hb^SHb^S) for defective haemoglobin. The distortion and destruction of the red blood cells which occurs in low oxygen concentrations lead to bouts of severe anaemia.

There is thus a selection pressure which tends to remove the homozygous recessive from the population. In such a case you expect the harmful Hb^s allele to be selected out of the population altogether. However, the heterozygotes (Hb^AHb^S) have virtually no symptoms of anaemia but do have the advantage that they are more resistant to malaria than homozygotes Hb^AHb^S.

The selection pressure of malaria therefore, favours the heterozygotes over homozygotes and the potentially the harmful Hb^S allele is kept in the population.

When Africans migrate to countries where does not occur, the selective advantage of the Hb^S allele is lost and frequency of population diminishes.

Peppered Moth

The common form of peppered moth is speckled but there is also variety which is black. The black variety was rare in 1850 but by 1895 in the Manchester area its numbers had risen to 98% of the population of the peppered moths.

Observation showed that the light variety was concealed better than the dark variety when they rested on tree trunks covered with lichens. In Manchester area, pollution had caused the death of the lichens and the darkening of the tree trunks with soot. In the industrial area the dark variety was better camouflaged (hidden) of the two and was not picked off so often by birds.

The dark variety survived better, left more offspring and nearly replaced the light form.

Existence of Drug Resistance

New species of germs that are resistant to drugs have arisen through the process of evolution. Today, there are species of TB bacteria that are resistant to drugs used to TB.

New species have evolved and they are resistant to penicillin.

In an ordinary population of weevils there are some resistant to certain insecticides and some not. For example, resistant individuals may have slightly thicker cuticle so that insecticides does not penetrate, or may possess an enzyme that breaks down the poison. As such, in normal natural environment the resistance is genetic that is inherited and they produce offspring.

Importance of natural selection

a. Improves other characters as well as size of organisms.
b. Changes the genetic composition of a population.
c. Enables organisms to adapt their environment.

Human communities practice a form of selection when they breed plants and animals for specific characteristics. This is ***artificial selection***.

Examples of artificial selection

1. Farmers cross strong bulls in herds of cattle for breeding and kill or castrate all weak ones.
2. Farmers breed cattle with high milk production or fast meat production.
3. Farmers choose only those tomatoes that produce large fruits for growing purposes.

Speciation

This is the formation of new species. Specie is a group of living organisms which are all very similar to one another.

How speciation occurs

1. Natural selection

Some of the members of any population will be better suited for the new environment. They will have a greater chance of surviving to maturity and producing offspring. Others will not be suited for the new environment and will die young without leaving offspring. Hence their genes will not continue in the population.

Natural selection will have taken place which results in changes in the population over a period of time and which may result in the origin of species.

2. Isolation

Isolation can produce new species. Isolation is a process which gives an account on how speciation is for the existing species to be split into two groups.

They must be separated by some kind of barrier which they cannot cross. For example, one population may live in drier area and another in wetter area. Each group continues to live and breed in its environment. If the two environments are different, then the selection pressures on the organisms will be different.

Biotechnology (Plant and animal breeding)

The biologists use their knowledge of genetics to produce new varieties of plants and animals by **cross pollination** and **cross breeding** respectively.

For example, suppose one variety of wheat produces a lot of grain but is not resistant to a fungus. Another variety is resistant to the disease but has only a poor yield of grain. If these two varieties are cross – pollinated, the F1 offspring should be disease resistant and give a good yield of grain.

Another instance, is when one breed of goats is found to have some resistance to diseases but its milk production is low while another breed has high milk production but not resistant to diseases. If these two breeds of goats are cross –bred,

the new breed of goats will have high milk production and high resistance to diseases.

The crossing process that involves plant and animal breeding is called **hybridization**. The offspring from the cross of the two varieties are called **hybrids**.

Importance of hybridization

i. The hybrids gain valuable characters from both parents.
ii. Improves the quality and yield of plants and animals.

Examples of plant and animal breeding in Malawi

Production of hybrid seeds

Low yield/high resistant seed was crossed with high yield/low resistant seed and all offspring are heterozygotes having high yield/high disease resistant.

When the farmer grows the seeds of these hybrids, the maize harvested will be of high yield and high resistance to fungus disease. However, if the farmer plants seeds from the harvest of this hybrid maize, there is difficulty that the farmer will experience.

Production of varieties of poultry

Nowadays, new varieties of poultry such as hybrid chicken have been introduced. These chickens take short period of time to grow old and such production has increased food availability. The products of these varieties are readily available such as eggs.

Production of dairy cattle

Desirable characteristics such as high milk yield and resistance to disease may be crossed. Stock breeders will select calves from cows which give large quantities of milk.

Selective breeding in farm stock can be slow and expensive because the animals often have small number of offspring and breed only once a year.

Application of biotechnology

1. Agriculture
   It is used in agriculture through genetically modified organisms (GMOs) in order to increase food production on a yield.
2. Medicine
3. Manufacturing industry
   - food microbiology (using microbes to produce and protect food and beverages
   - Fermentation technology (production and manufacture of products like vitamins and enzymes).

Implication of biotechnology

- Advances in biotechnology may produce biological weapons that are even more toxic, fast acting, and resilient.
- Production of new organisms or toxins designed to target specific populations

Genetic engineering

This is the process that involves transferring lengths of DNA from one species to another.
Genetic engineering consists mainly of obtaining lengths of DNA from an organism and inserting them into other organisms, usually bacteria

Application of genetic engineering

1. Improves the quality of yields
   Genetic engineering has been used to improve the qualities of rice. In the 1960s, shorter semi – dwarf varieties were bred. This allowed farmers to increase yields with fertilizers without having the long thin stems of full-height rice fall over before harvest. This development was a major part of the "green revolution" in the 1960s, in which grain yields kept pace with a rise steeply world population, preventing widespread famine. More recently, genetic engineering techniques have been used to introduce a gene for a precursor of vitamin A, lacking in white rice. This so-called "golden rice" may help prevent blindness due to vitamin deficiencies.

2. Production of resistant crops and products

   Genetic engineering is used for producing frost- and disease-resistant crops and products with a longer period and a better taste. For example, it could result in the herbicide-resistant gene inserted in a grain variety being transferred through involuntary hybridization into a natural population of a related "weedy" or deleterious species, allowing it to prosper out of control.

How insulin is produced

The gene for human insulin is harvested and be inserted into a bacterium called Escherichia coli. Its bacterial cells are given genetic instructions to produce human insulin. The bacterium is thus made to produce insulin which can be isolated and purified from the bacterial culture and used for treating diabetics.

Note

Human insulin was the first medicine to be created through recombinant DNA technology. Insulin is a protein hormone produced by the pancreas that is important for regulation of blood sugar.

Topic 17 Human diseases

Human disease is noticed by **microbiology**, thus, study of microorganisms (microbes). Furthermore, the microorganisms that cause infectious diseases are called **pathogens**. Pathogens are also known as parasites and they live on another living organisms called host and cause harm to the host.

When pathogen establishes itself in a host, there is a period of time before symptoms appear. This is called **incubation period**. Incubation period is the period of development of symptoms of diseases after infection.
The pathogen is spread throughout the body by the way of lymph or blood.

Human diseases are caused by the number of groups of microorganisms such as;

a. Bacteria
b. Viruses
c. Fungi
d. Protozoa

Parasitic bacteria cause diseases by entering and establishing themselves in a host and begin reproducing as well as producing toxins that cause irritation of tissues.

Diseases caused by bacteria

Pneumonia

This disease is caused by bacteria called streptococcus pneumonia. Pneumonia is buildup of a fluid in the lungs.

Mode of transmission

Airborne – through inhaling contaminated air which is coughed or exhaled by infected person.
Bacteria attacks the lining of the lungs causing them to produce quantities of liquid filling the lungs.

Symptoms

- Chest pains
- Coughing
- Fever
- Patients die by drowning

Prevention, control and treatment

- Treated by antibiotics. Antibiotics are chemicals used to treat bacteria.
- Artificial ventilation with additional of oxygen may be needed to help the patient breath.
- Avoid overcrowding, that is, live in a well – ventilated rooms.

Tuberculosis (TB)

This disease is caused by mycobacterium tuberculosis and bovis. This is a major killer and commonest cause of death of women in developing countries.

Mode of transmission

- **Airborne** – pulmonary tuberculosis is caused by mycobacterium tuberculosis which is inhaled in droplets spread from coughing of an infected person.
- **Through milk** from infected cows – bovine tuberculosis is caused by mycobacterium bovis which is present in the untreated milk of infected cows.

Symptoms

- Fever
- Bacterium can infect many organs that lie dormant for years after initial mild infection.
- Tuberculosis of lungs
- General weight loss and coughing with blood.
- Scaring of lung tissue thus, reduces the area for gas exchange.
- Death arises from ventilatory failure.

Prevention, control and treatment

- **Treated** by antibiotics, i.e. para-amino salicylic acid and isoniazid.
- **Controlled** by vaccination – the BCG vaccine is harmless form gives immunity for 3 – 5 years and streptomycin is used to kill the bacteria causing tuberculosis.
- **Eradication** of tuberculosis in cows by vaccination.
- **Pasteurization** of milk – heat treatment of milk to destroy mycobacterium bovis.
- **Better nutrition** helps reduce incident of the diseases. A high protein content in the diet reduces incident of this disease.

Cholera

This disease is caused by bacteria called **vibrio cholerae** which multiply in the small intestines and invade its epithelial cells.

Mode of transmission

Waterborne – common where drinking water has been contaminated by human faeces especially after flooding.

Symptoms

- Toxins released by bacteria cause inflammation of the gut and severe diarrhoea.
- Loss of water and mineral salts may result in death by dehydration and kidney failure.

Prevention, control and treatment

- **Antibiotics** to kill the bacteria
- **Rehydration** either by saline drippers or oral rehydration using clean water mixed with salts and glucose.
- **Controlled** by purifying water and supply of drinking water away from domestic sewage outlet.
- **Vaccination**
- **Dispose** human sewage safely.

Typhoid

This disease is caused by a bacterium called **salmonella typhi**.

Mode of transmission

- Waterborne
- Food borne

Symptoms

- Incubation period of 6 to 7 days.
- Mild fever initially followed by higher fever.
- Severe diarrhoea.
- Ulceration of small intestines
- Death by dehydration

Prevention, control and treatment

- Treated by antibiotics
- Controlled by clean water supply and safe disposal of human sewage.
- Vaccination
- Safe food handling

Diseases caused by viruses

Common cold

It is caused by many different viruses.

Mode of transmission

Air by droplet infection – through coughing or sneezing. Viruses remain ineffective for some hours on a skin surface and may be spread through touch.

Symptoms

- High body temperature
- Production of mucus which run from nose.
- Sneezing
- Sore throat

Prevention, control and treatment

- Isolation of patients
- Avoid overcrowding

Influenza (Flu)

A serious illness which kills older people and children.

Mode of transmission

Air by droplet infection

Symptoms

- High body temperature
- Aching joints
- Fever
- Sneezing

Prevention, control and treatment

- Isolation of patients
- Avoid overcrowding places

Measles

One of the six diseases which regularly kills children. Symptoms develop from 7 to 14 days of infection. This is called **incubation period**.

Mode of transmission

Air by droplet infection

Symptoms

- High fever
- Running nose and cough
- Red and sore eyes
- Temporary blindness in severe cases.
- Rash in the mouth and behind ears, spreading to the rest of the body.

Prevention, control and treatment

- Isolate patients to prevent further spread.
- Vaccinates the children
- Immune after first infection.

Chicken pox

This disease is caused by **varicella virus**.

Mode of transmission

Spread by direct contact or indirect from scabs clothing or other things touched by infected person.
The virus may also be transmitted through the air by droplets.

Symptoms

- Fever with headache
- Aching limbs
- Blister like lesions (rash)

Prevention, control and treatment

- Isolation of infected patient
- Vaccination

AIDS

AIDS – stands for Acquired Immune Deficiency Syndrome. This disease is caused by a virus called Human Immune deficiency Virus. The virus is found in body fluids such as blood, semen or vaginal fluids. The virus attacks the cells in the body that protect against many fungal and bacterial infections.

Mode of transmission

- **Through sexual intercourse**, there is much higher risk of infection when a person has more than one sexual partner.
- **Injections**, especially when unsterilized needles are used for injection of drugs by addicts and when people share implements such as razors and tooth brushes.
- **Blood transfusion**[10].
- **Through placenta**, an infected mother can also pass on the disease to her child before and possibly during birth.

Symptoms

- Chronic diarrhoea
- Sudden loss of weight
- Severe cough
- Inflammation of lymph nodes.

Prevention, control and treatment

- Abstain sex before marriage
- Having protected sex by using condoms.
- Education

[10] Blood transfusion is well explained in immunity, you may refer topic 14 on blood transfusion.

- Treated by anti – retroviral drugs (ARVs)

Diseases caused by fungi

Ring worm

Ringworm is a skin infection caused by the fungus **tinea**. This fungus lives on the skin and causes scalp in children.

Forms of tinea are tinea canis and tinea corporis.

Mode of transmission

- Direct contact of head
- Using infected combs, brushes and hats.
- A highly infectious parasite

Symptoms

- Scaly round grey patches on the skin which causes itching.
- Hair loss

Prevention, control and treatment

- Isolate infected person
- Personal hygiene
- Controlled by using your own combs.
- Treated by fungicidal creams and drug griseofulvin.

Thrush (Candidiasis)

This fungal disease is caused by yeast like fungus called **candida albicans**. Attacks the epithelium of the mouth or vagina.

Symptoms

- Itching of the infected parts
- Rash

Prevention, control and treatment

- Applying fungicidal creams
- Isolation

Athlete's foot

This disease is also known as **tinea pedis** and is caused by **tribopbyton rubrum**. This fungicidal disease is contagious mostly in hot weather.

Mode of transmission

Direct or indirect contact with skin lesions of infected people or contaminated floors and other articles used by victims.

Symptoms

- Blisters or splitting of skin between toes.
- Itching between toes.

Prevention, control and treatment

- Personal hygiene
- Avoid contact with affected parts of the patients or personal objects of the patients.
- Keep the affected parts clean and dry.
- Apply ointment in between toes.
- Apply antiseptics e.g. alcohol in between toes.

Diseases caused by protozoa

These diseases are caused by protozoa carried by a vector. A **vector** is an animal that carries disease causing organism. Hence diseases caused by protozoa by a means of vector are called vector transmitted diseases.

Malaria

This is caused by **plasmodium** carried by people and mosquitoes. It is one of the commonest and most weakening of all the illness in tropical countries.

Mode of transmission

Female anopheles mosquitoes bite a person with malaria and the plasmodium is sucked together with blood.
Anopheles mosquitoes must have blood to produce its eggs. The anopheles mosquito bites a healthy person so that he becomes infected.
Plasmodium reproduces asexually in form of **cyst** and ripens which burst into **sporozoites**. They enter bloodstream of the mosquito and are carried into its salivary gland. The mosquito bites a person firstly it injects saliva to prevent the person's blood from clotting and it sucks blood as its meal.
The sporozoites remain in the liver for 8 days and later enter bloodstream where they attack red blood cells.

Symptoms

- High fever
- Shivering and chills followed by sweating which regulates temperature.
- General ill – health, aches and pains.
- The patient becomes anaemic due to destruction of red blood cells.
- Enlargement of liver and spleen.

Prevention, control and treatment

- Sleeping under nets. This prevents an individual from mosquito.
- Covering the skin by wearing long trousers and sleeved shirts.
- Treated by antibiotics such as quinine, chloroquine, paludrine, novidar and LA.
- Get rid of mosquitoes.

How to control the population of mosquitoes?

a. Spraying rooms and houses with insecticides to kill the adult mosquitoes.
b. Spray oil on all stagnant water found in our surrounding area. The oil forms a layer at the surface of the water and it cuts off the oxygen supply to the larvae and die due to suffocation.
c. Use of fish or ducks in slow breeding mosquitoes. The fish or ducks eat the larvae and pupae of the mosquitoes.
d. Drain the breeding areas that is all stagnant water. This kills and prevents the mosquitoes at the larvae, egg and pupae stage.

Sleeping sickness

This disease is also known as **trypanosomiasis**. It is caused by protozoan called **trypanosome**. This microorganism lives in bloodstream of human beings, cattle and buffaloes.

Mode of transmission

The parasite enters the human blood stream through the bite by a vector called **tsetse fly**. The vector carries the parasites and passes it to the human beings through the bites. The parasite releases poisonous chemicals that moves to the brain and cause a person to become unconscious.

The vectors are prevalent in the bushy places near game parks or streams where buffaloes are numerous.

Symptoms

- Fever and lethargy
- Loss of appetite.
- Running nose and possible blindness.
- Frequent sleeping resulting into death.
- Swollen lymph nodes.

Prevention, control and treatment

- Treatment by drugs to kill the parasite.
- Controlled by clearing the bush to get rid of tsetse flies.
- Application of insecticides

Elephantiasis

This disease is caused by tiny nematode worms called filarial worms. The worms move into lymph vessel and block them. This leads to chronic inflammation of the affected organs and repeated attacks by filarial worms lead to permanent blockage of lymph vessels which results into gross enlargement of the affected organs called **elephantiasis**.
The affected organs become thick and hard. The organs mostly affected are legs, arms and breasts.

Mode of transmission

Anopheles and culex mosquitoes pass filarial worm one person to another person.

Prevention, control and treatment

Get rid of mosquitoes. Note that some of the methods of prevention, control and treatment elephantiasis as are the same as those of malaria.

Prevention and control measures of diseases at household and community level

1. Water treatment

Water must be treated with chlorine so that bacteria causing disease should be killed. Another way of killing bacteria is by boiling drinking water. The treated water must be then poured into clean storage and cover them properly.

2. Disposal of human and domestic wastes

The sewage discharge should be free from any intestinal bacteria before its discharge into rivers. This should be ensured regularly because untreated sewage contains pathogenic micro-organisms which become a source of infection.

3. Personal hygiene

We are always encouraged to wash our hands after visiting the toilet with soap to get rid of bacteria. Wearing shoes during rainy season and when visiting the toilet can help prevents infection of athlete's foot.

4. Pest control

The kitchen utensils should be kept clean to prevent spread of diseases. Application of insecticides can get rid of mosquitoes, flies and cockroaches that carry disease-causing organisms.

5. Food treatment

The intestinal disease can be prevented by washing hands before and after handling food substance. Food should be treated by being prepared, stored and displayed in such a way that flies

cannot walk on it, or infected droplet fall on it.

6. Health services

The practice of applying iodine, hydrogen peroxide, or alcohol to minor cuts in the skin, and we know the purpose of this is to prevent bacterial infection. The use of such chemicals destroys many harmful bacteria.

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