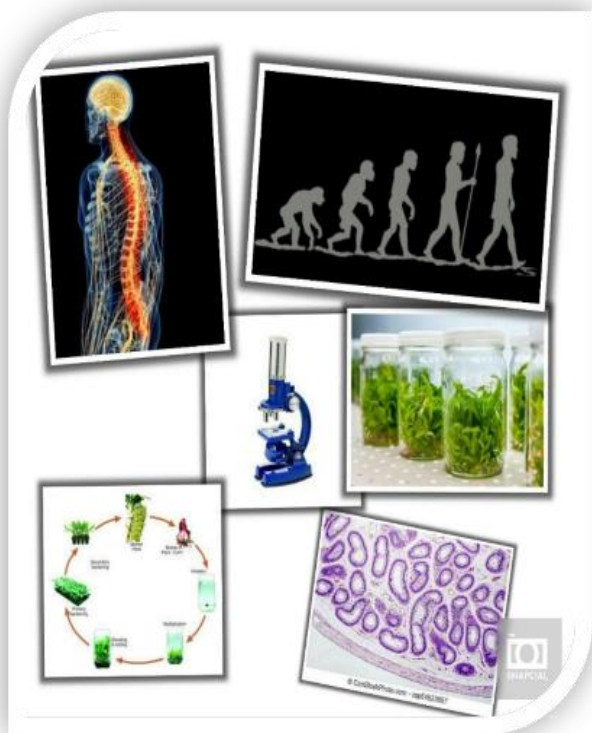




LIFE SCIENCES YEAR NOTE

GRADE 11

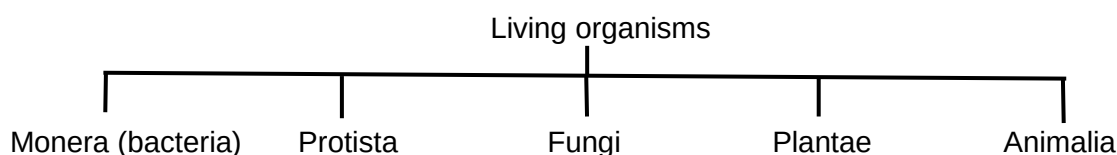
*A straight to the point note
compiled in compliance with CAPS
documents and the Life Sciences
Examination guidelines.*

ISRAEL ADEYANJU

TOPIC 1:

BIODIVERSITY AND CLASSIFICATION OF MICROORGANISMS (PAPER 2 – 29 MARKS)

Living organisms are divided into five kingdoms:



All living organisms are classified into TWO groups (according to their cell structure):

- Prokaryotes (Monera)
- Eukaryotes (Protista, Fungi, Plantae, Animalia)

Prokaryotes	Eukaryotes
Organisms without a true nucleus	Organisms with a true nucleus
DNA is not enclosed by a nuclear membrane and occurs freely in the cytoplasm	DNA is enclosed by a nuclear membrane inside the nucleus
Membrane-bound organelles are absent	Membrane-bound organelles occur in the cytoplasm

MICROORGANISMS

- They are so small and cannot be seen with a naked eye. Can only be seen with the help of a microscope.
- Several groups of microorganisms include **viruses, bacteria, Protista, fungi**.
- Microorganisms are the most abundant organisms on earth and are found in huge numbers in every environment.
- Most are harmless to plants and animals.
- Some causes disease and are known as **pathogens**.
- Most pathogens are parasites and live in or on other organisms
- ALL viruses and SOME bacteria, protists and fungi are pathogenic in nature.

VIRUSES

- They are difficult to classify and are not placed under any of the five kingdoms.
- Viruses have properties of both non-living particles as well as living organisms.
- They are dormant (inactive) outside a living cell. However, they only reproduce inside cells of living organisms.
- They are acellular (have no cell) and are therefore not classified as prokaryotes or eukaryotes.

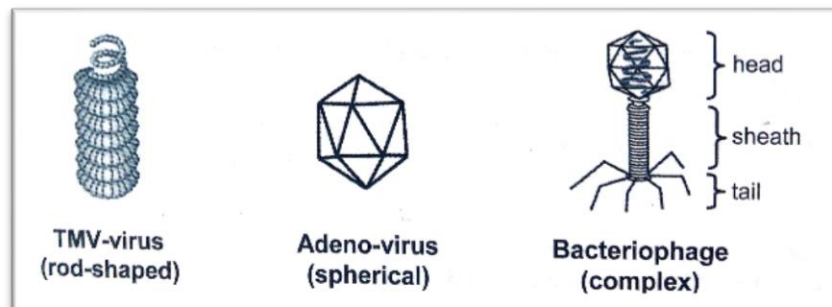
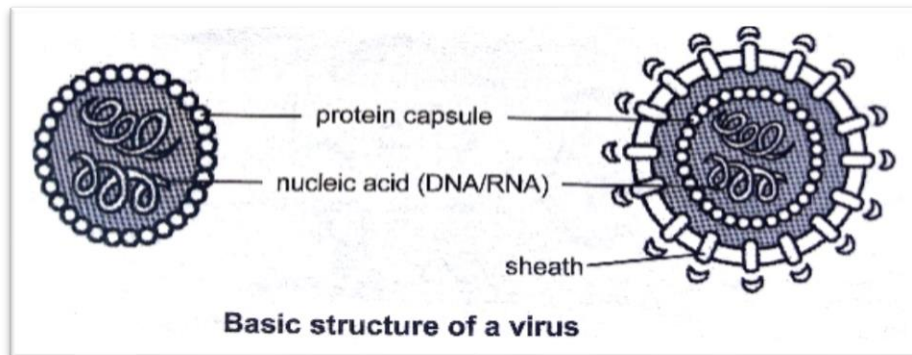
General characteristics

- Viruses are parasites (organisms that lives on living cells or material and causes harm).
- They are host – specific, while some are tissue – specific, e.g. poliovirus that only infects cells of nerve tissue.
- They are pathogens and causes diseases in plants and animals e.g. TMV (tobacco mosaic virus in plants), AIDS, colds, flu, rabies, measles, polio etc.

- Viruses reproduce by converting the genetic material (DNA or RNA) of the host cells into viral nucleic acids so that new viruses can be produced.

Basic Structure of Viruses

- Viruses are very small (20nm – 450nm in diameter) and simple in composition.
- They contain DNA or RNA (never both).
- They are acellular and have no nucleus, cytoplasm or organelles.
- Viruses can infect plant, animal or bacterial cells. A virus that infects bacterial cell is called a **bacteriophage**.
- The shape of viruses varies from rod – shaped, spherical to more complex shapes.



BACTERIA

- The smallest and simplest living organism.
- They occur in almost any imaginable habitat on earth.
- Some live in the presence of oxygen (**aerobic bacteria**).
- Others live in the absence of oxygen (**anaerobic bacteria**).
- Some are pathogenic and cause diseases e.g. cholera, tuberculosis, anthrax.

General characteristics

- Bacteria are unicellular.
- They have no true nucleus (**prokaryotic**).
- Some are AUTOTROPHIC and produce their own organic substance (food) by photosynthesis or chemosynthesis.
- Majority are HETEROTROPHIC and cannot produce their own organic substances.

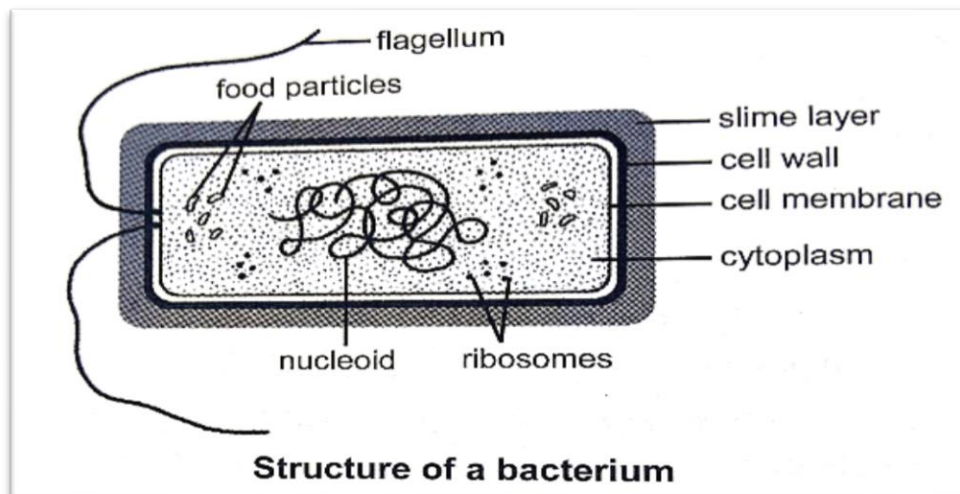
Three types of heterotrophic bacteria are:

- Parasitic bacteria (obtain food from living organisms).
- Saprophytic bacteria (obtain food from dead organic material).
- Mutualistic bacteria (obtain food from symbiotic relationship with another organism – both benefit in the relationship).

Reproduction in bacteria occurs ASEXUALLY by binary fission, where a cell divides into two identical cells (same DNA).

Basic Structure of Bacteria

- Bacteria are unicellular and occur as single cells, filaments or colonies.
- Bacterium cell is surrounded by a cell wall that consists of polysaccharides, proteins and lipids.
- In some bacteria, the cell wall is surrounded by a slime layer or capsule, which protects the bacterial cell from desiccation and enemies.
- A plasma or cell membrane which encloses the cytoplasm, occurs directly below the cell wall.
- The cytoplasm has no membrane-bound organelles, such as vacuoles, plastids, mitochondria or ER, but ribosomes do occur.
- True nucleus is absent.
- Genetic material (DNA) is concentrated in a chromatin body (nucleoid).
- Some bacteria move in liquid by means of flagella (singular: flagellum).



Bacteria occur in various shapes:

	bacilli	cocci	spirilla	vibrio
rod-shaped (bacillus/bacilli)				
spherical/round (coccus/cocci)				
Spiral-shaped (spirillum/spirilla)				
Comma-shaped (vibrio)				

PROTISTS

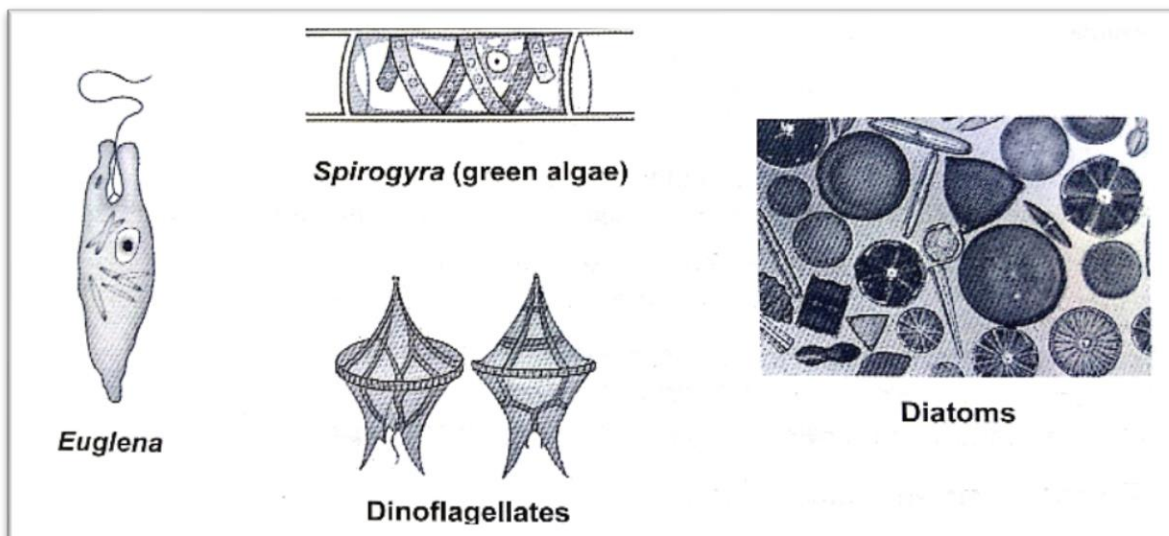
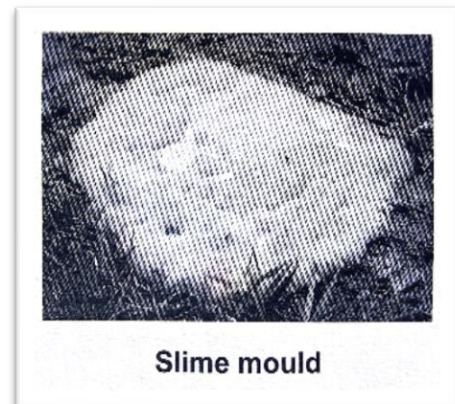
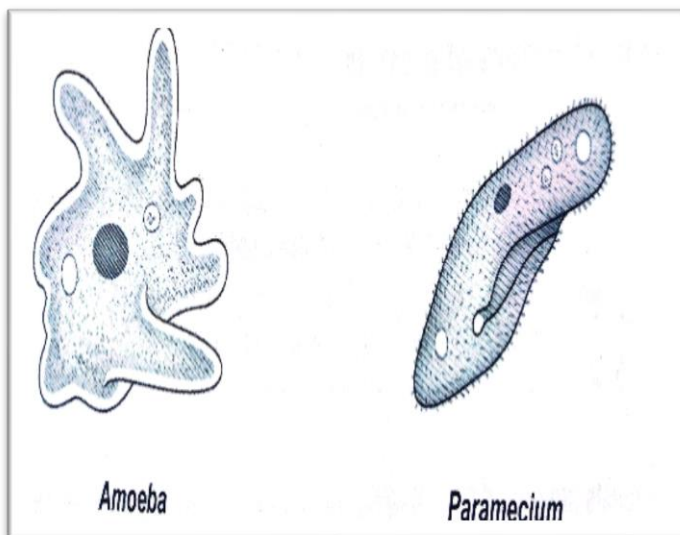
- They include mostly unicellular organisms that do not fit in any other kingdom.
- It is the kingdom with the greatest diversity (with over 200 000 known species).
- Protists are difficult to classify due to the large variety of organisms with different modes of nutrition, mechanisms of locomotion, cell coverings and life cycles.

Protists are divided into three main groups:

Protozoa – animal-like, unicellular, heterotrophic organisms e.g. amoeba, paramecium and plasmodium.

Algae – plant-like, uni- or multicellular, autotrophic organisms e.g. macroscopic and multicellular red, brown and green algae, microscopic and unicellular diatoms, Euglena and dinoflagellates.

Slime and water moulds – fungus-like, multicellular, heterotrophic organisms.



General characteristics

- All protists have true nuclei (eukaryotic).
- Some are unicellular and microscopically small.

- Others are simple multicellular organisms that show a primitive level of cell differentiation and specialisation.
- Algae are autotrophic while other protists are heterotrophic.
- Reproduction is mostly **asexual** (binary fission). However, some algae do reproduce **sexually**.
- Protists live in almost any environment where water occurs as most protists are aquatic.

Basic Structure of Protists

- Protists are uni- or multicellular.
- Algae can **photosynthesise** because of presence of chloroplasts in their cells.
- Various locomotory structures occur; pseudopodia (amoeba), cilia (paramecium), flagella (euglena and dinoflagellates).
- Protozoa (animal-like) ingest their food by **phagocytosis**.
- Cell wall composition varies in plant-like protists; green algae have cellulose cell wall, diatoms have cell walls of silica (shiny appearance).

FUNGI

They are divided into TWO main groups:

- Macroscopic fungi e.g. mushrooms
- Microscopic fungi e.g. yeasts (unicellular), thread-like moulds such as bread mould (multicellular) – some parts may be seen with the naked eye, but other parts are microscopic.

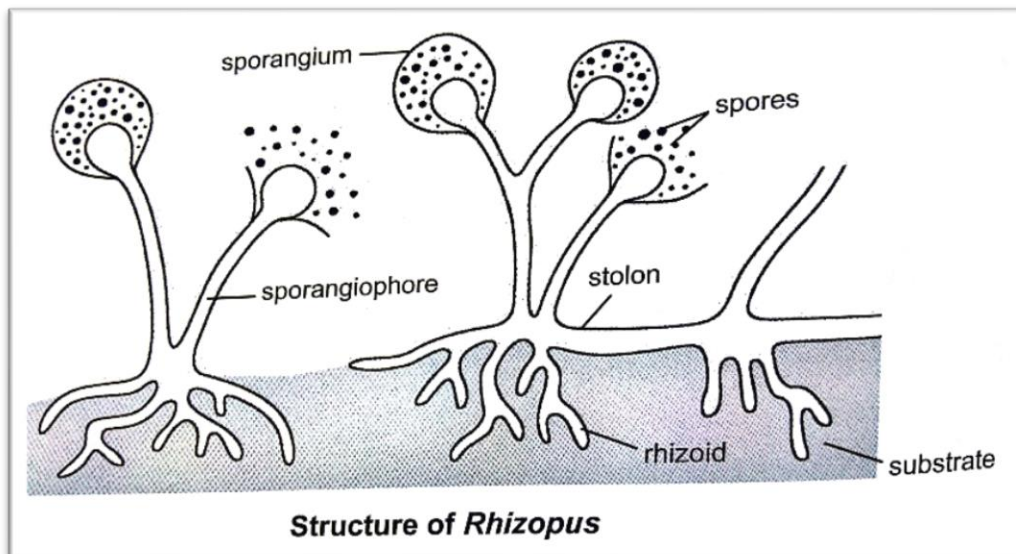
General characteristics

- Yeasts are unicellular, while mushrooms and moulds are multicellular.
- All fungi have true nuclei (eukaryotic).
- All fungi have cell walls made up of chitin.
- All fungi consist of a mass of branched filaments or hyphae.
- Fungi have no chlorophyll and are therefore heterotrophic. Most fungi are saprophytes (live off dead organic plant and animal matter, e.g. bread mould and mushrooms. Some are parasites (feed on living material), e.g. fungus that causes athlete's foot. Some are mutualistic with other organisms (both organisms benefit)
- Reproduction is,
Unicellular fungi - **asexually** (binary fission).

Multicellular fungi – **asexually** by spores (favourable condition), **sexually** by gametes (unfavourable condition).

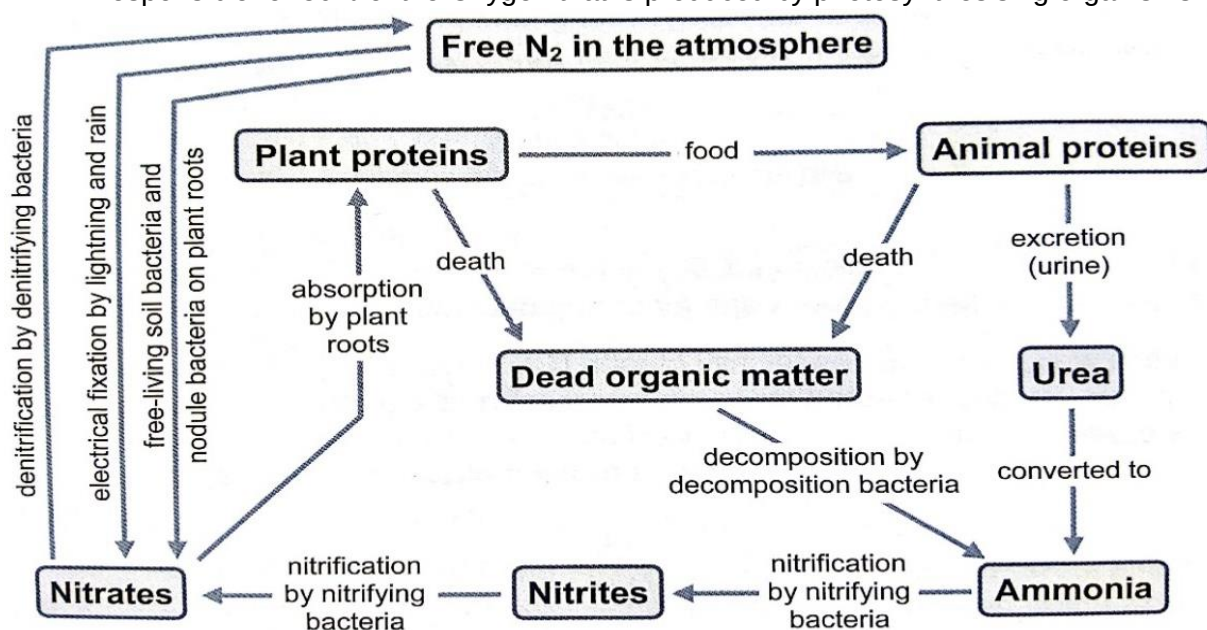
Basic Structure of Fungi (Structure of Rhizopus)

- Rhizopus is multicellular and consists of a mass of branched filaments (HYPHAЕ).
- The hyphae are interwoven to form the vegetative body, known as the mycelium.
- Three types of hyphae can be distinguished: stolons, rhizoids, sporangiophore.
- Rhizopus are thallus (no true roots, stems and leaves can be distinguished).



ROLE OF MICROORGANISMS IN MAINTAINING BALANCE IN THE ENVIRONMENT AND FOOD WEB

- **Role as producers in the food chain** – autotrophic bacteria and algae (protists) produce their own organic nutrients.
- **Role as decomposers** – decomposition bacteria, saprophytic fungi and protists (e.g. slime moulds) breakdown dead organic matter to their building blocks. In this way, elements like C, N, P, S are recycled in the environment and are made available for uptake by plants.
- **Role in the nitrogen cycle:** Free-living bacteria and nodule bacteria convert free nitrogen into nitrates and make it accessible to plants. Nitrifying bacteria converts ammonia into nitrites and then nitrates which can be absorbed by plants. Denitrifying bacteria converts ammonia and nitrates into free nitrogen in the atmosphere.
- Maintaining balance between Oxygen and Carbon dioxide – autotrophic bacteria and algae use carbon dioxide and release oxygen during photosynthesis. Algae is responsible for 50% of the Oxygen that is produced by photosynthesising organisms.



Role of microorganisms in symbiotic relationships

Nitrogen-fixing bacteria – nodule bacteria absorb nitrogen from the air spaces between the soil particles and convert it into nitrates that the plant can absorb. In exchange, the nodule bacteria receive carbohydrates from the legume plant.

Bacteria in the human intestine – Escherichia coli (E. coli) produce vitamin K, which plays an important role in blood clotting in humans. They also produce certain B vitamins. In exchange, E. coli bacteria obtain both nutrients from the human intestine as well as a protected habitat.

DISEASES CAUSED BY MICROORGANISMS

- HIV/AIDS
- Tuberculosis (TB)
- Malaria
- Thrush (Candidiasis)

HIV/AIDS

Acquired Immune Deficiency Syndrome is a sexually transmitted disease caused by a virus (Human Immunodeficiency Virus). The virus infects cells of the human immune system (CD4 – cells). The virus reproduces (replicates itself) and destroys the CD4 – cells, which weakens the immune system, leaving the person more susceptible to other diseases.

Effects on human body

First phase shows few or no symptoms – flu symptoms (sore throat, headache, moderate fever, tiredness, muscle and joint pains, swelling of lymph glands and mouth ulcers) can occur.

As the CD4 – count decreases further, more and more symptoms appear. These includes repeated cold sore infections, skin infections, prolonged fever, night sweats, chronic diarrhoea, opportunistic infections.

Opportunistic infections are conditions that attack the body when the immune system is weak. Examples include respiratory infections, pneumonia, rare skin cancer, neurological conditions, lymph cancer, TB etc.

The **final phase** of HIV infection is AIDS. Rare diseases and cancers become evident. The CD4 – count is very low. Death normally occurs as a result of the opportunistic infections.

Effects on children, families and SA economy

In an affected family, HIV can have an enormous impact on health, income, productivity and the ability to care for each other.

If the breadwinner in the **family** becomes sick or dies, the family is left without income. When both parents die, the **children** become orphans (become the responsibility of their relatives or even government).

AIDS affects people in their most productive years (20-40 years). Due to loss of young adults, the labour force is drastically reduced, and this has a negative impact on the SA economy (mining industry has a high rate of HIV infection).

Direct costs associated with HIV/AIDS include the cost of medical care and medication shouldered by the government.

Indirect costs include time lost due to illness, recruitment and training costs to replace workers and costs for the care of AIDS orphans.

Management of HIV/AIDS

Testing – know your HIV status. Pre and post-counselling are vital.

Treatment – currently there is no cure.

- Antiretroviral drugs (ARVs) – decrease the viral load and give the immune system the chance to strengthen, but they cannot destroy the virus.
- Healthy diet and vitamin and mineral supplements are important.
- Treatment of common and opportunistic infections.

Prevention – people must be well informed and educated.

- Avoid sexual intercourse.
- Have only one faithful, long-term, HIV-negative sexual partner.
- Practice protected, safe sex (use a condom, even though it is not 100% safe).
- Treat other STDs (syphilis, gonorrhoea etc.)
- Avoid direct contact with blood (wear gloves, don't share sharp objects)
- Avoid alcohol and drug abuse – can lead to reckless sexual activity

TUBERCULOSIS (TB)

Infectious disease caused by *Mycobacterium tuberculosis*. It mainly affects the lungs but can also affect any other organ in the body.

A person infected with the disease releases bacteria into the air by coughing, sneezing or spitting. The infected droplets may be inhaled, and the bacteria are thus transmitted to another person.

TB is a poverty-related disease. In poor communities, people live together in over-crowded areas. Rooms lack light and ventilation, which increases the chances of infections. People's resistance to the disease is further compromised by malnutrition and HIV/AIDS.

Effects on human body

When TB bacteria are inhaled, they reproduce and cause infection in the lungs. If the body's immune system is strong, it will fight the infection and prevent the bacteria from spreading. If the immune system is weak, it may develop into **active TB**, where pneumonia occurs repeatedly and the bacteria spreads to other parts of the body.

Symptoms of TB include:

- Constant cough
- Tiredness and fatigue
- Loss of weight
- Night sweats
- Chest pain
- Coughing up blood in saliva or mucus

Effects on family and community

TB patients may lose months of income because he/she cannot work. If the breadwinner dies of TB, poverty increases in the extended family and dependents in the community.

There is a **stigma** attached to TB. In certain communities, a man may leave his wife if she has TB. Untreated TB patients can infect family members and people in the community.

Management of TB

Treatment – involves aggressive course of antibiotics over 6 months.

Prevention

- People must be educated and well-informed about the spread of TB, the importance of hygienic conditions, sunlight, fresh air and a balanced diet.
- Treatment of patients must begin directly after diagnosis to prevent the spread of TB.
- Health care workers who work with TB patients must be well-informed about the risks of becoming infected.
- Every baby must be vaccinated with the BCG vaccine against TB shortly after birth to provide immunity during childhood.

Drug -resistant TB

TB bacteria that are drug resistant do not respond to medication. The resistance is largely due to badly managed TB care and the incorrect use of anti-TB drugs.

Multi-drug resistant TB requires long term **chemotherapy** involving very expensive medication and will only cure 50% of patients. These treatments are also very much more expensive than the treatment for normal TB.

TB and HIV/AIDS

TB is the most common opportunistic infection and cause of death for many HIV+ patients. If an HIV+ person develops active TB, the progression to the final stage of AIDS occurs much faster.

TB and HIV/AIDS are a deadly combination, the one accelerates the other.

MALARIA

It is a parasitic disease caused by a protist of the genus *Plasmodium* and it is transmitted by the female *Anopheles* mosquito.

When the mosquito bites an already infected person, a small quantity of blood is sucked up. This blood contains malaria parasites and they develop further inside the mosquito.

When the mosquito bites the next person, the parasites are injected into the bloodstream via the mosquito's saliva.

The *Anopheles* female mosquito is the primary host as well as the **vector** (an organism that transmits a pathogen from one host to another) of the malaria parasite, while humans are the secondary hosts.

Effects of malaria

The parasites move in the bloodstream to the liver after infection, where they multiply. The parasites then enter the blood, multiply within the red blood cells and cause the following symptoms:

- Fever
- Headache
- Shivering
- Joint pain
- Vomiting
- Convulsions

Complications, such as brain damage, may also develop and cause a condition known as **cerebral malaria**.

Malaria is associated with poverty but can also be a cause of poverty.

Management of malaria

- Treatment
- Elimination of the vector mosquitoes
- Use of mosquito nets treated with insecticides
- Use of prophylactic medication to prevent the disease
- Immunisation/vaccination

IMMUNITY

Immune response – the way in which an organism protects itself against pathogenic viruses, bacteria, protozoa or fungi. The immune system must be able to determine what belongs to the body, as opposed to what is foreign to the body.

Immune response is divided into TWO main categories

- Natural immunity – present at birth.
- Acquired immunity – developed through exposure to pathogens.

Natural immunity is the first line of defence against pathogens that infiltrate the body. It is not aimed at one specific type of pathogen, but able to destroy different pathogens.

If the pathogen penetrates the first line of defence, the acquired immune response will be activated.

Immune response in animals (Humans)

Humans have both natural and acquired immunity.

NATURAL IMMUNITY – external barrier that prevents harmful substances from entering the body.

First line of defence

- Skin
- Coughing and sneezing reflexes

- Washing action of tears
- Mucus secreted by the respiratory tracts (to trap microorganisms).

Second line of defence

Fever (increases body temperature) and inflammation (causes redness, pain, heat and swelling at the site of injury) which prevent the multiplication and spread of pathogens.

ACQUIRED IMMUNITY – It may be classified in TWO ways according to the method in which immunity is obtained.

Naturally acquired immunity – antibodies transferred from mother to foetus either through the placenta or mother's milk (**passive**) OR direct contact with pathogens which stimulates the immune system to produce antibodies.

Artificially acquired immunity – develops through deliberate action such as immunisation.

In acquired immunity, pathogens that have penetrated the body tissues are actively destroyed and the body stores a memory of the response.

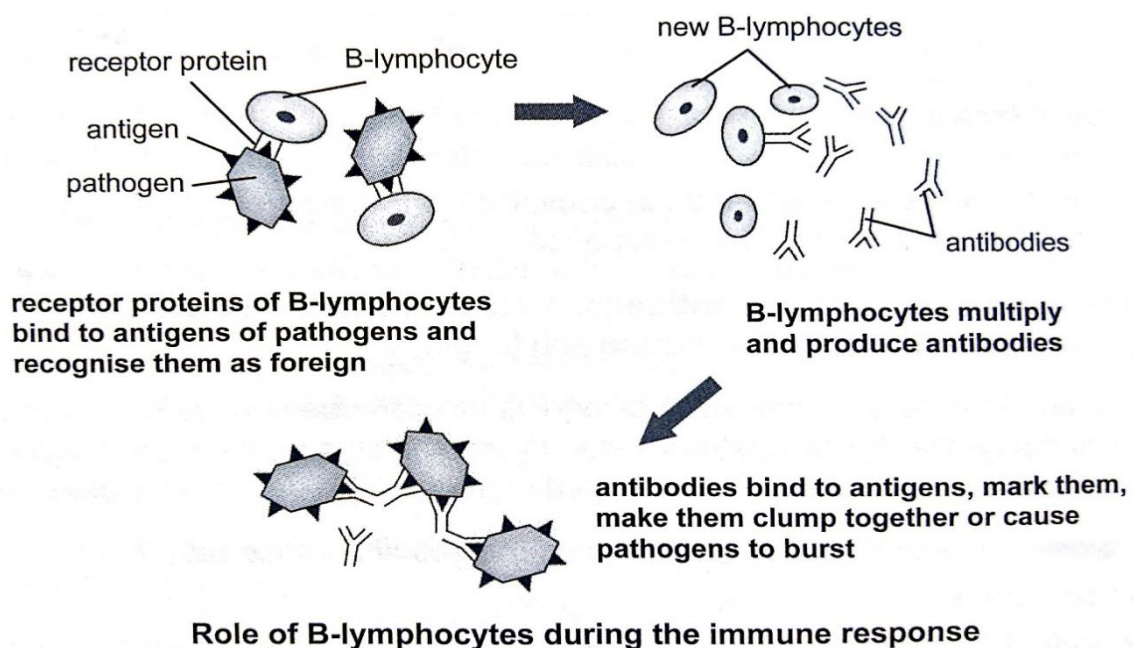
ANTIGENS – protein molecules that occur as markers on the surface of all body cells, viruses, bacteria, protozoa and fungi.

The white blood cells (leucocytes) recognise the pathogens as foreign cells as soon as they enter the bloodstream, due to the antigens on their cell surface. The pathogens are immediately destroyed or neutralised by the white blood cells.

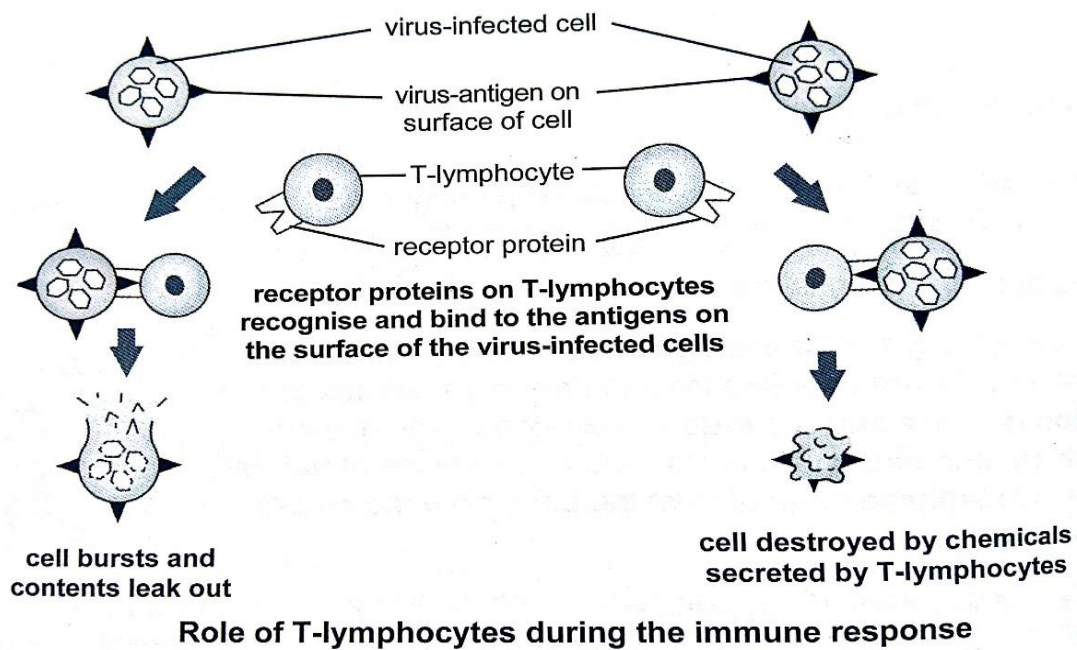
There are TWO types of leucocytes:

- Lymphocytes (B- and T-lymphocytes) which occur in the lymph glands, spleen and blood.
- Phagocytes are large white blood cells that can change shape and are produced in the red bone marrow.

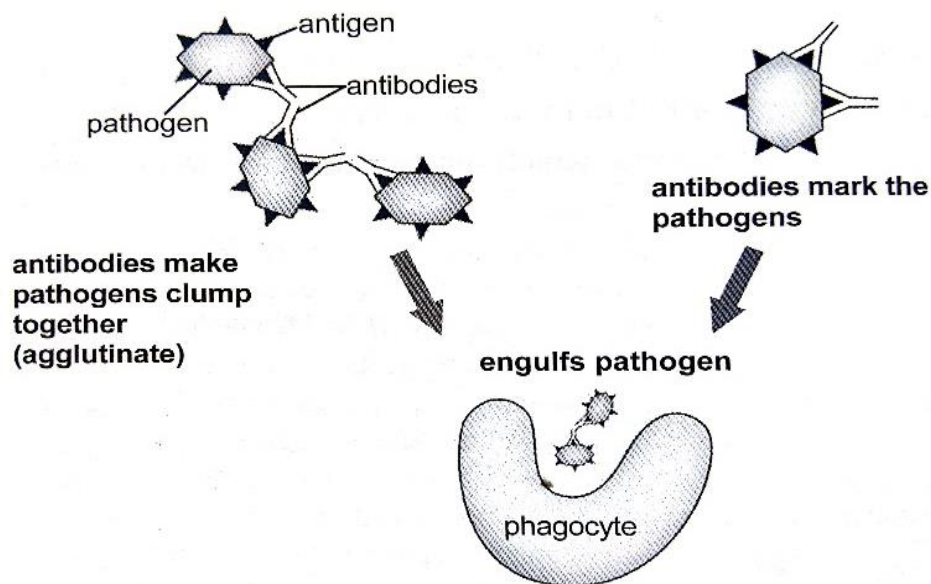
B – lymphocytes



T – lymphocytes



Phagocytes



Role of phagocytes during the immune response

Newly formed B-lymphocytes produce antibodies (1000's per second) that are released into the blood plasma.

The CD4-cells (T-helper cells) are another type of T-lymphocyte, which help other T-lymphocytes by initiating the immune response against infection.

Some B- and T-lymphocytes become memory cells that remain in the blood. When the body is infected by the same pathogen, the memory B-lymphocytes will multiply and produce more

antibodies. The T-lymphocytes will also react faster if the body is re-infected with the same pathogen. The pathogen is killed before it can multiply and cause illness.

It is the **memory cells** that remain in the blood, **not the antibodies**.

The process by which phagocytes engulf pathogens is **phagocytosis**.

IMMUNISATION AND VACCINE

Immunisation (vaccination) – administration of vaccine orally (by mouth) or by means of injection to develop immunity to a disease.

A **vaccine** is usually made up of dead or weakened form of the pathogen that causes the disease. The vaccine stimulates the body's immune system to produce antibodies and also to develop a memory of the response.

BIOTECHNOLOGY

Biotechnology – the use of living organism (particularly microorganism) or biological systems in industrial processes. These include:

Production of antibiotics – antibiotics are chemical substances that destroy only bacteria and not viruses e.g. Penicillin extracted from fungus *Penicillium notatum*.

Production of insulin

Production of food – some bacteria, yeasts and fungi are used in making foods such as bread, wine, beer, cheese etc.

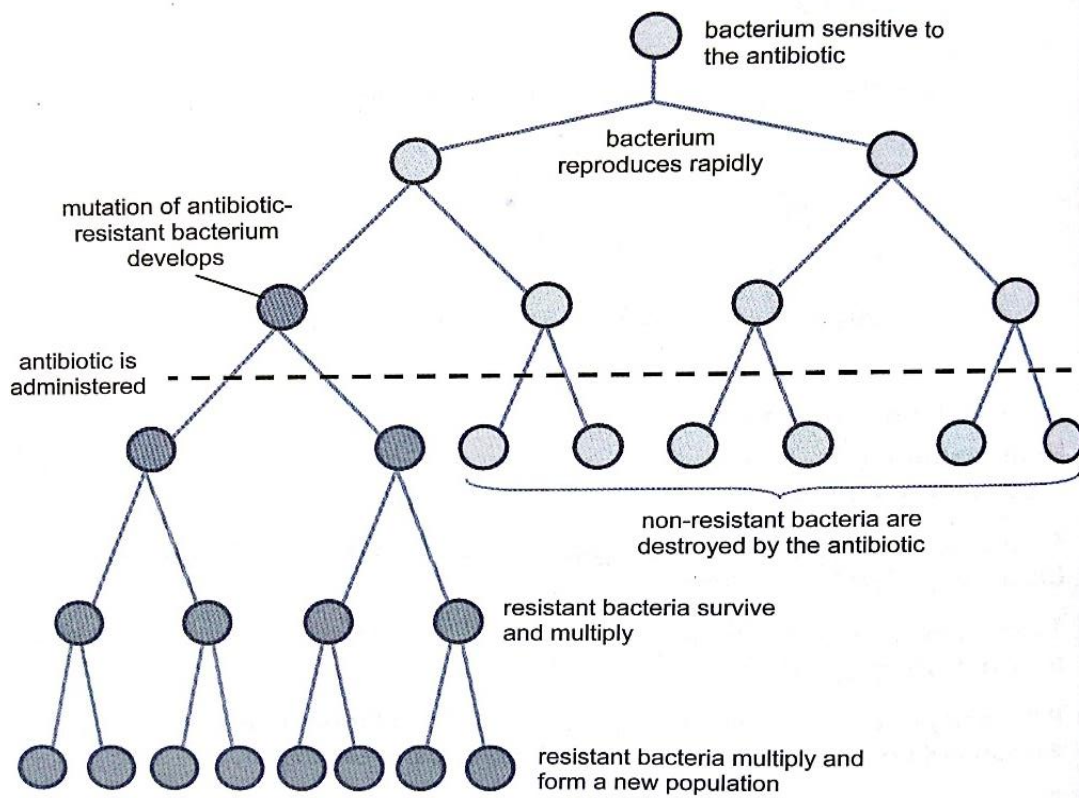
Antibiotics

Chemical compositions of antibiotics differ. They work in different ways to destroy different bacteria.

Some kill bacteria by destroying the structure of the bacterium e.g. cell wall, cell membrane. Others inhibit the metabolism of the bacterium e.g. no cell proteins and enzymes can be produced, which leads to the death of the cell.

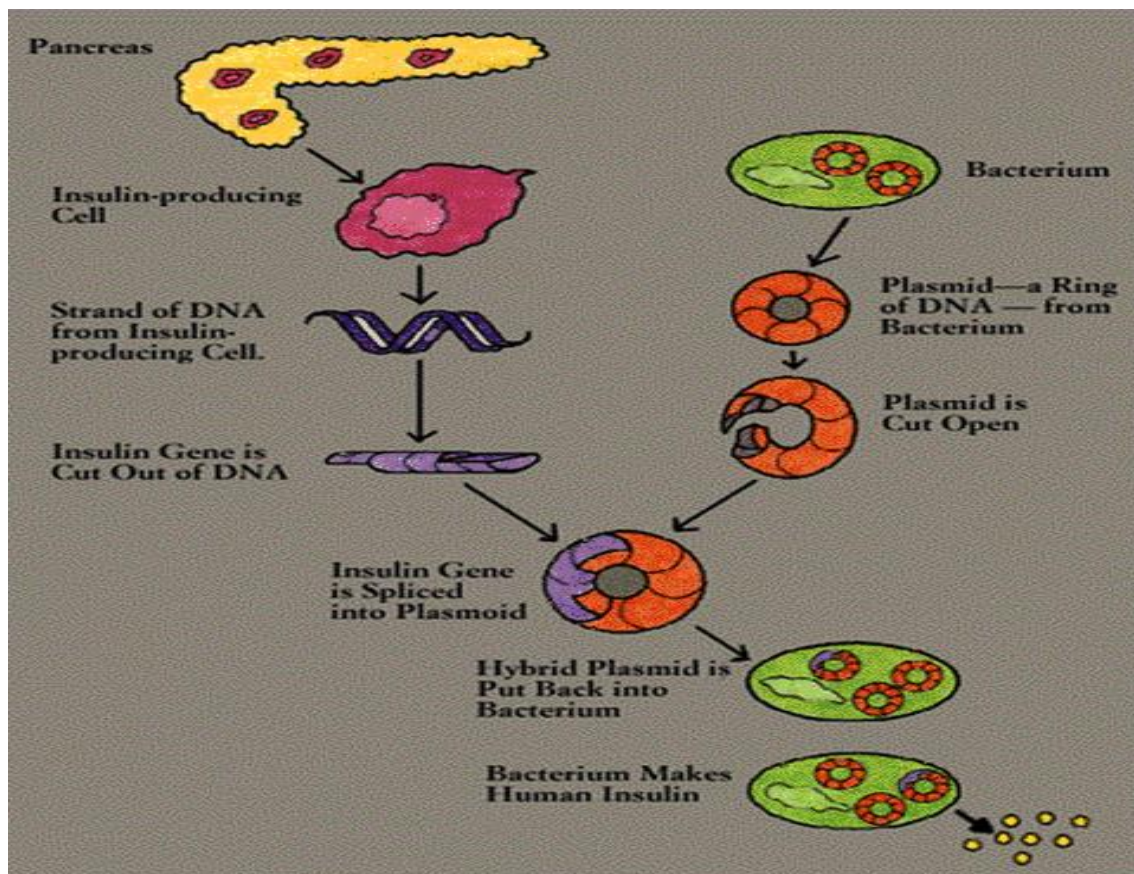
Bacteria may develop RESISTANCE to certain antibiotics through mutation. Reasons may be;

- Incorrect antibiotic treatment – wrong antibiotic prescription, course of antibiotic is not completed, incorrect diagnosis (treating viral infection with antibiotics).
- Unnecessary use of antibiotics.



Development of antibiotic-resistant bacteria

Production of insulin



TOPIC 2:

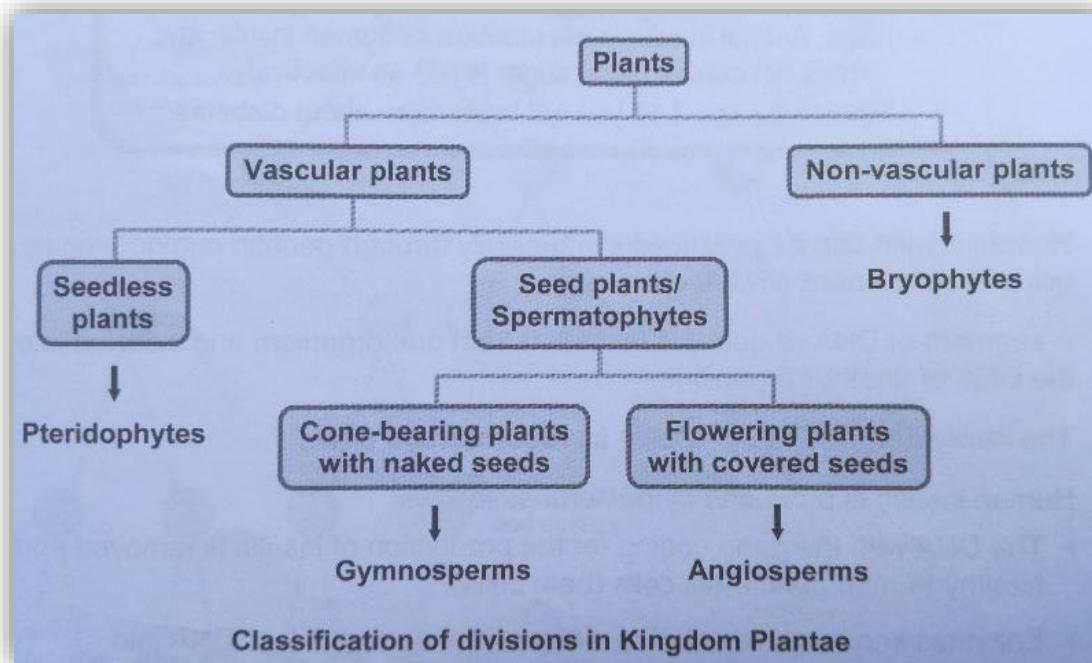
BIODIVERSITY OF PLANTS AND REPRODUCTION IN PLANTS (PAPER 2 – 29 MARKS)

The Kingdom Plantae is divided into FOUR main groups or divisions:

- BRYOPHYTES – mosses, liverworts and hornworts
- PTERIDOPHYTES – ferns
- GYMNOSPERMS – conifers, cycads, gnetales and ginkgo
- ANGIOSPERMS – flowering plants

Plants are divided into the four groups according to:

1. The presence or absence of:
 - Vascular tissue (xylem and phloem) - conducting tissues
 - True leaves, stems and roots
 - Spores or seeds
 - Fruits
2. The dependency on water for reproduction.



Alternation of generation

During the life cycles of each of the four plant groups two definitive generations occur:

- Gametophyte generation – which is sexual and produces gametes
- Sporophyte generation – which is asexual and produces spores.

These two generations alternate in that the one generation gives rise to the other. This phenomenon is known as ALTERNATION OF GENERATION.

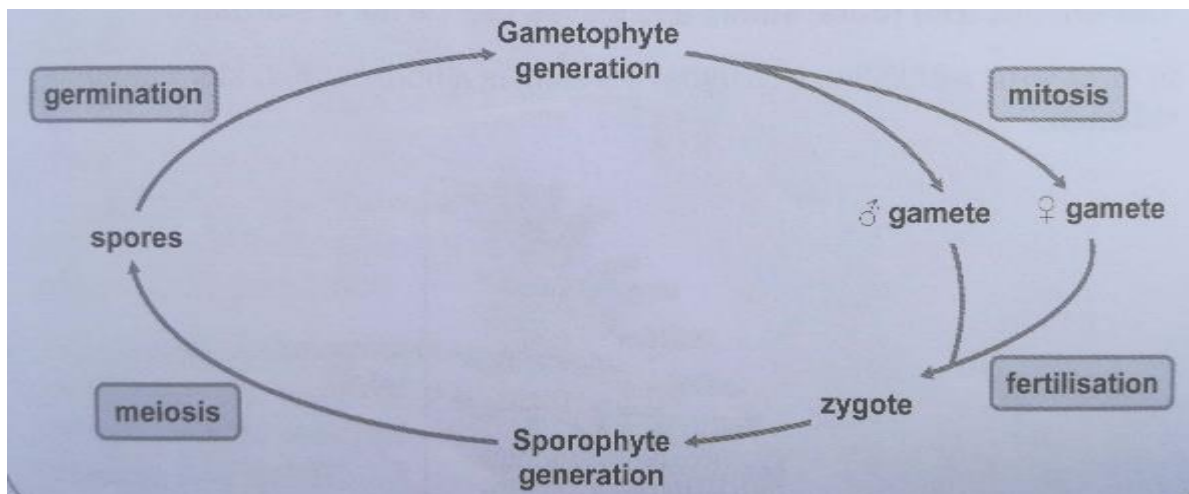
Dominant generation

This refers to how often a plant uses the gametophyte or sporophyte stage in their life cycle. It is the generation that occupies the largest portion of the life cycle.

- In BRYOPHYTES the dominant generation is the **gametophyte generation**.
- In vascular plants (PTERIDOPHYTES, GYMNOSPERMS and ANGIOSPERMS), the dominant generation is the **sporophyte generation**.

Advantage of a dominant sporophyte generation was fertilisation and dispersal of new/next generation timed with environmental conditions.

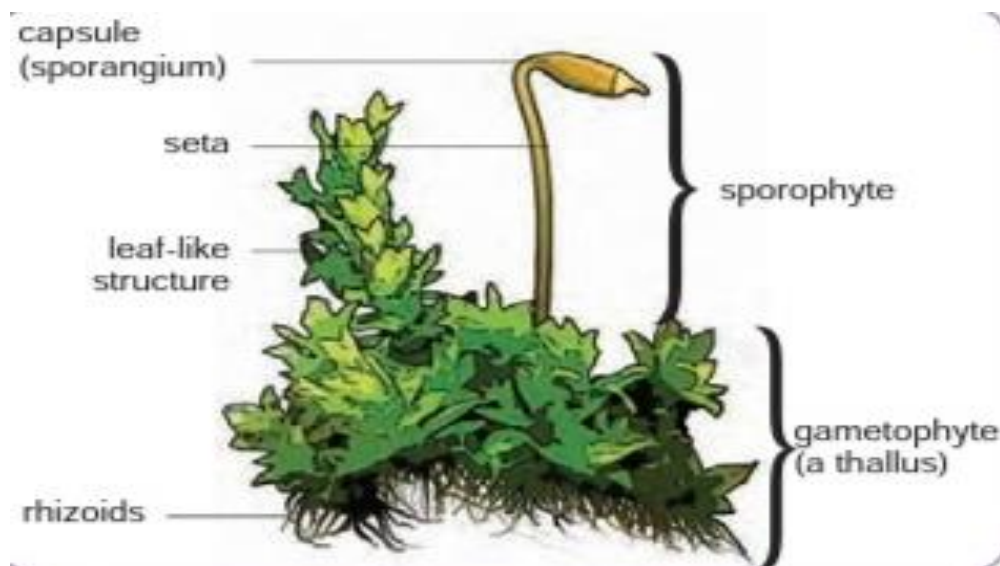
Pollen grains in seed-bearing plants contain spores that when mature become the male gametophyte.

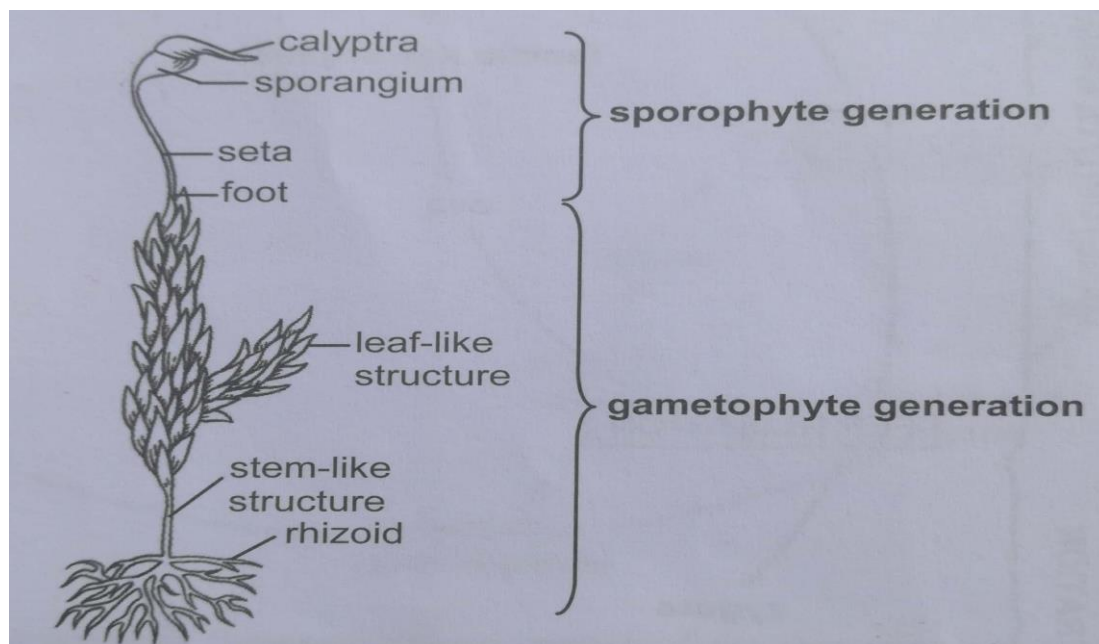


BRYOPHYTES (e.g. mosses, liverworts, hornworts)

The most primitive land (terrestrial) plants. They can only grow in moist and shady environments as they are dependent on water to complete the life cycle.

Most mosses are able to withstand long periods of drying out and then seemingly spring back to life when water is available.

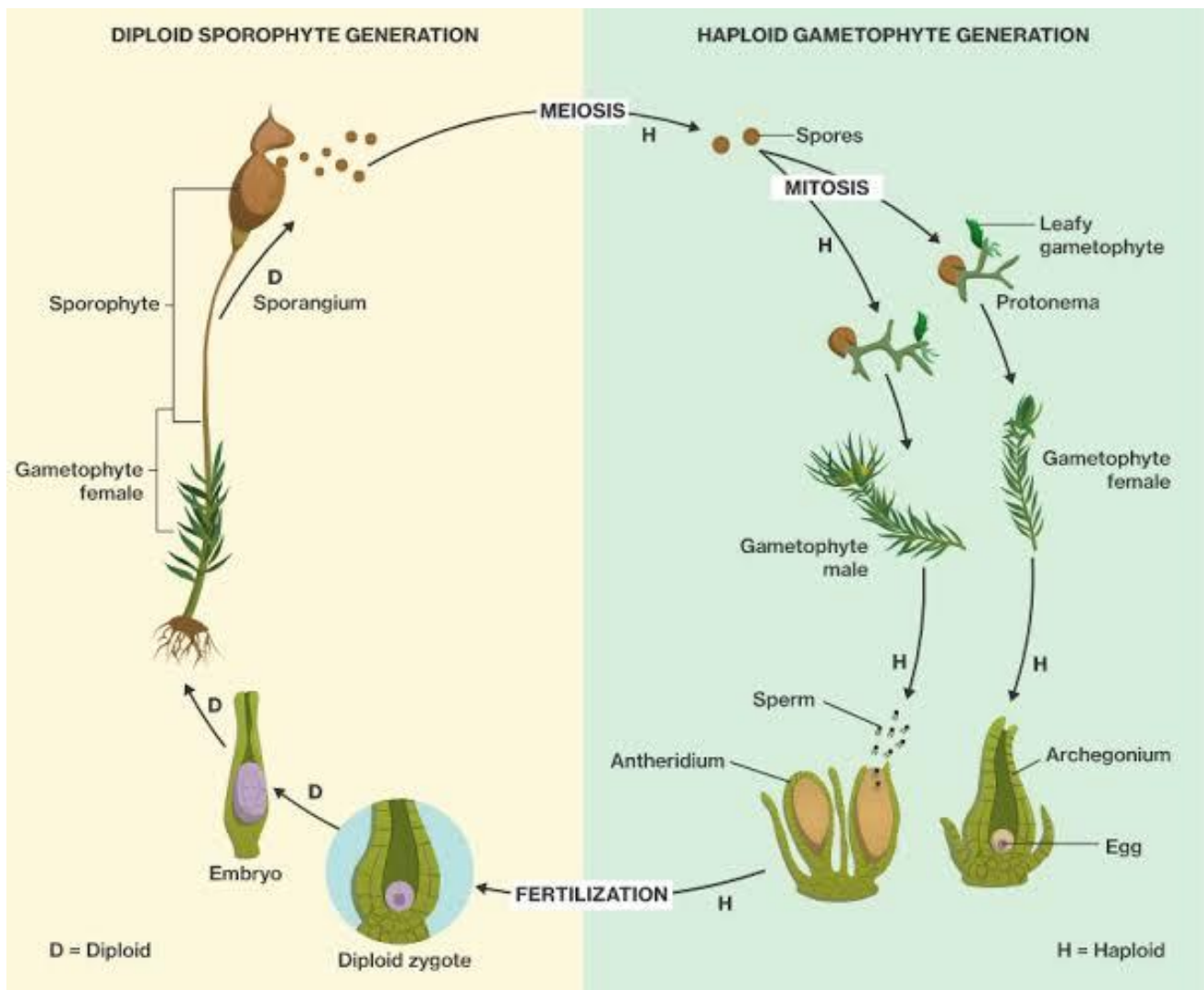




Characteristics

STRUCTURE OF DOMINANT GENERATION	VASCULAR TISSUE	SPORES/SEEDS	FRUITS	DEPENDENCY ON WATER FOR REPRODUCTION
GAMETOPHYTE – the plant body is known as a thallus (no true roots, stems and leaves). They do not have a waxy, waterproofing cuticle covering them as is the case in true leaves. Mosses lose water easily. The absence of a cuticle, however, enables them to absorb water directly through any part of the plant body (thallus) and not only through the rhizoids.	They are non-vascular. Xylem and phloem are absent, so they need to absorb water directly from the soil and the air.	Spores are the asexual reproductive structures formed by the sporophyte generation of the life cycle. The spores are formed in a sporangium called the capsule.	None	The sperm requires water to move to the ovum for fertilisation to occur.

Life cycle

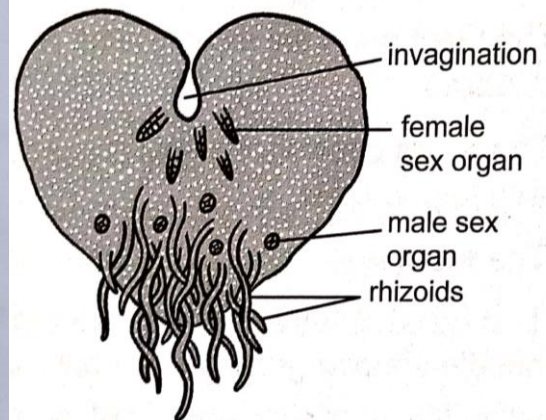
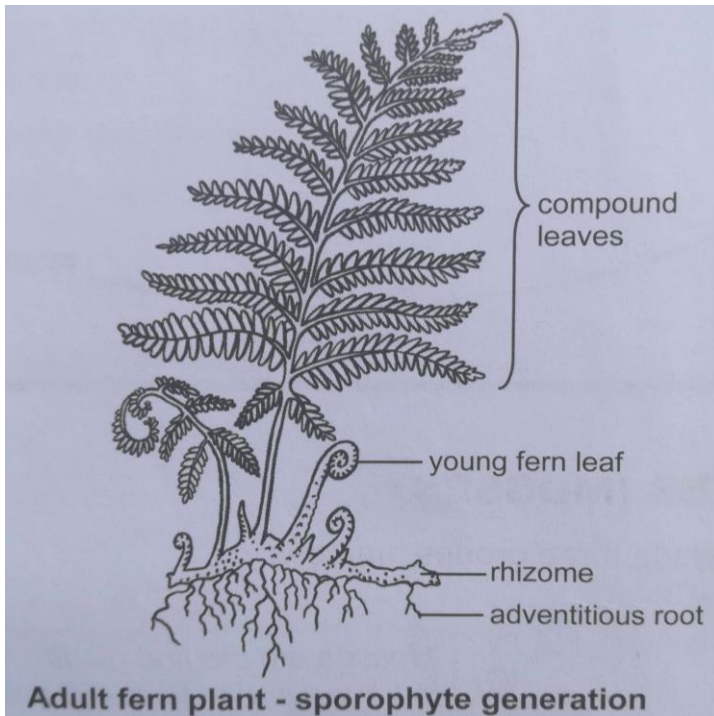
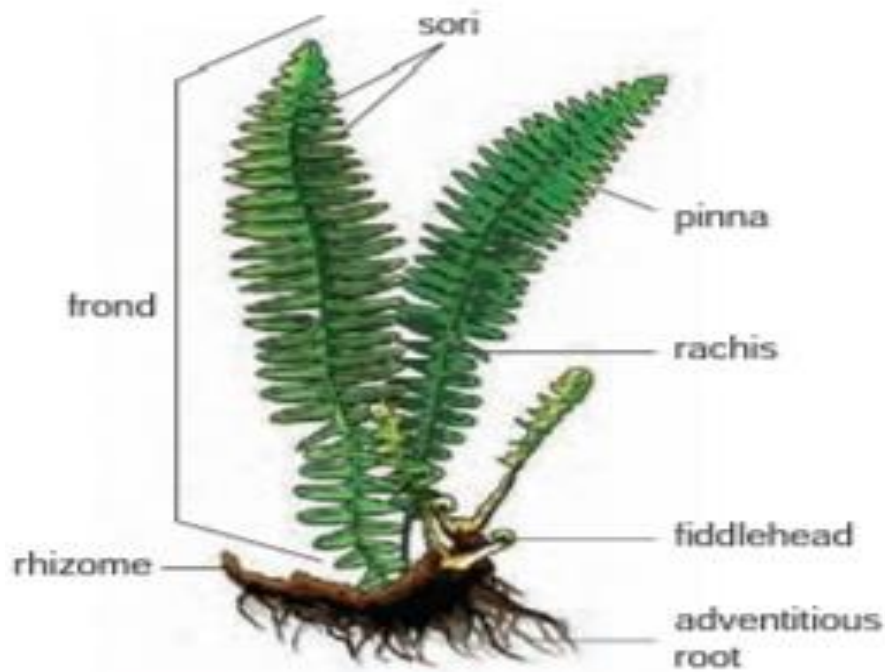


PTERIDOPHYTES (e.g. fern plant)

An intermediate group of plants between bryophytes (mosses) and seed plants. They occur in moist, shady environment.

Ferns are more advanced in other respects in that they have vascular tissue and they are better adapted to living on land.

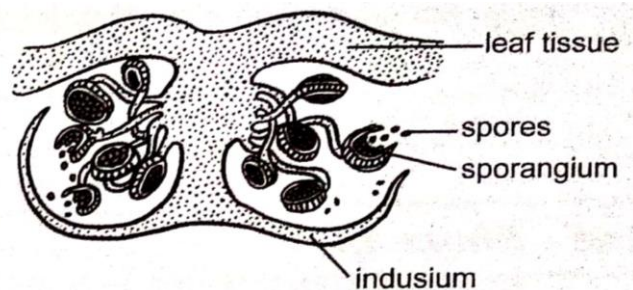
Ferns can inhabit a wider range of habitats than mosses, but the water-dependent sexual generation of the life cycle is still a restriction on their distribution.



Prothallus - gametophyte generation



Underside of fern leaf

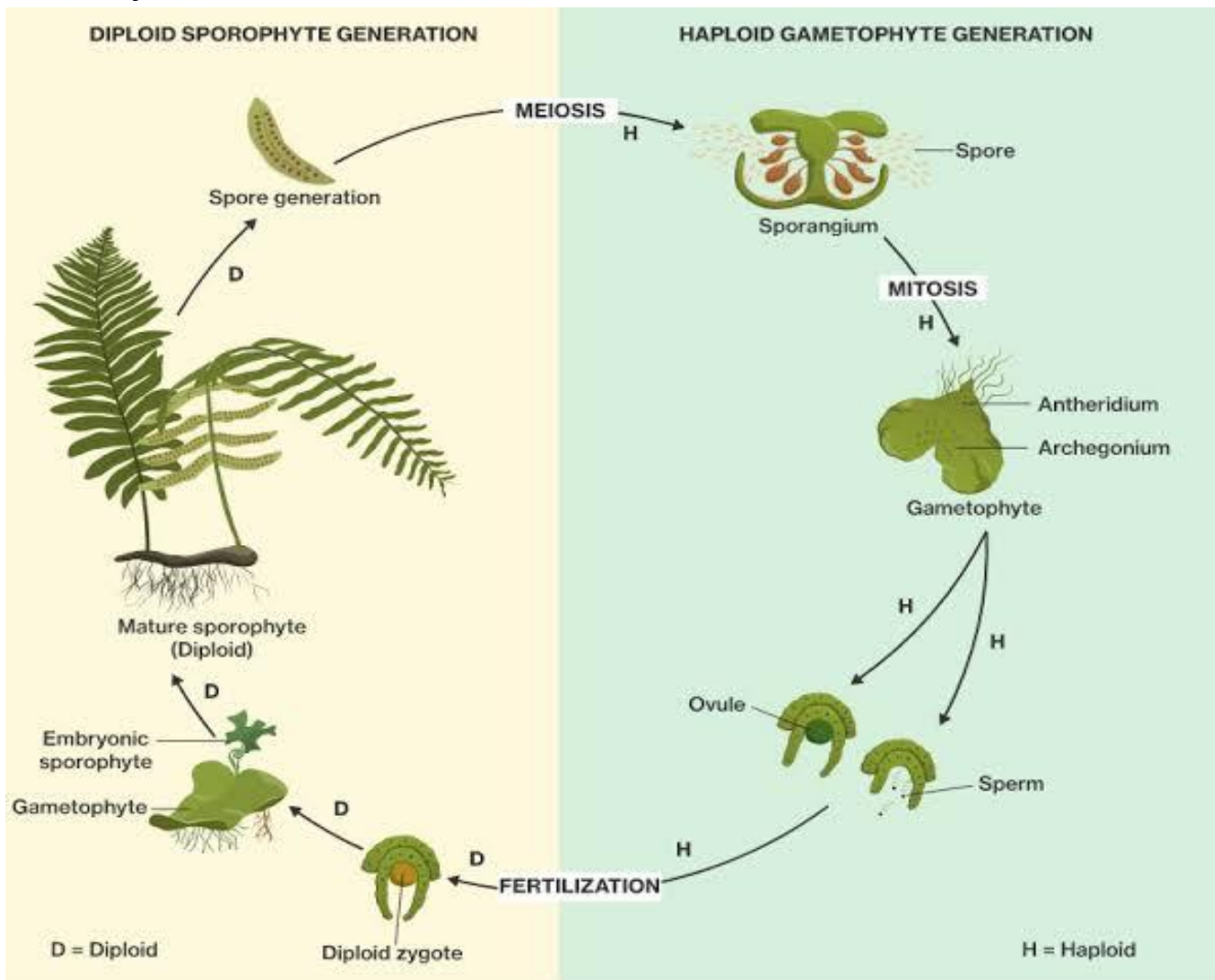


Structure of a sorus

Characteristics

STRUCTURE OF DOMINANT GENERATION	VASCULAR TISSUE	SPORES/SEEDS	FRUITS	DEPENDENCY ON WATER FOR REPRODUCTION
SPOROPHYTE – true roots, underground stem, large compound leaves. True leaves have a cuticle that prevents water loss. Ferns use their tough, wiry adventitious roots to absorb water, as well as to anchor the plant in the soil. These roots grow off an underground stem called a rhizome.	Xylem and phloem present. The vascular tissue provides some support and this has enabled ferns to grow taller on land than mosses.	Spores Underneath the leaves small structures called sori (singular: sorus) develop. The sori contain a number of sporangia. Spores are released from the sporangia and dispersed by the wind. When a spore germinates it gives rise to a green heart-shaped <u>prothallus</u>	No fruit is produced Ferns do not have seeds.	The sperm requires water to move to the ovum for fertilisation to occur.

Life cycle



GYMNOSPERMS (e.g. pine tree)

gymnos = naked; sperm = seed

Examples are conifers (most abundant), cycads, gnetales and ginkgo



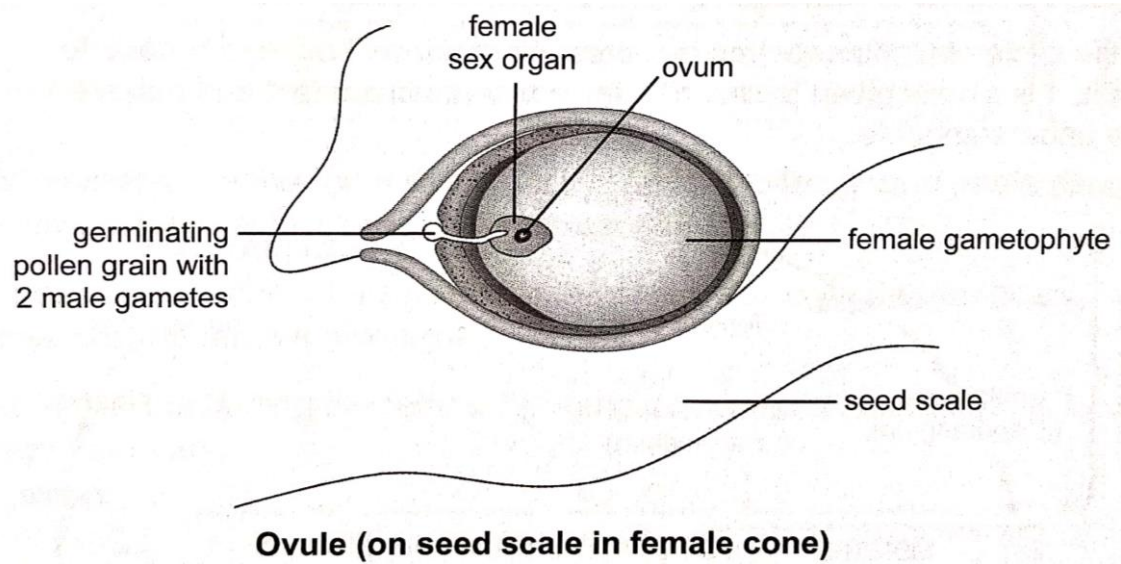
Conifers



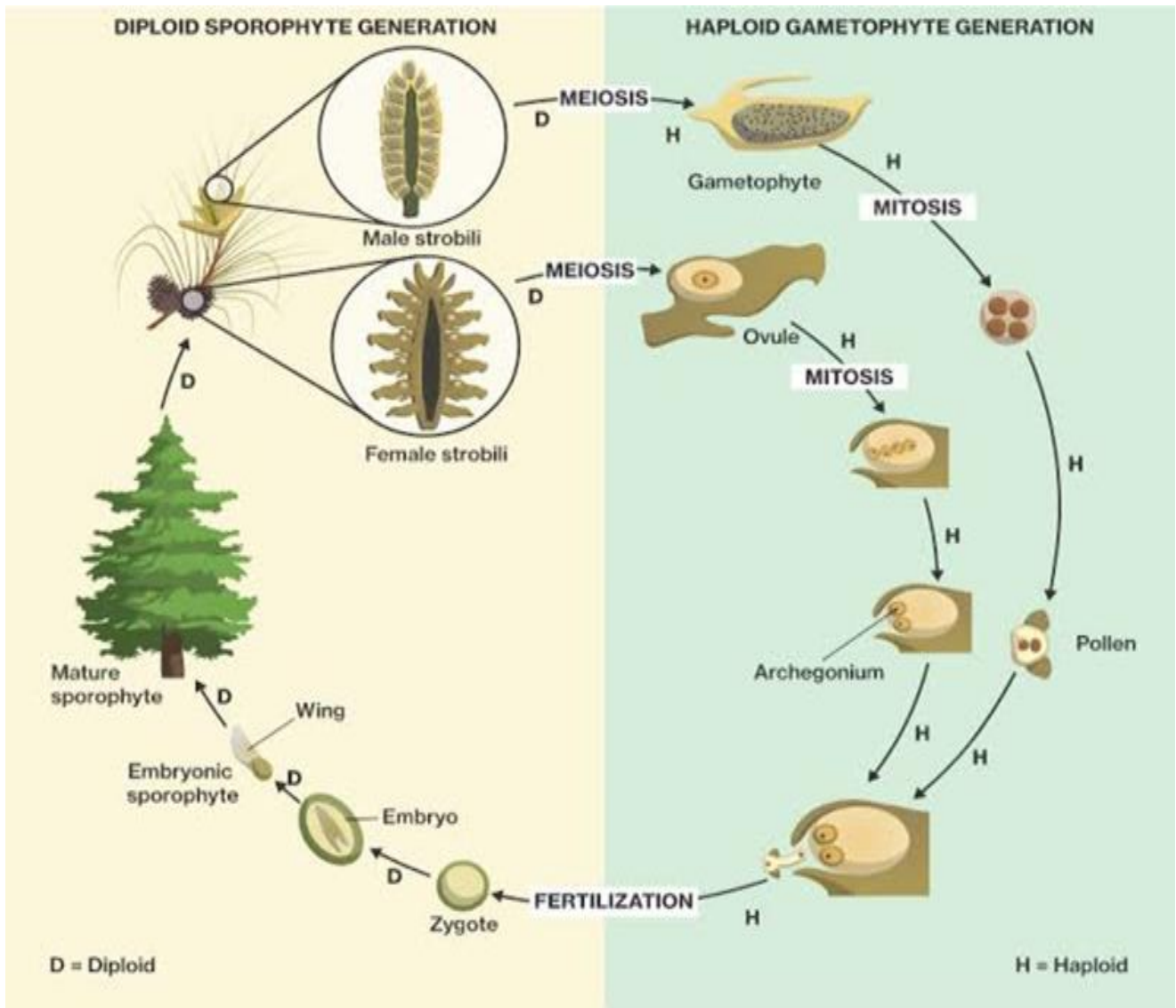
Cycads

Characteristics

STRUCTURE OF DOMINANT GENERATION	VASCULAR TISSUE	SPORES/SEEDS	FRUITS	DEPENDENCY ON WATER FOR REPRODUCTION
SPOROPHYTE – tap root system (with lateral roots), small leaves, woody stems. Leaves are in the form of needles. The narrow, thin shape, as well as the cuticle covering the needles, minimise water loss from the leaves. The leaves photosynthesise. The root network is large and goes deep into the soil.	Xylem and phloem present and well developed	Spores give rise to separate male and female gametophytes The first group of plants to produce seeds. Seeds or spores are produced in cones. The male cones bear the pollen sacs containing pollen grains (male spores). The female cones bear the ovules containing female spores.	None. The seeds that gymnosperms produce are not surrounded by a fruit and so are called naked seeds. Another feature of the plants in this group is the presence of cones. The seeds develop on the surface of the scales of female cones.	Water is not required for fertilisation.



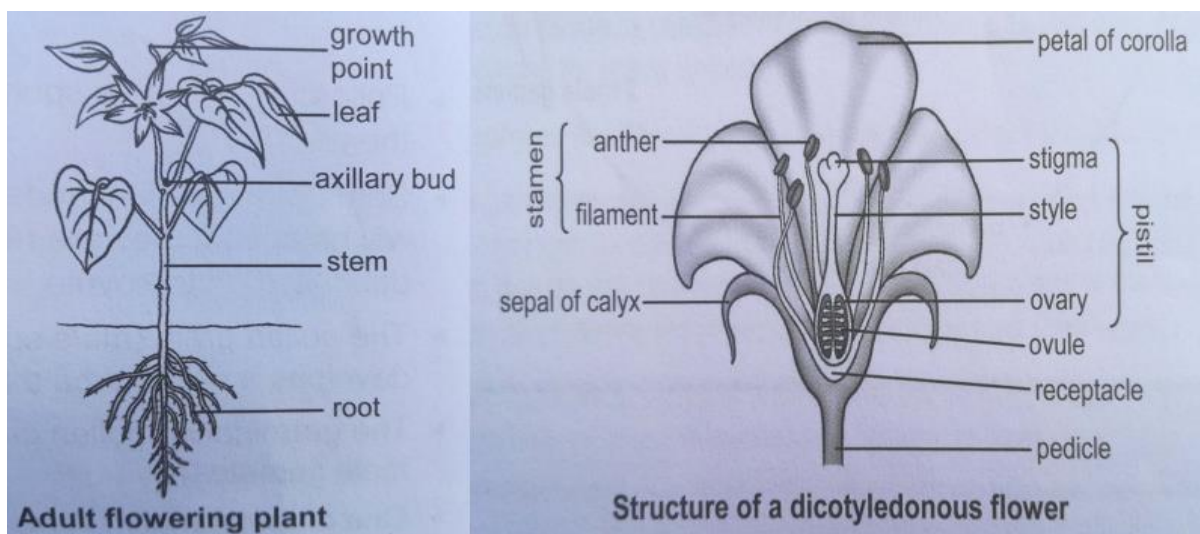
Life cycle



ANGIOSPERMS

The most advanced plants and most successful terrestrial plants e.g. mono- and dicotyledonous, Aloe and Petunia.

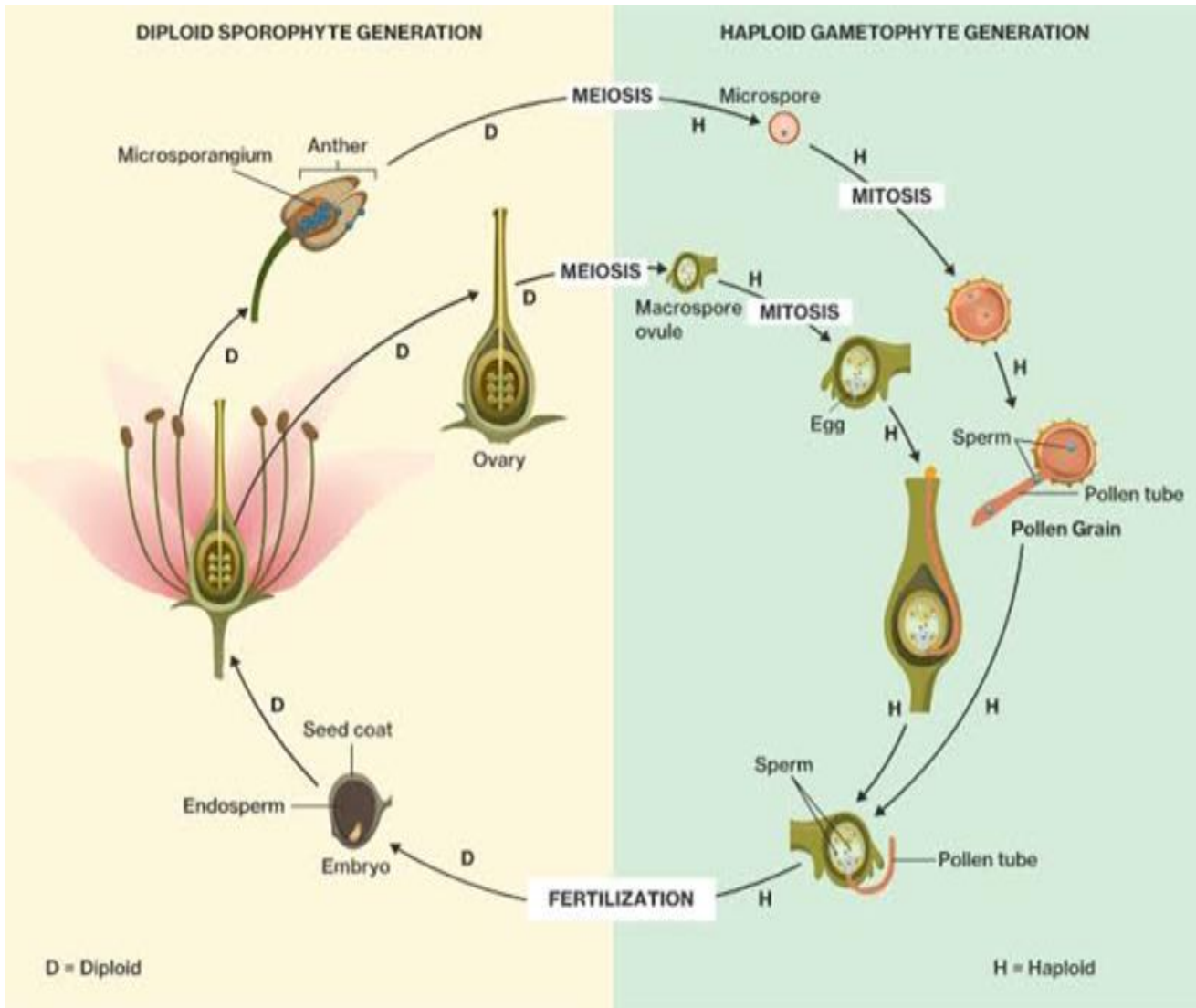
Angiosperms provide food for humans in the form of cereals, fruit and vegetables.



Characteristics

STRUCTURE OF DOMINANT GENERATION.	VASCULAR TISSUE	SPORES/SEEDS	FRUITS	DEPENDENCY ON WATER FOR REPRODUCTION
SPOROPHYTES – true roots, stems, leaves and flowers. All leaves have a cuticle to restrict water loss. The leaves also have pores, called stomata, for gaseous exchange on their undersurface.	Xylem and phloem present.	- Spores give rise to separate male and female gametophytes - Seeds are produced	Seeds are covered by fruits Seeds are housed and protected inside a fruit, which forms from the swollen and enlarged ovary of the flower.	Water is not needed for fertilisation

Life cycle



Adaptations for a successful life on land

Adaptation includes:

- **CUTICLE** – to prevent water loss
- **STOMATA** – for gaseous exchange
- **TRUE ROOTS, STEMS, LEAVES** – for absorption of water and mineral salts, transport and photosynthesis
- **VASCULAR TISSUE** (xylem and phloem) – for efficient transport in the plants
- **SUPPORTING AND STRENGTHENING TISSUE** – to keep the plant upright.
- **SEEDS** – ensure that unfavourable conditions can be overcome, and the embryo can have a chance of survival.

The adaptations are absent in the gametophyte generation of the Bryophytes and Pteridophytes. The gametophytes are poorly adapted to life on land.

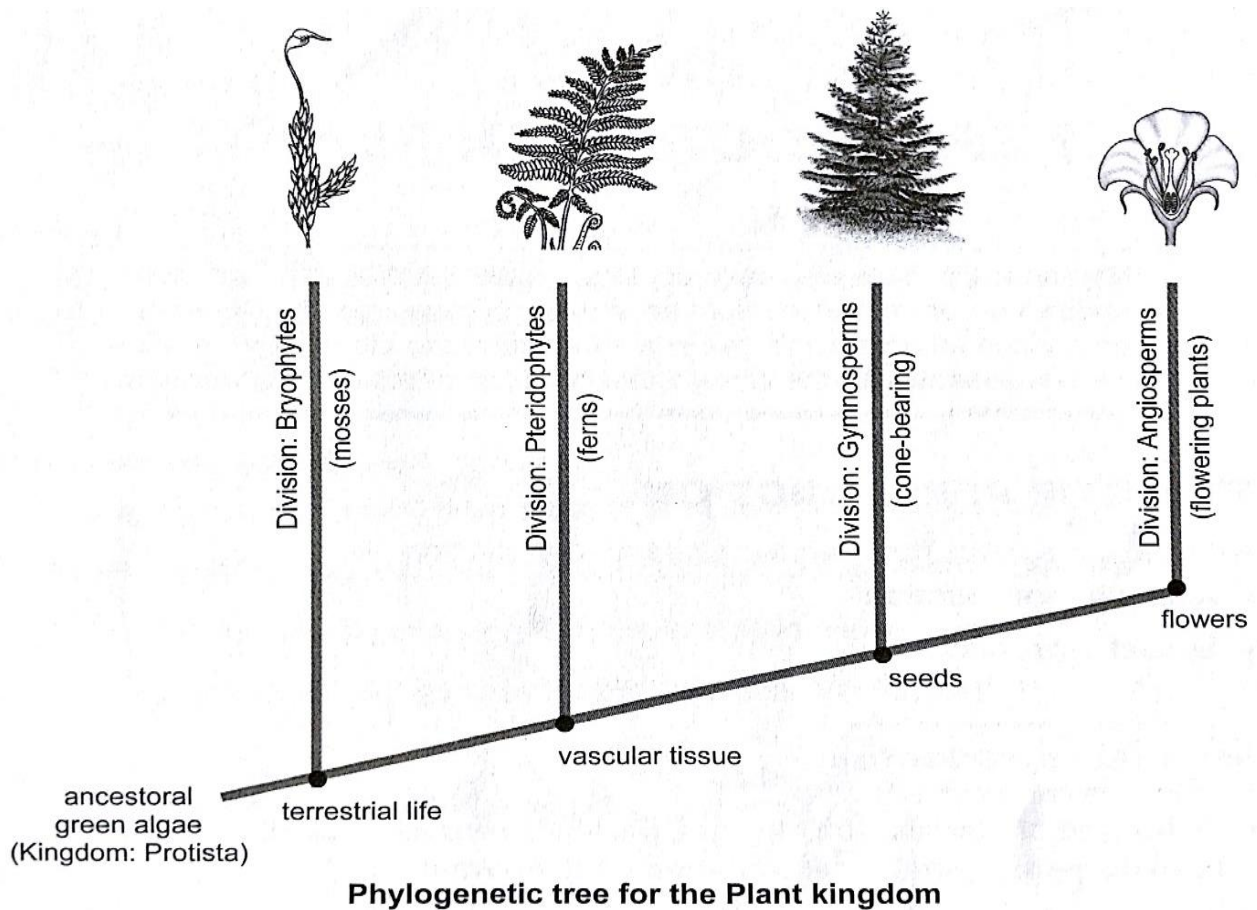
The sporophyte generations of the two are better adapted but Pteridophytes are better suited to a terrestrial environment than that of Bryophytes. The sporophytes of Pteridophytes have

true roots, stems and leaves, vascular tissue, a cuticle, stomata and sporangia that require dry environment for spore dispersal.

Bryophytes and Pteridophytes are both dependent on water for fertilisation.

Gymnosperms and Angiosperms are a step above the Pteridophytes. They are not dependent on water for fertilisation and they also form seeds.

Angiosperms are the best adapted of all the groups. They bear flowers, and the seeds are enclosed in fruits.



REPRODUCTION IN PLANTS

TYPES OF REPRODUCTION

Asexual reproduction – only one parent is involved, and ALL offspring have the same genetic composition as the parent. No gametes (sex cells) are involved. The process occurs by mitosis. Asexual reproduction is more common in plants than in animals.

Advantages

- In favourable conditions, a large number of offspring are produced rapidly and simply.
- Energy expenditure is low, because no gametes are produced.
- Offspring will easily adapt in the same environmental conditions as the parent because they are identical.

Disadvantages

- All the offspring share the same weak characteristics. If the stable environment changes, the consequences could be fatal and drastically reduce their chances of survival.
- Too many offspring are usually produced. This leads to overpopulation. Competition for food and space increases.

Sexual reproduction – two parents are involved, and their genetic materials combines. The offspring are not identical to each other, or to either of the parents. Gametes (sex cells) are produced by meiosis. Fertilisation takes place, during which the male gamete (sperm) and a female gamete (egg cell) fuse to form a zygote, which will develop into a new individual.

Advantage

- Offspring show greater genetic variation. They are more adaptable and have a greater chance of survival in changing environments.

Disadvantages

- The process takes longer than asexual reproduction. Gamete formation takes time.
- Fewer offspring are produced, decreasing the chances of survival.
- Energy expenditure is higher than in asexual reproduction. Special reproductive organs (flowers) develop.
- Plants need agents (e.g. water, wind or insects) to disperse pollen and seeds.

FLOWERS AS REPRODUCTIVE ORGANS

Flowers are the reproductive organs of Angiosperms.

Flower of a dicotyledonous plant, e.g. Petunia consists of four whorls (ring of floral parts):

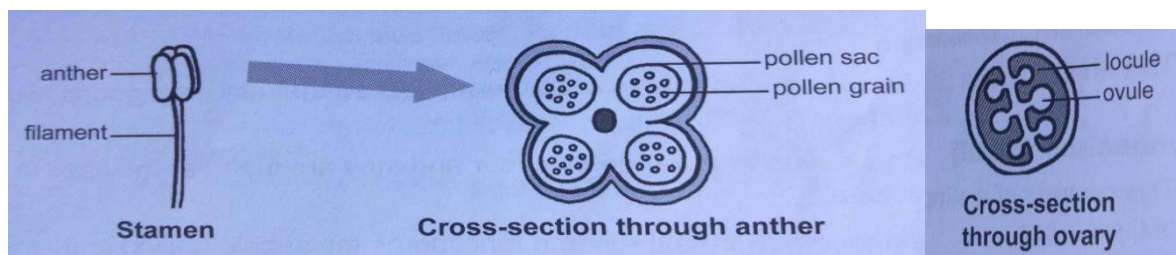
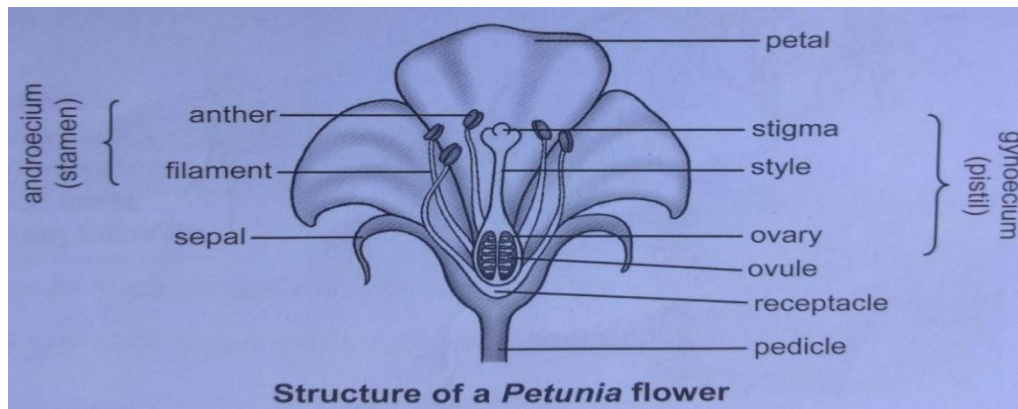
CALYX – the outermost whorl. It consists of five small, green sepals. The **SEPALS** surround the other whorls and protect the flower in the bud stage.

COROLLA – it consists of five striking, brightly-coloured petals that are fused together to form a trumpet-shaped corolla. The **PETALS** attract insects and birds to the flower for pollination.

ANDROECIUM – it composes the male part of the flower known as **STAMENS**. The Petunia has five stamens that are attached to the inside of the petals. Each stamen consists of a long

filament ending in a lobed ANTHHER. The anther contains pollen sacs in which the pollen is formed.

GYNOECIUM – it is the female part of the flower. It consists of a single STIGMA, a thin STYLE and an OVARY. The surface of the stigma is sticky so that the pollen grains can stick to it. The ovary contains two locules (small cavities) with a large number of ovules.

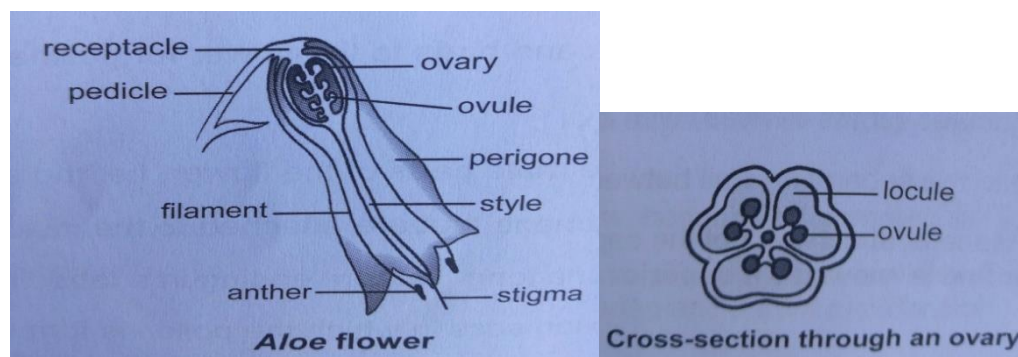


Flower of monocotyledonous plant, e.g. Aloe consists of three whorls:

PERIGONE – the calyx and corolla are fused to form a PERIGONE. The Aloe flower consists of six perigone leaves that are arranged in two whorls of three leaves each. The perigone performs the same function as the sepals (CALYX) and petals (COROLLA).

ANDROECIUM – it consists of six stamens arranged in two whorls of three each.

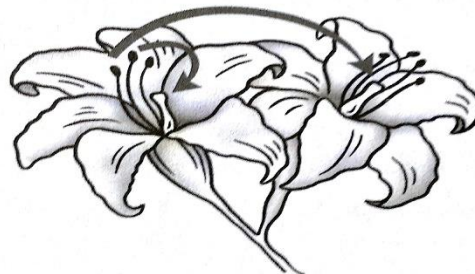
GYNOECIUM – it consists of stigma, style and ovary. The ovary has three lobes.



POLLINATION

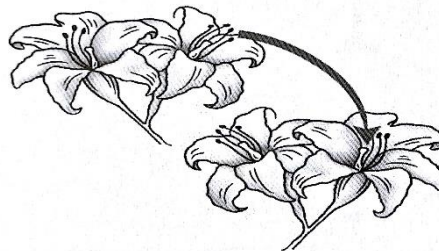
It is the transfer of ripe pollen from an anther to a receptive stigma so that fertilisation can occur. Two types of pollination can be distinguished:

Self-pollination: Transfer of ripe pollen from an anther to a receptive stigma of the same flower or other flowers on the same plant.



Self pollination

Cross pollination: Transfer of ripe pollen from the anther of one flower to the receptive stigma of a flower on another plant of the same species.

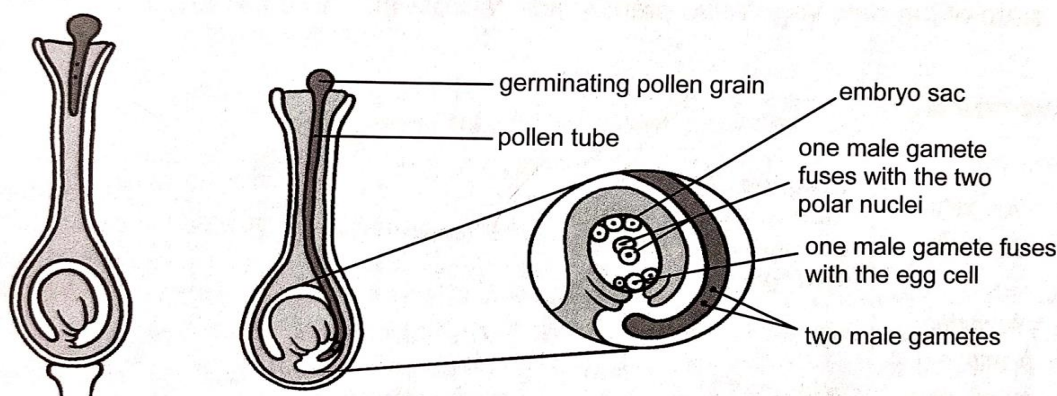


Cross pollination

How pollination takes place

During pollination, a ripe pollen grain (male spore) lands on a receptive stigma. After pollination the pollen grain germinates and develops a pollen tube with two male gametes. The germinating pollen grain, containing the two male gametes, represents the male gametophyte.

The pollen tube grows down the style into the ovary and penetrates the ovule and eventually the embryo sac to release the two male gametes. The embryo sac inside the ovule contains an ovum and two polar nuclei.



Fertilisation in Angiosperms

Adaptation of flowers for pollination

Pollination occurs by means of various pollinators (agents that transfers pollen), e.g.

- Wind
- Insects
- Birds
- small mammals (mice or bats)
- Water

Pollination by wind

A wind pollinated flower;

- Has small, not easily noticeable flowers without any bright petals
- Is simple – petals and sepals are usually absent for better exposure to the wind.
- Produce no nectar.
- Has its flowers carried in groups, close to each other, at the tips of long stems.
- Has long thin filaments hanging out of the flowers and are easily shaken by the winds.
- Has large anthers which release large quantities of pollen.
- Has small and light pollen grains that are easily carried by the wind.
- Has long and feather-like stigma with a large surface area. They are suspended outside the flower, easily trapping pollen.

Pollination by insects

An insect pollinated flower;

- Is brightly coloured to attract insect
- Has a sweet scent.
- Produces nectar as food for insects.
- Has a sticky pollen so that it can easily stick to the insect's body.
- Has stamens and stigma positioned inside the flower to ensure that the pollen on the insect's body can rub off onto the sticky stigma while it searches for nectar.

Pollination by birds

A bird pollinated flower;

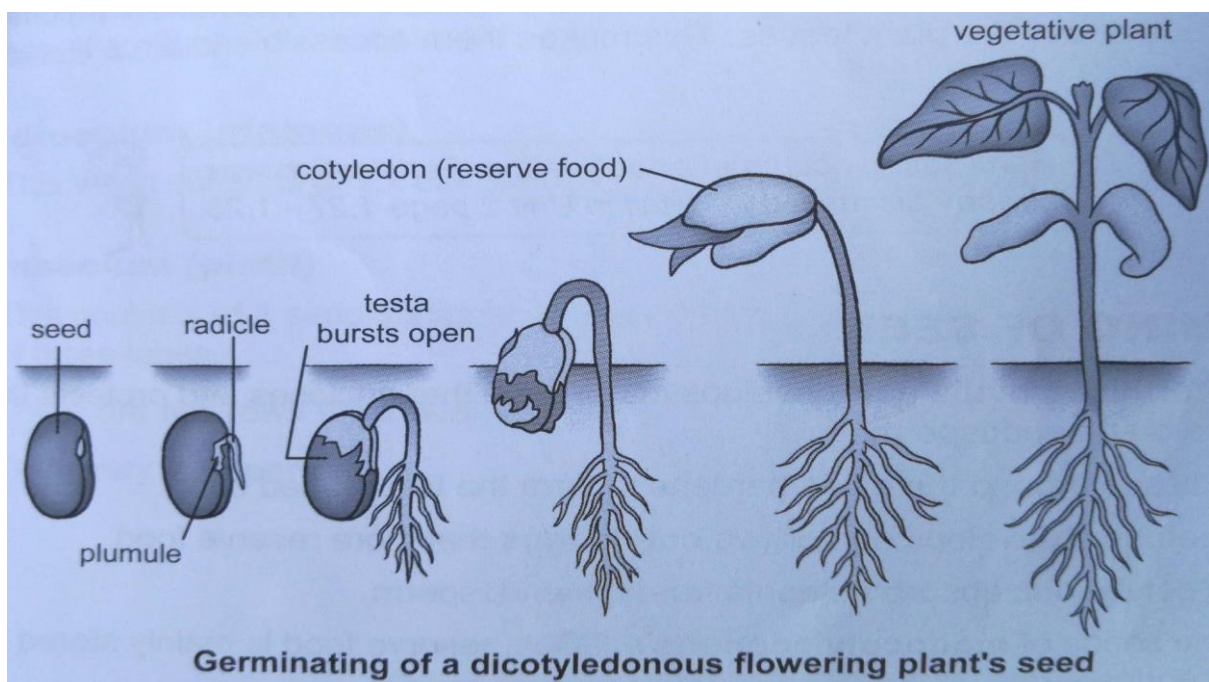
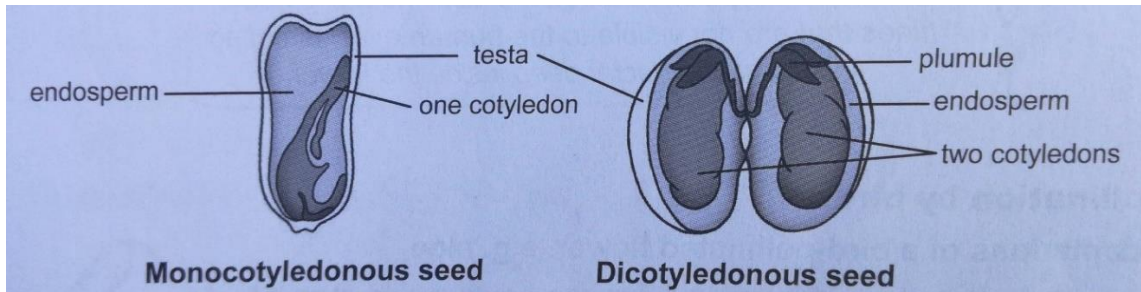
- Is brightly coloured, often red, orange or yellow, to attract birds.
- Produces large quantities of nectar to attract birds.
- Has little or no smell – birds have a weak sense of smell.
- Is trumpet-shaped, with stamens and stigma protruding from the flower.
- Has flowers placed on the tips of long, solid, leafless stems that protrude above the plant leaves. This makes them accessible to birds in search of nectar.

FORMING OF SEEDS

Fertilisation occurs after pollination.

- The fertilised ovule now develops into a **seed** that encloses and protects the embryo and endosperm (tissues in the embryo).
- The tissue around the ovule hardens to form the **seed coat (testa)**.

- The embryo develops into one or two cotyledons that store reserve food.
- The ovary around the fertilised ovule develops into a **fruit** that protects the developing seed. The fruit either opens or is eaten to release the seeds.
- Seeds are dispersed by the wind, water, insects or animals (including humans).
- Germination occurs when the seed absorbs water.



Importance of seeds

- Seeds are adapted to be dispersed by winds, insects, animals, water or humans. Effective seed dispersal means that the new seedlings germinate far from the parent plant. In this way species are well distributed to reduce competition.
- Seeds store reserve food in the endosperm for the early development of the embryo. Reserve food makes it possible for seeds to survive harsh weather conditions by remaining dormant.
- The hard, resistant seed coat (testa) that surrounds the seed protects the embryo against unfavourable condition.
- The cotyledons of the embryo provide food for the young developing seedlings after germination.

Seed as a source of food

Plants with edible seeds are a major source of food for humans and animals. Edible seeds are divided into THREE categories, i.e.

- GRAINS e.g. corn, wheat, rice and oats are an important source of the energy-rich carbohydrates (starch).
- LEGUMES e.g. peas, beans and lentils are an important source of proteins.
- NUTS e.g. almonds, cashews, chestnuts, macadamias, walnuts have a high protein content, and are also high in fibre, anti-oxidants and mono-unsaturated fatty acids. Mono-unsaturated fatty acids help to protect the body against coronary heart disease.

Many seeds, such as sunflower, peanut, soya and flax are rich in oils and are used to manufacture plant oils.

Use of seed banks to maintain biodiversity

Large numbers of wild plants in nature are endangered, mainly because of the destruction of habitats and climate change. By storing the seeds of these endangered plants, their extinction may be prevented. If the seeds of these plants are stored in a seed bank, they will not die out.

Seeds stored in seed banks can be used to:

- Re-establish endangered or extinct plants.
- Rehabilitate damaged or destroyed habitat.
- Cultivate plants that are overexploited.
- Cultivate new hybrids that are harder and more resistant to disease.
- Conserve endemic species.

The protection of plant diversity is essential for food security as well as ecological well-being.

TOPIC 3:

BIODIVERSITY OF ANIMALS (PAPER 2 – 18 MARKS)

Kingdom Animalia can be divided into two main groups:

- Invertebrates – Animals without a vertebral column (backbone)
- Vertebrates – Animals with a vertebral column

The TWO groups can be further subdivided into phyla according to shared characteristics. There are approximately 30 phyla in the animal kingdom, but only SIX will be discussed.

- Phylum Porifera e.g. sponges
- Phylum Cnidaria e.g. jellyfish, corals, sea anemones, blue bottles
- Phylum Platyhelminthes (flatworms) e.g. Planaria, bilharzia worm, tapeworm
- Phylum Annelida e.g. earthworms, sea worms, leeches
- Phylum Arthropoda e.g. insects, spiders, crustaceans, myriapoda.
(All five are invertebrates)
- Phylum Chordata (vertebrates) e.g. fish, amphibians, reptiles, birds, mammals.

BODY PLANS

Scientists use body plans to classify animals into groups (phyla). Animals with similar body plans are classified together in a phylum.

The following FOUR common features of an animal's body plan are important when an animal is classified.

- Symmetry and cephalisation
- Number of tissue layers that develop in the embryo
- Presence and absence of coelom and a blood system
- Number of openings in the digestive tract (alimentary canal).

Symmetry and cephalisation

Symmetry occurs when an animal can be cut into one or more planes to obtain two mirror images.

Asymmetry – Animals that show no symmetry are asymmetrical. Example is the sponges.

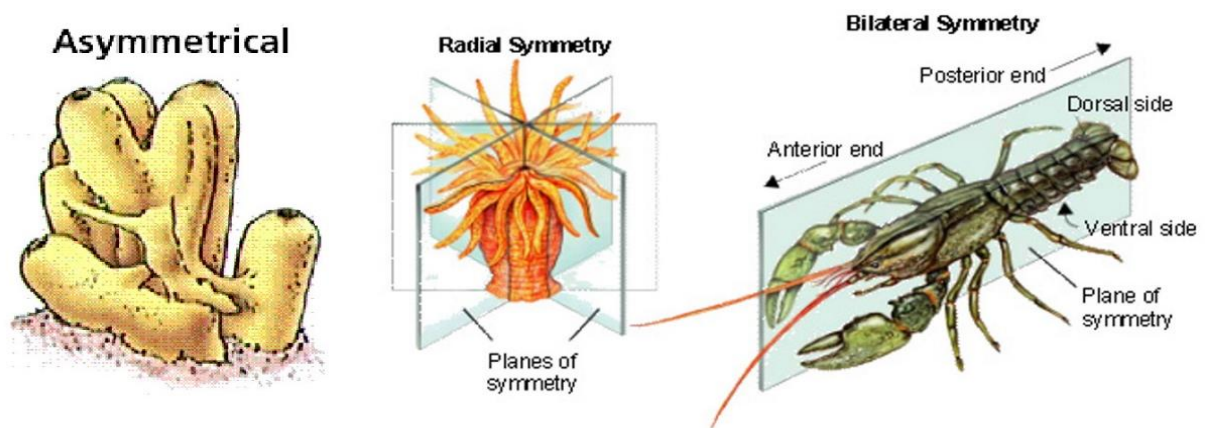
Radial Symmetry – A radially symmetrical animal can be cut in more than one vertical plane through its centre to obtain two mirror images. They have no right or left side.

Animals with radial symmetry are usually sessile (sedentary and attached to a substrate) or free-flowing. The major disadvantage of radial symmetry is that locomotion is slow and inefficient.

Bilateral symmetry – A bilaterally symmetrical animal can only be cut in one vertical plane through its centre to form two mirror images. It has a definitive dorsal (top) and ventral (bottom) side, a left and right side, an anterior and a posterior end.

Bilateral symmetry usually goes together with the development of specialised, sensitive area, the head, at the anterior end of the body. This concentration of nerve cells at the anterior end

of the body is known as **cephalisation**. A central nervous system is formed. Locomotion is made possible by cephalisation.



Tissue layers that develop in the embryo

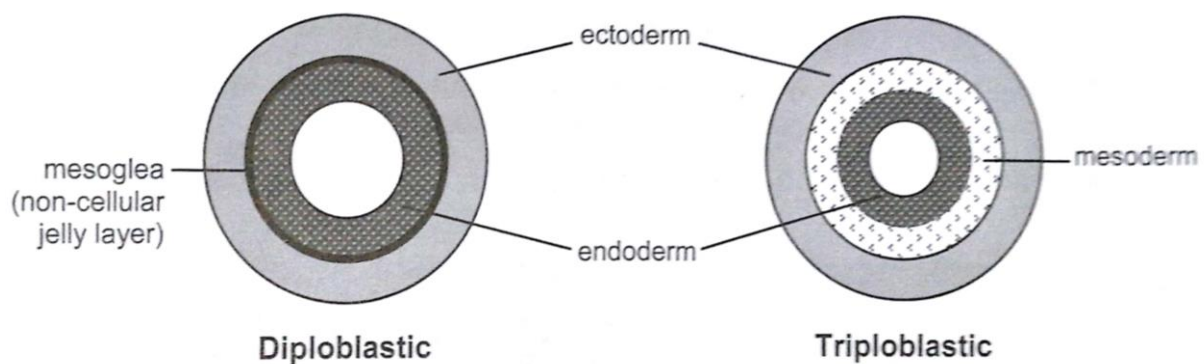
The developing animal embryo consists of a mass of cells that are arranged in the shape of a ball. Different tissue layers (known as germ layers) can be distinguished:

- Ectoderm – outer germ layer
- Endoderm – inner germ layer
- Mesoderm – germ layer between ectoderm and endoderm

According to the number of germ layers that occur in the developing embryo, animals are classified as:

DIPLOBLASTIC – the embryo has two germ layers: an outer ectoderm and inner endoderm. These two cell layers are separated by a non-cellular, jelly layer, the **mesoglea**.

TRIPLOBLASTIC – the embryo has three germ layers: an ectoderm, endoderm and a mesoderm between the ectoderm and endoderm.



Animals that show radial symmetry only have two germ layers and are always diploblastic. Diploblastic animals have a tissue level of organisation and do not develop organs.

All bilaterally symmetrical animals are triploblastic with three germ layers and an organ level of organisation. Triploblastic animals are more advanced and complex than diploblastic animals.

GERM LAYER	Tissues/organs that develop from each layer
Ectoderm	- Outer protective layer - Nervous system and sense organs
Ectoderm	- Epithelial lining of the digestive tract
Mesoderm	- Internal organs that form part of the blood system, muscular system, reproductive system, skeleton as well as connective tissues

Coelom and blood system

A **coelom** is an internal fluid-filled cavity that develops in the mesoderm of triploblastic animals. The coelom separates the digestive tract from the body wall.

Diploblastic animals do not have a coelom.

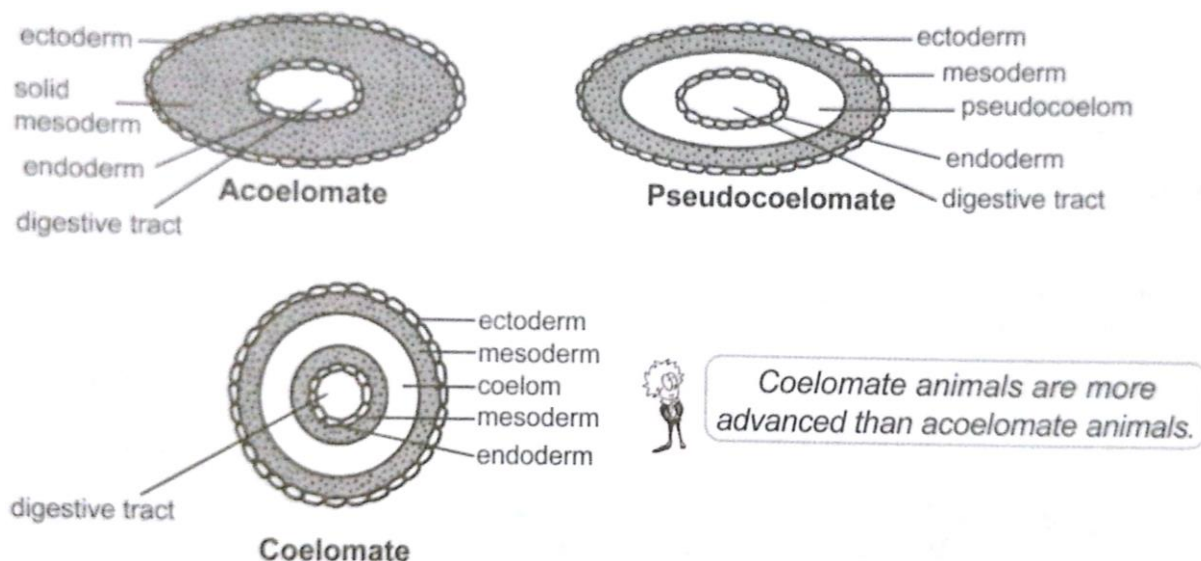
In triploblastic animals we distinguish between acoelomate, pseudocoelomate and coelomate animals.

Acoelomate – has no cavity (coelom) in the mesoderm.

Pseudocoelomate – has a coelom, but it is not seen as a ‘true’ coelom because it is not only surrounded by mesoderm tissue.

Coelomate – has a true coelom (a cavity) in the mesoderm. Coelomate animals are more advanced than acoelomate.

A **blood system** developed in most triploblastic animals for the transport of O₂, CO₂ and digested nutrients as well as an excretory system to transport waste products. When the blood is restricted to the blood vessel, it is known as a CLOSED BLOOD SYSTEM. But when the blood is not restricted to the blood vessel, it is known as an OPEN BLOOD SYSTEM.



Biological importance of coelom

- It separates the digestive tract and the body wall – ensuring that each function independently of the other.
- A fluid-filled coelom can act as a hydrostatic skeleton.

- The presence of a coelom allows animals to reach a considerable size and become more complex by providing space for organs to develop.
- Coelomic fluid serves as a transport medium for substances such as gases, nutrients and wastes.

Digestive tract

Simple acoelomate animals only have one opening to the outside through which ingestion as well as egestion occurs. New food can only be taken in once all food already ingested has been digested and the undigested remains are egested.

Coelomate animals are more complex and have two openings: a mouth and an anus. This is known as THROUGH GUT (complete gut). Incomplete food does not mix with outgoing undigested remains.

Comparative table of the relationship between the mode of living and body plan of 6 phyla

Phylum	Mode of life	Symmetry and cephalisation	Number of tissue layers	Presence/absence of coelom and blood system	Type of body cavity	Presence/absence of through gut/complete gut
Porifera	› aquatic (sea water) › sessile	› asymmetrical › no cephalisation	› cellular (consist of loose cells)	› acoelomate › no blood system	› spongocoel	› none
Cnidaria	› aquatic (fresh and sea water) › sessile and free-living	› radially symmetrical › no cephalisation	› two layers (diploblastic)	› acoelomate › no blood system	› coelenteron	› absent › only one opening
Platyhelminthes	› aquatic › free-living and parasitic	› bilaterally symmetrical › cephalisation	› three layers (triploblastic)	› acoelomate › no blood system	› none	› absent › only one opening
Annelida	› aquatic (fresh and sea water) › terrestrial (moist environments) › free-living	› bilaterally symmetrical › cephalisation	› three layers (triploblastic)	› coelomate › closed blood system	› coelom	› present › two openings
Arthropoda	› occur everywhere - aquatic (fresh and sea water) › terrestrial, underground, in the air › free-living	› bilaterally symmetrical › cephalisation	› three layers (triploblastic)	› coelomate › open blood system	› coelom (haemocoel)	› present › two openings
Chordata	› occur everywhere, terrestrial, in the air, aquatic (fresh and sea water) › free-living	› bilaterally symmetrical › cephalisation	› three layers (triploblastic)	› coelomate › closed blood system	› coelom	› present › two openings

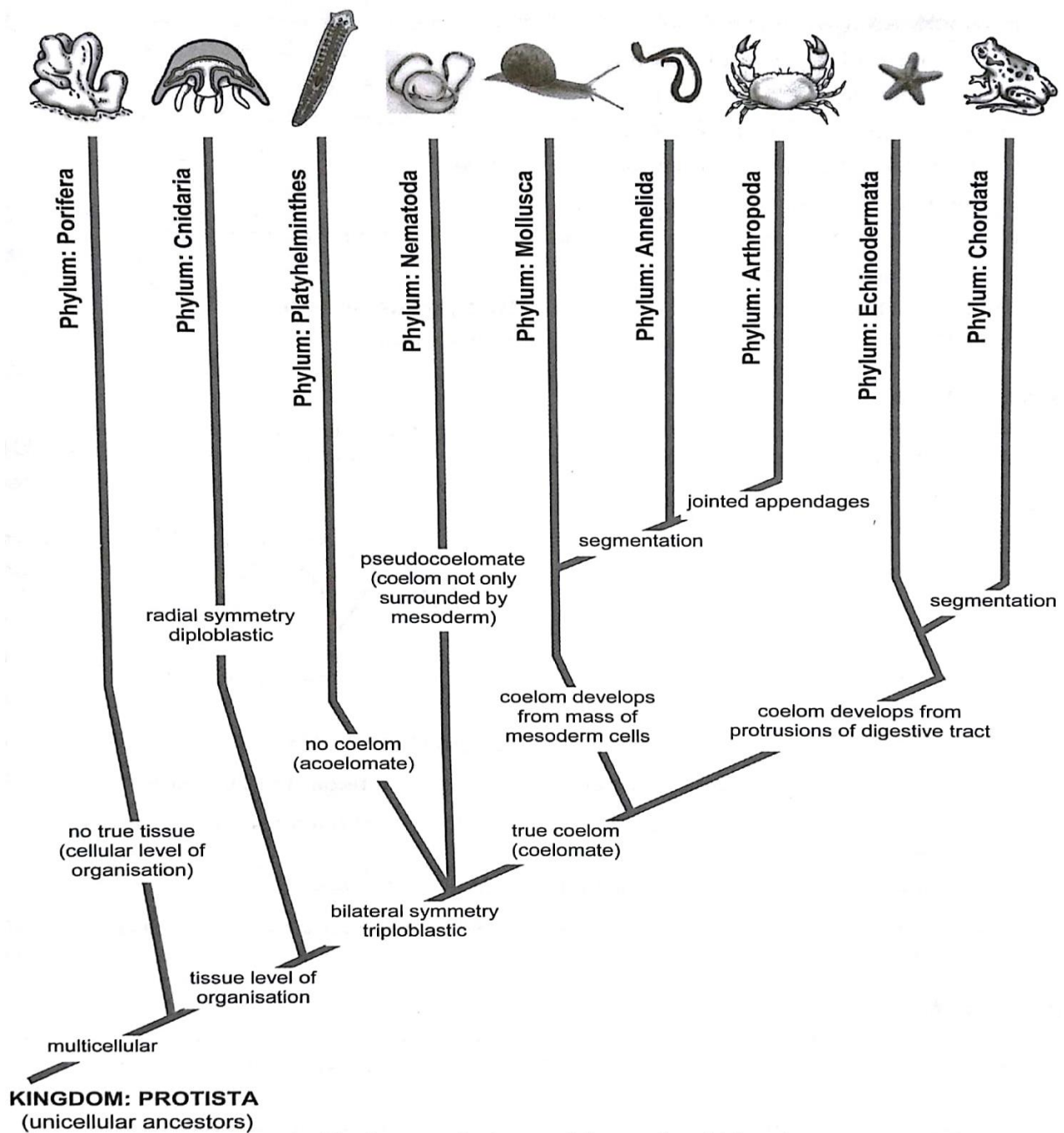
ROLE OF INVERTEBRATES IN AGRICULTURE AND ECOSYSTEMS

Pollination – Insects like honeybees and butterflies act as pollinators.

Decomposition – Invertebrates like beetles, flies, earthworms breaks down dead plant and animal matter to simpler chemical substances which are released into the soil and made available to plants.

Aerating the soil – Earthworms, ants and termites dig underground tunnels. This digging loosens the soil and traps more air between the soil particles, which makes it easier for water to infiltrate the soil.

EVOLUTIONARY HISTORY OF ANIMALS



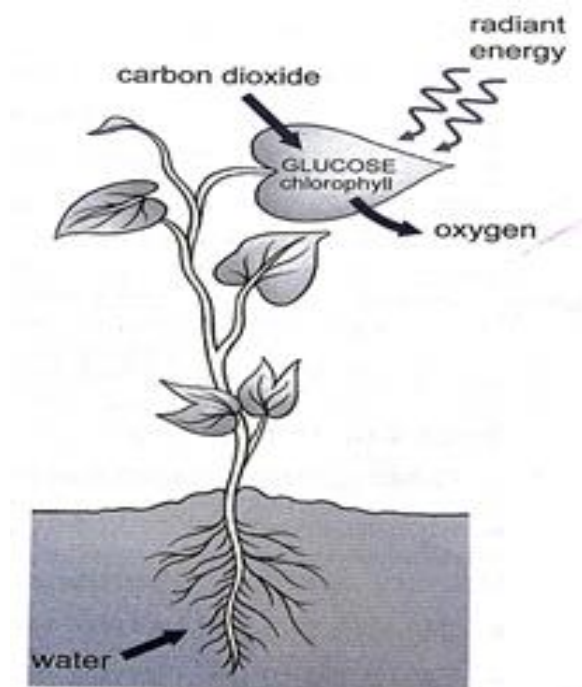
TOPIC 4:
ENERGY TRANSFORMATION TO SUSTAIN LIFE (PAPER 1 – 31 MARKS)

PHOTOSYNTHESIS

Photosynthesis is the **building up of carbohydrates** (glucose) from carbon dioxide and water using radiant energy from the sun that is trapped by chlorophyll. Oxygen is released.

Raw materials required for photosynthesis

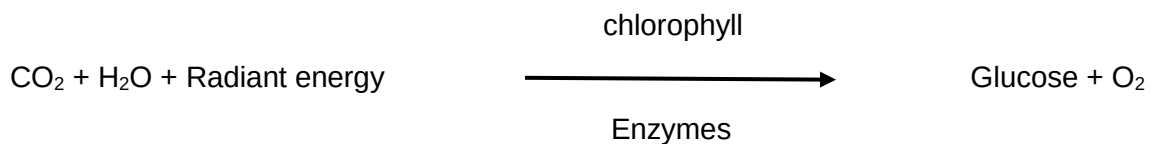
- Carbon dioxide from the atmosphere
- Water from the soil
- Radiant energy from the sun
- Chlorophyll in the chloroplasts of green plants
- Enzymes



Products of photosynthesis

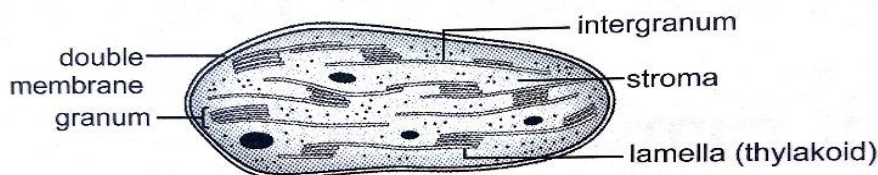
- Glucose, which is stored in plant as starch
- Oxygen, which is released into the atmosphere

Equation for the process of photosynthesis:



Process of photosynthesis

Photosynthesis takes place in the chloroplasts of plant cell.



Structure of a chloroplast

Two phases can be distinguished:

LIGHT PHASE – this takes place in the presence of light (light dependent)

DARK PHASE – this can take place in light or darkness (light independent)

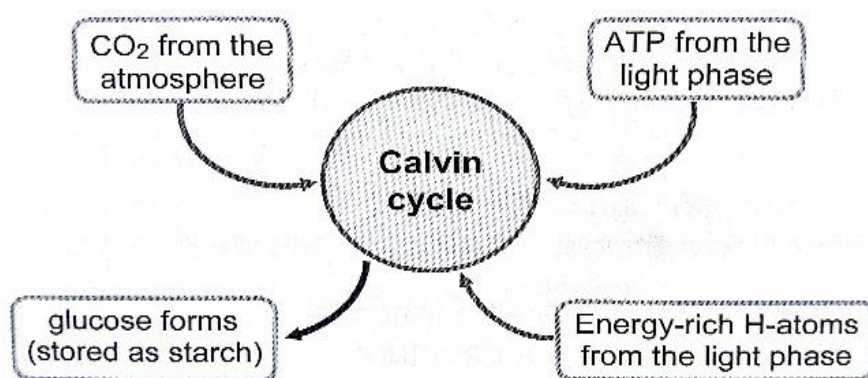
Light phase

The light phase takes place in the **grana** (granum) of the chloroplasts. Radiant energy is absorbed by the chlorophyll molecules in the lamella. This radiant energy is transformed into chemical energy. The chemical energy is used for two processes:

- Water molecules are split up into energy-rich hydrogen atoms (which are transferred to the dark phase) and oxygen atoms (which are released into the atmosphere as a gas). This process is known as **photolysis**.
- The energy carrier ATP is formed, and it is used again in the dark phase.

Dark phase (Calvin cycle)

The dark phase takes place in the **stroma** of the chloroplasts. Carbon dioxide that is absorbed from the atmosphere combines with the energy-rich hydrogen atoms from the light phase using the energy that is released from ATP (formed in the light phase). Energy-rich carbohydrates (glucose) are formed. Excess glucose is converted to starch for storage.



A representation of the dark phase of photosynthesis

Importance of photosynthesis

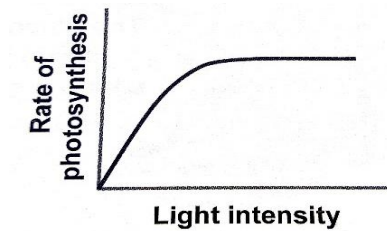
- It keeps the concentration of oxygen in the atmosphere and water constant.
- It keeps the level of carbon dioxide in the atmosphere and water constant.
- Photosynthesis provides food for heterotrophic organisms.
- Photosynthesis makes chemical energy available for cell functioning during cellular respiration.

Factors that influence the rate of photosynthesis

- Light intensity
- Temperature
- Carbon dioxide concentration

Light intensity

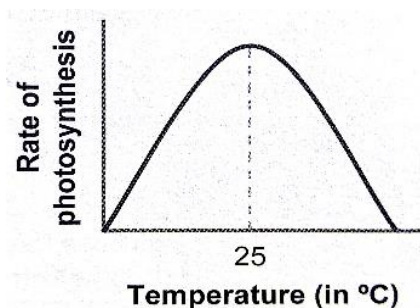
An increase in light intensity results in an increase in the rate of photosynthesis, but only to a maximum level. If the light intensity becomes too high, the stomata close and carbon dioxide then become a limiting factor.



Temperature

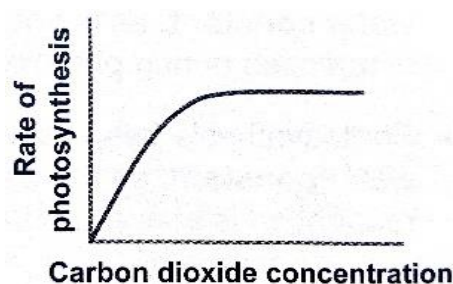
Plants photosynthesise optimally at 25°C. Temperature that are too high or too low inhibit the rate of photosynthesis.

At low temperatures, enzymes become inactive and at high temperatures, enzymes denature. At high temperatures, the stomata close to limit water loss and then carbon dioxide becomes a limiting factor once again.



Carbon dioxide concentration

A decrease in CO₂ concentration leads to a decrease in the rate of photosynthesis. An increase in CO₂ concentration leads to an increase in the rate of photosynthesis.



ROLE OF OPTIMUM LIGHT, TEMPERATURE AND CO₂ ENRICHMENT IN A GREENHOUSE SYSTEM

A greenhouse is a structure with a glass roof and walls where plants are cultivated. It becomes fairly warm inside a greenhouse, because the sun heats the air, plants, soil and other objects within the structure. The warm air is trapped in the greenhouse.

The **aim** of a greenhouse is to provide optimal conditions of light, temperature and CO₂ for maximum growth of the cultivated plants.

- Optimum light intensity accelerates photosynthesis and stimulates the growth rate of the plants.
- It must be possible to regulate the temperature of the air in the greenhouse to keep it at an optimum temperature for maximum growth of specific plant types.
- CO₂ enrichment can occur on large scale by pumping CO₂ gas from tanks into the greenhouse. Also, addition of sodium bicarbonate and organic materials to the soil, will increase the CO₂ levels.



TOPIC 5:

ANIMAL NUTRITION (PAPER 1 – 31 MARKS)

Animals are unable to produce their own organic food. All animals are heterotrophic organisms that are dependent on other organisms for their nutrients.

Animals usually obtain their organic food in a complex, insoluble form. Before the animal tissues can use this food, it must first be broken down into simpler, soluble nutrients.

Five main processes in nutrition

INGESTION – the food is taken in and enters the alimentary canal.

DIGESTION – food is exposed to mechanical and chemical processes that change solid, insoluble food to simpler, soluble substances.

ABSORPTION – the end products of digestion are absorbed into the bloodstream.

ASSIMILATION – the cells absorb the nutrients from the blood and use it to build new cell structures and compounds.

EGESTION – the process through which undigested remains are removed from the body in the form of faeces.

Necessity for food

- Provides energy – most of the energy is provided through the ingestion of carbohydrates and fats.
- Growth and repair of damaged tissues – this requires ingestion of proteins
- Regulation of body processes (e.g. cellular respiration and excretion) – this requires ingestion of vitamins, water and mineral salts.

MODES OF NUTRITION IN ANIMALS

Herbivores – e.g. cattle, sheep, antelope and giraffes, feed on plant material.

Large volumes of food are ingested, as plant material has a very low energy value.

Herbivores' teeth are adapted in the following ways:

- Incisors are sharp to cut off plant material
- Canines are often absent.
- Premolars and molars are large and flat to grind plant material.

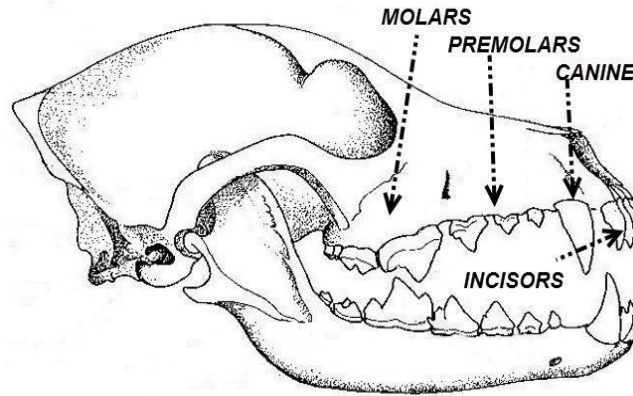


Carnivores – e.g. lions, cats and leopards feed on animal material (meat).

They ingest less food than herbivores, as the proteins and fats in meat have a much higher energy value than plant material.

Carnivores' teeth are adapted in the following ways to hold and tear off pieces of meat:

- Incisors have sharp ends to bite off food.
- Canines are long and strong to pierce, kill and tear prey apart.
- Premolars and molars have protrusions with sharp edges to cut off the food.



Omnivores – e.g. baboons and pigs, live on both plant and animal material.

The amount of food omnivores consume depends on the energy value of the food they eat.

Omnivores' teeth are very similar to those of carnivores, except that their molars do not have such prominent protrusions.

Both baboons and pigs possess well-developed canines which are used mainly for self-defence and social display (baboons).

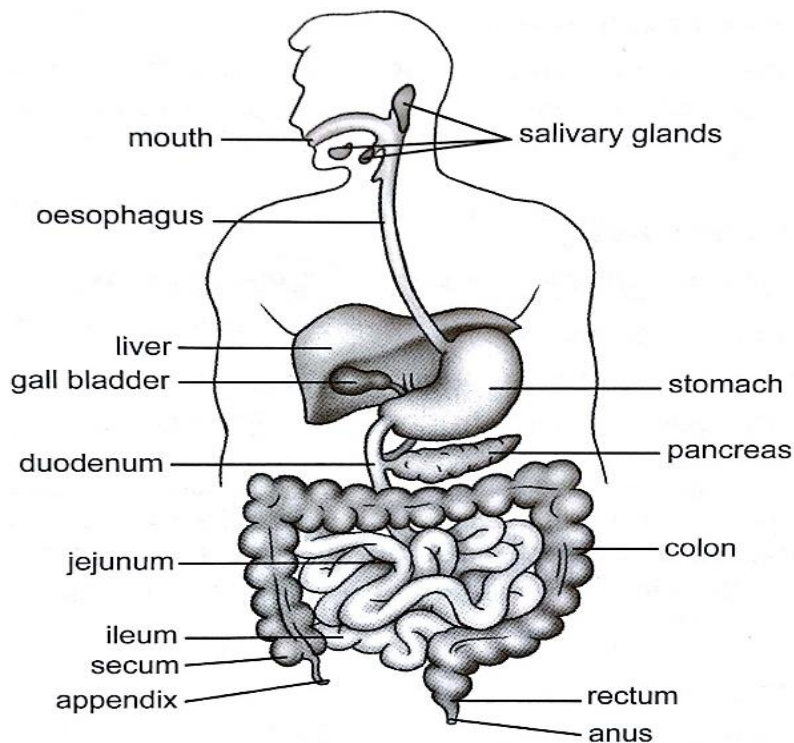


HUMAN NUTRITION

THE DIGESTIVE SYSTEM – The human digestive system consists of the **alimentary canal** and **accessory organs**.

ALIMENTARY CANAL – a long tubular structure that extends throughout the body. It consists of the mouth and mouth cavity, pharynx, oesophagus, stomach, small intestine, large intestine and anus.

ACCESSORY ORGANS – it includes the tongue, salivary glands, pancreas, liver, gall bladder.



Structure of the human digestive system

Structure and functions of the alimentary canal

MOUTH AND MOUTH CAVITY – it is the upper opening of the alimentary canal. The roof of the mouth cavity consists of a hard, ridged palate at the front and a soft palate at the back. The mouth cavity also contains the tongue and the teeth toward the front, as well as salivary glands.

Function

- The mouth cavity receives the food and begins the process of mechanical digestion by breaking down larger particles of food into smaller particles and mixing it with saliva.

PHARYNX – located at the back of the mouth cavity. It leads to two openings (oesophagus and trachea –wind pipe). During swallowing, the opening to the trachea is closed by a small leaf-shaped cartilage structure called epiglottis which prevents food from entering the trachea and choking a person.

Function

- The pharynx is a common passage for food and air from the mouth to the oesophagus and the trachea.

OESOPHAGUS – a hollow, muscular tube that connects the pharynx to the stomach. It is located behind the trachea.

Function

- The muscle in the wall of the oesophagus are responsible for peristaltic movements, which push the food bolus forward.

STOMACH – it is a sickle-shaped, sac-like organ that is located just below the diaphragm.

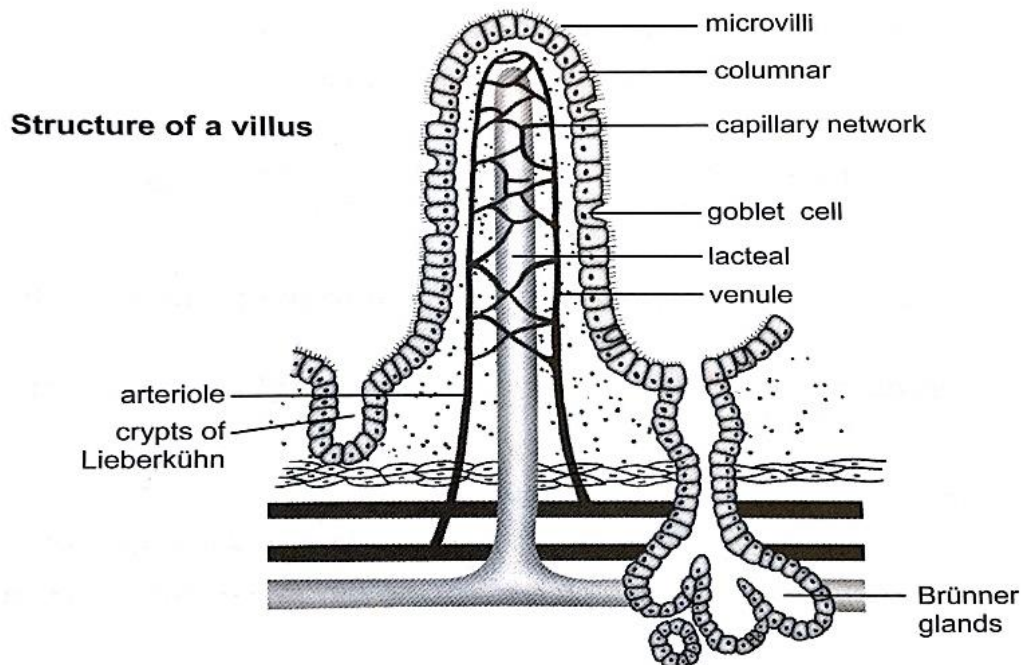
Functions

- The muscular wall causes churning movements that assist with physical digestion and also ensure that the food is mixed with gastric juices.
- The glands in the stomach wall secrete gastric juices for digestion.

SMALL INTESTINE – long, muscular tube of approximately 5m to 6m in length. It consists of three parts which are **duodenum**, **jejunum** and **ileum**.

Functions

- The layer of muscles in the wall of the small intestine causes peristaltic movements, which moves the chyme (semi-solid food) forward and ensures that it becomes thoroughly mixed with the digestive juices.
- Glands in the duodenal wall (crypts of Lieberkuhn and Brunner glands) secrete digestive juices (intestinal juice), which play a role in digestion.
- The small intestine has millions of villi to increase the surface area for the absorption of digested nutrients.



LARGE INTESTINE – consists of three parts which are colon, caecum and rectum (which ends with an opening on the outside, the anus).

Functions

- The large intestine secretes large amounts of mucus to aid egestion.
- Water and useful substances (certain vitamins and bile salts) are absorbed from the semi-solid waste in the colon.
- Undigested waste (faeces) is stored temporarily in the colon before it is egested via the anus.

Structure and function of the accessory organs

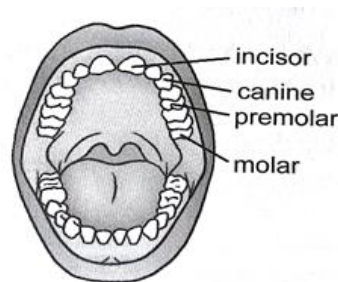
TONGUE – it is a muscular organ. The back of the tongue is attached to the mouth floor.

Functions

- It has taste buds and serve as a taste organ.
- It helps with the chewing process by pressing food against the hard palate and between the teeth.
- This ensures that chewed food is mixed with saliva.
- It rolls the food into a bolus (ball)
- It helps with the swallowing process as it pushes the food bolus towards the opening of the throat.

TEETH – Humans have four types of teeth, each with four different functions.

- Incisors – bite and cut off food
- Canines – hold food in place and tear it off
- Premolars – chew and grind the food
- Molars – chew and grind the food



The human dental formula is:

$\frac{2. 1. 2. 3}{2. 1. 2. 3}$

SALIVARY GLANDS – the salivary glands open into the mouth cavity. There are three pairs of salivary glands:

- Parotid salivary glands (located below the ears)
- Submandibular salivary glands (located in the lower jaw)
- Sublingual salivary glands (located under the tongue)

Function

- They produce and secrete saliva via ducts that open into the mouth cavity.

PANCREAS – a tongue-shaped gland located just below the stomach. The pancreas is both an exocrine and endocrine gland. It is composed of two types of cell:

- Normal pancreatic cells
- Islets of Langerhans

Functions

- Normal pancreatic cells secrete pancreatic juice with enzymes which play a role in digestion.

- The islets of Langerhans secrete two hormones (insulin and glucagon) which control the blood glucose levels in the body.

LIVER – the largest gland in the body and is located just below the diaphragm. It consists of two lobes, a large right lobe and a smaller left lobe. Each lobe is made up of tiny lobules that in turn consist of liver cells. The liver cells produce bile that is transported away from the liver to the gall bladder for storage via the common hepatic duct.

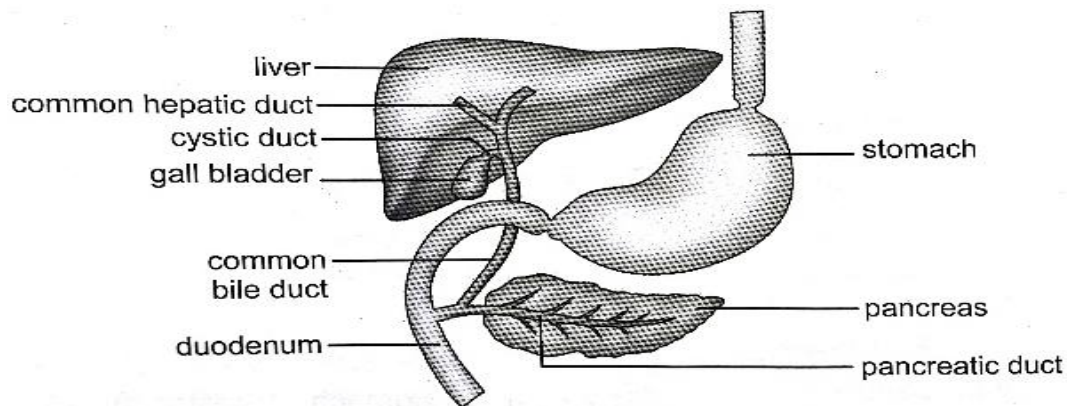
Function

- The liver produces bile, which is stored in the gall bladder.
- Glucose is converted into glycogen for storage in the liver.
- Any excess glucose is converted into fat and stored.
- Excess amino acids are broken down to form urea and glucose in the liver by a process called deamination.
- The liver is a detoxifying organ that absorbs and neutralises certain toxins such as alcohol.
- Vitamins A, D, E, K and B12 are stored in the liver.
- The liver synthesises heparin which prevents blood clotting.

GALL BLADDER – a muscular sac located between liver lobes. It contracts to release bile when it is stimulated.

Function

- The gall bladder stores and releases bile that is produced in the liver. Bile contains bile acid, which are critical for digestion and absorption of fats and fat-soluble vitamins in the small intestine.



The stomach and accessory organs

DIGESTION

Complex, insoluble food particles are broken down by digestion into simple soluble nutrients. There are TWO types of digestion:

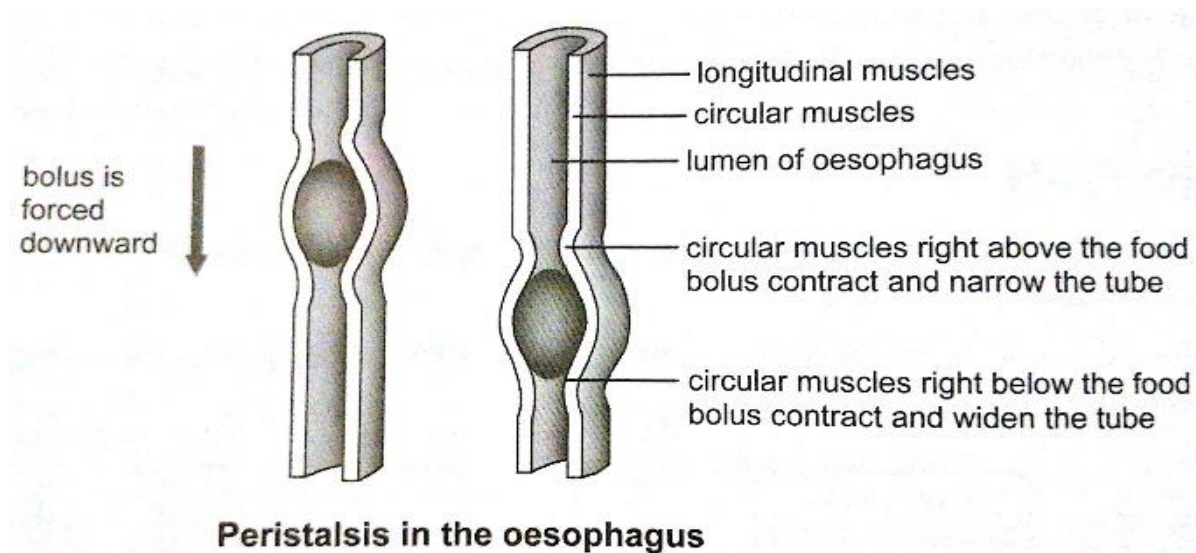
- Mechanical or physical digestion
- Chemical digestion

MECHANICAL/PHYSICAL DIGESTION – it includes chewing process (mastication), bolus formation, churning movement and peristaltic movement.

CHEMICAL DIGESTION – breaking down o large, insoluble molecules in food into smaller, soluble molecules by the addition of water. The reaction is known as **hydrolysis** and it takes place with the help of enzymes.

Role of water during digestion

- Acts as lubricant and facilitates chewing and swallowing
- Acts as solvent for digested food
- Transports digested food
- Medium in which digestive reactions occur
- Reagent for hydrolysis.



Enzymes involved in chemical digestion

Substrate (complex molecules)	Enzyme	pH	Place of production	Digestive juice	End product
Carbo-hydrates	Carbohydrases, e.g. salivary amylase	7,2 - 8,0	mouth	saliva	glucose
	pancreatic amylase maltase sucrase lactase		pancreas small intestine	pancreatic juice intestinal juice	
Proteins	Proteases e.g. pepsin	1,5 - 2 8	stomach	gastric juice	amino acids
	renin trypsin		pancreas	pancreatic juice	
Lipids (fats)	Lipase	8	pancreas small intestine	pancreatic juice intestinal juice	glycerol and fatty acids

ABSORPTION

Digested food is absorbed into the bloodstream. Most absorption of digested food occur in the small intestine.

The small intestine is structurally adapted for maximum absorption. The length of the small intestine ensures that food remains for long periods, allowing enough time for maximum absorption.

There are millions of villi in the wall of the small intestine, which increase the absorption surface considerably. The soluble (dissolved) nutrients are mainly absorbed through the villi.

Absorption Process

Glucose, the end product of carbohydrate digestion, is actively absorbed, against the concentration gradient, into the blood capillaries of the villi.

Amino acids, the end product of protein digestion, are also actively absorbed, against the concentration gradient, into the blood capillaries.

Glycerol and fatty acids, the end products of lipid digestion, are absorbed by diffusion.

Vitamins – fat soluble vitamins A, D, E and K are passively absorbed into the blood capillaries, while water soluble vitamins B and C are passively absorbed or aided by carrier molecules.

Mineral salts are both passively and actively absorbed into the capillaries.

Water is absorbed into the capillaries by osmosis.

Large amounts of water, certain vitamins and mineral salts are also absorbed in the colon.

HOMEOSTASIS

Homeostasis is the tendency of living organisms to maintain a constant composition of their internal environment within narrow limits, irrespective of changes in the external environment.

Internal environment – body fluid in which the cells are bathed.

For cells to function optimally, these factors must be kept constant:

- Glucose levels
- Ion/salt concentration
- Water content
- Oxygen and carbon dioxide concentration
- Body temperature
- pH/acidity
- Metabolic waste

Hormonal control of glucose concentration in the blood

Two hormones (insulin and glucagon), secreted by the islets of Langerhans in the pancreas, control the glucose concentration in the blood.

When the blood sugar level is higher than normal, the beta (β -) cells of islets of Langerhans detect this increase and **insulin** is secreted into the blood.

Insulin reduces the blood sugar level in two ways:

- It increases the rate at which glucose is absorbed by the cells (especially liver and muscle cells)

- It stimulates the conversion of glucose into glycogen and fat in the liver and muscles

The decrease in the glucose is detected by the beta cells of islets of Langerhans, which in turn, inhibits the secretion of insulin.

When the blood sugar level is lower than normal, the alpha (α -) cells of islets of Langerhans detect this increase and **glucagon** is secreted into the blood.

Glucagon increases the blood sugar level by stimulating the conversion of glycogen to glucose for release into the bloodstream.

The increase in the glucose is detected by the alpha cells of islets of Langerhans, which in turn, inhibits the secretion of glucagon.

Insulin and glucagon are **antagonistic hormones** as they have opposite effects in the body.

Diabetes mellitus

It is a metabolic disease characterised by high glucose levels in the blood. It is a chronic, incurable disease.

It is as a result of the beta cells of islets of Langerhans not producing enough insulin or not producing at all or insulin is produced but the body cells cannot use it effectively.

Diabetes may occur:

- When the body's immune system attacks and destroys its own beta cells.
- As a result of obesity and a person being overweight.
- As a result of inactivity.
- Age.

Treatment and management:

- Daily insulin injection
- Regular exercise
- Maintaining normal body weight through a balanced diet.

Balanced diet

A balanced diet contains all the necessary nutrients in the correct quantities. It should include the following:

- Energy foods such as carbohydrates and lipids (fats).
- Building materials such as proteins.
- Protective nutrients such as vitamins and minerals.

Human nutritional requirements vary according to their age, gender and level of activity:

- Growing children need more protein than adults.
- Men need more food than women.
- Active people need more energy food.
- Pregnant women need more calcium.
- Older people need less food.

Energy in food – the energy value in food is measured in the units kilojoules/kilocalories (1 kJ = 4,2 kcal).

Nutritional supplement – enhances or adds to the amount of vitamins, minerals, proteins and fats in the diet. Supplements are usually taken for health, sports, beauty/anti-ageing.

Malnutrition

If a person does not follow a balanced diet, he/she will suffer from malnutrition which can lead to a variety of nutrition-related diseases/conditions.

- Kwashiorkor – occurs due to a lack of protein in the diet. It often occurs in growing children.
- Marasmus – results from a general lack of energy food (especially carbohydrates and fats). It occurs in children older than six months who are breastfeeding without additional food.
- Anorexia nervosa – a psychological condition where the person refuses to eat, although food is available.
- Obesity – occurs when a diet high in energy foods is followed over a long period of time. Energy intake exceeds energy consumption, leading to excessive fat deposits in the tissues and around the organs. Obesity can lead to the following life-threatening diseases/conditions like high blood pressure, high coronary heart disease, high cholesterol, diabetes, depression, cancer.
- Food allergy – occurs when the body considers a substance in food harmful and develops a defence mechanism against it.

TOPIC 6:
ENERGY TRANSFORMATION TO SUSTAIN LIFE 2 (PAPER 1 – 22 MARKS)

CELLULAR RESPIRATION

Cellular respiration is the **breaking down of organic compounds** (glucose) with the gradual release of energy that is stored in ATP molecules. Oxygen is required, and carbon dioxide and water are released as waste products.

All living organisms are composed of cells. Cells constantly perform work and therefore require energy.

Organisms use energy for the following life processes:

- Growth
- Cell division
- Digestion
- Movement
- Transport of substances in the body
- Active transport against a concentration gradient.

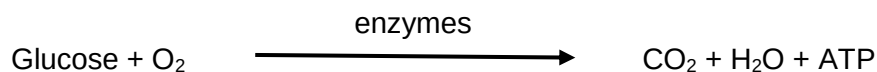
Raw materials needed for cellular respiration

- Glucose
- Oxygen

Products of cellular respiration

- Carbon dioxide
- Water
- ATP (energy) – the energy is not always used straight away. It is temporarily stored in the energy carrier, ATP.

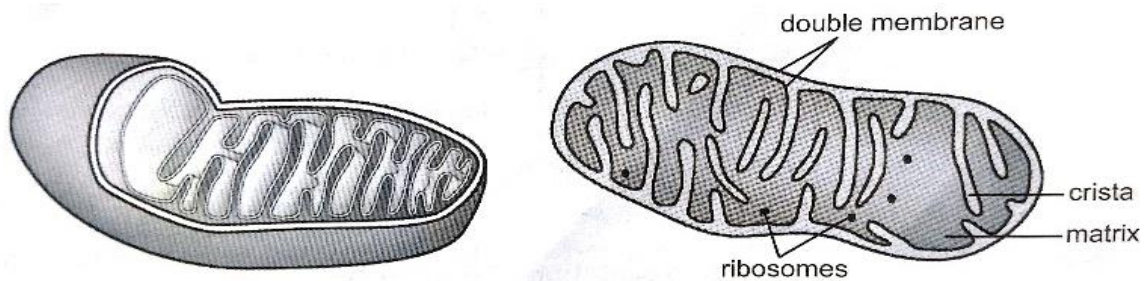
Equation for the process of cellular respiration:



Photosynthesis is an anabolic (building up) process, because energy-rich glucose is built up. Cellular respiration is a catabolic (break-down) process, because energy-rich glucose is broken down.

Places where cellular respiration takes place

The first phase takes place in the cytoplasm outside the mitochondrion, known as the cytosol. The second and third phases occur inside the mitochondrion.



Structure of a mitochondrion

Process of cellular respiration

- Aerobic respiration (requires oxygen)
- Anaerobic respiration (does not require oxygen)

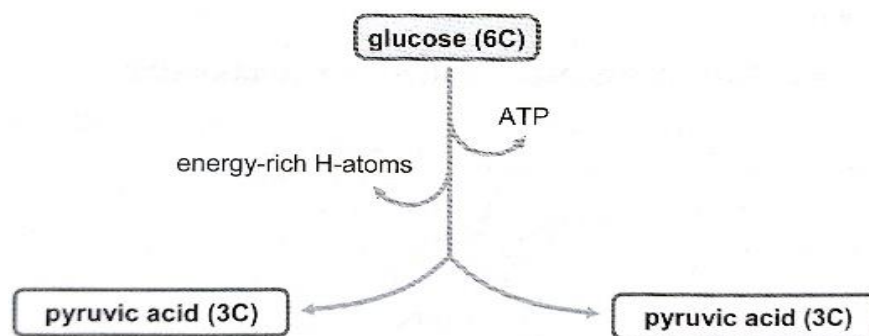
AEROBIC RESPIRATION – three stages can be distinguished:

- Glycolysis
- Kreb's cycle
- Oxidative phosphorylation

Glycolysis

Occurs in the **cytosol** just outside the mitochondrion. This phase requires no oxygen and is therefore an anaerobic phase.

- Glucose (which consists of 6 carbon atoms) is broken down step by step.
- Two molecules of pyruvic acid, with 3 carbon atoms each, are formed.
- Energy-rich H-atoms as well as small amount of energy, is released and stored in ATP.
- Coenzymes (hydrogen carriers) carry the energy-rich H-atoms to the third phase (oxidative phosphorylation).



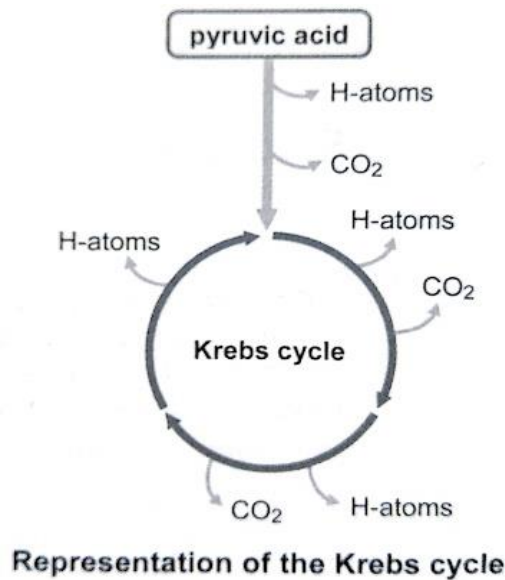
Representation of Glycolysis

Kreb's cycle

Occurs inside the mitochondrion. This phase requires oxygen and is therefore an aerobic phase.

- Pyruvic acid enters the mitochondrion.
- A series of cyclic reactions takes place.
- Energy-rich H-atoms and CO_2 is released.

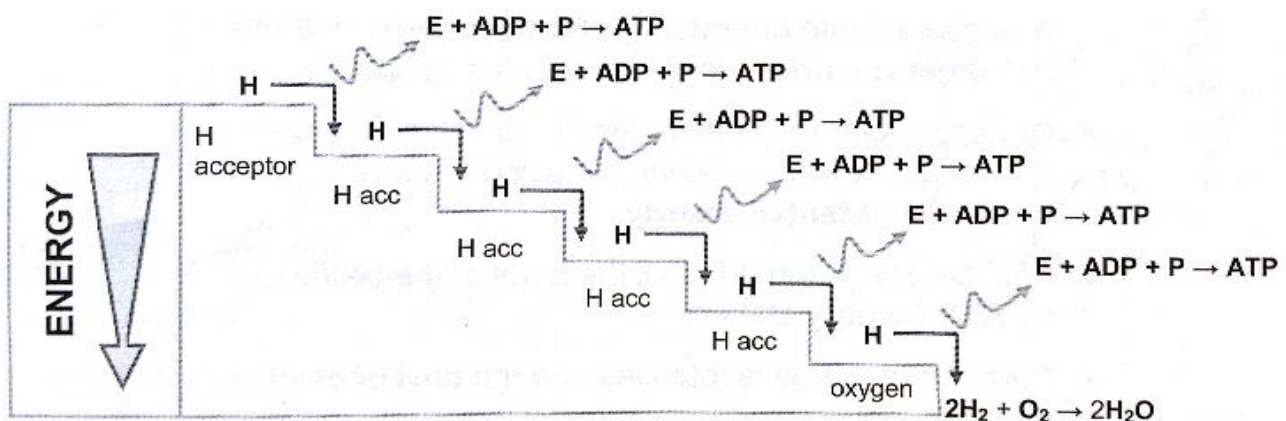
- Coenzymes act as hydrogen carriers that transmit the energy-rich H-atoms to the next phase.



Oxidative phosphorylation

It takes place in the **cristae** of the mitochondrion. This phase requires oxygen and is therefore an aerobic phase.

- Energy-rich H-atoms from the Krebs cycle are carried to a hydrogen transfer system by coenzymes.
- H-atoms are transferred from one hydrogen acceptor to the next.
- Every time an H-atom is transferred from one acceptor to the next, energy is released.
- This energy binds a phosphate (P) molecule with ADP to form ATP, which is the energy carrier in the cell.
- Oxygen is the final hydrogen acceptor. Two hydrogen atoms combine with one oxygen atom to form a molecule of water (H₂O).



Representation of oxidative phosphorylation

ANAEROBIC RESPIRATION – it takes place in the absence of oxygen. Glucose is only partially broken down and therefore less energy is released.

Anaerobic respiration in the muscles during exercise

- During vigorous exercise, the muscles do not receive enough oxygen.
- The muscle cells must therefore respire anaerobically.
- Only glycolysis takes place.
- Glucose is broken down
- Pyruvic acid is formed
- Only a small amount of energy is released
- Pyruvic acid is converted into lactic acid, which is released in the muscle cells
- This process is known as **lactic acid fermentation**.

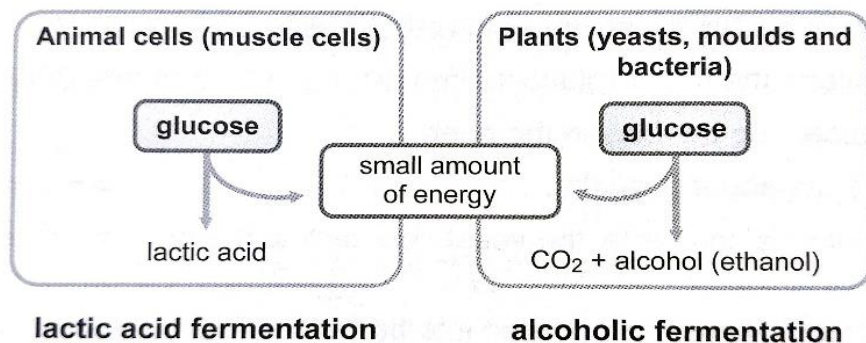
Lactic acid is a toxin that leads to muscle stiffness and muscle pain. Oxygen is needed to convert the lactic acid back to pyruvic acid.

Moderate exercise with deep breathing is needed to get rid of muscle stiffness. If there is sufficient oxygen, aerobic respiration takes place and pyruvic acid enters the Krebs's cycle.

The oxygen needed to get rid of lactic acid which accumulates in the cells is called **oxygen debt**.

Anaerobic respiration in plants (e.g. yeast)

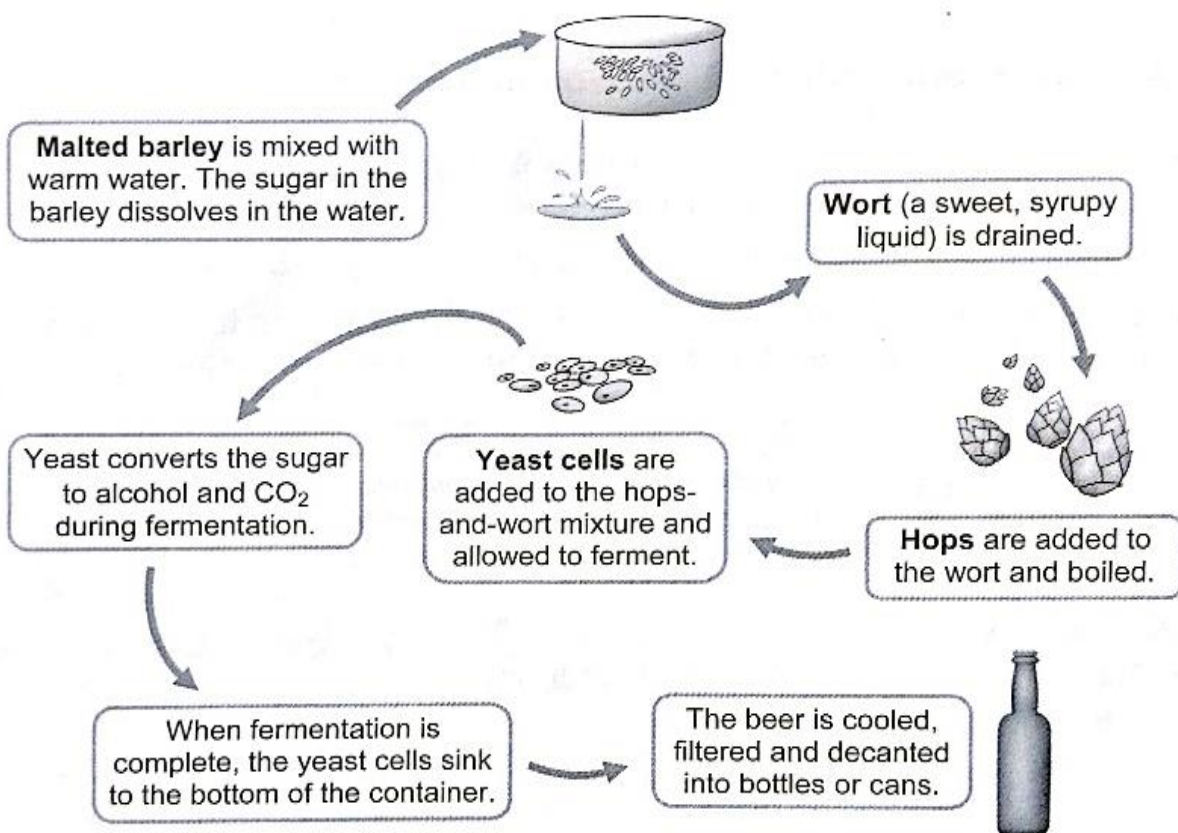
- Only glycolysis occurs
- Glucose is broken down
- Pyruvic acid is formed
- Only a small amount of energy is released
- Pyruvic acid is broken down further
- Carbon dioxide is released
- Alcohol (ethanol) is formed.
- This process is known as **alcoholic fermentation**



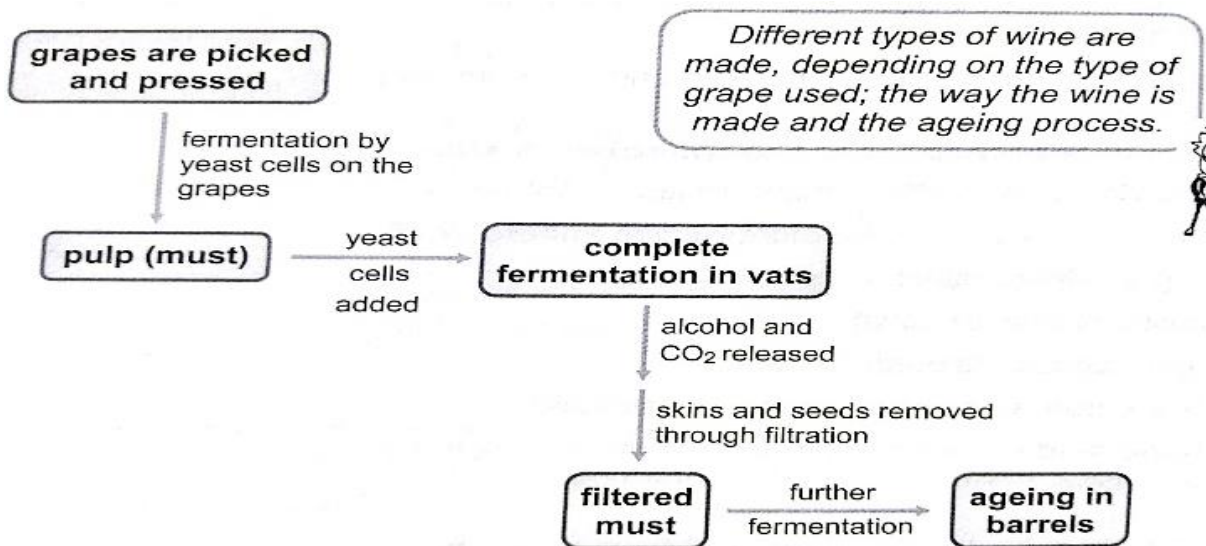
The role of anaerobic respiration in industry

- Yeast cells and other fungi respire anaerobically and are used to produce alcoholic beverages, such as beer and wine.
- Yeast cells are also used to cause bread to rise during the baking process.
- Certain bacteria can be used to produce cheese, yoghurt and sour milk under anaerobic conditions in the presence of sugar (lactose).

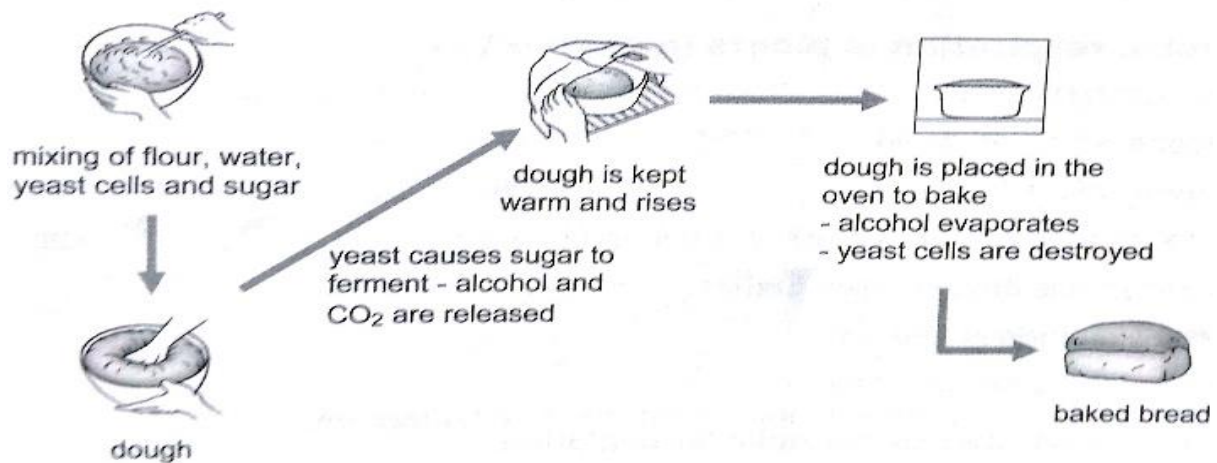
Making beer



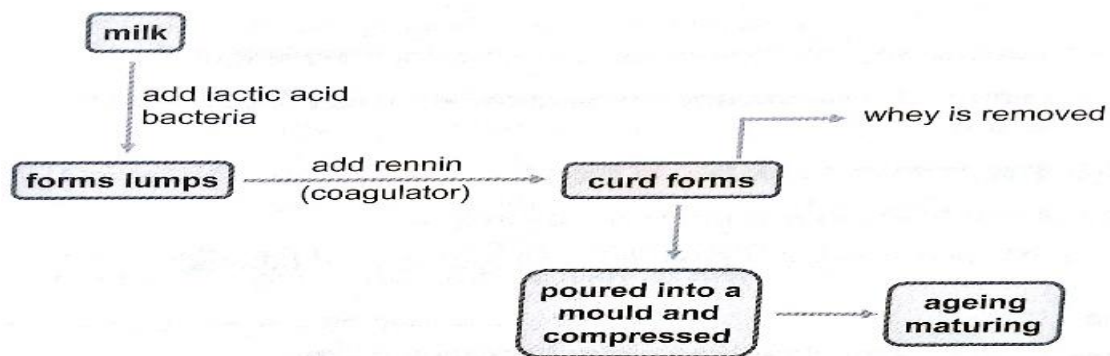
Making wine



Making bread



Making cheese



Comparison between aerobic and anaerobic respiration

Similarities

- Glucose serves as raw material in both processes.
- CO₂ is released in both processes.
- Energy is released in both processes.

Differences

Aerobic respiration	Anaerobic respiration
► It occurs in the presence of oxygen.	► It occurs in the absence of oxygen.
► Products are carbon dioxide and water.	► Products are lactic acid (animals) or carbon dioxide and ethanol (plants/yeast cells).
► A large amount of energy is released because the glucose molecule is broken down completely.	► A small amount of energy is released because the glucose molecule is only broken down partially.
► It takes place in the cytosol and inside the mitochondrion.	► It only takes place in the cytosol.

TOPIC 7:

GASEOUS EXCHANGE (PAPER 1 – 31 MARKS)

Breathing – the mechanical process whereby air moves in and out of the lungs.

Gaseous exchange – the exchange of oxygen and carbon dioxide across a gaseous exchange surface.

Cellular respiration – the gradual release of energy from organic compounds (glucose) in the presence of oxygen.

Necessity for gaseous exchange

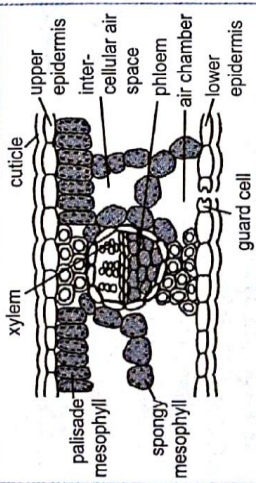
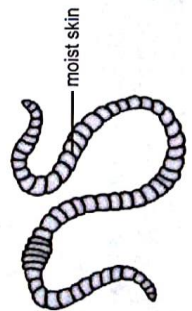
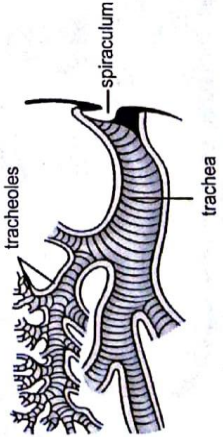
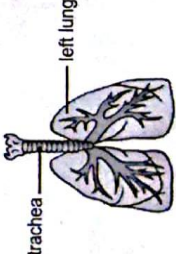
- The main function of the respiratory system is to absorb oxygen from the atmosphere and make it available to the cells for respiration.
- Carbon dioxide is released by the cells during respiration and must continually be removed through gaseous exchange.
- The increased carbon dioxide concentration in the body can dangerously lower the pH of the body fluids.

Requirements for an effective gaseous exchange system/surface

The gaseous exchange surface;

- must be **large** – to maximise gaseous exchange.
- must be **thin** – for quick and easy diffusion.
- should be **moist** – gases must be in solution in order to diffuse through a membrane.
- must have a **transport system** – for efficient transport of gases.
- must be **well protected** – it is very thin and fragile.

Gaseous exchange occurs by **diffusion**. Diffusion is the movement of molecules from a high concentration to a low concentration until equilibrium is reached.

Organism		Habitat	Adaptations for efficient gaseous exchange	
Dicotyledonous plant			Terrestrial	- With plants, gaseous exchange primarily takes place in the leaves. - Gases enter or leave the leaf mainly by diffusion through the stomata, which are primarily found in the lower epidermis. - The gaseous exchange surface is largely the outer surface of the spongy mesophyll cells. - These large round cells have a large surface area and thin cell walls that are moist, so that O₂ and CO₂ can easily dissolve. - The spongy mesophyll cells have large intercellular air spaces that enable transport of gases. - Spongy mesophyll cells occur inside the leaf and are therefore protected by the surrounding plant tissue.
Earthworm			Terrestrial	- The total surface area of the earthworm's skin forms the gaseous exchange surface. - Gases (O₂ and CO₂) move directly through the skin by diffusion. - The elongated body increases the surface area. - The earthworm's skin is very thin (thin epidermis), and is kept moist by mucus secretions from the skin epidermis, as well as the coelomic fluid secreted onto the skin. - O₂ diffuses into the skin's blood vessels, and larger blood vessels transport it to the rest of the body. CO₂ is transported to the skin in the same way and then diffused out of the body. - The skin is protected by mucus and coelomic fluid.
Insect, e.g. locust			Terrestrial	- With locusts, gaseous exchange takes place through a tracheole system. - Air enters or leaves the body through small openings, known as spiracles, which are found on the thorax and abdomen. - The tracheal system consists of an extensive network (with a large surface area) of tubes (trachea) that branch throughout the body. These tracheae become smaller and eventually form tracheoles that branch out between the tissues. - The walls of the tracheoles are very thin. - The tracheoles contain a liquid that keeps the walls moist. - O₂ diffuses directly from the tracheoles into the tissue cells, while CO₂ diffuses from the tissue cells to the tracheoles. - Air sacs that function as a ventilation system are located near the main muscles. They ensure that air moves quickly to and from the tissues. - The tracheal system is found inside the animal and is therefore protected by the surrounding tissues.
Bonefish			Aquatic	- With fish, gaseous exchange takes place in the gills. - Four gills are found in gill chambers on either side of the head, with gill slits opening to the exterior. - The gills consist of a large number of filaments, which greatly increase the surface area. - These filaments have thin walls, and are kept moist by water flowing over them. - The gills are richly supplied with blood capillaries. - As the fish swims, water flows into the mouth and over the gill filaments. Dissolved O₂ in the water diffuses into the blood capillaries. CO₂ in turn diffuses from the capillaries into the water. The CO₂-rich water leaves the body through the gill slits. - The gill slits are covered by gill covers that protect the underlying gill filaments.
Mammal			Terrestrial	- With mammals, gaseous exchange takes place in the lungs. - The gaseous exchange surface inside the lungs consists of millions of alveoli, which significantly increase the surface area. - The walls of the alveoli are very thin and consist of a single layer of squamous epithelium. - The walls of the alveoli are lined with a thin layer of moisture. - The alveoli are surrounded by a system of blood capillaries for efficient transport of gases. - The movement of the ribs, diaphragm and intercostal muscles increase and decrease the volume and pressure in the lungs and thoracic cavity - in this way, efficient ventilation takes place. - The lungs are protected by the intrapleural fluid between the two pleura that surround the lungs; the chest (spine, ribs and breastbone) and intercostal muscles also serve to protect them.

HUMAN GASEOUS EXCHANGE

Structure of the respiratory system

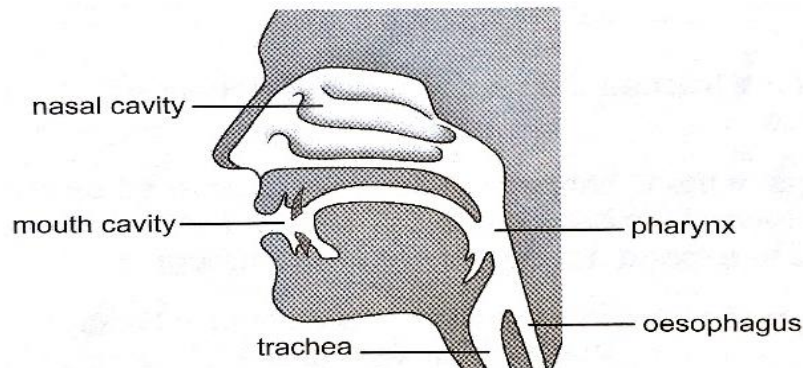
The human respiratory system consists of the:

- Air passages
- Lungs
- Respiratory muscles

AIR PASSAGES

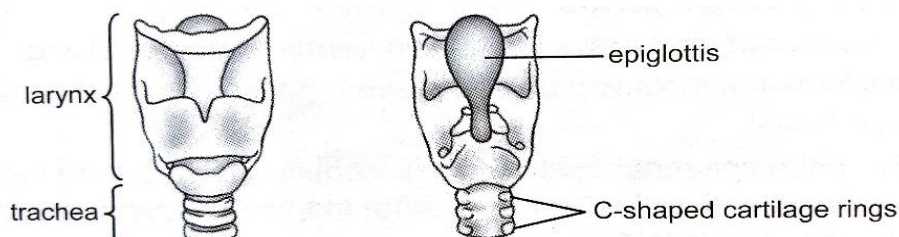
The air passages transport air to and from the lungs and include the nasal passages, pharynx (throat), trachea (windpipe), bronchi and bronchioli.

- Nasal cavities: two external nostrils lead to the nasal cavities that are separated by a septum. Small hairs in the nasal cavities filter larger particles from the inhaled air. Each nasal cavity is divided into three passages by three curved turbinate bones.
- Pharynx (throat): the nasal cavities open into the pharynx. The pharynx leads to two openings; the opening known as the glottis – which leads to the trachea and the opening leading to the oesophagus (gullet).



The airways

- Trachea (windpipe):
It is a long, tubular structure located at the front of the oesophagus. The larynx (voice box) which houses the vocal cords, is located at the top of the trachea. The larynx is a triangular box made of cartilage.
At the top of the larynx is the **epiglottis**, a thin, leaf-shaped structure made of cartilage. The epiglottis closes the opening to the trachea (**glottis**) during the swallowing process. This prevents food from entering the trachea and choking the person.
The wall of the trachea is reinforced and kept open by C-shaped cartilage rings. The openings of the C-shaped cartilage rings, covered by involuntary muscle tissue, face toward the back and press against the oesophagus. This allows the oesophagus to expand as food moves down through it.



The larynx

- Bronchi and bronchiole:

The trachea divides into a right and left bronchus that enter the right and left lung respectively. The bronchi are lined with a mucous membrane and are held open by O-shaped cartilage rings.

Inside the lungs, the bronchi divide into smaller branches, lose their cartilage and form the bronchioles. Each bronchiole ends in an infundibulum which consists of groups of alveoli.

NOTE: All air passages are lined with a mucous membrane of ciliated columnar epithelial cells.

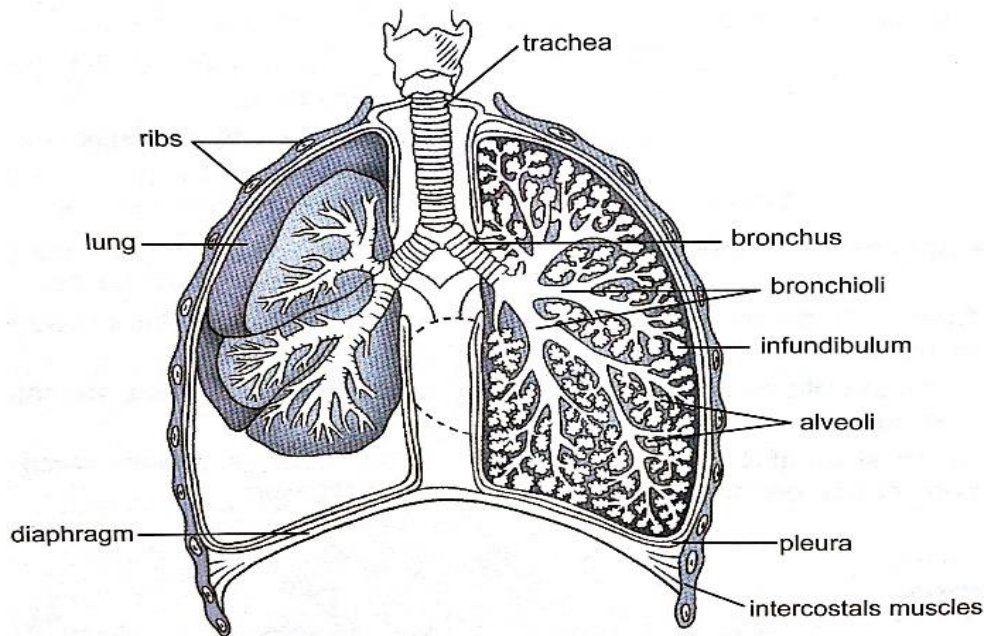


Diagram of the human respiratory system

Adaptations of the air passages to their functions

Adaptation	Function
Nasal cavities have hairs	filters larger dust particles from the inhaled air
All air passages are lined with a mucous membrane of ciliated columnar epithelial cells: - richly supplied with superficial capillaries - goblet cells that secrete mucus - cilia perform sweeping movements	- warms the incoming air - traps dust and germs - antiseptic – preventing germs from multiplying - moistens the incoming air - prevent gaseous exchange surface from drying out - carries dust and germ-carrying mucus toward the outside
Opening to the trachea closed by the epiglottis	trachea closed during swallowing; prevents choking
Trachea walls supported by C-shaped cartilage rings	supports and keeps trachea open
'Open' sides of C-shaped rings in contact with oesophagus	oesophagus able to stretch during swallowing

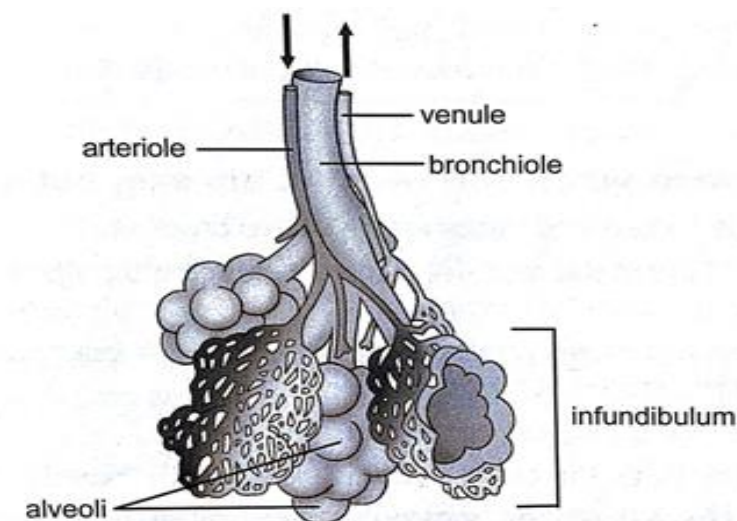
LUNGS

External structure

- The two lungs are located in the chest and are surrounded and protected by 12 pairs of ribs.
- The intercostal muscles are found between the ribs.
- The right lungs consist of three lobes, while the left lung has two.
- The lungs are spongy and elastic.
- Each lung is surrounded by a double membrane, **the pleura**.
- There is intrapleural fluid between the two pleural membranes that prevents friction that occurs when the lungs shrink or expand.
- The lungs are conical and rest at the bottom on a dome-shaped muscle plate, **the diaphragm**.

Internal structure

- Inside the lungs the bronchi branch out, becoming smaller and forming bronchiole
- As the bronchioli branch out into smaller bronchioli, they lose their cartilage support and end in infundibula (lung sacs), which consist of group of alveoli.
- The walls of the alveoli are very thin and consist of a single layer of squamous epithelium.
- The alveoli are surrounded by a network of capillaries. The walls of the capillaries consist of a single layer of squamous epithelium (endothelium).



Structure of the gaseous exchange surface

The pulmonary arteries enter the lungs and branch into smaller arterioles to form a network of capillaries around the walls of the alveoli.

The capillaries unite again and form venules that flow together to form larger veins and finally the pulmonary veins, which then leave the lungs.

Adaptations of the lungs for their functions

Adaptation	Function
The lungs are spongy and elastic.	▸ can expand and contract easily during breathing
Lungs are surrounded by a double membrane, with intrapleural fluid between the two membranes	▸ prevents friction during breathing
Bronchioli eventually end in millions of alveoli	▸ increase the gaseous exchange surface
Wall of an alveolus consists of a single layer of squamous epithelium	▸ thin surface for efficient gaseous exchange
Alveoli are surrounded by a network of blood capillaries.	▸ transport of O ₂ to the tissues and CO ₂ to the lungs
Walls of the blood capillaries consist of a single layer of endothelium.	▸ thin surface for efficient gaseous exchange

RESPIRATORY MUSCLES

Different muscles play a role during breathing:

- Diaphragm: In its relaxed state, the diaphragm is a dome-shaped muscle plate. This muscle plate separates the chest and abdomen to form an airtight thoracic cavity.
- Intercostal muscles: The intercostal muscles are located between consecutive ribs and consist of two sets (i.e. external intercostal and internal intercostal muscles).

Ventilation of the lungs

The process is also known as the **mechanism of breathing**.

The movement of air between the atmosphere and the lungs is caused by a difference in air pressure between the atmospheric air and the air in the thoracic cavity and lungs (alveoli).

The movement of the respiratory muscles (diaphragm and intercostal muscles) changes the volume of the thoracic cavity, which causes the difference in pressure.

Ventilation of the lungs takes place in two phases, i.e.

- Inhalation – air moves from the environment into the lungs.
- Exhalation – air moves from the lungs to the environment.

INHALATION

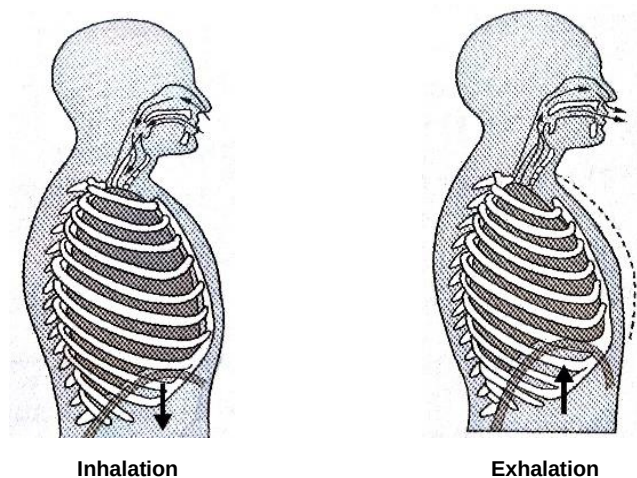
- The diaphragm contracts and become flatter.
- The thoracic cavity enlarges from top to bottom.
- The external intercostal muscles contract, causing the ribs to move upwards and outwards.
- The thoracic cavity enlarges from side to side and from front to back
- The abdominal muscles relax so that the abdominal cavity can accommodate the viscera (all the internal organs) being pushed down by the diaphragm.
- The total volume of the thoracic cavity is increased.
- The pressure in the thoracic cavity and lungs decrease.
- The elastic lungs expand.
- Since the atmospheric pressure is higher than the pressure in the thoracic cavity and lungs, oxygen-rich air flows into the lungs.

NOTE: Inhalation is an active process, because it is associated with contraction of the diaphragm and external intercostal muscles, which increases the volume of the thoracic cavity.

EXHALATION

- The diaphragm relaxes and returns to its original dome shape.
- The thoracic cavity becomes smaller from top to bottom.
- The external intercostal muscles relax, causing the ribs to move downward and inward.
- The thoracic cavity reduces in size from side to side and from front to back
- The total volume of the thoracic cavity is reduced.
- The pressure in the thoracic cavity and lungs increase.
- Since the pressure in the chest cavity and lungs is higher than the atmospheric pressure, carbon dioxide-rich air flows out of the lungs.

NOTE: Exhalation is a passive process, because it is associated with relaxation of the diaphragm and external intercostal muscles, which decreases the volume of the thoracic cavity.



What happens when you whistle, sneeze, cough or shout?

- Exhalation is forced and becomes an active process.
- The internal intercostal muscles contract, causing the ribs to move even further inward.
- The abdominal muscles contract and the intestines are pushed up against the diaphragm, forcing it further upward.
- The volume of the thoracic cavity is further reduced.
- The pressure within the chest cavity is significantly increased.
- Air is forced from the lungs, making whistling, sneezing, coughing or shouting possible.

Gaseous exchange

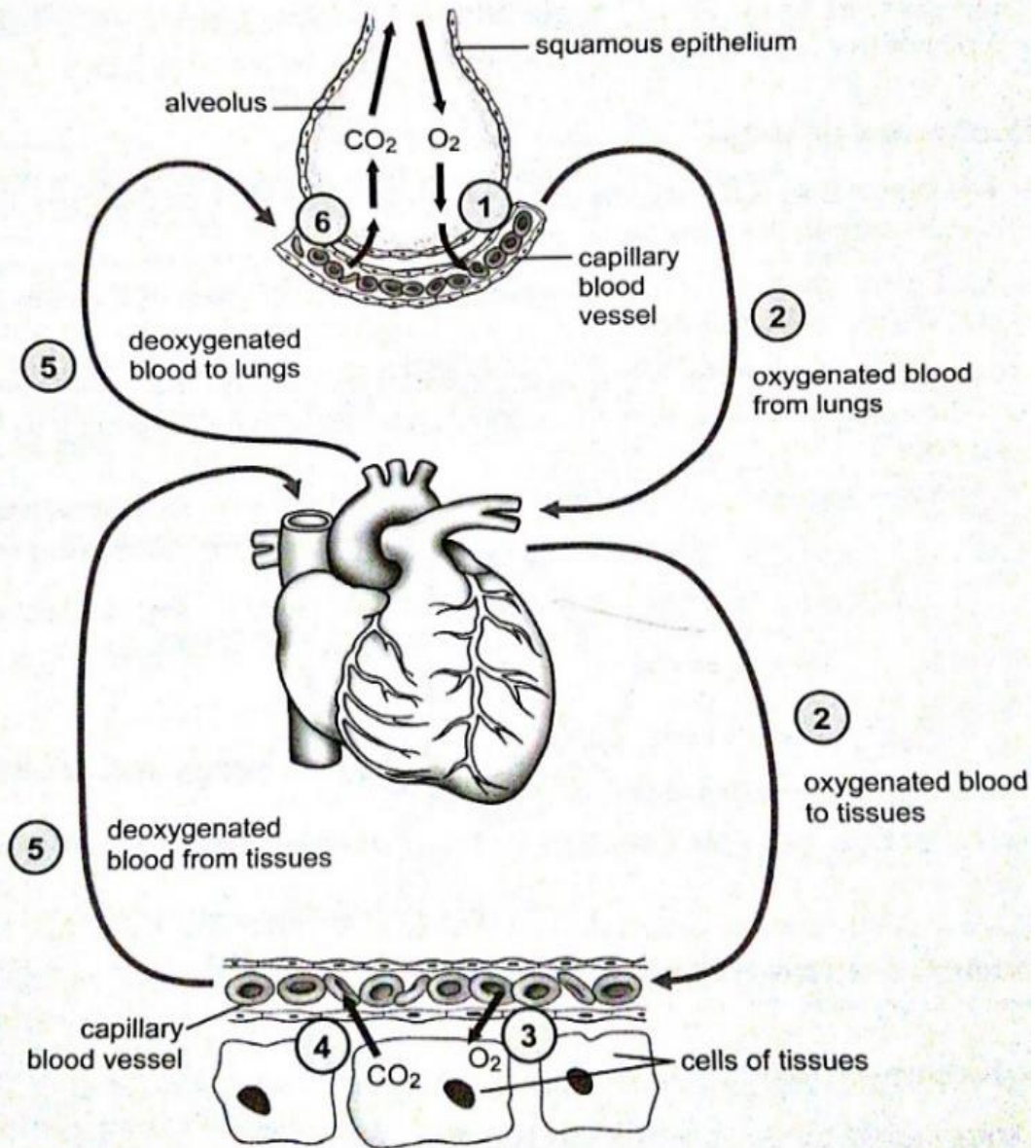
Gaseous exchange takes place in the alveoli as well as in the tissues, from where the gases are then transported to their destinations in different ways:

- Gaseous exchange in the alveoli.
- Gaseous exchange in the tissues.
- Transport of gases in the blood.

Key:

1 - exchange of O_2 at alveoli
3 - exchange of O_2 at tissues
5 - transport of CO_2 to lungs

2 - transport of O_2 to tissues
4 - exchange of CO_2 at tissues
6 - exchange of CO_2 at alveoli



Representation of gaseous exchange at lung and tissue level

Gaseous exchange in the alveoli

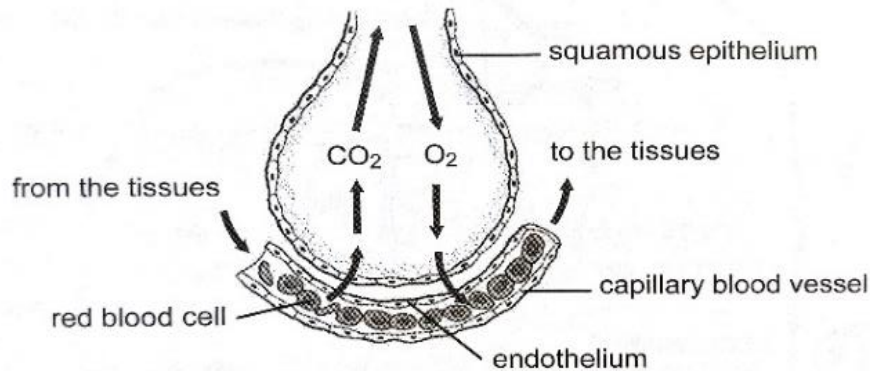
Exchange of O_2

- The inhaled air in the alveoli has a higher oxygen concentration than the blood in the surrounding blood capillaries.
- A diffusion gradient is therefore created between the air in the alveoli and the blood in the capillaries.

- Oxygen dissolves in a thin layer of moisture that lines the alveoli and diffuses through the thin walls of the squamous epithelium of the alveoli and endothelial walls of the capillaries into the blood.

Exchange of CO₂

- The blood that reaches the alveoli from the tissues has a higher carbon dioxide concentration than the air in the alveoli.
- A diffusion gradient is therefore created between the blood in the capillaries and the air in the alveoli.
- Carbon dioxide diffuses from the blood in the capillaries through the endothelial walls of the capillaries and thin squamous epithelial walls of alveoli into the air in the alveoli.



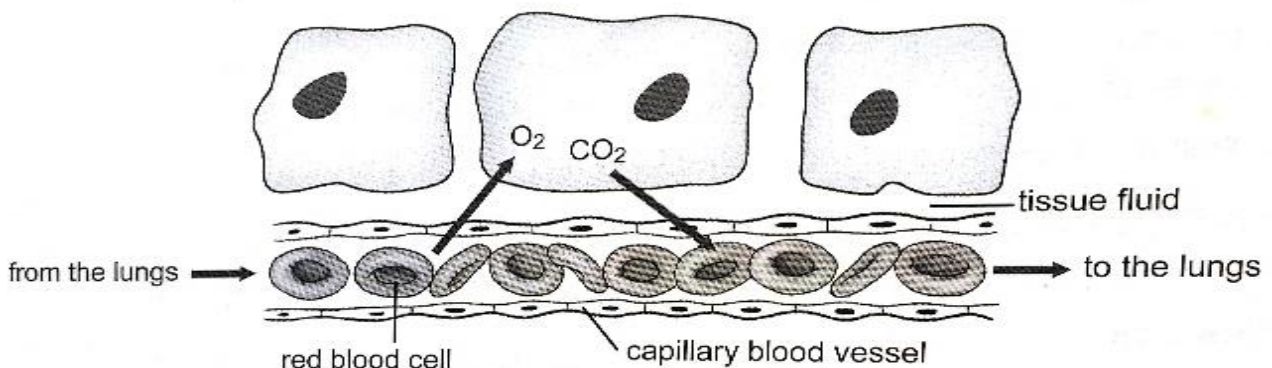
Gaseous exchange in the tissues

Exchange of O₂

- Oxygenated blood reaches the tissues.
- The blood in the capillaries has a higher oxygen concentration than the cells of the tissues.
- A diffusion gradient is therefore created between the blood in the capillaries and the cells.
- The oxygen diffuses through the endothelial walls of the capillaries into the tissue fluid that surrounds the cells and into the cells.

Exchange of CO₂

- The cells have a higher carbon dioxide concentration than the blood in the capillaries.
- A diffusion gradient is therefore created between the cells and the blood in the capillaries.
- The carbon dioxide diffuses from the cells into the tissue fluid and then diffuses into the blood in the capillaries.



Transport of gases in the blood

Transport of O₂

Oxygen is transported in the blood in two ways:

- Most of the oxygen that diffuses from the air in the alveoli to the blood in the capillaries combines with haemoglobin in the red blood cells to form oxyhaemoglobin.
- A very small portion of the oxygen dissolves in the blood plasma.

Oxygen is transported via the heart to all the tissues in these two ways.

Transport of CO₂

Carbon dioxide is transported in the blood in three ways:

- Most of the carbon dioxide that diffuses from the cells into the blood in the capillaries combine with water to form carbonic acid, after which it dissociates and is transported as bicarbonate ions.
- A portion combines with haemoglobin to form carbaminohaemoglobin.
- The smallest portion of the carbon dioxide dissolves in the blood plasma.

Carbon dioxide is transported via the heart to the lungs in these three ways.

Composition of inhaled air vs exhaled air

Component of air	Inhaled air	Exhaled air
Nitrogen	78%	78%
Oxygen	21%	15%
Carbon dioxide	0,04%	4,0%
Water vapour	Varies according to environmental conditions	Saturated

EFFECTS OF EXERCISE ON THE RATE AND DEPTH OF BREATHING

During exercise, the body needs more oxygen so that respiration can occur faster and more energy can be released. As a result, carbon dioxide is released, and the body has to get rid of the excess carbon dioxide.

In order to breathe in more oxygen-rich air and breathe out more carbon dioxide-rich air during exercise, there is an **increase in the rate and depth of breathing**.

The **heart rate also accelerates** in order to increase the oxygen supply to the muscle tissues and the carbon dioxide removal from muscle tissues.

The respiratory centre in the medulla oblongata of the human brain controls the breathing rate. The cardiovascular centre is also located in the medulla oblongata and controls the heart rate.

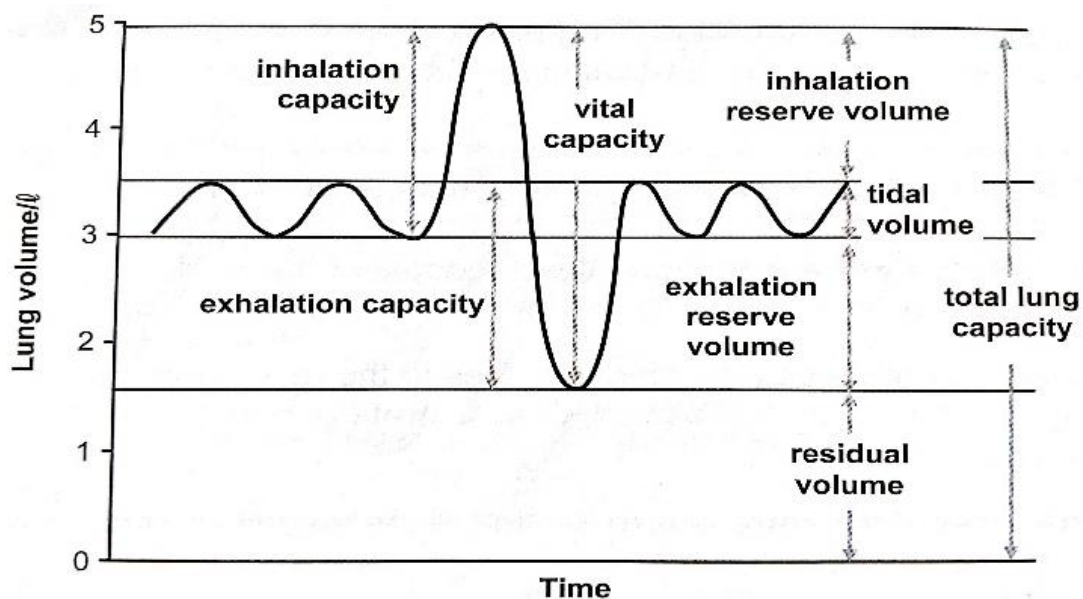
Lung capacity

Lung capacity refers to the total volume of air that the lungs can accommodate. The human lung capacity is about 5 litres (5 000 cm³).

- Amount of air that is breathed in and out during normal breathing – **tidal volume**
- Additional air breathed in after normal inhalation – **inspiratory reserve volume**
- Additional air breathed out after a normal exhalation – **expiratory reserve volume**
- Tidal volume + inspiratory reserve volume + expiratory reserve volume = **vital capacity of the lungs**
- After the full exhalation, there is still air in the lungs, this is known as the **residual volume** and is never exhaled. With each inhalation, fresh air mixes with the residual volume.

During times of increased demand for oxygen (e.g. during exercise) the tidal volume increases by using the reserve air volume to get more fresh air into the lungs. The result is that the depth and rate of breathing increases.

The depth of breathing can be determined before and after exercise, by measuring the tidal volume before and after exercise.



HOMEOSTATIC CONTROL OF BREATHING

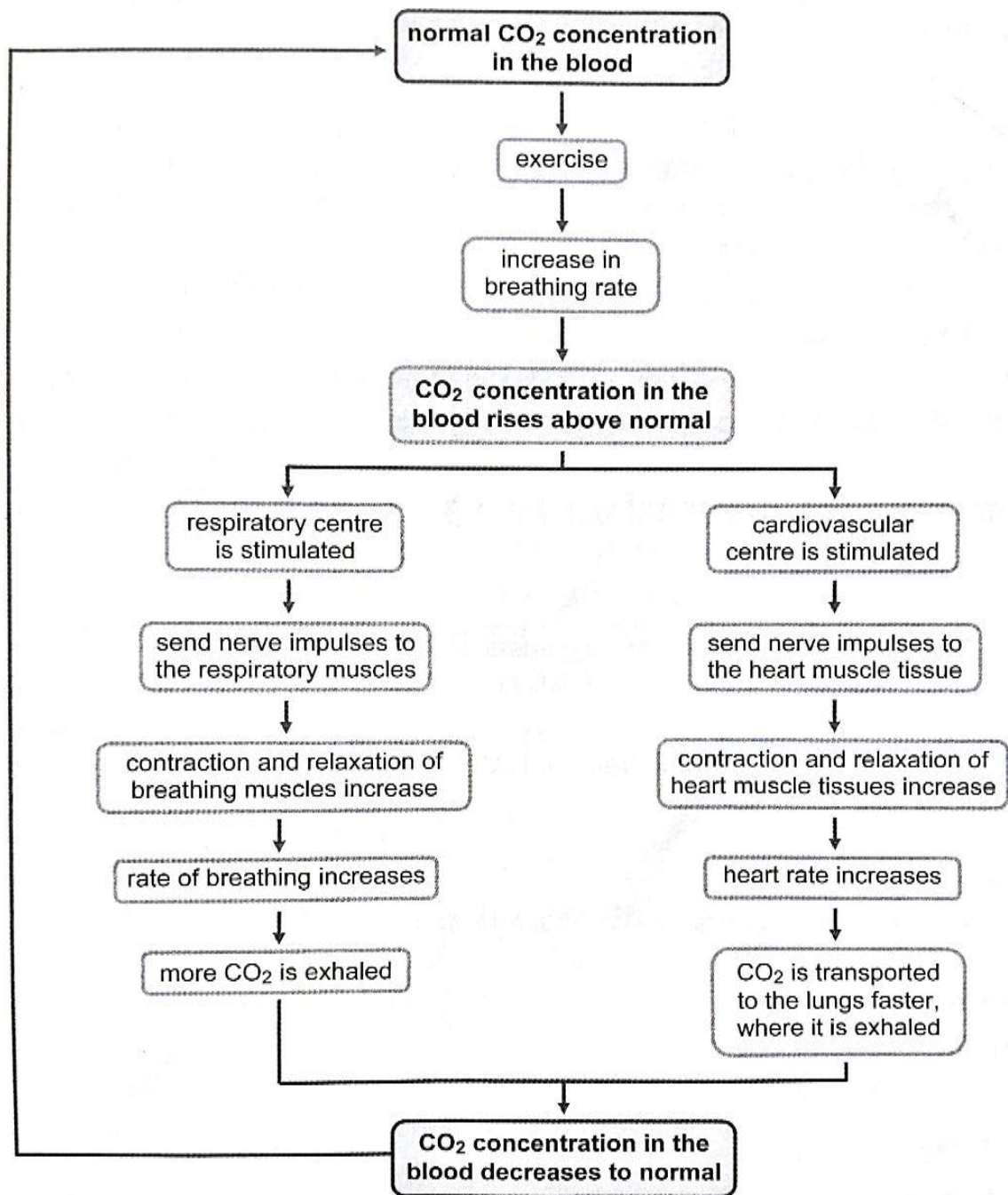
Chemoreceptors in the wall of the aorta and at the base of the jugular arteries are very sensitive to changes in the carbon dioxide concentration in the blood.

As soon as the CO₂ concentration in the blood increases (e.g. after/during exercise), the **chemoreceptors** send nerve impulses to the respiratory and cardiovascular centres in the **medulla oblongata** of the brain.

The respiratory centre in turn sends nerve impulses to the diaphragm and intercostal muscles to accelerate contraction and relaxation. The rate and depth of breathing thus increases and more CO₂ – laden air is exhaled.

The cardiovascular centre sends nerve impulses to the heart muscle and arterioles. The heart rate increases, the arterioles constrict and the blood flows faster. CO₂ is transported to the lungs faster, where it can be exhaled.

The CO₂ concentration in the blood thus returns to normal.



Effect of altitude on gaseous exchange

With an increase in altitude (height above sea level), atmospheric pressure drops and so does the amount of oxygen.

People living at a high altitude usually have more red blood cells to transport a maximum amount of oxygen efficiently.

If a person living at sea level goes to an area high above sea level for a while, his/her body will adapt after a few days or even weeks and produce more red blood cells.

In this way the oxygen – carrying capacity of the blood is increased.

NOTE: it is especially important for athletes living at the coast, which is a sea level (e.g. Cape Town) who plan to participate in a competition at a higher altitude (e.g. Mpumalanga), to arrive at the higher altitude in advance. This gives his/her body enough time to adjust or else he/she will tire quickly.

His/her body has too few red blood cells to carry enough oxygen to the muscle tissues for respiration and consequent energy release.

Respiratory diseases and abnormalities

DISEASE	DESCRIPTION	CAUSES	SYMPTOMS
TUBERCULOSIS	Highly contagious, chronic bacterial infection of human tissues and organs, especially the lungs.	Bacterium known as <i>Mycobacterium tuberculosis</i>	Persistent cough, tiredness and fatigue, weight loss, night sweats, chest pain, blood in mucus coughed up
ASTHMA	A chronic allergic inflammation of the air passages that causes narrowing of the air passages and difficulty in breathing.	- Allergic reaction to dust, grass, pollen, cigarette smoke or food. - Infection of the upper air passages.	- Shortness of breath - Coughing at night - Wheezing or coughing after exercise
HAY FEVER	An allergic inflammation of the nasal passages.	Allergens such as dust, mould or pollen are inhaled and the body secretes chemicals known as histamines.	- Itchy nose, mouth, eyes, throat and skin - Runny nose - Sneezing - Watery eyes
BRONCHITIS	Inflammation of the bronchi and mucous membranes	- Mainly caused by viruses - Often occurs after infection of the upper air passages	- Coughing - May cough up mucus after a few days - Mild fever
EMPHYSEMA	Lung disease in which the walls of the alveoli tear and form holes. Blood capillaries disintegrate and gaseous exchange becomes increasingly difficult.	- Mainly smoking - Inhalation of toxins	- Shortness of breath - Coughing with production of mucus - Wheezing - Feeling of suffocation
LUNG CANCER	Uncontrolled growth of abnormal cells in the lung tissue. It can form tumours and impede the functioning of the lung.	- Smoking - Inhalation of toxins in the air	- Coughing up blood - Shortness of breath

The Effect of smoking on gaseous exchange

Cigarette smoking causes a variety of diseases (lung cancer, coronary heart disease, stroke, emphysema and chronic bronchitis).

Three harmful toxins found in cigarette smoke are nicotine, tar and carbon monoxide. These toxins cause hardening of the arterial walls (atherosclerosis). It stimulates the secretion of adrenaline, which leads to an increase in heart rate and blood pressure, which in turn increases the risk of heart disease and stroke.

The tar paralyses the tiny cilia in the air passages and hampers their functioning. The tar accumulates and can eventually result in lung cancer.

Smoking also causes the walls of the alveoli to tear and form holes. A condition known as emphysema could result.

If a person stops smoking, the lungs can slowly start to function more efficiently, but the torn walls of the alveoli will not heal.

Artificial respiration

If a person stops breathing, artificial respiration is necessary. Artificial respiration can be applied with a machine known as a ventilator.

The most common form of artificial respiration is mouth-to-mouth resuscitation, which is applied as follows:

- Carefully remove any blockage from the person's air passages.
- Place two fingers under the chin and the other hand on the forehead and tilt the person's head back.
- Pinch the patient's nose closed, breathe in and place your mouth over that of the patient.
- Exhale until his/her chest rises.
- Remove your mouth from his/her mouth and allow the chest to move down.
- Give 12 breaths per minute.
- Continue in this way until the person starts breathing by himself/herself.

TOPIC 8:

EXCRETION (PAPER 1 – 31 MARKS)

A large number of chemical reactions are continuously taking place in the body cells. The sum total of all the chemical reactions that occur in a cell is known as **metabolism**.

During metabolism, waste products such as carbon dioxide, excess water, salts and nitrogenous wastes (e.g. urea, uric acid and creatinine) are formed. These waste products must be removed continuously because they will poison the cells and inhibit normal functioning if allowed to accumulate.

There are three confusing terms to be noted and distinguished:

Excretion – the removal of metabolic wastes from the body.

Egestion – the removal of undigested substances – substances that are not products of metabolism and were never inside the cells.

Secretion – the release of useful substances that are produced by cells for important functions e.g. digestive juices, hormones and milk.

In humans, the metabolic waste products diffuse out the cells, via the tissue fluid that surrounds them, to the blood in the blood vessels.

The waste products are transported in the blood to several excretory organs, which have the ability to remove these waste products from the bloodstream and release them out of the body.

Different excretory organs

LUNGS – excrete carbon dioxide, water vapour and heat.

KIDNEYS and BLADDER – excrete urine. Urine consists of:

- excess water
- mineral salts
- nitrogenous waste products (urea, uric acid and creatinine).

LIVER – excretes urea and bile pigments. Urea is transported in the blood to the kidneys and is excreted in urine. Bile pigments pass into the small intestine and are excreted as bile salts in the faeces.

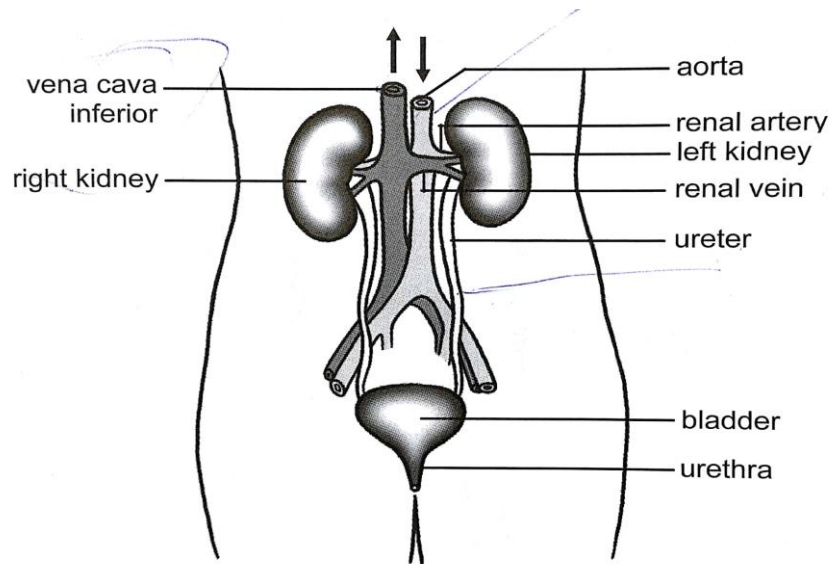
SKIN – excretes sweat via the sweat glands. Sweat mainly consists of:

- excess water
- salts
- small amount of urea

Metabolic waste products and their origin

- **CO₂** is formed as a product of cellular respiration.
- **Excess water** is formed as a product of cellular respiration, as well as from the intake of fluids and food.
- **Urea** is formed in the liver from deamination of excess amino acids.
- **Uric acid** is the end product of metabolism of nucleic acids.
- **Creatinine** is formed from creatinine phosphate in the cells.
- **Bile pigments** are formed in the liver during the breakdown of haemoglobin.

URINARY SYSTEM IN HUMANS



The urinary system consists of two kidneys, two ureters, the bladder and the urethra. Two types of blood vessels, namely the **renal arteries** and **renal veins**, are associated with the urinary system.

The two kidneys occur in the abdominal cavity, on either side of the vertebral column, just below the diaphragm. The kidneys receive oxygenated blood, rich in metabolic waste products, from the renal arteries. Deoxygenated blood, purified of metabolic waste products, is transported away from the kidneys via the renal veins.

- The **ureter** (a tube) extends from each kidney and opens separately into the bladder.
- The **bladder** is a thin walled muscular sac in which urine is temporarily stored.
- The **urethra** is a tube that transport urine from the bladder to the exterior (outside).

At the base of the bladder, is a **sphincter muscle** which controls the flow of urine to the urethra.

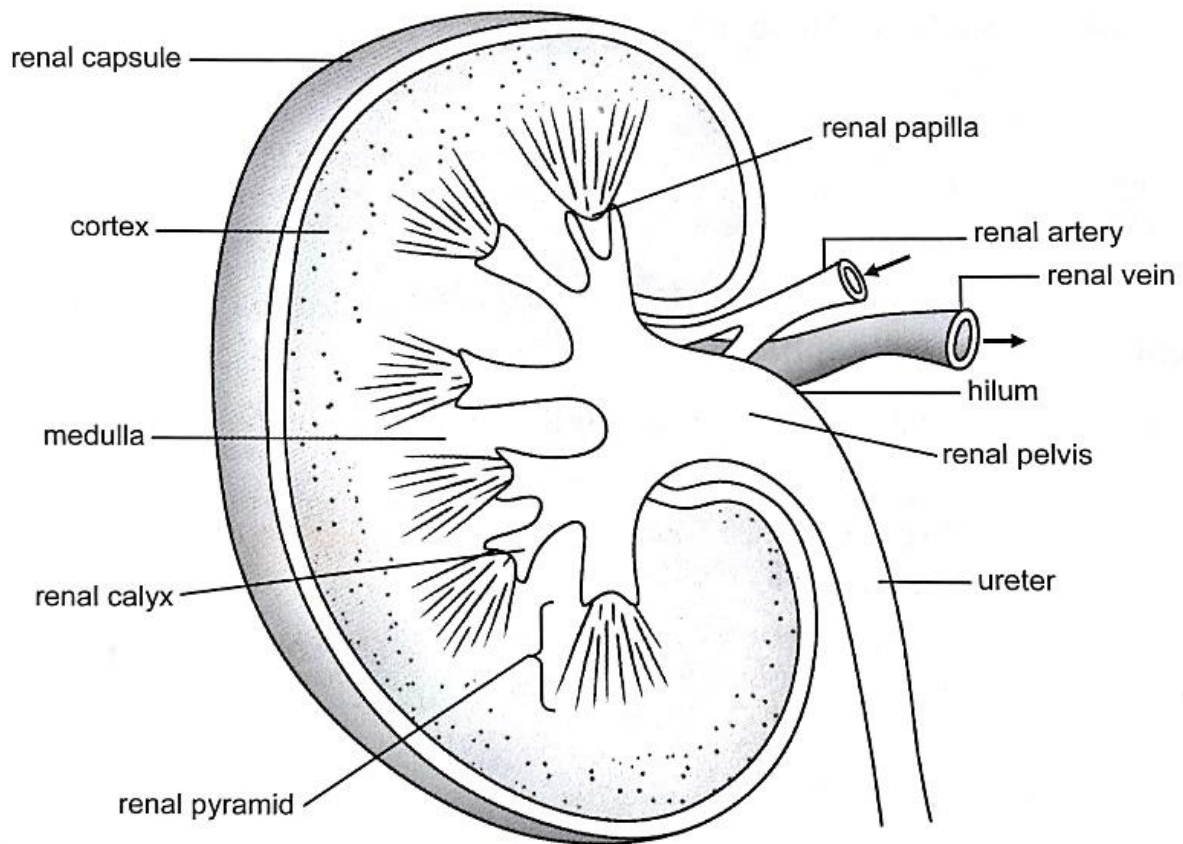
STRUCTURE OF THE KIDNEY

External structure

Dark red, bean-shaped organ with the concave side facing the vertebral column. The renal artery enters the kidney and the renal vein and ureter leave the kidney at an indentation called the **hilum**.

Kidneys are enclosed by a layer of fat, which;

- protects the kidneys against mechanical injuries,
- insulates them,
- keeps them in position.



Longitudinal section of the kidney

Internal structure (macroscopic)

The kidney is surrounded by a connective tissue membrane, the **renal capsule**, for protection. Directly under the renal capsule is a reddish-brown region (the **cortex**).

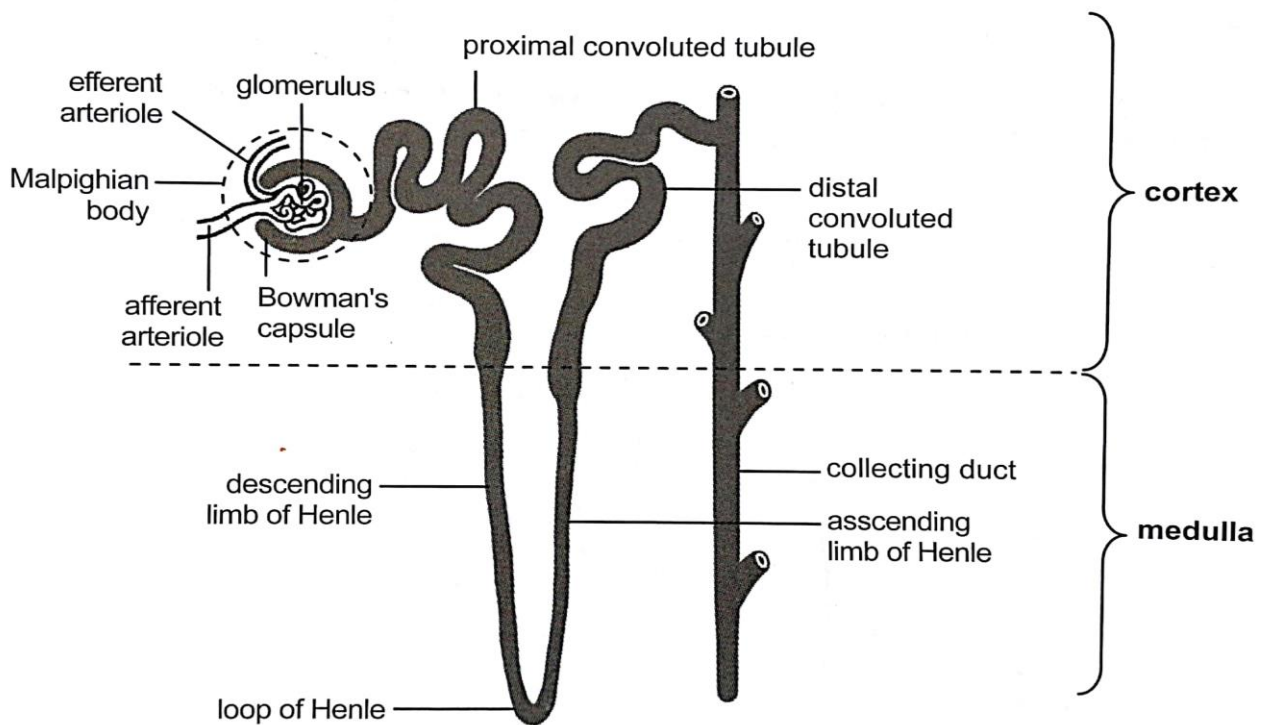
The inner region of the kidney, the **medulla**, is lighter in colour and contains tubes which are arranged in groups (the **renal pyramid**). The apex of each pyramid is known as the **renal papilla**. The tubes in each renal papilla open into a common **renal calyx** (pl: **calyces**). The renal calyces open into the widened region of the ureter, known as the renal pelvis.

Internal structure (microscopic)

Each kidney is made up of about one million small structures known as **nephrons**. The nephrons are the structural and functional units of the kidney.

- Structural units – the building blocks making up the kidney.
- Functional units – independent units performing the functions of the kidney.

Structure of a nephron



Each nephron is made up of two main parts:

- Malpighian body
- Renal tubule

Malpighian body

It occurs on one end of the nephron and is situated in the cortex.

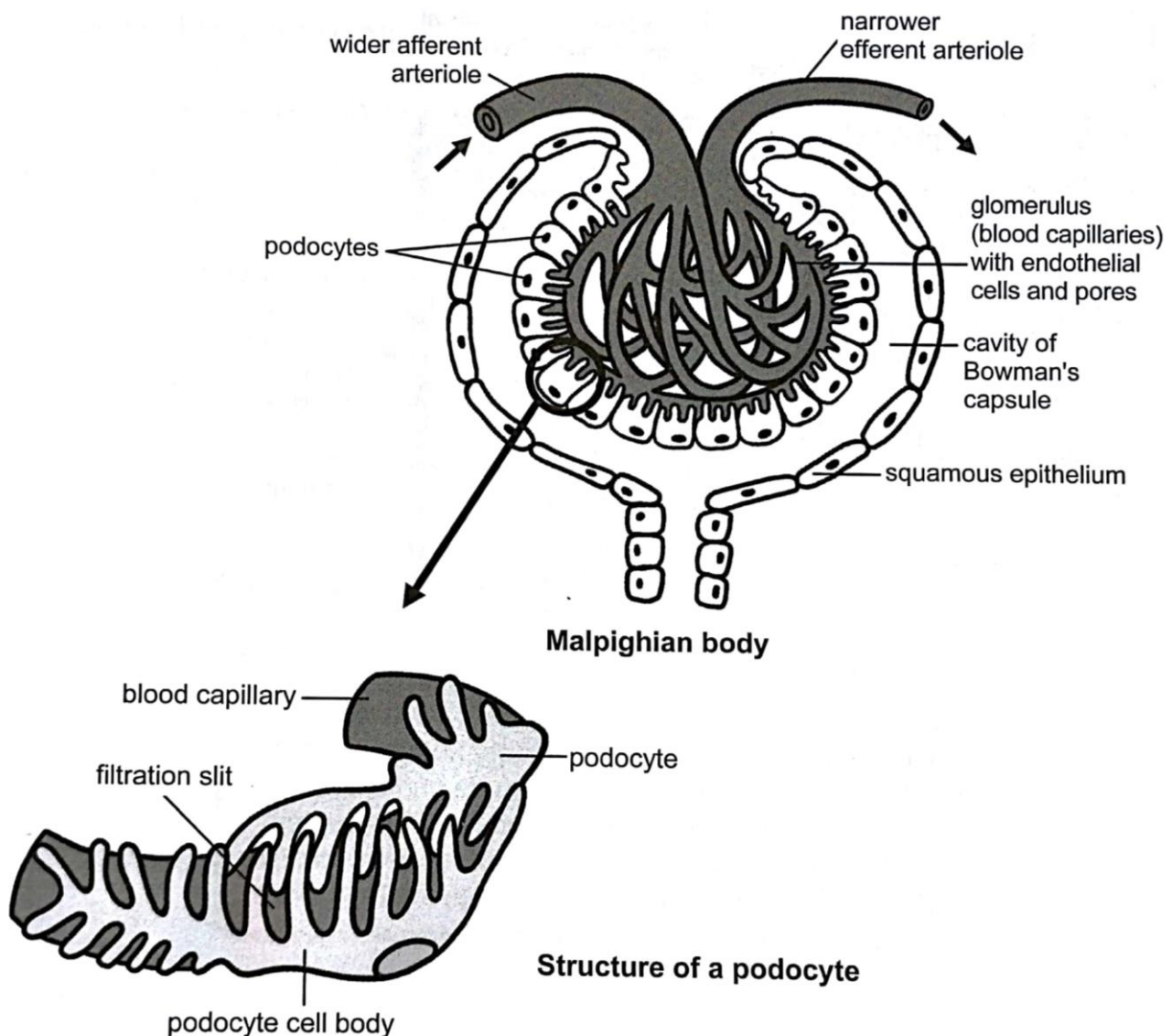
It consists of two parts:

- Bowman's capsule (double-walled and cup-shaped)
- Glomerulus (a network of capillary blood vessels).

These capillary blood vessels are lined with a single **endothelial layer** (squamous epithelium) with pores between the endothelial cells.

The blood vessel that transports blood to the glomerulus is known as the **afferent arteriole**. The blood vessel that transports blood away from the glomerulus is known as the **efferent arteriole**.

The inner wall of the Bowman's capsule consists of specialised cells, the **podocytes**. The podocytes are cells with projections between which small openings, the filtration slits, occur.



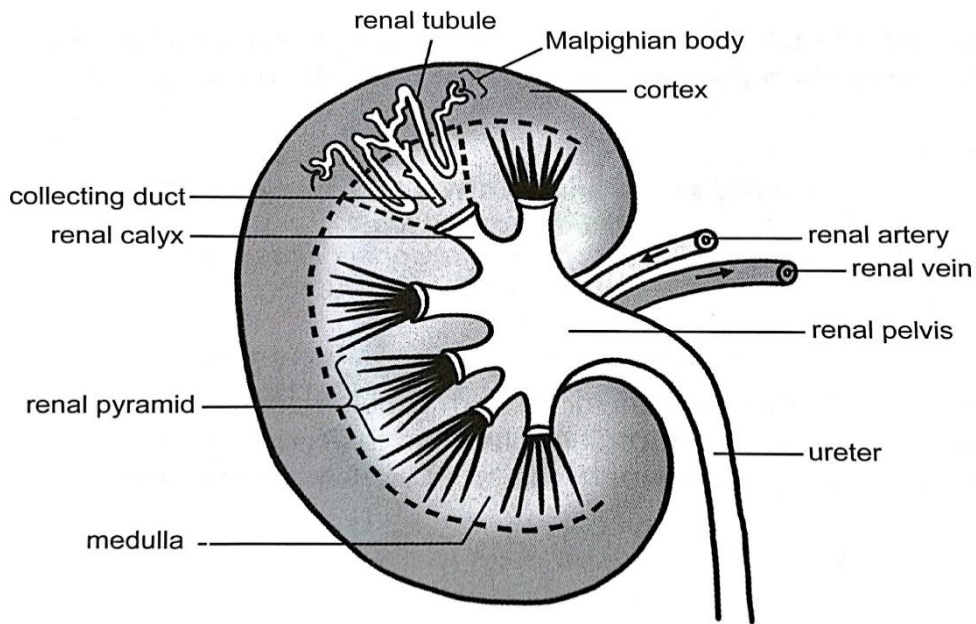
Renal tubule

Long convoluted (coiled) tubule that is situated partially in the cortex and partially in the medulla. It consists of three parts:

- Proximal convoluted tubule (directly after the Bowman's capsule and is situated in the cortex). The widest part of the renal tubule.
- Loop of Henle (situated in the medulla).
- Distal convoluted tubule (situated in the cortex).

The proximal and distal convoluted tubule are both lined with a single layer of cuboidal epithelium.

Distal convoluted tubule from opens into a **collecting duct** together with a number of distal convoluted tubules from other nephrons. A few collecting ducts converge and form the **ducts of Bellini**. The ducts of Bellini are the tubes forming the pyramids that open into the renal calyx of the renal pelvis.



Position of nephrons in the kidney

BLOOD SUPPLY OF THE KIDNEY

Renal artery (a branch of the aorta) carries oxygenated blood rich in metabolic wastes to the kidney. The renal artery enters the kidney at the hilum. The artery branches into smaller arteries and branch further until they form the smallest branches in the cortex called afferent arterioles. One afferent arteriole extends to each Bowman's capsule.

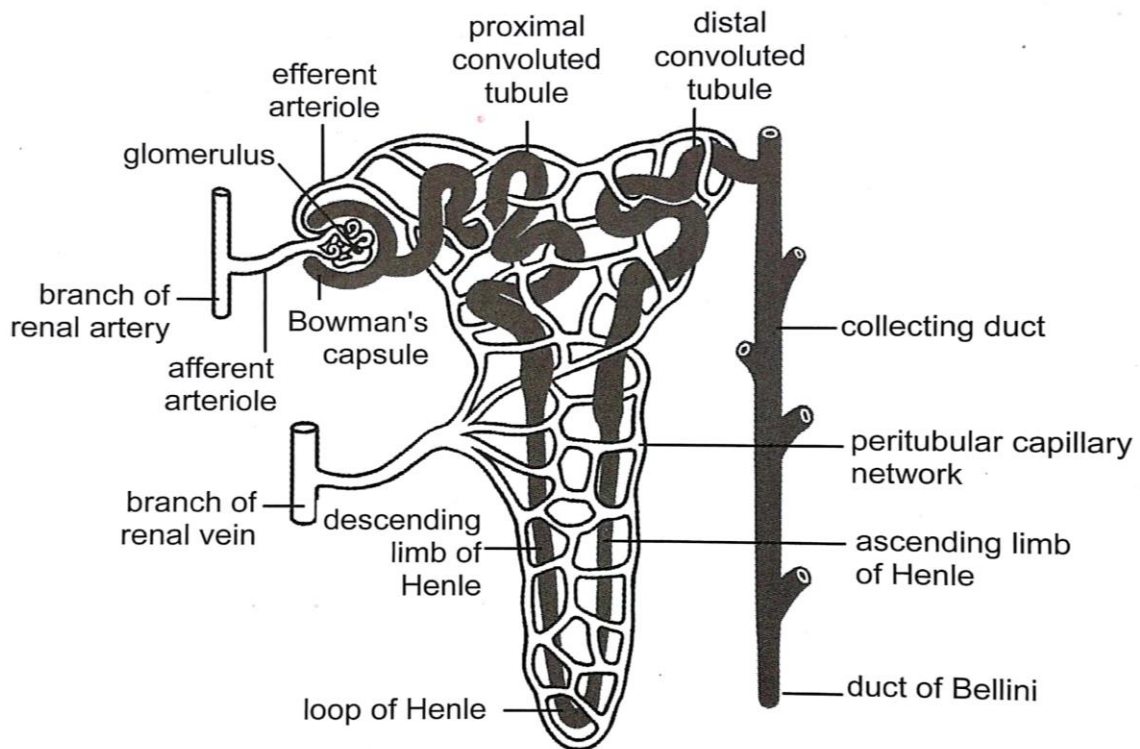
The afferent arteriole divides to form a capillary network, the glomerulus, which fits inside the cup-shaped hollow of the Bowman's capsule. The blood capillaries then merge and form an efferent arteriole, which transports blood away from the Bowman's capsule.

The efferent arteriole branches again to form a second network of blood vessels, the peritubular capillary network, which surrounds the renal tubule.

The peritubular capillaries combine to form venules and larger veins that eventually form the renal vein (which takes deoxygenated blood, minus waste products, from the kidney via the inferior vena cava).

NOTE:

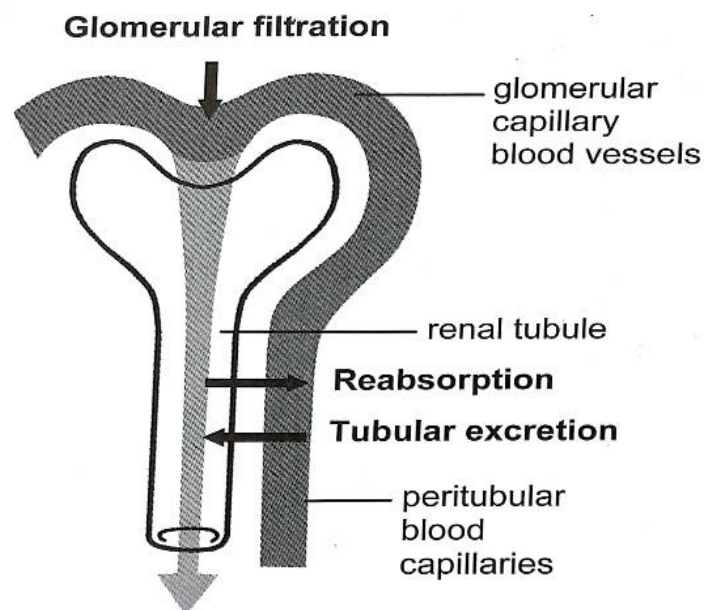
The afferent arteriole is much wider than the efferent arteriole. Blood flows to the glomerulus under high pressure.



FUNCTIONING OF THE KIDNEY

The functioning of the kidney can be divided into three main processes:

- Glomerular filtration
- Tubular reabsorption
- Tubular excretion



Glomerular filtration

It occurs in the Malpighian tubules in the cortex of the kidney. The blood in the glomerulus is under high pressure because the diameter of the afferent arteriole is larger than that of the efferent arteriole.

The thin endothelium with pores lining the blood capillaries of the glomerulus, together with the podocyte layer with filtration slits of the Bowman's capsule, form an ultrafine filter through which the filterable parts of the blood are forced. The blood cells and plasma proteins are too large to filter and they remain behind in the capillaries.

The part of the blood that moves into the Bowman's capsule is known as the glomerular filtrate. It contains useful substances as well as waste products.

Useful substances include:

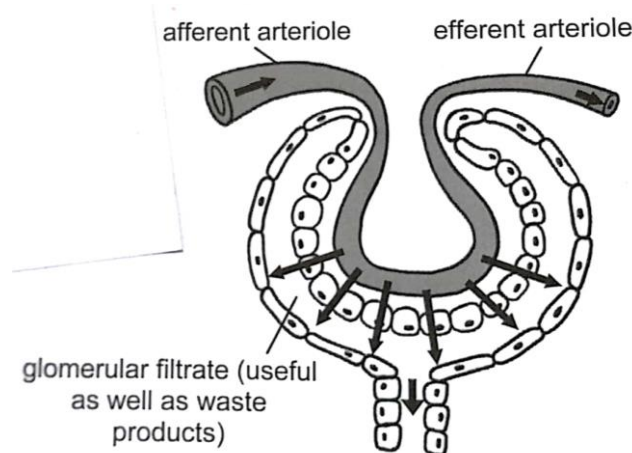
- Water
- Amino acids
- Glucose
- Vitamins
- Mineral salts

Waste products include:

- Urea
- Uric acid
- Creatinine

The filtration process is promoted by:

- The high blood pressure in the glomerulus
- A large filtration surfaces
- The permeability of the glomerular membrane.



Adaptations of the Malpighian body for filtration

- The **afferent arteriole is wider than the efferent arteriole** – causes a high blood pressure in the glomerulus, promoting filtration.

- The **capillary network of the glomerulus has a large surface area** – increases the efficiency of filtration.
- The **Bowman's capsule is cup-shaped** – provides large surface for effective filtration.
- The **endothelial layer** of the glomerular capillaries and the **podocyte layer** of the Bowman's capsule – form an ultrafine filter through which substances are filtered.
- The **endothelial layer has pores** – only allow smaller parts of the blood to filter through.
- The **podocytes have filtration slits** – only allow smaller parts of the blood to filter through.

Tubular reabsorption

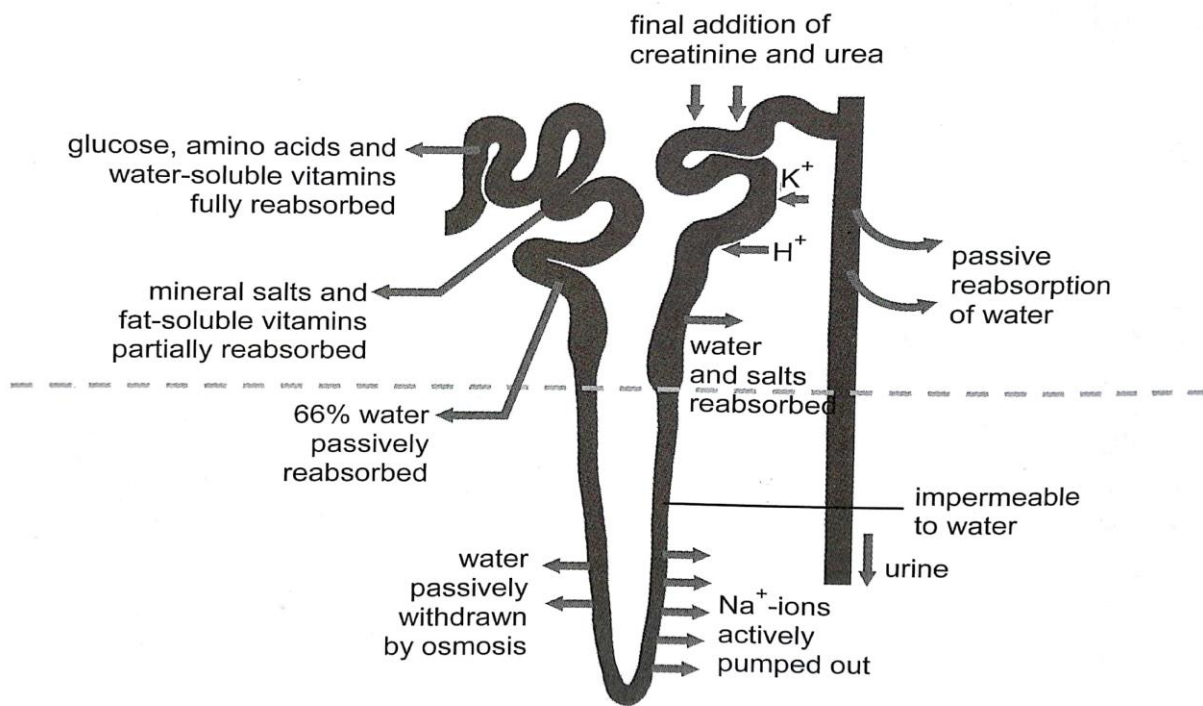
Useful substances must be reabsorbed and returned to the bloodstream. This process prevents useful substances forming part of urine and being excreted. The filtrate leaves the Bowman's capsule and enters the proximal convoluted tubule.

Adaptation of the proximal convoluted tubule for reabsorption

- The tube is long and convoluted – enlarges the surface for maximal reabsorption.
- The peritubular capillary network surrounds the renal tubule – reabsorbed substance can easily move into the bloodstream.
- The cuboidal epithelial cells, which line the tubule, have many mitochondria – provide energy, this indicates an active mechanism.
- The cuboidal epithelial cells have finger-like projections – increase the absorption surface.

Reabsorption of useful substances

- All glucose, amino acids and water-soluble vitamins are **actively** reabsorbed into the peritubular capillary vessels.
- Mineral salts (e.g. Na⁺) and fat-soluble vitamins are also **actively** reabsorbed, but only selectively, as they are needed by the body.
- Approximately 66% of water is **passively** reabsorbed into the peritubular capillaries by osmosis.



Reabsorption and excretion by renal tubule

Tubular excretion

This process occurs in the proximal and distal convoluted tubules. Substances are secreted from the blood in the surrounding peritubular capillaries through the epithelium of the renal tubule and added to the filtrate.

Hydrogen ions (H^+), potassium ions (K^+), creatinine, urea, drugs, preservatives, colourants and other foreign substances are actively added to the filtrate.

Urine formation

The filtrate flows into the collecting ducts and is now called **urine**. Urine flows through the ureter into the bladder where it is temporarily stored.

Composition of urine

Urine is a yellowish fluid with a characteristic smell. The composition and colour although are influenced by the level of activity, health, amount of fluid intake, type of food eaten, medication etc.

Urine consists of water, inorganic salts (e.g. chloride, sulphate and phosphate ions of calcium, sodium and magnesium), metabolic wastes (urea, uric and creatinine) and foreign substance (colourants, preservatives etc.).

HOMEOSTATIC CONTROL

Regulation of the pH of the blood

- The blood pH is regulated in the distal convoluted tubule. The range is between 7,35 and 7,45.

- Excess H^+ ions in the blood lowers the pH and makes the blood acidic.
 - Secretion of H^+ ions from the blood to the tubules occurs when the pH of the blood becomes too low (excess H^+ ions).
 - The excess H^+ ions are thus removed from the blood, and the pH increases and returns to normal.
 - Phosphate compounds or ammonia (NH_3) occur in the filtrate and binds with the H^+ ions in the filtrate. The H^+ ions are excreted as hydrogen phosphate compounds or ammonium (NH_4^+) ions in the urine.
 - These forms of H^+ ions prevent the pH in the urine from becoming too low (too acidic).
-
- When the pH of the blood increases (becomes too alkaline), fewer H^+ ions are secreted from the blood into the tubules and more bicarbonate ions (HCO_3^-) are secreted from the tubules into the blood.
 - An increase in HCO_3^- increases the pH (more alkaline).

Regulation of the salt concentration of the blood

The hormone **aldosterone** (secreted by the cortex of the adrenal gland), regulates the concentration of sodium ions and potassium ions in the blood.

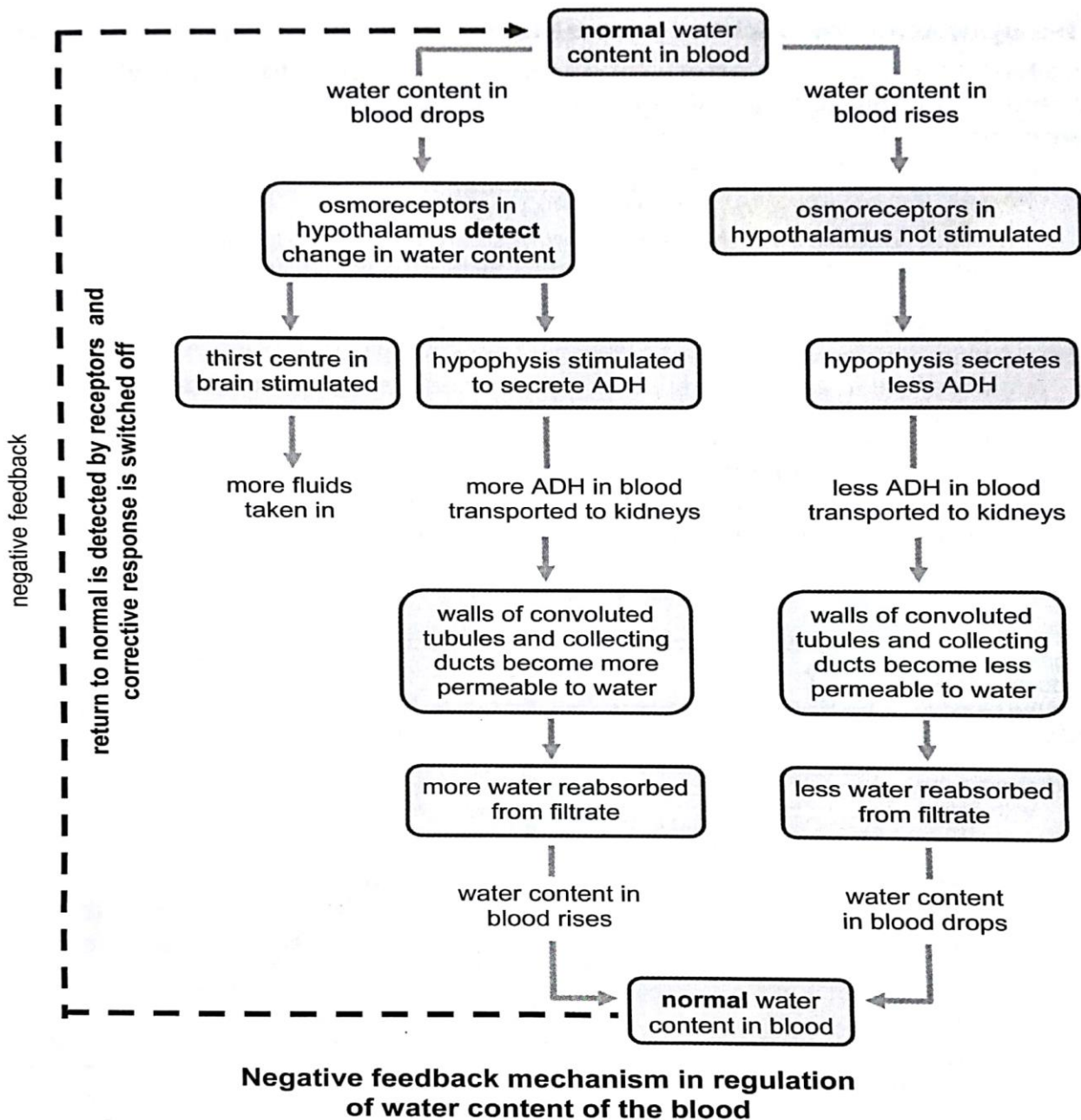
- When the sodium concentration in the blood is **too low**, the adrenal cortex of the adrenal gland is stimulated to secrete **more** aldosterone.
 - More sodium ions are reabsorbed from the distal convoluted tubule and collecting duct into the blood in the peritubular blood capillaries.
 - The concentration of sodium ions in the blood increases and fewer sodium ions are excreted in the urine.
-
- When the sodium concentration in the blood is **too high**, the adrenal cortex of the adrenal gland is stimulated to secrete less aldosterone.
 - Fewer sodium ions are reabsorbed from the renal tubule.
 - The concentration of sodium ions in the blood decreases and more sodium ions are excreted in the urine.

Regulation of water content of the blood – Osmoregulation

The hormone ADH (**anti-diuretic hormone**), secreted by the hypophysis (pituitary gland), regulates the water content of the blood.

- When the blood has too much water, osmoreceptors in the hypothalamus is stimulated and a message is sent to the pituitary gland which secretes LESS ADH into the blood.
 - As a result, the distal convoluted and collecting ducts become LESS permeable to water. This cause LESS water to leave the tubule by osmosis and enter the medulla.
 - MORE water thus remains in the tubule forming very dilute urine which is excreted from the body
 - LESS water is thus reabsorbed into the capillaries and the water content of the blood decrease and returns to normal.
-
- When the blood has less water, osmoreceptors in the hypothalamus is stimulated and a message is sent to the pituitary gland which secretes MORE ADH into the blood.

- As a result, the distal convoluted and collecting ducts become MORE permeable to water. This cause MORE water to leave the tubule by osmosis and enter the medulla.
- LESS water thus remains in the tubule forming very dilute urine which is excreted from the body
- MORE water is thus reabsorbed into the capillaries and the water content of the blood increase and returns to normal.



FUNCTIONS OF THE KIDNEY

- Excretion of nitrogenous wastes.
- Regulation of the water content in the blood (osmoregulation).
- Regulation of the salt content in the blood.
- Regulation of the pH in the blood.

DISEASES THAT AFFECT KIDNEY FUNCTIONING

Kidney stones – nitrogenous wastes and mineral salts form solid crystals.

- If the kidney stones become too big, they can block the ureter, leading to serious pain in the side, lower abdomen and groin.
- The kidney stones can be broken up into smaller pieces by ultrasound waves, which can then be excreted in the urine.
- Kidney stones that are too large are usually removed surgically.

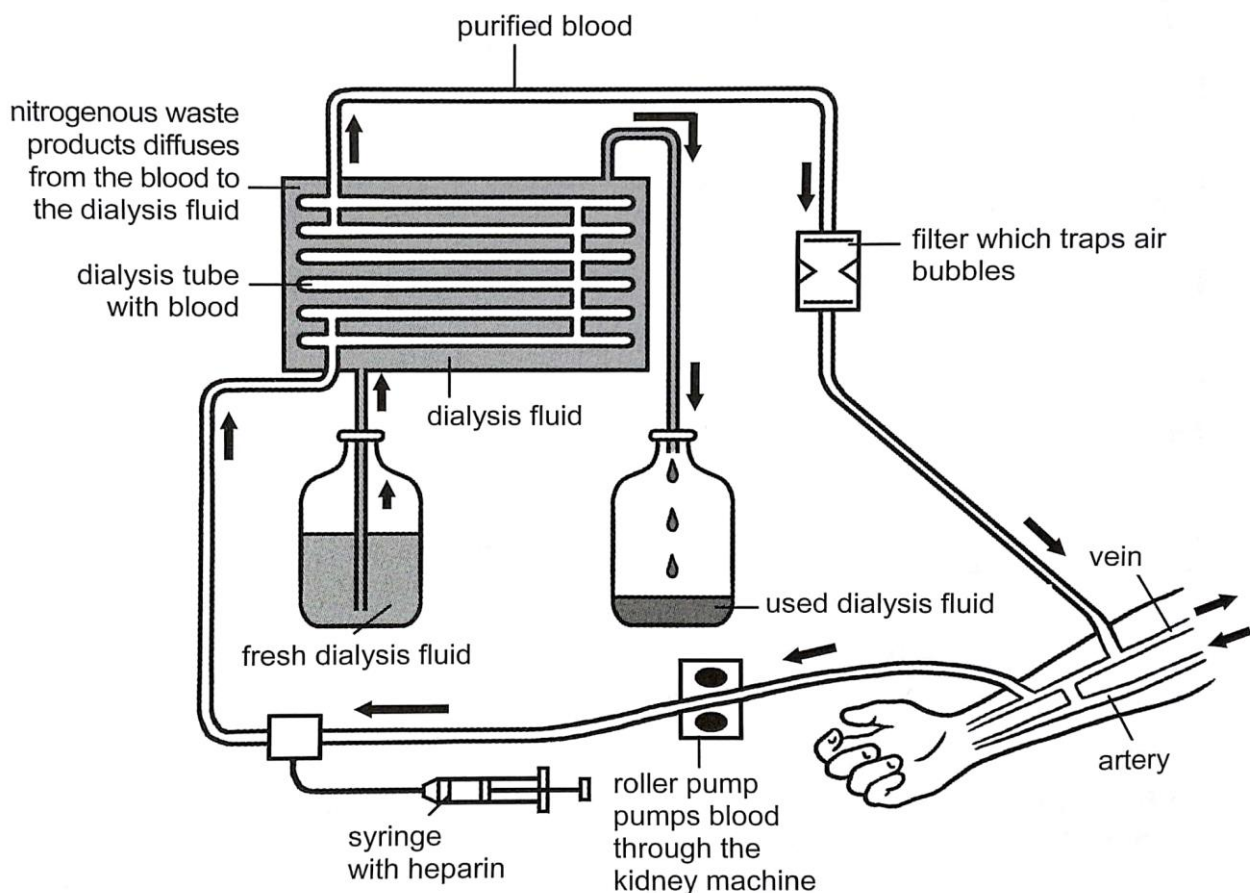
Bilharzia – a disease that is caused by the *Schistosoma* parasite.

- It affects the general health of the infected person.
- The most harmful effects are bleeding and the formation of ulcers in the gut or bladder.
- Long term effects include liver damage, renal failure and cancer of the bladder.

Renal failure – a state where the kidney is so damaged that it can no longer function. The waste products and excess water accumulate in the blood and body.

- The most common cause is diabetes and untreated high blood pressure.
- A person suffering from renal failure can be kept alive by dialysis or should otherwise undergo a kidney transplant.
- People with renal failure can have their blood purified artificially by the process of dialysis, using a kidney machine.

Assignment: Write on kidney dialysis and kidney transplant.



TOPIC 9:
POPULATION ECOLOGY (PAPER 2 – 37 MARKS)

Population ecology – the part of ecology that focuses on the factors influencing the population size, growth rate, growth forms and distribution of individuals inside a population.

Species – group of organisms with similar characteristics, which produce fertile offspring.

Population – group of the same species that are found in an area at a time.

Community – group of populations occurring in an area e.g. populations of lion, zebra, giraffe and rhino in the Kruger National Park.

Ecosystem – a unit of living organisms interacting with each other as well as with the non-living factors in area.

Environment – external factors (living and non-living) surrounding an organism and influencing its development and survival.

Habitat – specific environment (home) in which a plant or animal species normally occurs.

POPULATION SIZE

Population size is the total number of individuals in a population.

Population density refers to the number of individuals of a population per unit area e.g. 10 sheep per hectare.

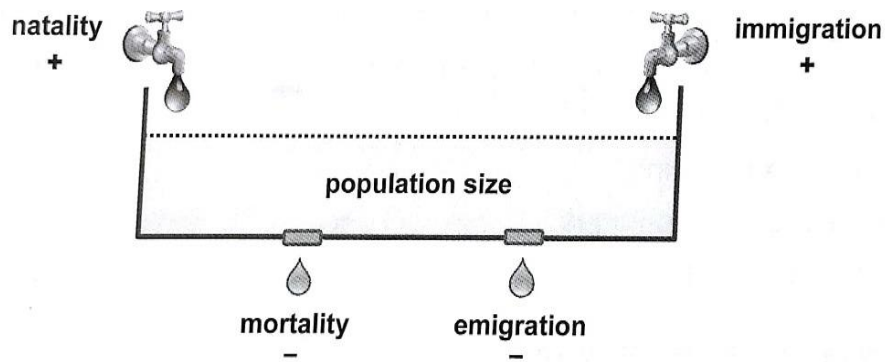
Population parameters

Four main factors (parameters) influence population size.

- Natality – the birth rate of a population (normally expressed as the number of live births per thousand individuals per year).
- Mortality - the death rate of a population.
- Immigration – the one-way movement of organisms into an area where they become established.
- Emigration – the one-way movement of organisms out of an area to become established.

Natality and immigration cause an increase in population size, while mortality and emigration cause a decrease.

A population where immigration and emigration do not occur is known as a **closed population**, e.g. fish in a dam or animals on an island. The only parameters that affect the population size in a closed population are natality and mortality.



Representation of the four parameters affecting population size

Determining population size

Direct techniques – involve the total count of all individuals in the population. These includes:

- Census (in a human population)
- Counting, e.g. large animals in a nature reserve counted with the aid of a helicopter.
- Aerial photographs of groups of animals, e.g. a penguin colony.

Indirect techniques – involve the counting of only part of the population. It includes the following:

- Mark-recapture technique
- Quadrat technique

Mark-recapture technique

- A specific area is demarcated.
- Several individuals are caught, counted and marked (1st sample) and are later released into the environment. They are allowed to mix with the rest of the population.
- Another group of individuals is caught and counted (2nd sample).
- The number of marked individuals in the 2nd sample (marked during the 1st sampling) are counted.
- The data is used to determine the estimated size of the population using the following formula:

$$P = \frac{m \times s}{t}$$

- P = estimated population size
 m = total number of animals captured and marked in sample 1
 s = total number of animals captured in sample 2
 t = number of marked individuals in sample 2

EXAMPLE

In a practical investigation to determine the size of a beetle population in a demarcated area, a sample of 50 beetles was caught (1st sample) and a spot of paint was applied to each beetle.

These marked beetles were put back into the area and allowed to move around freely. Two days later, a sample of 90 beetles was caught in the same area (2nd sample) of which 5 beetles were marked with a spot of paint.

Determine/estimate the size of the beetle population by using the following

formula: $P = \frac{m \times s}{t}$

P = estimated size of beetle population
m = total number of beetles in 1st sample
s = total number of beetles in 2nd sample
t = number of marked beetles in 2nd sample



To make this technique more accurate (improve), repeat the sampling a few times and calculate an average population size. This technique is only valid under the following conditions:

- The marking method should not injure or damage the organism.
- The marks should be clearly visible for the duration of the investigation.
- The marking method should not affect the movement or behaviour of the organism.
- Marked organisms should be allowed enough time to mix with the rest of the population before the next sample is taken.
- The population must be closed, so no immigration or emigration takes place.
- The period between the two samplings should be sufficiently brief, so that no births or deaths occur.

Quadrat technique

- A square frame of known size is used.
- An area where organisms must be counted is demarcated and the surface area determined.
- The quadrat is placed on the ground in the demarcated area and the organisms concerned are counted inside the square frame.
- This process is repeated a few times in different areas of the demarcated area by placing the quadrat randomly on the ground. Through random sampling, each member of the population has an equal and independent chance of being included.
- The total number of individuals in the population is determined using the following formula:

Population size = average number of individuals per quadrat $\times \frac{\text{surface area of the area}}{\text{surface area of the quadrat}}$

The reliability of this technique depends on the following:

- The exact number of organisms in each quadrat must be known.
- The surface area of the quadrat must be known.
- The surface area of the demarcated area must be known.
- The quadrat must be placed randomly in the demarcated area.

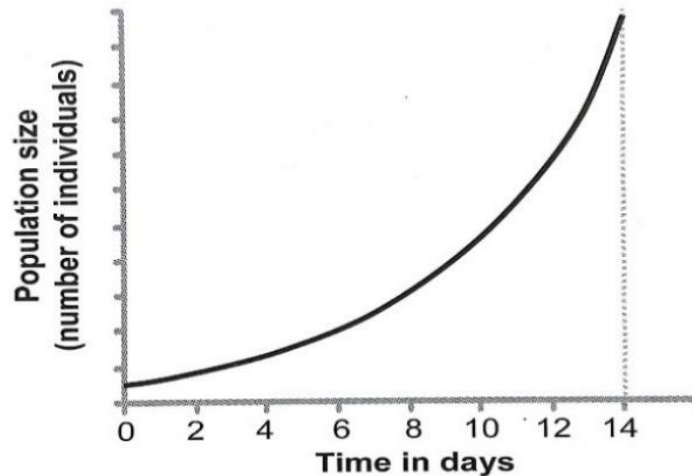
POPULATION GROWTH FORMS

It is the distinctive growth patterns of a population. Two basic growth forms are distinguished:

- Geometric J-shaped growth form
- Logistic or S-shaped (sigmoid) growth form.

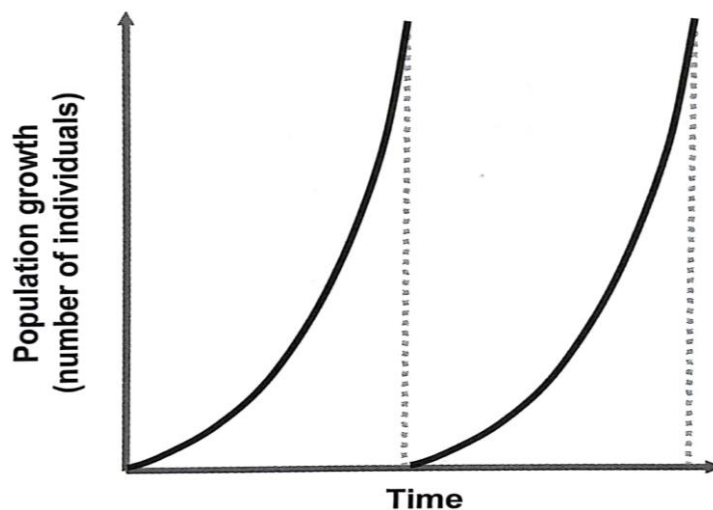
Geometric (J-Shaped) Growth Form

Unlimited resources such as food, water, space and no predators can make a population reach its full reproductive potential. These ideal environmental conditions result in the maximum possible growth rate and population figures increase rapidly.



Characteristics of geometric growth form

- A distinctive J-shape.
- Increase in number is slow at the beginning, as there are few individuals.
- In time there is a sharp increase in individuals due to optimum environmental conditions.
- A sudden standstill often occurs. This occurs when conditions become unfavourable, e.g. shortage of food, unfavourable temperature or poisoning.
- Once conditions are favourable again, the growth pattern can be repeated.



LIMITING FACTORS

Factors that prevent unlimited growth in a population. They play a huge role in the regulation of population size.

Limiting factors can be classified as:

- Density dependent factors – factors that take effect when population size or density increases. The larger the population, the greater the effect of these factors. Examples include shortage of food and water, shortage of living space, shortage of shelter, predation, spread of diseases and parasites, accumulation of toxins.
- Density independent factors – factors that limit the size of a population regardless of the size or density of the population. Examples include extreme changes in temperature, natural disasters (floods, drought, fire, earthquakes, tsunamis, volcanic eruptions and hurricanes).

Together, they are called **environmental resistance**. When the numbers a population increase, the environmental resistance increases.

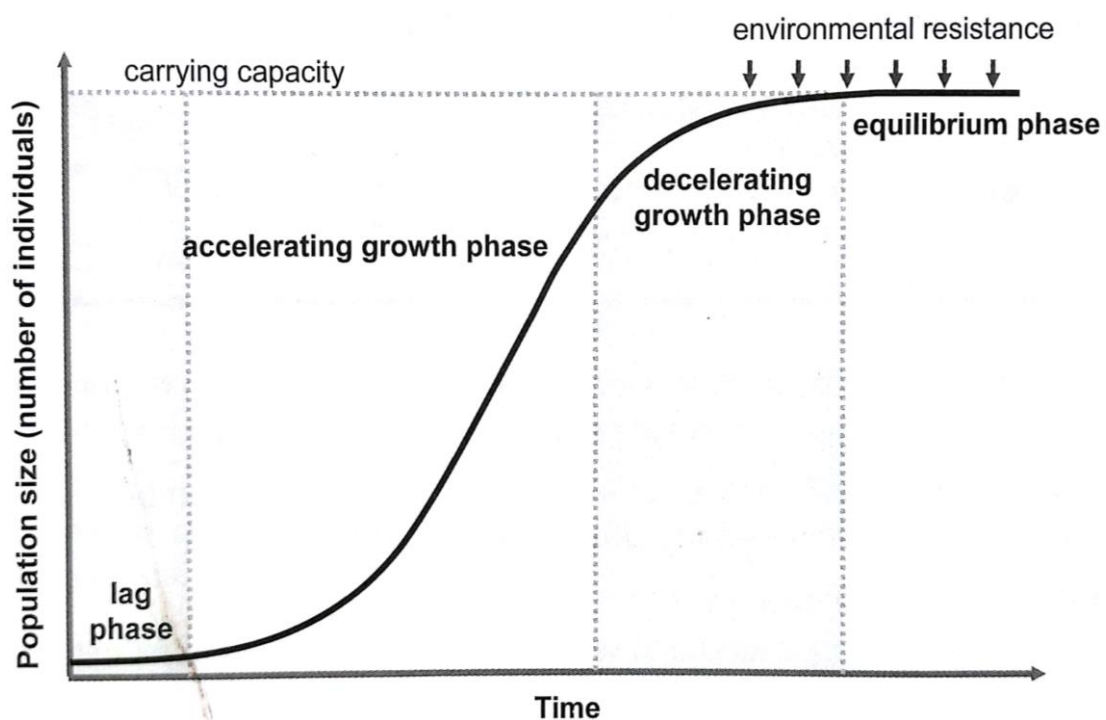
Logistic (S-shaped) Growth Form

Limiting factors (environmental resistance) can transform the J-shaped curve into an S-shaped curve.

An S-shaped growth form occurs when a young population consisting of only a few individuals is in an area with sufficient food, water, space and little predation.

Four distinctive phases can be distinguished on the logistic (S-shaped) curve:

- Lag phase
- Geometric/ exponential/ accelerating growth phase
- Decelerating growth phase
- Equilibrium/stationary phase.



Lag phase

The population grows slowly at the beginning. This is because;

- population acclimatises and adapt to the environment.
- individuals must become sexually mature.
- individuals seek partners for mating.
- it takes time before new offspring are produced (gestation period or incubation).

Geometric/exponential/accelerating growth phase

The population grows rapidly and reaches its maximum growth rate. There is very little or no environmental resistance at this stage. Natality is higher than mortality.

Decelerating growth phase

Growth rate decreases due to an increase in environmental resistance. Natality is still higher than mortality. As the population grows, the available resources decrease, and competition increases.

Equilibrium/stationary phase

The population number now reaches the carrying capacity of the environment and stabilise around this value. Natality and mortality are approximately equal during this phase.

Carrying capacity is the maximum number of individuals that a specific environment can sustain.

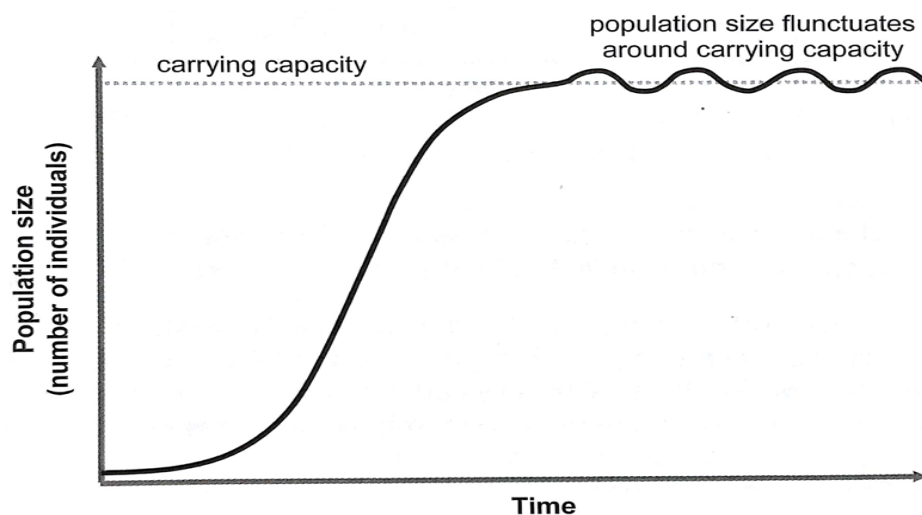
REGULATION OF POPULATION

Once a population reaches its maximum size in a given environment, the numbers will not remain constant, but fluctuate within narrow boundaries due to changes in environmental resistance.

If the population numbers increase beyond the carrying capacity, the environmental resistance will increase and result in a decrease in numbers.

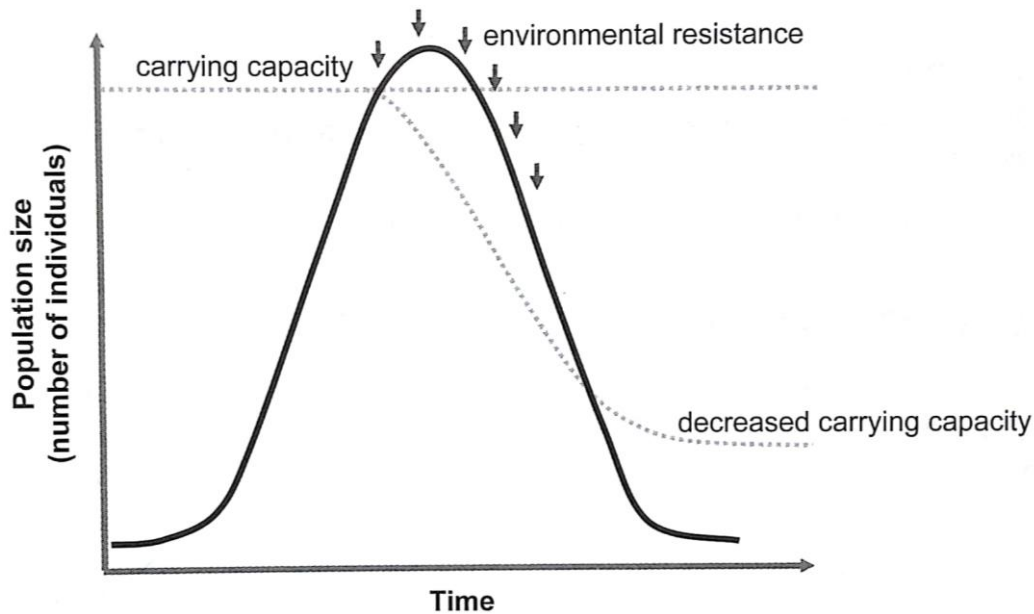
If the population numbers decrease below the carrying capacity, the environmental resistance decrease, and the population numbers will increase.

A **stable population** is a population where the numbers fluctuate around the carrying capacity.



When population numbers far exceed the carrying capacity, the habitat will most likely be damaged, leading to a decrease in the carrying capacity of the environment. This type of population is called an **unstable population**.

The environment can no longer sustain the population and the population numbers will decrease, it may even become extinct.



INTERACTION IN THE ENVIRONMENT

In Grade 10, you learnt about:

Trophic level – the position an organism or group of organisms occupies in the food chain.

Producers – green plants that can produce their own food through photosynthesis.

Consumers – organisms that cannot produce their own food. They depend directly or indirectly on the producer for their food. They are primary (herbivores and omnivores), secondary (carnivores, scavenger and omnivores) and tertiary consumers (carnivores).

Decomposers – they feed on dead organic matter, e.g. bacteria and fungi.

There is a fine balance in natural environment, where every individual is involved in a daily struggle for survival. Interaction between individuals increases their chances of survival and leads to the successful survival of several species in a community.

Five types of interaction occur in communities in the environment:

- Predation
- Competition
- Mutualism
- Commensalism
- Parasitism

PREDATION

This is a feeding interaction where one organism, the **predator**, hunts, kills and eats another organism, the **prey**.

Predators are well adapted to hunt and catch their prey and have the following qualities:

- Agility
- Great speed
- Intensified sense of smell
- Sharp teeth and claws
- Good camouflage

Prey are adapted to escape from predators. They have the following qualities:

- Herding
- Good camouflage
- Warning colouration
- Ability to secrete poisonous substances.

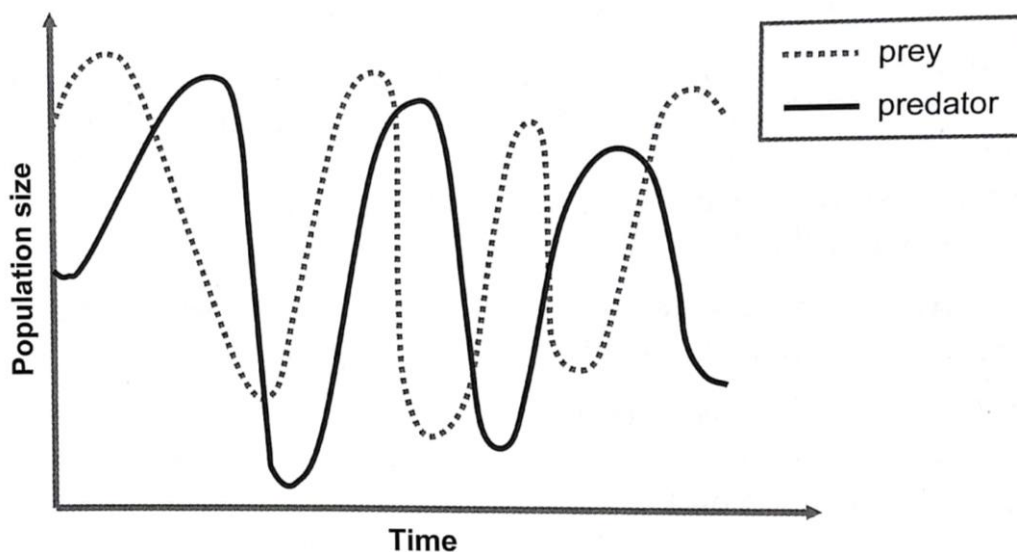
Predator-prey relationship

The relationship between predator and prey causes fluctuations in both predator and prey numbers. Predation therefore helps to control the sizes of both populations.

Predators control the prey numbers, but at the same time the number of available preys also controls the number of predators.

The higher the prey numbers, the more predation will occur. The lower the prey numbers, the fewer predators will survive due to a shortage of food.

Predation is therefore a **density-dependent factor**.



Examples of South African predators

Lion (*Panthera leo*) – Lions have unbelievable power, agility, sharp teeth, claws and camouflage, are well-adapted to be successful hunters. Their only shortcomings are their lack of stamina when chasing their prey.

Their prey includes wildebeest, zebra, gemsbok, kudus, buffalo, giraffe and warthogs.

Female lions (lioness) are predominantly hunters, but sometimes a stronger male is needed to help bring down larger prey such as buffalo.

Lions usually hunt at night and work as a group to ambush their prey.



Nile crocodile (*Crocodylus niloticus*) – The ability of crocodiles to drift quietly and unseen with most of their body submerged, together with their high speed over short distances, make them effective hunters of larger prey.

The prey is grasped by the powerful jaws, pulled into the water and held underwater until it drowns.

Adult crocodiles eat larger vertebrates, such as wildebeest, zebra, warthogs, sheep, goats and cattle.

COMPETITION

Each species has a specific role to play in the community. This role is known as its **ecological niche**. In its specific role, each species needs a particular set of environmental conditions and resources to survive and reproduce in its habitat. The survival of a species therefore depends on how successfully the organisms use their available resources.

Competition takes place when two or more individuals compete for the same limited resources, such as food, water, space, shelter and mating partners.

There are two types of competition:

Intraspecific competition: takes place between individuals of the same species. They live in the same habitat and use the same resources. It is a very intense type of competition. Example: Two male lions competing to mate with the same female.

Interspecific competition: takes place between individuals of different species. Example: Hyenas and vultures competing for the same food source.

As the numbers of population increase and resources become increasingly limited, intraspecific competition between individuals increases.

With the increase in population numbers, the ecological niches of the different species may also overlap more and more, which will in turn increase interspecific competition.

Competition therefore is a **density-dependent factor**.

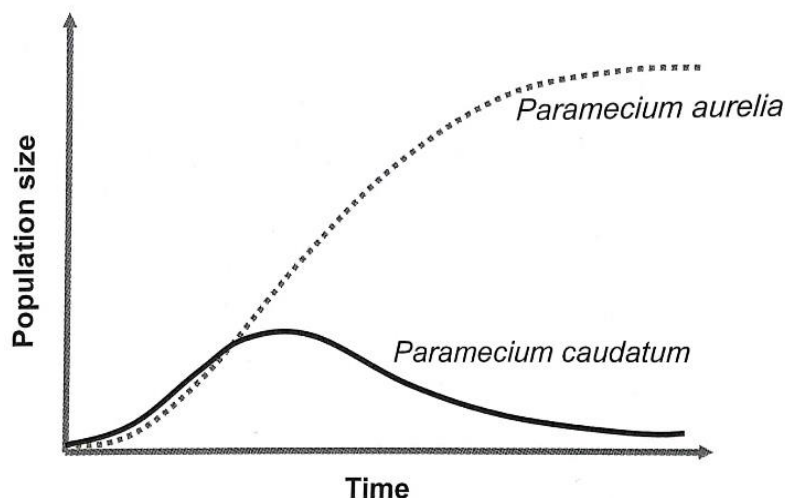
Competitive exclusion

Two different species that need the same limited resources cannot occupy the same niche in the same habitat over a long period. Usually, one species will outcompete the other, which could result in the emigration (moving out) or even extinction of the other species.

This is known as the principle of competitive exclusion.

Two species of *Paramecium* (*aurelia* and *caudatum*) were both cultivated under the same laboratory conditions, together on the same culture medium.

After an initial lag phase in both species, *Paramecium aurelia* out-competed *Paramecium caudatum* and drove it to extinction.



Resource partitioning

Two species can co-exist in one habitat and use the same resources, but only if they occupy separate, specialised niches. The resources are used differently, and co-existence is possible.

Types of resource partitioning includes:

- Using the resource at different times, e.g. one species feed during the day and the other at night.
- Using different parts of the resource, e.g. two different species of ape feed at different heights in a tree.
- Using the resource in different habitats, e.g. two different species of monkey feed on the same species of tree, but in different parts of the forest.

Large herbivores in the African savannah are adapted to partition their food resource successfully. Grazers (e.g. wildebeest and zebra) and browsers (e.g. kudu and giraffe) are not in competition, as they partition their resources.

Different plant layers (strata) are adapted to survive at different intensities of light, and therefore the resource is divided between the different layers of plants. Tall trees get the most sunlight, short trees are exposed to less light, shrub layer survive in an environment with low light intensity while shade plants and herbaceous layer are shade plants.



Decrease in light intensity from A to B to C to D

SYMBIOSIS

Some organisms of different species live together in a relationship. This relationship is known as symbiosis.

Mutualism

A symbiotic relationship between two organisms of different species, where both benefits.

Bees are attracted by the bright colours of flowers, where they find and feed on nectar and pollen. While the bee is feeding, pollen grains stick to its body. As the bee moves to the next flower, the pollen is transferred, and cross-pollination takes place.



Honeybee



Honey badger and honeybird

Honeybird and honey badger both prefer honey, honeycomb, bees and larvae to any other food. The honeybird can find the beehive, but it is difficult for honey badger to find one. Honey badger has strong, sharp raking claws to break open the beehive, but the honeybird is not big or strong enough to tackle swarms of bees. The honey badger is led to the food source (beehive) by the honeybird while the honeybird gets food because the honey badger breaks open the beehive and makes the food accessible.

Commensalism

A symbiotic relationship between two organisms of different species where one benefits and the other is neither harmed nor benefits.

The small remora or suckerfish attaches itself to a shark by means of a sucking disc on top of its head. The suckerfish feeds on the shark's leftover scraps of food and also enjoys a great deal of protection, because the shark scares off the suckerfish's predators or even eats them. Consequently, the suckerfish benefits, while the shark is neither advantaged nor disadvantaged.



Shark and suckerfish

Epiphytes are plants that grow on the branches of trees. Epiphytes use the branch only for support to obtain maximum light and do not absorb water or nutrients from the tree. Consequently, the epiphyte benefits, while the tree is neither advantaged nor disadvantaged.



Epiphytes on tree branches

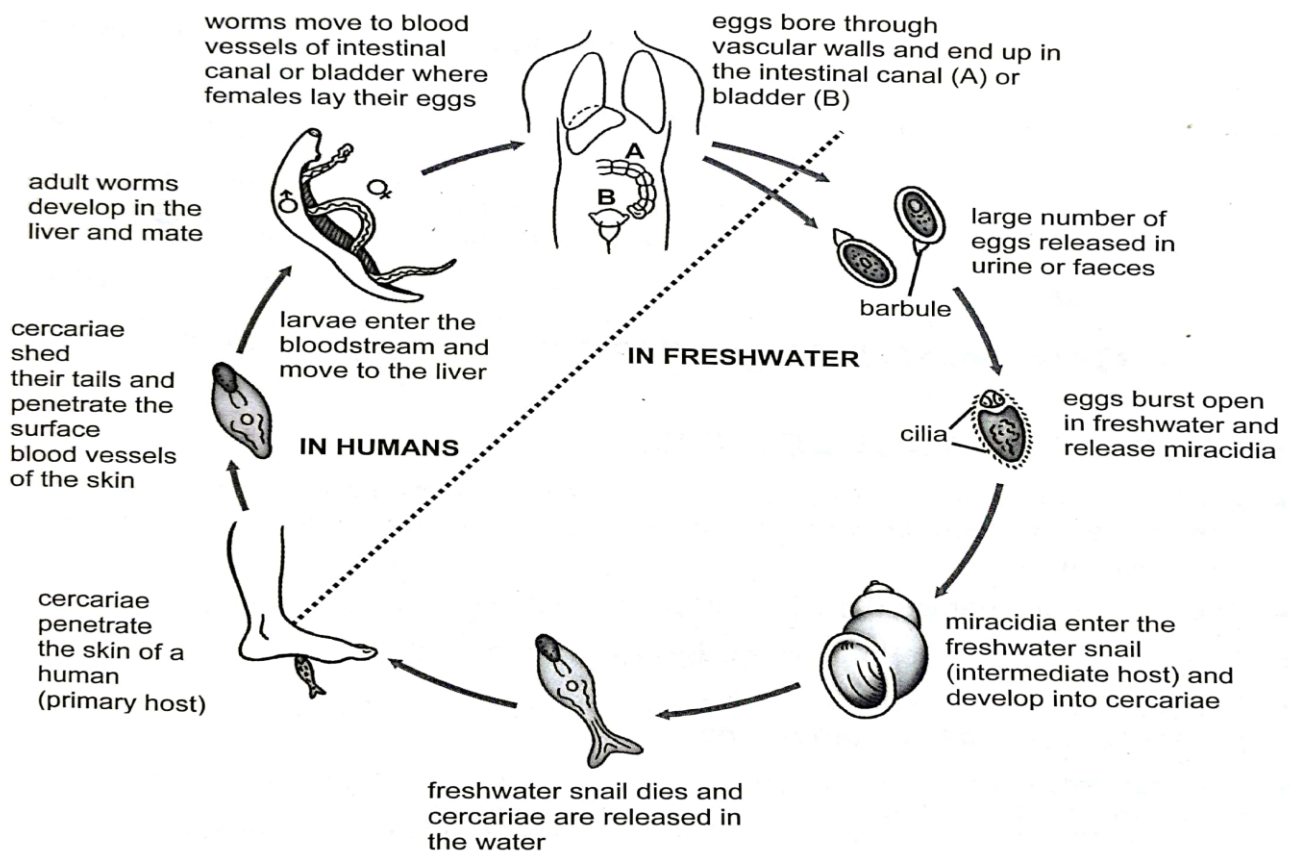
Parasitism

A symbiotic relationship between two organisms of different species where one benefits and the other is harmed. The parasite is the organism that benefits while the host is the organism that is harmed.

Types of parasites

Ectoparasites live on the external surface of the host's body. Examples include ticks, lice and fleas on animals, and plant lice (aphids), dodder and mistletoe on plants.

Endoparasites live inside the host's body. Examples include the tapeworm, the bilharzia and malaria parasites in animals.



Life cycle of the bilharzia parasite

Parasitism vs Predation

- Both interactions involve an organism deriving benefit and the host or prey being disadvantaged.
- However, parasites differ from predators as they do not kill their hosts deliberately. It is important to the parasite that the host stays alive. Should the host die, the parasite loses its habitat and food source.
- Predators are larger than their prey, while parasites are smaller than their hosts.

SOCIAL ORGANISATION

Many organisms occur in groups (herds, packs or swarms) or colonies where the animals are interdependent. There is a social organisation evident in these groups or colonies that consists of various survival strategies. These strategies help the animals to survive in their environment.

Herds or swarms as anti-predation strategy

Each individual group member reduces the danger to itself by staying as close as possible to the centre of the group – staying as a unit.

The herd can also scatter in all directions. This confuses the predator and makes it harder to catch the prey.

In some cases, a predator can be attacked by a large herd or flock.

Some animals confuse predators with colouring that makes them difficult to identify. For example, a single zebra is clearly visible on a grassy plain, but in herd of zebra, the stripes merge together and present the predator with one confusing image.



Packs as a successful hunting strategy

Some predators such as the African wild dog, lions and hyenas, hunt together in packs – **cooperative hunting**. It seems that this hunting strategy in a species consists of learned behaviour rather than instinctive behaviour, which is passed from one generation to another.



A pack of wolf

Sharing of tasks (castes)

Animals that reach the highest level of social organisation in a community are called eusocial animals and live together in highly organised colonies. The most well-known examples are social insects, such as bees, ants, termites and wasps.

The only mammalian examples are the naked mole rat and the Damaraland mole rat.

In social insects (e.g. bees), there are different groups or castes that perform specialised functions in the colonies. These functions include finding food and building nests, (workers), protecting the nest (soldiers) and caring for the young. A single dominant fertile female, the queen, is characteristic of these colonies.



COMMUNITY CHANGES OVER TIME

ECOLOGICAL SUCCESSION

This refers to the sequence of communities, where one community replaces another over time, resulting in long-term changes in the ecosystem. These changes continue until a complex, stable ecosystem develops. This is known as the **climax** or **endpoint of succession**.

The first plants and animals that become established in an area are known as **pioneers** or **pioneer communities**. The pioneers change or alter the environment and create conditions that are favourable for the establishment of more complex organisms. Pioneers are usually replaced by herbaceous plants, then shrubs and trees.

A distinction is made between primary succession and secondary succession.

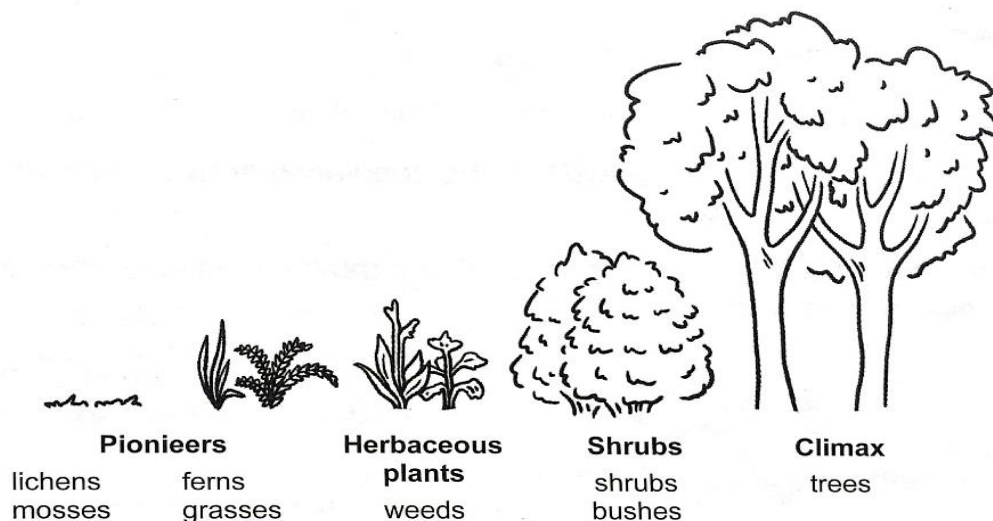
Primary succession

It takes place when plants and animals settle for the first time in an area where there was previously no life. This usually occurs in areas where initially there was no soil (e.g. bare rocks, sandy surfaces, areas with lava deposits or newly formed dams/lakes).

Secondary succession

This takes place when plants and animals settle in an area disrupted by human activities, such as ploughed fields or cleared forests, or by natural disasters, such as bush fires or floods.

It takes place much faster than primary succession, because the area where the pioneer species is settling already has soil, organic nutrients and seeds from previous growth.



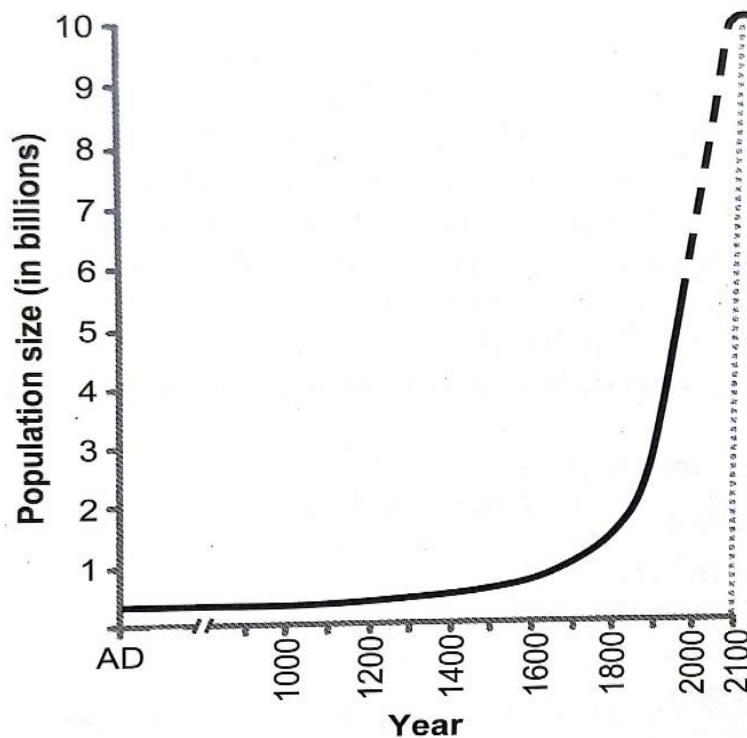
Ecological succession

HUMAN POPULATION

Population growth

For the greater part of human history up to and including the 18th century, the population growth was very slow, with the estimated world population at about 800 million. After 1750, the world population grew considerably. At present the world population stands at 7,08 billion.

World population growth and estimates



The J-shaped growth (exponential) is mostly due to a decrease in deaths and not an increase in fertility. Reasons for exponential growth:

- Improved methods for treating diseases.
- Development of vaccination against infectious diseases.
- The cultivation of new disease-resistant food crops, e.g. rice.
- The use of fertilisers.
- The use of more effective farming methods.

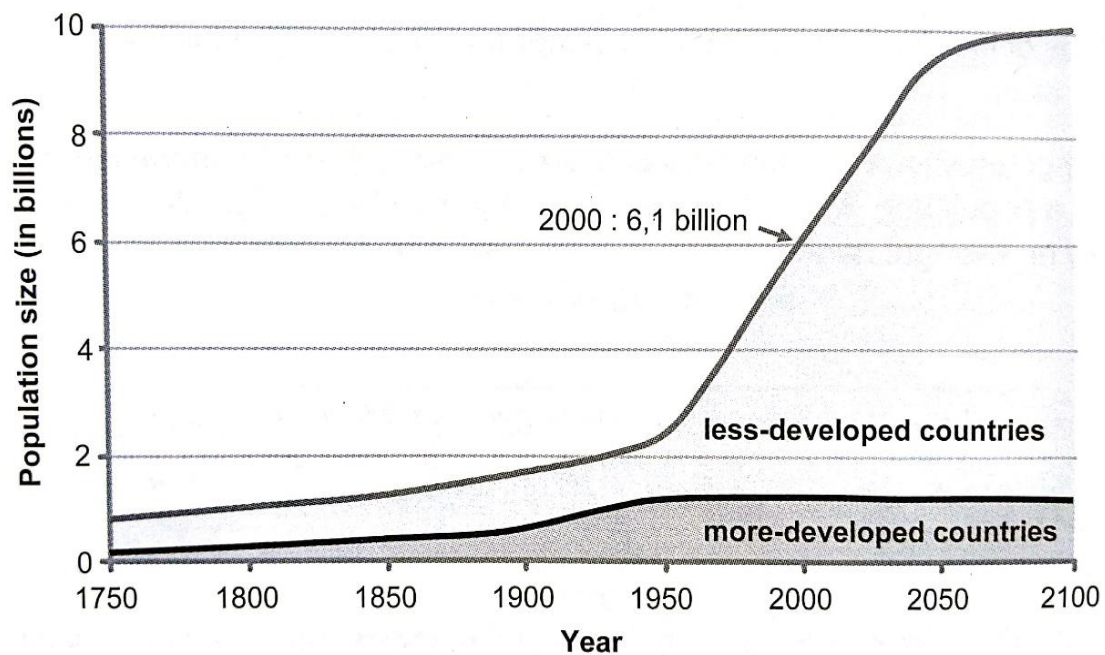
Fertility rate

Fertility rate is the number of births per 1000 female individuals of child-bearing age (15 – 44 years) per year.

Developed countries have a lower fertility rate than less-developed countries. This is because young people are better educated, get married later, use contraceptives or abstain from sex. Less-developed countries have a much higher population growth rate due to their fertility rate.

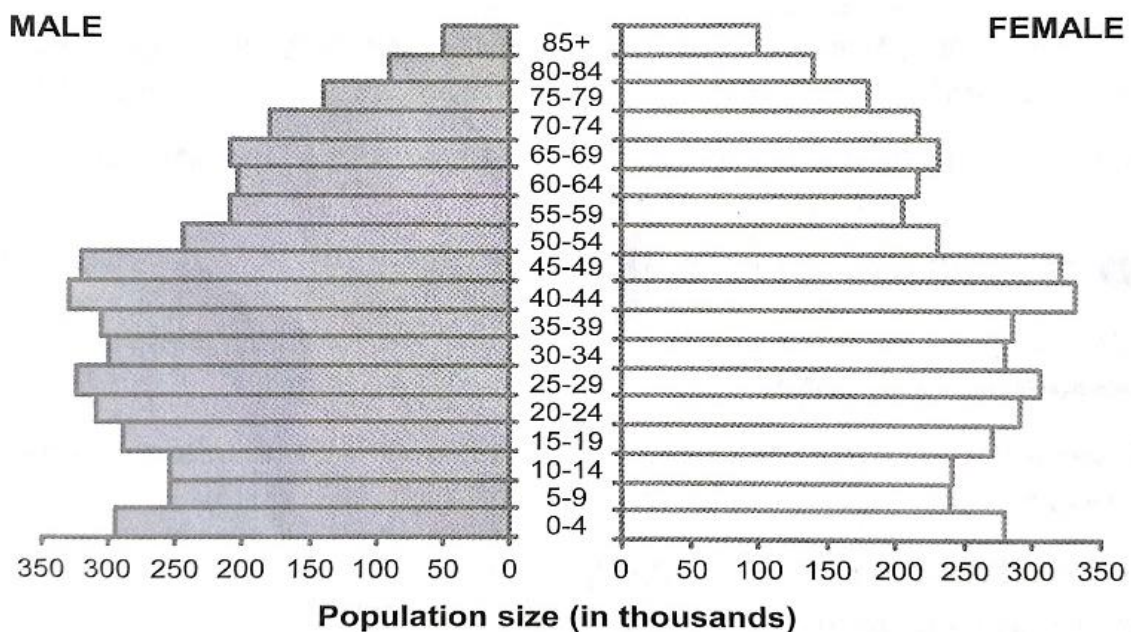
There is a direct correlation between population growth and the level of development. The lower the level of development, the higher the population growth and vice versa.

The world population will reach an estimated 9,1 billion in 2050. It is obvious that the most growth will take place in less-developed countries.



AGE AND GENDER DISTRIBUTION

The age and gender distribution of a population can be presented graphically using a population pyramid.



Age structure distribution refers to the number of individuals per age group in a specific population. Three age categories are distinguished:

- Pre-reproductive group
- Reproductive group
- Post-reproductive group

Gender distribution in a particular population refers to the proportion or ratio of male individuals to female individuals.

Classification of population pyramid

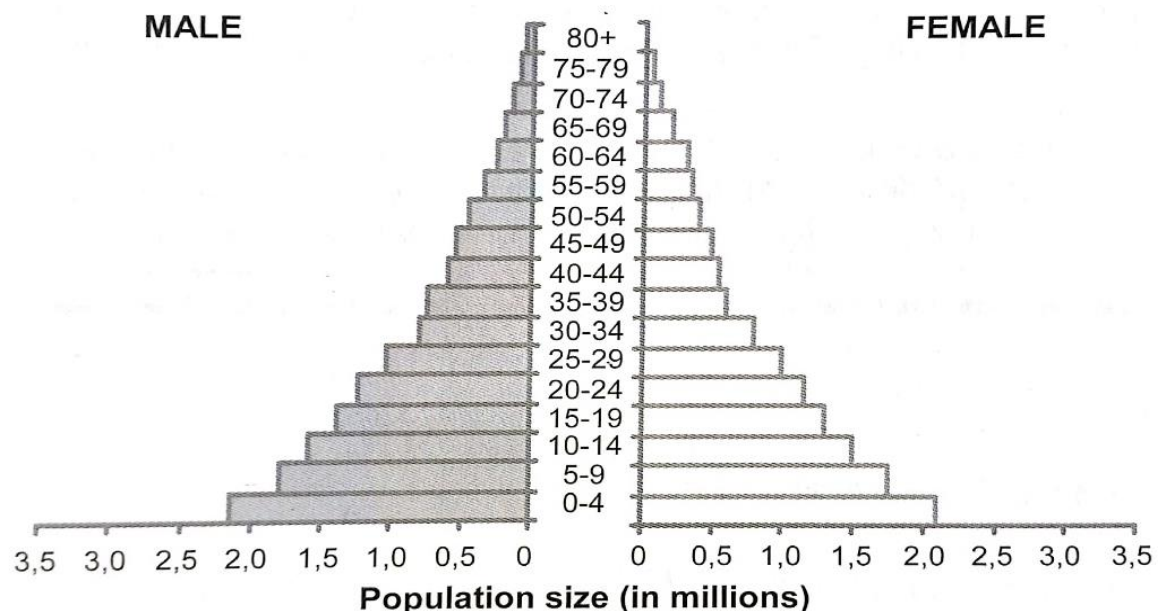
There are three types of population growth, each resulting in differently shaped pyramids.

- Rapid population growth
- Stable population growth
- Negative population growth

Rapid population growth: This pyramid shows a classic triangular shape with a wide base and narrow top. The wide base indicates high birth rate, and the narrow top a high death rate.

This type of graph is indicative of population with;

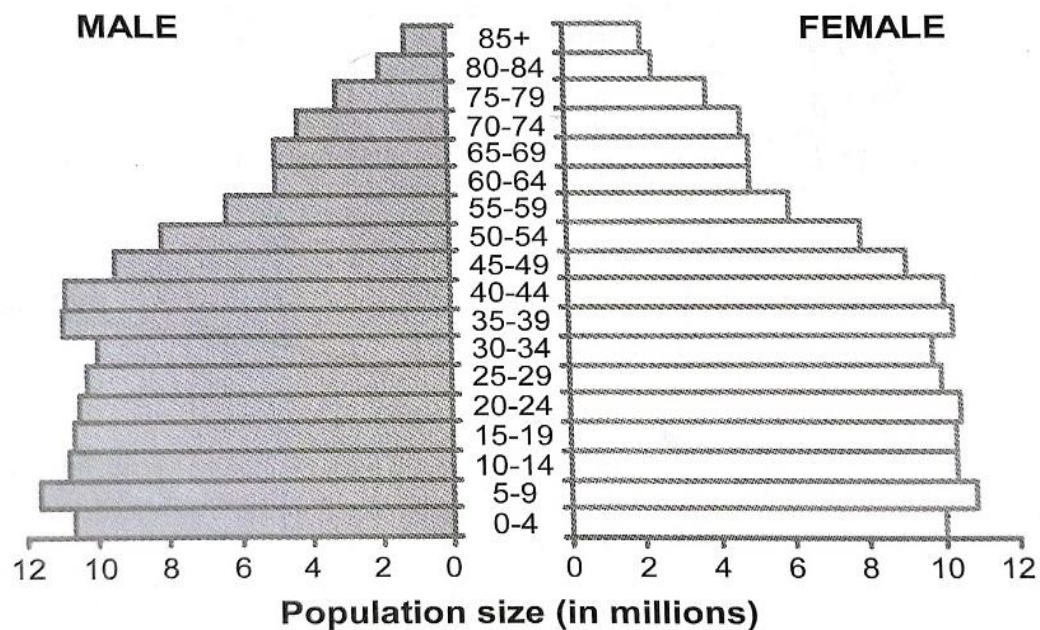
- a low standard of living, which usually occurs in less-developed countries.
- high natality (birth rate): as a result of unavailability of contraceptives and a low level of education.
- high mortality (death rate)/low life expectancy occurs due to poor medical care and nutrition.



Stable population growth: This pyramid is more square shape. The base of the pyramid is more or less the same width as the reproductive section of the population.

A high standard of living is characteristic of stable populations and usually occurs in more-developed countries:

- low birth rate: occurs as a result of good family planning, financial planning and a high level of education.
- low mortality (higher life expectancy): occurs as a result of good medical care, nutrition and education.

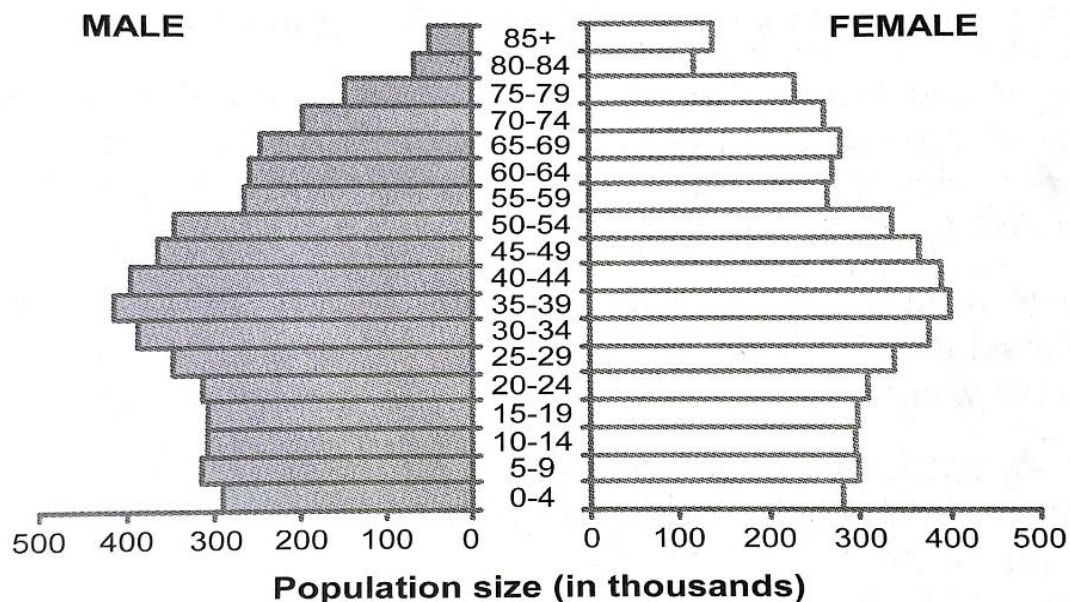


Negative population growth: The base of the pyramid is narrower than the reproductive section of the population.

This indicates;

- Low natality (birth rate)
- Stable mortality (death rate)
- Increasing emigration

This type of pyramid is characteristic of populations in well-developed countries.

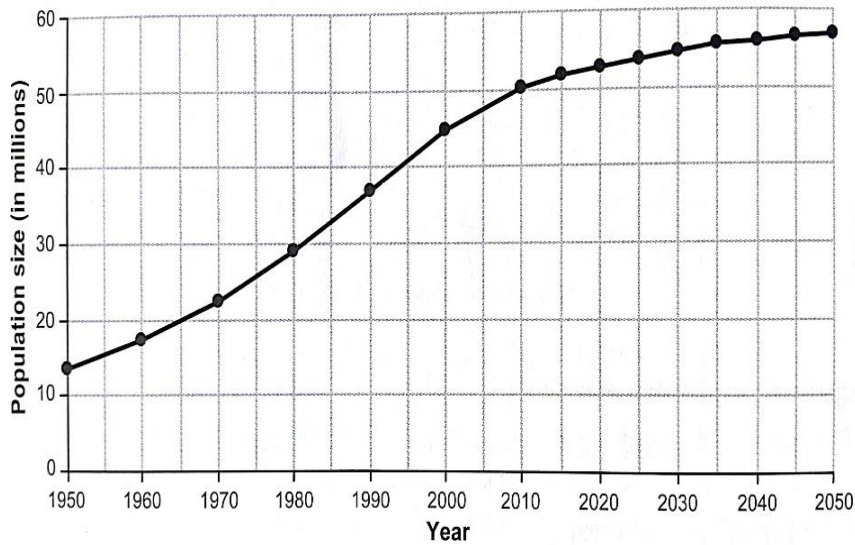


HUMAN POPULATION GROWTH IN SOUTH AFRICA

South Africa's population size was 51,7 million in October 2011. This indicates an increase of 15,5% in the population over the past 10 years since the previous census in 2001 when 44,8 million people were counted.

The table and graph below show the human population of South Africa from 1950 and estimated to 2050.

Year	Population size (in millions)
1950	13,70
1960	17,40
1970	22,50
1980	29,10
1990	36,80
2000	44,70
2010	50,10
2015	51,90
2020	52,70
2025	53,80
2030	54,70
2035	55,50
2040	56,00
2045	56,50
2050	56,80



It is evident that from the data that there is a decrease in growth rate after 2010. The decrease in the rate of population growth can mainly be attributed to large numbers of HIV-related deaths in South Africa.

South Africa is moving from a high rate of population growth (characteristic of less-developed countries), to a more stable rate of population growth (characteristic of more-developed countries).

This could possibly be ascribed to the gradual decrease in both the birth rate and the death rate. Improved education, higher standard of living and better health care also plays a role.

TOPIC 10: HUMAN IMPACT (PAPER 2 – 37 MARKS)

CONCEPTS AND TERMS

1. Atmosphere

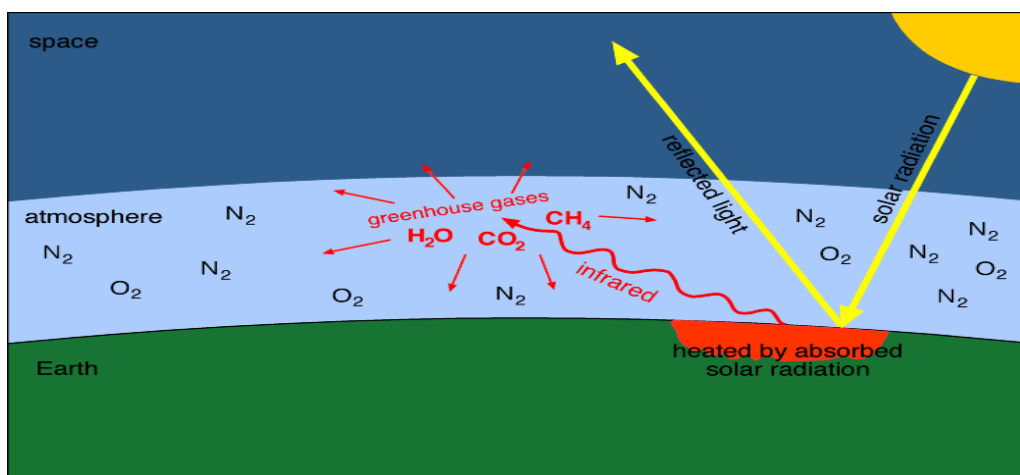
The Earth's atmosphere is a mixture of many different gases. Some gases, also known as greenhouse gases, in the atmosphere such as CO_2 , CH_4 (methane), N_2O (nitrous oxide) and water vapour can trap heat from the sun. These four gases play a vital role in the control of the Earth's temperature.

2. Climate

Climate refers to the average of daily weather over about 30 to 50 years. This includes fluctuations in, amongst other variables, daily temperature, rainfall, air pressure, etc.

3. Greenhouse effect – (Svante Arrhenius first used the term).

Gases in the atmosphere absorb, reflect and re-radiate energy in the climate system. Maintains a stable Earth's temperature for life forms to flourish.



4. Climate change

Refers to long-term changes in climate. Climate change usually also refer to significant and lasting changes in long-term weather patterns in a specific region or across the whole Earth.

To observe changes in climate requires several years of data observation, e.g. changes in rainfall, temperature, etc. over the last 30 years. Climate change describes changes in daily weather patterns over 30 to 50 years which, inter alia, includes the following variables, rainfall, daily temperature and air pressure.

5. Global warming

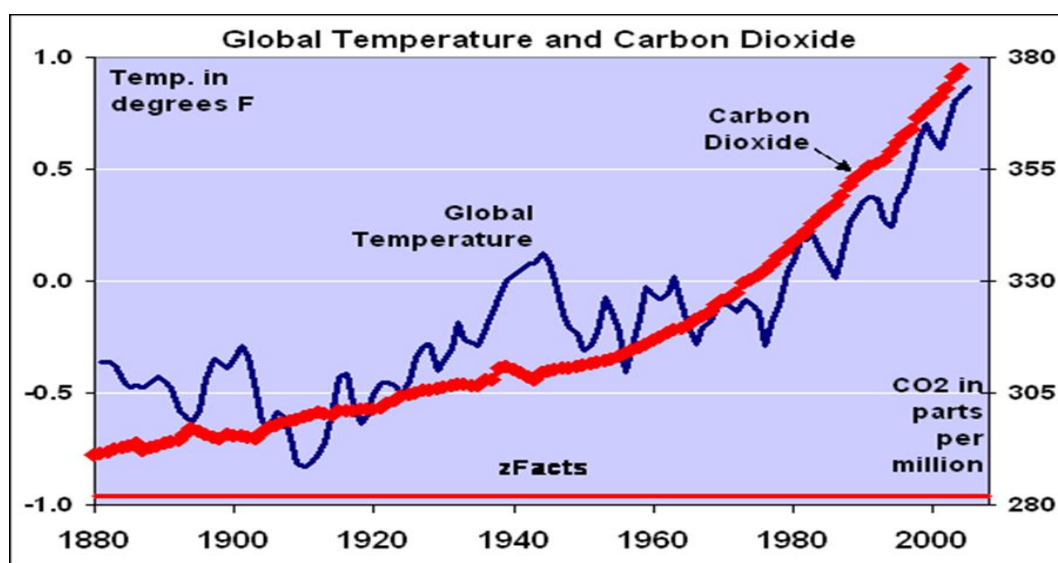
Global warming refers to a **rise in the Earth's temperature** and is just one aspect of climate change.

ATMOSPHERE AND CLIMATE CHANGE

Greenhouse gases in the atmosphere such as CO_2 , CH_4 (methane), N_2 , N_2O (nitrous oxide) and water vapour can trap heat from the sun in the same way as the walls of a greenhouse. The glass of the walls of the greenhouse allow sunlight to enter the greenhouse but prevent heat from going out again. The gases trap the energy of the sun and the greenhouse become warm as a result. Therefore, these gases are called **greenhouse gases**.



Release of Carbon Dioxide over time



- The increase of the release of CO_2 from 1880 to 2000 can clearly be observed in the graph above.
- The increase in the Earth's temperature can also be observed.

What cause the increased releasing of CO_2 ?

Since 1950 the level of release of carbon dioxide has started to rise sharply. The beginning of the Industrial Revolution has caused this increase. Major changes in mining, agriculture, transportation, manufacturing and technology occurred.

1. CO_2 is released by the burning fossil fuels (coal, petrol, paraffin and diesel) in:
 - Households (electricity, burning of wood and coal), and
 - vehicles and industries (power stations, fabrics, etc.)

2. The release of gases (CH₄ and CO₂) from landfills and sewage works
3. Farming activities (farming implements and machinery) also release CO₂

Consequences of the increased releasing of CO₂ in the atmosphere

The global temperature is increased very rapidly, due to the extreme higher release of CO₂ since 1950. CO₂ trap the energy from the sun and the Earth becomes warm as a result – Global Warming.

Global warming can lead to climate changes which have the following effects:

- More extreme weather events e.g. increase in floods and droughts
- Reduced agricultural yields
- Melting polar ice caps, increasing of sea levels
- Extinction of plants and animal species which cannot survive the rapid climate changes.

Carbon footprint

It is the amount carbon (in tons per year) released as CO₂ in the atmosphere by human activities. It is used to show how sustainable a lifestyle of a country is. Usually it is calculated for a year.

Each person, organisation, industry, region, country or continent have a carbon footprint.

Type	Profile / characteristics	footprint (ton / year)
Carbon destitute	No car, walk, cycles, house built of natural materials, no electricity, grow most food themselves, wood used for cooking and heating	0 – 0,2
Carbon saver	Small car doing ± 9 000 km, small house/ flat, uses electricity sparingly, solar water heater, recycles, eats mostly local unprocessed foods, uses consumer products and services with discretion	5 – 8
Carbon glutton	Large car doing ±25 000 km, large house and garden, no energy-saving devices, local and overseas return flights, eats large quantities of processed foods and beverages, latest electronic and technological gadgets, products and services	30

Question: How can the carbon footprint of our country be reduced?

Deforestation

Is when forests are cut down or burned. Forests (trees and forest plants) are necessary for the removal of large amounts of CO₂ from the atmosphere for photosynthesis.

Forests are called 'carbon sinks'. Forests also help to maintain an efficient carbon cycle.

Why does deforestation occur?

- Soil used for agriculture
- Harvesting firewood
- Trees used for building materials, furniture and ornaments
- Cutting down trees to prepare charcoal
- Increasing frequency of forest fires
- Planting commercial forests to produce paper.
- Urbanisation

Consequences of deforestation

- Indigenous forest ecosystems are destroyed – Loss of biodiversity.
- Deforestation accounts for nearly 20% of all global greenhouse gas emissions.

DESERTIFICATION

Process through which semi-arid or arid land is transformed into a desert. A drastic loss of vegetation cover occurs. Desertification occurs when human place too much pressure on fragile land and ecosystems in arid regions.

Human Activities that leads to Desertification

- Poor land management e.g. overgrazing, over-cultivation, poor irrigation
- Deforestation.

Consequences of Desertification

- Loss of vegetation cover
- Loss of biodiversity
- Reduced productivity
- Poverty in local communities

Methane gas emissions

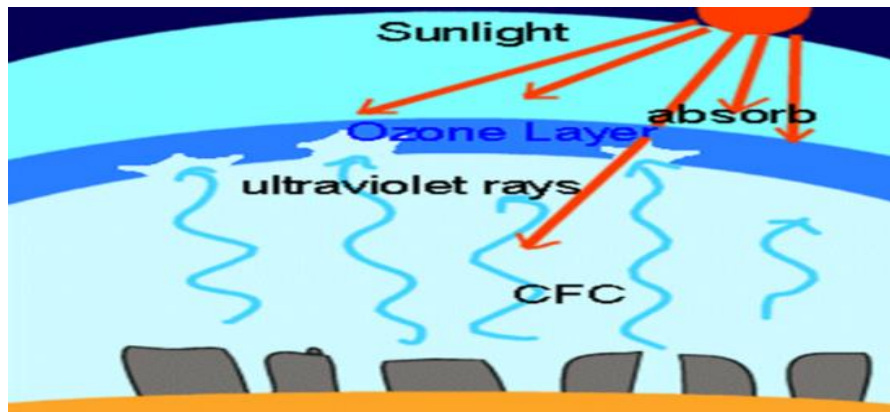
Methane is an odourless and colourless gas released by the fermentation of organic materials. Methane released from natural decomposition of organic matter in wetlands or moist forest floors is part of the natural carbon cycle.

However, released from rotting municipal landfills sites, large cattle ranches, waste dumps, mining, industrial processes; then it becomes greenhouse gases.

Ozone depletion

Ozone layer is necessary for all life because it absorbs harmful ultraviolet rays (UV-B) from the sunlight before they strike the Earth. Where the ozone layer thins out or disappears, these UV rays reach the Earth and damage plant and animal tissues.

Ozone layer is thinned or destroyed by ozone-destroying pollutants such as, chlorofluorocarbons (CFCs) and hydrofluorocarbons (HFCs).



Consequences of Ozone-depletion:

- UV rays can cause mutations in the DNA of plants, animals and micro-organisms.
- Humans may develop skin cancer, cataracts and weakened immune systems.
- Marine food chains can become disrupted because of organisms dying.
- UV-B rays disrupt the photosynthesis process which reduces the agriculture yield.

AVAILABILITY OF WATER

At the moment, SA requires 50% more fresh water than 50 years ago. Reasons:

- the rapid increase in our population
- the increase in agricultural irrigation systems
- decreasing annual rainfall in some regions
- the increase in industrial and social development
- cost of water

Water availability is influenced by the following factors:

- Construction of dams
- Destruction of wetlands
- Poor farming practice
- Droughts and floods
- Exotic/alien plantations and depletion of water table
- Boreholes and their impact on aquifers
- Wastage
- Cost of water

Construction of dams

Purpose:

- Water supply for domestic and industrial use
- Flood control
- Generation of hydroelectricity

Disadvantages:

- Loss of biodiversity
- Water loss through evaporation
- People and communities are uprooted

Destruction of wetlands

A wetland is a piece of land that is saturated by surface or groundwater. It is characterised by waterlogged soil, a high-water table and many aquatic plants. It includes springs, marshes, swamps, floodplains, pans, estuaries, riverbanks and wet grasslands.

Wetlands are usually covered by water for the greater part of the year. Wetlands play a key role in the ecosystem:

- Purify water by acting as filters for pollutants
- Store water and ensure a reliable water supply in times of drought
- Reduce water movement and thus control floods and soil erosion
- Replenish the water table
- Increase biodiversity as they provide a habitat for a large variety of plant and animal species, some of which are endangered.

Factors affecting the survival of wetlands

- Draining of wetlands for grazing and crops
- Overgrazing which results in soil erosion
- Incorrect placement of dams
- Pollution
- Mining
- Urban development

All these factors change the flow of water and the water quality, which ultimately results in the destruction of wetlands.

Poor farming practice

Inefficient irrigation methods – South Africa uses about 60% of the water for irrigation.

Wastage of water

- Leaking pipes and dripping taps
- Using washing machines and dishwashers for a few items only
- Showering instead of bathing
- Brushing teeth under a running tap
- Washing the car with a hose instead of a bucket
- Ineffective irrigation method

Cost of water

- Cost of dams
- Maintenance of pipes and pumps
- Power to transport the water
- Purification of water
- Administration staff

QUALITY OF WATER

Water quality is affected by the following:

- Domestic water pollutants
- Industrial waste into rivers and dams
- Agricultural waste such as excess fertilisers or pesticides
- Mining waste
- Human waste in rivers causes diseases

Agricultural waste such as excess fertilisers

This could lead to a condition known as **eutrophication**:

Eutrophication is the addition of high levels of nutrients especially nitrogen and phosphorus to water.

- Excess fertilisers are washed into rivers, lakes or dams
- This leads to algae bloom/aquatic plants on top grows faster than the ones below
- They prevent the plants below from getting direct sunlight (could not photosynthesise)
- These plants died and were decomposed aerobically (in the presence of oxygen) by bacteria.
- The level of oxygen in the water becomes depleted leading to the death of other organisms in the water
- This destroys the quality of water and leads to loss of biodiversity

Solution

Purification and recycling

Need for Purification and Recycling

- Many available freshwater sources are contaminated by pathogenic microorganisms
- Many people in remote, rural areas do not have access to safe, clean drinking water
- In some areas, there are water shortages

FOOD SECURITY

Refers to a country's ability to provide physical and economic access to sufficient, safe and nutritious food to its people.

Factors affecting food security:

- Human population growth
- Climate changes, droughts and floods
- Harmful farming practices
- Genetically modified organisms
- Production cost
- Wastage

Harmful/Poor Farming Practices

- Monoculture – practising only one type of crop for a number of consecutive years. This might increase the number of pests of that crop.
- Pest Control – pests can be controlled in three ways:

- a) Physical/Mechanical control, which has to do with manual removal of pests.
- b) Chemical control, which includes the use of pesticides.
- c) Biological control, which includes the use of the natural enemy of the pest to control it. Biological control is the best way of controlling pests as other methods could damage crops while dealing with pests.
- Loss of topsoil (erosion), which could result in **leaching**.
- Excessive use of fertilisers
- Invasive plants and the reduction of Agricultural land

Invasive plants and the reduction of agricultural land

Alien invasive plants use much more water than indigenous plants and have well-developed root systems that can absorb deeper groundwater and thereby deplete the water table.

Some alien invasive plants change the pH of the soil (often making it acidic), which makes it unsuitable for agricultural crops.

Strategies to control alien invasive plants include:

Mechanical control – use of labour to remove them e.g. handpicking, cutting and burning. It is time consuming.

Chemical control – use of herbicides to control plants. It is effective but expensive and can adversely affect surrounding plant or animal species. Herbicides also contribute to soil and water pollution.

Biological control – use of natural enemies of the plants (e.g. insects) to destroy them. It is cheaper and does not adversely affect the environment.

Genetically Modified Food

Genetic engineering can be used to increase food security. Farmers make use of selection to control the reproduction of their plants and animals in such a way that each new generation will have the most desirable traits (characteristics) of the parents.

Advantages of GM food

- They deliver greater crop yields which leads to increased food production. Crops often have high nutritional value, survive in areas where unmodified crops cannot grow, resistant to pests.
- GM animals are often more resilient, resistant to diseases and produce more meat, milk and eggs.
- GM crops are often more resistant to pests, drought and diseases.

Disadvantages of GM foods

- May have potentially adverse effects on human health
- GM seeds are expensive for farmers to buy and this leads to increases the cost of food production
- Ethical and religious reasons e.g. tampering with nature, food may contain the genes of prohibited or avoided foods.

Solutions to food insecurity

- slow population growth
- reduce poverty – job creation
- sustainable agricultural development
- Grow own food – vegetable garden/subsistence farming

LOSS OF BIODIVERSITY

The greatest threats to biodiversity:

- Habitat destruction
- Poaching and hunting of wildlife
- Invasion of alien plant and animal species
- Overexploitation of resources
- Pollution leading to climate change
- Excessive use of fertilisers
- Trade in endangered species

Habitat Destruction

It can be caused by

- Poor farming practice
- Golf estates
- Mining
- Urbanisation
- Deforestation
- Destruction of wetlands and grasslands

Poaching

- Illegal hunting/trapping of animals and illegal removal of plants
- Illegal trade in plants and animals as well as their products e.g. rhino (horns), elephants (tusks), wild animals (meat), tortoises, cycads - living fossil seed plants, shellfish etc.

SOLID WASTE DISPOSAL

Waste is classified into two main categories:

- General waste – household waste, waste from construction site, waste from businesses.
- Hazardous waste – contains harmful, toxic and/or explosive substances e.g. nuclear waste, wastes from factories, mines and hospitals.

Control of Solid Waste Disposal

- Management and Rehabilitation of dump sites
- Recycling
- Nuclear wastes (hazardous) should be put in a sealed container before being buried.