South Sudan

Secondary Biology 3

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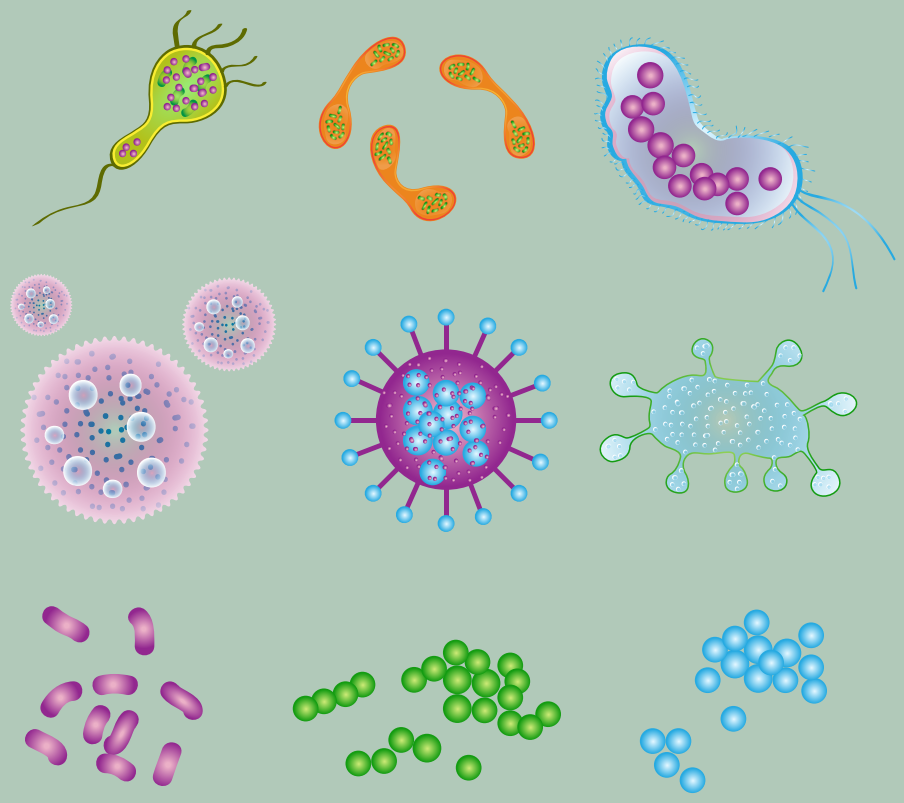

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South Sudan

SECONDARY
3

Biology

Secondary 3

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Contents

Unit 1 Classification of living things

Learning outcomes		
Knowledge and understanding	**Skills**	**Attitudes**
• Understand the systems of classifying organisms.	• Classify organisms according to the seven level system. • Use different equipment and laboratory techniques for collecting and preserving specimen for identification. • Investigate the features of each group (for example, phylum and class among others) through field study using equipment such as sweep nets, specimen bottles or containers, forceps, hand lens, trays and microscopes.	• Appreciate and value knowledge of classification of living organisms.

Introduction to classification

Name as many living things that you know and you have interacted with. Where do they live? Briefly state the observable features of the named organisms.

Did you know?

There are over five million different kinds of living organisms on earth today. But only about two million of them have been identified and named by scientists to date. Not all organisms have been discovered.

1.1 Definition of classification

Research Activity

Individually:

Find out the meaning of the word classification from textbooks or the Internet. Write a report and share with your class members.

Classification is the process of placing and organising organisms into groups according to their similarities and differences in structure and the ancestral origin showing their biological relationship. In Secondary One, you learnt about the necessity of classification of organisms in the five major Kingdoms, Phyla and Divisions. Below are examples of different types of living things.

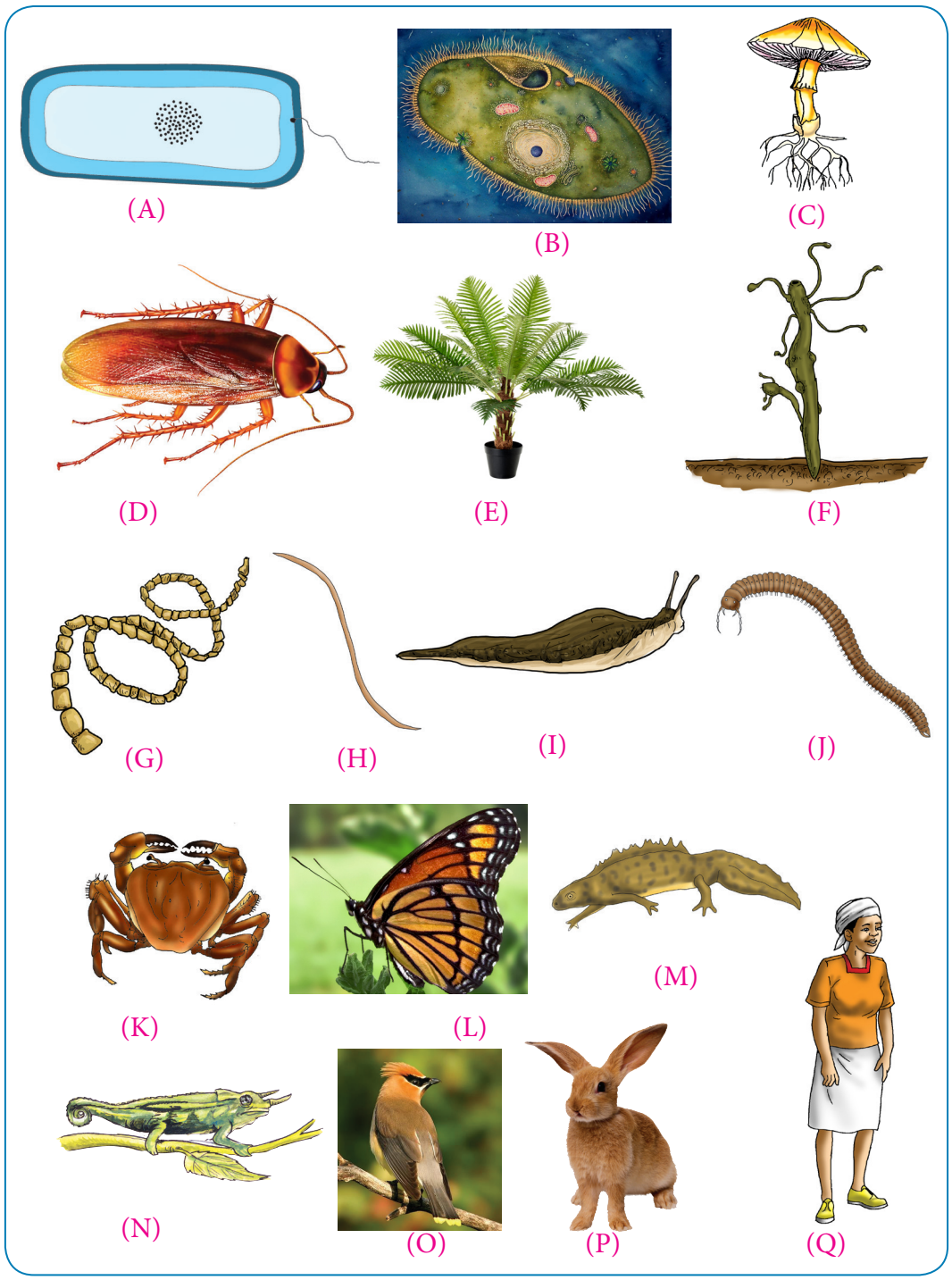


Fig. 1.1: Different types of living things.

Activity 1.1: Collection and observation of plant specimens

In groups:

Requirements

Containers or specimen bottles, tongs, forceps and hand lens among others.

Procedure

1. Using the apparatus or equipment above, collect different leaves and flower specimens. **Note:** Take care to minimise damage to the plants.
2. Take each specimen at a time and observe it carefully using the hand lens. Identify it using the local name and the scientific name.
3. Draw and work out the magnification of each.
4. Record the main observable features in each specimen.

Activity 1.2: Collection and observation of animal specimens

In groups:

Requirements

Containers or specimen bottles, tongs, forceps, hand lens, microscope, sweep nets, pitfall trap and pooter among others.

Procedure

1. Using appropriate apparatus or equipment above, collect different types of animal specimens taking care not to harm the specimens.
2. Place each specimen into an appropriate container and close it.
3. Take each specimen at a time and observe it carefully using the hand lens.
4. Record the main observable features in each specimen.
5. Identify each animal using the local name, English name and the scientific name. For the organisms whose scientific names you do not know, get help from the following sources.
   (a) The Biology teacher.
   (b) Taxonomy textbooks.
   (c) The National Museum.
   (d) Arboretum.
   (e) Various research institutions such as The Sudd Institute and International Institute of Tropical Agriculture (IITA).
6. Draw and work out the magnification of each.

Remember!

The environment in which the organisms are, should always be protected and taken care of to keep it as natural as possible.

Work to do

1. State precautions which should be taken during collection of specimens.

2. Distinguish between classification and taxonomy?
3. Group the following organisms into plants and animals: Donkey, pawpaw, cat, rat, grass, housefly, sugarcane, mango, cow, orange, bird and dog.

Check your progress 1a

1. State the functions of the following apparatus: Pooter, pitfall trap, sweep net, bait trap, fishnet, forceps and hand lens.
2. Name the taxonomic units used for classification.

1.2 Necessity of classification

From Activities 1.1 and 1.2 you can clearly see that it can be difficult to group different organisms which exhibit common features while others have different features. This is equivalent to mixing rice, white beans, sorghum and millet. Then you are told to separate them out. Hence the necessity of classification.

- To help in the identification of living organisms into their correct groups for easier reference.
- To help us arrange the information about living organisms in an orderly manner to avoid chaos and confusion which would arise if done arbitrarily.
- To help us understand the evolutionary relationship (phylogeny) between different organisms.
- To enable us to separate living organisms with different features and group those with similar characteristics.

The facts

There are two types of classification:

- Natural classification
- Artificial classification

Natural classification is grouping of organisms based on natural relationships between organisms inclusive of internal, external features, biochemistry and physiology. In the natural system, all living things were traditionally placed under two major groups called **Plantae** and **Animalia kingdoms** (refer to Activities 1.1 and 1.2).

Artificial classification or modern classification is based on one or a few easily observable features and is usually designed for a practical purpose with an emphasis on simplicity and convenience.

It does not take into account the important natural relationships. An example of artificial classification is grouping different types of fish regardless of their natural environment.

Work to do

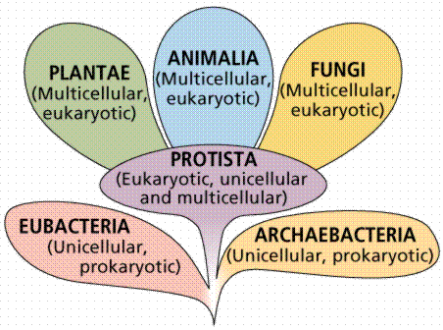
Based on the descriptions above, create Table 1.1 to show differences between natural and artificial classification.

Table 1.1: Differences between natural and artificial classification.

Natural classification	Artificial classification

Note: Phylogenetic classification is the one based on the evolutionary relationships hence the family tree.

2. Watch the video link https://www.youtube.com/watch?v=oxhYaiSnlAo
3. Study the evolutionary tree below.



1.3 Taxonomy

The science of classification is called **taxonomy**. It has **two** branches, namely: nomenclature and systematics.

- **Nomenclature** is the naming of organisms.
- **Systematics** is placing of organisms into groups which are referred to as taxa (plural) or taxon (singular) on the basis of their similarities and differences.

Did you know?

Biologists who study taxonomy are called **taxonomists.**

In 1707 – 1778 a Swedish naturalist named Carolus Linnaeus pioneered the classification technology for taxonomy which is called numerical taxonomy in which he devised a way of recording data.

1.4 Hierarchical taxonomical units of classification

Activity 1.3: Naming organisms

In groups

1. Using Practical Activities 1.1 and 1.2, name the organisms in your native language.
2. Do all members of the discussion group or the class understand the names you have given?
3. What is the impact of the observation in question 2 above?

The facts

It is difficult to identify living things using their local names. This is because of the existence of several local languages. To assist scientists from different parts of the world to communicate, one scientific name is given. This ensures:

- No confusion when studying the organisms.
- No change of name. Scientific names rarely change.
- Use of a common language around the world.

My heritage my pride!

Our language reflects who we are as a people. It is our nation's identity. Always be proud of your language.

Activity 1.4: Grouping different lengths of plant stem

In groups:

Requirements

Rulers, forceps and plant stems.

Procedure

1. Using the apparatus provided above, measure the lengths of plant stems labelled a, b, c, d, e, f, g and h.
   - (a)
   - (b)
   - (c)
   - (d)
   - (e)
   - (f)
   - (g)
   - (h)
2. Record the lengths from the longest to the shortest.

Study question

Compare the order of lengths of the stems with hierarchy of classification.

The facts

Organised order enables easier study of specimens or organisms during classification. The study of grouping of organisms depending on their similarities is called taxonomy. Different levels of classification form taxonomic units. These refer to the groups called taxa (plural) or taxon (singular).

Group Activity 1

1. Look at Figure 1.2 below.
2. In groups, discuss and work out the reason the figure is presented as an upside down pyramid.

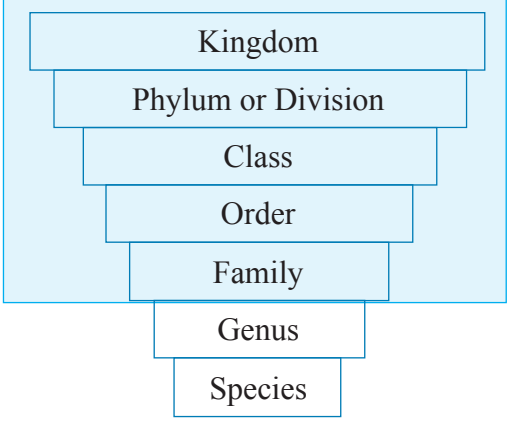


Fig. 1.2: Taxonomic hierarchy used in classification.

Activity 1.5 Grouping organisms

In groups, use pictures of the specimens in **Practical Activity 1.1** and **Practical Activity 1.2** to group the various organisms into various taxa using the observable features of the specimens.

The facts

Kingdom

It is the largest group of the taxonomical units with the highest number of organisms based on similar characteristics.

In this hierarchy, the similarities increase while the differences decrease from the highest rank to the lowest rank. Members of the same kingdom have fewer characteristics in common than those in the lower level.

Basically, there are five kingdoms namely; **Monera, Protoctista, Fungi, Plantae** and **Animalia**. The kingdoms are divided into Phyla (singular: phylum) For animals or Divisions for plants. The Phylum or Division is divided into Classes which are further divided into Order, then Family, Genus or Genera (plural) and then Species.

Species

Species is the smallest unit with the most specific organisms in the group. Members of the same species have the same number of chromosomes and interbreed naturally or freely to give rise to viable or fertile offspring. However, organisms from different species can reproduce but the offspring is infertile or sterile. For example, a donkey and a horse reproduce a mule or a hinny which is sterile.

Remember!

Do not destroy the natural habitat of the specimens. Our environment is a source of knowledge.

1.5 History of classification

Classification of living things and naming

In science, the practice of classifying organisms is called **taxonomy** (*taxis* means arrangement and *nomos* means method). The modern taxonomic system that was developed by Linnaeus used simple physical characteristics of organisms to identify and differentiate between different species, and is based around genetics.

Linnaeus developed a hierarchy of groups for taxonomy. To distinguish different levels of similarity, each classifying group, called **taxon** is subdivided into other groups.

Remember!

To remember the order, it is helpful to use a **mnemonic device**. Such as, Dear King Philip Came Over for Good Soup or Do Kids Prefer Cake Over Fried Green Spinach?

The taxa in hierarchical order are:

- Domain – Archea, Eubacteria, Eukaryote
- Kingdom – Plantae, Animalia, Fungi, Protists, Eubacteria (Monera) and Archaebacteria
- Phylum
- Class
- Order
- Family
- Genus
- Species – smallest classification unit.

Three-domain system is a biological classification introduced by Carl Woese et al., 1977 that divided cellular life forms into **archaea, bacteria** and **eukaryote domains**. In particular, it emphasises the separation of prokaryotes into two groups, originally called Eubacteria (now Bacteria) and Archaebacteria (now Archaea). Woese argued that, on the

basis of differences in **RNA genes**, these two groups and the eukaryotes each arose separately from an ancestor with poorly developed **genetic** machinery. To reflect these primary lines of descent, he treated each as a domain, divided into several different kingdoms. Woese initially used the term "kingdom" to refer to the three primary phylogenic groupings, and this nomenclature was widely used until the term "domain" was adopted in 1990.

Parts of the three-domain theory have been challenged by scientists such as Radhey Gupta, who argues that the primary division within prokaryotes should be between those surrounded by a single membrane, and those with two membranes. The domain is the broadest category, while species is the most specific category available.

The taxon domain was only introduced in 1990 by Carl Woese as scientists reorganised living things based on new discoveries.

Two kingdoms classification

In his *Systema Naturae*, first published in 1735, Carolus Linnaeus distinguished two kingdoms of living things: Animalia for animals and Plantae (Vegetabilia) for plants. He classified all living organisms into two kingdoms – on the basis of nutrition and locomotion (mobility). Linnaeus placed unicellular (protozoans) and multicellular (metazoans) animals under animal kingdom because of their compact body, holozoic nutrition (ingestion of food) and locomotion. All other organisms were grouped under plant kingdom because of their immobility, spread out appearance and autotrophic mode of nutrition. Thus, the traditional plant kingdom comprised bacteria, algae, plants and fungi.

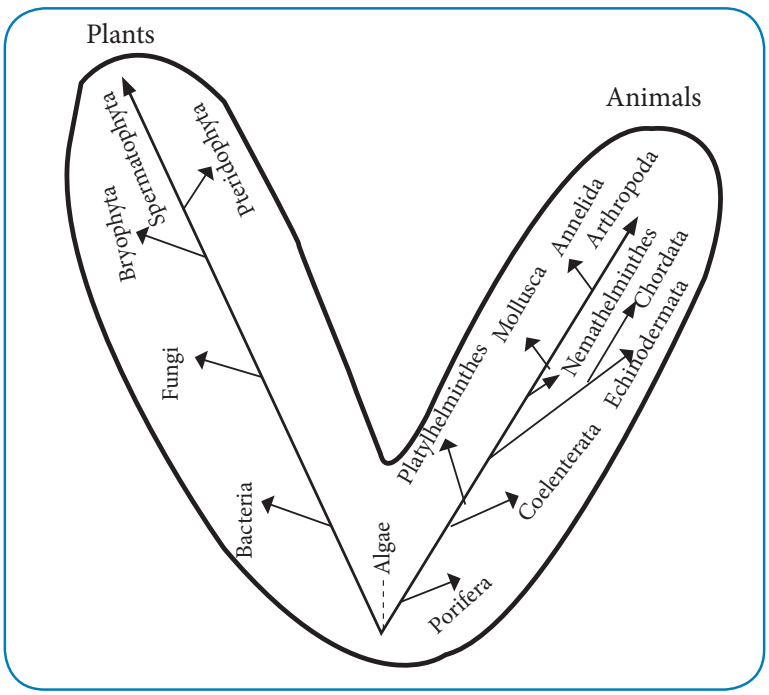


Fig. 1.3: Two kingdoms classification.

Linnaeus developed the present system of naming organisms using two names in Latin language. This is because the Latin language was used widely by the scientists during the time and it did not change over time.

Fig 1.4: Carolus Linnaeus

R. H. Whittaker proposed the Five Kingdom classification in 1969. The most common system of classification in use today is the Five Kingdom classification. In this system, all living organisms are divided into five kingdoms as shown in Figure 1.5 below.

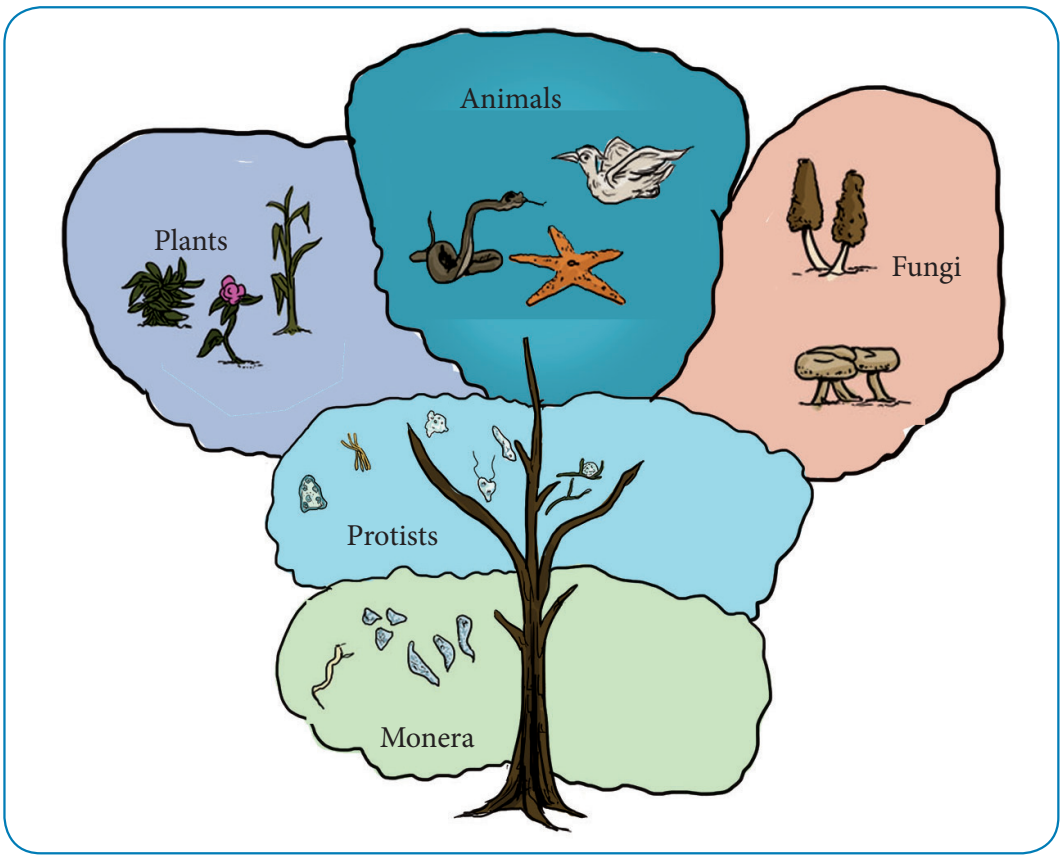


Fig. 1.5: Five Kingdom classification.

Basically, organisms have their common names and scientific names.

Group Activity 2

In groups of three, role play Linnaeus, Woese and Whittaker by explaining their systems.

Table 1.2: Differences between common names and scientific names.

Common name	Scientific name
The local names used and known by the local people.	It is known and internationally accepted all over the world.
It is written in vernacular language.	It is written in Latin language.
Does not bear generic name and specific name.	Bears the generic name and specific name.

The facts

In scientific naming, an organism is given two names which adopt the double naming system. This system of naming is called **binomial system**. The organism bears the generic name and specific name. For example, *Zea mays* is the scientific name for maize, where *Zea* denotes the generic name and *mays* denotes the specific name.

The assigning of scientific names to living organisms is governed by a definite set of internationally recognised and accepted rules referred to as **binomial nomenclature**.

Principles of binomial nomenclature

- The first part of the scientific name is the generic name and it begins with a capital letter whereas the second part of the name is the specific name. The specific name is written in small letters.
- The generic name refers to the Genus while the specific name refers to the Species.
- The scientific name should be printed in italics. For example, *Pisum sativum* for garden pea (English) and when hand written or typed it should be underlined as separate words. For example, Pisum sativum.
- All the scientific names should be Latinised (written in Latin). For example, *Aloe kilifiensis.*
- The scientific name should bear the name of the first scientist who adequately described and named the organism. For example, *Balanus balanoides Linnaeus.*

Examples of naming of organisms, with scientific names, are shown in Table 1.3 below.

Table 1.3 Classification of some organisms

Taxon	Garden pea	Maize	Napier grass	Domestic dog	Lion	Leopard
Kingdom	Plantae	Plantae	Plantae	Animalia	Animalia	Animalia
Phylum or Division	Angiospermae	Angiospermae	Angiospermae	Chordata	Chordata	Chordata
Class	Dicotyledonae	Monocotyledonae	Monocotyledonae	Mammalia	Mammalia	Mammalia
Order	Rosales	Poales	Poales	Carnivora	Carnivora	Carnivora

Family	Leguminosae	Poaceae	Poaceae	Canidae	Felidae	Felidae
Genus	Pisum	Zea	Pennisetum	Canis	Panthera	Panthera
Species	sativum	mays	purpureum	familiaris	leo	pardus
Scientific name	*Pisum sativum*	*Zea mays*	*Pennisetum purpureum*	*Canis familiaris*	*Panthera leo*	*Panthera pardus*

From the table 1.3 above the garden pea and maize are of different Genus and different Species while lion and leopard are of the same Genus because of common features but they are of different Species.

Check your progress 1b

1. Study the table below and answer the questions that follow:
   (a) Fill in the blank spaces in the table.

Taxon	Human being	Maize	Napier grass	Domestic dog	Domestic cat	Leopard
Kingdom		Plantae	Plantae	Animalia	Animalia	Animalia
Phylum or Division		Angiospermae	Angiospermae	Chordata	Chordata	Chordata
Class		Monocotyledonae	Monocotyledonae		Mammalia	Mammalia
Order				Carnivora	Felidae	Carnivora
Family				Canidae	Canidae	Canidae
Genus			Pennisetum		Felis	
Species			purpureum		domestica	
Scientific name		*Zea mays*	*Pennisetum purpureum*	*Canis familiaris*		*Panthera pardus*

   (b) Are the domestic cat and domestic dog closely related? Give your reason.
   (c) Explain why the leopard and lion cannot procreate.
2. A learner wrote a scientific name as CANIS LUPUS. State the mistakes he or she made.
3. Define binomial nomenclature.
4. Define the term species.

Group Activity 3

As a class, debate:

a) why Linnaeus is held in high esteem today, and
b) why the five kingdom binomial system is favoured today.

1.6 The five Kingdoms

The facts

In the modern classification, as earlier stated, there are five major kingdoms:

- Monera
- Protoctista
- Fungi

- Plantae
- Animalia

These kingdoms are arranged from simplest form to the complex forms.

Kingdom Monera

This kingdom consists mainly of the bacteria such as *Azotobacter, cocci, vibro cholerae, Salmonella typhi, Bacillus anthracis, Treponema, Nostoc, Cyanobacteria* or blue green, among others. These are the simplest forms of organisms. The study of bacteria is referred to as bacteriology which is a branch of microbiology.

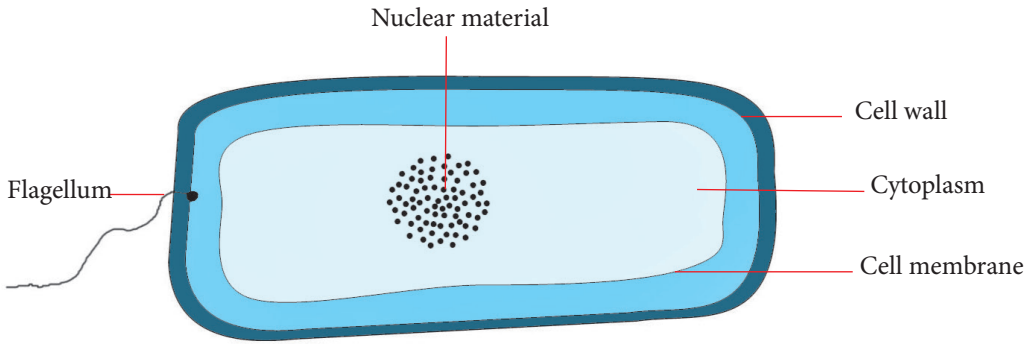


Fig. 1.6: Generalised diagram of a bacterium.

Did you know?

Small self replicating circle of extra DNA with fewer genes (plasmids) in the cytoplasm of a bacterium gives extra survival advantage such as resistance to antibiotics and enable some to break down complex chemicals such as food and sewage containing hydrocarbons.

The facts

General characteristics

- They have different body forms. Some are microscopic, some unicellular (single-celled organisms) and some live in colonies or singly.
- They are prokaryotic (their cell organelles are not bound by a nuclear membrane).
- They have slimy mucin cell wall, fewer organelles and no mitochondria.
- They move by use of flagella (plural) or flagellum (singular).
- Most have single circular DNA molecule while some species contain one or more plasmids.
- Most are heterotrophic or saprophytic or parasitic. A few are autotrophic.
- Most reproduce by asexual reproduction or binary fission while others by sexual reproduction or conjugation.
- Most of them respire anaerobically though few respire aerobically.

Distinguishing characteristics

- They are prokaryotic (the cell organelles are not nuclear membrane bound).

- The cell wall is made of slimy mucin.
- They have fewer organelles and lack mitochondria.

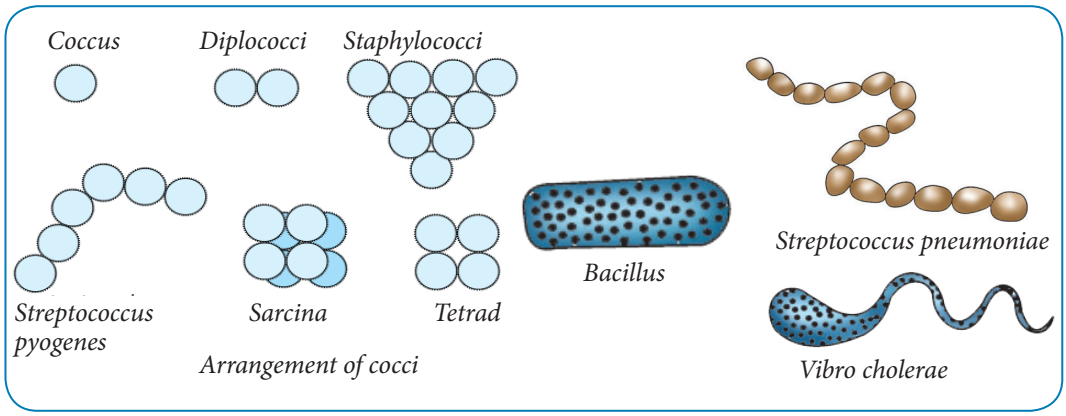


Fig. 1.7: Examples of bacteria.

Work to do

1. Find out from the books in the library which bacteria cause both food poisoning and mastitis in camels.
2. Find out the economic importance of bacteria to man.

Kingdom Protoctista

The members of Kingdom Protoctista are: amoeba, paramecium, euglena, Plasmodium, chlamydomonas, spirogyra and trypanosome.

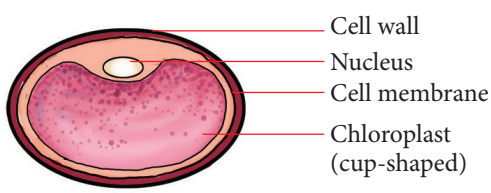


Fig. 1.8: Chloroplast of chlamydomonas

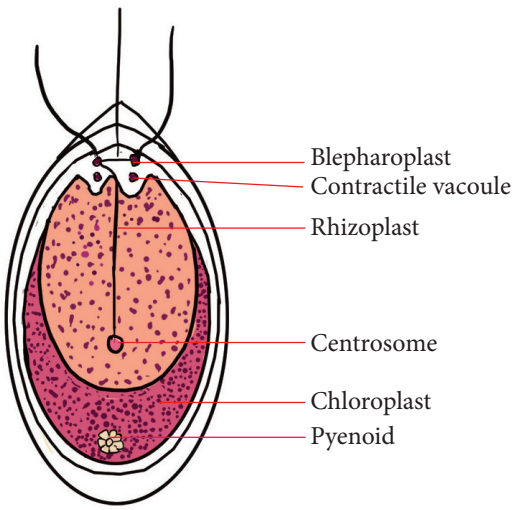
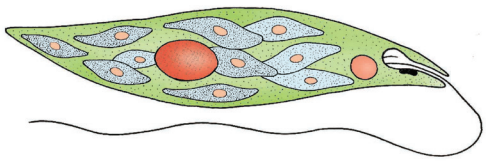


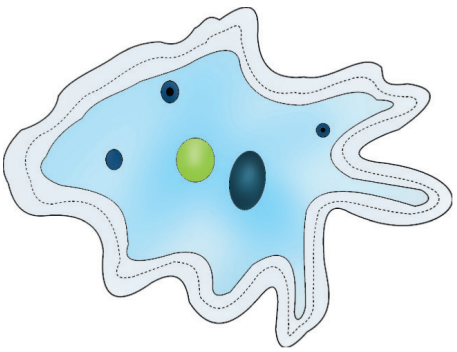
Fig. 1.9: Chlamydomonas structure

Paramecium

Trypanosome



Euglena



Amoeba

Fig. 1.10: Examples of members of Kingdom Protoctista.

Practical Activity 1.5: Observing organisms from pond water using microscope

Requirements

Microscope, coverslip, cover slide a dropper, pond water culture and mounting needle.

Procedure

1. Using the dropper, place pond water onto a glass slide.
2. Gently lower the coverslip on the drop of pond water.
3. Examine the setup under low and medium power objective lens of the microscope.

4. Draw and label organisms observed.

The facts

General characteristics of protoctista

- These organisms are unicellular, microscopic or colonial, or form multicellular thalloid. For example, the spirogyra.

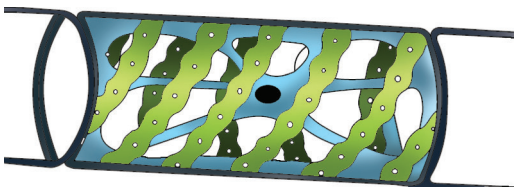


Fig. 1.11: Spirogyra

- They are eukaryotic (the organelles are nuclear membrane bound).
- They have many organelles including mitochondria.
- They exhibit asexual reproduction (binary fission, fragmentation and sporulation) though some show sexual reproduction by conjugation.
- Some are motile; they use flagella or cilia or pseudopodia while others are sessile. Amoeba move by pseudopodia, paramecium moves by cilia and chlamydomonas moves by flagella.
- Some are autotrophic while others are heterotrophic.
- Some have specialised structures that perform specific functions. For example, contractile vacuoles for osmoregulation.

Did you know?

Protoctista are colourless. They take the colour of the materials inside them, including the food they have just eaten.

Kingdom Fungi

The members of this kingdom include: mushroom, toadstool, yeast and mould.

Practical Activity 1.6: Examination of bread mould (*Rhizopus*)

Requirements

Bread with mould, hand lens, mounting needles, glass slides, coverslip and microscope.

Procedure

1. Using the mounting needle, isolate a little portion of the mould and place it on the glass slide.
2. Using a hand lens, observe the structure of the mould.
3. Draw a well labelled diagram of at least two complete observable structures of the mould.
4. Repeat the procedure in step 1 and mount another little portion of the mould on the microscope.
5. Observe the structures under low power objective lens, medium power objective lens and then high power objective lens.
6. Draw a well labelled diagram of at least two complete structures of moulds under medium power objective lens.

The structure is likely to appear as the one below.

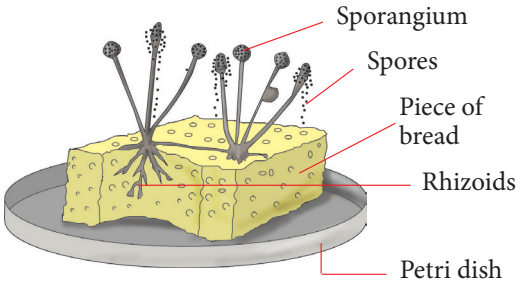


Fig. 1.12: Image of bread mould.

Practical Activity 1.7: Examination of yeast cells

Requirements

Yeast culture, dropper, glass slides, coverslip, microscope and Bromothymol blue.

Procedure

1. Using the dropper, suck a little of the yeast culture, place it on the glass slide and stain using Bromothymol blue. Slowly lower the cover slip.
2. Mount the prepared cover slide on the microscope, observe the structure of yeast.
3. Draw a well labelled diagram of at least two complete observable structures of yeast cells under low power objective lens, medium power objective lens and then high power objective lens.
4. Draw a well labelled diagram of at least two adjacent cells under medium power objective lens.

The structure of a yeast cell is likely to appear as the one below.

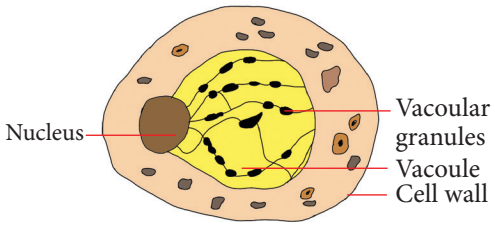


Fig. 1.13: Image of a yeast cell.

Work to do

Add some live yoghurt culture to milk. Write a report on your observation.

Practical Activity 1.8: Observation of mushrooms

Procedure

1. Visit a forested area near your school. Observe various fungi on the barks of trees and dead logs. Collect large sized fungi such as mushrooms.

   Precaution: Some species are poisonous. Wash your hands thoroughly after handling them.
2. Note the structures of attachment and structures used in spore production.
3. Draw a well labelled diagram of a mushroom.

The structure is likely to appear as the one below.

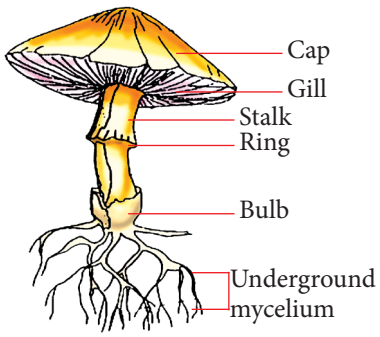


Fig. 1.14: Image of a mushroom.

The facts

General characteristics of fungi

- They are eukaryotic.
- Some are unicellular like yeast while others are multicellular like mushrooms and toadstools.
- They store glycogen or oil droplets.
- The cell wall of fungi is made up of chitin although a few have cellulose cell walls.
- Their basic unit is the hypha which has a cell wall enclosing the cytoplasm with numerous nuclei. Several hyphae filaments form a structure called mycelium.
- Some are saprophytes, some are parasites and others are symbiotic. The hyphae used for feeding in saprophytic fungi are called **rhizoids** while in parasitic fungi are called **haustoria**.
- Some reproduce asexually through sporulation and budding while others reproduce sexually by conjugation.

Work to do

Find out the following from the Internet or reference books.

a) Health benefits of mushrooms.

b) History of antibiotics and members of the Kingdom Fungi.

c) Major fungal infections frequently diagnosed in hospitals.

Kingdom Plantae

The Kingdom Plantae comprises of all green plants.

Did you know?

Scientists have come up with a new way of energy conservation which involves using plants as a source of light. This is done by inserting bioluminescence from insect gene in plants to grow.

General characteristics of plants

- Plants are eukaryotic and multicellular.
- Most of them are differentiated into stems, leaves and roots.
- They have cellulose cell wall.
- They have chlorophyll necessary for photosynthesis.
- Most have vascular bundles: they have phloem for translocation of manufactured food from the leaves to other parts of the plant while xylem transports water and mineral salts to the leaves and other part of the plant.
- They show alteration of generations.

- Exhibit both sexual and asexual reproduction.
- They have localised movement resulting from tropisms and taxes.

Main characteristics of major Divisions of Kingdom Plantae

Plants are grouped into three major Divisions. These are:

- Bryophyta
- Pteridophyta
- Spermatophyte

The criteria used to group the plants into three Divisions are based mainly on;

- presence or absence of vascular bundles
- production of seeds or spores for reproduction.

Division Bryophyta

Bryophytes include liverworts, hornworts and mosses.

Practical Activity 1.9: Investigation of features of Bryophytes

Requirements

Hand lens, scalpels, mature moss plants, liverworts and a tray or white paper.

Procedure

1. Go to the field or for a nature walk in a forest near your school.
2. Collect a few mature moss plants and liverworts.
3. Place the moss on the white paper or tray.
4. Using a hand lens and a mounting needle, isolate one mature moss plant carefully and examine it.
5. Note the size of the leaves, stem and root-like structures, the cluster of leaves and the colour of the plant.
6. Draw a well labelled diagram of the specimen.
7. Repeat steps 1–4 with the liverwort plant.

Work to do

1. Describe the size and the colour of the moss and liverwort.
2. State the observable features used to classify the specimens under Bryophyta.

The facts

General characteristics of bryophytes

- These are the simplest forms of plants with no vascular transport system hence they rely on diffusion.
- They contain chlorophyll necessary for photosynthesis.
- They have developed rhizoids for anchorage and absorption of water and mineral salts.
- They are thalloid (undifferentiated vegetative body) like liverworts or differentiated into simple leaf-like, stem-like and root-like structures. For example, moss.
- They lack support tissues hence they do not grow tall or large.
- They grow in shady, damp or wet areas.
- They show alteration of generation. The gamete producing gametophyte is dominant over the spore producing sporophyte.

The sporophyte is born on the gametophyte on which it is dependent on. The male gametes are produced by antheridia and female gametes by archegonia. Fertilisation depends on availability of water.

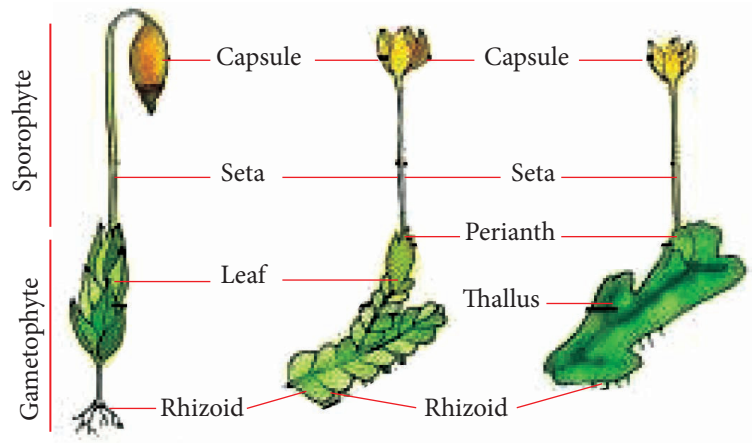


Fig. 1.15: External features of moss and liverworts.

Fig. 1.16: Moss growing on the bark of a tree.

Fig. 1.17: Liverwort growing in a swampy place.

Division Pteridophyta

Pteridophytes include ferns and horsetails.

Practical Activity 1.10: Investigation of the features of pteridophytes

Requirements

Mature intact fern, hand lens, scalpel and white tile/paper/tray.

Procedure

1. Go for a nature walk or to the field and collect ferns.
2. Place a fern on the tray.
3. Examine the fern and note the following:
   - Size of the plant.
   - Structure of leaves and the roots.
   - Colour of the fern.
4. Identify and cut off a leaflet. Using the hand lens, examine the underside of the leaflet and record your observations.
5. Draw a well labelled diagram of the observable structures of the leaflet.

The facts

General characteristics of pteridophytes

- Leaves are compound structures known as fronds, with leaflets called pinnae. The lower side of the mature pinna bears sori (plural) or sorus (singular) which contain sporangia that bear spores.
- They are green, non flowering plants which have roots, stems and leaves.
- They have a defined vascular system with both phloem and xylem in the roots, stems and leaves.
- They show alteration of generation. Diploid sporophyte is the dominant part which forms haploid spores in sori. The haploid spores germinate to form gametophyte called **prothallus** which produce haploid male gametes and female gametes which fuse during fertilisation, dependent on water to form a zygote that develops into sporophyte. Dependency of water during fertilisation explains why the ferns grow in a wet environment.

Fig. 1.18: Fern

Did you know?

Pteridophytes and bryophytes such as moss, liverworts and fern are used for landscape decoration.

Kingdom Animalia

Animalia Kingdom is divided into nine phyla namely: Polifera, Coelenterata, Platyhelminthes, Nematoda, Annelida, Mollusca, Arthropoda, Echinodermata and Chordata.

Work to do

1. From the general knowledge on animals, state four main characteristics of Kingdom Animalia.
2. Watch the YouTube clips on marine animals in https://www.youtube.com/watch?v=x3Cmy.W18vCo

The facts

General characteristics of members of Animalia Kingdom

1. They are multicellular and eukaryotic.
2. All are heterotrophic.
3. Their cell lacks cell wall.
4. Most exhibit locomotion but a few are sessile.
5. Most reproduce sexually and a few reproduce asexually.

Phylum Cnidaria (Coelenterata)

Examples of members of Phylum Coelenterata include hydra, obelia, physalia (Portuguese man-of-war), jellyfish and sea anemone.

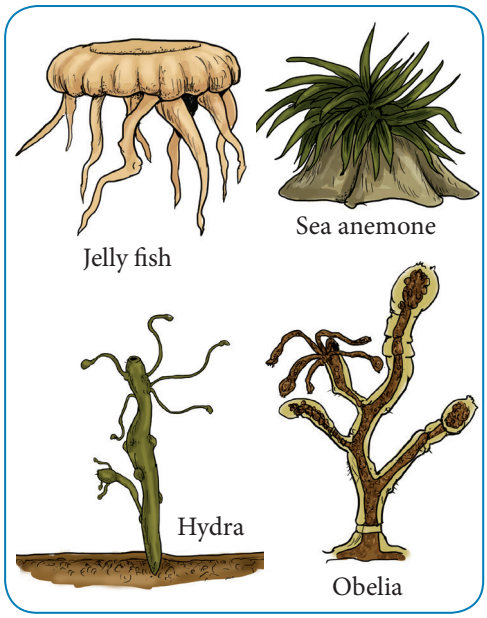


Fig. 1.19: Examples of cnidarians.

The facts

General characteristics of cnidarians

The cnidarians, formerly called coelenterates are:

- Multicellular organisms that are mostly living in the marine environment.
- They have a hollow sac-like body, which has a single opening; the mouth that is used both for taking in food and for removing indigestible materials. Their mouths are surrounded by tentacles, which are used for catching prey. The tentacles contain stinging cells (nematocysts) that kill or paralyse the prey.
- Their body wall is diploblastic which means that it consists of two layers of cells. These are an outer **ectoderm** and an inner **endoderm**.

Phylum Platyhelminthes (Flatworms)

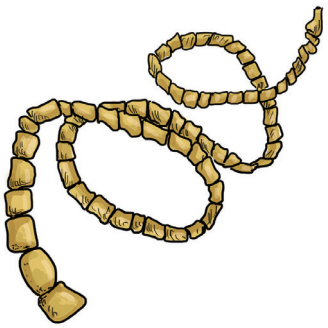


Fig. 1.20: Flatworm

The facts

General characteristics of platyhelminthes

- The platyhelminthes have relatively long and flattened bodies. This shape increases the surface area to volume ratio and reduces the distance over which gases and excretory materials have to diffuse.
- They are bilaterally symmetrical. This means that their bodies can be cut into two similar right and left halves along one plane only running along the mouth and the digestive tract.
- Their body wall is triploblastic which means that it has three layers of cells. These are ectoderm, mesoderm and endoderm. They have no body cavity and are thus said to be acoelomate (coelom; body cavity).
- Their muscular and reproductive systems are well developed. They are all hermaphrodites with both male and female reproductive organs in the same individual.
- They have a distinct head often with some sense organs. The

digestive system is well developed with extensive branching of the intestine. However, the gut has only one opening, the mouth through which food enters and undigested materials leave.

- There is no circulatory system. Some flatworms, for example, Planaria are free-living (non-parasitic). Others are parasitic, living on or in the bodies of other animals. Examples are flatworms which include the trematodes or flukes which are parasitic to man and other animals. Others are the cestodes or tapeworms which are parasitic to man and several other vertebrates.

Phylum Nematoda

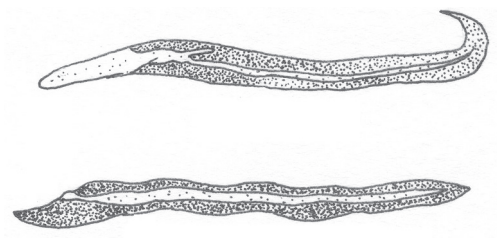


Fig. 1.21: Examples of nematodes.

The facts

General characteristics of nemtodes

- The nematodes have a cylindrical unsegmented body that is pointed at the ends. They range in size from a few millimetres to over a metre long.
- They live in the soil, water, and in the bodies of larger animals and ants.
- The whole body is covered with a tough cuticle that is moulted as the worm grows. The cuticle enables the worms that live in the gut of vertebrates to resist digestion by the host's enzymes. In free-living forms, the cuticle enables them to resist desiccation.
- The digestive system is complete with a mouth that is continuous with a straight and slender intestine and ends with the anus. Ingested food is absorbed through the intestinal wall of the worm into a fluid filled cavity called the pseudocoelom and thence into the cells. The pseudocoelom serves as a hydrostatic skeleton. There are separate male and female roundworms with the male being generally smaller. They are bilaterally symmetrical. They lack a circulatory system.

Phylum Annelida (segmented worms)

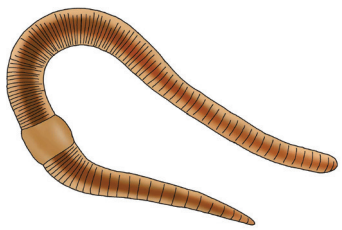


Fig. 1.22: Example of a segmented worm.

Did you know?

The sex organs of hermaphrodic annelids are located in such a way that the worms cannot fertilise their own eggs.

The facts

General characteristics of annelids

- They include the earthworms, leeches and many marine and freshwater worms.

- The annelids are distinguished from other worms by the segmentation of their bodies. The anterior segment carries the head which contains the brain and the mouth. The posterior segment carries the anus. The external segmentation is continued internally where segments are separated from one another by transverse partitions called septa.
- They also have a primitive brain and nerves. The gut, the major blood vessels and the major nerves extend the whole length of the body but excretory structures and muscles are repeated in each segment.
- The body wall is covered by a thin epidermis, beneath which are strong circular and longitudinal muscles. The muscles aid in swimming, crawling and burrowing. In many annelids, each segment has two pairs of bristles called chaetae or setae which grip the ground during locomotion.
- The circulatory, digestive and excretory systems are well developed in all annelids.
- In terrestrial annelids like the earthworm, there are no special respiratory organs. Gaseous exchange takes place through the epidermis that is kept moist by glandular secretions. In aquatic annelids, gaseous exchange occurs through gills.
- Some annelids like earthworms are hermaphrodites. The clitellum produces secretions which form a cocoon into which eggs are laid; other annelids have separate male and female individuals.

Phylum Mollusca

This phylum includes the snails, oysters, octopuses, slugs, squids and clams.

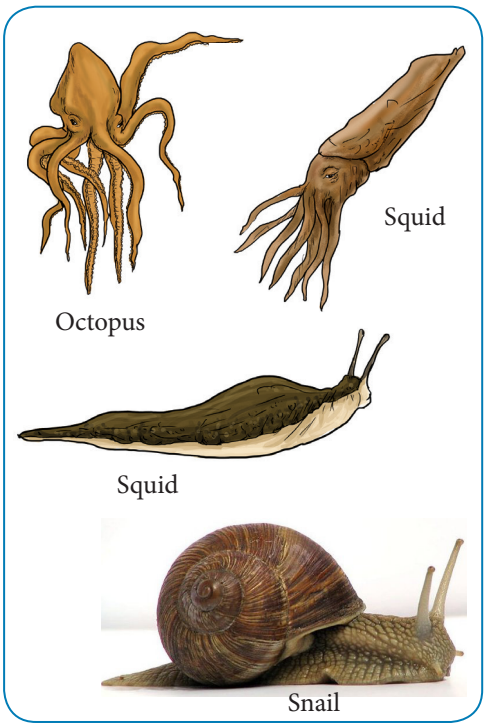


Fig. 1.23: Example of molluscs.

Did you know?

Pearls and shells from molluscs are used to make jewellery and fine art pieces.

The facts

General characteristics of molluscs

- They live in all kinds of habitats from seawater, freshwater and on land.
- The molluscs include a wide variety of animals most of which are enclosed in a shell. A few molluscs like the slugs and octopuses have no

shells. They protect themselves from predators by their colouration or by discharging coloured materials that camouflage them in the background environment.

- All molluscs have a soft unsegmented body. The upper part of the body called the visceral mass is in most cases covered by a shell. The shell is used to protect the organism from predators and to prevent desiccation in land dwellers. In normal circumstances only the visceral mass is enclosed by the shell.

Work to do

1. Touch the tentacles of a snail or slug using a stick and take note of the reaction.
2. Do the people in your community consider molluscs as a source of food? If not, find out why and also inform them of countries where they are considered as a source of food.

Phylum Arthropoda

Practical Activity 1.11: Observation of the external features of members of Arthropoda.

Requirements

Sweep nets, specimen bottles or containers, forceps, pooter, hand lens and tray.

Procedure

1. In groups, go for a nature walk in the nearby bush.
2. During the nature walk, use a hand lens to observe various organisms such as grasshopper, butterflies, cockroaches, centipede, millipede, spider and ticks among others.
3. Draw the organisms labelling the features observed under the lens.
4. List the common features of all the animals you observed.
5. Use images, video clips and pictures for the organisms not present in your immediate environment.

The facts

General characteristics of Arthropods

- Arthropods include a large variety of small animals that live on land, seawater, freshwater and in the air. Their distribution ranges from the cold polar regions to the hot equatorial regions.
- Their bodies are divided into three parts; the head, thorax and abdomen. In some, the head and the thorax are fused to form a cephalothorax.
- The body is covered by an outer rigid coat called the exoskeleton or cuticle. It is made of chitin, a nitrogen containing polysaccharide.

- They are bilaterally symmetrical.
- They all have several pairs of jointed appendages; legs (which are modified to different structures to perform different functions like jaws, gills, walking legs or paddles). There may be 3 pairs, 4 pairs, 5 pairs or many pairs.
- Body is triploblastic.
- They are haemocoelomate. Coelom, that is, body cavity is filled with blood or fluid.
- Head bears a pair of compound eyes and antennae.
- They have open circulatory systems.
- Digestive system is complete, straight and well developed. The mouth bears mouth parts for ingestion of foods. Mouths are modified for chewing, biting, sponging, piercing and siphoning.
- Respiration takes place through the general body surface or gills (in crustaceans) or trachea (in insects, diplopoda and chilopoda) or book lungs (in Arachnida) and book gills (in king cobra).
- Excretion takes place through the Malphigian tubules (in terrestrial form) or green glands or coxal glands (in aquatic forms). The aquatic forms excrete ammonia while the terrestrial forms excrete uric acid.
- They are unisexual, that is, sexes are separate.
- Fertilisation is internal or external. They are either oviparous or ovoviviparous.
- Sensory organs include antennae, sensory hairs for touch and chemoreceptors, simple and compound eyes, auditory organs (in insects) and statocysts (in crustaceans).

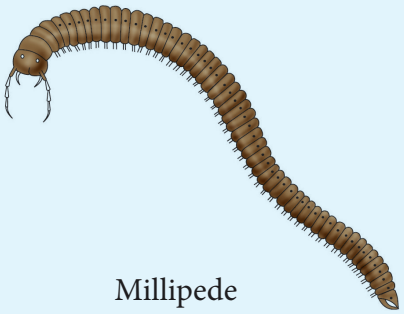
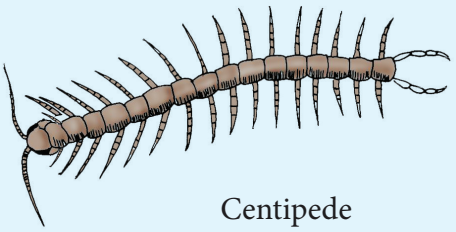
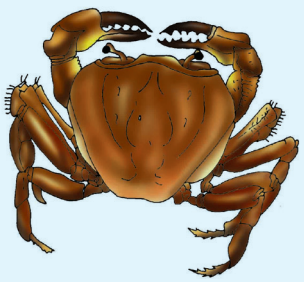
Distinguishing characteristics of arthropods

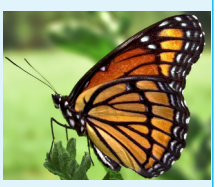
1. Despite their incredible diversity and sheer numbers, arthropods share a number of important distinguishing characteristics. These are:
    - Exoskeleton.
    - Segmented bodies.
    - Jointed appendages.
    - Bilateral symmetry.
    - Open circulatory system.
2. The other major Classes of **Phylum Arthropoda** include the **crustacea** (crabs, lobsters, shrimps, barnacles and woodlice among others), the **diplopoda** (millipedes), **chilopoda** (centipedes) and **arachnida** (scorpions, king crabs, spiders, mites and ticks among others). Arthropods are animals that have jointed legs.

Group Activity 4

Look at the organisms below and place them in their correct class.

Table 1.4: General characteristic of classes of arthropoda

Class	General characteristics	Examples
	• Have cylindrical segmented body. • Have two pairs of legs per segment. • Have three body parts: head, short thorax and body trunk. • Have a pair of short antennae and mandibles. • Have many simple eyes. • Have no poisonous claws.	 Millipede
	• The body is dorso ventrally flattened. • Segmented body divided into two parts; head and trunk. The head has a pair of simple eyes, a pair of antennae and a pair of poisonous claws.	 Centipede
	• Hard flexible exoskeleton. • They have gills. • Branched antenae. • The body has two body sections; abdomen and cephalothorax. • They are mostly aquatic.	 Crab

	• Have two body sections; abdomen and cephalothorax. • Have ventral side cephalothorax. • Have two chelicerae. • No antennae but they have pedipalps. • Have four pairs of legs. • Gaseous exchange takes place through the trachea system, gills or book lungs.	 Tick  Scorpion
Insecta	• They have three body parts; head, thorax and abdomen. The head has a pair of compound eyes and several simple eyes. • Have one pair of unbranched antennae. • Have three pairs of legs. • Gaseous exchange is through tracheal system. • Have well differentiated mouthparts consisting of mandibles, maxillae and labia (singular: labium). • Excretion is through Malpighian tubules which remove uric acid.	 Cockroach  Butterfly  Housefly  Bee

Did you know?

The oldest arthropod known to have lived on land is the *Pneumodesmus newmani*.

Work to do

1. Find out some of the diseases, insects transmit to human beings.
2. Firefly is an insect that produces light at night through a chemical

reaction known as bioluminescence. Find out from the Internet how this phenomenon is being exploited in life science research.

Practical Activity 1.12: Classification of members of Phylum Arthropoda

Requirements

Millipede, tick, weevil, grasshopper, prawn and termite.

Procedure

1. Observe the external features of the specimen provided and record.
2. Use observable features only to group the specimens into respective Classes.
3. Release the organisms back to their environment.

Phylum Chordata

This phylum includes amphibians, fishes, reptiles, birds and mammals.

The term chordata was derived from the term notochord. A notochord is a long flexible rod–shaped structure comprising of neurones that forms the main support of the body in all chordates during some stage of their development. It persists throughout the lives of some animals. It is protected by endoskeleton consisting of vertebral column formed during late stages of embryology. In verterbrate animals, the notochord is replaced by the vertebral column.

Group Activity 5

Read the features below and name the Class.

Class	Distinguishing characteristics
	Three pairs of legs and body parts divided into distinct head, thorax and abdomen.
	Has two pairs of legs in each segment, a head and a long trunk with many segments.
	Has a pair of antennae, one pair of legs in each segment and body is divided into head and a long segmented trunk.
	Body divided into a cephalothorax and abdomen, has two pairs of antennae and five or more pairs of legs.
	Body divided into a cephalothorax which has pedipalps and abdomen, no antennae and has four pairs of legs.

Practical Activity 1.13: Examination of the features of organisms in phylum chordata

Your teacher will provide you with model and photographas of chordates.

1. Observe the models and photographs. How are they different from other organisms you have already learnt about?
2. Compare your finding with other class members.

Class Pisces (Fishes)

Practical Activity 1.14: Examinination of the features of organisms in Class Pisces

Requirements

Tilapia or other suitable fish, hand lens, scalpel or scissors and tray.

Procedure

1. Place any freshly obtained bony fish or tilapia on a tray.
2. Examine the external features of the specimen and record them.
3. (a) Draw a well labelled diagram of the specimen.
   (b) State the functions of various external features.
4. Cut out the operculum and pull out the gill.
5. Examine the gill.
6. Draw a well labelled diagram of the gill.
7. Calculate the surface area of the drawn gill.
8. Explain the structural adaptations of the gill to its function.

The facts

General characteristics of pisces

- The bodies of most fish are covered with scales.
- They move by means of fins hence they show swimming movement.
- They have a streamlined body.
- Gaseous exchange takes place through gills.
- All fishes have a lateral line that detects vibrations in the surrounding water.
- Eyes are covered by nictating membrane.
- They have a variable body temperature that changes with that of the surrounding. They are for this reason said to be poikilothermic or ectothermic.
- They have single circulatory system with a heart consisting of two main chambers; auricle and ventricle.

Class Amphibia

The amphibians include frogs, toads, newts and salamanders.

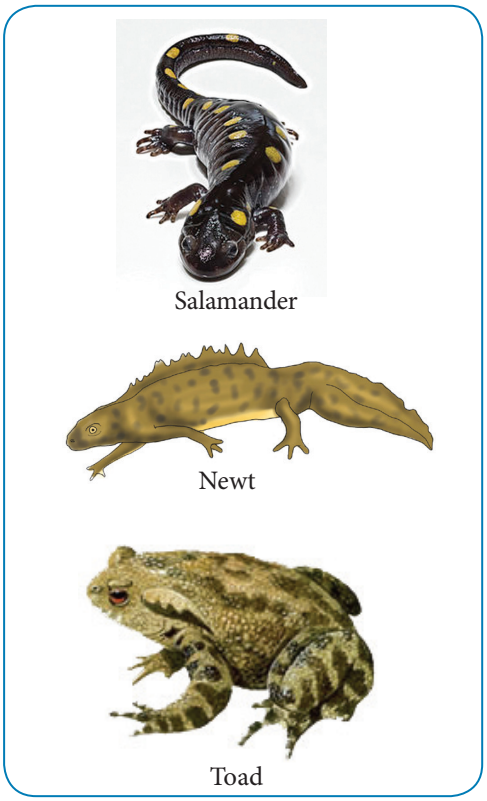


Fig. 1.24: Examples of amphibians.

The facts

General characteristics of amphibians

- They have a moist skin due to the secretion of mucus by glands under the skin. This helps the skin to act as a medium of gaseous exchange in addition to the lungs. To ensure that the skin remains moist, amphibians must live in damp places. The skin of toads is however drier than that of frogs.
- Amphibians are poikilothermic.
- They exhibit sexual reproduction with external fertilisation taking place in frogs and toads and internal fertilisation in salamanders. The larval stages (tadpoles) develop in water whereas the adults live on land but go back to water to breed.
- Gaseous exchange takes place through external gills in tadpoles, while adults use moist skin and lungs.
- They have a double circulatory system. The heart has three chambers with two atria and only one ventricle.
- Adults have four legs that are used for movement both on land and in water. In frogs and toads, the hind legs are large and strong and their feet are webbed. They are used for jumping and swimming.

Work to do

1. In your free time, observe and if possible take photographs of different frogs in your locality.
2. Talk to an elderly person in your community about some myths associated with frogs.
3. How can amphibians survive in South Sudan's hot and dry climate.

Did you know?

The biggest frog in the world is Goliath frog in West Africa. It weighs as much as a human baby.

Class Reptilia

This comprises of snakes crocodiles lizards, alligators, chameleons, turtles and tortoises.

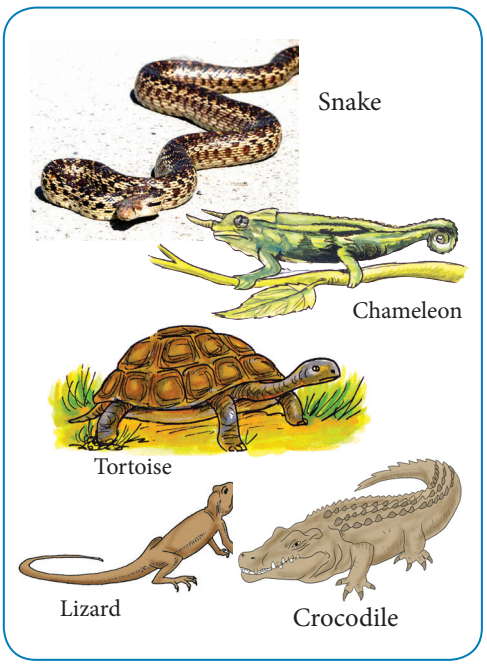


Fig. 1.25: Examples of reptiles.

The facts

General characteristics of reptiles

- Some are adapted to live in terrestrial habitat and others in aquatic habitat.
- They all have a dry scaly skin, which protects them from drying out.
- They have a three or four chambered heart hence double circulatory system.
- They have homodont teeth.
- Like amphibians, they are poikilothermic.
- Some reptiles have four pentadactyl limbs for walking or crawling on the ground while few others have no legs hence slithers.
- Some live on land but others live in water.
- Gaseous exchange is through lungs.
- All reptiles, including the aquatic ones, lay eggs that are enclosed by a protective shell on land. Since sperms cannot penetrate the shell, fertilisation takes place inside the female's body before the shell is formed. The eggs hatch into young reptiles that develop into adults without going through larval stages. In a few reptiles, for example, some species of chameleons, fertilised eggs are retained in the female's oviduct until they are hatched.
- Reptiles excrete their nitrogenous waste in the form of uric acid.

Work to do

1. Identify features of a crocodile, lizard, snake, tortoise and chameleon and explain how their features are adapted to their environment.
2. Why do reptiles often bask in the sun in the morning but seek shade from the heat of the day.

Class Aves (birds)

Some common birds are given below. Identify the distinguishing features of each bird. How are the different species of birds adapted to their different environments?

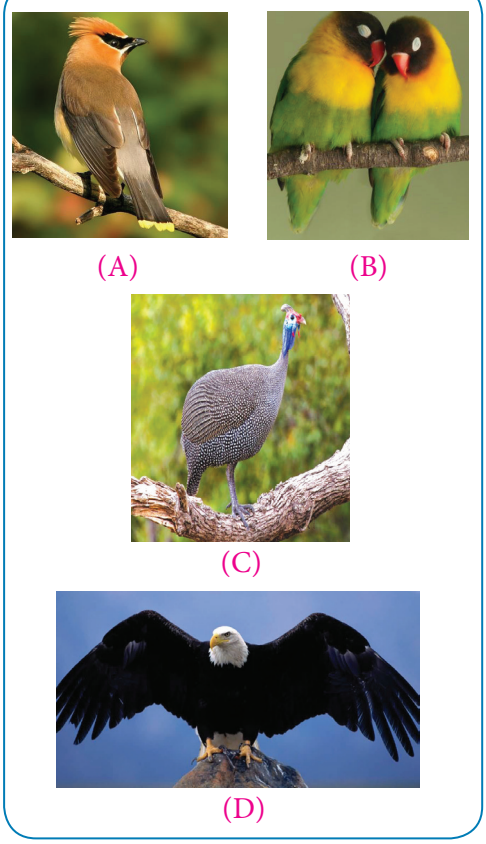


Fig. 1.26: Different types of birds.

The facts

General characteristics of aves

- They have two pairs of limbs. The forelimbs are modified as wings

that propel them during flight. The hind limbs are covered with scales and are used for walking, swimming or perching. Some birds like the penguin, kiwi, ostrich and emu, are flightless.

- The bodies of birds are covered with feathers, which protect them from mechanical damage and insulate them against heat loss except the legs.
- Birds have a constant body temperature that is independent of the temperature of the surrounding. For this reason, they are said to be homeothermic.
- All birds lay shelled fertilised eggs that hatch into young ones. In addition to feathers and wings, birds have many other adaptations for flight.
- They excrete their nitrogenous waste as semi-solid uric acid. Since they have no urinary bladder, the uric acid is delivered to the cloaca from where it is voided with faeces.

Did you know?

Emu oil, a beauty product, is derived from the thick fat pocket in the back of the emu bird.

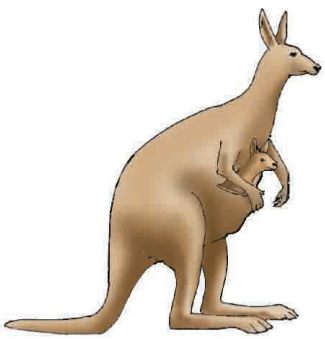
Work to do

What is the scientific name of the Emu bird? What are its characteristics and economic importance?

Class Mammalia

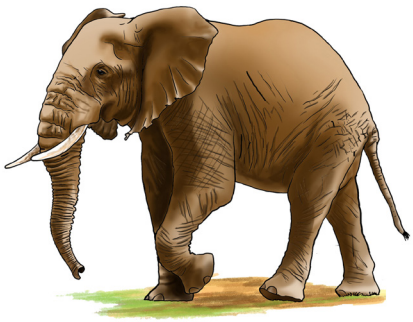
Examples of mammals are given in the pictures below. Can you identify them? What are the distinguishing features of each?


(A)


(B)


(C)

(D)



(E)

(F)

(G)

(H)

(I)

Fig. 1.27: Examples of mammals.

The facts

General characteristics of mammals

- They are the most highly developed animals. Most of them are covered with hair. The hair acts as an insulator against cold and against mechanical damage.
- They have heterodont dentition.
- They have well developed ears which are divided into outer, middle and inner ears.
- All mammals are homoiothermic.
- They have a four chambered heart with double circulation.
- They have sweat glands and sebaceous glands on their skins.
- They have a diaphragm which separates the body into thoracic cavity and abdominal cavity.
- They exhibit sexual reproduction. In most mammals, the foetus develops in the mother's uterus being connected through the placenta for nourishment.
- They have mammary glands.
- They have a highly developed brain.

Did you know?

Only mammals have mammary glands, sweat glands, heterodont dentition and external pinna.

Work to do

Visit the National Museum of Southern Sudan. Study the organisms in the Phylum Chordata. Note their diversity. Compare their observable characteristics and use them to group the organisms in their Classes.

Check your progress 1c

1. You have discovered that the back of an Emu bird has fat deposit that is used to manufacture emu oil. Your class has come up with an idea of rearing the birds to sell to pharmaceutical companies that need the oil. The first task is to draft a proposal to submit to the school administration. In your proposal draft, include the scientific name of the bird and in your introduction highlight some of its characteristics that makes it belong to Class Aves and other economic values of the bird.
2. A landscape designer is considering moss, fern and liverworts as plants to use in decorating the museum entrance that is located in your neighbourhood.

   From their characteristics that you have learnt in this unit, advice the designer on whether to proceed or not.
3. Insects are considered as a nuisance by a majority of people but from the knowledge you have gained in this unit, your mindset has changed. You and your classmates are designing posters which have pictures of some of the insects in your locality and enumerating their benefits to the society. You will need their scientific names. Write a draft of the insects that you have chosen and against their names also write their benefits.

Unit 2

Pathogens and diseases

Learning outcomes		
Knowledge and understanding	**Skills**	**Attitudes**
• Explain the role of pathogens in causing diseases.	• Investigate pathogens and their role in causing diseases in living organisms generally. • Identify and isolate bacteria and protozoa. • Develop the skill of using a microscope.	• Appreciate the importance of disease control and hygiene.

2.1 Pathogens and their mode of transmission

Majok was not feeling well, so he failed to turn up for school and instead went to a nearby hospital. After physical examination, the doctor gave him a note requesting for laboratory tests, which he took to the laboratory technician.

Fig. 2.1: A doctor examining Majok.

The laboratory technician took a blood sample from his arm then gave him a bottle and a wooden stick to scoop a small portion of his faecal matter and bring to the laboratory. After waiting for an hour, he was given the test results to submit to the doctor. Upon carefully examining the results, the doctor concluded that Majok was suffering from both malaria and typhoid, and also needed to deworm himself.

The doctor sent him with a note to the pharmacy to get the medication he had prescribed for his condition. It turns out that Majok lived in a place where there

were bushes and poor drainage. He was neither sleeping under a treated mosquito net nor drinking treated water. He was also having a running nose which usually happens to him whenever the rainy season sets in but the doctor said it is normal and will clear after some time.

Group Activity 2.1

In groups, discuss which microorganisms were responsible for the conditions Majok was suffering from. Classify these microorganisms into the kingdoms they belong to as you learnt in Unit One of this book. Suggest a general term for the microorganisms that caused the conditions from what you read.

Did you know?

Anton van Leeuwenhoek was the first person to observe microorganisms in the year 1670.

The facts

Pathogens are microorganisms that cause diseases. They exist in five groups, viruses, bacteria, protozoa, helminthic and fungi. For these pathogens to infect a host, they need to gain entry into the body of the host.

In order to survive within the host, the pathogens need to find ways of overcoming the immune resistance from the host. Because of the tag of war between the host's immune system and the pathogen, the **symptoms** such as headaches, fatigue, nausea, diarrhoea and lack of appetite occur. The pathogens also need to multiply within the host and finally exit to infect another host in order for them to continue existing.

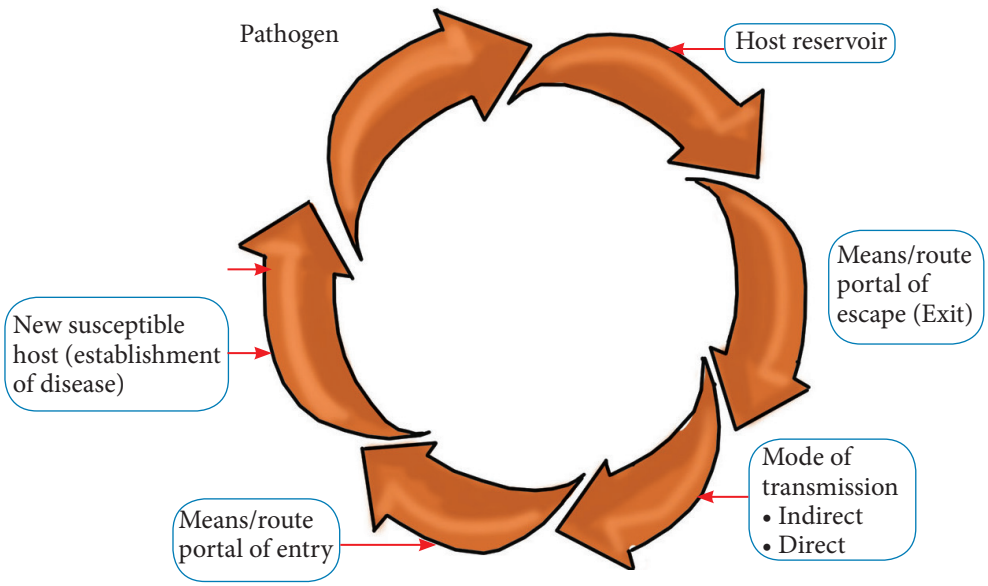


Fig. 2.2: Pathogen infection cycle.

The pathogens that cannot complete their life cycle outside a host are **obligate pathogens** while those that exist within a host but only produce disease when the host's immune system is compromised are known as **opportunistic pathogens**. Some microorganisms that can only cause disease in a specific host may find their way into other hosts and cause disease. These types of pathogens are **accidental pathogens**.

Modes of pathogen transmission

Obligate pathogens that cannot exist outside a host require a mode of transmission to move from one host to another. The following are some of the modes used by these pathogens.

(a) **Through physical contact**: Diseases that spread through physical contact include skin diseases which are spread through sharing clothing with infected people and sexually transmitted diseases, which are transmitted through sexual contact.

(b) **Through food or water:** Some pathogenic microorganisms spread diseases through contaminated food and water. Such diseases are called waterborne diseases. Examples include cholera, amoebic dysentery, typhoid and bilharzia.

(c) **Through the air:** Pathogens are spread through liquid droplets that are released when an infected person coughs or sneezes. Infected droplets are inhaled by another person; he or she may acquire the disease causing microbes. Diseases that spread through air are called airborne diseases. These include common cold, flu, pneumonia, diphtheria, tuberculosis, and whooping cough. In crowded places, such diseases may spread rapidly to many people.

(d) **Vector transmission:** Diseases can also be transmitted by a **mechanical** or **biological vector**. Animals typically arthropods carry the disease causing agents from one host to another. **Mechanical transmission** is facilitated by a **mechanical vector**; an animal that carries a pathogen from one host to another, without being infected. For example, a fly may land on faecal matter and later transmit bacteria from the faeces to food that it lands on; a human eating the food may then become infected by the bacteria, resulting in a case of diarrhoea or dysentery.
Biological transmission occurs when the pathogen reproduces within a biological vector that transmits the pathogen from one host to another. Most arthropod vectors transmit the pathogen by biting the host, creating a wound that serves as a portal of entry.

Did you know?

The ratio of human cells to microorganisms living in them is 1:1.

2.2 Disease causing organisms or pathogens

Viruses

From the story of Majok's illness, what did you conclude causes the running nose? Why was he only showing this symptom during the rainy season?

Why did the doctor not prescribe a medication for the condition?

Did you know?

There are more viruses in a litre of coastal seawater than there are people on earth.

The facts

Viruses are infectious, obligate intracellular parasites comprising of a genetic material (DNA/RNA) surrounded by a coat and an envelope derived from a host cell.

They are found everywhere on earth; in air, water and in all living organisms. In fact, we breath and eat them daily. However, we do not become sick regularly because our immune system is constantly fighting them. Most of the viral infections only take place when our immune systems are compromised. A **viral infection** is a proliferation of a harmful virus inside the body. Viruses cannot reproduce without the assistance of a host.

Did you know?

Every person inherits a gut virus from their mothers from the time they are born.

Group Activity 2.2

In groups look at Figure 2.3 below. Discuss the text and draw each stage in the life cycle of viruses with a description of what happens.

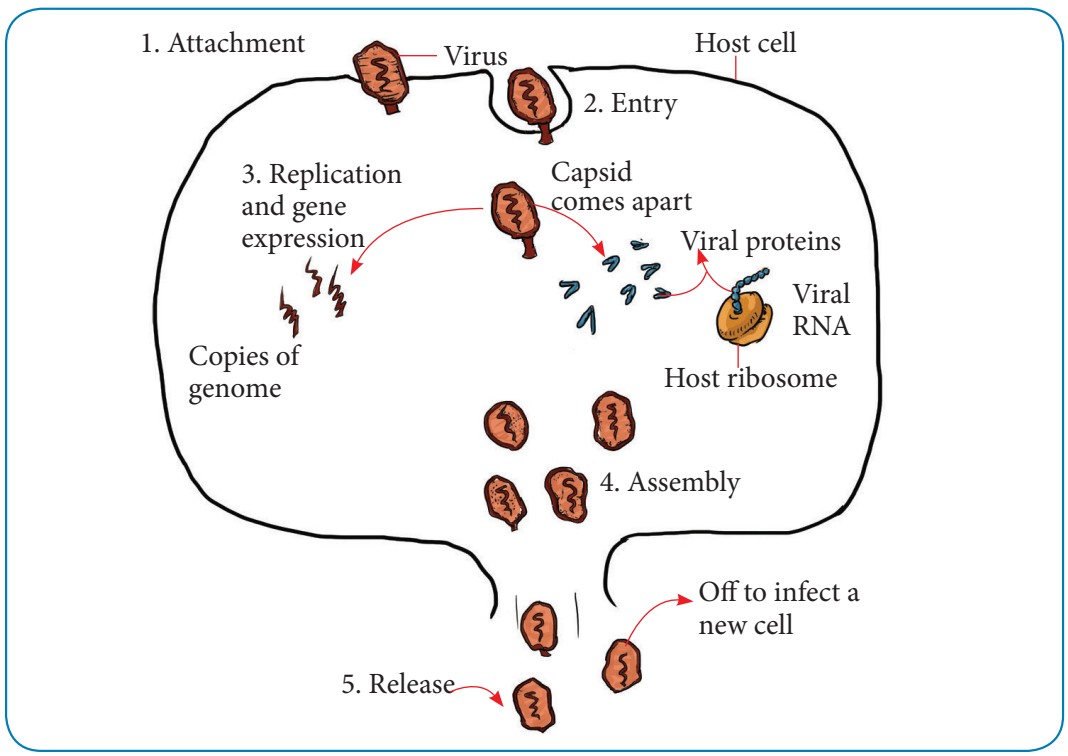


Fig. 2.3: General life cycle of viruses.

Viral entry

For the virus to reproduce and thereby establish infection, it must enter cells of the host organism and use those cells' materials. To enter the cells, proteins on the surface of the virus interact with proteins of the cell. In most cases, specific attachment proteins on the surface of viruses bind to specific receptors on the surface of animal cells. Cellular receptors are usually either glycoproteins or glycolipids, and have other functions for the cell in addition to virus binding. The specific interaction between attachment proteins and cellular receptors is a major determinant of the host-range, or tropism of the virus. Some viruses have a very narrow host range, meaning that they can only infect one or a small number of cell types, while others have broad host ranges, meaning that they can infect a large number of different cell types. This is partially determined by whether the receptor for the virus is expressed on many or a limited number of cell types.

Attachment, or adsorption, occurs between the viral particle and the host cell membrane. A hole forms in the cell membrane and then the virus particle or its genetic contents are released into the host cell, where replication of the viral genome starts. Animal viruses do this primarily by one of two mechanisms.

Endocytosis: Many viruses enter cells via **receptor mediated endocytosis**. In this pathway, viruses bind to receptors at coated pits. The coated pits pinch off to form coated vesicles, which are uncoated and then fuse with endocytic vesicles, and eventually with lysosomes. The **endosomes** become more **acidic**. Viral genomes must therefore escape the endosome before they are destroyed by proteases and nucleases among others. For some enveloped viruses, this usually occurs by membrane fusion mediated by a **fusion protein**.

Viral replication

The virus takes control of the host cell's replication mechanisms. It is at this stage that a distinction between susceptibility and permissibility of a host cell is made. Permissibility determines the outcome of the infection. After control is established and the environment is set for the virus to begin, replication occurs rapidly. With some viruses, the genome is completely released from the capsid during or after penetration. This is known as "uncoating". In others, such as retroviruses and reoviruses, the first stages of the viral replication cycle (transcription and replication) actually occur inside the capsid. These capsids undergo some conformational changes during infection that allow viral gene expression and/or replication to begin, and the resulting structures are sometimes known as partially uncoated particles. Since almost all DNA viruses replicate in the nucleus of infected cells, they must be targeted there. In many cases, the entire nucleocapsid enters the nucleus, where uncoating then takes place.

In order for new virus to be assembled, both new viral genomes and other virion components (proteins) must be produced. Exactly how this occurs varies greatly depending on the virus family. Almost all DNA viruses have genomes that are similar to the host cell; that is, they are composed of double stranded

DNA, and are therefore able to utilise host enzymes to express viral genes and replicate viral DNA. Most DNA viruses replicate in the cell nucleus, where cellular replication and transcription proteins are localised. After infection, the nucleocapsid of DNA viruses is therefore usually delivered to the nucleus where uncoating occurs. However, pox viruses are an exception because they replicate in the cytoplasm of infected cells.

The replication cycle can be broken down into the following steps.

1. **Early gene expression**. Transcription of these genes occurs using **cellular RNA polymerase II** and **cellular transcription factors**. These proteins bind to the viral DNA in regions called **early promoters or enhancers**, and promote synthesis of the early pre-mRNAs. The early RNAs are processed (capped, polyadenylated and spliced) in the nucleus, and are then transported to the cytoplasm where they are **translated**, giving rise to the **early proteins**. In many cases, one primary transcript can give rise to several different mature mRNAs via a process known as **alternative splicing**. These different mRNAs then encode different proteins. Early proteins typically play several roles in the viral life cycle, including the following;
   a) They are required for **replication of the viral genome**.
   b) Early proteins are also involved in the **regulation of viral gene expression.**
   c) Early proteins also play a role in altering host-cell metabolism by activating pathways that induce cell entry into S phase.
2. **Viral DNA replication**. Once the viral early genes have been expressed, and the cells have been induced to enter S phase, viral DNA is replicated. This occurs in the nucleus of infected cells, and gives rise to new viral genomes.
3. **Late gene expression.** After viral DNA replication has begun, the late genes are transcribed and translated to give rise to **late proteins**. Both late and early viral proteins are synthesised in the cytoplasm, but are often transported back to the nucleus where both viral replication and nucleocapsid assembly occurs.

Viral shedding

The process by which virus progeny are released to find new hosts is called shedding. After a virus has made many copies of itself, it has usually exhausted the cell of its resources. The host cell is now no longer useful to the virus, therefore, the cell often dies and the newly produced viruses must find a new host. This is the final stage in the viral life cycle.

Viral latency

Some viruses can "hide" within a cell, either to evade the host cell immune system or simply because it is not in the best interest of the virus to continually replicate. This hiding is called latency. During this time, the virus does not produce any progeny, it remains inactive

until external stimuli such as light or stress prompts it to activate.

There is a period between infection of a cell and the appearance of new infectious virus that is known as the latent period. During this time, different stages in the virus life cycle occur.

Viral transmission

Viruses can be transmitted from one host to another in various ways such as touch, saliva, sexual contact or by sharing contaminated needles, contaminated food and water and air. Insects including ticks and mosquitoes can act as vectors.

Different viral infections

There are a number of viral infections ranging from common cold, polio to HIV, among others. In this unit, we will only discuss HIV.

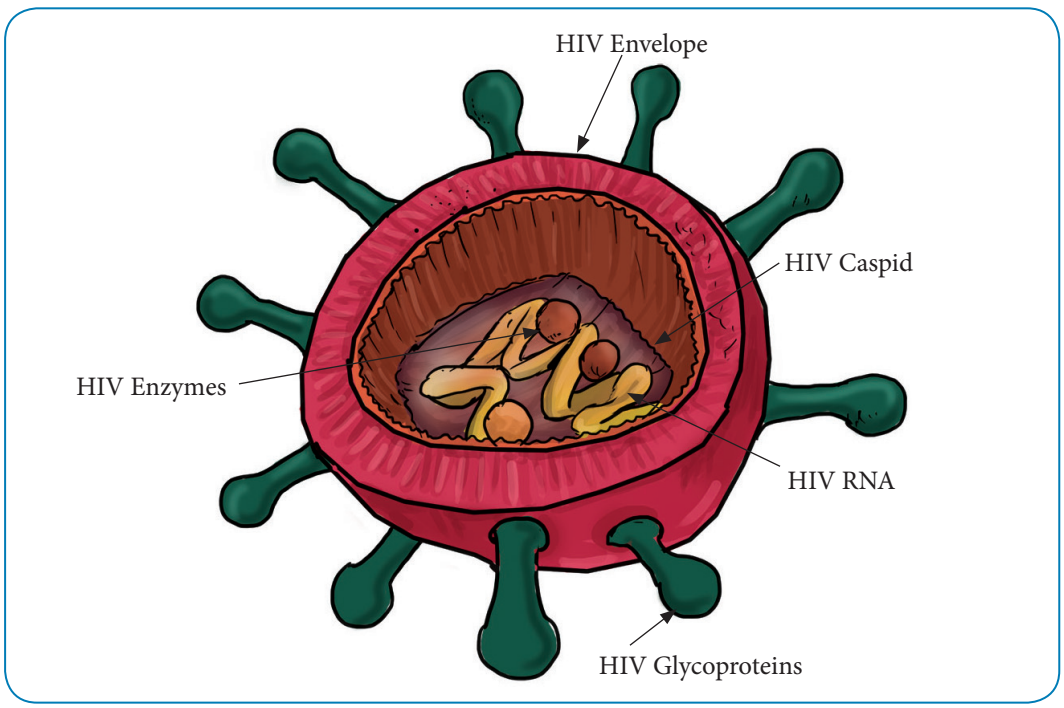


Fig. 2.4: The structure of Human Immunodeficiency Virus.

- **Human Immunodeficiency Virus (HIV)** is a virus that affects certain types of T cells of the immune system. Progression of the infection decreases the body's ability to fight disease and infection, leading to **Acquired Immune Deficiency Syndrome (AIDS)**. HIV is transmitted by coming into contact with blood or bodily fluids of an infected person, infected mother to baby during birth or breastfeeding.

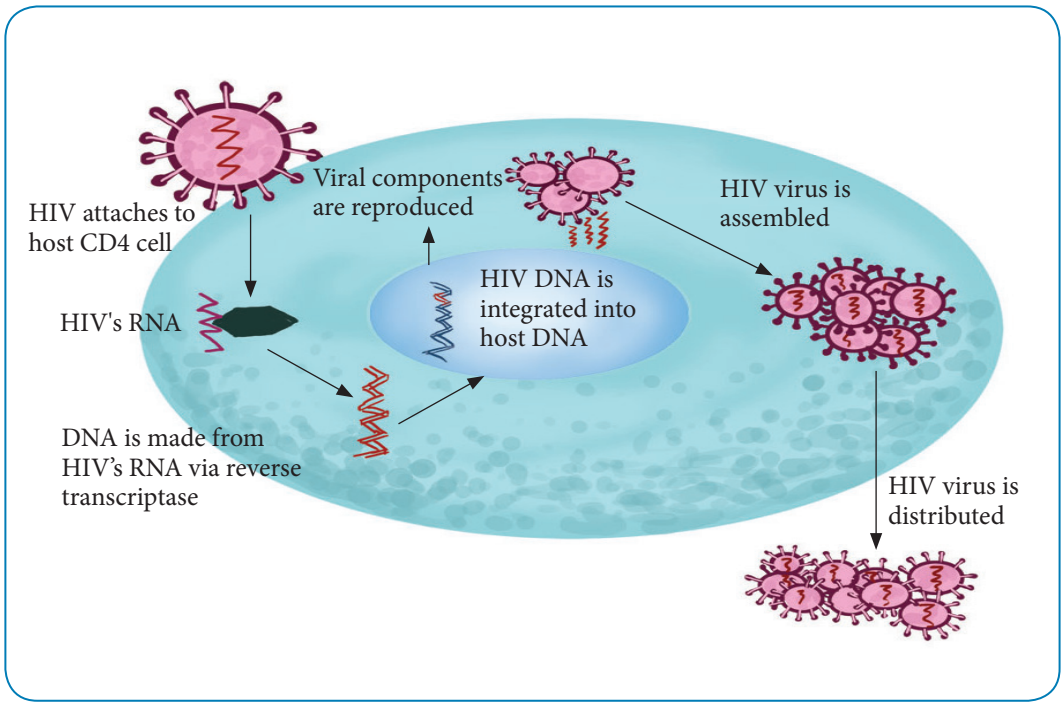


Fig. 2.5: HIV life cycle.

Beneficial importance of viruses

- In biomedical research, scientists use viruses to insert new genes into cells.
- Viruses also participate in the process of evolution by transferring genes among different species.
- Some viruses protect the host against other infections like the ones that cause chickenpox.

Viruses can affect many areas in the body, including the reproductive, respiratory, and gastrointestinal systems, the liver, brain and skin hence the viral infection.

Did you know?

There is no cure for viral diseases but they can be prevented using vaccination. Some of the vaccines against viral infection available include, small pox, rubella, influenza, measles, polio and Hepatitis B, among others.

Study the graph below.

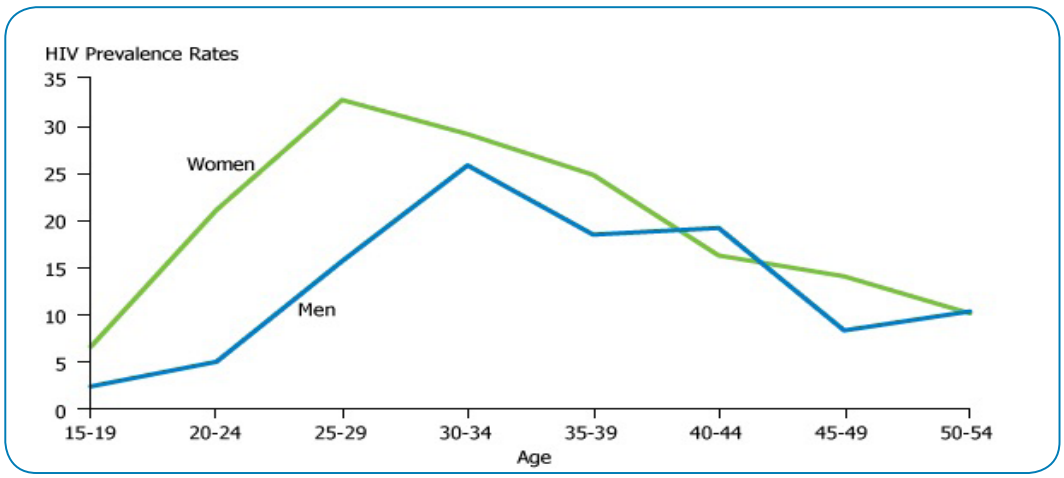


Fig. 2.6: HIV prevalence graph

Describe the pattern you see in the graph.

Bacteria

Examples of pathogenic bacteria

Vibro cholerae

Vibro cholerae causes cholera which is a serious disease. It usually occurs as an epidemic where sanitation is poor and compromised due to overcrowding or poor sewage treatment. The bacteria can live in water or food contaminated with human faecal material for a long time until they find a suitable host. Houseflies can also act as a vector when it feeds on human faecal material and encounters food. Cholera is a waterborne or foodborne disease.

Group Activity 2.3

In groups, look at Figure 2.7 on page 44. Discuss the text and point out where life cycles could be interrupted to prevent or reduce infections.

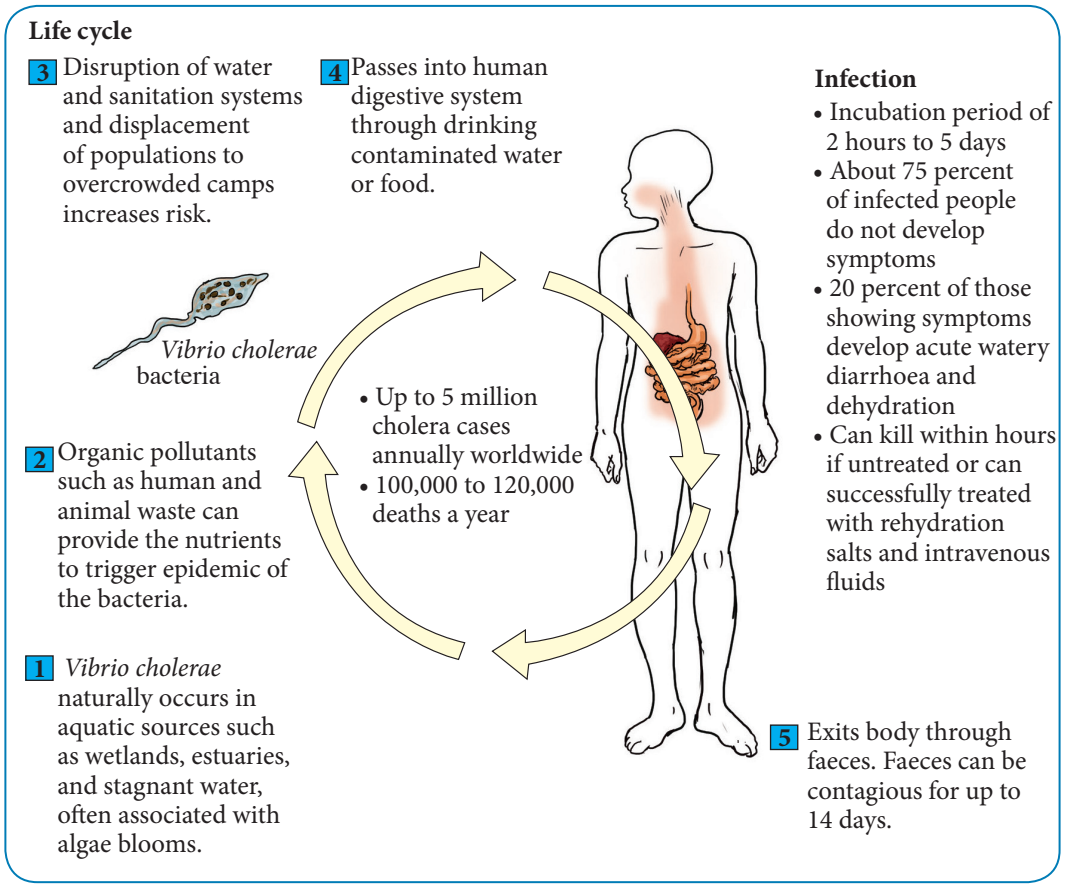


Fig. 2.7: Life cycle of Vibrio cholerae.

When food or water is contaminated with human faecal material, human beings ingest *Vibro cholerae*. The bacteria undergoes incubation of 1-6 days. They rapidly multiply in the small intestine and produce highly toxic substances that destroy the epithelial lining, leading to the symptoms.

Mycobacterium tuberculosis or Mycobacterium bovis

Mycobacterium tuberculosis or *Mycobacterium bovis* causes tuberculosis which kills about 2 million people a year, mostly in sub-Saharan Africa and it is the worst killer disease.

Transmission

Mycobacterium tuberculosis or *Mycobacterium bovis* are inhaled into the lungs (droplet infection). It requires prolonged contact between people hence it is associated with overcrowding living conditions particularly poor ventilation such as in refugee camps, dormitories and prisons.

Tuberculosis can affect almost all body tissues or organs. However, the lungs have the highest risk of infection.

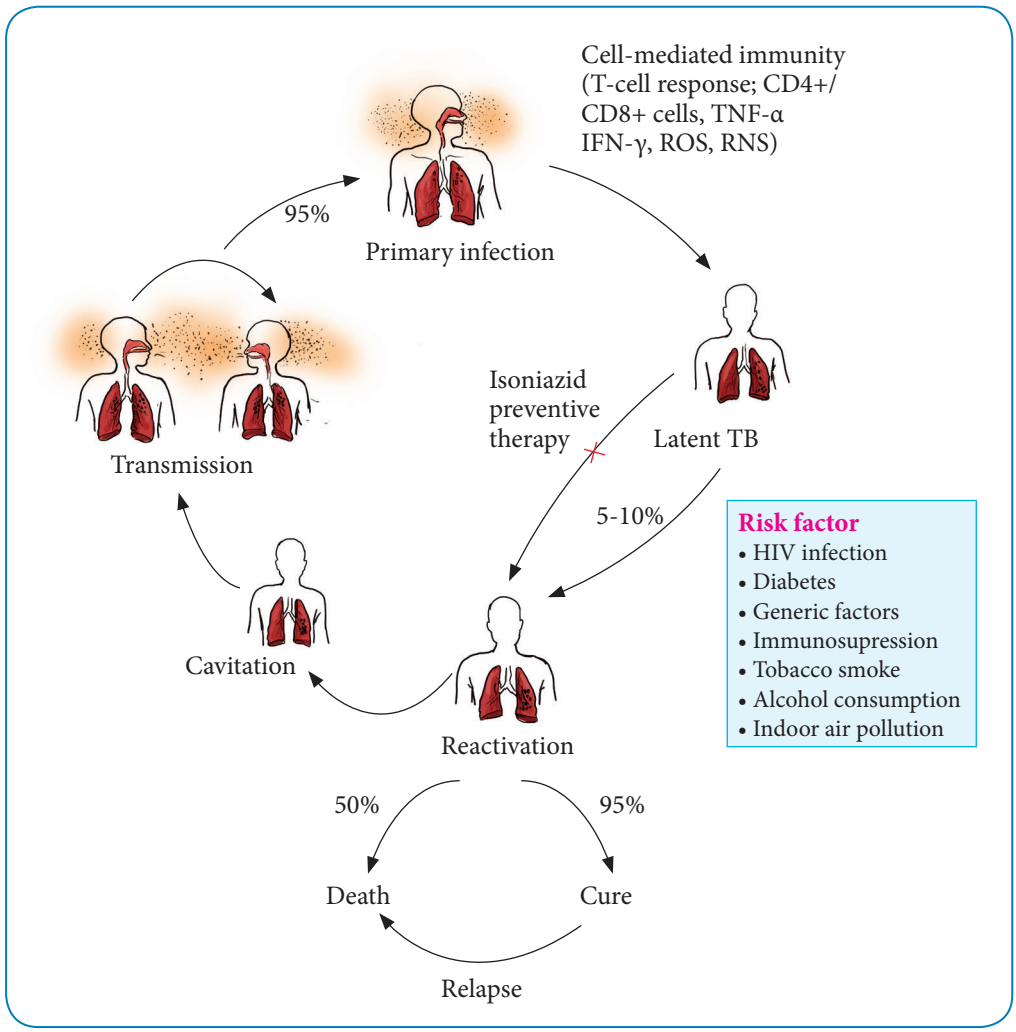


Fig 2.8: Life cycle of Mycobacterium tuberculosis.

Group Discussion Activity 2.4

In groups, role play the life cycle of *Mycobaterium tuberculosis* shown in Figure 2.8 above.

Did you know?

Failure to complete your TB medication is a crime that is punishable by law.

Table 2.1: Summary of diseases caused by pathogenic bacteria

Pathogenic bacteria	Disease caused	Mode of transmission	Signs and symptoms	Treatment and control
Corynebacterium diphtheriae	Diphtheria	Drop infection	Slight fever Sore throat Severe damage of nerve cells, heart and adrenal gland	Immunisation with toxoids
Clostridium botulinum	Botulism	Contaminated food	Constipation, vomiting, intense thirstiness and paralysis of muscles	Administration of antitoxins
Shigella dysenteriae	Bacterial dysentery	Contaminated food (as cholera)	Diarrhoea with mucus and blood, abdominal pains	Use of antibiotics
Clostridium tetani	Tetanus	Wound infection	Muscular spasms beginning in the mouth and neck regions and spread through out the body Convulsions and death	Immunisation with toxoids
Rickettsia	Typhus	Vector (rat flea and louse	Measles–like rashes on the forelimbs, Headache. Back pains and on the limbs. Delirium and coma	Use of antibiotics
Neisseria gonorrhoea	Gonorrhoea	Sexual contact	Males have a burning feeling when passing urine and a yellow discharge accompanied by fever and headache in females there are no signs	Use of antibiotics
Treponema pallidum	Syphilis	Sexual contact	Painless sore on the penial glans, nipple or vagina Fever, Skin rashes	Use antibiotics

Protozoan disease causing organisms

Large number of protozoa is parasitic to man. They cause serious diseases such as Trichomoniasis, amoebic dysentery, malaria and sleeping sickness.

Plasmodium spp

There are various species of plasmodium: *Plasmodium vivax, Plasmodium falciparum, Plasmodium malariae* and *Plasmodium ovale*.

Plasmodium causes malaria, which is also a killer disease in Africa. The endoparasites are transmitted from a sick individual to a health one through bites of a female anopheles mosquito.

Group Activity 2.5

In groups, role play the life cycle of plasmodium as shown in Figure 2.9.

Identify how to prevent the spread of malaria and why we use different strategies.

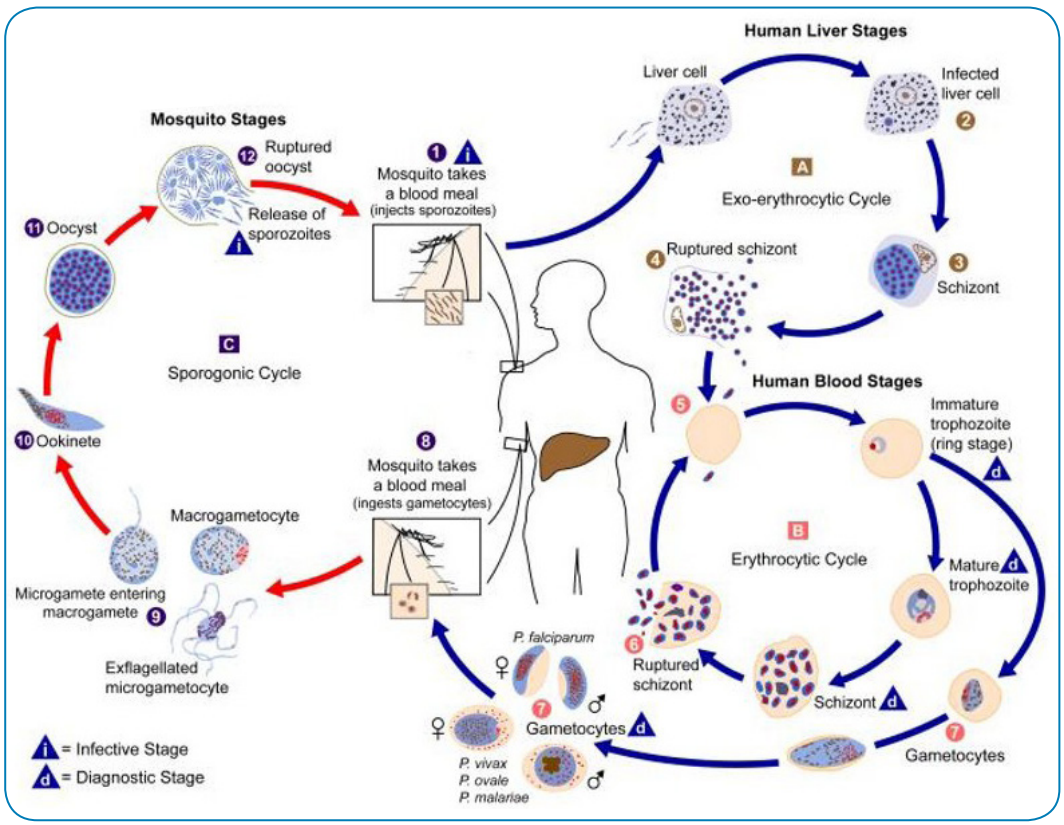


Fig. 2.9: Life cycle of plasmodium.

The female anopheles mosquito is infected with *Plasmodium* parasites as it sucks blood from an infected person. The parasites reproduce sexually by multiple binary fission in the mosquito's stomach wall. The parasites' offspring migrate to the salivary glands of the mosquito where they are injected into man's circulatory system as female anopheles mosquito feeds. The offsprings migrate to the liver where they asexually reproduce. The liver cells rapture releasing the parasites into the bloodstream where they attack the red blood cells or brain cells. Further, asexual

reproduction in red blood cells leads to the destruction of the cells, which rapture to release the parasites in man. In the brain, they cause cerebral malaria or mental disorder. This leads to signs and symptoms.

Did you know?

Professor Israel Kligler was the pioneer of malaria eradication in Israel through drainage of swamps and clearing of bushes.

Group Activity 2.6

In groups, look at Figure. 2.10 below. Discuss the text and point out where the life cycles could be interrupted to prevent or reduce infections.

Trypanosoma gambiensis or *Trypanosoma rhodesiense* or *Trypanosoma cruzi*

Trypanosoma gambiensis and *Trypanosoma rhodesiense* cause sleeping sickness or *Trypanosomiasis* or *African trypanosomiasis*. *Trypanosoma cruzi* causes Chaga's disease or *South American trypasonomiasis*. Sleeping sickness is transmitted from a sick individual to a healthy one through the bites of a tsetse fly.

Life cycle of *Trypanosoma gambiensis* or *Trypanosoma rhodesiense* or *Trypanosoma cruzi*

When sucking blood from an infected individual, the tsetse flies get infected. The parasites multiply rapidly in the tsetse flies' stomachs and then migrate to the salivary glands where they are injected into suitable hosts as they suck blood. Further multiplication occur at the site of infection. They latter invade the bloodstream where they destroy heart muscles and valves, the blood clotting mechanism and brain cells.

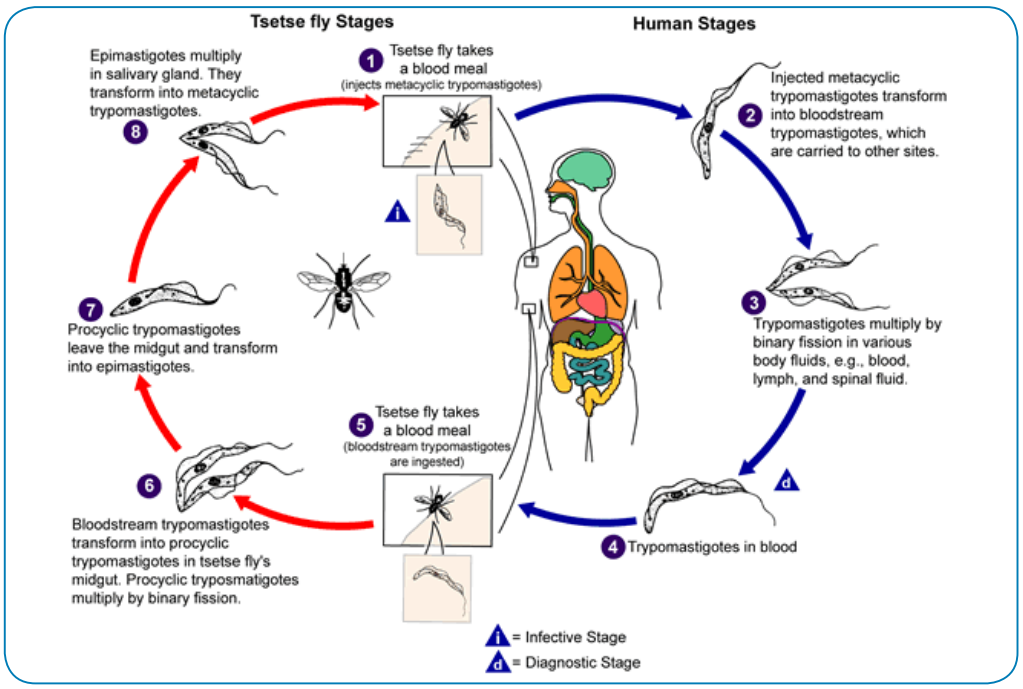


Fig. 2.10: Life cycle of Trypanasoma.

Did you know?

Scientists have discovered that tsetse fly is attracted to blue colour.

Pathogenic worms

They are endoparasitic in man.

Blood fluke or Bilharzia worm

Group Activity 2.7

In groups, role play the life cycle of blood flukes as shown in Figure 2.11 below

Have different species which includes: *Schistosoma haematobium*, *Schistosoma japonicum and Schistosoma mansoni.* Adult blood flukes live in the veins draining the urinary bladder and the intestines. The worms are found in pairs. The male holds the female which is much slender in a groove in its ventral side (Fig. 2.8)

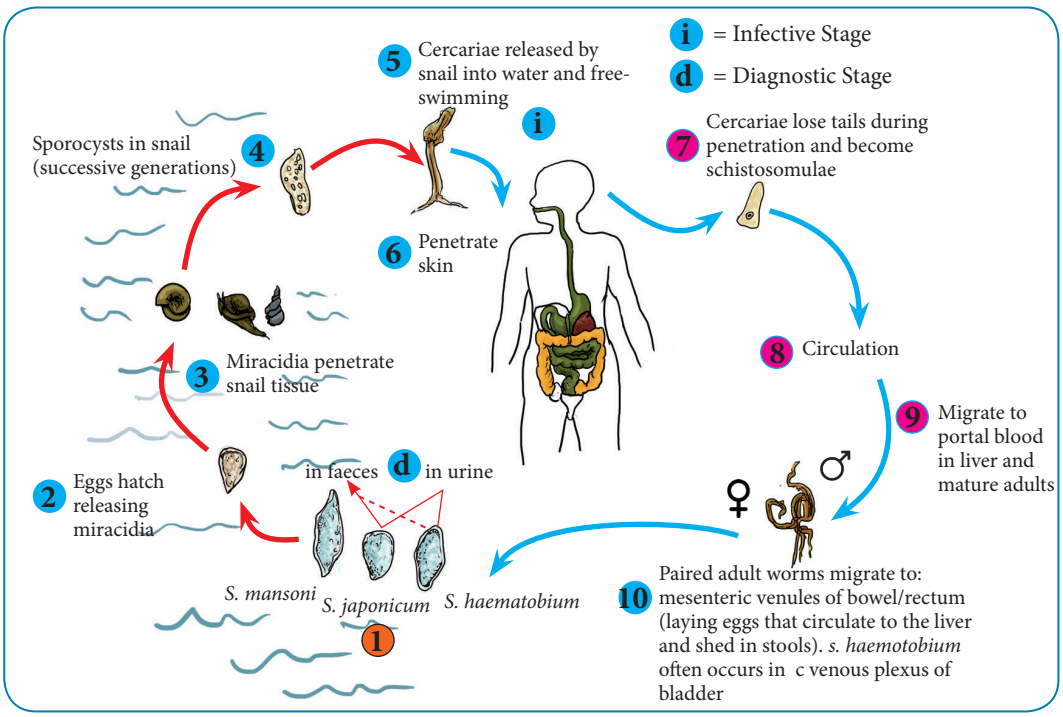


Fig 2.11: Life cycle of blood flukes.

The female lays eggs which have a sharp pointed part which penetrates the blood vessels, into the bladder or intestine. The eggs are released through urine and faeces. When eggs are released into water, they hatch into miracidium larvae which penetrate into the tissues of a snail, the intermediate host, and develop into sporocysts. The sporocysts then develop into cercariae which are released into water and infect man by penetrating through the skin. They enter the circulatory system which takes them to the liver, heart, lungs and finally into the veins, draining into the intestines and the bladder where they develop into adult flukes.

2.3: How to identify bacteria using different biochemical tests

Group Activity 2.8

In groups, explain the need to identify bacteria before treatment.

Growing bacteria in Petri dishes

You may not believe what you find hiding in all corners of every home and school and location in the world! Take samples around you and see what bacteria will grow in an agar-filled Petri dish. A Petri dish prepared with nutrient agar (a seaweed derivative with beef nutrients added) is an ideal way to reveal the bacteria hiding all around you.

Practical Activity 2.1: Growing bacteria in a Petri dishes

Requirements

- Teaspoon
- Hot water
- Microwave-safe container
- Agar
- Petri dishes
- Source of heat

Procedure

1. Use a clean, microwave-safe container (a quart-sized bowl works great) to mix the agar with water and then boil it.

   These proportions make enough nutrient agars to prepare two Petri dishes. Thoroughly, stir these together:

   - $\frac{1}{2}$ teaspoon agar (about 1.2 grams).
   - $\frac{1}{4}$ cup (60 ml) of hot water.
2. Boil the mixture for three minutes to completely dissolve the agar.

   CAUTION: Teacher supervision is required to boil water. If you are using a microwave oven to boil the mixture, be careful not to let it boil over. The mixture should be clear with no particles floating in it after boiling. Handle cultured bacteria with care to avoid dangerous infections.
3. Remove the mixture from the microwave and allow it to cool for 3 to 5 minutes.
4. Remove the lid off from the Petri dish (the lid is larger than the dish) and carefully pour the warm nutrient agar mixure into the petri dish to cover the bottom-half of the Petri dish.
5. Loosely cover the bottom portion and allow the mixture to cool and harden for one hour.

   NOTE: Just like gelatin, agar needs to boil for a certain amount of time to properly gel. If necessary, pour any unset mixture in each Petri dish back into the bowl (cover the empty dish) and microwave it again until you see it boil. Watch it boil (but not boil over) for 10-15 seconds before turning off the microwave. There should be no "floaters" in it. Pour the hot agar mixture back into the dishes (cover them) as you did before and it should solidify within an hour.

6. Collect some bacteria on the end of a cotton swab by rolling a clean cotton swab in your mouth or remote or door handles or pencil and then lightly draw a squiggle with it on the gelled agar. However, many people like to test something even grosser like the keys on a computer keyboard, a cell phone case, the pump handle of a soap dispenser, or the television remote control. Unless someone recently cleaned the buttons on the remote, you may be seeing some real goobers in a short time. Dampen a cotton swab and roll it in your fingers as you pull it across the surface of your choice.

   NOTE: Place a drop (no more) of a hand sanitising gel in the middle of one of the squiggles to prevent antibacterial growth.

7. Lift the lid off the Petri dish and LIGHTLY draw a squiggly line in the agar with the end of the cotton swab. Roll the swab in your fingers as you draw the line. Replace the lid and label the dish with the date and the name of the item you tested.

8. Use a sanitising wipe to thoroughly clean one of the surfaces you tested in Step 6, for example, cellphone.

9. With a clean swab, redo the squiggle test in the other half of the Petri dish from Step 6 to confirm your cleaning efforts. NOTE: You have to add a variable, or something that changes in the experiment.

In the Growing Bacteria Activity described above, adding an anti-bacterial hand sanitiser is a variable. Make one dish of microorganisms and one dish of microorganism with a drop of the anti-bacterial sanitiser or, better yet, make three dishes: one to act as the control (just microorganisms), one with an anti-bacterial sanitiser, and a third dish with another brand of anti-bacterial sanitiser. Then you can see which anti-bacterial sanitiser is more effective in killing microorganisms. Make sure all three Petri dishes have microorganisms collected from the same place in your home or classroom at the same time so you know they are all exposed to the same bacteria. The dishes also need to be grown in the same warm, dark place for the same amount of time so that the conditions are standardised as much as possible.

Test for identifying Gram Positive Bacteria

- Catalase test

$$2H_2O_2(l) \xrightarrow{catalase} 2H_2O\,(l) + O_2(g)$$

- Test starch hydrolysis test
- Mannitol Salt Agar (MSA)
- Blood Agar Plates (BAP)
  - Streak-stab technique
- Taxos P (optochin sensitivity testing)
- Spirit Blue agar

- Motility Agar
- Coagulase Test
- Taxos A (bacitracin sensitivity testing)
- CAMP Test
- Bile Esculin Agar
- Nitrate Broth

Note: Few tests will be discussed at this level.

Catalase test

This test is used to identify organisms that produce the enzyme, catalase. This enzyme detoxifies hydrogen peroxide by breaking it down into water and oxygen gas.

The bubbles resulting from production of oxygen gas clearly indicate a catalase positive result. The samples on the top and right respectively are in Fig. 2.12 are catalase positive. The *Staphylococcus* spp. and the *Micrococcus spp.* are catalase positive. The *Streptococcus* and *Enterococcus spp*. are catalase negative.

Practical Activity 2.2: Identifying organisms that produce enzyme catalase

Requirements

- Microscope slides of cultured bacteria
- Sterile wooden splint
- 3% Hydrogen peroxide

Procedure

1. Using a sterile wooden stick, touch the colony in a microscope slide of cultured bacteria.
2. Touch a drop of 3% Hydrogen peroxide on the microscope slide.
3. Observe for presence or absence of bubbles.

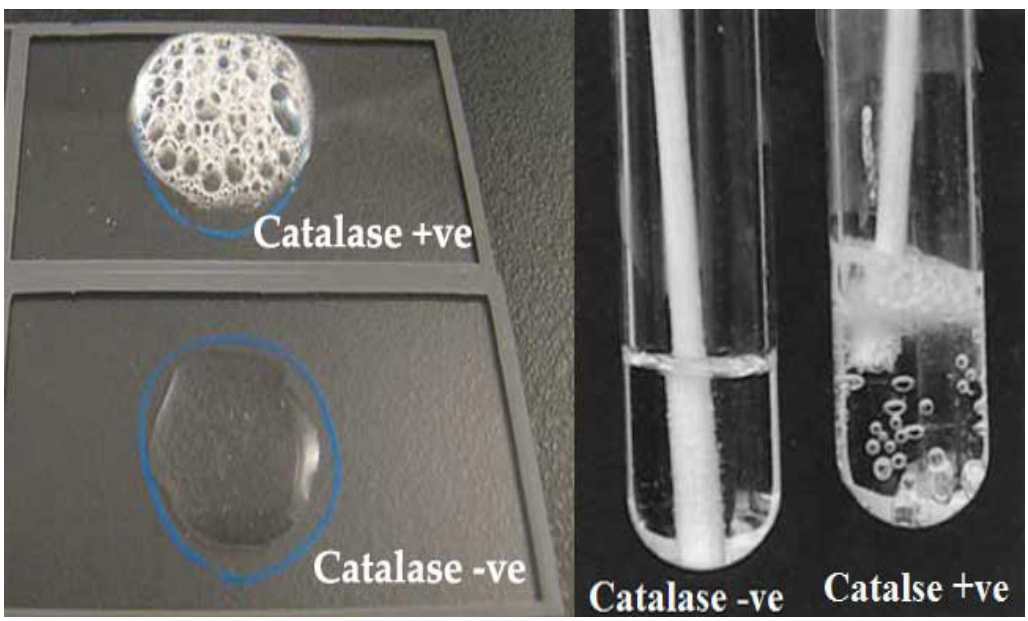


Fig. 2.12: Catalase positive and negative observations.

Starch hydrolysis test

This test is used to identify bacteria that can hydrolyse starch (amylose and amylopectin) using the enzymes amylase and oligo-1,6-glucosidase. It is often used to differentiate species from the genera *Clostridium* and *Bacillus*. Because of the large size of amylose and amylopectin molecules, these organisms cannot pass through the bacterial cell wall. In order to use these starches as a carbon source, bacteria must secrete α-amylase and oligo-1,6-glucosidase into the extracellular space. These enzymes break the starch molecules into smaller glucose subunits which can then enter directly into the glycolytic pathway. In order to interpret the results of the starch hydrolysis test, iodine must be added to the agar. The iodine reacts with the starch to form a dark brown colour. Thus, hydrolysis of the starch will create a clear zone around the bacterial growth. *Bacillus subtilis* is positive for starch hydrolysis.

Tests used to identify Gram Negative Bacteria

- Motility Agar
- MacConkey agar
- Simmon's Citrate Agar
- Urease test
- Sulphur Indole Motility Media (SIM) Oxidase Test
- Sugar (for example, glucose) broth with Durham tubes
- Methyl Red/Voges-Proskauer (MR/VP)
- Kliger's Iron Agar (KIA)
- Nitrate Broth

Kliger's Iron Agar (KIA)

This is a differential medium. It tests for organisms' abilities to ferment glucose and lactose to acid and acid plus gas end products. It also allows for identification of sulphur reducers.
This media is commonly used to separate lactose fermenting members of the family *Enterobacteriaceae* like *Escherichia coli* from members that do not ferment lactose, like *Shigella dysenteriae*.

These lactose non-fermenting enterics generally tend to be the more serious pathogens of the the gastrointestinal tract (GIT).

The first differential ingredient, glucose, is in very short supply. Organisms capable of fermenting this sugar will use it up within the first few hours of incubation. Glucose fermentation will create acidic byproducts that will turn the phenol red indicator in the media yellow. Thus, after the first few hours of incubation, the tube will be entirely yellow. At this point, when the glucose has been all used up, the organism must choose another food source. If the organism can ferment lactose, this is the sugar it will choose. Lactose fermentation will continue to produce acidic byproducts and the media will remain yellow (see the picture on the far left in Figure 2.13).

If gas is produced as a result of glucose or lactose fermentation, then fissures will appear in the agar or the agar will be lifted off the bottom of the tube.

If an organism cannot use lactose as a food source, it will be forced to use the amino acids (proteins) in the media. The

deamination of the amino acids creates ammonia (NH_3), a weak base, which causes the medium to become alkaline. The alkaline pH causes the phenol red indicator to begin to turn red. Since the incubation time is short (18-24 h), only the slant has a chance to turn red and not the entire tube. Thus an organism that can ferment glucose but not lactose, will produce a red slant and a yellow butt in a KIA tube (see second picture from the left in Figure 2.13). These organisms are the more serious pathogens of the GIT such as *Shigella dysenteriae*.

If an organism is capable of using neither glucose nor lactose, the organism will use solely amino acids/proteins. The slant of the tube will be red and the colour of the butt will remain unchanged (see picture on the far right below in Figure 2.13). *Pseudomonas aeruginosa* is an example of a nonfermenter.

KIA tubes are also capable of detecting the production of Hydrogen sulphide H_2S. It is seen as a black precipitate (see second picture from the right in Figure 2.13). Sometimes, the black precipitate obscures the butt of the tube. In such cases, the organisms should be considered positive for glucose fermentation (yellow butt). *Proteus mirabilis* (See second picture from right in Figure 2.13) is a glucose positive, lactose negative, sulphur reducing enteric.

Fig. 2.13: Kliger's Iron Agar results.

Class trip

Your teacher may organise a visit to a nearby centre or invite a physician to visit the school or show a video clip describing symptoms and treatment of infectious diseases.

Group Activity 2.9

In groups, discuss how to prevent and control the infectious diseases and present to the class.

Further reading

Use books in the library and Internet to identify specific microorganisms involved in the roles indicated in the Figure 2.14 on Page 55.

Economic importance of some pathogens

Fig. 2.14: Benefits of microorganisms.

2.4: Communicable and non-communicable diseases

Methods used to prevent infectious (communicable) diseases

1. Natural barriers

Skin is an example of a natural barrier that prevents the pathogens from penetrating our bodies.

Secretions from the body, for example, mucus and tears, trap the pathogens.

Hydrochloric acid in the stomach kills some of the disease-causing microorganisms.

Antibodies, which are made by the white blood cells, engulf pathogens and kill them.

Sebum, secreted by sebaceous glands in the skin is antiseptic, that is, it kills bacteria.

2. Water treatment

Water is treated by:

(a) Boiling

(b) Adding chemicals (chlorination)

Note: Filtered water should be boiled or treated with chemicals before drinking

3. Observe personal and environmental hygiene

General cleanliness of the body and the surroundings should be observed. One should wash his or her hands after visiting the toilets, and before and after eating. Wash fruits and vegetables thoroughly before eating.

4. Food treatment and preservation

This immobilises the bacteria and halts the bacterial activities, which cause food to deteriorate.

Refrigeration and freezing prevent bacterial and fungal multiplication.

Other methods of food preservation include:

(a) Pickling
(b) Boiling
(c) Smoking
(d) Drying
(e) Salting
(f) Canning
(g) Pasteurisation
(h) Chemical treatment

5. Drug therapy

This is the wise and sound use of drugs, for example, antibiotics which cure a wide range of bacterial, viral and protozoan diseases.

6. Immunisation

This is the introduction of a vaccine into the body of an organism to increase the ability of the body to fight against infectious diseases.

7. Balanced diet

Eating a balanced diet makes someone strong and healthy.

8. Bathing

Avoid bathing in streams and ponds. Bath in clean water.

9. Overcrowding

Avoid overcrowded places.

10. Coughing

Cover your mouth with a clean handkerchief when coughing.

11. Food

Cover your food all the time except when eating.

12. Good behaviour

Avoid risky behaviour such as taking excessive alcohol, having unprotected sex, prostitution anddrug abuse like taking cocaine,s among others.

Non-communicable diseases

1. Diabetes

(a) Diabetes insipidus

When the pituitary gland releases very little ADH or fails to release it completely, the kidney nephrons are unable to reabsorb the required amounts of water. This leads to the production of excessively large volumes of dilute urine. This is known as **diuresis**. The urine can also be described as being "tasteless" or **insipid** thus the name diabetes insipidus. This condition may be caused by disease or injury. Diabetes insipidus can quickly lead to dehydration. People with this condition therefore drink lots of water.

Regulation of blood sugar level

Blood glucose is important in the body because it is the source of energy for cell respiration.

The normal blood glucose level required in the body for normal cell function is kept within a narrow range of 90-100 mg per 100 ml of blood. The source of glucose in our bodies is our diet. Glucose is the end product of digestion of carbohydrates. It is absorbed into the bloodstream from the ileum. This raises the blood glucose level. It also raises the glucose in tissue fluid. Glucose levels above the normal can make cells to lose water and become crenated due to increase in osmotic pressure.

(b) Diabetes mellitus

This is a condition in which the pancrease fails to produce insulin or produces inadequate amounts. This may be due to hereditary reasons or disease affecting the islets of Langerhans cells. A person with diabetes mellitus has an abnormally high level of glucose in the blood (hyperglycaemia). Symptoms of diabetes mellitus are:

- Passing urine frequently
- Constantly feeling thirsty
- Dehydration
- Loss of weight
- Poor resistance to infection

The kidney eliminates some glucose in the urine which is an unusual condition known as **glycosuria** (sweet urine). If untreated, it can lead to death. It is managed by daily doses of the insulin hormone, which decreases the glucose level to normal and reduces the symptoms of the disease. Insulin is administered through injection into a vein.

Work to do

Suggest reasons why insulin is not taken orally.

A diabetic person is advised to limit carbohydrates intake in the diet. This ensures that blood sugar level is manageable.

Diabetes mellitus is becoming common today because of poor diets and alcoholism.

Be careful on your diet and avoid alcohol and other drugs.

Group Activity 2.10

In groups, make fliers on communicable and non-communicable diseases and hold a campaign in your locality to talk to the people about the disease.

2. Cancer

Cancer is a condition characterised by uncontrolled growth of cells in the body. More than 200 types of cancers are known today. Cancer, if untreated, may cause death. Breast cancer is the most common cancer in women while prostate cancer is most common in men. Cancer affects several parts of the body. They include:

- Liver
- Breasts
- Throat
- Colon
- Cervix
- Skin
- Prostate glands
- Blood (leukemia)

Causes of cancer

Growth in the body of an organism is as a result of new cells being formed by cell division process of mitosis. Sometimes, this process in which cells divide to form new cells get out of control. This abnormal multiplication of cells in the body may be due to mutation. A mutation is an abnormal activation of the gene processes that controls cell division. The cells, therefore, have uncontrolled cell division. The extra cells form a mass called tumour. The following are other causes of cancer:

- **Diet**, **physical inactivity** and **obesity**. This is because obesity has negative effects on immune and endocrine system.

- Infections by **microorganisms**. For example, a virus known as **oncovirus** can cause cancer.
- **Radiation** – If an organism's body is exposed to some types of radiation such as gamma or x-rays, they can get cancer. This is because the rays penetrate the body cells where they interfere with the chromosomes.
- **Heredity** – Some people get cancer because of an inherited genetic defect.

Types of cancer

Cancer always appears as a growth of a mass of cells in addition to the existing body cells. As learnt earlier, the mass of cells formed is known as tumour. There are two types of tumour: benign tumour and malignant tumour.

(a) Benign tumours

These are cells that grow at a certain part of the body but they do not spread or invade other cells. Such cancers are not harmful. They grown on one part of the body only.

(b) Malignant tumours

These are abnormal growths whose cells spread and invade other cells of the body. They attack and destroy healthy body cells and may spread throughout the body and cause death. Examples of cancerous disease are discussed below.

(i) Leukaemia

Leukaemia is cancer of the blood. It affects the bone marrow and the lymphatic system. Many types of leukaemia exist. Some forms of leukaemia are more common in children. Other forms of leukemia occur mostly in adults. Leukaemia usually starts in the white blood cells.

In people with leukaemia, the bone marrow produces abnormal white blood cells, which do not function properly.

Signs and symptoms

Common leukaemia signs and symptoms include:

- Fever or chills.
- Persistent fatigue, general body weakness
- Frequent or severe infection
- Loss of weight
- Swollen lymph nodes and enlarged liver or spleen.
- Prolonged bleeding even on bruising
- Recurrent nosebleeds.
- Tiny red spots on skin.
- Excessive sweating especially at night.
- Bone pain or tenderness of bones.

(ii) Skin cancer

This is abnormal growth of skin cells. It mostly occurs when skin is exposed to the sun's UV rays. But this form of cancer can also occur on areas of your skin not ordinarily exposed to sunlight. It is most common in albinos who lack melanin pigment in their skin. Melanin prevents damage from sun's rays on the skin.

Signs and symptoms

- Dark lesions on palms, soles, fingertips or toes, or on mucous membranes lining the mouth, nose, vagina or anus.
- Skin appearing burnt and dark patches on skin in albinos.

Factors that increase the risk of cancer

- Smoking
- Excess alcohol consumption
- Over-exposure to radiation
- Some viral infections
- Some chemicals
- Hereditary factors

Smoking

Smoke from cigarettes contain substance called **tar**. Tar contains substances called **carcinogens** that are known to initiate cancer in the lungs, mouth and throat.

Excessive alcohol consumption

Alcohol damages liver cells making them to develop cancer. It is also converted to other chemicals that initiate cancer in the liver and the throat.

Over-exposure to radiations

Some radiations such as X-rays and gamma rays increase chances of development of cancer in the cells. Strong sun rays (UV) radiation can also cause skin cancer.

Viral diseases

Some viral diseases such as hepatitis increase chances of cancer in the liver. Also, *Human papilloma* virus causes cervical cancer.

Chemicals

Chemicals such as mercury are carcinogenic and hence initiate cancer in the body.

Effects of cancerous cells in the body

Cancerous cells have the following effects in the body.

- They form lumps or masses of tissue called tumours. **Tumours** can grow and interfere with the various systems in the body. Some of the systems that are affected are the digestive, nervous and circulatory systems.
- Some cancers can release chemicals that can alter body function.
- They compete with cells for nutrients.
- They cause organs to malfunction. For example, kidneys to fail.
- Normal body cells die.

Ways of preventing and controlling cancer

(a) Living a healthy lifestyle

Here are some suggestions:

- Avoid smoking to reduce cancers of the lungs, mouth, oesophagus and larynx.
- Stay active and maintain a healthy weight.
- Eat plenty of plant foods such as fruits and vegetables.
- Get immunised for Hepatitis B to limit liver cancer and HPV (*Human papilloma* virus) that leads to cervical cancer.

- Work to reduce stress.
- Eat a diet high in antioxidants like beta-carotene, vitamin C and vitamin E.
- Limit fat in the diet. Choose fewer high fat foods because they have high calories and may increase the risk of overweightness which in turn can increase risks of cancer attack.
- Avoid drinking alcohol. The risk of various types of cancer, including cancer of the breast, colon, lungs, kidney and liver increases with the amount of alcohol taken and length of time a person has been drinking.
- Protect yourself from strong sunlight. It is known to contribute to skin cancer.

(b) Avoid risky behaviours

Some sexually transmitted infections may increase the risk of cancer. For example, HIV. People who have HIV and AIDS have a higher risk of cancer of the anus, cervix, lungs and immune system.

HPV (*Human papilloma* virus) is associated with cervical cancer, but it may also increase the risk of cancer of the anus, penis, vulva and vagina. Sharing needles with infected people can also expose someone to HIV as well as hepatitis B and C that can increase the risk of liver cancer.

(c) Cancer screening

This is a process by which cancer is detected after it has formed but before any noticeable symptoms appear. This may involve physical examination, blood or urine tests and medical imaging such as X-ray.

(d) Palliative care

This is a specialised medical care for people with serious illnesses. The aim is to provide relief to the patient from pain, stress and discomfort brought about by the illness. It aims at improving the quality of life for the patient. It is done by a team composed of a doctor, nurses and other health specialists. It is used to provide support to cancer patients and other patients with terminal illnesses. *(A terminal illness is any illness that has reached a stage where it will automatically cause death)*. It is a disease that cannot be reversed by any form of treatment. Palliative care helps the patient to cope with the pain and other problems, for example:

- Difficulties in breathing
- Fatigue
- Constipation
- Difficulties in sleeping
- Depression
- Side effects of drugs

Check your progress 2

1. A patient suffering from tuberculosis has been arraigned in court for failure to complete his prescription. You are the prosecution lawyer. Write notes on why the state should charge the accused.
2. The WHO has classified cholera as an indicator of social development. Do you agree with their conclusion? In either case, write an essay to support your position.

3. Malaria is still a major killer in Africa yet Israeli managed to eradicate it within a short time by clearing bushes and draining swamps. If you were Professor Israel Kligler, what strategies would you use to change the African malaria situation.
4. Your locality is infested with tsetse flies. After the knowledge gained from this unit that the flies are attracted to blue colours, you decide to contribute to eradication of these flies in your community. How would you incorporate the knowledge you have gained about the flies to ensure the measures they have put in place eradicate the flies?
5. Viral diseases do not have a cure necessitating the use of vaccines. Suggest the reason why this is so.
6. You have seen an advert on an antibacterial/antimicrobial soap claiming to be removing 100% germs. From the knowledge you have gained in this unit, you are well informed that we need some microorganisms on the skin. Design a campaign slogan against this soap citing some of the microorganisms that are essential for our skin.

Unit 3 Biodiversity, human activities and climate change

Learning outcomes		
Knowledge and understanding	**Skills**	**Attitudes**
• Understand biodiversity, habitat, ecosystems, populations and the impact of climate change.	• Classify meteorological data, and be able to also read satellite imageries of climatic nature. • Observe and gauge changes in biodiversity. • Measure greenhouse concentration in the atmosphere.	• Appreciate the negative impact of human activities on biodiversity and local, regional and global climate. • Appraise biodiversity values and the efforts exerted by man to conserve and protect them.

3.1 Biodiversity

Group Activity 3.1

How much life can you find around you?

In this activity you are going to document as much wildlife as you can find around you, school, home, on the way to school and on your visits.

Keep records using a camera, a diary, drawings and sketch maps to show what you saw and where.

Try to capture the most amazing life.

Report to the class using PowerPoint, posters, oral presentations or other media. Use scientific language in all your reports.

Group Discussion

- Suggest to the class local names or descriptions of these different species you have in your report.
- Identify the groups the different species belong to.
- Why are they different from each other?
- Discuss how organisms feed?

- Where do they line?
- What were they doing in that location you found them?
- How many different species of organisms did you record?

The facts

Biodiversity is the assortment of life on Earth, it comprises of all organisms, **species**, and **populations**, their genetic dissimilarity and their complex interactions of **communities** and **ecosystems**.

Often, the term "**biodiversity**" is used to refer to number of different species in different groups of organisms. South Sudan is rich in birdlife with close to 800 species.

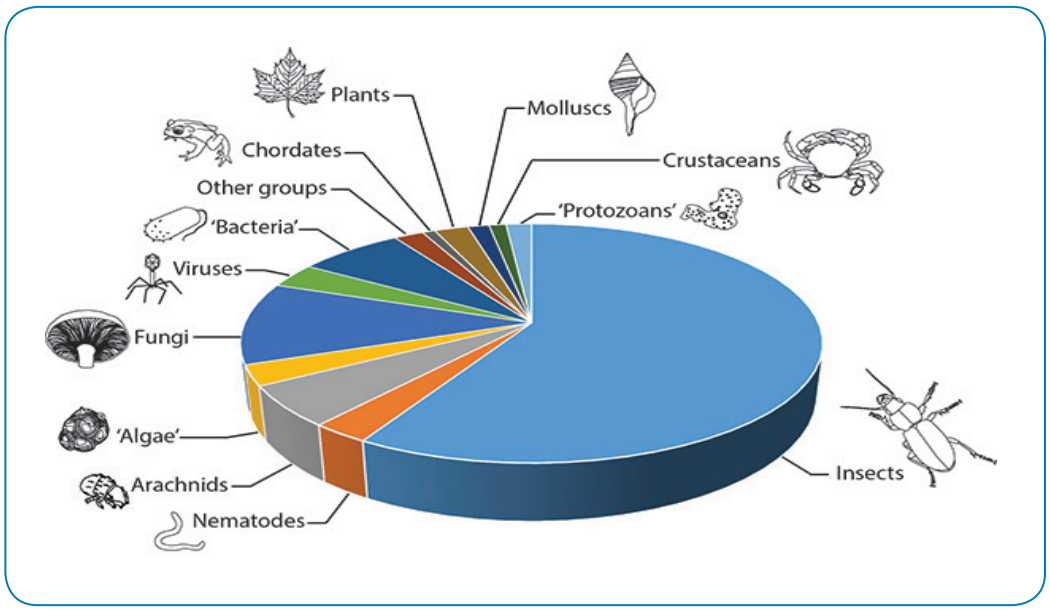


Fig. 3.1: Estimate of all species currently known.

Of these 1,412,500 species globally there are about 30,000 endangered species. Endangered species are extremely low in numbers; almost extinction. Those species that are likely to be endangered in the foreseeable future are said to be **threatened species**.

Table 3.1: Endangered, threatened and rare species in South Sudan

Name	Status	Name	Status
Elephant	Vulnerable	Shoebill stork	Vulnerable
Mongalla gazelle	Vulnerable	Black-crowned crane	Vulnerable
Leopard	Near threatened	Beisa oryx	Near threatened
Eastern chimpanzee	Endangered	Rhinoceros	Critically endangered

Wild dog	Endangered	Northern Giraffe	Threatened
Hippopotamus	Vulnerable		

Did you know?

South Sudan is known to be the only country in Africa with both species of eland– the common eland (*Taurotragus oryx*) and the Derby's (Giant) Eland (*Taurotragus derbianus*).

(a) Common eland (b) Derby's eland

Fig. 3.2: The two species of Eland.

Biodiversity is the difference of genes, species and ecosystems as well as their interactions with their environment.

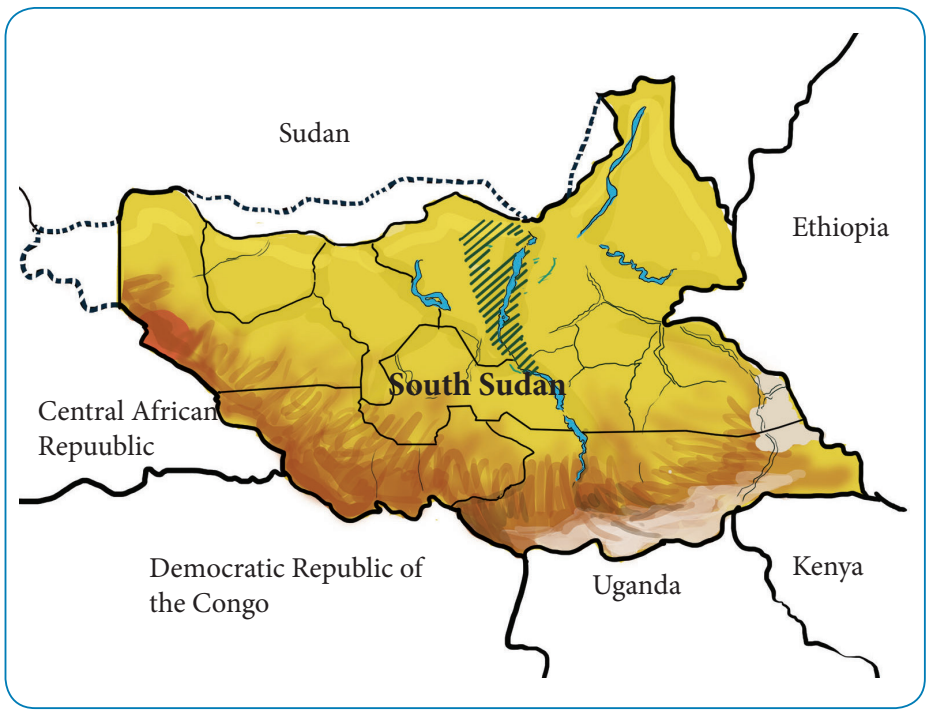


Fig. 3.3: The map of Southern Sudan.

Group Activity 3.2

"The loss of genetic diversity may be rapid in South Sudan and many species may be declining particularly for plant variety even if they are not yet extinct without any documented information."

The Fifth report to the convention on biological diversity.

What do you understand by this statement?

Visit this link on the Internet and read:

https://www.cbd.int/doc/world/ss/ss-nr-05-en.pdf

What do you think are the main causes of biodiversity loss?

Types of biodiversity include:

- Genetic diversity is all the various genes in all organisms.
- Species diversity is all the various species including variations among members of the same species.
- Ecosystem diversity is all the various habitats, ecological communities and ecological processes, including intra-ecosystems differences.

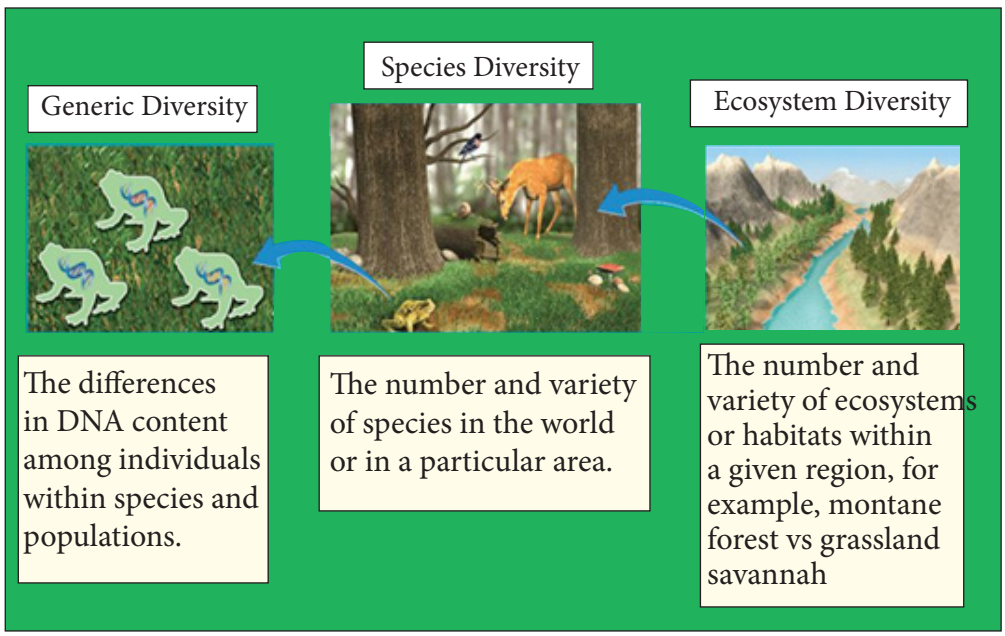


Fig. 3.4: Types of biodiversity.

The Draft South Sudan Wildlife Conservation and Protected Area Policy, 2012 categorises the ecosystems in South Sudan as follows: Lowland Forest, Montane Forest, Savannah Woodland, Grassland Savannah, Floodplain, Sudd Swamps and other wetlands (former "inland delta") and Semi-Arid Region. (To read more visit this link: https://www.cbd.int/doc/world/ss/ss-nr-05-en.pdf).

Fig. 3.5: Sudd Swamps

Did you know?

The world's population stronghold of the shoebill and black-crowned crane occur in the Sudd Wetland.

Fig. 3.6: The Shoebill and Black-crowned crane of South Sudan.

Hotspots of biodiversity regionally and globally

Group Activity 3.3

Why are parts of South Sudan protected areas? Research in the document given in this link: https://www.cbd.int/doc/world/ss/ss-nr-05-en.pdf

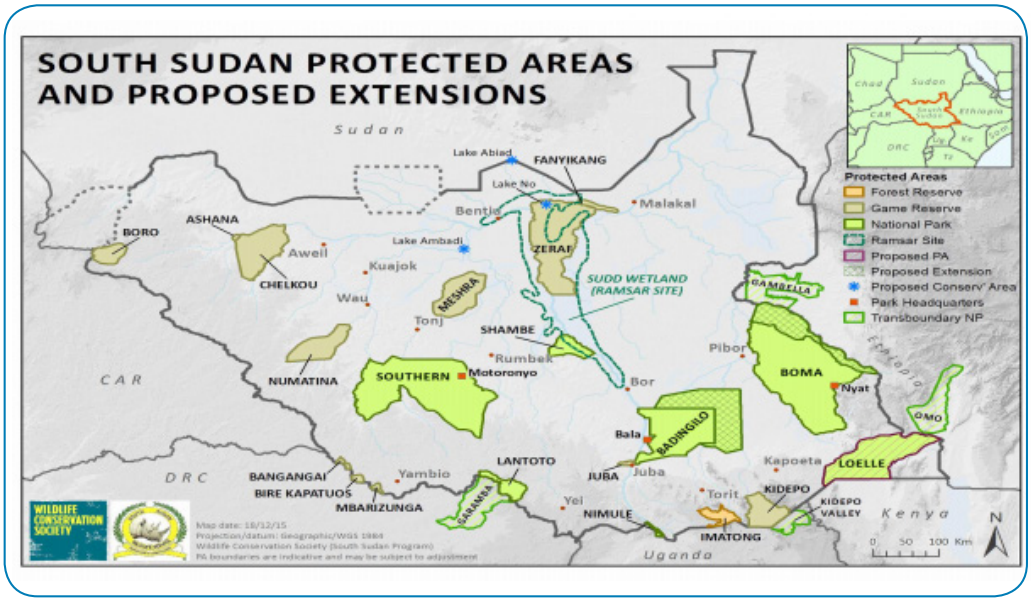


Fig. 3.7: Protected areas of South Sudan.

The facts

Biodiversity is greatest in the tropics and decreases as you move further from the equator towards the north and south pole.

Those regions of the world with extremely large concentration of species are referred to as biodiversity hotspots. Examples of global biodiversity hotspots include:

- Island of Madagascar.
- The cape region of South Africa.
- Indonesia
- **Montane Forests**, located on the mountains (Imatong, Dongotona, Acholis, Didinga and Jebel Gumbiri). The montane forests of South Sudan are part of the Eastern Afromontane ecosystem, which is categorised as one of **Africa's biodiversity hotspots**.
- Tropical rainforests are thought to have more species than previously thought.

Group Activity 3.4

Research on the Internet about this plant called Rosy Periwinkle from Madagascar *Catharanthus roseus*. Why is the plant important?

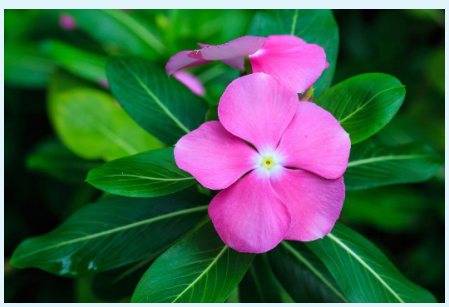


Fig. 3.8: Catharanthus roseus

Group Activity 3.5

Role play Minister of Environment in the Government of South Sudan preparing the President's and his senior team's speech on the value of biodiversity and global importance of South Sudan. Make sure the English is of high quality for the President.

The facts

Value of biodiversity

Biodiversity is a natural resource of unimaginable value. The value could be direct or indirect.

Direct value

Medicinal value: most medicines in use today worldwide are derivatives of organisms. The *Catharanthus roseus* from Madagascar one of biodiversity hotspots, has extracts used to treat childhood leukaemia. It increases the survival rates from 10% to 90%.

Agricultural value: the domesticated crops are derivatives of wild plants many years ago and the same wild plants have been used by scientists to solve current problems like awhile ago a virus attacked rice in Africa and the wild rice varieties offered the solution.

Consumptive use value: wild fish and other marine life have provided food to humans with aquaculture contributing very little.

Indirect value

Indirect value includes biogeochemical cycles support, **waste disposal,** fresh water catchment, soil erosion control, Climate control, and **ecotourism**.

Did you know?

In terms of ecosystems and biological diversity, South Sudan is credited with having the following:

- One of the world's most spectacular animal migrations, thought to rival the migration of the wildebeest in the Maasai Mara/Serengeti ecosystem in Kenya/Tanzania.
- The Sudd Wetland, considered the largest tropical wetland in Africa and possibly the world.
- The largest intact savannahs in Africa (UNDP, 2009).

3.2 Biodiversity and human activities

Group Activity 3.6

Read this passage of a true report about South Sudan

"The catchments of the Nile River are the highlands along the border with the Central African Republic and the Democratic Republic of Congo. These have in the past been undergoing degradation arising from land clearance for agriculture, deforestation and possibly climate change. They are the sources of the Rivers Kir, Lol, Jur, Gal, Peyia and the Yei, which contribute their waters to the Nile River. In the past, these rivers had been permanent but have been reported to become seasonal over the last two decades (GOSS and UNDP, 2011).

In addition, they also carry heavy loads of silt, which affects aquatic life. As a result of these changes, certain species of fish have been reported to be on the decline or have become locally extinct.

The status of forest and woodlands biodiversity is directly related to deforestation and forest degradation. This is more evident in the montane and lowland forests that are rich in biodiversity but occupy a very small area of the country. Extraction of timber, especially the high value Podocarpus, at the higher altitudes and mahogany at the lower elevations is leading to serious deforestation.

Charcoal and brick making operations consume high volumes of wood, a direct cause of deforestation and/or forest degradation. Livestock farming also leads to deforestation by removing seedlings, which eliminates the capacity of the forests/woodlands to regenerate. There are fish species lost due to catchment degradation. Fishermen in Nyamlel on River Lol suspect that five fish species out of the 15 species they know have disappeared from their river.

They also reported that the size of fish caught had also decreased, noting that the Mudfish (*Protopterus aethiopicus*) could reach a length of 1.5 m in the past, but the size had decreased in recent fish catches to a maximum of 0.5 m in length. In their opinion, the fishermen did not think that the problem was due to overfishing since fishing in these rivers is quite limited and simple techniques are being used."

Habitat fragmentation caused by road network expansion and the expansion of extractive industries (such as minerals mining and oil industry development).

(Adopted from South Sudan Tropical Forests and Biological Diversity Assessment, Usaid)

http://www.usaidgems.org/Documents/FAA&Regs/FAA118119/SouthSudan2014.pdf

Group Discussion

What activities do you think are a threat to biodiversity in South Sudan? And what is their impact to South Sudan?

What do you think will be the effect of biodiversity destruction in South Sudan (a) Currently (b) 20 years from now?

The facts

Deforestation

Rapid tree cutting to provide firewood, hardwood and building materials, clearing land for agriculture, grazing and herding livestock in the forests destroy biodiversity and habitats of other organisms. Herding livestock in the forests removes seedlings of plants. Slashing and burning land to clear it also contributes to deforestation.

Effects of deforestation

- Reduction in soil fertility.
- Flooding and silting of water ways and lower lands.
- Recycling of carbon (IV) oxide and oxygen reduces.

- Climatic changes because of less transpiration, affecting the water cycle. Suggest how it is affected? Sunlight radiation is rapidly absorbed by the bare soil hence thermal gradients increase leading intense to and frequent winds.
- Species extinction because their habitat is destroyed or because their food web is broken.

Did you know?

One animal and one plant species become extinct every 30 minutes as a result of deforestation somewhere in the world.

Habitat destruction

The amount of land being turned to be used for agriculture is increasing, including draining of swamps and shift cultivation. This removes habitats for many species like the cranes and mudfish leading to loss of biodiversity in South Sudan.

Check your progress 3a

The future of the white-eared Kob may be threatened by the new trunk roads in Jonglei state. True or False? Suggest how the life of the White-eared Kob in Jonglei State would be in 20 years.

Poaching is a serious problem and leading to overhunting being largely attributed to the demand for products from wild animals such as bush meat and game trophies, and for money to get rich quickly. The end effect is the population reduction and soon wildlife to attract tourists to South Sudan will be extinct. Tourists bring foreign currency that our government may use to buy items like medicine and machinery to build roads and telecommunication infrastructure.

Overfishing occurs when more fish are caught than the population can replace through natural reproduction. This can happen by design (because of market demands) or because of mixed fishing; where when fishing one species of fish other species of similar size would be caught. The other fish could be premature therefore their removal from the natural reproduction cycle leads to a considerable decrease in the fish population. Overfishing may be controlled by:

- Selecting the correct mesh size and shape allowing immature fish to escape.
- Limiting the quantities of fish each fisherman can catch per day.
- Creating protected none fishing areas particularly the breeding grounds.
- Controlling the size and number of fishing boats.

Check your progress 3b

Studies of individual fish species such as Tilapia, indicate the age and size at which they reach maturity. Why is it better to catch Tilapia after they reach maturity rather than before? Suggest ways the South Sudan government can protect overfishing in the Jonglei State.

Use of pesticides and other agrochemicals

Agrochemicals include pesticides, insecticides, herbicides and fungicides meant to kill organisms the farmer does not want on her agricultural produce. When pesticides kill sometime they also kill other harmless organisms therefore destroying biodiversity, destroying the habitat of some organisms and destroying the food web members of some organisms.

ex-situ and in-situ conservation

The Earth Summit in Rio de Janeiro in 1992 required that all countries took the responsibility of implementing Biodiversity Action Plans (BAP). Therefore, all councils are required to prepare plans for conserving and enhancing local habitats and wild species. South Sudan is a Party to the Convention on Biological Diversity, which calls upon all Parties to develop and update in a timely manner national biodiversity strategy and action plan for conservation and sustainable use of biological diversity.

Remember

Biodiversity is the term used to describe all living things on Earth. It includes the diversity at species, genetic and ecosystem level.

Ex-situ conservation is the preservation of components of biological diversity outside their natural habitats. This involves conservation of genetic resources, as well as wild and cultivated or species, and draws on a diverse body of techniques and facilities.

In-situ conservation is the on-site conservation or the conservation of genetic resources in natural populations of plant or animal species, such as forest genetic resources in natural populations of tree species.

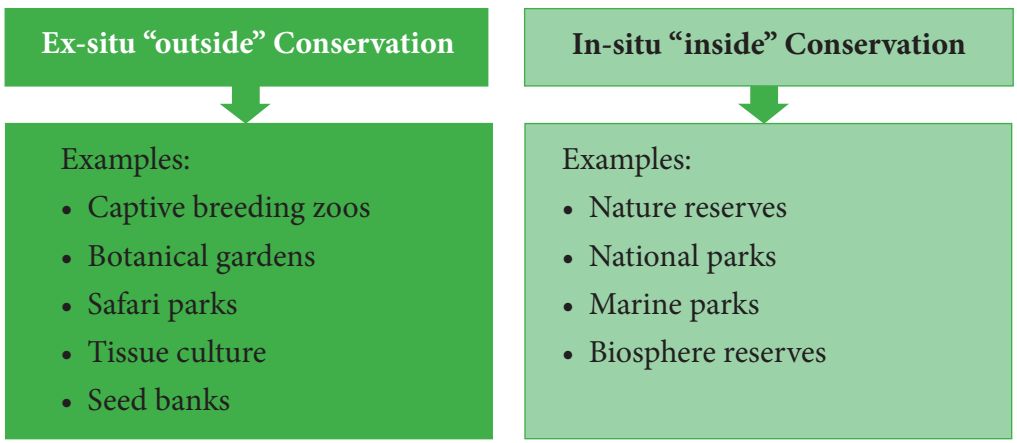


Fig. 3.9: In-situ and ex-situ conservation.

3.3 Environmental pollution

Group Activity 3.7

What do you observe in Figure 3.10? Suggest how the situations captured in the photographs can be prevented. What changes can be made in laws on environmental protection? Suggest how you may correct the situation.

Fig. 3.10: Images of environmental pollution in South Sudan.

The facts

Pollution is any process which leads to adverse harmful changes in the environment.

Types of pollution include:

- Air pollution
- Water pollution
- Soil pollution

Air pollution

Sulphur (IV) oxide produced from food processing industries causes respiratory diseases, and affects gaseous exchange. It combines with moisture and forms acid rain which falls and destroys plant leaves reducing the surface area meant for photosynthesis and also corrodes metallic rooftops of buildings.

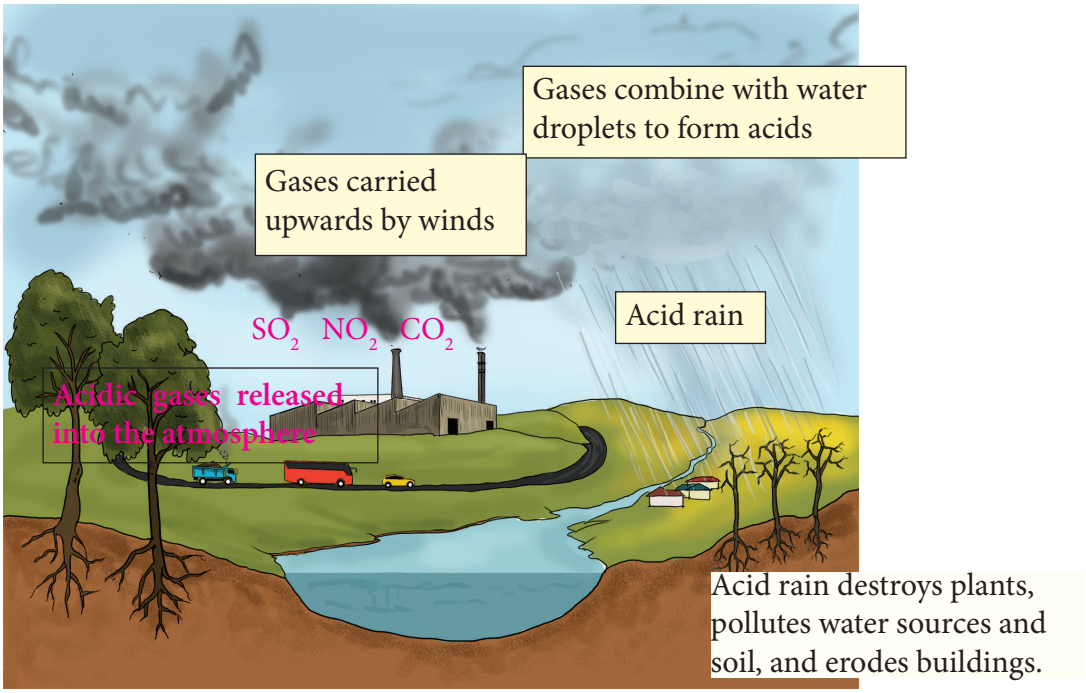


Fig. 3.11: Acid rain

Aerosols (including pesticides, fungicides, herbicides and acaricides) which are sprayed to control pests, diseases and weeds contain copper based chemicals that affect the respiratory system of animals by causing irritation and poisoning.

Chlorofluorocarbons (CFC's) produced for refrigeration and air condition units, destroy ozone layer. This increases filtration of radioactive rays from the sun, which in turn cause genetic mutation and sunburns or skin cancer.

Fig. 3.12: Chlorofluorocarbons

Smoke and **fumes**, produced in areas with heavy industries or motor vehicles that have incomplete burning of fuels contribute to environmental pollution. Smoke contains carbon (II) oxide, which reacts with haemoglobin and reduces its ability to carry oxygen, causing suffocation and finally death.

Fumes also settle on plant leaves surfaces hence reducing the rate of photosynthesis.

Fig. 3.13: Smoke and fumes from a car.

Excessive production of carbon (IV) oxide in smoke leads to increase of the greenhouse effect resulting into overheating of the Earth's surface

inhabited by living organisms, beyond the optimum levels for enzymatic reactions.

Sound produced nonstop form heavy machines, vehicles and airplanes, destroys the eardrum and this impairs hearing.

Dust produced in quarries, dusty roads, cement and limestone producing industries, settle on plant leaves and block leaf surface area meant for absorption of carbon (IV) oxide, hence lower the rate of photosynthesis.

Dust particles also get into the respiratory surfaces where they clog them reducing their efficiency.

Cutting down trees: This interferes with the carbon cycle, that is, carbon (IV) oxide accumulates in the atmosphere and causes temperature inversions that lead to thermal pollution.

Radioactive emissions from mines, atomic bombs, nucleus reactants, cause mutation or change genetic make-up.

Control of air pollution

- Industries and chemical factories to be built away from residential areas.
- Use of alternative sources of power apart from coals or charcoal (for example, wind or hydro electric power).
- Massive planting of trees to balance carbon (IV) oxide level in the atmosphere.
- Use of lead free fossil fuels.
- Filtration of waste gases to remove harmful gases.

Water pollution

Oil spills from oil tankers or broken oil pipes, when discharged into water bodies in large scale block oxygen penetration into the water, causing suffocation and death to aquatic life.

Fig. 3.14: Oil spills

Heavy oils also coat photosynthetic phytoplanktons and cause them to die since they cannot carry out photosynthesis. Heavy oils cause clogging of the gills of fish reducing their effectiveness.

Industrial wastes which contain elements like mercury, lead and cyanide are discharged into water. These elements are absorbed into the blood when taken in drinking water. Mercury interferes with the process of melanin formation, and causes poisoning in man resulting into blindness, paralysis and death. Some of these elements accumulate in the liver, kidney and bones where they reduce the physiological function of these organs. Tiny solid particles of industrial waste and surface run-off water clog gills of fish, causing death.

Agro chemicals such as fungicides and insecticides contain toxic elements like cyanide and lead which may find their way into man along food chains, for example, through eating fish. These cause toxicities and death when they accumulate to higher levels.

Untreated sewage from urban centres that get discharged into water bodies cause eutrophication, that is, increase in the fertility or nutrient contents in water bodies. This leads into certain effects, for example, algal blooms. Substantial reduction in amount of dissolved oxygen, due to rapid bacteria decomposition, thus result in suffocation and death of aquatic animals.

When oxygen concentration goes down due to heavy microbial activities most of microorganisms will respire anaerobically. This leads to production of carbon (IV) oxide due to rapid bacteria action. Thus, leading to increase in greenhouse effect in the water bodies. The result causes thermal pollution too and increases acidity in the water.

Heat production industries may discharge hot water directly into the water bodies. Hot water causes reduction in the amount of dissolved oxygen: This is because oxygen becomes lighter due to heating and evaporates. This then causes suffocation.

Control of water pollution

- Treat sewage and industrial wastes before discharge into water bodies.
- Use of biological control of insects and other pests.
- Use of safe methods of controlling pests and diseases, for example, cultural or mechanical controls.
- Use of organic farming.
- Educating all farmers on use of agrochemicals.

3.4 Climate change

Group Activity 3.8

With the help of your teacher, plan for an investigation on average daily temperatures in South Sudan.

The facts

Climate is commonly thought of as the expected weather conditions at a given location over time. Climate can be studied using geographic scales – for example, cities like Juba, countries like South Sudan, or the entire globe – by such data as average

temperatures, average number of rainy days, the average wind speeds, average wind direction and the frequency of droughts.

Climate change refers to variation in these statistics over many years, decades, or even centuries.

Mammoth advancement has been made in increasing our understanding of climate change and its causes, and a purer picture of current and future impacts is developing.

There are five vital signs of the planet's climate change. These are:

- Change in carbon (IV) oxide concentration.
- Change in global temperature.
- Change in arctic sea ice.
- Change in land ice.
- Change in sea level.

Any deviation of any of these five signs means the global climate is changing.

Group Activity 3.9

Supposing you were a lawyer and you were defending the Earth against destroying human charged in court. The Earth argues that humans caused the climate change that resulted in earth's destruction. What is the evidence that humans caused climate change? Create a courtroom complete with a judge, prosecutor and lawyers. Role play before the rest of the class.

The facts

Climate is driven by the sun's energy and controlled by natural processes and biogeochemical cycles in the Earth system.

Since 1880, scientists have been collecting data, and analysing and studying Earth's surface temperature using thermometers and a variety of satellite sensors at thousands of locations, on the land, over and under the currents of the oceans.

The study and analysis has shown that Earth's average surface temperature has increased by more than 0.8°C over the past 100 years, particularly in the last 35 years.

These satellite sensors have shown that there are greater climatic extremes, for example, heat waves are becoming more frequent, cold breaks are now shorter and milder, snow and ice cover are decreasing in the Northern and Southern hemisphere, glaciers and ice caps on mountains around the world are melting, and distribution of biodiversity is shifting to cooler latitudes or higher altitudes because it is too warm to stay where they are.

What causes global climate change?

Greenhouse effect causes climate change.
Increase of greenhouse gases therefore causing an increase in greenhouse effect.

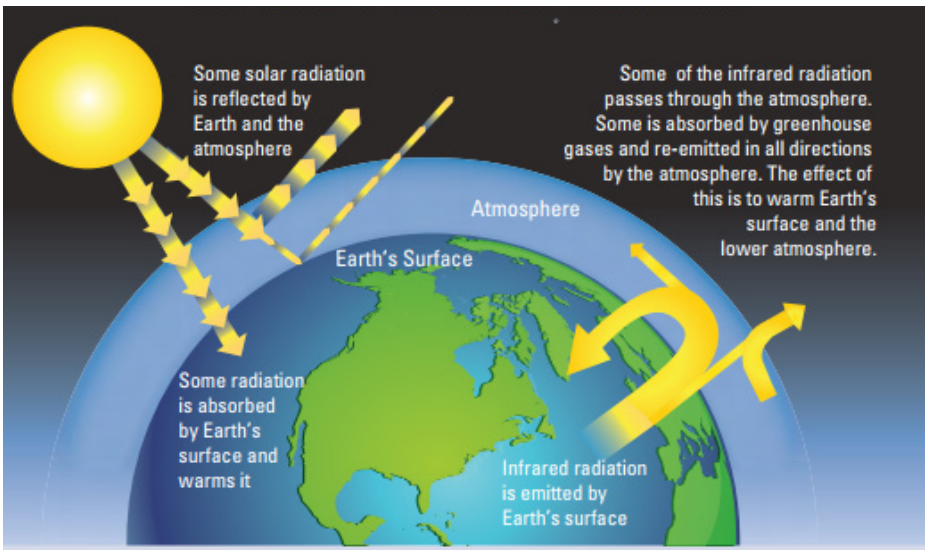


Fig. 3.15: The natural greenhouse effect.

The Earth's climate obtains its energy mainly from the sun. The sunlight is reflected by bright surfaces like ice and clouds which is called Earth albedo (a high albedo is desirable), and the rest absorbed by the Earth surface and atmosphere.

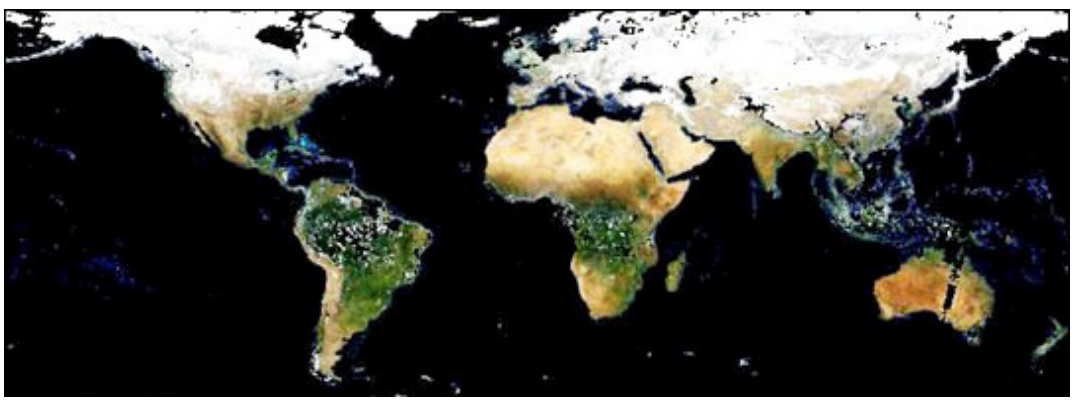


Fig. 3.16: Earth Albedo is the "whiteness" of the Earth's surface.

The Earth's surface re-emits solar energy as heat or infrared radiation or longwave radiation.

Some of the heat is absorbed by the atmosphere and re-radiated while some will escape to the outer space.

This balance could be offset by:

- Sun's energy output increase would increase Earth temperatures.
- Too much heat being lost to the outer space would lower the Earth's temperatures drastically.

Water vapour, carbon (IV) oxide, chlorofluorocarbons (CFCs), methane, and nitrogen (I) oxide are examples of greenhouse gases that trap heat in the atmosphere then emit it in all directions including back to the Earth's surface.

This is the greenhouse effect and in this respect, it is natural and "necessary evil".

Did you know?

More methane is produced by termites on Earth than it is produced by all the ruminant mammals.

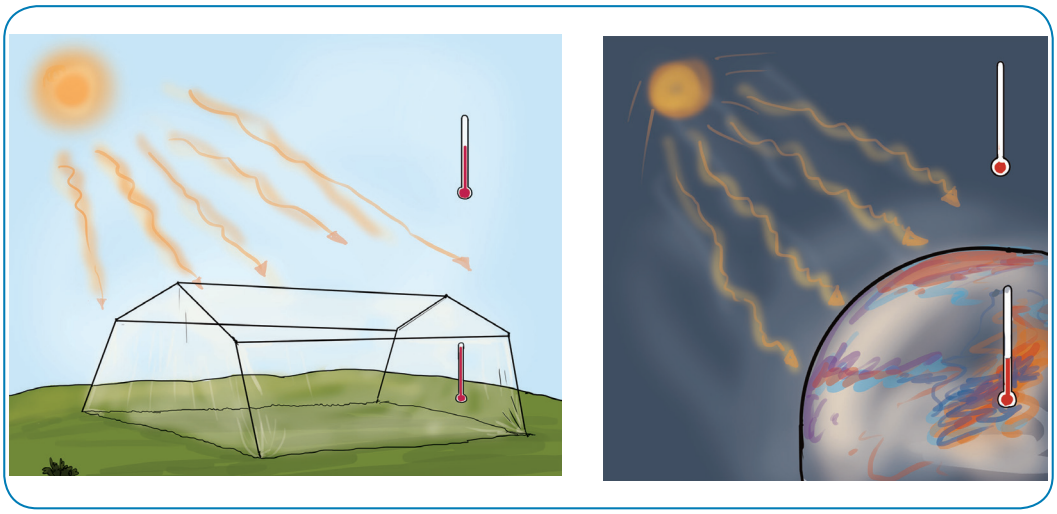


Fig. 3.17: Greenhouse effect analogy.

The life on Earth as we know it would not have evolved without the greenhouse effect. The concentration of greenhouse gases makes the atmosphere more effective in preventing heat loss into outer space. If the amount of solar radiation entering the Earth's atmosphere is more than amount lost, what would be the resultant effect?

Did you know?

Kyoto Protocol aims at stabilisation of greenhouse gas concentrations in the atmosphere by reducing the concentrations of four greenhouse gases namely: carbon (IV) oxide, nitrous oxide, methane and sulphur hexafluoride. On September 16, 1987, World nations agreed on the protocol.

Deforestation causes climate change

Land-use change alters the biodiversity therefore, the carbon stored in the vegetation is released into the atmosphere. Deforestation to pave way for land for agriculture is the main cause of destruction of biodiversity.

Sulphur aerosols and black carbon cause climate change.

Volcanic activities and industries release sulphates into the atmosphere. Black carbon is soot produced by incomplete combustion from industries, traffic, outdoor fires, and the burning of coal and biomass fuels.

Natural causes are insignificant in causing climate change.

Natural causes of climate change include changes in the sun's output and in Earth's orbit around the sun, volcanic

eruptions, and internal fluctuations in the climate systems (such as El Niño and La Niña). But scientific simulations of the contribution of natural causes to climate change even for 20 centuries yield very little climate change.

Impact of climate change

The following are the effects of climate change:

- Increased temperatures.
- Frequent extreme weather.
- Rising sea levels.
- Increased carbon (IV) oxide levels.

These four changes will lead to further changes in global and local stage. These include:

- Extreme heat leading to cardiovascular failure.
- Severe weather would lead to injuries and poor mental health.
- Air pollution would result in increase in Asthma cases.
- Changes in the disease vector ecology like more cases of mosquito transmitted diseases.
- Water quality would decrease and as a result waterborne diseases would increase.
- Water and food shortages are on the increase, therefore more cases of malnutrition.
- Environmental degradation means less grazing grounds and less fishing areas therefore, civil conflicts follow.

Did you know?

Increase in carbon (IV) oxide as a greenhouse gas is the single largest contributor to global warming.

Global warming and prevention measures

What could we do to slow global warming if we wanted to?

The facts

Theory of global warming

According to report by USAID, all projections agree that South Sudan will get warmer by an average of 1°C by 2060, with lower increases in the south.

Human beings are responsible for global warming is the stay of the global warming theory. Greenhouse gases in the atmosphere trap heat called greenhouse effect and keep the Earth's surface in an optimum temperature for all forms of living things. Accumulation of greenhouse gases in the atmosphere as a result of human activities has led to increased warming of the Earth's surface called global warming, which is a heightened greenhouse effect.

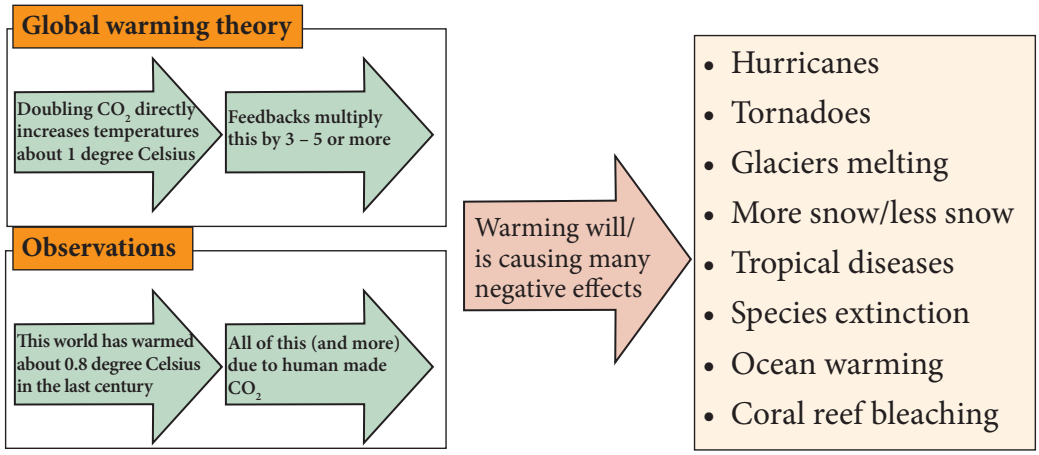


Fig. 3.18: Global warming theory.

Combustion of fossil fuels and deforestation as well as use of natural gas may double the quantities of carbon (IV) oxide in the atmosphere in about 100 years to come.

Check your progress 3c

What assumption(s) does the global warming theory make?

Global warming is the increase in the surface temperatures of the Earth.

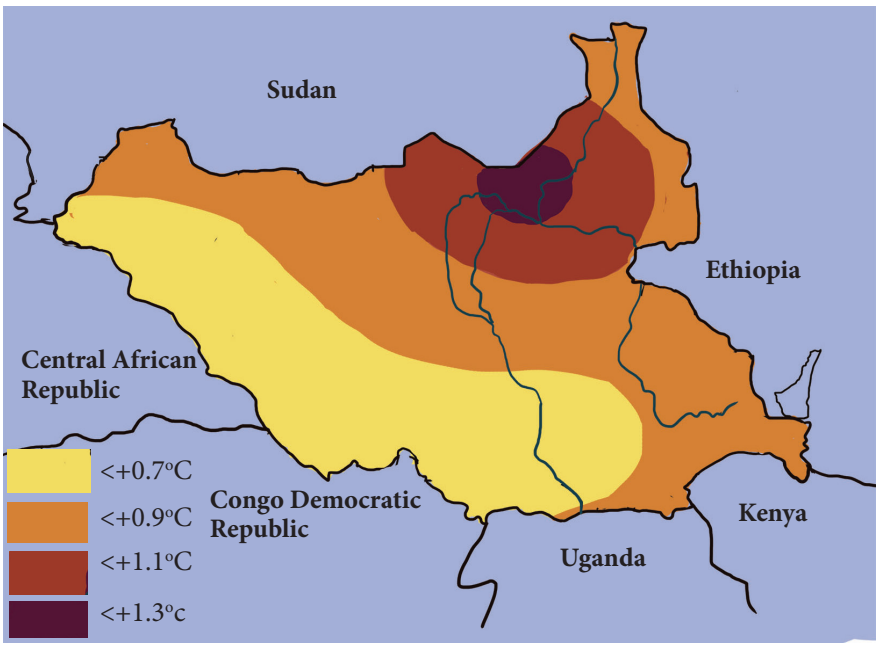


Fig. 3.19: South Sudan's global warming predictions.

The predicted effects of global warming are already happening, for example:

- Glaciers are melting and reducing in size leading to flooring in the river valleys.
- Snow cover is reducing in winter.
- Tree lines are shifting towards the poles and upwards towards the mountain tops.
- Spring season will start earlier meaning a shorter winter season.
- Biodiversity is shifting towards to poles and mountaintops.
- The ocean heat content increases resulting in increase in incidences of coral reef bleaching, destroying lives of photosynthetic organisms supporting the ocean food webs, therefore loss of marine life and sources of human livelihoods too.
- Sea ice reduces.
- Sea surface temperature increases.
- Sea levels increase, resulting to floor the sea shores and all sea level areas. How do you think this would affect life around the Sudd Swamp?
- Ice sheets reducing in the northern pole.
- Air temperatures increase near the Earth-land surface.
- Air temperatures increase over the ocean's surface.
- Relative humidity increases too.

Specifically, for South Sudan an increase by average temperature of 10°C will:

- Increase the unpredictability of seasonal rains.
- Increase intensity of rainfall storms.
- Increase the length and frequency of droughts.

These three effects will be felt in South Sudan in the following ways:

- Increased crop failure because of desertification.
- Loss of grazing lands and water for livestock, therefore, more conflicts among the pastoralists.
- Reduction in biodiversity habitats in wetlands and forests.
- Reduction in water flowing in the rivers, therefore, dry water beds.
- Few suitable habitats for wildlife, therefore, reduction of tourism to the country.

Check your progress 3d

1. What would happen if there was no greenhouse effect on Earth?
2. What are the four main greenhouse gases in the atmosphere?
3. What do you predict would happen if more greenhouse gases are added to the atmosphere?
4. What human activities add greenhouse gases to the atmosphere?
5. How will the increasing temperature impact other things on Earth?
6. What can you do to help reduce greenhouse gas emissions?

Did you know?

The increase of carbon (IV) oxide concentration in our atmosphere is the result of human activities like, deforestation, fossil fuel use, cement production, paddy rice production, keeping ruminants, natural gas use, use of nitrogen based fertilisers, farming, refrigerators and fire extinguisher chemicals.

Methods of dealing with global warming

Group Activity 3.10

Using computers or phones, please visit this site: https://www.conserve-energy-future.com/stopglobalwarming.php

Read and in your own words and in reference to your own home or school area list 10 actions you will take to prevent more global warming.

Present your action plan with the group members.

How else would you educate the public about global warming and their roles to prevent it?

The facts

The future without global warming

What if global warming does not occur, what would be the consequences of taking the above actions?

Natural greenhouse effect has been around since the planet was moulded and has supported life for millions of years. Greenhouse gases have been in our atmosphere. Minus them, the Earth would be too cold for all living organisms, including you. Naturally occurring greenhouse gases, like carbon (IV) oxide and methane gas, allow sunlight to reach the Earth's surface, while trapping infra-red radiation from the Earth on its way back out to space.

The trapped heat warms the Earth's surface to about 35°C warmer than a freezing atmosphere.

If humans beings stopped the production of CO_2 completely, it would take many thousands of years for atmospheric CO_2 to return to 'pre-industrial' levels due to its very slow transfer to the deep ocean and ultimate burial in ocean sediments.

Earth's surface temperatures would remain high for thousand years, suggesting enormously long-term vow to a warmer planet due to past and current emissions, and sea level would likely continue to rise for many centuries even after temperature stopped increasing.

Significant cooling would be required to reverse melting of glaciers and the Greenland ice sheet, which formed during past cold climates.

The present CO_2-induced warming of the Earth is, therefore, fundamentally irreversible on human lifespan.

The quantity and rate of further warming will depend almost entirely on how much more CO_2 people emit.

Ozone layer and human activities

How do human activities affect the ozone layer?

Group Activity 3.10

In your groups describe the graph below. What do you see? What does that mean? Suggest the human activities that contribute to the variations in the graph.

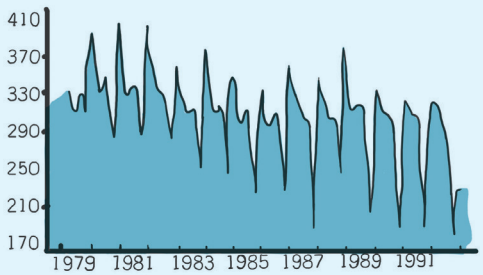


Fig. 3.20: Ozone layer depletion graph.

The facts

The Earth's atmosphere has three main problems: ozone layer depletion, acid rain formation and greenhouse effect.

Ozone layer is a layer in the Earth's atmosphere containing a high concentration of trioxide (O_3). There are two types of ozone layers: high-level ozone (stratosphere ozone or protective ozone) and low-level ozone (ground level or troposphere ozone or harmful ozone).

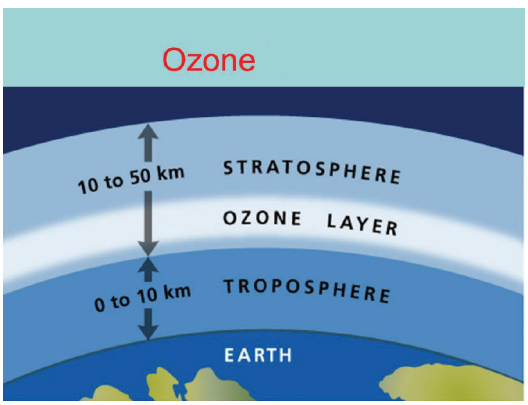


Fig. 3.21: Earth's atmosphere.

Over Antarctica, there have been found (in 1985) holes in the high-level ozone layer that are thought to be caused by the action of chlorine from CFCs.

Chlorine + Ozone ⟶ Chlorite + Oxygen

The high-level ozone depletion increases with each chlorite released.

Reduction of high-level ozone exposes biodiversity to harmful ultraviolet radiation from the sun. This increases the risk of skin cancer, cataracts, mutations, as well as sunburns.

Ozone depletion preventive measures

To reduce destruction of the high-level ozone layer, reduce or eliminate the production and use of CFCs by developing alternatives, because CFCs have low-biodegradability.

Individual efforts include avoiding using products containing chlorofluorocarbons; do not buy chlorofluorocarbon products.

National efforts include government of South Sudan should ban chlorofluorocarbons. The government of South Sudan should encourage the use of chlorofluorocarbons free products. Government should also sign international agreements on reducing ozone depletion.

Global efforts include the Montreal Protocol signed as an international agreement by many countries in 1987. The treaty aims to reduce the use of chlorofluorocarbons and stop using it completely by 2000. USA and 12 countries in Europe agreed to stop using chlorofluorocarbons in 2000.

Did you know?

If your shadow is taller than you are (in the early morning and late afternoon), you are probably getting less UV exposure.

If your shadow is shorter than you are (around midday), you are getting higher levels of UV radiation. Seek shade and protect your skin and eyes.

Global warming control

How could global warming be controlled?

Group Activity 3.11

"Healing the planet starts in your car garage, in your kitchen and at your dining room table." Write an essay to explain these words. Present your essay before the class. This link might help you: http://globalwarming-facts.info/50-tips/2/

The facts

- Global warming is primary because of greenhouse gases, therefore, reduce burning of fossil fuels and natural gas and instead use renewable energy sources.
- Also, reduce of cutting of trees for agricultural activities such as keeping ruminants and growing paddy rice.
- Expand the use of renewable energy and transform our energy system to one that is cleaner and less dependent on coal and other fossil fuels.
- Increase vehicle fuel efficiency and support other solutions that reduce South Sudan fossil fuel use.
- Place limits on the amount of carbon that polluters are allowed to emit.
- Build a clean energy economy by investing in efficient energy technologies, industries, and approaches.
- Reduce tropical deforestation while increasing tree planting.
- Move near your workplace or work from home to reduced reliance on cars.
- Investing in new infrastructure. Bad roads can lower the fuel economy of even the most efficient vehicle.
- Build more efficient buildings requiring less air conditioning.
- Improved power plant efficiency and transmission of power to end users.
- Substituting natural gas for coal to reduce black carbon emission.
- Promote the use of nuclear energy to generate electricity.
- Development in the use of wind power.
- Use of solar photovoltaic power.
- Use of biofuels.
- Agricultural soils management.

Check your progress 3e

Suggest ways of deaking with environmental pollution and climate chage in your locality.

Unit 4

Respiratory system and exchange with the environment

Learning outcomes		
Knowledge and understanding	**Skills**	**Attitudes**
• Explain the structure and function of the respiratory systems in animals and its role in exchange between organisms and the environment.	• Investigate the process of aerobic and anaerobic process of respiration and the effect of temperature. • Observe and compare the structures of respiratory systems of humans, frogs, fish, among others.	• Appreciate the role of respiration in living organisms. • Appreciate how organisms produce energy

4.1 Respiration

Group Activity 4.1

Given that composition of inhaled and exhaled air as tabulated in Table 4.1 below, design a bar chart to compare the inhaled and exhaled air.

Table 4.1 Composition of inhaled and exhaled air

Substance	Inhaled air (%)	Exhaled air (%)
Nitrogen	78	78
Oxygen	21	16
Carbon (IV) oxide	0.39	4

(a) What do you observe from the bar chart?

(b) Describe what that observation means?

(c) How would you demonstrate that what your bar chart shows is true?

The facts

In Biology, the term "respiration" may mean one of two biological processes, therefore we will consider both, namely the internal or cellular respiration and external respiration involving gaseous exchange.

Types of respiration

Internal or cellular respiration is the chemical process of releasing energy in the cell occurring in the presence of oxygen (aerobic respiration) or in the absence of oxygen (anaerobic respiration).

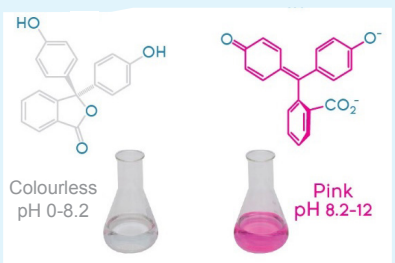
External respiration or gaseous exchange or breathing is the process of transferring oxygen and carbon (IV) oxide across the respiratory surface to and from blood respectively.

Practical Activity 4.1

You should have prerequisite knowledge from Chemistry on acidic/alkaline reactions, reaction of carbon (IV) oxide in water, pH levels and acidic/alkaline reactions with phenolphthalein solution.

Requirements per group of five learners

- 5 big balloons
- 2 conical flasks of 250 ml
- 2 straws
- 1 bicycle pump
- 10% KOH (potassium hydroxide) in a test tube
- 2 droppers
- Phenolphthalein indicator in a test tube



A *B*

Fig. 4.1: Phenolphthalein in lower and higher pH conditions.

Procedure

1. Take two conical flasks and put 200 millilitres of water into both.
2. Add 20 drops of 10% KOH to both conical flasks using a dropper.
3. Add 20 drops of phenolphthalein solution and stir it with a straw.
4. Label the beakers as A and B.

   What are you trying to investigate with this experiment?
5. Each of you, blow air through your mouth into the balloons until they are full.
6. Fix the mouth of the balloon to one end of a straw while the other end is in conical flask A.
7. Release the air into the straw.

   Repeat this process for every member of the group.
8. Write down what you observe. Explain the reason for your observation.
9. Using the bicycle pump, pump fresh air into conical flask B.
10. Write down what you observe.
    - Explain the reason for your observation.
    - Compile a group report and present it to the rest of the class highlighting:
      - What you have learned from this experiment.
      - The precautions you took into considerations during the experiment.

- The assumptions that you made in the experiment.
- Compare your findings in this experiment with your observations in Group Activity 4.1.

The facts

Respiratory systems in animals

1. Investigate the structure of respiratory systems in animals such as fish, frogs, insects and mammals, with an emphasis on human respiratory structures.
2. Understand the role of respiration as gaseous exchange with the environment.

Gas exchange surfaces or respiratory surfaces

The most important component of respiratory system in animals is the respiratory surfaces because it is a transfer point of oxygen and carbon (IV) oxide between the environment and the cells.

Examples of respiratory surfaces:

- In fish, they are **gill filaments.**
- In frogs, they are the **skin**, **mouth lining** and **lung alveoli** in adult frogs and gills in tadpoles.
- In insects, they are the **tracheoles**.
- In human beings, they are the lung **alveolis**.

Work to do

Explain the adaptations of the gill to its function.

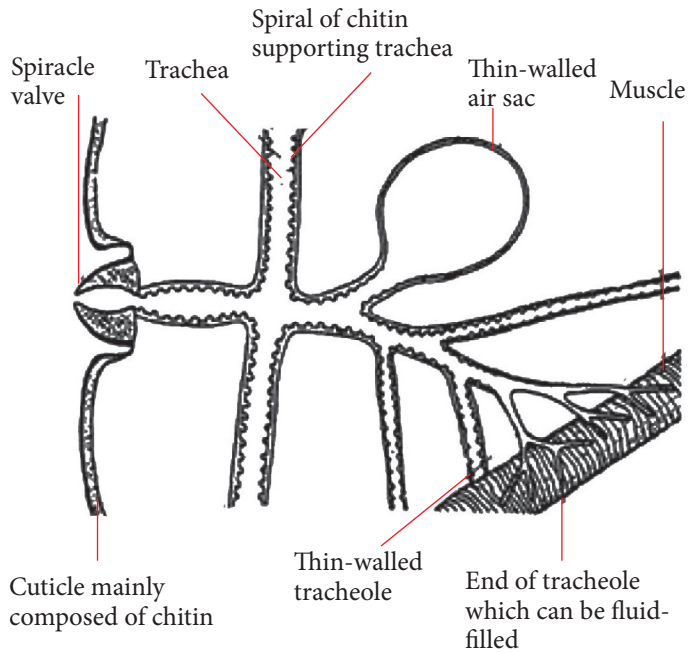


Fig. 4.2: Tracheole of insects.

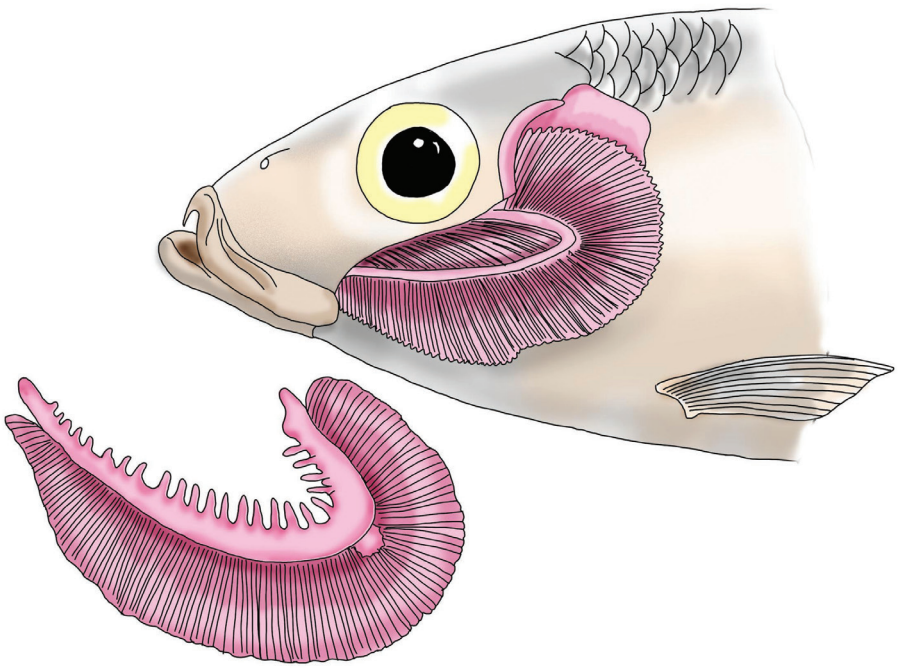


Fig. 4.3: Gill filaments of fish.

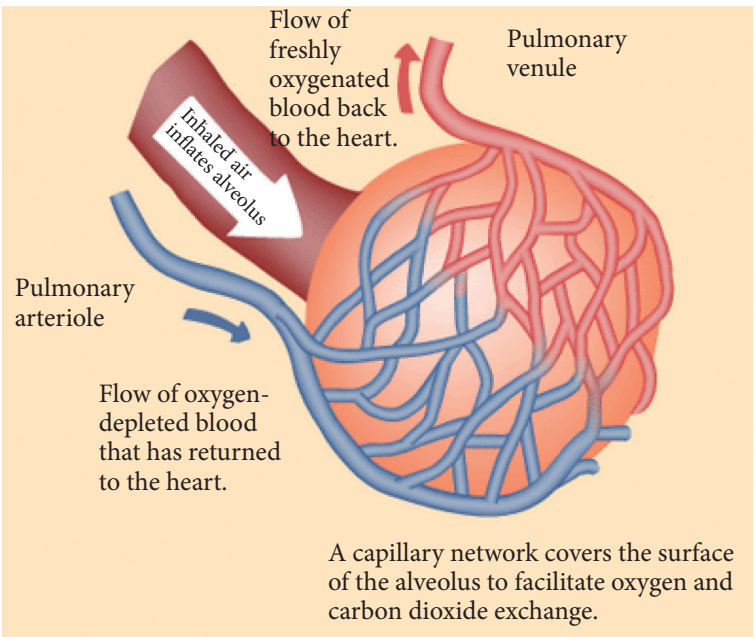


Fig. 4.4: Alveolus of human beings.

Fig. 4.5: Tadpole showing external gills.

The facts

Characteristics of respiratory surfaces

- Provide a large surface area for gaseous exchange.
- Moist and permeable surfaces.
- Highly ventilated.
- Highly **vascularised**.
- One cell thick squamous epithelium.
- Close association with respiratory pigment.

Practical Activity 4.2

Requirements

- A grasshopper
- Specimen bottle
- A hand lens

Procedure

1. Catch a grasshopper from the field.
2. Put it in a specimen bottle.
3. Using a hand lens, observe how it is breathing in and out.
4. Release the grasshopper back to its environment.

Gaseous exchange system of insects and its functions

When the spiracle valves open, air containing oxygen is drawn into the tracheal system due to low pressure created as a result of relaxation of the abdominal muscles resulting in an increase in abdominal volume.

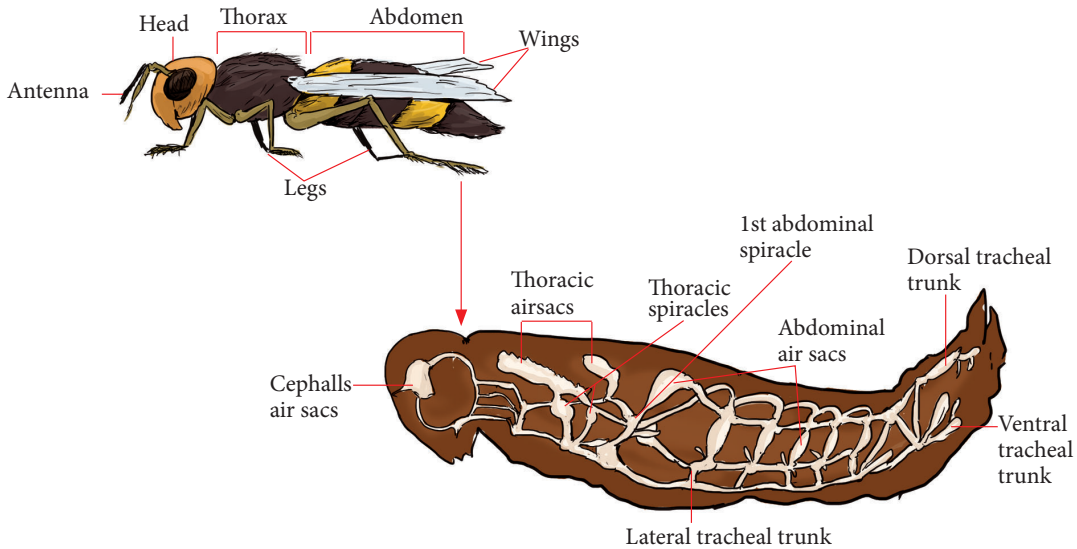


Fig. 4.6: Inhalation and exhalation in insects.

When the spiracle valves close, oxygen is forced along the tracheal system due to contraction of abdominal muscles and into the air sacs and into the tracheoles. Gaseous exchange takes place in the tiny tracheoles which are in direct contact with tissue fluid. Oxygen diffuses into the tissue fluid through a concentration gradient, while carbon (IV) oxide diffuses into the tracheoles where it is in lower concentration, then diffuses to the tracheae and is expelled through the spiracles as a result of movement of abdominal muscles. If the tracheoles are supplying a muscle, the fluid located inside tracheoles at rest is withdrawn into the surrounding tissues when the muscle is active. This occurs when the muscle respire anaerobically producing lactic acid which increases the osmotic pressure of the tissue fluid in the muscle, so water is drawn out of the tracheoles by osmosis. This increases the rate of diffusion of oxygen into the muscle cell.

Adaptations of the tracheal system to its functions include spiracle valves can open and close to prevent water loss if air is dry. Spiracles have hairs or spines in the opening of the tracheae just inside the spiracle, to trap dust ensuring clean air gets inside the tracheal system. The tracheal walls are spirally thickened with chitin which supports the tracheae keeping them open and allowing faster air diffusion, if the air pressure inside is reduced.

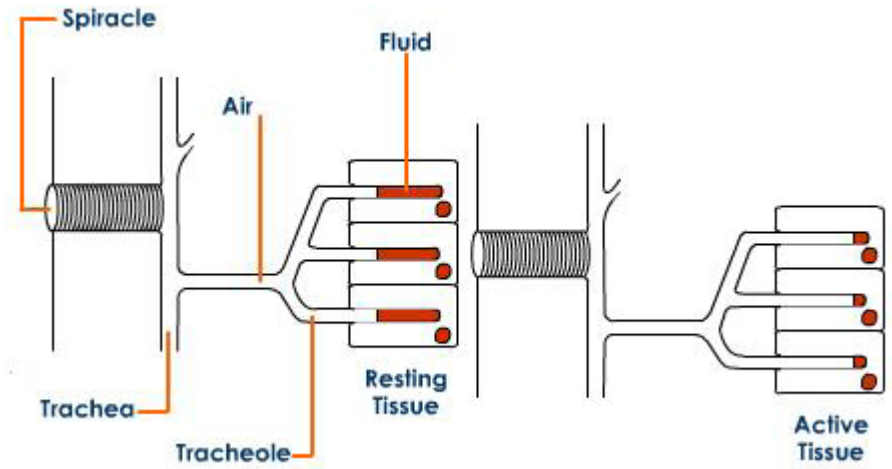


Fig. 4.7: Tracheole of when the insect is active and when resting.

The tracheal system is extensive spreading to every tissue, close to each cell. This reduces the distance the air has to diffuse to get to respiring cells. Tracheoles penetrate into every tissue up to the cell membrane, reducing the distance of diffusion. Tracheoles are very small and numerous increasing the gaseous exchange surface area. Tracheoles, internal surfaces are moist to dissolve oxygen before diffusion into the cell occurs. Tracheoles, walls are thin reducing the distance of diffusion and increasing the rate of **diffusion**. The removal of the fluid from the end of the tracheoles speeds up the rate at which oxygen can diffuse along it.

The facts

Gaseous exchange system of a frog and its functions

Practical Activity 4.3

Requirements

- A frog
- A hand lens
- Specimen bottle

Procedure

1. With the help of your group members, catch a frog and put it in a specimen bottle.
2. Observe the frog's breathing in and out.
3. Release the frog back to its environment.
4. Explain the behaviour of the mouth as the frog breathes in and out.

The gaseous exchange system in frogs consists of,

- The moist skin.
- Mouth cavity.
- The lungs.

The skin: Oxygen in the atmosphere dissolves into the moist, thin skin and diffuses into the dense blood capillary network below the skin. Due to its lower concentration in the blood than on the skin surface, oxygen is then transported to tissues through the red blood cells. Carbon (IV) oxide transported from the tissues diffuses into the skin's surface and into atmosphere from the blood due to its higher concentration in the blood than on the skin surface.

Fig. 4.8: Moist frog skin.

Mouth cavity: Muscles of the mouth contract to lower the floor of the mouth, reducing its pressure lower than the atmospheric pressure: Air then moves in through the open nostrils into the mouth where gaseous exchange takes place in the dense blood capillary network in the mouth cavity. Oxygen diffuses into the blood and is transported by the red blood cells to tissues, while carbon (IV) oxide diffuses from the blood into the mouth cavity, where it is in lower concentration, and it is exhaled through the open nostril when the floor of the mouth is raised.

The lungs: Muscles of the mouth contract and lower its floor. The volume in the mouth cavity increases, reducing the cavity pressure in the mouth than in the atmospheric pressure. Air rushes into the mouth cavity through the nostril due to the reduced pressure. The nostril close and the floor of the mouth is raised to force air into the lungs.

Fig. 4.9: Lungs of a frog.

Gaseous exchange takes place between the alveoli and the blood. Oxygen diffuses into the blood where it is in lower concentration, while carbon (IV) oxide diffuses into the alveoli where it is in lower concentration, and is exhaled through the nostril by the force of the flexible lungs as they contract and relax.

Did you know?

There is a frog *Barbourula kalimantanensis*, in Borneo Indonesia that has no lungs and breathes entirely through its skin.

The facts

Gaseous exchange in the gills of a bony fish

The mouth opens and the floor of the mouth cavity is lowered by muscular contraction during inhalation. This increases the mouth cavity volume, and reduces mouth cavity pressure. As a result, water flows into the mouth. Meanwhile, each enclosed operculum on either side of the mouth bulges outwards to cause reduction of pressure and increase in volume of the gill cavity, so that water containing dissolved oxygen flows from the mouth cavity to the gill chamber over the gill filaments and **gill lamellae**.

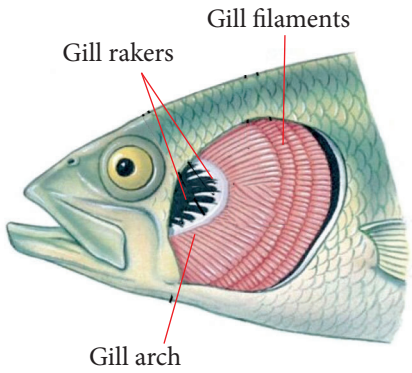


Fig. 4.10: Gills in fish.

The mouth then closes and the muscles contract to raise the floor of the mouth cavity, reducing cavity volume and increasing the cavity pressure. When this is happening, the higher external pressure presses the operculum against the side of the mouth. In this case, each operculum acts as a valve to ensure that water enters only through the mouth. This forces the remaining water in the mouth to flow towards the gill chamber.

Water entering the mouth has a higher concentration of oxygen which diffuses from the water flowing over the gill filaments and gill lamellae into the blood, through the thin walls of blood capillaries and **gill epithelium.** Oxygen absorbed combines with **haemoglobin** in fish blood flowing in the opposite direction to maintain a high concentration gradient, and is then transported to other parts of the body.

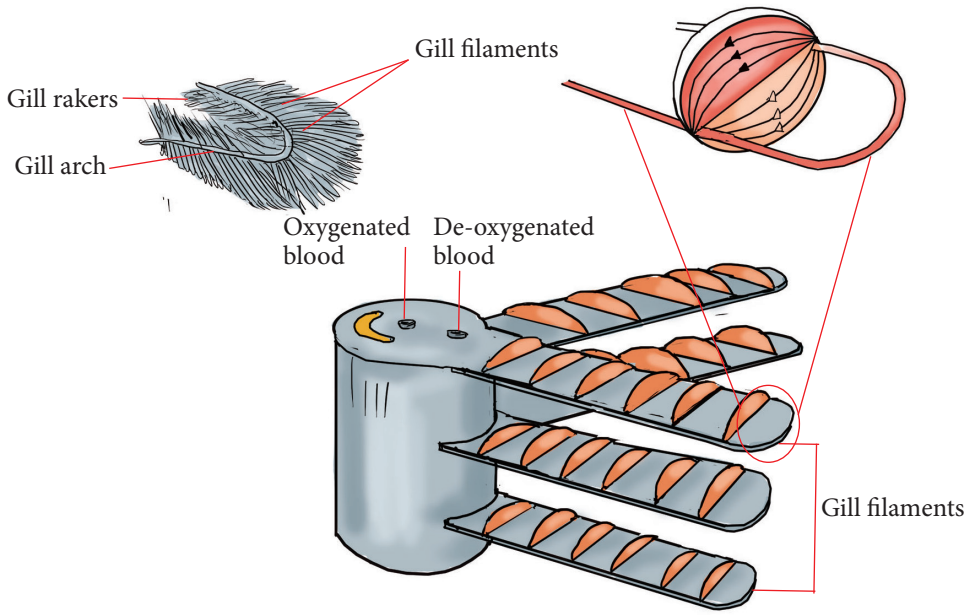


Fig. 4.11: Flow of water over the gill lamellae.

Gills are highly vascularised to maintain a high concentration gradient in favour of oxygen diffusing into the blood and carbon (IV) oxide diffusing out. The gill filaments are thin. This reduces the distance of diffusion of the gases. Bony gill arches provide support to gill filaments. Gill rakers are bony hair-like projections on the gill bar used to filter out and prevent solid particles from entering the gills hence avoiding clogging and mechanical damage. Gill filaments are numerous and bear gill lamellae to increase surface area for gaseous exchange.

The facts

Human respiratory system and its functions

The **nostrils** have goblets cells secreting mucus, which trap dust particles and pathogens, therefore cleaning the inhaled air. The nostrils also clean the air by filtering using nostril hairs.

The sinuses are moist to moisten the dry inhaled air. The nostrils have numerous capillaries to warm up the cold inhaled air. The epitheliums of nostrils have olfactory cells to detect harmful chemicals in the air. The inner passages of airways is lined with mucous membrane, which contains **ciliated epithelium. Cilia** movement to and from cause a sweeping action of dust particles and pathogens towards the pharynx, for swallowing, hence preventing their entry into the alveoli. The mucous membranes of the trachea and bronchial tubes, contains goblet cells, which produce mucus, to trap dust particles and pathogens and prevent them from finding their way into the airways.

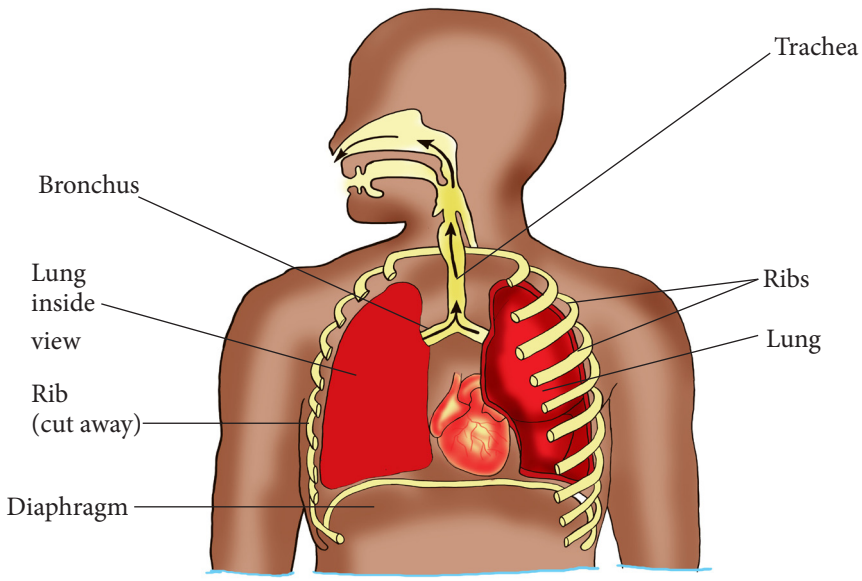


Fig. 4.12: Human respiratory system.

The **mucous membranes** are well served with blood capillaries, which keep the incoming air warm. The mucous membranes are moist, to moisten the air therefore preventing the drying of alveoli internal surface. The **epiglottis** on top of the trachea,prevents food, drinks and other solid particles from going in the trachea during swallowing.

The lung has numerous alveoli that provide a large surface area for efficient gaseous exchange. Epithelial lining between alveoli walls and blood capillaries is one cell thick (thin)S, to reduce the diffusion distance, therefore increasing diffusion rate and rate of gaseous exchange. The lungs are spongy, and have numerous alveoli that accommodates large volume of gases (oxygen). It is highly vascularised, ensuring a large concentration gradient in favour of gaseous exchange.

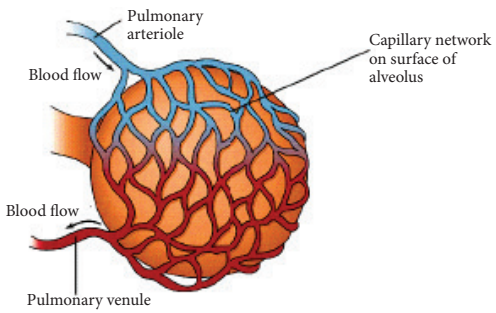


Fig. 4.13: Capillaries surrounding alveolus.

Its epithelial lining is covered by a thin layer of moisture or water film, to dissolve oxygen for easy diffusion in the blood plasma and red blood cells.

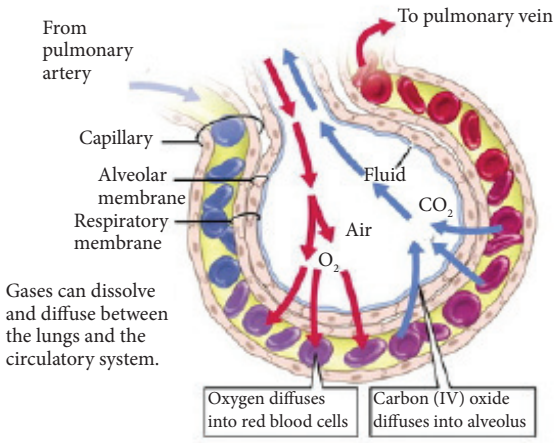


Fig. 4.14: Gaseous exchange between alveolus and capillaries.

The lung is connected to tree-like system of tubes, (the trachea and bronchi/ bronchioles), that supply oxygen and remove carbon (IV) oxide from the lungs. The whole lung is covered with the pleural membrane which is air tight thus changes in pressure within the lungs can occur without external interference.

The facts

How does carbon (IV) oxide that is produced in the leg muscle cell of human reach the atmosphere?

Carbon (IV) oxide dissolves in the plasma, enters the red blood cells, where it reacts with water to form **carbonic acid** which dissociates into **hydrogen carbonate.** It is transported as hydrogen carbonate, or it combines with haemoglobin to form **carbaminohaemoglobin** and is transported as carbon (IV) oxide, then diffuse from across the capillary and alveolar walls, where it dissolves into the thin water film/moist alveoli lining, and hence to the alveoli air filled cavity, from where it is forced out during expiration, through the bronchioles, bronchi, the trachea and finally out through the nasal/buccal cavity, to the atmosphere.

Cellular respiration

Remember

Combustion is an oxidation reaction of carbon and oxygen.

Cell cytoplasm consists of cytosol and organelles.

Functions of the mitochondria include provision of energy in form of Adenosine Triphosphate (ATP).

Group Activity 4.2

What do you observe in Figure 4.15? What are the requirements for the wood to burn?

Fig. 4.15: Wood burning.

What types of energy would you observe if you were the one that started this fire?

What types of energy transformations are occurring as the wood burns?

Suggest the type of molecules burning in the wood.

Suggest how the burning wood molecules compare with glucose in your body cell cytoplasm.

Would you put your finger in the fire? Why?

What is the difference between the carbon molecules in wood burning to provide energy and the carbon molecules called glucose being broken down to provide energy?

The facts

What is cellular respiration?

The difference between combustion of carbon molecules in wood and breakdown of the carbon molecule called glucose in the cytoplasm of your body cells is a process called cellular respiration.

Cellular respiration is an enzyme controlled process occurring in all cells to breakdown glucose (containing chemical energy) and release energy in form of biological energy molecules called Adenosine Triphosphate, carbon (IV) oxide and water. Cellular respiration occurs in the fluid part of the cytoplasm called cytosol and in the cell organelle called the **mitochondrion** (plural: mitochondria).

$$\text{Glucose + Oxygen} \xrightarrow{\text{enzymes}} \text{Carbon (IV) oxide + water + energy}$$

$$C_6H_{12}O_6 + 6O_2 \xrightarrow{\text{enzymes}} 6CO_2 + 6H_2O + \text{energy}$$

Cellular respiration may occur in the presence of oxygen in a process called **Aerobic respiration** or may occur in absence of oxygen in a process called **Anaerobic respiration**. Respiration is also called **tissue/internal respiration**.

Group Activity 4.3

1. Continually clench and unclench both fists with one arm drawn by your side and the other raised in the air.
2. Explain why the arm that is raised aches while the other arm does not.

The facts

Importance of energy in living organisms

Why is energy important in the lives of living organisms?

Energy is needed by living organisms so that they can carry out all metabolic processes which include catabolic processes and anabolic processes. These processes include;

- **Movement and locomotion:** which involves muscle contractions when moving limbs and **chemotaxis** of organisms. Movements to find food, mates and shelter require energy too.
- **Reproduction:** This is the process of **meiotic cell division** to form **gametes.** The movement of gametes uses energy.
- **Nutrition:** This involves processes like churning of food in the stomach, chewing of food, absorption process, peristalsis, and synthesis of enzymes, which use biological energy.
- **Irritability:** Active transport of substances across cell membranes result in coordination movements like nerve **impulse** conduction, **nastic movements** in plants, and tropisms.
- **Growth and development:** Formation of new cells in the process of mitotic cell division, and synthesis of proteins from amino acids.
- **Excretion and Homeostasis:** This involves maintaining constant body temperature in homeotherms so that enzymes have optimum temperature to function in, removal of metabolic waste products like the process of deamination in the liver.
- **Respiration and gaseous exchange:** Even the process of energy transformation requires energy for it to proceed. Breathing in and out require contraction of intercoastal muscles and diaphragm muscles.

The facts

Importance of respiration

Why is respiration essential in living organisms?

Adenosine Triphosphate is the energy currency of the cell. Respiration is the process that produces most of the Adenosine Triphosphate abbreviated as ATP. All cell activities, like active transport, require energy in form of ATP. It is the only way a cell can utilise energy. During aerobic respiration, each molecule of glucose yields a total of about 38 molecules of ATP molecules. This is an equivalent of 1,178 kJ (one molecule of ATP is equivalent to 31 kJ). The heat energy is released little by little, in stages to prevent sudden overheating of the cells.

Glucose is an energy-rich molecule but it is a chemical energy that the cell cannot utilise until respiration transforms the energy into biological energy molecules. Respiration process packages energy in quantities that would not destroy the cell when released. Combustion of glucose would release energy in quantities harmful to the cell.

There are two types of respiration, namely aerobic and anaerobic respiration.

The facts

Process of respiration

The breakdown of glucose, catalysed by respiratory enzymes takes place in many steps.

While some of the steps use energy,

others release energy and therefore ATP is synthesised.

The steps may be categorised into three stages, namely **glycolysis** (splitting a glucose molecule into two pyruvate molecules), **Krebs cycle or citric acid cycle, and electron transport system stage.**

Glycolysis is the only stage that is common to both aerobic respiration and anaerobic respiration.

Glycolysis

Glycolysis occurs in the cell cytosol which is the fluid part of the cytoplasm.

Glycolysis is the breakdown of a glucose molecule into two pyruvate molecules (pyruvic acid) and production of 2 ATP molecules.

The first step of this process requires energy as ATP to increase the free energy of the glucose molecule and convert it into fructose-1,6-diphosphate.

This is called **phosphorylation**. This molecule has two phosphate groups and six-carbon atoms, therefore, it can be broken down into two molecules of 3 carbon sugar each also called triose sugar. The two triose sugar molecules are converted into **pyruvic acid**.

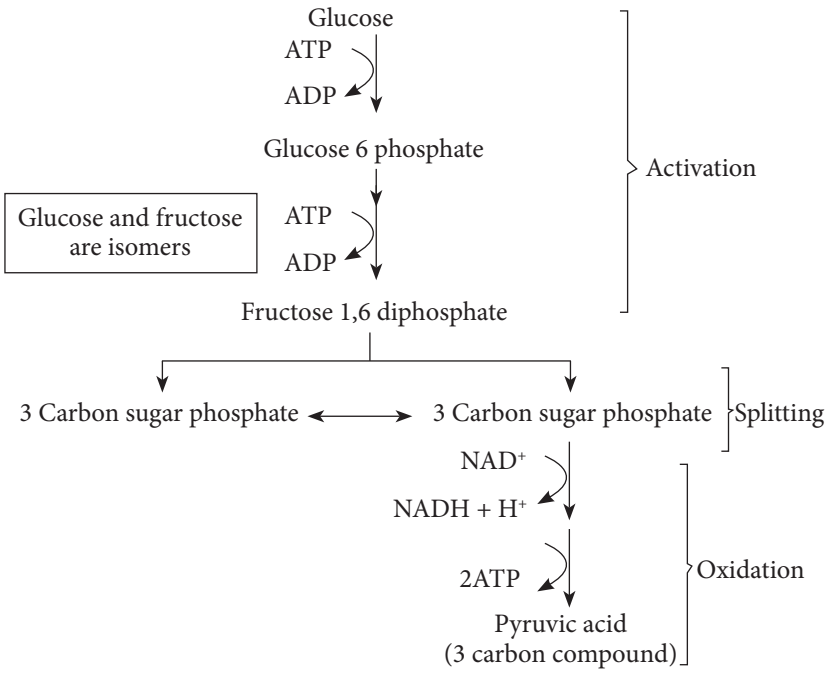


Fig. 4.16: Glycolysis flowchart.

Glycolysis produces four ATP molecules and uses two ATP molecules therefore the net ATP production is two molecules and synthesis of two molecules of nicotinamide adenine dinucleotide hydrogen (NADH). Nicotinamide adenine dinucleotide is a hydrogen acceptor or carrier transferring the hydrogen ion to the electron transport system in the mitochondria.

The fate of pyruvic acid is depended on the availability of oxygen. If oxygen is present, pyruvic acid is converted into a 2-carbon compound called **acetyl coenzyme A**. It can then proceed to the Krebs cycle inside the matrix of the mitochondrion.

If oxygen is absent, then pyruvic acid under goes anaerobic respiration without further energy production. In human muscles and other animals, anaerobic respiration produces lactic acid, whereas plants and yeast cells produce ethanol and carbon (IV) oxide.

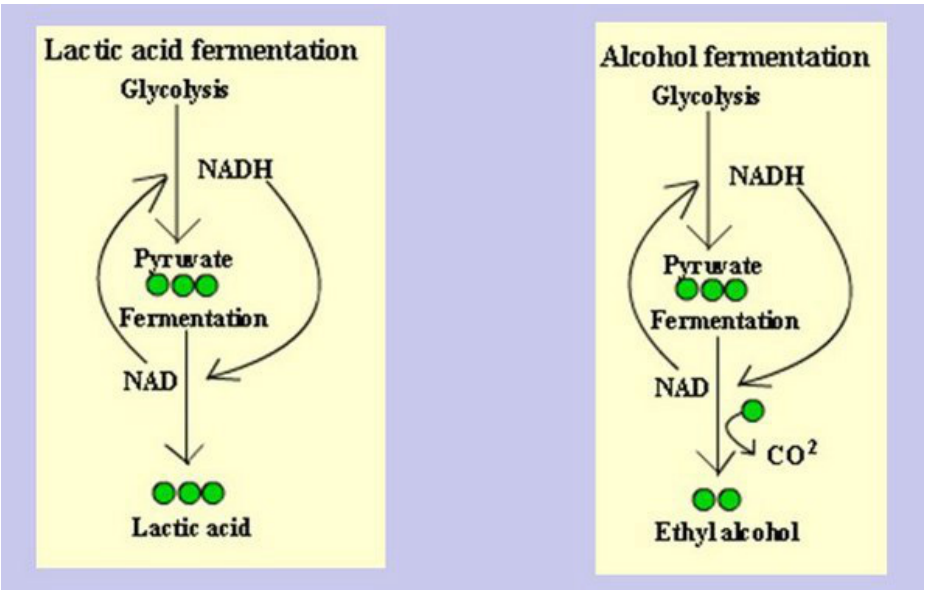


Fig. 4.17: Alcoholic and lactic fermentation.

Did you know?

Your muscle cells have the ability to respire for a short time without oxygen using anaerobic respiration. Using this reaction, glucose that has been stored in your muscle cells is converted into lactic acid. This is what made your raised arm ache in Group Activity 4.3

The facts

Aerobic and anaerobic respiration

Work to do

What are the differences between aerobic and anaerobic respiration?

Group Activity 4.4:

Complete the table below on the differences between aerobic and anaerobic respiration

Question	Aerobic respiration	Anaerobic respiration
Where does it occur?	Cytosol and mitochondria.	Cytosol only.
What is glucose broken down into?		Carbon (IV) oxide and Ethanol in plants or yeast, and lactic acid in animals or bacteria.
How many molecules of ATP are produced?	38 molecules of ATP from each molecule of glucose.	
Are there further reactions?		Ethanol and lactic acid can be broken down further in the presence of oxygen.
For how long can the reaction occur in your body?		
How fast is ATP production process?		Fast
Is oxygen needed?	Yes	No
How efficient is it?	40%	2%

Did you know?

Most cars have a fuel combustion efficiency of about 20-25%. Therefore, aerobic respiration has doubled the efficiency of cars.

Check your progress 4a

Copy the flow diagram in Fgure 4.18 below and complete the terms used to compare aerobic and anaerobic respiration.

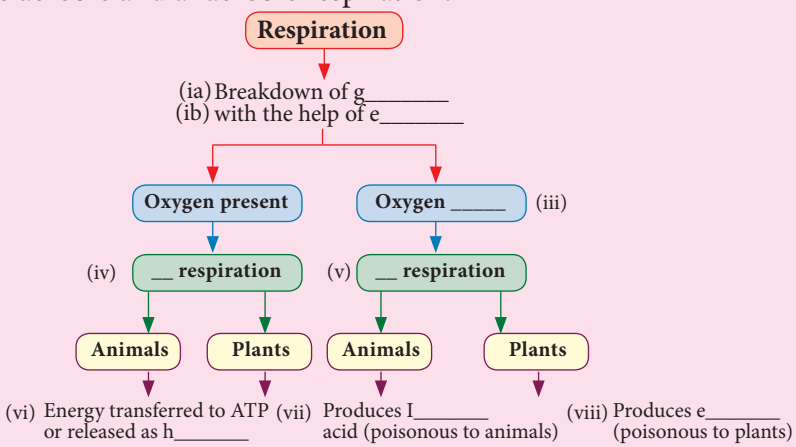


Fig. 4.18: Flow diagram of aerobic and anaerobic respiration.

Role of oxygen in respiration

After glucose is converted into pyruvic acid, oxygen is required so that the pyruvic acid can move to the next stage and be converted to acetyl-CoA. Acetyl-CoA enters the mitochondria matrix where enzymes break it down in the Krebs cycle to release energy and some of the energy is used to move hydrogen ions to the intermembrane space in the electron transport system. The accumulated hydrogen ions move back (a process called Chemiosmosis) to the matrix via the ATP synthase enzyme which uses oxygen to form water and release about 34 ATP molecules. From one molecule of glucose a total of 38 molecules of ATP are synthesised (2ATP molecules from Glycolysis, 2 ATP molecules from the Krebs' cycle and 34 ATP molecules from the electron transport system).

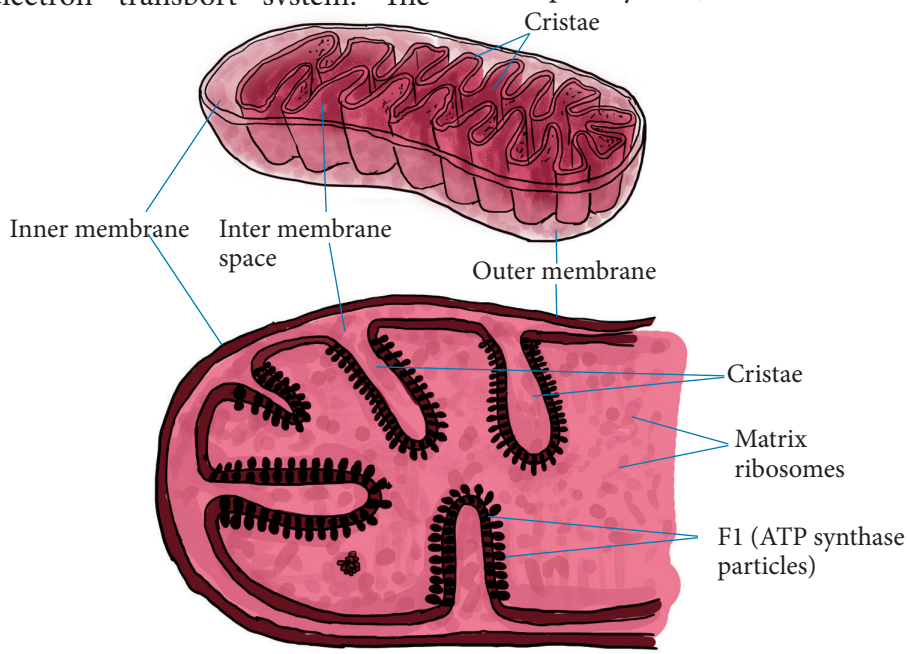


Fig. 4.19: Mitochondrion

During strenuous exercise like when you run 100 metres race, the demand for ATP is higher than the supply of oxygen, therefore, the muscle cells respire anaerobically and produce lactic acid. The accumulation of lactic acid in the muscles would change the pH of the tissue fluid around the muscle cells and is therefore toxic and can cause cramps. Faster heartbeat after the running quickly carries the blood containing **lactic acid** to the liver where it is oxidised to carbon (IV) oxide and water by the lactic acid **dehydrogenase** enzyme or into pyruvic acid.

The quantity of extra oxygen required to break down the lactic acid is called **"oxygen debt"**.

The extra oxygen is supplied during the rapid and deep breathing called **panting**, after intense physical exercise.

The facts

Stages of aerobic respiration

Aerobic respiration is a complex enzyme-driven biochemical process that takes place in the presence of oxygen in the living cells, resulting in the release of energy, carbon (IV) oxide and water.

Aerobic respiration is a very complex biochemical process involving three main stages. These are:

Stage I: Glycolysis

Stage II: **Citric acid cycle** (Krebs Cycle)

Stage III: **Electron transport system**

Krebs' cycle (Stage II): in this cycle pyruvic acid, in presence of oxygen, is broken down to carbon (IV) oxide and hydrogen ions.

Summary of the Krebs' cycle is:

2 Pyruvic acid + 8NAD + 2FAD + 2ADP $\longrightarrow$ $6CO_2$ + 8NADH + $2FADH_2$ + 2ATP

III Electron transport system: This is a very complex system involving the transfer of the hydrogen ions through several types of acceptor molecules like NAD (**nicotinamide adenine dinucleotide**) which forms $NADH_2$ and $FADH_2$ (**Flavin adenine dinucleotide hydrogen**). Their hydrogen ion is taken up by oxygen to form water resulting in energy release. This energy is taken up by ADP to form 34 molecules of ATP per molecule of glucose. This process occurs in the ATP synthase in the granules attached on the cristae.

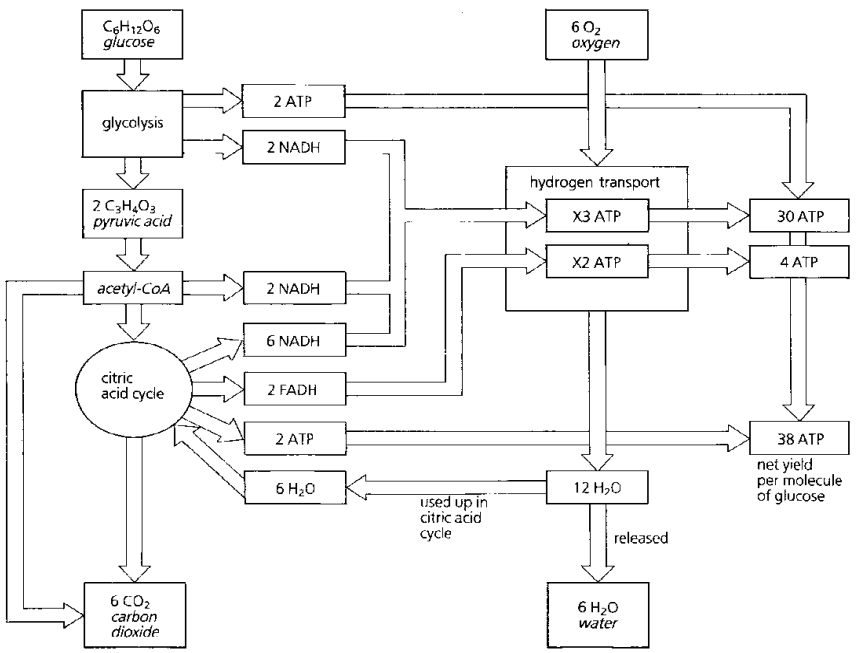


Fig. 4.20: Summary of aerobic respiration stages.

Did you know?

Hydrogen carriers NAD and FAD are derived from vitamin B complex and are called coenzymes.

Check your progress 4b

1. Why is pyruvic acid converted into alcohol or lactic acid during fermentation?
2. Why is there less release of energy during anaerobic respiration?
3. List the three phases of aerobic respiration of glucose. Where in the cell do these reactions take place?
4. What is the role of oxygen in aerobic respiration?
5. Name the substrate and products of the Krebs' cycle.
6. How do fatty acids enter the Krebs' cycle?

Factors affecting the rate of respiration

- Temperature affects all chemical and enzyme driven reactions. Low temperatures below optimum slow down the rate of respiration while temperatures above optimum denature the respiratory enzymes. At optimum temperature the respiration rate is highest.
- Molecular oxygen is the final acceptor of electrons in the electron transport chain, as the oxygen concentration increases from zero, the rate of aerobic respiration increases.
- Carbon IV oxide concentration, increase in the tissues retards the rate of respiration.
- Hydration increase of germinating seed tissues increases rate of respiration.
- Inorganic ions uptake in plants requires ATP from respiration therefore plants increase the rate of respiration when absorbing mineral ions.
- Other chemicals like cyanides, carbon II oxide, inhibit the rate of respiration.
- Wounding a tissue causes an increase in the respiration rate of cells close to the wound.
- Age and type of tissue, with young and developing tissues respires more vigorously than mature tissues.

Enzymes

Practical Activity 4.4:
To demonstrate the presence of Enzymes in cells.

Requirements

- Basin
- Conical flask
- Syringe
- Delivery tube
- Pestle and mortar
- Measuring cylinder
- Water
- Hydrogen peroxide
- Petroleum jelly
- Stop watch
- Water trough
- Raw Irish potato

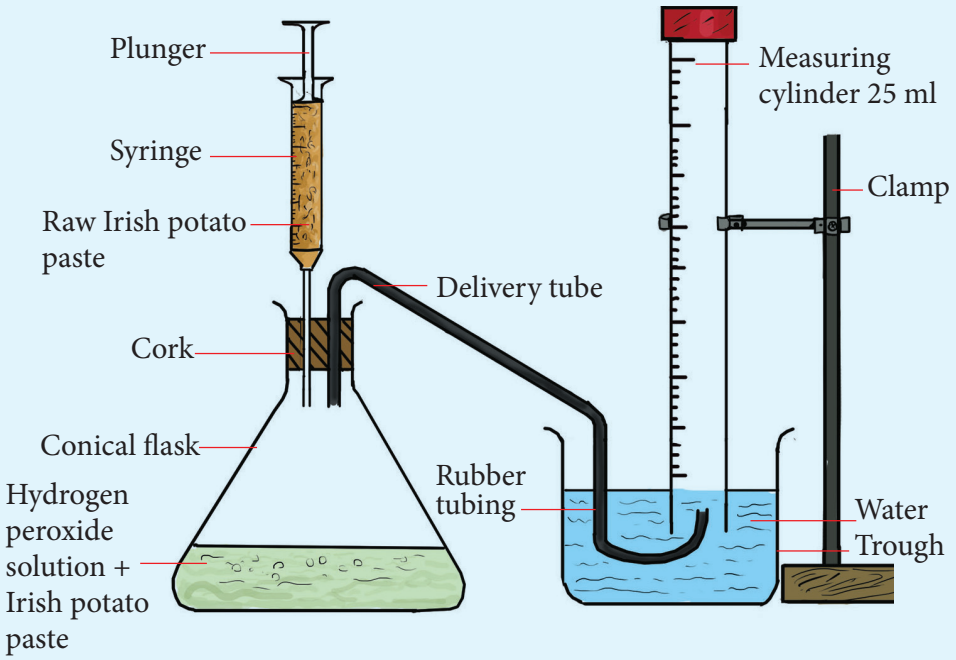


Fig. 4.21: Setup for demonstrating presence and actions of enzymes in cells.

1. Set the apparatus as show in fig 4.21 above.
2. In a 500 ml conical flask, add 30 ml hydrogen peroxide solution.
3. Fix the cork securely in the flask.
4. Half-fill the water trough, small basin or sink with water.
5. Fill three 25ml measuring cylinders with water. Invert them over the basin of water. Have one with the open end under the surface of the water in the basin and with the end of the rubber tubing in the measuring cylinder then use a clamp to hold it in place.
6. Peel an Irish potato then chop it up to small pieces. Place the pieces in a mortar and grind them to a fine paste using the pestle.
7. Use a 20 ml syringe to measure of potato paste.
8. Put the syringe in place in the cork of the flask but do not push the plunger as yet. WAIT.
9. Apply petroleum jelly at all joints of the setup.
10. Push the plunger of the syringe with the potato paste to add 1 ml paste into the hydrogen peroxide and immediately start the stop watch.

11. After 20 seconds, make a reading of the volume of oxygen gas in the measuring cylinder and create a table to record your readings.
12. Push the plunger of the syringe with the potato paste to add 2 ml paste into the hydrogen peroxide and immediately start the stop watch and after 20 seconds make a reading.

- Push the plunger of the syringe with the potato paste to add 3 ml, then 4 ml, then 5 ml; upto 10 ml paste into the hydrogen peroxide and immediately start the stop watch and after 20 seconds make a reading.

  (After the first measuring cylinder is full of oxygen replace it with another one).
- Calculate the rate of oxygen production in cm^3/s.
- Plot a graph of rate of oxygen production against potato paste volume. Suggest what the potato paste represents. (Hint: From your Chemistry lessons, how do you produce oxygen using hydrogen peroxide?)

Note: Hydrogen peroxide is a poisonous substance if left to accumulate in the body. It is, therefor,e broken down to water and oxygen by the catalase enzyme.

Group discussion

1. Suggest the reactants in this experiment and the products too.
2. How would you confirm that the gas produced is oxygen? Did you confirm?
3. Identify any inconsistencies in your results.
4. Describe the shape of the graph and explain the shape of the graph in relevant biological terms.
5. Describe any technical difficulties you had with this apparatus and explain how these could be overcome.

6 Design a similar experiment and demonstrate to investigate the presence of the catalase enzyme in liver or yeast cells.

The facts

Enzymes are protein catalysts which increase the rate of biochemical reactions by lowering the activation energy.

Catalysts have the following properties;

- Catalysts increase the rate of chemical reactions.
- Catalysts are not used up in the reactions therefore they are recycled.
- Catalysts are not changed at the end of the reactions.

Protein catalysts referred to as enzymes are made of amino acids joined by peptide bonds to form long polypeptide chains that fold into a unique three-dimensional shape. The functional

parts of enzymes are called **active sites** and catalytic abilities. The reacting molecules called **substrates** have to fix into the active sites for the enzyme to work on them and form a temporally **enzyme-substrate complex.**

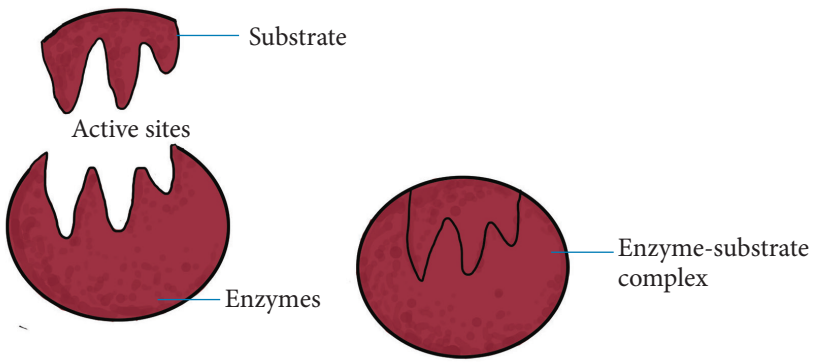


Fig. 4.22: Enzyme-substrate complex formation.

Hydrogen peroxide left in an open beaker for a few days would dissociate into water and oxygen. But what did you notice when you placed pieces of liver, potato, or yeast in a beaker containing peroxide, the reaction was very fast as the enzyme **catalase** breaks down hydrogen peroxide into oxygen and water. The oxygen gas was trapped by the fluid to form bubbles filling the beaker. The reaction is speeded up over 100 billion times.

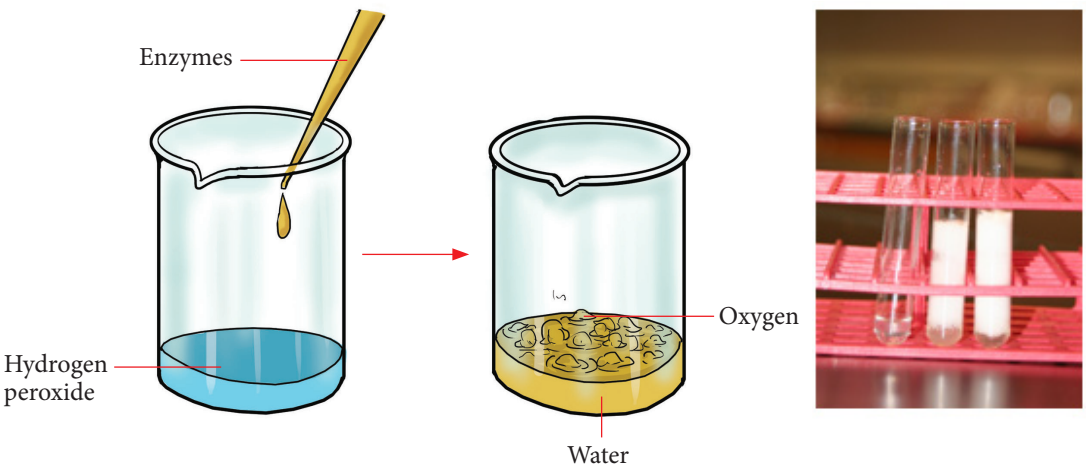


Fig. 4.23: Reactions of catalase enzyme and Hydrogen peroxide.

The active site has a definite shape and therefore the enzyme is very specific on the substrate it can synthesis or break down. The catalase enzyme cannot break down sucrose. The enzyme and substrate work like a key and lock.

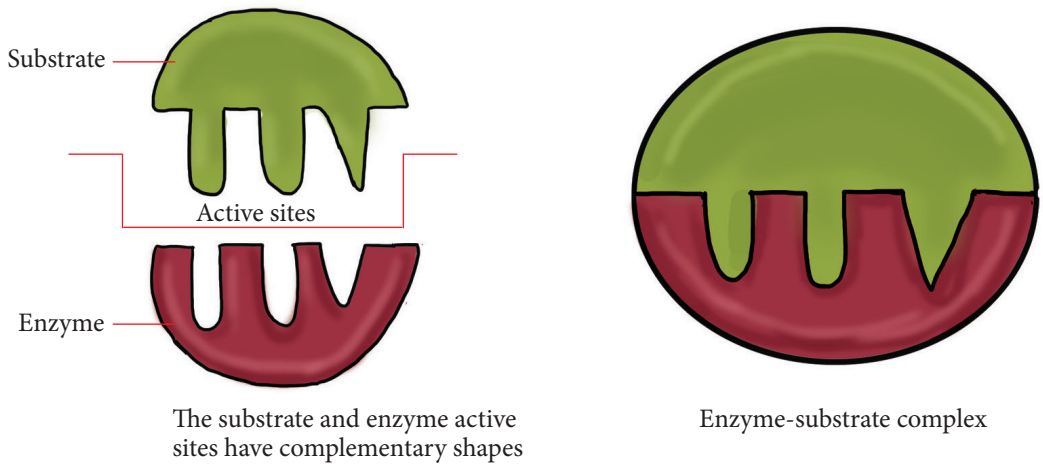


Fig. 4.24: Enzyme active sites are specific.

The characteristics of enzymes

Temperature: Most enzymes function best within a certain range of temperature, called **optimum temperature**. Lower than optimum temperatures **inactivates enzymes** because the substrate has low kinetic energy, while higher than optimum temperature **denatures enzymes** by deforming the active sites.

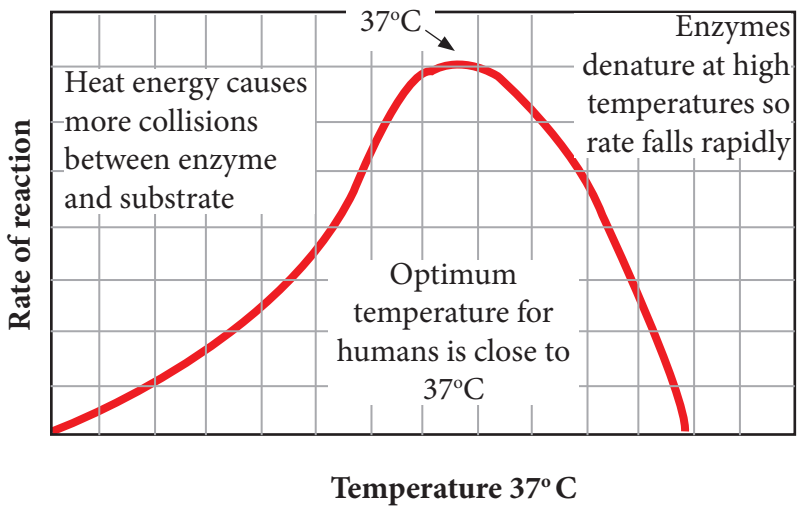


Fig. 4.25: Effect of temperature on enzymes in humans.

Sensitive to pH changes: Enzymes work best at a specific optimum pH. Some work best in alkaline, others in acidic, while some in neutral media. When the pH is below or above the optimum the enzyme is denatured.

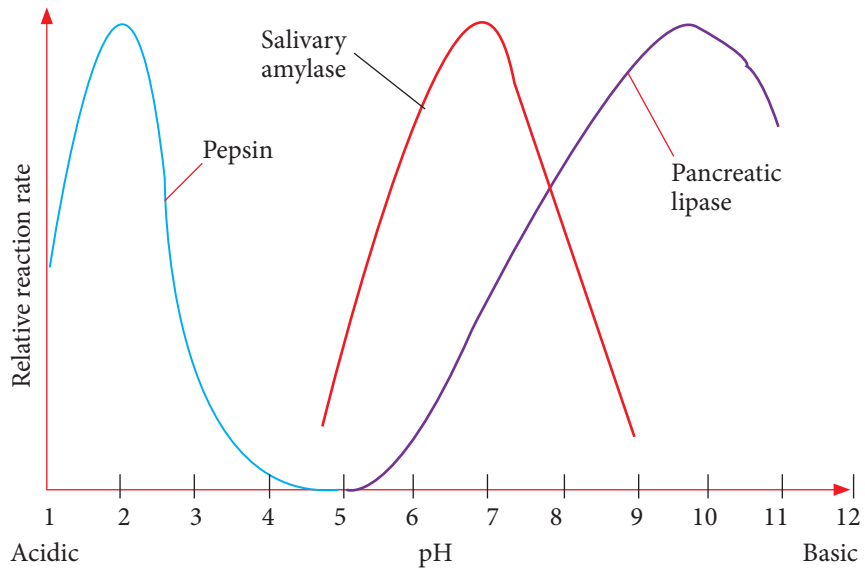


Fig. 4.26: Effect of pH on enzyme activity.

Specificity: Particular enzymes act on specific substrates, like carbohydrase on carbohydrates, lipase on lipids and protease on proteins.

Examples enzymes involved in respiration

- *Hexokinase* converts glucose to glucose-6-phosphate by adding a phosphate group.
- *Hexose phosphate isomerase* converts glucose-6-phosphate to fructose-6-phosphate.
- *Dehydrogenase* removes hydrogen ions from various molecules.
- *Aldolase* splits the fructose -1,6-diphosphate (6-carbon) to 3-phosphoglyceraldehyde (triose sugar).
- *ATP synthase* is involved in the synthesis of ATP in the cristae.
- *Decarboxylase* releases or removes carbon (IV) oxide.
- *Lactic acid dehydrogenase* breaks down lactic acid to water and carbon (IV) oxide in the liver in the presence of oxygen.

Reversibility: Enzymes can cause reactions to follow any direction, depending on the concentration of substrates, reactants and products.

$$\underset{\text{Carbon (IV) oxide}}{CO_2} + \underset{\text{Water}}{H_2O} \underset{\text{Carbonic anhydrase}}{\rightleftharpoons} \underset{\text{Carbonic acid}}{H_2CO_3}$$

Fig. 4.27: Reversible action of carbonic anhydrase in different concentrations of substrate, reactants and products.

Enzymes are not used up in the reaction that they control: that is, they do not form parts of the products thus they can be used again.

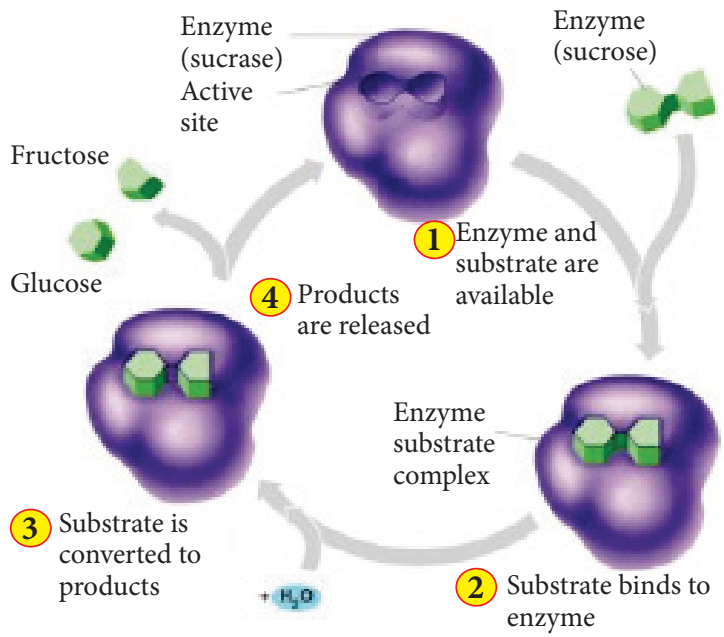


Fig. 4.27: Enzyme is recycled.

Anaerobic respiration experiments

Conduct experiments to investigate anaerobic respiration involving yeast, fungi and germinating peas or beans.

Fig 4.28: Yeast cells

Remember

Yeast are unicellular eukaryotic fungi from the Kingdom Mycota. They require energy to carry out metabolic activities. Through cellular respiration, they obtain the energy from carbohydrates like sucrose.

Yeasts are facultative anaerobes, therefore, in the presence of oxygen, yeasts will respire aerobically to completely break down carbohydrates into carbon (IV) oxide and water releasing energy. When given the choice, yeasts will do aerobic respiration because the ATP yield is more than anaerobic respiration. When oxygen is absent, yeast can use anaerobic respiration in a process called alcohol fermentation. In aerobic respiration, they partially break down carbohydrates and produce carbon (IV) oxide and ethanol (C_2H_5OH). The carbon (IV) oxide produced turns limewater cloudy. Air dissolved in sucrose solution can be expelled by boiling and the yeasts are killed by boiling at 100° C.

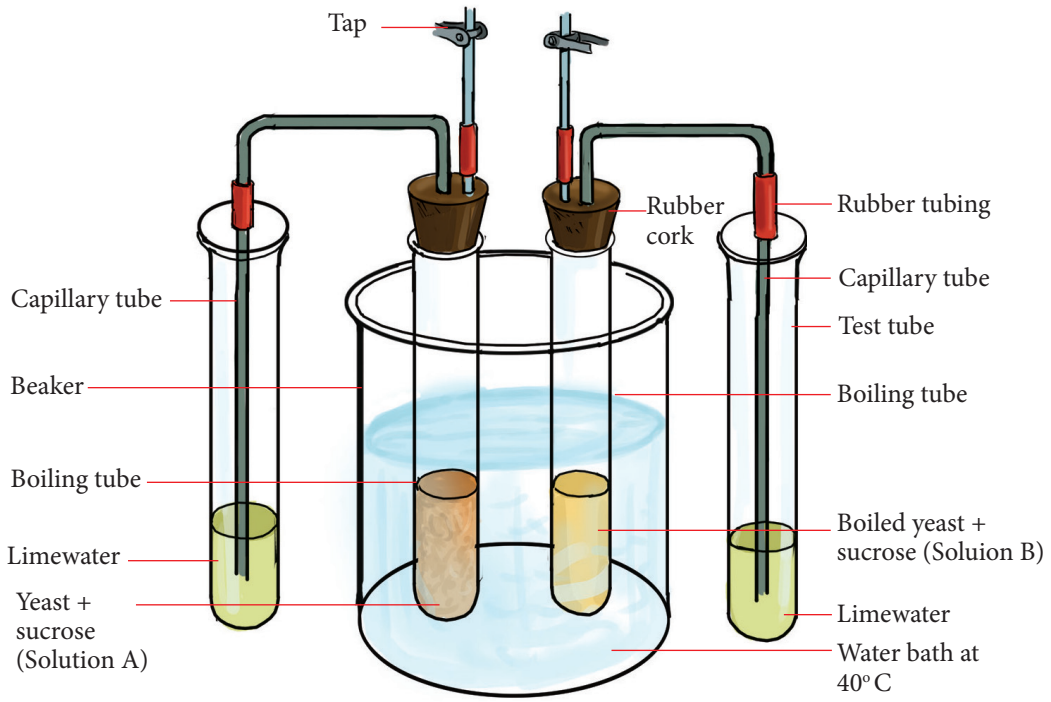


Fig. 4.29: Experiment setup

Practical Activity 4.5: To investigage anaerobic respiration involving yeast

Requirements

- Hot water source
- 1,000 ml beaker
- 2 boiling tubes
- 2 test tubes
- 2 grams of dried yeast
- 2 ml of yeast boiled at 100 – 150° C for 20 minutes in an oven.
- 10 ml of 5% sucrose solution made with boiled water. Tap water should be boiled for 30 minutes to expel dissolved gases. Dissolve the sucrose in the boiled water while still warm and without shaking and store the solution in stoppered volumetric flasks.

- 15 cm^3 limewater
- 2 ml cooking oil
- 2 labels for labelling the boiling tubes
- 2 containers for living and dead yeast
- 2 droppers
- 20 ml syringe.
- Thermometer

Procedure

1. Place about 20 ml limewater into each of the two test tubes.
2. Label the two boiling tubes solution A and B respectively.
3. In boiling tube A, add 1 gram of dried yeast.
4. In boiling tube B, add 1gram of boiled yeast at 100–150°C.
5. Draw 10 ml of sucrose solution using a syringe and add to each boiling tube ensure the mouth of the syringe touches the side of the boiling tube to prevent introduction of air. You should avoid shaking the solution.
6. Using a dropper draw cooking oil and place five drops of oil in the mixture in each boiling tube.
7. Fit the rubber corks with the delivery tubes as in Figure 4.30.
8. Half fill-the 1,000 ml beaker with hot water at about 40 °C use the thermometer to measure temperature and add cold water if too hot.
9. Dip the two boiling tubes in the warm water bath and their respective delivery tubes other ends into the test tubes containing limewater.

Group discussion

Discuss the following questions and answer them in your notebooks then have the group leader present your findings to the rest of the class.

1. What do you observe in the limewater and the boiling tubes? Why?
2. Would your observation agree with hypothesis that yeast's respire anaerobically?
3. How has this experiment ensured that the evidence of respiration is because of yeast anaerobic respiration and not anything else?
4. What assumptions have you made in this experiment?
5. How will you setup a control experiment for the observations made in limewater?
6. Evaluate this experiment and suggest how the design was done to ensure anaerobic respiration occurred.
7. Suggest what else you could use instead of sucrose and why.
8. How would you use this knowledge in the real world?
9. Suggest changes you would make to this experiment to investigate aerobic respiration in yeast.

Remember

The combination of sodium hydroxide and pyrogallic acid (sodium pyrogallate) absorbs oxygen and carbon (IV) oxide from the atmosphere.

Practical Activity 4.6

Requirements per group

- 2 rubber bungs with a hole same fitting as the capillary tube
- Petroleum jelly
- 2 labels
- Thread
- 2 conical flasks
- Scissors
- 2 × 30 cm long capillary tube of about 0.5 mm bore size
- 20 ml measuring cylinder
- 5 ml test tube
- 2 ml sodium hydroxide
- 2 × 200 ml beakers
- 4 ml pyrogallic acid
- 20 certified bean seeds soaked overnight (From Seed company)
- 20 dried beans
- Permanent marker pen

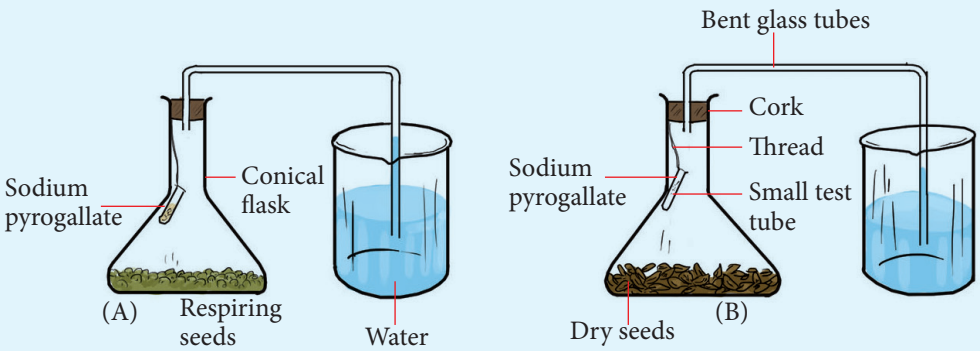


Fig. 4.30: Anaerobic respiration of germinating seeds.

Procedure

1. Label two conical flasks A and B.
2. In conical flask A, place 20 sprouting beans after overnight soaking.
3. In conical flask B, place 20 dried beans (not soaked).

4. Tie each of 5 ml test tube with a thread long enough to suspend the test tube over the beans.
5. Then measure 1 ml of sodium hydroxide solution and place into each of 5 ml test tubes.

   CAUTION: Wash off any sodium hydroxide on your skin with lots of water.
6. Add 2 ml of pyrogallic acid to each of the test tubes and do not shake. It will turn dark brown or black.
7. Place the test tube containing the mixture of sodium hydroxide and pyrogallic acid in the conical flask and let it hang from the rubber as per the Figure 4.31.
8. Connect the capillary tube and insert in a beaker half full of water.
9. Use a permanent marker pen to mark the level of water in the capillary tubing.
10. Apply petroleum jelly at all fixings joints.
11. Leave both flasks in a warm place for 48 hours.
12. At the end of two days, note how many seeds germinated in each flask in an appropriate table.
13. Copy the table below and record your observations.

Conical flask	Observation after 48 hours
A	
B	

Group discussion

1. Suggest the aim of this experiment.
2. Supposing you were asked to state the hypothesis of this experiment, what would you state? Why?
3. How do you explain the observations you have made?
4. Why did you setup two conical flasks A and B?
5. How would you design an experiment to demonstrate that germinating seeds produce carbon IV oxide?
6. How is the knowledge you have gained here used in real world?
7. Prepare a presentation of your findings then have one member present to the class.

Economic and industry applications of anaerobic respiration (fermentation)

Alcoholic and **lactic fermentation** is economically beneficial in several ways:

- **Baking industry:** In bread-making, yeast is mixed into the dough and when the carbon (IV) oxide is heated during baking, it expands and escapes and leaves behind the small holes that give bread its light and spongy texture.
- **Alcohol production:** In beer-making, beer is made from germinating grains, for example, barley and in wine-making, juices from crushed plant parts are mixed with yeast in anaerobic conditions.
- **Biogas production:** Biogas is produced using methanol a form of alcoholic fermentation.

- **Gasohol production:** Gasohol is produced using ethanol from alcoholic fermentation.

Lactic fermentation

- **Cheese production:** Bacteria like *Streptococcus lactis* are added to pasteurised milk. The bacteria converts galactose to lactic acid which curdles the milk. The curd is hardened and flavoured to form cheese.
- **Yoghurt making:** Yoghurt is made from milk which is treated with *Streptococcus* bacteria. This form lactic acid and so cause the milk to curdle.
- **Silage production:** Lactic acid produced in lactic fermentation is used to preserve forage for livestock.

The facts

4.2 Carbon cycle

Carbon cycle is a biogeochemical cycle showing how carbon circulates between the living organisms (biotic) and their environment (abiotic).

Practical Activity 4.7: Investigating the presence of carbon (IV) oxide in a living organism

Requirements

- Eye protection gear
- Crushed natural chalk
- Vinegar (or hydrochloric acid)
- Flask
- Balloon
- Test tube
- Limewater (calcium hydroxide solution)

Caution: Wear eye protection.

Procedure

1. Pour limewater into a test tube.
2. Place crushed chalk into a flask and add vinegar (or hydrochloric acid) to the flask.
3. Place a deflated balloon tightly over the flask neck so that no gas can escape.
4. When the reaction has stopped, pinch the balloon tightly at the balloon neck, so that no gas escapes.
5. Remove the balloon from the flask and place it over to the test tube. Then squeeze it so that the gas goes into the limewater. Observe and record what happens.

   Alternatively, you can breathe out into lime water using a straw.

Group discussion

1. What colour was the limewater before the reaction?
2. What happened to the limewater when you added the gas from the balloon?
3. Where did the gas in the balloon come from?
4. What reaction was responsible for creating it?
5. What gas was released from the chalk by the reaction?
6. Look at the diagram below and answer the questions that follow:

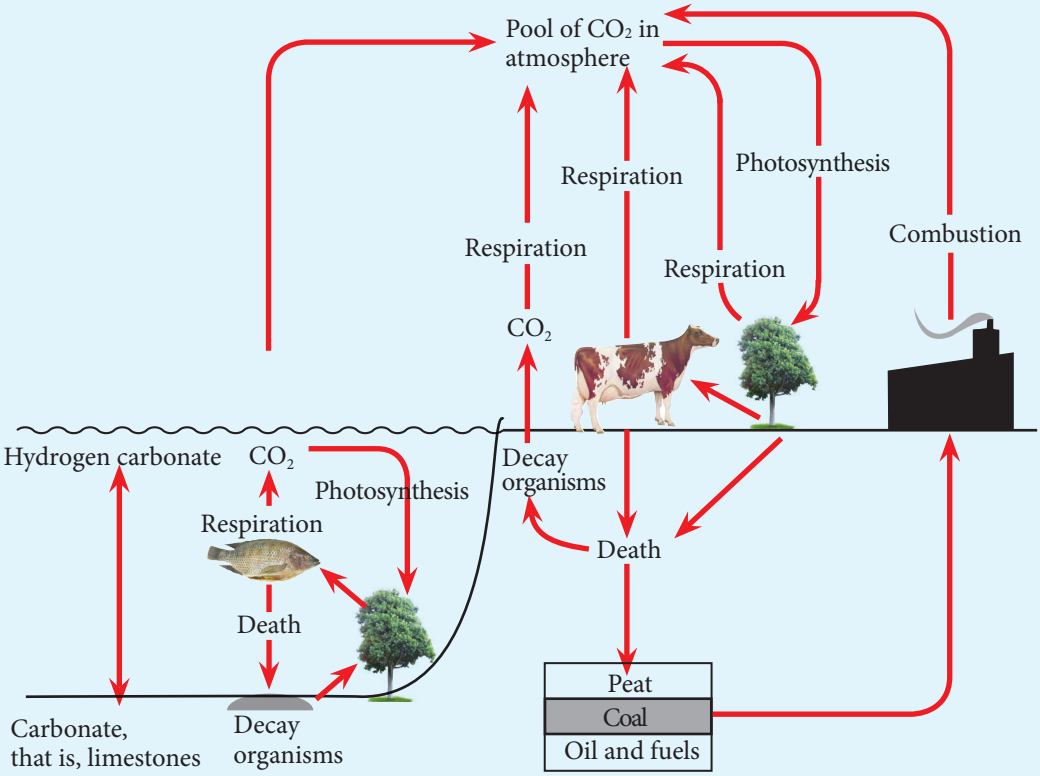


Fig. 4.31: The Carbon cycle.

(a) What processes are involved in the carbon cycle?

(b) How are these processes interrelated?

(c) Identify processes that:

- Increase carbon (IV) oxide into the atmosphere.
- Reduce carbon (IV) oxide from the atmosphere.

(d) Which human activities increase the amount of carbon (IV) oxide in the atmosphere?

The facts

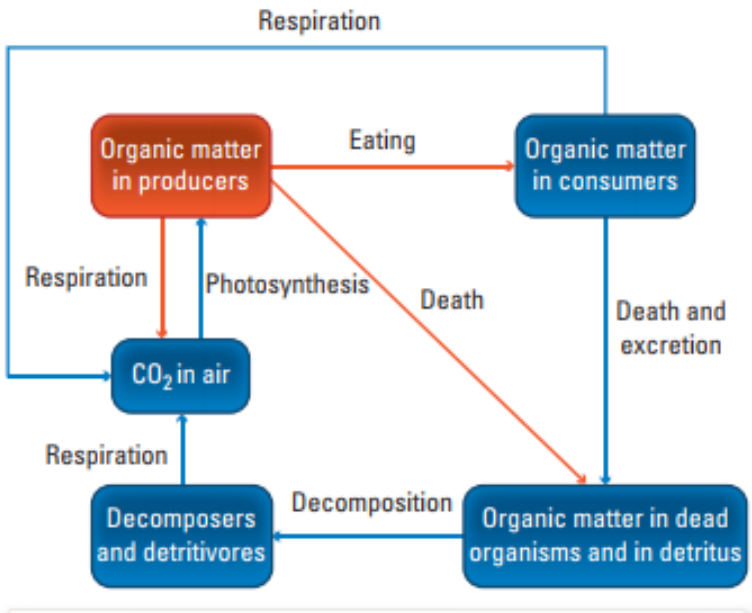


Fig. 4.32: Simple carbon cycle.

There are five main reservoirs of carbon on Earth. In order from the largest to the smallest reservoirs, they include:

- Oceans
- Soil and fossil fuels
- Atmosphere
- Organisms

The atmosphere is the main pool of carbon IV oxide and organisms exchange with it. Through the following processes, organisms exchange carbon with their environment:

- **Respiration**: The living plants, decomposers and animals respire, therefore, release carbon (IV) oxide to the atmosphere.
- **Decomposition**: Living plants, animals and decomposers die and their waste materials are decomposed to release carbon (IV) oxide to the atmosphere from the soil organic matter.
- **Deforestation for charcoal and firewood**: Firewood and charcoal burning and use release carbon (IV) oxide to the atmosphere and reduce the number of trees using carbon (IV) oxide from the atmosphere.
- **Fossil fuel combustion**: About 299 – 300 million years ago, massive organic matter was buried before it could decompose. Consequently, fossil fuels like coal, oil and natural gas were formed. Their combustion today releases carbon (IV) oxide to the atmosphere significantly.
- **Diffusion:** Carbon (IV) oxide reacts with water and diffuses into the ocean as hydrogen carbonate. Aquatic life respire and release

carbon (IV) oxide that too reacts with water forming hydrogen carbonate. Calcium carbonate shells of dead marine life form limestone after geological forces act on them.

- **Photosynthesis**: Green plants use carbon (IV) oxide from the atmosphere in photosynthesis while aquatic green plants and phytoplankton use hydrogen carbonate from the ocean water in photosynthesis.

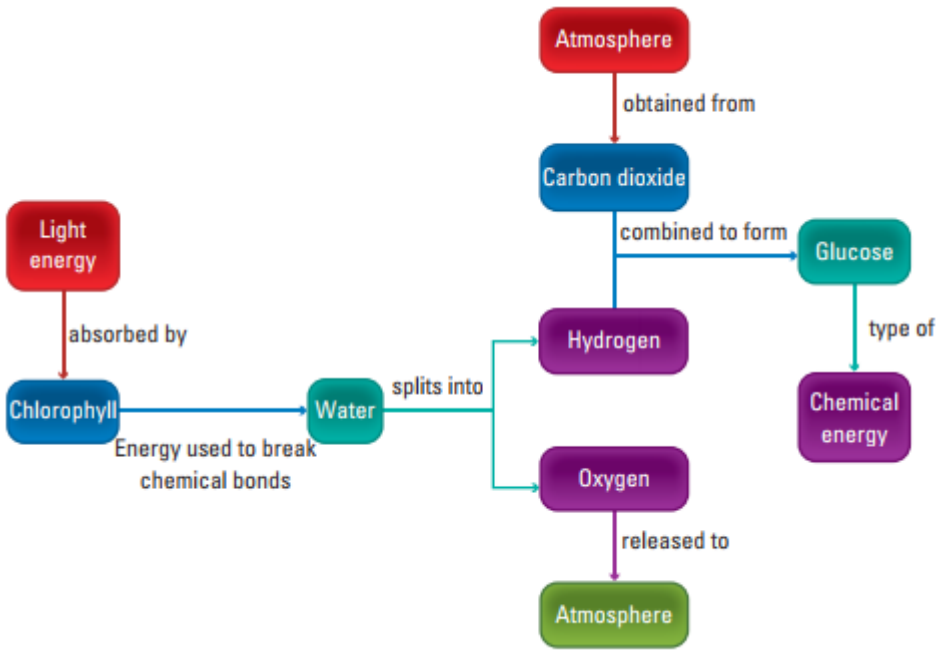


Fig. 4.33: Simple carbon cycle.

Group activity 4.5

Reducing your personal carbon footprint.

1. Find out ten easy and practical things you can do in personal space, at your school, home, village, estate and town to help stop global warming.
2. What are you doing at your personal level that is adversely affecting the carbon cycle?
3. What can you do to reduce your carbon footprint?

Carbon (IV) oxide and the global warming.

Fossil fuels combustion has increased the quantity of carbon (IV) oxide in the atmosphere. Global warming is expected to happen due to carbon (IV) oxide and other greenhouse gases.

Compensation point

Just before dawn when there is very little light, the rate of photosynthesis is low. The plant cells are respiring and producing carbon IV oxide. The rate of respiration at this time is higher than the rate of photosynthesis. Therefore, its rate of release of carbon IV oxide is higher than its rate of consumption.

As light intensity increases, the rate of photosynthesis increases, and the amount of carbon (IV) oxide being used also increases. A point is reached when the rate of photosynthesis becomes equal to the rate of respiration. The rate of release of carbon (IV) oxide by respiration is the same as the rate of consumption of carbon (IV) oxide (by photosynthesis).

This point at which the rate of respiration is equal to that of photosynthesis is called **compensation point**. In most plants, compensation point is reached at around dawn.

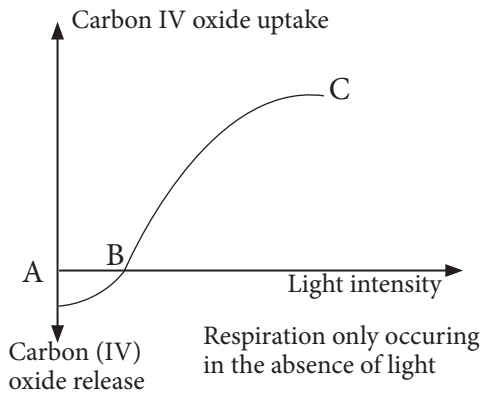


Fig. 4.34: Graph illustrating the compensation point.

From the graph, at point:

A: Respiration rate is high and carbon IV oxide release is high.

A – B: Increasing light intensity and photosynthesis commences. Carbon (IV) oxide uptake increases whereas release of CO_2 reduces.

B: Compensation point. Rate of photosynthesis is equal to rate of respiration and therefore rate of CO_2 uptake equals rate of its release to the atmosphere.

B – C: Rate of photosynthesis is much higher than rate of respiration, therefore, rate of uptake of carbon (IV) oxide is more than rate of release of carbon (IV) oxide.

Group Activity 4.6

Study the photosynthesis and cellular respiration equations below.

Solar energy

$$CO_2 + 6H_2O \underset{\text{Cellular respiration}}{\overset{\text{Photosynthesis}}{\rightleftharpoons}} C_6H_{12}O_6 + O_2$$

Chemical energy (ATP) + heat

1. What do you observe?
2. What does that mean to the carbon cycle?
3. What do you think would happen if a plant was to be in this state for a long period of time? Why?
4. Suggest how nature avoids this condition?
5. Write an essay titled "Compensation point in plants" then read it to rest of the class.

Check your progress 4c

1. Define respiration.
2. What is the role of O_2 in electron transport chain?
3. How many molecules of ATP are released when a molecule of glucose is oxidised to (a) CO_2 and H_2O? (b) Ethanol and CO_2?
4. Name the end products of electron transport chains.
5. Respiration is a continuous process in green plants. Then why is it that they give out O_2 and not CO_2 during the day?
6. What is the site for (a) Glycolysis, (b) Krebs' cycle, (c) ATP generation by oxidative phosphorylation?
7. What is the fate of pyruvic acid in the (a) presence, and (b) absence of oxygen?

   Write the equations representing the processes, that take place in (a) and (b).
8. What is the significance of stepwise oxidation of organic molecules instead of one step reaction?
9. What is the significance of photorespiration?
10. List the substrates that enter and the products produced in (a) glycolysis (b) Krebs cycle
11. How is yeast useful in industry? Give any three examples.
12. How does exchange of respiratory gases take place in plants?
13. Mention the significance of TCA cycle.
14. Why does fermentation yield less energy than aerobic respiration?
15. What are the three major phases of glycolysis?
16. What is the importance of the Krebs' cycle?
17. Differentiate between aerobic and anaerobic respiration.
18. Which of the following statements best describes the process of respiration?

    Respiration in living organisms is:

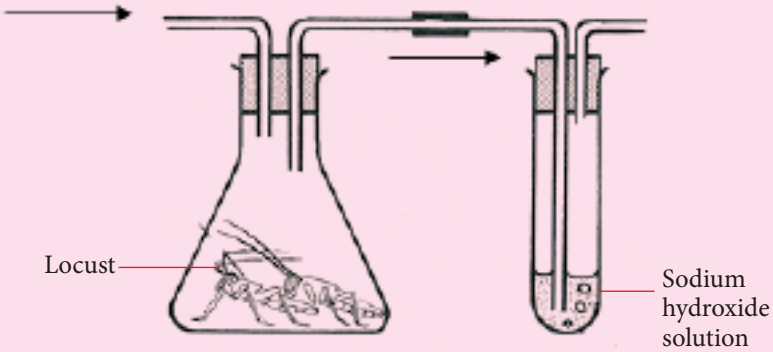
    (A) the intake of oxygen and output of carbon dioxide
    (B) the intake of food and the output of energy
    (C) the intake of food and the release of carbon dioxide
    (D) the breakdown of food to release energy
    (E) the oxidation of food to carbon dioxide.
19. Explain what an oxygen debt is and how it is caused.
20. When a carbohydrate is oxidised to carbon dioxide and water in the body, 21 kJ energy is produced for every litre of oxygen used. In an experiment, a girl absorbed 2 litres of oxygen in minutes.

    What is her energy production in kilojoules per hour?
21. The process of respiration is often summarised by the equation:

    $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + 2{,}830$ kJ

On the basis of this equation, what would you regard as acceptable evidence that respiration was taking place in a sample of living tissue?

22. A learner sets up an experiment to try and demonstrate that locusts are respiring. The diagram below shows the apparatus used.



After 15 minutes, the limewater had gone milky and the learner claims that this proves that the locusts are respiring. Criticise the design of the experiment and show how you would improve it.

23. The table below shows the energy used up each day either as kilojoules per kilogram of body mass or as kilojoules per square metre of body surface.

		kJ per day	
	mass/kg	per kg body mass	per m^2 body surface
Pig	128.0	80	4510
Human	64.3	134	4360
Dog	15.2	216	4347
Mouse	0.018	2736	4971

(a) According to the table, what is the total amount of energy used each day by (i) a human being? (ii) a mouse?

(b) Which of these two shows a greater rate of respiration in the body cells?

(c) Why do you think there is so little difference in the energy expenditure per square metre of body surface?

Unit 5

The digestive and circulatory systems in animals

Learning outcomes		
Knowledge and understanding	**Skills**	**Attitudes**
• Explain the structure and function of the digestive and circulatory systems. • Explain the effect of exercise on the heartbeat. • Understand the important role of glands and organs. Describe the functions of the rhythmic movement of food.	• Investigate the action of digestive enzymes. • Identify the role of chemical and physical processes of digestion.	• Appreciate the role of blood in protecting the body from diseases.

Introduction

What did you eat for breakfast, lunch or dinner yesterday? Did you eat the same type of food? Why did you eat different types of food? Why do you eat food? When you say that a meal was mouth-watering, what does that mean in biological terms? What happens to food after you put it into your mouth? Referring to this book, research what happens to food at each stage of its journey through the human digestive system. Prepare a role play or a storyboard with your group to show what you have found out. For example, Stage 1: Here in the mouth, I am being cut and chewed into small pieces while being mixed with lots of liquid. I am starting to feel sweeter.

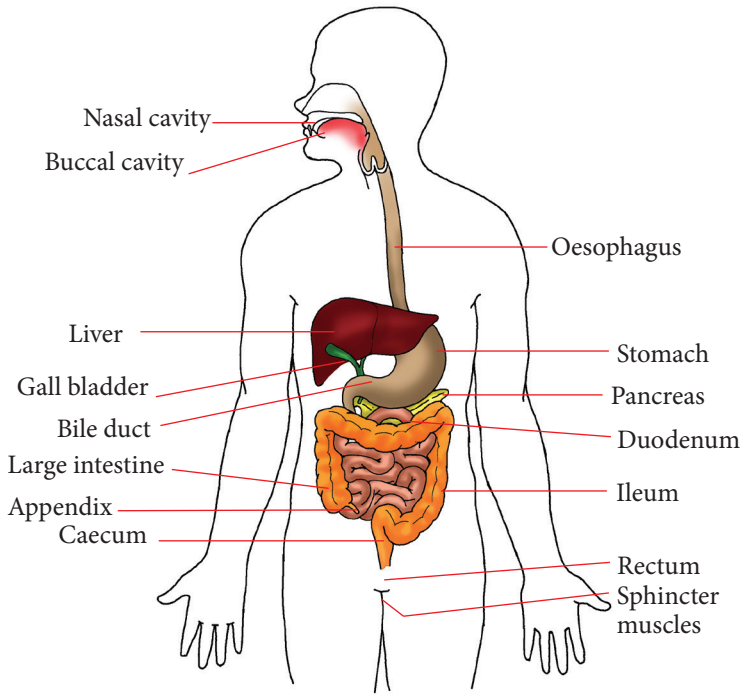


Fig. 5.1: The human digestive system.

Which parts of the digestive system will come into contact with the food and in what order?

When you eat food, it is because your body needs food to function and perform the characteristics of living organisms namely; movement and locomotion, respiration, irritability, growth and development, excretion and reproduction as well as finding food and feeding. The food you eat will get into your mouth, you chew it while your tongue mixes it with saliva and forms it into a bolus. Then you swallow it into the oesophagus and it is delivered to the stomach. After the stomach the food will be moved along the intestines and remaining undigested food is egested.

5.1 Digestion in animals

How does the process of digestion occur in animals?

Human digestive system

Practical Activity 5.1

You are provided with the following items:

- Any starchy foods like cassava, millet, bread, injera, rice or asida
- Knife
- A means of timing
- Iodine solution

Procedure

1. Cut a small cube of the food about 1 cm cube using a clean knife.

2. Put it in your own mouth of course observing hygienic conditions.
3. Without swallowing the saliva chew the food for about 30 seconds. Describe the taste of food in your mouth at the start of chewing and after the 30 seconds.
4. After the 30 seconds of chewing spit out a tiny amount of the food into a beaker or on a white tile.
5. Add two drops of iodine solution onto the chewed food. What do you observe? What colour do you observe and why?
6. Without swallowing, proceed to chew the remaining food for another 3 minutes then spit a tiny amount of food on the white tile and add iodine solution. What do you observe and what colour do you observe? Is the colour different and why? What caused the change of taste over time? (You may swallow the rest of the food)
7. Using a drawing illustrate the physical change that has occurred to the food as you chewed it. Would you suggest the name of this process? Why is the process important?
8. Write a word equation for the chemical change that has occurred to the food.
9. Cut another small cube of the food and add iodine solution to it. What do you observe? What colour do you observe and why? As a scientist, why is this part of investigation important?
10. How would you report the findings of this investigation?
11. Why are the findings of this investigations important to you as a biologist?

The facts

Digestion is the breakdown of complex food substances to simple absorbable molecules.

Digestion in the mouth

Digestion in the mouth is both mechanical and chemical. Inside the mouth cavity, food is lubricated by mucus from the saliva and chewed by the teeth. This is mechanical digestion. The tongue pushes food between the teeth for chewing and mixes the food with saliva so as to make it softer; and make it easy to swallow.

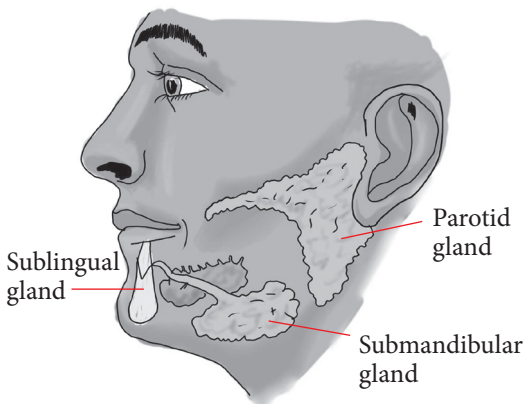


Fig. 5.2: Salivary glands

Did you know?

A healthy average person secretes about 1 litre of saliva every day (equivalent to 3 standard bottles of soda a day or 21 bottles in a week).

Saliva also contains an enzyme **salivary amylase** which begins the **extracellular** chemical digestion of starch even before the food is swallowed. The enzyme salivary amylase breaks down starch to maltose (a sweet sugar).

Mouth has four types of teeth:

- **Incisors** have sharp edges for cutting.
- **Canines** are pointed for holding food.
- **Premolars** and **molars** have rigged and flattened **cusps** for grinding.

Fig. 5.3: Human teeth

Did you know?

If you swallowed food while standing on your head, the food would move through the digestive system?

The chewed food is then formed into a **bolus** and is pushed to the pharynx by the action of the tongue in the swallowing process.

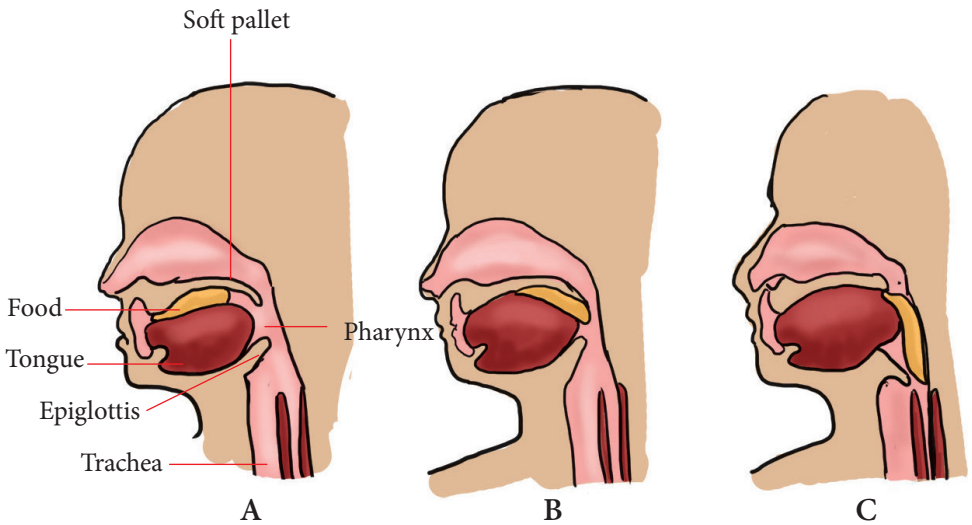


Fig. 5.4: Swallowing of food bolus.

A: The food is chewed and formed into a bolus in the mouth.

B: Swallowing begins as the tongue pushes food into the pharynx.
C: As the soft pallet rises to close passage to the nasal cavity, the epiglottis tends to close off the trachea and open the oesophagus.

The act of swallowing forces food into the **oesophagus** (gullet). The food is forced down the oesophagus towards the stomach by peristalsis which is a process of the

smooth muscles contracting and relaxing in a wave-like rhythmic movement. The food passes into the stomach via the **cardiac sphincter**.

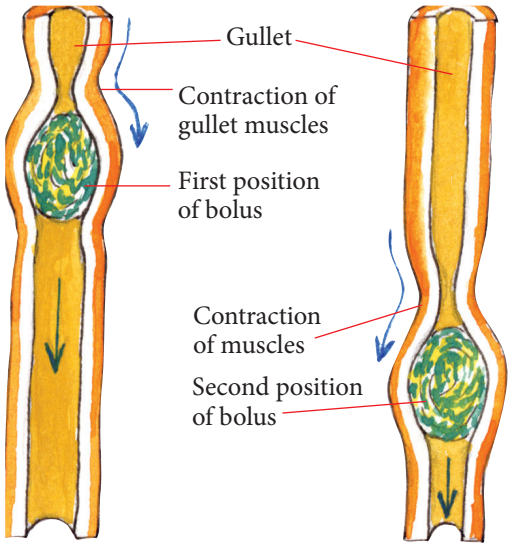


Fig. 5.5: Peristalsis of the oesophagus.

Practical Activity 5.2

Your group is provided with the following:

- White tile or spot plate
- Wall clock (for the class)
- 10 or 20 ml measuring cylinder or syringe
- 250 cm^3 beaker
- Dropper
- 11 test tubes
- 2 test tube racks
- 11 labels
- 1% starch solution (about 50 ml)
- 0.05 M sodium carbonate solution (10 ml)
- 0.1 M ethanoic acid (10 ml)
- Iodine solution (10 ml)
- pH universal indicator
- Standard colour chart

pH range	Description	Colour
< 3	Strong acid	Red
3 – 6	Weak acid	Orange or yellow
7	Neutral	Green
8 – 11	Weak base	Blue
>11	Strong base	Violet or indigo

Fig 5.6 pH colour chart

Procedure

1. Wash the test tubes, beaker and droppers provided before use.
2. Use the labels provided to label the five test tubes A and B and C and D and E.(ensure the test tubes are dry before sticking the labels).
3. Using the measuring cylinder, place 5 ml of 1% starch solution in all the five test tubes.
4. Add ethanoic or sodium carbonate to each test tube as according to the table below. Clean the measuring cylinder after using it to measure sodium carbonate solution and before adding ethanoic acid.

Test tube	Starch solution and amylase plus
A	1 ml sodium carbonate solution
B	0.5 ml sodium carbonate solution
C	Nothing
D	2 ml ethanoic acid
E	4 ml ethanoic acid

5. Label six test tubes 1-6 and add 2 ml of universal indicator solution in each of them.
6. Drop five drops of iodine solution on five separate spots on the spot plate or white tile.
7. Measure and add 1 ml of amylase solution to all the six test tubes then shake well by hold the test tube with the index finger and thumb then stroking it.

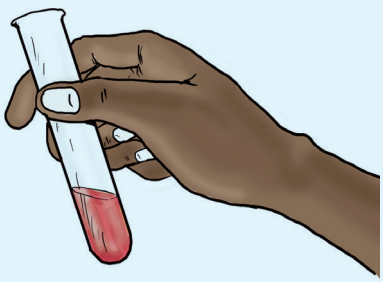


Fig. 5.7 Holding a test tube.

8. Clean a dropper and draw out a sample from each test tube in turn and drop the sample on a white tile or spot plate containing iodine solution.

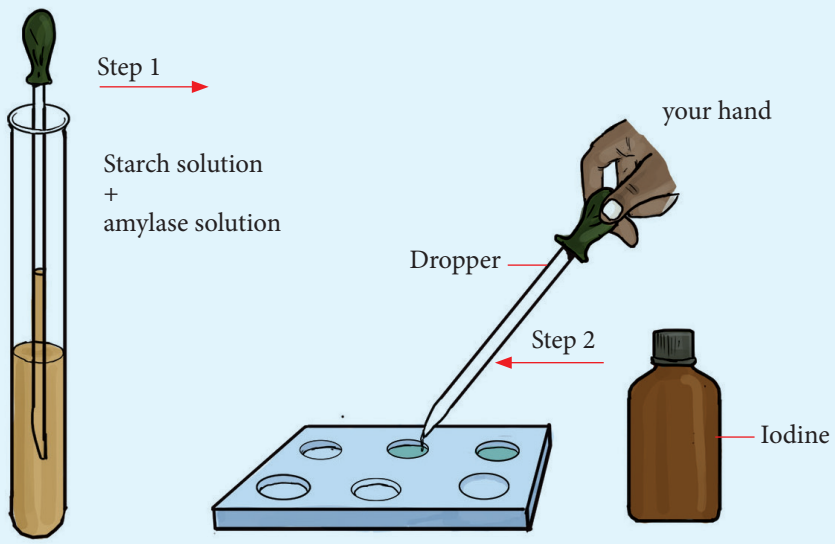


Fig. 5.8: Procedure of the testing.

9. Using a clean dropper each time, continue sampling at intervals. When a sample fails to give a blue-black colour with iodine solution, note the time and stop taking samples from that particular test tube. What colour do you observe?
10. If after fifteen minutes some samples are still giving a blue-black colour with iodine solution, there is little point in continuing to test the mixture in these test tubes.

11. Clean the dropper and use it to draw a sample from test tube A. Add 3 drops into one test tube containing universal indicator.
12. Compare the colour produced in the test tube with the standard chart provided.
13. Repeat this for each test tube, cleaning the dropper between samples.
14. Wash your mouth of food particles with clean safe water and spit into test tube labelled 6 containing universal indicator to test the pH of your mouth.
15. What was the pH in your mouth? Why is this important?
16. Enter your observations in the table below.

Table 5.1 Table of results

Tube	Starch solution and amylase plus:	pH	Time for blue-black colour to cease appearing
A	1 ml sodium carbonate solution		
B	0.5 ml sodium carbonate solution		
C	Nothing		
D	2 ml ethanoic acid		
E	4 ml ethanoic acid		

Group discussion

In your group, discuss the following questions:

1. Why did you add the mixture of starch and amylase to iodine solution?
2. What did you observe? Why?
3. In which test tube was the reaction between starch and amylase the fastest? What was the pH of the mixture in the test tube? How does that pH of the mixture in that particular test tube compare with pH of your saliva? Explain.
4. In a scenario where you have eaten starch containing food, what would happen to the starch-amylase reaction in the stomach? Why? How would you prove that?
5. Sodium carbonate and ethanoic acid altered the pH of the mixture. Suggest how else they could affect the starch-amylase reaction.
6. How else would you design the experiment to eliminate the probability of Sodium carbonate and ethanoic acid affecting the starch-amylase reaction in any other way except through pH change.
7. Write 200 words report of this Practical Activity 5.2 and submit to your teacher to comment.

Digestion in the stomach (monogastric digestion)

Stomach is a muscular bag that stores food consisting of longitudinal and circular muscles that contract and relax (**peristalsis**) to churn the food into semi-fluid chyme.

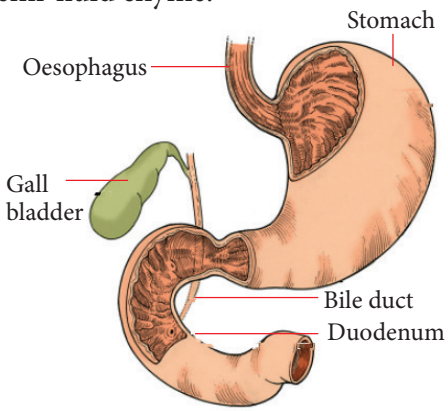


Fig. 5.9: Stomach

The **stomach** also contains gastric glands which secrete **gastric juice** which contains hydrochloric acid.

The role of hydrochloric acid in gastric juice includes:

- **Neutralises** the slightly alkaline pH of saliva from the mouth.
- Provides optimum **pH** for the enzymes in the gastric juice.
- Kills **pathogens** or bacteria that may be present in the food.
- **Activates** conversion of pepsinogen into pepsin.
- **Denatures** the salivary amylase.

In the stomach of infants and young ruminants, the **enzyme rennin** curdles milk increasing its surface area for digestion by pepsin. **Gastrin hormone** stimulates the gastric glands in the stomach wall to secrete gastric juice into the stomach.

Did you know?

Borborygmic is the stomach rumbling which happens all the time, but gets louder when your stomach is empty. Guess why?

Digestion in human small intestines

The small intestine consists of the **duodenum** and the **ileum** which is relatively long and coiled to provide a large surface area and slow down the speed of movement of food therefore allowing more time for digestion and absorption of digested food products.

The opening of ducts allow the **bile** from the liver and **pancreatic juice** from the pancrease into duodenum. **Secretin hormone** stimulates the pancreas to secrete **pancreatic juice** into the duodenum. **Cholecystokinin** stimulates the secretion of bile from the **gall bladder** into the duodenum.

Did you know?

The large intestine is about 1.5 metres while the small intestine is about 6.9 metres long and adult female's small intestine is longer than the average adult male's.

Goblet cells in the intestinal wall produce **mucus** which lines the inner walls of the intestines to protect them from being digested by proteolytic enzymes and also lubricates food as it moves through the lumen reducing any friction in the gut.

The wall of the small intestines, just like in the oesophagus and stomach, is

made up of circular and longitudinal muscles which contracts and relax antagonistically to facilitate peristalsis and mix food with juices and enzymes for rapid digestion.

Walls of the small intestine have glands that secretes enzymes, for example **maltase**, **sucrase**, **lactase**, and **peptidase** which digest food into simple absorbable particles. Intestines internal wall epithelium have numerous **villi** with microvilli on their surfaces which further increase surface area for absorption of food. **Microvilli** have a thin epithelial layer providing a shorter diffusion distance for digested food. There is a presence of **lacteal** vessels in the small intestine into which **fatty acids** and **glycerol** are absorbed for transportation into the lymphatic system.

What happens to the fatty acids and glycerol next?

The intestines are highly vascularised which supply them with oxygen and also ensure faster absorption of digested products by maintaining a steep concentration gradient.

Colon is the site for absorption of water and mineral salts and rectum is the site for temporary storage of undigested and indigestible materials.

Did you know?

Detergents claiming to remove oil and blood stains contain digestive enzymes like salivary amylase, pancreatic lipase and proteases like pepsin.

Physical exercises are known to increase digestive systems movements and helps one get in shape too.

Group Activity 5.1

In groups of four, role play the action of digestive enzymes and absorption of digested food.

Digestive system of Ruminants (Polygastric digestion)

Ruminants are herbivores and include animals like goats, sheep and cattle. However, camels are pseudo-ruminants.

Group Activity 5.2

What do you observe in the Figure 5.10 below? Observe Figure 5.1 again and draw a comparison with Figure 5.9. Identify the differences in the digestive parts.

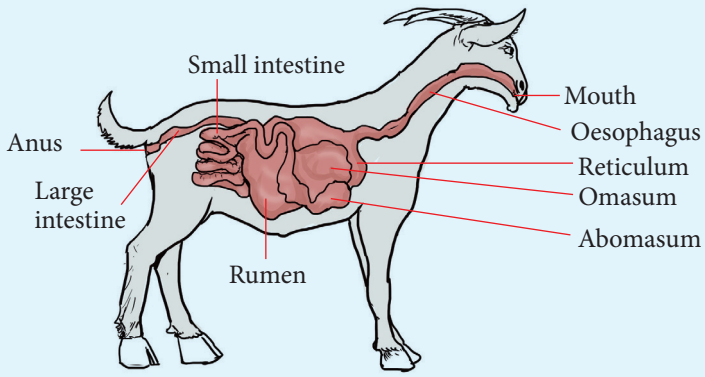


Fig. 5.10: Goat digestive system.

Observe the photographs below. What do you see?

Fig. 5.11: The rumen and reticulum of ruminants.

Which part of the ruminant are shown in the photographs? Why do ruminants need these parts seen in the photographs?

The facts

Ruminants are herbivorous mammals which are animals that feed exclusively on vegetation cellulose material that forms the cell wall. They lack incisors in the upper jaw, instead they have a hard pad against which grass is pressed and cut with incisors in the lower jaw. Incisors in the lower jaw are well developed with sharp chisel edge for cutting and tearing of grass and other plants. They have no canine teeth, instead they have a gap called diastema which helps to hold the regurgitated grass before pushing it to the premolars and molars for grinding. The molars and premolars have ridges/cusps in the grinding surfaces which slide over one another with the grass in between hence grinding into tiny particles. The enamel of the molars and premolars have large surface area for grinding food. The joints of the jawbones are loose allowing circular jaw motion in the horizontal plane ideal for grinding food. Their premolars and molars have open enamel in the crown allowing continuous growth of teeth throughout their life; hence reduces the incidence of wear and tear due to grinding. They have long and elaborate digestive systems for effective breakdown of indigested food. In Figure 5.10, you observe that ruminants have four chambered stomachs with rumen, where digestion of cellulose takes place due to the presence of bacteria and protozoa; that selects enzyme **cellulase**. In Figure 5.10, the food swallowed enters the **rumen** the largest chamber, where fermentation occurs. The fermenting food continues to the next chamber called the **reticulum**. The fermenting food is regurgitated to the mouth for grinding by the premolar and molar teeth. This is called **chewing cud**, which is physical digestion. The re-swallowing of the fine ground food directs the food

to the **omasum** where water is extracted and semi solids passed on to the **abomasum**, the true glandular stomach, like human stomach see Figure 5.10.

The rest of digestion is similar to the human digestion.

Did you know?

Some cows will make between 40,000 to 60,000 jaw movements a day chewing cud.

Digestive system of insects (locust)

Practical Activity 5.3

In groups

The locust is a relatively large insect to dissect.

Requirements

- Live locust or grasshopper or cockroach
- Sharp scalpel or razor blade or fine pair of scissors
- Dissection board or wax tray
- Dissection pins or office pins
- Hand lens
- Sharp pencil and paper
- Eraser

Procedure

Divide roles amongst the group members.

1. Obtain a mature locust from the school field and put it in an airtight jar containing chloroform.
2. Remove the locust from the jar and cut off the wings.
3. Starting from the posterior end of the body, cut the body wall along the lateral side to the head using a sharp scalpel.
4. With the cut lateral side up, pin the specimen on the dissection board.
5. Flip open the dorsal part of the body wall to one side and the ventral part of the body wall to the opposite side. Loosen the body wall further by cutting at the anus and at the head.
6. Pin out the body wall to expose the internal organs.
7. Identify the structures and their functions referring to Figure 5.10 and any other resources available.
8. Make a large well-labelled diagram annotating it to the functions of each structure.

The facts

In a locust, the mouth leads to a short oesophagus. Posterior to the oesophagus is a relatively large crop which stores food. At the posterior of the crop are gizzard and gastric caecae. Gastric caecae secrete digestive enzymes and provide a larger surface area for absorption while the gizzard is an active grinding organ using ridges of cuticle. The oesophagus, crop, gizzard and gastric caecae form the fore gut.

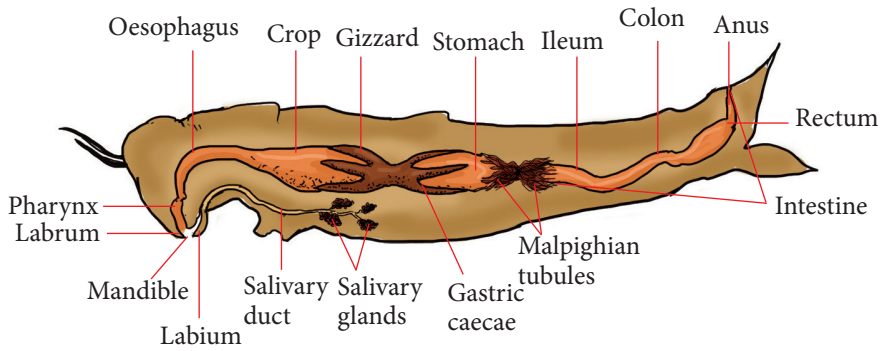


Fig. 5.12: Locust's digestive system.

Posterior to gastric caeca is the midgut or stomach where digestion and absorption takes place. The **Malpighian tubules** are to the posterior of the midgut. They are organs of excretion extracting water from the faecal pellets. The pellets proceed to pass through the colon, rectum and out through the anus.

Digestive system of fish

Practical Activity 5.4

You are provided with the following items;

- Whole Tilapia fish
- Sharp fine scissors
- Wax tray
- Hand lens

Procedure

1. Using the pair of scissors, cut out the operculum or gill cover to expose the gills beneath.
2. Observe carefully to see that from the gill arches, the gill rakers, projects inwards.
3. Make a small cut by inserting a fine scalpel blade into the anus (vent) of the fish.
4. Extend the cut anteriorly along the fish's belly towards the head. Make the cut through and between the pelvic fins.
5. Use the pair of scissors to cut anteriorly through the bones attached to the pelvic fins to expose the mouth cavity.
6. With the help of your teacher or the Internet, identify the digestive system of fish.

Internet

Use this link: http://share.nanjing-school.com/sciences/files/2013/02/fish-dissection-2e5c6ra.pdf

The facts

The digestive system in fish is variant being adapted to the mode of feeding of the fish, either carnivorous and herbivorous fish. However, most fish have digestive systems that include a mouth, teeth, **gill rakers**, oesophagus, stomach, **pylorus, pylorus caeca,** pancreatic tissue area, liver, gall bladder, intestine and anus. The table below compares the digestive systems of two types of fish on the bases of feeding **mode**.

Table 5.2: Summary on digestion in fish

Digestive system part	Carnivorous fish digestive system	Herbivorous fish digestive system
Mouth	Large	Small
Teeth	Pointed jaw and pharyngeal teeth	Pharyngeal teeth
Gill rakers	Fine filters	Course filters
Oesophagus	Mucus lubricated	Mucus lubricated
Stomach	Elastic muscular wall	Thin wall
Pylorus	Control sphincter	Control sphincter
Pylorus caeca Posterior to stomach	Enzyme secretion or absorption	Enzyme secretion or absorption
Pancreatic tissue area	Exocrine /endocrine roles	Exocrine /endocrine roles
Liver	Secretes bile	Secretes bile

Protein digestion in human beings

Practical Activity 5.5: Demonstrtion of the presence and action of enzymes in cells

You are provided with the following items:

- Suspension W (10% egg white)
- NaOH solution
- $CuSO_4$ solution

Procedure

1. Using the reagents provided, carry out food tests. In the table below, record the food test, the procedures, observations and conclusion.

Food substance	Procedure	Observation	Conclusion

2. Mention two enzymes that may be required to digest suspension W in the alimentary canal of a mammal.
3. (i) State the purpose of hydrochloric acid in the stomach.
   (ii) State the purpose of sodium hydrogen carbonate in the duodenum.

The facts

Protein digestion begins in the mouth. Protein food is broken down mechanically by the teeth into tiny particles to increase surface area for subsequent enzymatic digestion. It is also mixed with saliva that contains mucus to lubricate it for easy swallowing. When food reaches the stomach, it stimulates the production of gastrin hormone that influences the production of gastric juice from gastric glands in the stomach walls. Gastric juice contains **rennin**, **pepsin** and **hydrochloric acid**. Rennin curdles milk increasing its surface area for digestion by pepsin. Hydrochloric acid promotes conversion of inactive pepsinogen into active pepsin, which then digests proteins into peptides.
Hydrochloric acid also provides an acidic medium suitable for proper functioning of rennin (chymase) and pepsin. It also destroys pathogens contained in the food. The chyme then moves into the duodenum through sphincters. Presence of food in the duodenum stimulates production of secretin hormone from duodenal wall. Secretin hormone in turn stimulates liver cells to produce bile. It also stimulates the pancreas to produce pancreatic juice. Pancreatic juice contains trypsinogen which is converted into active trypsin. By the action of enterokinase, trypsin then digests polypeptides into dipeptides. The dipeptides are then digested into amino acids by peptidase produced in the ileum.

Remember

Spelling of rennin as renin refers to a hormone secreted into the blood by cells lining the efferent glomerular vessels of the kidney. Renin reacts with angiotensin from the liver to stimulate adrenal gland to release aldosterone.

Lipid digestion in human beings

The facts

Lipid digestion starts in the duodenum. Bile from the gall bladder is released and contains bile salts which breakdown fats to tiny fat droplets to increase the surface area for enzyme pancreatic lipase to digest. The process of breaking down of lipids by bile salts is called emulsification. Pancreatic lipase digests lipids into fatty acids and glycerol. The intestinal juice secreted by the intestinal wall glands contains intestinal lipase which breaks down the remaining lipids into fatty acids and glycerol.

Food absorption and assimilation

How does the process of food assimilation occur within the small intestine?

The facts

Protein and simple sugars absorption: Amino acids, fructose, galactose and glucose diffuse through the thin epithelial lining of the microvillus into blood capillaries and are transported into the liver via hepatic portal vein.

Protein assimilation: The proteins in the body are used for synthesis of new cells, growth and repair of worn-out tissues some of the non-essential amino acids are used in protein synthesis. Excess amino acids are broken down

(deaminated) into urea and carbon residue. Urea is eliminated from the body as urine while the carbon residue is used in the carbohydrate metabolism and either converted into the glycogen for storage in the liver or during food shortage converted into glucose and broken down during respiration to provide energy.

Glucose assimilation: Excess glucose is converted to glycogen by action of insulin. Excess glucose is converted to fats and some glucose is used in cell respiration to provide energy.

Physical and chemical digestion

How does the chemical and physical digestion processes occur in the body?

Practical Activity 5.6. The action of amylase on starch

Requirements

- Hot water bath
- Four test tubes labelled A, B, C and D
- 2% starch solution
- Amylase solution
- Iodine solution
- Benedict's solution
- Measuring cylinder

Procedure

1. Using the measuring cylinder, place 5 cm^3 of 2% starch solution in each test tube.
2. Rinse the measuring cylinder then use it to add 2 cm^3 amylase solution in each of tubes B and D then shake the test tubes to mix the contents and allow them to stand for 6 minutes.
3. After 6 minutes, add 3 drops of iodine solution to tubes A and B.

   Rinse the measuring cylinder then use it to add 2 cm^3 of Benedict's solution to tubes C and D then place the tubes in the hot water bath for 5 minutes.
4. Compare the final colours in the tubes and complete the table of results (Table 5.3).

Table 5.3: Table of results

Test Tube	Test tube content	Reagent used	Observation	Conclusion
A	2% starch solution	Iodine		
B	2% starch solution + amylase	Iodine		
C	2% starch solution + amylase	Benedict's		
D	2% starch solution	Benedict's		

(a) What normally happens when iodine solution is added to starch?

(b) Tube B contained starch solution at the beginning of the experiment. How do you explain the reaction with iodine at the end of the experiment?

(c) What food substance is Benedict's solution a test for?

(d) Was this food substance present in tubes C or D at the beginning of the experiment? What evidence do you have to support your answer?

(e) What evidence is there to suggest that this food substance is present in tube C at the end of the experiment?

(f) What chemical change could have taken place in tubes B and D after adding amylase, which would explain the results in these tubes after applying the iodine test and Benedict's test?

(g) What part could amylase have played in this chemical change?

(h) Suggest a control to the experiment which would help to support your answers.

The facts

Digestion: In the mouth, protein food is broken down mechanically by the teeth into tiny particles to increase the surface area for subsequent enzymatic digestion. It is also mixed with saliva that contains mucus to lubricate it for easy swallowing.

Digestion of starch in the mouth is partly mechanical or physical and partly chemical digestion. Mechanically, the chewing action of the teeth and the movement of the tongue breaks down the food into smaller particles. Chewing produces a greater surface area for the action of enzymes.

The physical digestion of food is possible by mastication and churning of food particles to fine pieces and emulsification of lipids to smaller lipid droplets.

Mastication, churning and emulsification increase the surface area of foods for the action of enzymes.

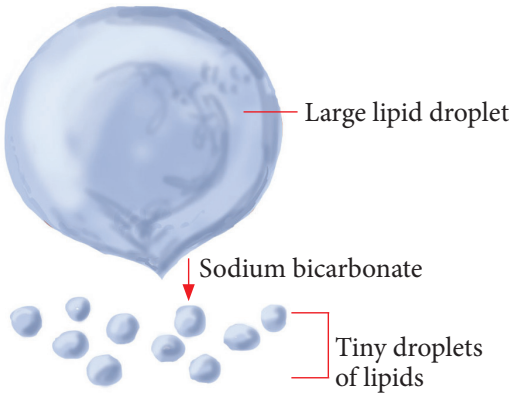


Fig. 5.13: Emulsification of lipids.

The starch food is broken down chemically by the action of salivary amylase which converts some of the starch present into maltose. Saliva also moistens and lubricates the food.

The starch is then swallowed into the oesophagus where it moves down to the stomach by peristalsis. As the stomach muscles continue peristaltic agitation (churning), all the food types are physically broken down into smaller particles. Salivary amylase continues to digest starch until the gastric juice penetrates the softened food mass, denaturing the salivary amylase.

When food reaches the stomach, it stimulates the production of gastrin hormone that influences the production of gastric juice from the gastric glands in the stomach walls. Gastric juice contains rennin, pepsin and hydrochloric acid. Rennin curdles milk increasing its surface area for digestion by pepsin. Hydrochloric acid promotes conversion of inactive pepsinogen into active pepsin which then digest proteins into peptides. Hydrochloric acid also provides an acidic medium suitable for proper functioning of rennin (chymase) and pepsin. It also destroys pathogens contained in the food.

No enzymatic action takes place on carbohydrates when the food is in the stomach. However, the hydrochloric acid produced by the gastric gland starts the hydrolysis of sucrose to glucose and fructose or lactose to galactose and glucose or maltose to glucose. The food leaves the stomach through the **pyloric sphincter** and reaches the duodenum, the first part of the small intestine.

Here, the food mixes with bile (to neutralise its acidity) and pancreatic juice which contains a starch digesting enzyme pancreatic amylase. Pancreatic amylase converts the starch to maltose. As the food moves to the ileum, it mixes the intestinal juice or succus entericus which contain several enzymes that complete the digestion of carbohydrates as follows: **Maltase** which hydrolyses or changes or converts maltose to glucose, **Sucrose** which hydrolyses sucrose to glucose and fructose, **lactase** which hydrolyses lactose to glucose and galactose. These are then absorbed into the blood capillaries in villi.

The chyme then moves into the duodenum through sphincters. Presence of food in the duodenum stimulates production of secretin hormone from duodenal wall. Secretin hormone in turn stimulates liver cells to produce bile. It also stimulates the pancreas to produce pancreatic juice. Pancreatic juice contains **trypsinogen** which is converted into active **trypsin**. By the action of enterokinase, trypsin then digests **polypeptides** into **dipeptides.** The dipeptides are then digested into **amino acids** by peptidase produced in the ileum.

Group Activity 5.3: Role play

Role play digestion by enzymes and absorption.

Different group members will have to play the part of (A) glucose molecules (initially joined together to make starch; (B) enzymes and (C) the wall of the intestine.

Steps:

1. (A) all hold hands to represent a long chain starch molecule.
2. (A) release hands as enzymes (B) break down the chain into small glucose sub-units.
3. (A) Who are now separate glucose molecules pass through narrow spaces between other learners (C) – the wall of the intestine–as they are absorbed into the body.

Functions of associate organs

What are the functions of glands, and organs which aid digestion?

Group Activity 5.4

The liver, the pancreas and gall bladder all are important to the process of digestion. Suggest how important? In your class suggest to each other what would happen if any of them was surgically removed?

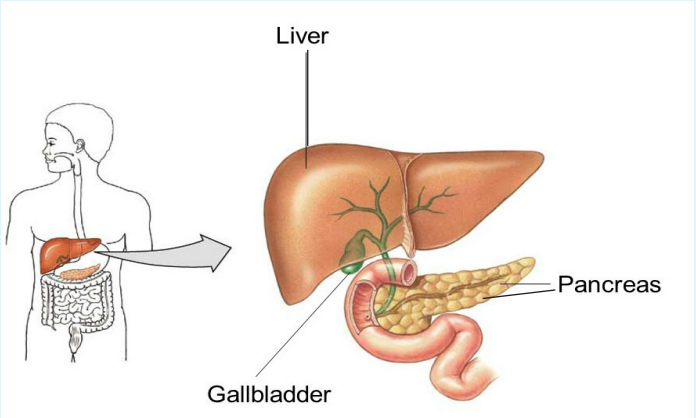


Fig. 5.14: Accessory organs

The facts

As Group activity 5.3 may have pointed out to you the duodenum has associate glands and organs. These are:

(i) Liver – secretes bile, stored in the gall bladder, which has bile salts that emulsify fats into tiny fat droplets to be chemically digested by pancreatic lipase.

(ii) Pancreas – which is an endocrine and exocrine gland. As an endocrine gland, it secretes insulin and glucagon to the bloodstream to regulate amount of glucose in the blood. As an exocrine gland, it secretes pancreatic juice which contains sodium carbonate that neutralises acidic chyme from the stomach providing alkaline medium for pancreatic enzymes action, pancreatic amylase enzyme that digest starch into maltose, pancreatic lipase that digest fats or lipids into fatty acids and glycerol, and trypsin enzyme that digests proteins into peptides

(ii) Brunner's glands – they secrete an mucus-rich fluid of high pH in the duodenum to prevent corrosion by the acidic chyme.

Sites of chemical digestion

Where in the body do most chemical digestion take place?

The facts

The chemical digestion sites and substrate food are tabulated below (suggest the end products of chemical digestion by each of the enzymes).

Table 5.4: Summary of digestion sites, food substrates and enzymes involved

Chemical Digestion Site	Substrate	Enzyme involved	Suggest the end products
Mouth	Starch	Salivary amylase	
Stomach	Milk casein	Rennin	
Stomach	Pepsin	Protein	
Duodenum	Starch	Pancreatic amylase	
Duodenum	Lipid	Pancreatic lipase	
Duodenum	Proteins	Pancreatic trypsin	
Ileum	Sucrose	Sucrase	
Ileum	Maltose	Maltase	
Ileum	Lactose	Lactase	
Ileum	Peptides	Aminopeptidase	

Muscles involved in digestion

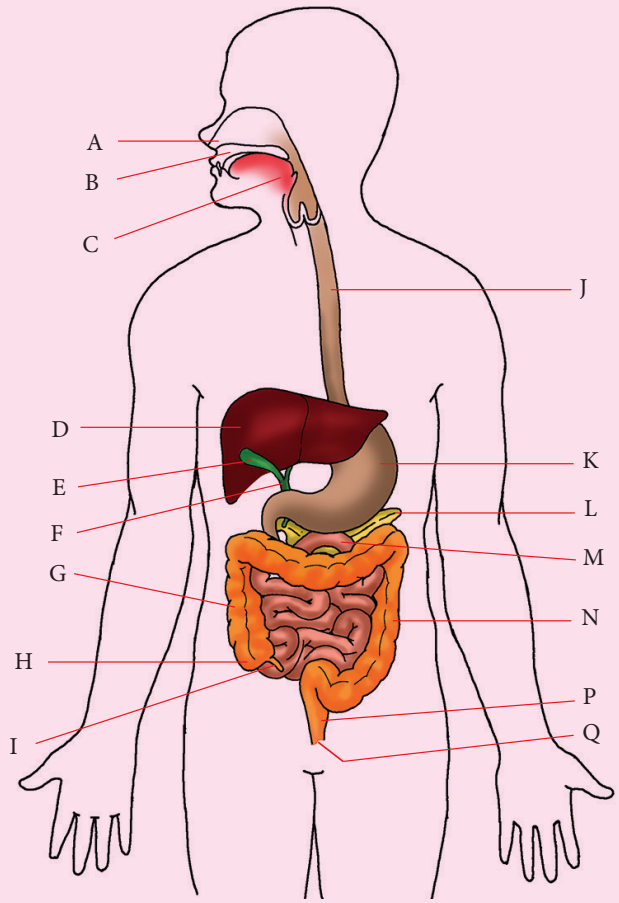
How do muscles move food through the digestive tract?

The role muscles play during digestion in human beings include:

- The cheek muscles are involved in the movement of cheeks sideways during chewing of food and therefore mixing the food.
- The alimentary canal muscles contract and relax during peristalsis to move the food along as it is digested.
- The cardiac sphincter muscles relax to allow passage of the food bolus into the stomach and contract to prevent food regurgitation during churning of food in the stomach.
- The pyloric sphincter muscles contract to regulate exit of food from the stomach into the duodenum for hours until churning is complete when it relaxes to allow regulated passage of the liquid food chyme.
- The thick and powerful circular and longitudinal muscles of the stomach wall contract and relax to churn food and in the process, break it into smaller particles. The result is chyme.

Check your progress 5a

1.



(a) Given the digestive system would you label and suggest the function(s) of all the parts involved in digestion of food.

(b) Create a table to summarise the main substances produced by digestion. The column headings should be titled: region of alimentary, digestive gland, digestive juice produced, enzymes in the juice, class of food acted upon and end substance produced.

2. Given an illustration of the digestive system in human beings, plus a ruler, pen and paper, how would you be able to label all parts and state function(s) of each named part.

3. Given an illustration of the digestive system in goats, a ruler, pen and paper, how will you be able to label all parts and state function(s) of each named part?

4. Given an illustration of the digestive system in a locust, a ruler pen and paper, how would you be able to label all parts and state function(s) of each named part.
5. Given an illustration of the digestive system in tilapia, a ruler pen and paper, how would you be able to label all parts and state function(s) of each named part?
6. Given the digestive system in human beings, cows, bees and Nile perch, how would you be able to compare them.
7. Given the following pairs of terms: **Ingestion and egestion, digestion and indigestible, absorption and assimilation,** and how would you be able to distinguish them?
8. Digestion occurs in human beings, ruminants, insects and fish. Why do you need to digest food?

5.2 Circulatory system

How are you today? Are you feeling well? How do you know you are well?

Group Activity 5.5

1. Observe the picture below. What do you see?

Fig. 5.15: Taking pulse rate.

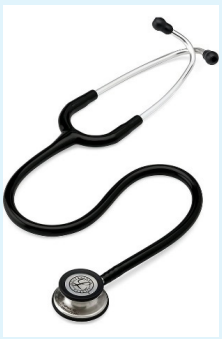


Fig. 5.16: Stethoscope

2. Do you remember the instrument in Figure 5.16 being used on you somewhere?
3. Why was it being used on you?
4. Form groups of four.
5. Using a stethoscope listen to each other's hearts. Record in your notebooks the number of heartbeats per minute and the heart sounds you hear.

   (If a stethoscope is not available then use the method in figure 5.15)
6. In turns, one learner will be the doctor while another learner will be the patient, the third learner will be the nurse recording what the doctor is observing (hearing), and the fourth learner is the time keeper and patient attendant making sure the patient is comfortable during the doctor's examination.
7. After the first reading change roles until each learner has had the chance to be a doctor, a nurse, a patient and a patient attendant.

   NB: Respect the patient's rights as the doctor and do not touch the patient inappropriately.

8. Why do doctors listen to your heartbeat as they examine you at the health facility?
9. What does this information tell them about your health?
10. Touch your left side of the chest. Do you feel the heartbeat? How does that heartbeat transfer to your neck?

Single and double circulation

The facts

Fig. 5.17a: William Harvey

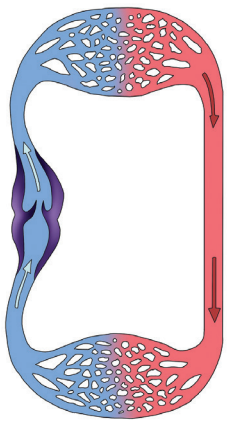


Fig. 5.17b: Single and double circulation

William Harvey was the first person to accurately document the functioning of the heart and the blood vessels. While he studied in Italy, his teacher taught him about dissections and when he returned to England he continued to dissect animals and refused to follow what the textbooks of those days said about the animal circulatory system.

He would later publish that blood is pumped by the heart to arteries and is circulated around the body and returns to the heart via the veins.

Work to do

Further reading

You are welcome to read more on this amazing human being by visiting this website link: https://www.famousscientists.org/william-harvey/

After the reading, design an illustration to summarise your understanding of the discoveries of the functioning of the heart and blood arteries.

The facts

Circulatory system is a blood transport system moving blood cells and blood plasma rapidly around the body while linking various organ systems. This is important to all **multicellular organisms** because they have a small surface area to volume ratio to control water loss, and internal organs are far from the organism's body surface.

A circulatory system has the following components: blood as the circulating fluid, heart as the pump, blood vessels as the connecting tubes, and valves to ensure one direction of blood flow.

Types of circulatory systems include;

- **Open circulatory system** found in arthropods and molluscs. The heart pumps blood or haemolymph to a body cavity called haemocoel, then the blood or haemolymph returns via collecting blood vessels.

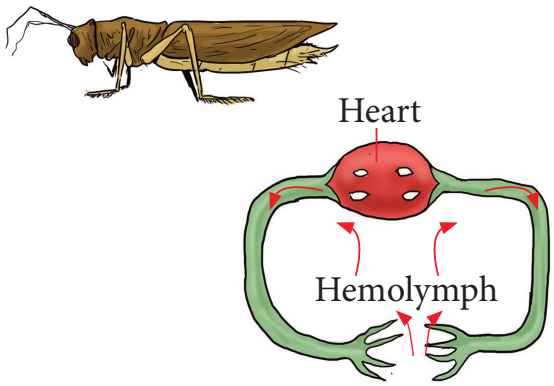


Fig. 5.18: Open circulatory system.

- **Closed circulatory system** found in chordates like birds, fish and mammals. The heart pumps blood to the body via continuous blood vessels and cells. That are not in direct contact with the blood. The blood pressure is higher than in open circulatory system and ultrafiltration at the body tissues forms tissue fluid.

Table 5.5: Comparison of open circulatory system and closed circulatory system

Open circulatory system	Closed circulatory system
Blood is pumped into body cavities	Blood vessels contain the blood throughout
Blood flows at lower pressure	Blood flow is at higher pressure
Animals have slow metabolism	Animals have faster metabolism
Suitable for animals with a larger surface area to volume ratio	Suitable for all sizes of animals

Types of closed circulatory systems include:

- Single circulatory system as seen in fish. The heart pumps the blood to gills via the afferent branchial arteries then the gill capillaries and efferent branchial arteries transport blood to dorsal aorta. The dorsal aorta branches to supply blood to body organs. The blood leaving the organs is at low pressure and collects in sinuses (large blood spaces) from which the heart can refill. This is a single circulatory system because the blood passes through the heart once to complete a cycle.

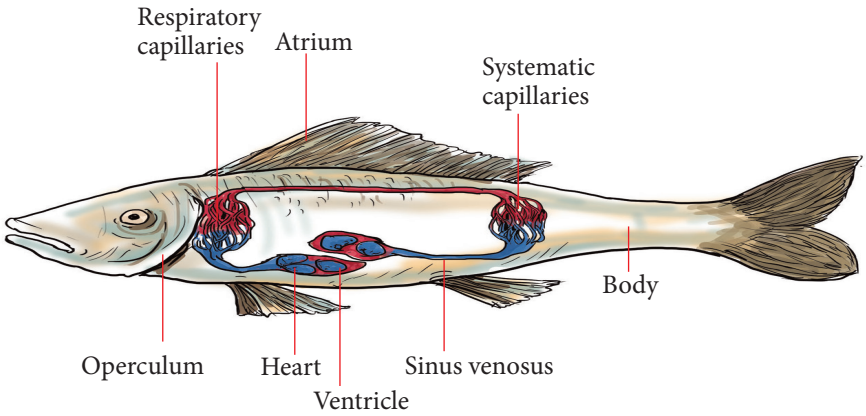


Fig. 5.19: Fish have single circulatory system.

- Double circulatory system as seen in amphibians, reptiles, birds and mammals. The heart pumps the blood to the lungs and back to the heart (pulmonary circuit), then pumps the same blood to the rest of the body and back to the heart (systemic circuit) therefore it takes two blood passes to complete a cycle, hence double circulatory system.

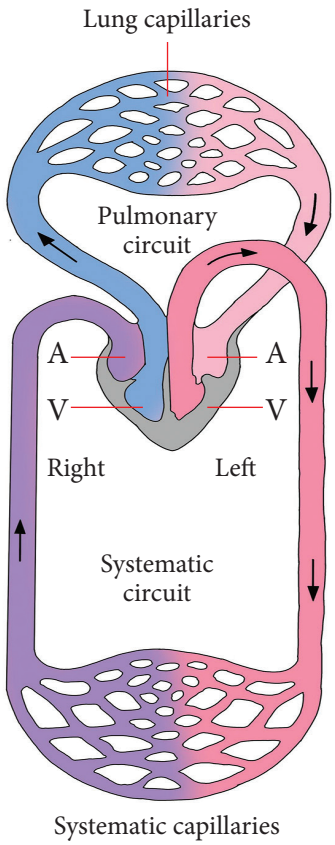


Fig. 5.20: Birds and mammals have double circulatory system.

Blood circulation in humans and birds

Group Activity 5.6

In collaboration with your classmates, form groups of six. Study and evaluate the diagram below then do the task that follows:

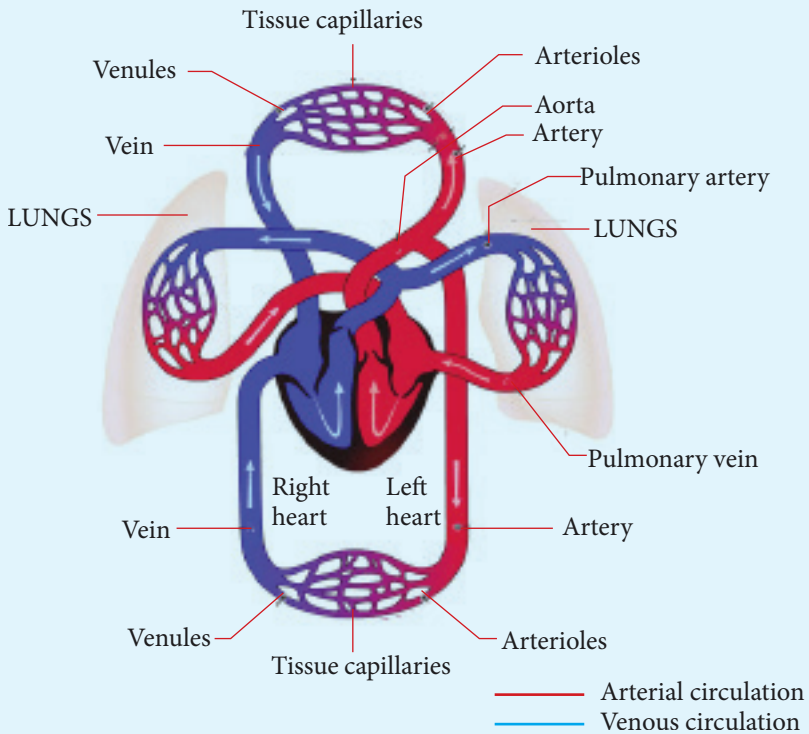


Fig. 5.21: Human and bird circulatory system diagram.

Your task today is to design a game to assist you understand how the blood circulation in birds and human beings work.

Student	Task: using available materials
1	Lung capillaries: receive deoxygenated blood from pulmonary artery and passes it on to the pulmonary vein as oxygenated blood. Go to the left atrium.
2	Left atrium: receives oxygenated blood from pulmonary vein and pumps it through bicuspid valve to the left ventricle. Go to the left ventricle.
3	Left ventricle: receives oxygenated blood from the left atrium and pumps it through aortic semilunar valve to the aorta, then arteries and rest of the body. Go to the systemic capillaries.

4	Systemic capillaries: receive oxygenated blood from the artery system and pass deoxygenated blood on to the veins, then vena cava to right atrium. Go to the right atrium.
5	Right atrium: receives deoxygenated blood from the vena cava and pumps it through tricuspid valve to right ventricle. Go to right ventricle.
6	Right ventricle: receives deoxygenated blood from the right atrium and pumps it via pulmonary semilunar valve and pulmonary vein to the lungs. Go to the lungs.

After designing and writing, post them on the wall at random.

Using a small tennis ball, hit at any card at random read, copy into your notebook and then follow the instructions given on the particular card. At the next card read, copy and obey instructions then the next until you are back to the first card you hit with the ball.

- Read what you have copied at each card.
- What do you observe?
- Whose path of movement did you trace?
- Ask the next member of the group to try a different throw of the ball on another card and repeat the process.
- Is the pattern the same?

Did you know?

Ancient Egyptians believed the heart, rather than the brain, was the source of emotions, wisdom and memory.

The facts

Blood circulation is needed to distribute dissolved nutrients, heat, metabolic waste products and hormones to the cells of the body.

Muscular contractions of the heart pump the blood around the body of birds and human beings.

Blood from the veins is received in the heart atria (singular: atrium) also called auricles.

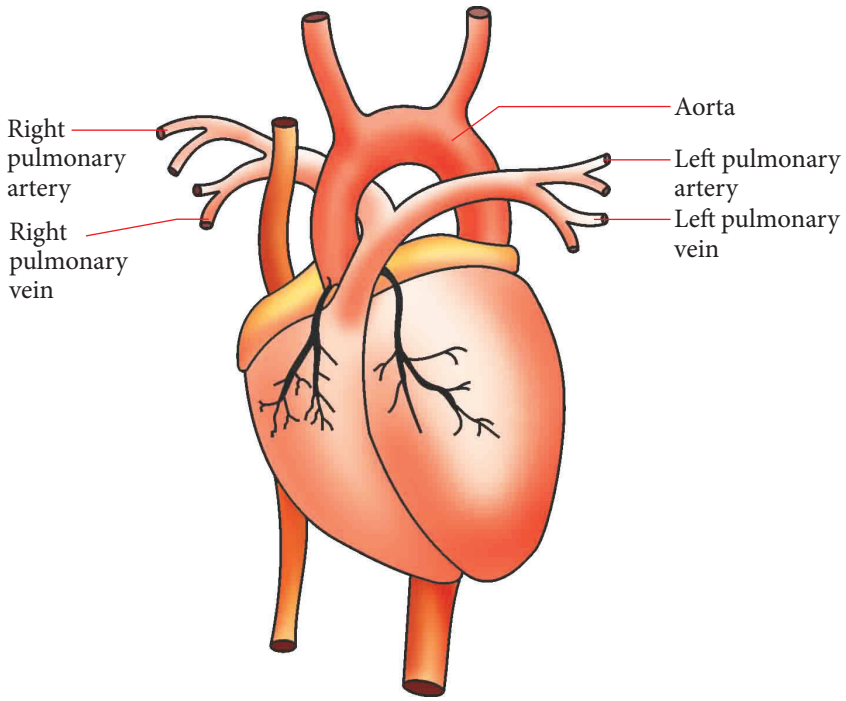


Fig. 5.22: Diagram of the human/bird heart.

Deoxygenated blood from the vena cava (largest vein) is received in the right atrium at the same time is received from the **pulmonary vein** in the left **atrium**.

When the left and the right atrium are full of blood the atrium contracts to pump blood past the cuspid valves, which are two: The left cuspid valves are called the **bicuspid valves** while the right cuspid valves are called the **tricuspid valves**.

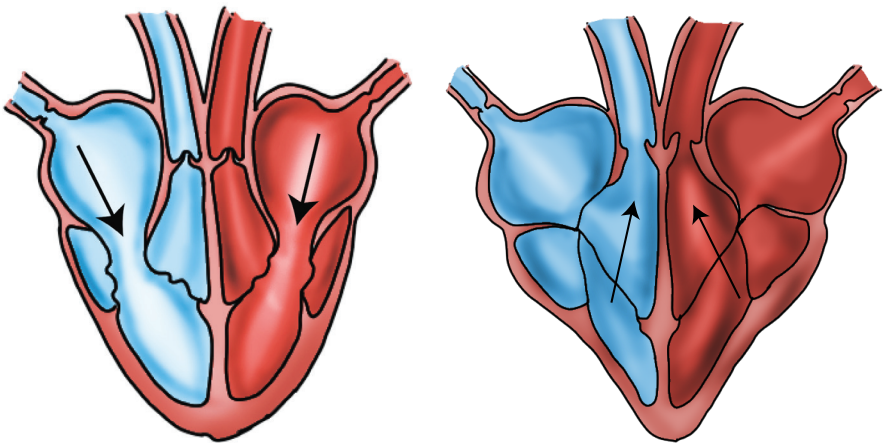
The contraction of the atria is simultaneous and is self-generated by the **pacemaker** (**sino-atria node,** SAN).

The atria contraction pumps blood into the ventricles and the two **ventricles** fill up with blood as they relax.

When full of blood, the cuspid valves close and both ventricles contract. The left ventricle pumps blood past the aortic semilunar valves to the aorta onwards to the other arteries, while the right ventricle pumps blood past the pulmonary **semilunar valves** into the pulmonary artery onwards to the lungs.

The blood from the lungs will return to the heart as oxygenated blood with lower carbon (IV) oxide content via the pulmonary vein into the left atrium.

The blood from the **aorta** will be conveyed to the **arteries** then **arterioles** then **capillaries** (only located in the tissues or organs) then **venules** and **veins** leading to the **vena cava**. The vena cava will deliver the blood to the heart right atrium of the heeart.



Diastole Systole

Fig. 5.23: Cardiac cycle, blood vessels and heart.

Did you know?

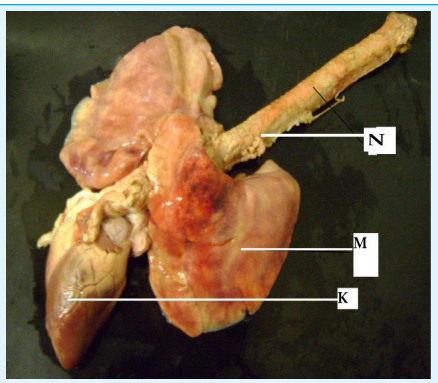
There are two main sounds ("lub" "dub") made by your heart and they are the sounds of the cuspid valves and semilunar valves closing. When the cuspid valves close they make a "lub" sound and when the semilunar valves close, they make a "dub" sound. The stethoscope is used to listen to these sounds. Why would this be important to your doctor?

Remember William Harvey

What made him great? Is it being King Charles' doctor? Is it his discovery of how blood flows?

Group Activity 5.7

Look at the photograph and the parts labelled M, N and K. Answer the following questions.



(a) What do you observe in the part labelled K?

(b) Where in the body of a goat do you think the specimens K,M and N were obtained from?

(c) What do you observe in the part labelled N?

(d) What do you observe in the part labelled M?

(e) Explain how parts K and M, in terms of their functions, are related.

(f) What do you think makes K function as well as it does?

The facts

Structural adaptations of the mammalian heart to its function

The heart has valves namely **atrioventricular valves** (cuspid valves) and the semi-lunar valves which when opened allow blood to flow in one direction only; and when closed prevent backflow of blood.

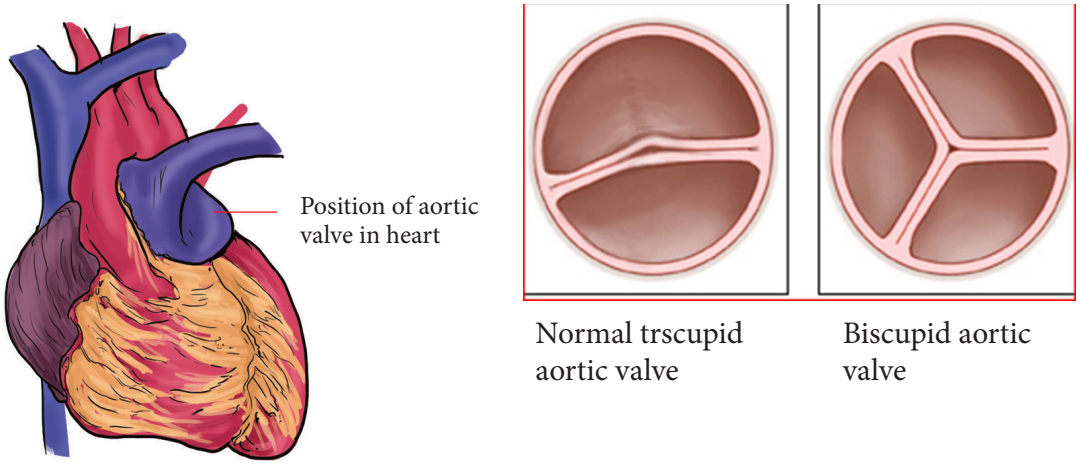


Fig. 5.24 (i): Heart valves

Valves have non-elastic chordae tendineae which prevent the atrioventricular valves from turning inside out into auricles during ventricular systole. Heart has thick muscular walls which contract to pump blood; and ensure its continuous flow. Heart has cardiac muscles, which are myogenic; and contract and relax without fatigue. Heart has sino atrial (SA) node and atrioventricular (AV) node which initiate cardiac muscle impulses and hence stimulate the contraction of the atria and ventricles respectively.

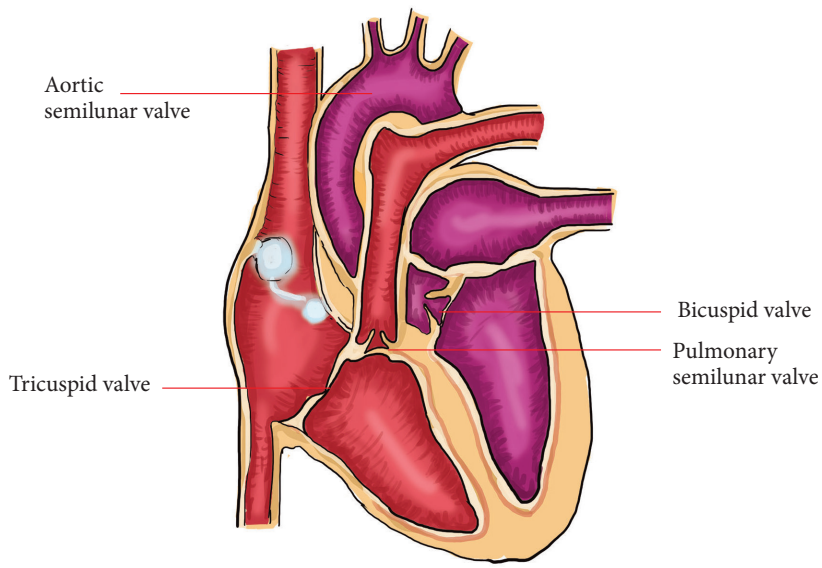


Fig. 5.24 (ii): Four heart valves.

Heart is served by vagus and sympathetic nerves which regulate the rate of the heart beat depending on body's physiological requirements. Cardiac muscles are served by coronary arteries, blood vessels, to supply oxygen and nutrients required by heart muscle cells to respire and by coronary vein which transports away carbon (IV) oxide and metabolic wastes. Heart has specialised interconnected cardiac Pürkinje fibres, which spread the wave of excitation throughout the heart muscles. The heart has four chambers, which hold blood briefly before it is pumped to the rest of the body and the lungs. **Heart septum** separates oxygenated blood on the left side of the heart from the deoxygenated blood on the right side increasing the efficiency of the heart as a double pump. Vena cava and pulmonary vein transport blood to the heart auricles from the rest of the body and lungs respectively. The pulmonary artery and the aorta transport blood from the heart ventricles to the lungs and the rest of the body respectively. The entire heart is enclosed by a tough double-layered protective sac, pericardium, which prevents the heart from being overstretched as it pumps blood. The pericardium secretes pericardial fluid, which lubricates its interior and reduces friction between the pericardial membranes as the heart moves within the inner membrane. The deposit of spongy fatty layer on the pericardium mechanically protects and cushions the heart.

Work to do

- Read the section about the adaptations of the heart to its function.
- Create a table with three columns titled; structure, modification and function.
- Complete the table by summarising what you understood after reading the section.

Group Activity 5.8

1. Observe Figure 5.25(ii). What do you see?
2. Suggest what you think the red arrows represent.
3. Suggest what you think the blue arrows represent

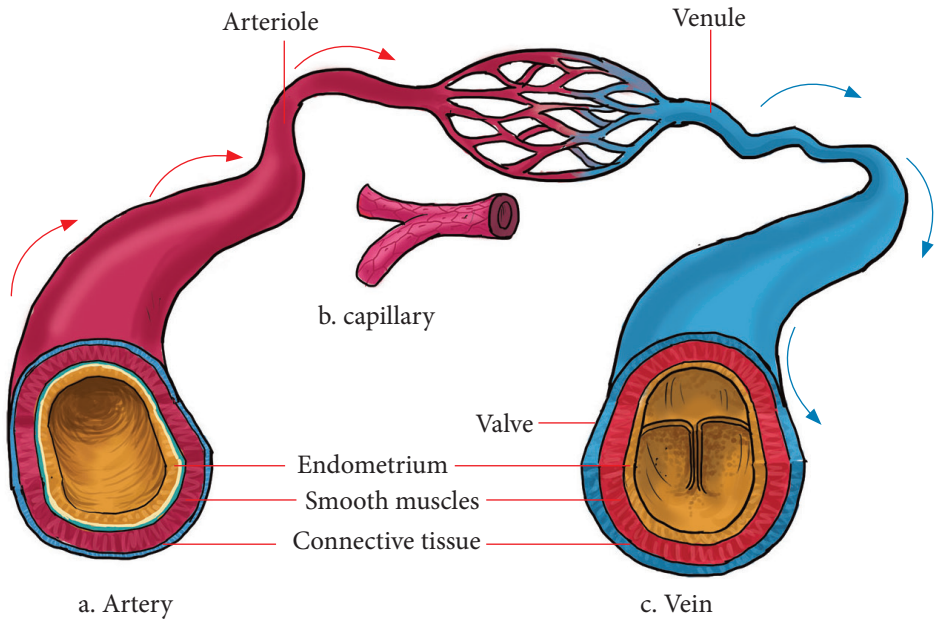


Fig. 5.25 (i): Diagram of the blood vessels.

Open your notebook and after reading the facts section label and write the function of each of the parts shown in Figure 5.21.

The facts

There are three main types of blood vessels:

- **Arteries** which transport blood away from the heart. The largest artery is the aorta and the smallest is the arteriole.
- **Capillaries** which transport blood from arterioles to venules. They are the smallest blood vessels, their walls are one cell thick and they offer the greatest resistance to blood flow. Capillaries are the sites of **ultrafiltration** and site of **tissue fluid** formation.
- **Veins** which transport blood towards the heart and have the widest lumen (internal diameter) with semilunar valves preventing backflow of blood.

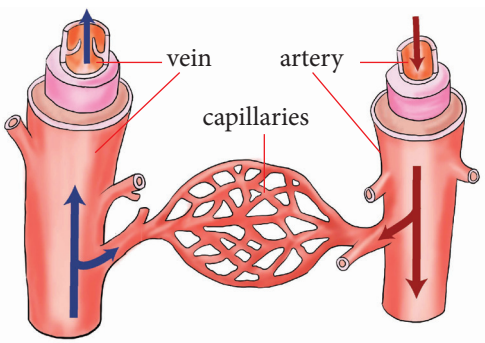


Fig. 5.25(ii): Arteries, veins and capillaries.

Do you remember William Harvey story?

What did he say about the blood vessels?

Table 5.6: Functional differences between arteries and veins

Arteries	Veins
Transport blood away from the heart	Transport blood towards the heart except hepatic portal vein which transports blood from the intestines to the liver
Convey oxygenated blood except pulmonary artery	Convey deoxygenated blood except pulmonary vein
Convey blood rich in nutrients	Convey blood low in nutrient content except the hepatic portal vein and vena cava
Convey blood low in nitrogenous waste materials	Convey blood high in nitrogenous waste materials except renal vein and vena cava
Blood is at high pressure	Blood at low pressure
Blood flow is in pulses	Blood flow is smooth
Have thick muscular elastic walls.	Walls are thin, less muscular and inelastic.
Have a narrow lumen.	Have a wider lumen.
Are located deep in the body.	Are located nearer the skin.

Table 5.7: Structural differences between arteries and veins

Arteries	Veins
Have a small lumen	Have large lumen
Have no valves except at the base of major arteries	Have semilunar valves
Have thick muscular walls which are elastic	Have thin walls which are less elastic
Located deeper away from the body surface	Located nearer to the skin

- Arteries have a high blood pressure compared to veins.
- Arteries have a narrower lumen, which maintains high pressure while veins have a wider lumen that reduces pressure.
- Blood is pumped directly into the arteries at high pressure by the heart.
- Blood pressure in the veins is reduced by capillary resistance before it enters the veins.

Did you know?

A red blood cell's diameter is slightly smaller than the internal diameter of the blood capillaries, therefore, they form a single-file line to fit through the blood capillaries in the body.

Role of hormones in regulation of blood pressure

Group Activity 5.9

- Observe Figure 5.26. What do you see?

Fig. 5.26: A Patient being examined by a doctor.

- Research in the library or Internet how to read the blood pressure.
- If the patient was a healthy person, what readings do you suggest the doctor will make?
- Explain the reading you have suggested.
- If you were the patient, how would you influence the readings?

The facts

The blood pressure may increase or decrease if there are changes in the following:

- The heartbeat rate increases, that increasing the volume of blood pumped to the artery per minute hence increasing blood pressure in the arteries.
- **Vasoconstriction** and **vasodilation** of arteries and arterioles hence increase and decrease of blood pressure respectively.
- Change in blood viscosity too would vary the blood pressure.

The medulla oblongata has a cardiovascular centre responsible for controlling blood pressure by regulating the heartbeat rate and the vasoconstriction or vasodilation of blood arterioles.

The following hormones influence the blood pressure regulation:

- By controlling the blood volume, **Renin hormone** released from the kidney regulates blood pressure through **Angiotensin II** which in turn influence the action of **aldosterone**.
- **Antidiuretic hormone** also increases blood pressure by causing more water retention by the kidney.
- The atria of the heart secrete a hormone called **atrial natriuretic peptide** responsible for lowering blood pressure through vasodilation and increase water loss by the kidney.
- **Flight hormones** released by the adrenal gland increase blood pressure too by increasing vasoconstriction and pulse rate.

Role of the heart in blood flow

How does the heart regulate the rate of blood flow within the body of organisms?

The facts

A human female heart beats about 77 times per minute while a male heart beats about 70 times per minute. Every heatbeat pumps about 140 cm^3 of blood out of the heart, therefore, in a day it pumps about 7,000 litres of blood around the circulatory system.

Group Activity 5.10

How many beats does your heart make in a day?

How would you increase the number of heartbeats your heart is making?

How many beats does an average human heart make in a day?

How many beats does an average human heart make in a lifetime?

The facts

The heartbeat rhythm is maintained by the pacemaker (also called the sino atrial node). The pacemaker has spontaneously active cells, that is they are myogenic cells and generate an impulse which is spread around the heart muscle–to the atria muscle first causing the contraction of the atria, then to the ventricle muscle via the heart conducting systems. The impulses are prevented from spreading directly to the ventricles by a fibrous layer between the atria and ventricles therefore, the heart conducting system of atrioventricular node and **Bundle of His** carry the impulse to the base of ventricular muscle at extremely high speed. From the base of the ventricular muscle the **Pürkinje fibres** transmit the impulse within the ventricular muscle.

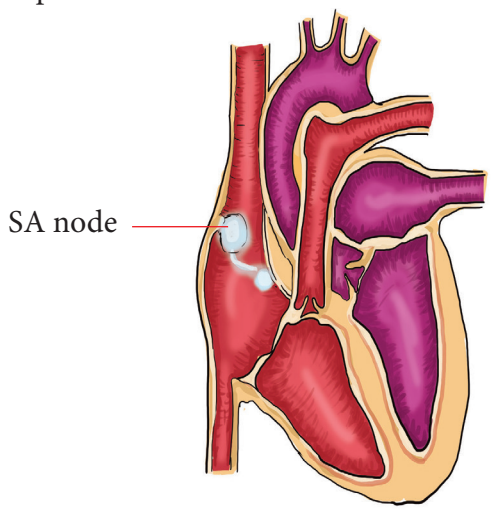


Fig. 5.27: Coordination of a heartbeat.

Group discussion

In your discussion group, discuss:

If you were the one designing your heart, why would you design it for the contractions to be coordinated as described above?

Individual Activity 5.15

Draw Figure 5.27 in your notebook. Then reread the passage before the figure and then label the parts mentioned in the passage.

The facts

The contraction of the ventricles pumps blood into the pulmonary artery and aorta. The left ventricle pumps blood a longer distance, therefore, has a thicker wall to generate more pumping power and pressure.

Did you know?

Why your heartbeat feels like it is on the left side of your chest yet it is on the central position but slightly to the left? Because the left ventricle makes more powerful contractions than the right side.

Hormones and heart rate

Your heartbeat speed may be increased or decreased by the autonomic nervous system. There are two types of **autonomic nervous systems**, namely the **sympathetic nervous system** and the **parasympathetic nervous system**.

The sympathetic system secretes hormones epinephrine (also called **adrenaline**) and **norepinephrine** to increase the heartbeat speed.

After which the **parasympathetic nervous system** secretes hormone **acetylcholine** to decrease the heartbeat rate.

Adrenal glands secrete the hormone adrenaline when you are afraid or angry causing an increase in heartbeat rate hence blood pressure and rate of use of glucose in the muscles.

These hormones stimulate the pacemaker to release impulses at a faster rate hence increase heart muscle contractions.

Blood components and functions

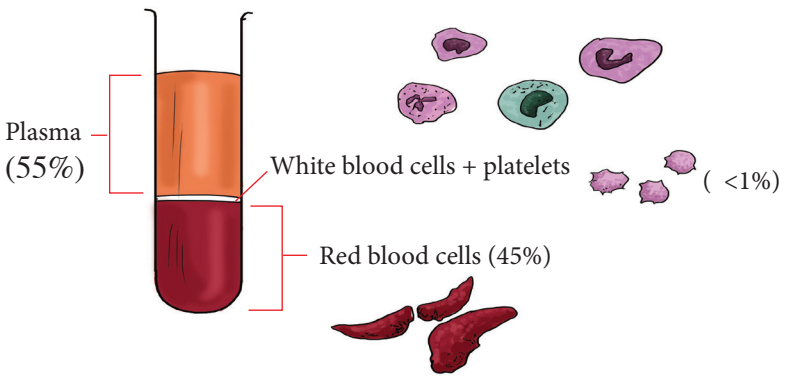


Fig. 5.28: Components of blood.

Blood components

Individual Activity

Study the diagrams in Figure 5.28 showing the blood components, then draw a table showing a component and its function.

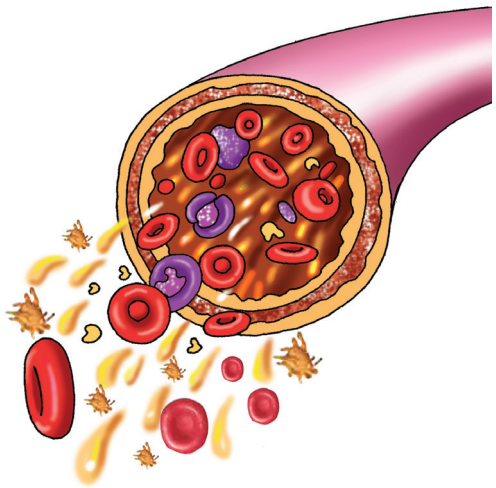


Fig. 5.29: Blood components mind map.

The facts

The red blood cells contain haemoglobin which has a high affinity for oxygen and combines with oxygen in areas of high oxygen tension to form oxyhaemoglobin. Haemoglobin also reacts with carbon (IV) oxide forming carbaminohaemoglobin. The red blood cell is biconcave in shape to increase its surface area for diffusion of oxygen and carbon (IV) oxide in and out of the cell. The mature red blood cell lacks a nucleus and other cell organelles to provide adequate spaces for packing haemoglobin involved in transport of the oxygen and carbon(IV) oxide.

Inside the red blood cells the rate of reaction between water and carbon (IV) oxide is increased by carbonic anhydrase to form carbonic acid. The haemoglobin reacts with hydrogen ions from the dissociation of carbonic acid therefore buffering the plasma pH. The red blood cells are the most numerous blood cells to ensure efficient transport of oxygen and carbon (IV) oxide to the respiring tissues and from the tissues respectively.

White blood cells fight infections in a number of ways, namely neutrophils and monocytes phagocytise (ingest) pathogens; eosinophils phagocytise antigen-antibody complexes and allergens; basophils release histamine which promotes blood flow to injured tissues and lymphocytes are involved in antibody production.

Thrombocytes, when damaged, release thrombokinase starting the process of blood clotting.

Blood plasma contains water which maintains blood volume and transports molecules like amino acids, fatty acids and glycerol from the small intestines to the liver, and other body tissues. Plasma proteins maintain blood volume and osmotic pressure, buffer blood pH at 7.4 and transport cholesterol. Plasma salts maintain blood osmotic pressure and pH while aiding metabolism.

Blood plasma transport hormones and enzymes from secretory glands to tissues where they are required. It also transports carbon (IV) oxide to lungs and urea from tissues to the kidneys. It also distributes heat throughout the body.

How the human body protects itself against pathogens

- Reflex actions like coughing, sneezing and vomiting help to remove foreign materials from respiratory and digestive tracts.
- Enzyme lysozyme present in the saliva, tears and nasal (nose) secretion digest the walls of certain bacteria and destroy them.
- Mucous secretions of the respiratory track (mucus) trap inhaled microorganisms or dust which are then forced upwards in the mucus by cilia to the pharynx where they are coughed out or swallowed.
- The skin cornified layer provides mechanical barrier to microorganisms from entering the body.
- Sebaceous glands produce sebum which is antiseptic.
- Gastric juice contains hydrochloric acid which lowers the pH in the stomach, killing microorganisms.

How blood protects the body against pathogens

- Phagocytosis by phagocytes engulfs and destroys foreign bodies that enter into the body.
- Lymphocytes produce various antibodies which destroy microorganisms in the following ways:
  - **Agglutinins:** Causes the pathogens to clump together stopping them from multiplying and later are engulfed and destroyed by phagocytes.
  - **Lysins:** Digest the cell membrane of the pathogens destroying them.
  - **Opsonins:** Stick to the outer surface of the pathogens making it easier for the phagocytes to engulf and destroy them.
  - **Antitoxins**: Neutralise the toxins produced by the pathogens.
- Clotting of blood prevents entry of microorganisms when the blood vessels are cut to expose blood.

Blood clotting process

- Platelets (thrombocytes) are involved in blood clotting process, where platelets produce enzyme thrombokinase.
- Thrombokinase activates prothrombin, in the presence of Calcium ions, into enzyme thrombin.
- Thrombin converts soluble fibrinogen to insoluble fibrin threads which trap red blood cells to form a blood clot.

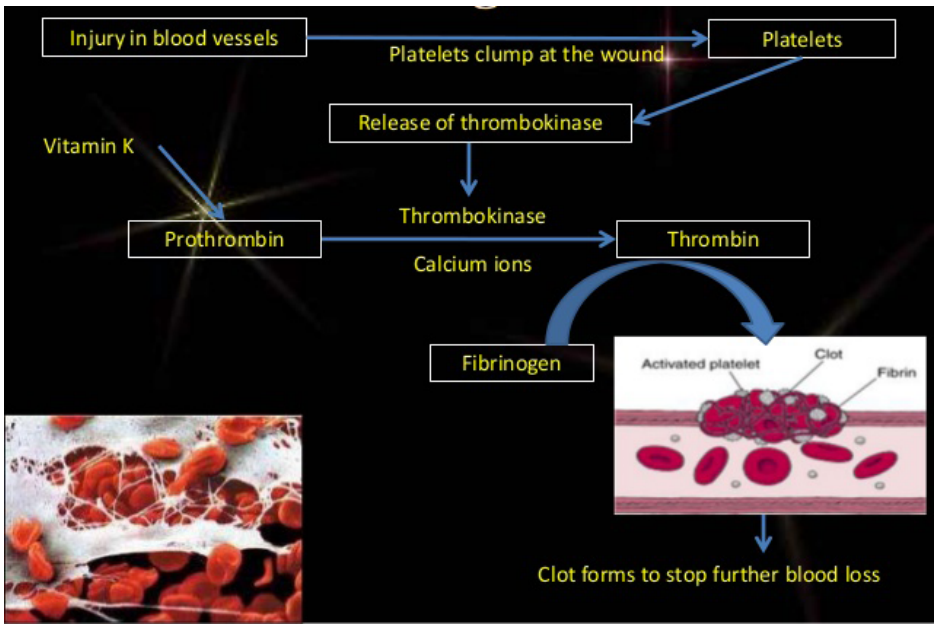


Fig. 5.30: Blood clotting mechanism.

Blood clotting and its importance:

- Provides a physical barrier to pathogens.
- Prevents excessive loss of blood, hence presents anaemia.
- Prevents excessive loss of nutrients.
- Prevents excessive loss of heat.
- Prevents excessive loss of water. Excessive loss of water leads to dehydration.

Check your progress 5b

1. Describe how blood is used in transportation of respiratory gases to and from the body tissues.
2. Describe the functions of blood plasma.
3. Describe how the human body protects itself against pathogens or disease causing microorganisms.

Glossary

Abomasum, also called the maw, rennet-bag, or reed tripe, is the fourth and final stomach chamber in ruminants.

Acetyl coenzyme A, also Acetyl-CoA, is a compound whose role is a coenzyme in many biological acetylation reactions and is formed as an intermediate in the oxidation of carbohydrates, fats and proteins.

Activate is to make something active or operative.

Adenosine Triphosphate (ATP) is energy the cell can use to do work.

Aerobic respiration is the process by which chemical energy is released in cells during the breakdown of food such as glucose.

Agricultural value is the productive value of biodiversity of wild species of plants that provides a rich source of genes to develop disease and pest resistant varieties of crops.

Aldolase is a protein (called an enzyme) that helps break down certain sugars to produce energy.

Amino acids are molecules that can link together in long chains to form proteins. They contain carbon, hydrogen, oxygen and nitrogen, and sometimes sulphur.

Anaerobic respiration is the release of a relatively small amount of energy by the breakdown of food substances in the absence of oxygen. Because the food is not completely broken down some of the energy remains in the waste products.

Angiotensin II is a peptide hormone that results to vasoconstriction which increases blood pressure.

ATP synthase is an enzyme that directly generates adenosine triphosphate (ATP) during the process of cellular respiration.

Biochemical reactions is the transformation of one molecule to a different molecule inside a cell facilitated by enzymes.

Biodegradable is the ability of a substance or organism to break down safely, reliably and relatively quickly by biological means into raw materials of nature and disappear into nature.

Biodiversity (biological diversity) is the total sum of all the living organisms that exist on our Earth. It is the amount of variation in life in a given species, ecosystem, biome or planet. It is essential for biosphere survival since it allows the differences in biological systems to absorb any drastic changes that may happen.

Biotechnology is any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use.

Blood circulation is the continual flow of blood from the heart through branching arteries, to reach and traverse the capillaries in all parts of the body, reconverging in the veins and returning to the heart, to flow through the lungs and back to the heart to start the circuit again.

Bolus refers to food that has been chewed and mixed with saliva in the mouth.

Breathing is a mechanical process where gases are exchanged between the lungs and the atmosphere. It is the first step in respiration.

Bundle of His is a collection of heart muscle cells that conducts the electrical impulses that regulate the heartbeat, from the atrioventricular node in the right atrium to the septum between the ventricles and then to the left and right ventricles.

Canines, also called eyeteeth or cuspids, are teeth used for ripping and tearing at foods that might be tough, such as meat. You have a total of four canines.

Carbaminohaemoglobin, also called carbhaemoglobin, is a compound of haemoglobin and carbon (IV) oxide, and is one of the forms in which carbon (IV) oxide exists in the blood.

Carbonic acid (H_2CO_3) is a relatively weak acid, which dissociates into hydrogen ions (H^+) and hydrogen carbonate ions (HCO_3^-).

Carbonic anhydrase is an enzyme present in red blood cells that aids in the conversion of carbon (IV) oxide to carbonic acid and hydrogen carbonate ions. When red blood cells reach the lungs, the same enzyme helps to convert the hydrogen carbonate ions back to carbon (IV) oxide, which we breathe out.

Cardiac sphincter is a valve between the bottom of the oesophagus and stomach.

Carrier is a person who has been infected but develops no signs and symptoms and can pass the disease to another.

Causative agent is the organism which causes a disease.

Cellular respiration is the enzyme controlled reaction in the cell to breakdown glucose in order to produce ATP, carbon (IV) oxide and water.

Cellulase is an enzyme that digests cellulose and is produced by microorganisms.

Chewing cud is when the grass eaten by a ruminant is regurgitated and chewed by the flat molars and premolars.

Chlorofluorocarbons are chemical compounds found in aerosol spray cans, refrigerators, air conditioners, and styrofoam cups, among other products. When released to the atmosphere, they damage the stratospheric ozone layer. CFCs are also known as Freon.

Churning is the peristaltic mixing of food in the stomach to break it up to smaller pieces.

Cilia are hair-like structures located in the respiratory tract and fallopian tubes. They waft mucus and ovum along respectively.

Ciliated epithelia are epithelial cells that have hair-like structures called cilia which move back and forth to help move particles out of our body. They are found in our respiratory tract and in the fallopian tubes of women. They contain goblet cells which secrete mucus.

Circulatory system is made up of your heart and blood vessels. The heart pumps blood to all areas of your body. The blood carries oxygen and nutrients to your body.

Citric acid cycle is a cycle where one turn of the cycle produces 2 molecules of CO_2, H combines with its acceptors

to make NADH and $FADH_2$ and ADP is converted into ATP. It occurs in the mitochondria of the cell.

Climate change is any change in climate over time, due to natural variability or as a result of human activity.

Climate is the prevailing weather conditions of a region which include, temperature, air pressure, humidity, precipitation, sunshine, cloudiness and winds, throughout the year, averaged over a series of years.

Closed circulatory system is a system that has the blood closed at all times within vessels of different sizes and wall thickness. Blood is pumped by a heart through vessels, and does not normally fill body cavities.

Colon is the large intestine where water and mineral ions are absorbed.

Consumptive use value is productive value of biodiversity of wild species like like hardwood such as mahogany.

Cusps are raised rough points on the crowns of teeth.

Cytosol is the liquid portion of the cytoplasm where many chemical reactions occur within the cell.

Decarboxylase is an enzyme that catalyses the release of carbon (IV) oxide from the carboxyl group of certain organic acids.

Deforestation is the removal of forests by cutting and burning of trees and other vegetation to provide land for agricultural purposes, residential or industrial building sites and roads, or by harvesting the trees for building materials or fuel.

Dehydrogenase is an enzyme that catalyses the removal of hydrogen atoms from a particular molecule.

Denature enzymes an enzyme is a protein, and at high temperatures, the shape of the protein is changed, preventing it from performing its function hence it is said to be denatured.

Deoxygenated blood is blood that has no oxygen.

Diaphragm is a dome-shaped muscular partition separating the thorax from the abdomen in mammals. During breathing, it contracts increasing the volume of the thorax and so inflates the lungs.

Diffusion is the spontaneous movement of a substance from a region of high concentration to a region of low concentration.

Digestion is the breakdown of big, insoluble food particles into small particles using mechanical and chemical processes.

Dipeptide are two amino acids joined together by a peptide bond.

Double circulatory system is the type of circulatory system that occurs in mammals where blood passes through the heart twice before completing a full circuit of the body.

Ecosystem diversity is a variety of interactions among organisms in communities.

Ecotourism is environmentally responsible travel and visitation to relatively undisturbed natural areas in order to enjoy, study and appreciate nature that promotes conservation, has visitor impact and provides for

beneficially active socioeconomic involvement of local populations.

Electron transport system is the process involving the stepwise transport of electrons to a final electron acceptor such as oxygen creating an electrochemical gradient across membranes to drive the phosphorylation to ADP to yield ATP.

Emulsification is the process whereby large globules of fat are broken down into smaller globules.

Endangered species are any species in danger of extinction throughout or a significant portion of their range due to destruction or interruption of environment (habitat loss), an alteration in the ecological balance resulting in an increase in predators and too few remaining members for sustainable breeding.

Endemic is a disease which is always present at the low level in a given population or region.

Enzyme catalase is an enzyme found in nearly all living organisms exposed to oxygen (such as bacteria, plants and animals). It speeds up the decomposition of hydrogen peroxide to water and oxygen.

Enzyme rennin is an enzyme that is needed for the breakdown of proteins.

Enzyme-substrate complex is a temporary structure formed when a substrate bonds with the enzyme active site.

Enzymes are proteins that speed up chemical reactions (catalysts).

Epidemic is a situation in which a disease spreads rapidly through a large number of people and later disappears.

Epiglottis is the flap of cartilage lying behind the tongue and in front of the entrance to the larynx. It is a valve-like cartilage which works with the larynx to act as a lid every time we swallow.

External respiration refers to the sequence of events that lead to the exchange of oxygen and carbon (IV) oxide between the external environment and the cells of the body.

Extracellular refers to situated or occurring outside a cell or cells.

Flavin adenine dinucleotide hydrogen is a redox cofactor that is created during the Krebs cycle and utilised during the last part of respiration.

Forest degradation is a decrease in the capacity of a forest to produce ecosystem services such as carbon storing and wood products as a result of anthropogenic and environmental changes.

Fructose is sugar found in fruits.

Gastric juice is the digestive fluid made up of pepsin and other enzymes that are produced by the glands of the stomach.

Gastrin hormone is a protein hormone produced in the wall of duodenum and pancreas that stimulates the release of gastric juice by the stomach wall.

Genetic diversity is diversity of genes within a species. There is a genetic variability among the populations and the individuals of the same species.

Gill epithelium is squamous or flattened epithelial cells lining the surface of gill filaments.

Gill filaments are the red, fleshy parts of the gills. They are the smallest division of the gill and they take oxygen into the blood.

Gill lamellae are a multi-tissue structures that are the transverse vertical platelets on the gill filament, through which capillaries run.

Gizzard is a muscular bag where grinding of food occurs.

Global warming is an average increase in the temperature of the atmosphere near the Earth's surface and in the troposphere, which can contribute to changes in global climate patterns.

Glucose is the simplicity type of sugar obtained from foods you eat and your body uses it for energy.

Glycolysis is the sequence of reactions that convert glucose into pyruvate in the presence of oxygen (aerobic) or lactate in the absence of oxygen (anaerobic) with the production of ATP.

Greenhouse effect is the partial trapping of solar radiation by the atmosphere, similar to the trapping of heat in a greenhouse. Sunlight that is not reflected by the clouds reaches the Earth's surface, warming it up. Infrared radiation reradiated from the surface is partially absorbed by carbon (IV) oxide in the atmosphere causing overall surface temperature to rise.

Greenhouse gases are gases that absorb infrared radiation and radiate heat in all directions. They include water vapour, carbon (IV) oxide, methane, nitrous oxide, ozone and any fluorocarbons.

Haemoglobin is the oxygen-carrying pigment of red blood cells that gives them their red colour and works to transport oxygen to the tissues.

Hexokinase is an enzyme that catalyses the ATP dependent phosphorylation of glucose to glucose-6-phosphate.

Hexose phosphate isomerase is an enzyme that catalyses the interconversion of d-fructose 6-phosphate and d-glucose 6-phosphate.

Hydrochloric acid is an acid found in the stomach that promotes conversion of inactive pepsinogen into active pepsin, which then digests proteins into peptides.

Hydrogen carbonate is hydrogen carbonate ion.

Hydrogen peroxide is a by-product of respiration produced in all living cells. It is harmful and must be removed as soon as it is produced in the cell. Cells make the enzyme catalase to remove hydrogen peroxide.

Inactivate enzymes are enzymes in their inactive form, they are at a point when the enzymes stops working.

Incisors are the front teeth present in most mammals.

Incubation period is a period of time between the original infection and the appearance of signs and symptoms.

Infective period is a period during which a person is capable of passing the disease on to another person.

Intercostal muscles are muscles of two sets: external intercostal that are found between the ribs with fibers running downwards towards the sternum. They pull ribs together raising the rib cage during inspiration.

Internal respiration is the physical process in which oxygen is taken up by capillaries of lung alveoli and carbon (IV) oxide is released from blood.

Lacteal is the smallest part of the lymphatic system that allows absorption of fats in the small intestines.

Lactic acid dehydrogenase, abbreviated as LDH, catalyses the conversion of lactate to pyruvic acid and back, as it converts NAD+ to NADH and back.

Lactic acid is a colourless or yellowish, syrupy, water-soluble liquid, which is a byproduct of anaerobic glucose metabolism.

Lactic fermentation occurs during rapid exercises when less oxygen is available. It produces soreness.

Lumen is the inside space of a tube-shaped structure, such as an artery or intestine.

Lung alveoli are tiny airsacs that are responsible for gaseous exchange within the lungs of tadpoles.

Malphigian tubules are organs of excretion in insects.

Medicinal value is relating to medicinal effects of medicinal substances or substances that can be used to treat and cure.

Microvilli are extensions of the cell membrane used to increase the surface area of the small intestines.

Mitochondrion is a membrane bound organelle found in the cells that make up plants, animals, fungi and other forms of life.

Molars are large, flat teeth at the back of the mouth used primarily to grind food during chewing.

Mucous membranes are wet or moist membranes that are always continuously bathed in the secretions.

Multicellular is a tissue, organ or organism that is made up of many cells.

Neutralises means creates a pH of 7 (neutral).

Nicotinamide adenine dinucleotide (NAD+) is a biological oxidising agent. The plus sign represents the positive charge on nitrogen.

Nostrils is one of the two channels of the nose, from the point where they separate to the external opening.

Notifiable disease is a disease which must be reported to doctors or health authorities due to its seriousness, for example, TB, Polio and Cholera.

Oesophagus, also called gullet or food pipe, is a long, muscular tube that connects your mouth to your stomach.

Omasum, also called the bible, the fardel, the manyplies and the psalterium, is the third chamber of the stomach in ruminants.

Open circulatory system is a system where blood, rather than being sealed tight in arteries and veins, suffuses the body and may be directly open to the environment at places such as the digestive tract.

Optimum temperatures are temperatures at which enzymes function best. For most enzymes, it is 40 degrees Celsius. At high temperatures, enzymes denature.

Oxygen debt is the amount of oxygen needed to get the body back to its resting rate and get rid of the excess lactic acid produced after intense physical exercises.

Ozone layer is a layer found between the stratosphere and the troposphere which contains 90% of atmospheric ozone (O_3). It filters out and converts harmful UV rays from the sun into heat energy.

Pandemic is an epidemic which spreads across a whole continent.

Pathogens are organisms that invade the body, live parasitically, and cause diseases.

Pepsin is an enzyme that breakdowns proteins into smaller peptides (that is, a protease).

Peptides are shorter chains of amino acids.

Peristalsis is the contractions of two sets of muscles in the walls of the gut. One set runs along the gut, while the other set circles it creating a squeezing action, moving down the gut.

pH (potential concentration of hydrogen ions) is a scale of acidity beginning at 0 to 14. It tells how acidic or alkaline a substance is.

Phosphorylation is the addition of phosphate group to an organic molecule. There are two types: substrate level and oxidative.

Poaching is the illegal act of hunting, killing or capturing animals.

Polygastric digestion is the digestion that occurs in ruminants which involves many stomach.

Polypeptides are long continuous and unbranched peptides.

Population is a group of organisms, all of the same species, that live in a specific area. Every organism you can think of is a member of a population. A healthy population will grow and die at a relatively steady rate unless it runs out of water, food or space, or is attacked in some way by diseases or predators.

Premolars or bicuspids, are transitional teeth located between the canine and molar teeth. You have two premolars per quadrant in the permanent set of teeth, making eight premolars in your mouth.

Prevention are measures taken to prevent a person from getting a disease, for example, vaccination, sewage treatment and hygiene among others.

Pseudomonas is a group of denitrifying bacteria.

Pürkinje fibres are special fibers that are located in the atrioventricular, or AV, bundle of the heart. They send nerve impulses to the cells in the ventricles of the heart and cause them to contract and pump blood either to the lungs or the rest of the body.

Pyloric sphincter is a band of smooth muscles at the junction between the pylorus of the stomach and the duodenum of the small intestine. It acts as a valve to control the flow of partially digested food from the stomach to the small intestine.

Pylorus caecae are finger-like projections located in the stomach of fish. They caeca secrete digestive enzymes and increase the surface area in the stomach for nutrient absorption.

Pylorus is the furthest part of the stomach that connects to the duodenum. It prevents intestinal contents from reentering the stomach when the small intestine contracts and limits the passage of large food particles or undigested material into the intestine.

Pyruvic acid is the end product of glucose breakdown that occurs in the process of glycolysis.

Renin hormone is a hormone that controls blood pressure and fluid balance.

Rennin, also known as chymase, is a protein-digesting enzyme that curdles milk by transforming caseinogen into insoluble casein.

Respiration is the oxidation of food substances (glucose) with the release of energy in living cells. It is a characteristic of life since all living things require energy for essential activities. There are two types: aerobic and anaerobic.

Respiratory surface is a thin, moist, epithelial surface that oxygen can cross to move into the body and carbon (IV) oxide can cross to move out of the body.

Reticulum is the second chamber of the ruminant stomach.

Reversibility is the ability of an enzyme causing a reaction to follow any direction, depending on the concentration of substrate, reactants and products.

Rumen, also called a paunch, is the first chamber in the alimentary canal of ruminant animals.

Ruminants are mammals that chew cud and have a stomach divided into four compartments. Examples are cows, sheep, moose, goats, antelopes and camels.

Salivary amylase is an enzyme found in the saliva of human beings and herbivorous animals that is involved in the predigestion of starches.

Signs are visible expression of a disease which can be found by examining a patient.

Single circulatory system is the type of circulatory system in which blood passes through the heart only once in each complete circuit around the blood system.

Species diversity is diversity among species in an ecosystem. Biodiversity hotspots are excellent examples of species diversity.

Species is a Latin word meaning "kind" or "appearance." It is a population or group of populations whose members have the potential to interbreed and produce fertile offspring.

Spiracle valves are muscular valves in the insect body, and their opening can be controlled, mostly in order to regulate water loss, since the tracheal system is always saturated with water vapour.

Stomach is a muscular organ located on the left side of the upper abdomen and it receives food from the esophagus.

Substrate is a substance acted upon by an enzyme.

Sucrose is a disaccharide, non-reducing sugar, made of a glucose molecule and a fructose molecule linked together.

Symptoms are an indication of a disease which is not detectable by examination and can only be reported by the patient, for example, headache and nausea among others.

The internal intercostal are found between the ribs. They depress the rib cage during forced expiration.

Thoracic cavity, also chest cavity is bounded by chest wall and below by diaphragm. It extends upwards into

the root of the neck about one finger breadth above the clavicle on each side. The chest cavity can be divided into a median partition, called mediastinum, and the laterally placed pleurae and lungs.

Threatened species are any species likely to become endangered in the foreseeable future. The population of a threatened species is declining at an alarming rate.

Tissue fluid is a solution that bathes and surrounds the tissue cells of multicellular animals. It is the main constituent of the extracellular fluid, whose other components are the blood plasma, lymph and transcellular fluid.

Trachea is a tube in vertebrate animals that leads from the larynx to the bronchial tubes and carries air to the lungs.

Tracheoles are extremely small, thin-walled, respiratory tubules originating from the ends of the smallest insect trachea.

Treatment are measures taken to cure a disease or alleviate symptoms once a person has the disease, for example, use of antibiotics.

Trypsin is a protease produced in the pancreas and it hydrolyses proteins.

Trypsinogen is an inactive substance secreted by the pancreas, from which the digestive enzyme trypsin is formed in the duodenum.

Ultrafiltration is high pressure filtration through a semipermeable membrane in which colloidal particles are retained while small sized solutes and the solvent are forced to move across the membrane by hydrostatic forces.

Unicellular eukaryotic are single-celled organisms. "Unicellular" means the organisms have only one cell, while "eukaryote" means each of these cells has a nucleus–and other organelles–held in place by membranes.

Vascularised is to provide a tissue or structure with vessels, especially blood vessels.

Vasoconstriction is the narrowing of the blood vessels as a result of contraction of the muscular wall of the vessels.

Vasodilation is the widening of blood vessels resulting from relaxation of smooth muscle cells within the vessel walls, in particular in the large veins (called venodilators), large arteries, and smaller arterioles, the opposite of vasoconstriction.

Vector is an organism which carries the causative agent from an infected animal or plant to another.

Villi are tiny finger-like structures in the lining of the small intestines.

Waste disposal is the discarding of unwanted materials from houses, street sweeping and commercial industrial and agricultural operations arising from man's activities.

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