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Malawi

Senior Secondary

Biology

Form 3

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Excel & Succeed

Senior Secondary Biology

Form 3

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Unit 1

Problem solving

Specific objectives

By the end of this unit, you should be able to:

(a) Identify problems from a given situation.
(b) Suggest possible solutions to problems.
(c) Test selected solutions and draw conclusions.
(d) Evaluate evidence and make decisions.
(e) Write reports.

Introduction

In Form One, we learnt about problem solving. We learnt that problem solving involves the use of scientific findings to come up with solutions to problems in our day-to-day lives.

In Form Three, we will apply problem-solving skills to solve various problems in our surroundings.

Problem solving process involves:

(a) Identification of problem

In Form One, we learnt that problems are identified by observing situations in our day-to-day lives.

(b) Definition of the problem to be solved

After a problem is identified, it must be put in form of a statement. For example, the problems identified in Hema village can be stated as follows:

- Poor health of children in Hema village.
- Deteriorating health of children of Hema village.

Definition of the problems gives a reason why a given investigation should be carried out.

(c) Gathering information

This involves reading about the problem from books, magazines, journals and talking to experts to gather information about the problem. In this case, one can read on disease symptoms from books or visit the local health centre to ask the Health Officers to explain the problem in a professional way.

In gathering information about the problem, one asks the following questions:

- Where else does the above problem occur or in which other place was such a problem observed?
- What other observations are made when such a problem occurs?
- What are the probable causes of the problem?
- What are the probable solutions to the problem?

(d) Suggesting possible solutions

After the information is gathered, it is analysed. In the analysis, information similar to the situation observed is identified. For instance, in which other area was such a problem observed? Possible solutions to the problem are then listed down. From the possible solutions, the ones more applicable to the situations observed are identified.

(e) Testing the possible solutions

Testing involves experimenting whether the solution suggested can really work to solve the problem. This is first done in a small group called a **sample.** If it works in a sample, then the solution can be implemented in the whole population. In testing the possible solutions the following are done:

1. Choose a sample population where the test will be carried out. Identify resources to be used in the test. For instance, educational materials, resource persons such as nurses and food items such as meat, milk and fish.
2. Identifying the variables to be used, what variable will be changed, what variable will be kept constant and what variable will be observed.
3. Choose the method to be used in the test. This is the systematic way of carrying out the test.

(f) Conclusions

From the data collected, a conclusion is made as to whether the suggested solution can really work. In the conclusion, the following are considered.

- Some factors that were not considered.
- Weaknesses of the method.
- Obstacles observed.

(g) Evaluation of the evidence

This involves evaluating the evidence in the conclusion to make decisions. The evaluation involves comparing the advantages and disadvantages of the solution. This is in terms of:

- How effective it can solve the problem.
- How expensive the method is. In this case, you consider whether funds can be available to solve the problem.
- The benefits of the solution. How was it received by the beneficiaries.

(h) Making decisions

This involves making a choice on whether to:

- Accept the solution and implement it as it is.
- Choose the solution but make some changes on the method before implementing it.
- Reject the suggested solution and propose an alternative one.
- After the decision is made, reasons as to why it is the best decision are given
- Consequences of the solution are also stated. These include possible reactions after the solution is implemented.

(i) Report writing

After a decision has been made, a report is written.

The report gives a guideline on how the problem was identified and tested. The report shows that the suggested solution can really work to solve the problem in the village.

The report should have the following parts:

(a) The aim of the investigation.

(b) Description of the method used.

(c) Presentation of results.

(d) Drawing of conclusions.

Activity 1.1:

You are provided with the following sets of situations observed in Malawi. Study them and design a problem solving method. Under each case, write a report.

Case 1

Most of Malawi was originally covered by forest but over the years, people have been cutting down the trees and burning them to open up areas for farming. This is commonly known as "slash and burn" agriculture. In the past, these areas were farmed for one to three years and then the farmers would move on, cut down some more forest and start all over again. When the population of malawi was small, the environment was able to recover as the trees would regenerate. Currently, the population of Malawi is estimated to be 15 million. This has increased pressure on available land. Today, more than 80% of Malawians live in the rural areas and are subsistence farmers.

Case 2

Plastic bags are useful tools but they are becoming a menace in our urban centres. A solution is needed for this problem.

Activity 1.2:

Observe the environment in your school or around your school. Write down several problems that you can note. Choose one problem and design a problem solving mechanism. Write a report.

Revision Exercise 1

1. Explain the importance of carrying out an investigation before implementing a suggested solution to a given problem.
2. Write an essay on important points to note in problem solving process.
3. Discuss obstacles that one faces when designing problem solving mechanisms.

Unit 2 Investigative skills and techniques

Specific objectives

By the end of this unit, you should be able to:

(a) Observe safety measures when doing investigations.

(b) Use scientific equipment and materials safely.

(c) Take measurements and make detailed drawings from observations.

(d) Design investigations.

(e) Do projects and write reports.

Introduction

In Form One, you learnt about the use of glassware in carrying out experiments. You also learned about using burners safely, safety measures in laboratory, using microscopes, taking measurements and carrying out investigations.

In this unit, we will apply the skills learnt in Form One to carry out various activities.

Use of glassware in heating substances

Carry out the experiment below and answer question that follow.

Activity 2.1: To determine whether chlorophyll dissolves in water

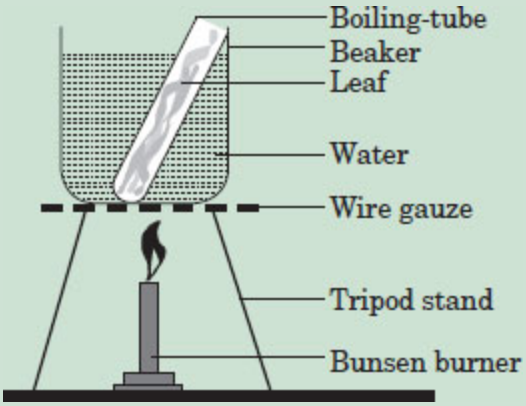
Materials and apparatus

- Boiling tubes
- Test tubes
- Alcohol
- Water

- Bunsen burner
- Test-tube holders
- Wire gauze
- Leaf

Procedure:

1. Take a 500 ml beaker and half fill it with water
2. Place it on the tripod stand and place a Bunsen burner with a good flame underneath.
3. Heat the water up to boiling.
4. Put alcohol into the boiling tube.
5. Put the leaf into the alcohol and ensure it is totally subemerged.
6. Dip the boiling tube with the alcohol and the leaf into the beaker with boiling water.



1. Heat for about 10 minutes.
2. Repeat the procedure using water instead of alcohol.
3. Record your observations.
4. Write a report on the above experiment.

Questions

1. Suggest reasons why alcohol in the experiment was not heated directly.
2. What name is given to the hot water in the beaker that was used to heat the alcohol?

3. When removing the boiling tube from the hot water which equipment did you use?

Discussion

From the experiment, you may have realised that in heating substances using glassware such as beakers, a wire gauze is used. The beaker is placed on the wire gauze to protect the glass from direct flame.

In heating alcohol, the boiling tube is dipped into a beaker with hot water. Alcohol is flammable and thus it cannot be heated directly. It can only be heated by use of a water bath. The beaker with hot water is called a **water bath.**

From the experiment, you may have noted that when a leaf is boiled in alcohol, it becomes decolourised. However, when boiled with water, it does not decolourise. This shows that the green colour of leaves is soluble in alcohol but it is insoluble in water.

Assembling glass apparatus in an experiment

In some experiments, more than one glassware are used. The glass are connected together to form a set of apparatus.

Tubes are used to connect one glassware to another. The mouth of glassware are closed by use of corks. Corks are made of soft materials such as rubber that fits tightly onto a glass without causing breakages. Tubes used to connect two glasses may be made of rubber or glass.

Let us carry out an experiment to investigate production of gas in fermenting sugar.

Activity 2.2: To investigate gas production when sugar is fermented

Materials and apparatus

- Glass tubes
- Conical flasks
- Glucose solution
- Yeast
- Corks

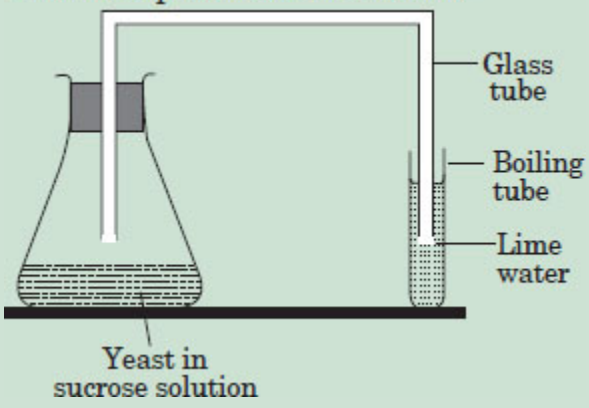
- Lime water
- Boiling tube
- Thermometer

Procedure

1. Put about $50cm^3$ of distilled water into a conical flask. Warm the water up to 37^oC. Add 20 grams of glucose or sucrose and stir the mixture.
2. Add about 10 grams of yeast powder into the water.
3. Cork the conical flask with a cork having one hole.
4. Fit a U-shaped glass tube into the hole on the cork down into the conical flask. The glass tube should not touch the yeast solution in the conical flask.
5. Put limewater into a boiling tube upto half full mark.
6. Dip the other end of the glass tube from the conical flask into the limewater.
7. Allow the set to settle on a bench and observe for 30 minutes.

The set-up is as shown below:

The set-up is as shown below:



Questions

1. What precautions did you carry out when setting the above apparatus?
2. What was the importance of using warm water instead of cold water?
3. What is yeast?
4. Explain the observations that were made from the experiment and write a report.

Discussion

In the experiment, warm water was used to increase the rate of activity. When temperatures are raised in chemical reactions, the rate at which chemical process take place also increases.

Yeast is an organism. It is in the same group as fungi. It acts on sugar causing fermentation.

As you may have noted, a gas was produced by the yeast in the conical flask. The gas rose up and passed through the glass tube into the lime water in the boiling tube.

The gas escaped from the lime water in form of bubbles. As the gas was escaping, it caused the lime water to turn milky. This means that the gas produced was carbon dioxide.

Use of microscope

In this section, we will use a microscope to observe onion epidermal cells and organisms found in pond water.

Activity 2.3: To examine cells from an onion epidermal cell.

Materials and apparatus

- Microscope
- Slide
- Water
- Cover slips
- Scalpel
- Onion bulb

Procedure

1. Remove a leaf from an onion bulb. Bend the leaf until it breaks. At the breaking point, check for a thin transparent structure (paper like) that appears. This is an epidermis.
2. Remove the epidermis using forceps, and place it on the slide.
3. Add a drop of water onto the tissue and cover carefully using a cover slip.

4. Mount the slide onto a microscope.
5. Focus the microscope and observe using low power lens and medium power lens.
6. Count the number of cells that are lined up from one end of the field of view to the other end when examined under:
   - Low power lens
   - Medium power lens
7. Draw two adjacent cells that you have observed.
8. Calculate the magnification of the observed images under:
   - Low power lens
   - Medium power lens
9. Write a report of your findings.

Questions

From the findings you have obtained from the experiment above, answer the following questions

1. Fill in the table below with the results you obtained from the experiment

Objective lens used	Lower power lens	Medium power lens
Magnification of the objective lens		
Magnification of the eye-piece lens		
Total magnification		
Number of cells counted across the field of view		

2. Compare the total magnification with the number of cells observed across the diameter of the field of view

Discussion

From the experiment, you may have realised that at low magnification, many cells are seen across the field of view. As the magnification increases,

the number of cells seen across the field of view are fewer.

You may have noted that at low magnification, the cells do not show a lot of details. As the magnification is increased, more details are seen in a cell.

Activity 2.4: To examine organisms in pond water

Materials and apparatus

- Pond water
- Microscope
- Slides
- Cover slip
- Dropper

Procedure

1. Place a drop of pond water onto a slide.
2. Lower the cover slip gently onto the drop of water.
3. Mount the slide onto a microscope.
4. Examine the specimen using low power and medium power objective lenses.
5. Identify organism that move and those that do not show any signs of movement.
6. Identify the structures used in movement by the organisms that you have observed.
7. Make a drawing of one organism you have observed.
8. Calculate the magnification of the image observed.

Discussion

From the activity, you may have realised that the microscope helps us to see tiny organisms that live in water that we cannot see with unaided eyes. Some of the organisms move freely in water by use of long whip like structures while others do not move.

In the pond water, tiny plants such as spirogyra and algae are also observed.

Taking measurement

In this experiment, we will take measurements of different specimens. From the measurements, we will determine surface area, volume, length, force and mass.

Activity 2.5: To determine volume and weight of different food materials of the same size

Materials

- A piece of potato
- A piece of sugarcane
- Maize seeds
- Bean seeds

Procedure

1. Design an experiment to compare the mass of 50 beans seeds with the mass of 50 maize seeds.
2. Write a report on your findings.

Carrying out investigations

In Form One, you learnt how to carry out scientific investigations. You learnt that every investigation has an aim, a hypothesis and a method to be used in the study.

The results obtained from the observation are recorded and the data analysed to come up with a conclusion. After completion of an investigation, a report is written.

Revision Exercise 2

Carry out the following activity

A student noted that in their homestead, the kitchen was invaded by red ants at night. He decide to investigate and find out locally available substances that can be used to keep off red ants in the kitchen. He decided to use salt, naphthalene and ash.

Instructions

1. Design an experiment that the student could use.
   Indicate the following:
   - Aim of the investigation.
   - Variable to be kept constant.
   - Variables to be observed.
   - Hypothesis.
   - Procedure.
   - Record expected observation.
   - Present your observation in form of tables or graphs.
   - Analyse the information and draw conclusions.
2. Write a report about your work.

Unit 3 Photosynthesis

Specific objectives

By the end of this unit, you should be able to:

(a) Label a diagram of a cross section of a leaf as seen through a light microscope.

(b) State the functions of the parts of a leaf.

(c) Explain the adaptations of leaves for photosynthesis.

(d) Label a mesophyll cell as seen through an electron microscope.

(e) Explain the functions of the parts of a plant cell.

(f) Describe the process of photosynthesis.

Review of photosynthesis

In Form Two, you learnt that all green plants make their own food in a process called photosynthesis

Photosynthesis is a process whereby green plants use light energy to make organic food substances by use of water and carbon dioxide.

The process of photosynthesis takes place in all green plants and other organisms such as the green algae that contains chlorophyll in their cells.

Parts of a leaf

Activity 3.1: Observing a cross-section of a leaf

Materials

- Pieces of carrot, scalpel or sharp blade, microscope slides, microscope cover slip, light microscope, water, dropper, mounting needle, dish for example petri-dishes or glass dishes, a fine brush, young leaf from a

dicotyledon such as black jack, peas, beans and monocotyledons like maize, grass among others.

Procedure

1. Take a carrot, wet it then slice it vertically halfway down the middle.
2. Insert the leaf blade into the slit made in the carrot. Make sure that the midrib of the leaf is placed vertically along the centre of the carrot. Trim off any protruding part of the leaf.
3. Hold the carrot in one hand, and cut several thin sections quickly and smoothly with a scalpel using the other hand.
4. Put the sections in water in a petri-dish.
5. Take a slide and put a drop or two drops of water on it using a dropper.
6. Select the thinnest section of a leaf preferably one that is cut through the midrib and place it into the
7. drop of water. Use a fine brush to transfer the sections to avoid damaging them.
8. Using a mounting needle, carefully place a cover slip on the section. Make sure no air bubbles are trapped.
9. Using tissue paper, wipe off excess water from the slide before observing it under the microscope. First use low power then medium power.
10. Try to identify the following layers of tissue: upper epidermis, palisade layer, spongy mesophyll, vascular bundles, lower epidermis and stomates.
11. Use a sharp pencil to draw the outline of the layers of tissues you have seen under low power magnification. Label the layers.
12. Under the medium power, examine and draw a cell from each of the following layers: upper epidermis, palisade layer, spongy mesophyll and lower epidermis.
    - What do you notice about the shape of each cell? What do you notice about the arrangement of the cells in the layers? Are they closely packed or loosely packed?
    - The transverse section of a leaf is as shown in Fig. 3.1 below.

Discussion

From activity 3.1, you may have identified the following parts of a leaf.

- Epidermis
- Mesophyll
- Air spaces
- Stomates
- Vascular bundles.

We will now look at the functions of the above parts of a leaf.

Functions of parts of a leaf Cuticle

It covers the upper surface of most leaves and makes them appear shiny. The cuticle is thin and transparent to allow light to pass through. It has a waxy material that protects the leaf from attacks by bacteria. The waxy material also acts as a waterproof layer which prevents excessive loss of water from the leaf.

Upper epidermis

This is the layer of cells below the cuticle. It is usually one cell thick to allow light to pass through the cells easily. Cells of the epidermis do not have any chloroplasts, this allows them to remain transparent for light to pass through. The epidermis forms a protective layer over the cells that carry out photosynthesis.

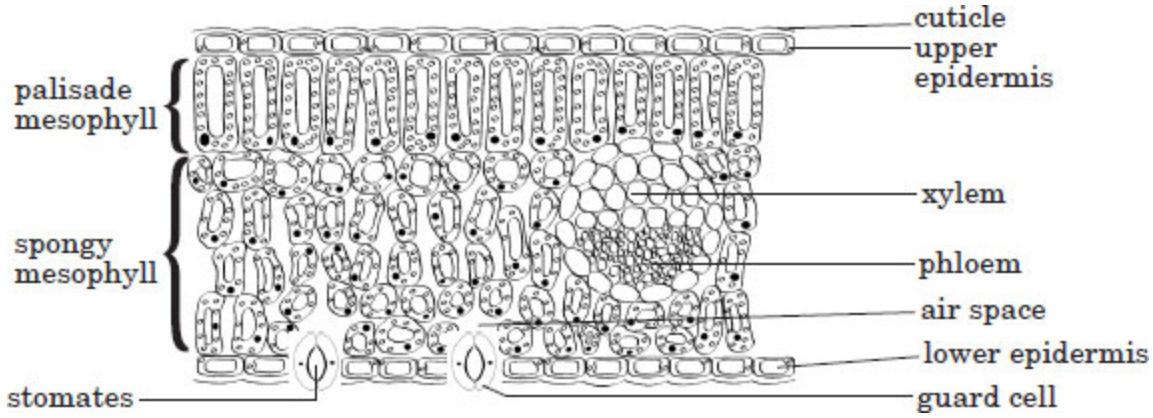


Fig. 3.1: Transverse section of a leaf.

Palisade mesophyll

This is a layer of cells located below the upper epidermis. Optimum photosynthesis takes place in the palisade mesophyll. Palisade cells are closely packed with few air spaces between them. The cells are elongated and lie at right angles to the leaf epidermis. They contain many chloroplasts. Their shape allows them to absorb most of the light falling on the leaf. They are close to the upper epidermis so as to absorb more light. The chloroplasts can move within the palisade cells to the side receiving the highest amount of light.

Spongy mesophyll

It is composed of cells located between the palisade mesophyll and the lower epidermis. Spongy mesophyll cells are also lined with moisture to facilitate uptake of oxygen and release of carbon dioxide gases. They have fewer chloroplasts than the palisade mesophyll cells. *Suggest why the mesophyll is described as spongy.* The cells are irregular in shape and are loosely arranged. They have large **air spaces** between them which allow air circulation and gaseous exchange between the cells and the air surrounding them.

Vascular bundles

The network of veins in the leaves is made up of **vascular bundles.** This tissue has vessels which supply water and mineral salts to the leaf. These are called **xylem.** Other vessels also take away manufactured food substances from the leaf to other parts of the plant. These are called **phloem.**

Stomates

Stomates are pores within guard cells. They are found on the upper or lower epidermis or both. They allow entry of carbon dioxide into the leaf to be used for photosynthesis.

Adaptation of leaves to photosynthesis

An adaptation is a characteristic that enables an organism to function properly. Let us carry out an experiment to investigate external features of a leaf and learn how they adapt the leaf to photosynthesis.

Activity 3.2: To identify external features of a leaf that adapt it to photosynthesis

Materials

A variety of leaves for example grass, *Hibiscus,* bean leaves, *Bougainvillaea* among others.

Procedure

1. Examine each leaf and list the observable characteristics that make it suitable for photosynthesis. As a guide for your observation, examine the following about the lamina.
   (a) Breadth.
   (b) Thickness.
   (c) Colour.
   (d) Structures that supply the leaf with water and minerals.
   (e) Structures that transport manufactured food from the leaf.
   (f) The firmness of the leaf
2. Draw and label the observable external features of the leaves.

Questions

1. List the features that are common in all the leaves.
2. State how the features mentioned in (1) above adapt the leaves for photosynthesis.

Discussion

In your examination of the different types of leaves, you may have noticed that their shape is broad, thin and flat. The figure below shows the external parts of a leaf.

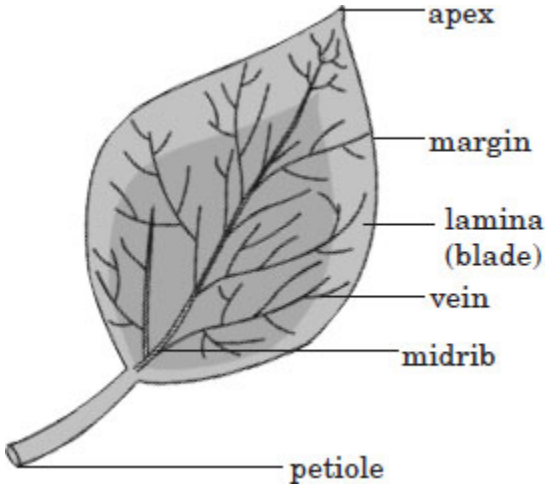


Fig. 3.2: External parts of a leaf.

Adaptations of leaves for photosynthesis

From the previous activity, you may have realised that the leaf has the following adaptations.

(i) The leaf is green in colour. This is because it contains a green colouring matter called **chlorophyll.** Chlorophyll traps light energy which is used in the process of photosynthesis.

(ii) The leaf surface is broad. This increases the surface area for absorption of light and carbon dioxide for photosynthesis.

(iii) Most leaves have thin blades. This reduces the distance across which carbon dioxide diffuses from the stomata to the photosynthetic cells.

(iv) Leaves have a network of veins that have branches all over the leaf. The veins have vascular bundles. These vasular bundles transport water and mineral salts to the leaf cells and manufactured foods from the leaf cells to all the other parts of the plant.

(v) The mesophyll cells are irregularly arranged leaving air spaces that allow efficient exchange of gases in the leaf cells.

(vi) The cuticle covering the leaves is transparent. This allows light to penetrate into the leaf cells.

(vii) The leaves have small pores on their surfaces. These allow air to move in and out of the leaf cells.

Parts of a mesophyll cell and their functions

Cell structure as seen under the electron microscope

Figure 3.3 shows a mesophyll cell as seen under the electron microscope. It has the following parts.

Protoplasm

Protoplasm includes all the cell contents except the vacuoles and the material that is released or taken in by the cell. The cell membrane is also part of the protoplasm.

The cell wall

The cell wall is the outermost part of most plant cells. It is made of a chemical substance called **cellulose.** Cellulose is tough and resists stretching. The cell wall gives **firmness** and a **fixed shape** to a plant cell. This is due to the presence of cellulose.

The cell wall has pores called **plasmodesmata** through which the cell exchanges materials with its environment. These pores also allow movement of substances between cells.

The cell wall also protects the cell from bursting. This is similar to the leather covering of a football which prevents the inner tube from bursting due to high air pressure.

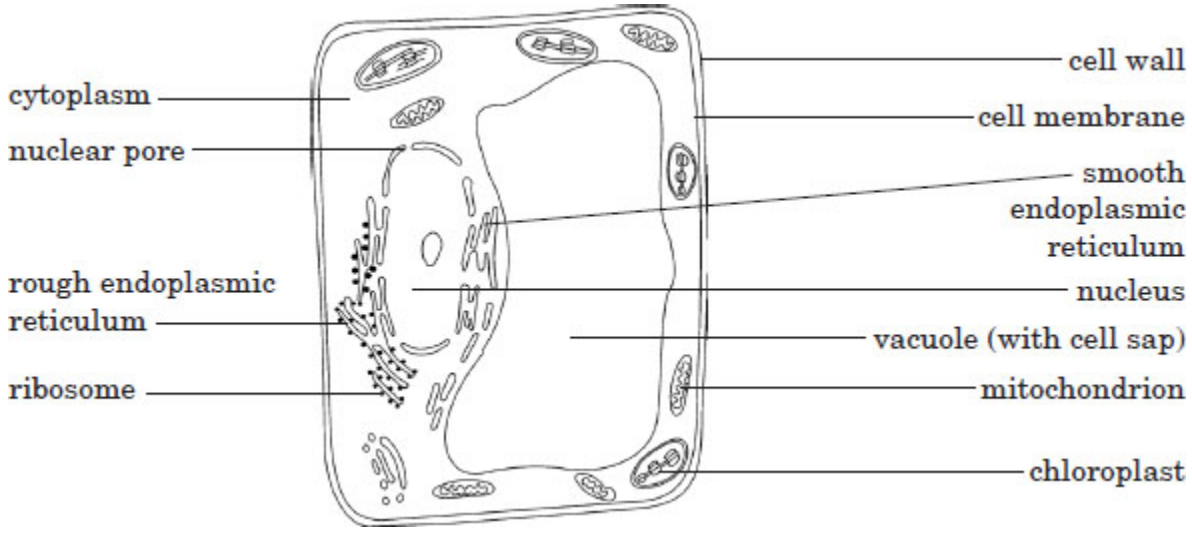


Fig. 3.3: A mesophyll cell as seen under an electron microscope.

The cell membrane

The function of the cell membrane is to hold or enclose the contents of the cell. It also regulates the movement of materials in and out of the cell.

Cytoplasm

Cytoplasm is composed of all the cell contents except the nucleus. The fluid and semi-fluid part of the cytoplasm is called **cytosol. Organelles** and **insoluble granules** of various kinds are suspended in the cytosol. Cytoplasm also contains many **dissolved substances** like food nutrients, mineral ions, dissolved gases and vitamins. Cytoplasm keeps moving about in the cell. Many chemical processes are carried out in the cytoplasm by the different organelles suspended in it.

Nucleus

The nucleus is large and oval or spherical in shape. The nucleus is made up of nuclear material called **nucleoplasm.** It is enclosed by a nuclear membrane. The nucleus controls the activities of a cell and heredity (passing on traits from parents to offsprings).

Ribosomes

Ribosomes are small, spherical organelles. Some are attached to the rough endoplasmic reticulum and others float freely in the cytoplasm

Ribosomes act as factories for making proteins. For example, in a bicycle factory, different parts like the seat, the tyres, the handle bars among others are put together or assembled to form the whole bicycle. Proteins are assembled in the ribosomes from amino acids in a similar way.

Endoplasmic reticulum

Endoplasmic reticulum is a system of canals or channels within the cytoplasm. It can appear either as **rough** or **smooth** when viewed under the electron microscope. The endoplasmic reticulum membranes are continuous with the outer nuclear membrane.

The rough endoplasmic reticulum provides a surface for attachment of ribosomes. Proteins made by these ribosomes enter the rough endoplasmic reticulum to be transported to places where they are required.

Smooth endoplasmic reticulum is not covered with ribosomes.

Mitochondria

The mitochondria are oval-shaped organelles. They produce energy for the cell. This energy is used in the cell for various activities. Mitochondria produces energy in a process called **respiration.**

Vacuoles

In plants they are large and centraly placed. They are filled with cell sap. They hold up the plant upright when filled up with water. They also store amino acids, salts and waste products.

In animals, vacuoles are tiny and are located at the periphery. They help in elimination of excess water and waste products.

Chloroplasts

Plastids are small organelles in the cytoplasm of plant cells. They may contain coloured substances called *pigments*. The chloroplasts are an example of plastids with green pigment called *chlorophyll*.

The chloroplast is an organelle in a plant cell where photosynthesis takes place. Chloroplasts are found in the cytoplasm of cells of palisade mesophyll, spongy mesophyll and guard cells. Cells that have chloroplasts are called **photosynthetic cells.** Each chloroplast is surrounded by two membranes. Inside each chloroplast are small units called **grana** (*singular:* ***granum).*** A granum consists of a number of discs placed on each other like a pile of coins. Each disc in the pile is a flat sac with a single membrane. One granum is connected to another by the **intergranal lamellae.** The remaining part of the chloroplast is filled with a fluid and is called **stroma.** The stroma contains enzymes involved in photosynthesis.

The internal structure of a chloroplast is as illustrated below.

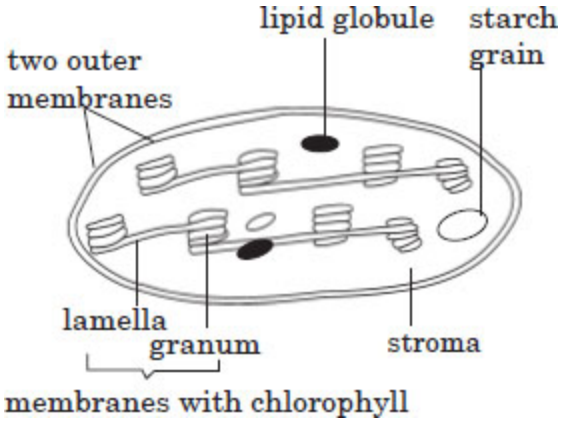


Fig. 3.4: Internal structure of a chloroplast

The process of photosynthesis

In Form One, we learnt that the raw materials for photosynthesis are water and carbon dioxide and the products are glucose and oxygen. This may be summarised as follows:

$$\text{Carbon dioxide + water} \xrightarrow{light} \text{glucose + oxygen}$$

$$6CO_2 + 6H_2O \xrightarrow{light} C_6H_{12}O_6 + 6O_2$$

During the process, six molecules of oxygen are produced as a by product. Photosynthesis takes place in two stages; the light stage and dark stage.

The light stage

It takes place in the **grana** of the chloroplast. During this stage, chlorophyll absorbs light energy. This energy is used in two ways.

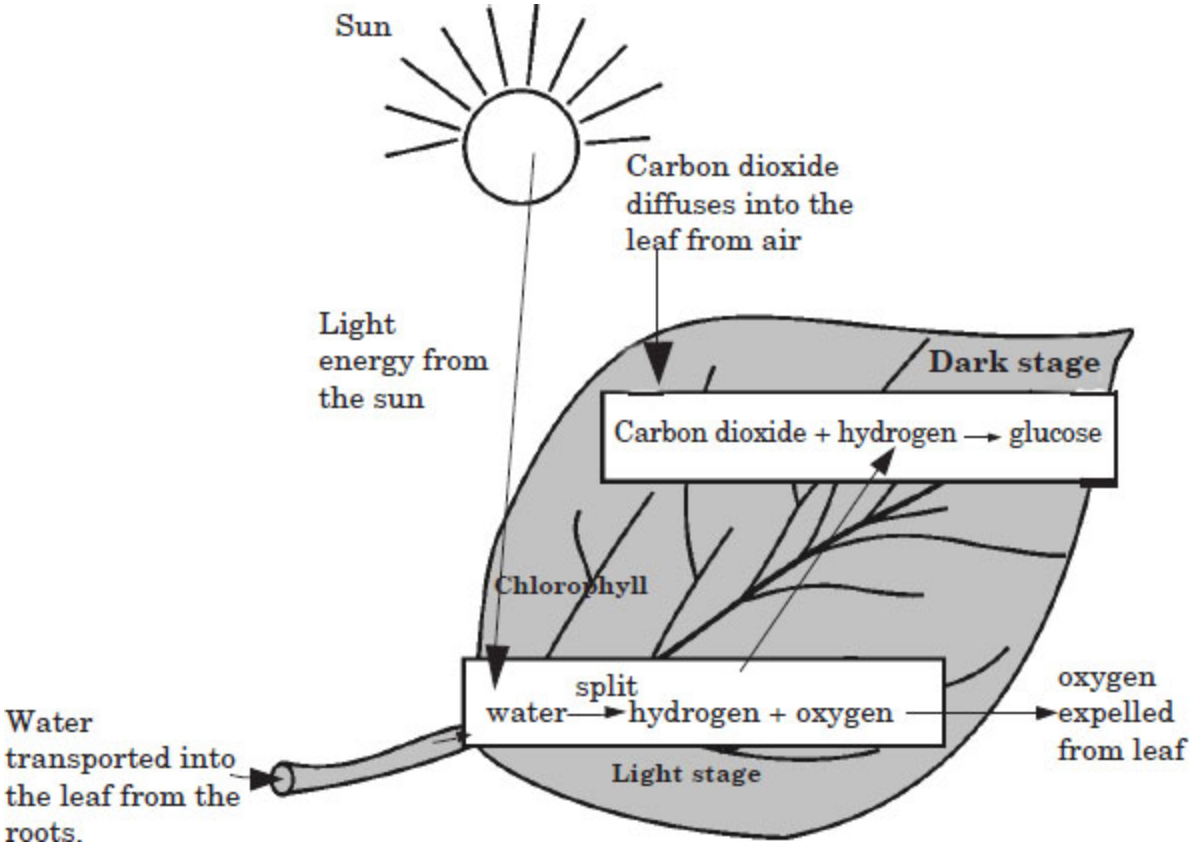


Fig. 3.5: Summary of the process of photosynthesis.

(i) Some is used to split up water molecules into **hydrogen ions** and **oxygen.** This is known as **photolysis** of water. The word *photo* means (light), *lysis* means (splitting). The hydrogen ions produced are used in the dark stage. Some of the oxygen formed is released from the leaf

through the stomates. The rest is used up in the plant cells for respiration.

(ii) Some of the absorbed sunlight energy is converted to ATP. The ATP is used in the dark stage.

The dark stage

The dark stage takes place in the **stroma** at the same time that the light stage is taking place in the ***grana.*** Carbon dioxide diffuses into the stroma from the cell cytoplasm. The hydrogen from the light stage combines with carbon dioxide to form glucose. This process uses the energy stored during the light stage. The manufacture of a carbohydrate (glucose) from carbon dioxide is called **carbon dioxide fixation.**

The fate of glucose after photosynthesis

As we mentioned earlier ***glucose*** is produced as the product during the dark stage. Glucose is the basic organic food substance. After photosynthesis, glucose is utilised in the following ways.

1. **Respiration**

   Some of the glucose is used by the plant cells for respiration to release energy.

2. **Storage**

   Most of the glucose produced in the leaf is usually converted to starch. Starch is stored in plant tissues. Some glucose is combined with fructose to form sucrose. Sucrose is stored in stems such as the stems of sugarcanes.

3. **Formation of cellulose**

   Some glucose is converted into a complex substance called *cellulose.* Cellulose is used in making of cell walls.

4. **Converted into lipids**

   Lipids are stored in plant tissues like the seed endosperm.

5. **Glucose is combined with nitrates to form proteins**

Functions of mineral elements involved in photosynthesis

- What are mineral elements?
- How many mineral elements do you know?
- List down the mineral elements.

Mineral elements are inorganic substances that are essential to all living organisms. This is because they are the basic units that form all substances making up the body of organisms.

Mineral elements are also involved in chemical reactions taking place in the body of living organisms.

In photosynthesis, mineral elements involved include.

- Carbon
- Pottassium
- Nitrogen
- Phosphorus
- Oxygen
- Sulphur
- Nitrogen
- Hydrogen
- Magnesium
- Iron.

These minerals are involved in the following functions.

1. **Formation of glucose**

   Glucose is made of three minerals elements: carbon, hydrogen and oxygen.

2. **Formation of chlorophyll**

   Chlorophyll is a pigment found in green plants. Magnesium is an essential component in chlorophyll formation. *Iron* is involved in activating chemical reactions in a cell during chlorophyll formation.

3. Opening and closing of stomates

Accumulation of potassium ions in the guard cells makes water to enter into the vacuole of the guard cells. This makes the guard cells to swell and become turgid. When guard cells becomes turgid, they open the stomates.

4. Enzyme formation

The process of photosynthesis requires enzymes. Enzymes are organic substances that speed up or slow down chemical reactions. Formation of enzymes require mineral elements such as nitrogen and sulphur.

5. Energy changes

Pottassium is involved in activation of enzymes involved in the process of photosynthesis. Phosphorus is involved in the formation of ATP in the light stage of photosynthesis.

Types of pigments in leaves

A pigment is any coloured substance found in cells. Leaves have three types of pigments.

Plant pigments are mostly found in the chloroplast of the cells. They include;

(i) Chlorophyll

(ii) Carotene

(iii) Xanthophylls

To carry out this study, we will first carry out the following activity.

Activity 3.3: To investigate types of pigments in plant leaves

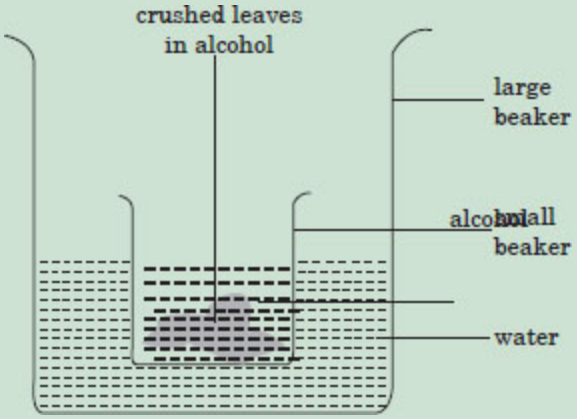
Requirements

- Green leaves
- Alcohol
- Filter paper
- Tape
- Beakers – small and large.

- Mortar and pestle
- Glass rod

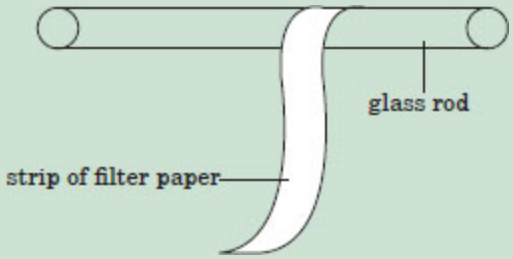
Procedure

1. Collect green leaves from plants in the school compound.
2. Chop the leaves into small pieces or crush them using pestle and mortar.
3. Place the crushed leaves into a small glass beaker.
4. Add alcohol to half fill the beaker.
5. Place the beaker into a large glass beaker half filled with water as shown below and then heat the large beaker. The large beaker with water is called a water bath.
6. Heat the beaker until the alcohol turns green. This shows that pigments in the leaves have dissolved into the alcohol.



Note: Do not heat alcohol directly because it catches fire easily

7. Remove the alcohol mixture from the beaker. Filter it into another small beaker
8. Cut the small long strip of filter paper about 3 cm wide and 10 cm long. Stick it unto a glass rod using a sellotape as shown below.



9. Suspend the filter paper strip into a container with the coloured alcohol such that the tip of the paper touches the mixture.
10. Allow the strip to absorb the coloured alcohol for about 30 minutes. Observe the colours formed on the strip from the bottom to the top.

Questions

1. Which colour was first visible as the alcohol was absorbed by the filter paper?
2. How many shades of colour can be observed on the filter paper strip?
3. Suggest the pigments that are represented by each of the colours.

Discussion

From the activity, you may have realised that the filter paper strip started to absorb the coloured alcohol. The absorbed substance rose up the paper forming different shades of colours.

The first and prominent colour to appear was green. Then three other colours appeared that included light green, yellow and light yellow.

The green colour represents the chlorophyll pigment. The yellow colour represents carotene pigment and the light yellow colour represents xanthophyll pigment.

1. Chlorophyll

This is the main pigment found in plant leaves. It is green in colour.

2. Carotene

Carotene is a pigment that is usually yellow, orange or red in colour.

3. Xanthophyll

This is a pigment that is usually light yellow in colour. It absorbs lesser amount of green and blue light.

Additional activity

1. Go to the field and collect leaves of different colours. In each leaf, suggest the pigments that they may contain.
2. Write a brief essay on how leaves change colour as they grow old.

Importance of photosynthesis

In your groups, discuss the importance of photosynthesis and write a report.

From your discussion, check whether you have come up with the following points.

1. **Production of food**

   During photosynthesis, glucose is formed as a product. Glucose is a simple sugar hence it is a food substance used by living organisms to produce energy.

   Glucose is also used to make other food substances such as starch, sucrose, proteins and lipids. These food substances are used by plants for food. When animals feed on the plants, they obtain the food.

   Photosynthesis therefore is the main source of food for the whole universe.

2. **Oxygen production**

   For every molecule of glucose formed, six molecules of oxygen are released. The oxygen is released into the atmosphere. Oxygen is required by all living organisms for respiration.

3. **Removal of carbon dioxide from the atmosphere**

   Photosynthesis prevents accumulation of carbon dioxide in the atmosphere. Therefore, it prevents global warming.

Plant products

These are substances produced by plants. They are used by human beings in various ways. These substances include:

1. **Food substances**

   These include starch stored in roots, stems, leaves, seeds and fruits, oils stored in seeds, proteins stored in cotyledons and sucrose stored in stems.

2. **Medicine**

These are substances stored in plant materials that are used for treatment of diseases. They include;

(a) Quinine

Quinine used in the treatment and control of malaria. It is found in the bark of *Cinchona* tree.

(b) Codine

This is a medicine for coughs. It contains caffeine which is a plant product.

(c) Eucalyptus

Eucalyptus tree produce chemicals which are used to relieve colds.

3. Industrial products

These are substances stored in plant materials that are used by humans to manufacture industrial goods. Such products include tannins and rubber.

(a) Tannins

This is a group of complex substances that are acidic. They occur widely in plants dissolved in the cell sap. They are quite common in the bark of trees like wattle trees, unripe fruits and leaves. They are used in the conversion of hide (cow skin) into leather. They are also used in dyeing clothes, printing fabrics and in the manufacture of ink.

(b) Rubber

The primary source of natural rubber is the plant called *Para rubber* tree. It produces latex which is used to manufacture rubber products such as tyres, shoes among others.

Revision Exercise 3

1. (a) Define the term photosynthesis.

(b) Name the two stages of photosynthesis.

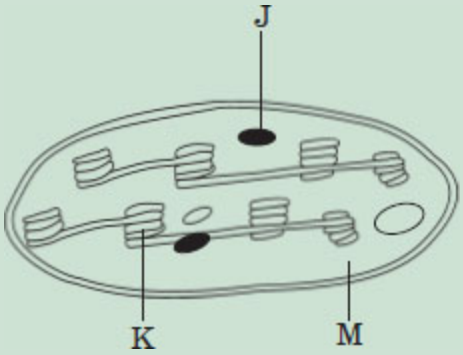
2. (a) State the site of photolysis in a plant cell.

(b) State the role played by light energy during photolysis.

3. (a) Give the product and a by-product of photosynthesis in a green plant.

(b) State the origin of the oxygen given out during photosynthesis.

4. The following organelle is found in plant cells.



(a) Name the organelle.

(b) State the functions of the organelle.

(c) Identify the structures labelled:

(i) J

(ii) K

(iii) M

(d) Explain the processes that take place in structures labelled K and M.

5. Study the process below then answer the questions that follow.

$$CO_2 + H_2O \xrightarrow[light]{chlorophyll} C_6H_{12}O_6 + X$$

(a) Name substance X.

(b) State the uses of substance X in animals.

6. Discuss the fate of glucose after photosynthesis.

7. Name three pigments found in the leaves.

8. What is the importance of photosynthesis?

Unit 4

Transport in plants

Specific objectives

By the end of this unit, you should be able to:

(a) Identify tissues that are used for transport in plants.

(b) Describe the structural and functional differences between the xylem and phloem.

(c) Describe the processes of diffusion, osmosis and active transport.

(d) Explain the factors that affect the rate of diffusion.

(e) Explain how substances are transported in the xylem and phloem.

(f) Explain the significance of diffusion, osmosis and active transport.

(g) Describe the transpiration stream.

(h) Explain the importance of transpiration.

(i) Explain the factors that affect the rate of transpiration.

Introduction

In this unit, we will learn about how substances move inside the plant. In the previous units, we learnt that plants use water, carbon dioxide and mineral salts during the process of photosynthesis. At the same time, substances such as glucose are formed during photosynthesis. All these substances need to be transported from one place to another in the plant.

Meaning of transport in plants

Transport is a process whereby substances move from one part of a plant to another. These substances include water, mineral salts and manufactured foods.

These substances are transported by structures called **vascular bundles.** These are conducting structures found in the roots, stems and leaves.

We will first study the structures of roots and stems to examine the structures involved in transport.

Tissues used for transport in plants

To investigate these tissues, let us carry out the following activities.

Activity 4.1: To observe permanent slides of dicotyledonous and monocotyledonous roots

Apparatus and materials

- Permanent slides of cross sections of dicotyledonous and monocotyledonous roots.

Procedure

1. Place a prepared slide of a dicotyledon root under the microscope. Observe under low power and high power magnifications.
2. Note the different tissues present and their location.
3. Draw a **plan diagram** to show the position and layout of different layers of tissue. Do not draw any cells or shade.
4. Compare your diagram with that of the plan diagram of the dicotyledonous root section in Fig. 4.1 and use it to identify the tissues.

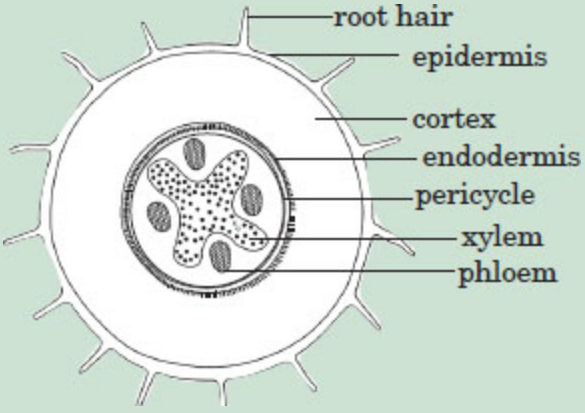


Fig. 4.1: Transverse section of a dicotyledonous root.

5. Repeat this procedure for the monocotyledonous root and compare your drawing with that in Fig. 4.2.

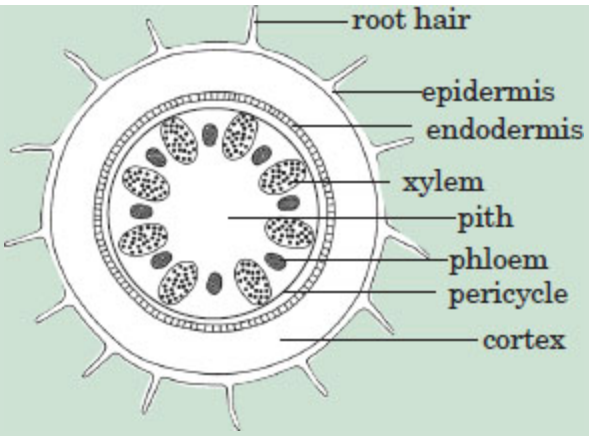


Fig. 4.2: Transverse section of a monocotyledonous root.

Questions

1. Describe the pattern in the arrangement of xylem in relation to phloem in the:
   (a) Dicotyledonous root
   (b) Monocotyledonous root.
2. What is the difference in distribution of tissues between the dicot root and the monocot root ?
3. Where are the root hair cells located in the root?

Discussion

The distribution of tissues in a transverse section of the dicotyledonous root is not the same as that in the monocotyledonous root.

In the dicotyledonous root, the xylem occupies the centre where it forms a star shape. The phloem is found in between the rays of the star.

In the monocotyledonous root, the xylem and phloem are arranged to form a ring in which xylem tissue alternates with the phloem tissue.

Activity 4.2: To observe permanent slides of dicotyledonous and monocotyledonous stems

Apparatus and materials

- Permanent slides of dicotyledonous and monocotyledonous stems

Procedure

1. Place a prepared slide of a dicotyledonous stem under the microscope. Observe under low power and high power magnifications
2. Note the different tissues present and their location.
3. Draw a **plan diagram** to show the position and layout of different layers of tissues. Do not draw any cells.
4. Compare your diagram with that of the plan diagram of the dicotyledonous stem in shown Fig. 4.3. Use it to identify the tissues.
5. Repeat this procedure for the monocotyledonous stem and compare your drawing with that shown in Fig. 4.4.

Questions

1. Is the distribution of tissues in the cross (transverse) section of a dicotyledonous stem the same as that in a monocotyledonous stem?
2. Describe the pattern in the arrangement of xylem in relation to phloem in the:
   (a) Dicotyledonous stem
   (b) Monocotyledonous stem.
3. What is a vascular bundle?

Discussion

The distribution of tissues in a transverse section of the dicotyledonous stem is not the same as that in the monocotyledonous stem, In the dicotyledonous stem, the vascular bundles which contain both xylem and phloem are arranged to form a ring as shown below.

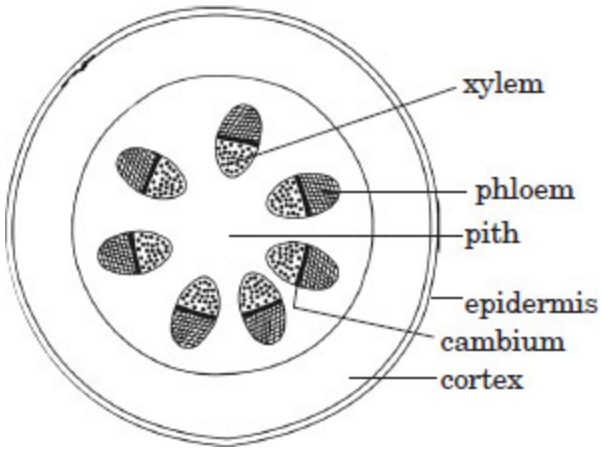


Fig. 4.3: Cross section of a dicotyledonous stem.

In the monocotyledon stem, the vascular bundles appear scattered in the stem as shown below.

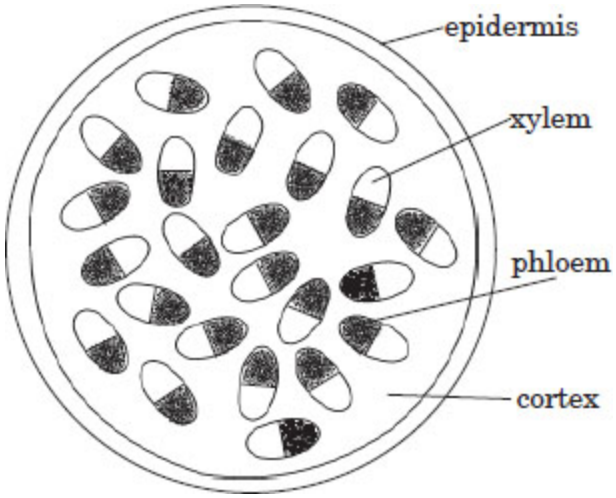


Fig. 4.4: Cross section of a monocot stem

Most of the tissues in the root and stems are similar. This is because these tissue are continuous from the root into the stem. Common tissues to both the root and stem are the epidermis, cortex, endodermis, xylem and phloem. The stem has additional tissue known as **pith**. Note that there is no cambium in monocot stems. Some plant tissues are made of only one type of cell. Some tissues are found throughout the plant and some are found only in specific parts.

Structure of xylem and its functions

Xylem tissue is a specialised tissue which is modified to carry out two functions:

(a) To transport water and mineral salts.

(b) To give support to the plant.

The xylem contains two types of modified cells namely **tracheids** and **vessel elements.**

Tracheids

Tracheids are empty dead cells. They are elongated and have tapering end walls. Water passes through them easily because they have no cellular contents that would otherwise cause obstruction. Their walls are reinforced by strengthening material known as **lignin.** The walls also have tiny pores known as **pits.** Tracheids are arranged end to end and also side by side. Water passes from one tracheid to another through the pits.

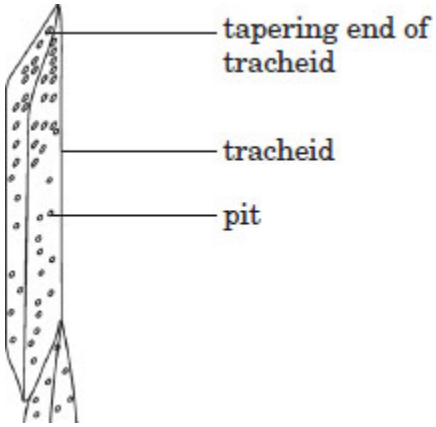


Fig. 4.5: Tracheid element

Vessel elements

They are very long tube-like structures which are continuous from the root to the leaves of a plant. Several vessels are found side by side. They too are dead tissue and have no cell contents. This allows water to move through them freely. Their walls are reinforced with **lignin** which makes them strong and rigid to give support to plants.

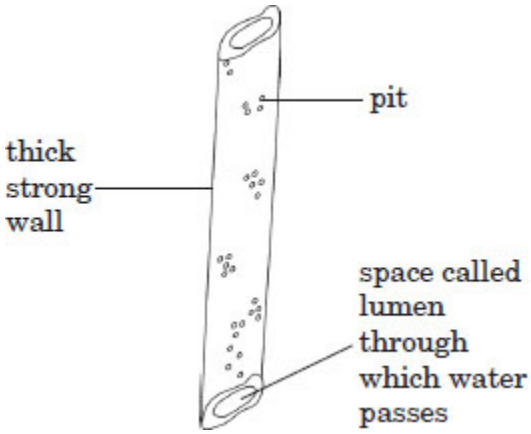


Fig. 4.6: Vessel element

Structure of phloem

Phloem tissue is made up of **sieve tubes** and **companion cells**.

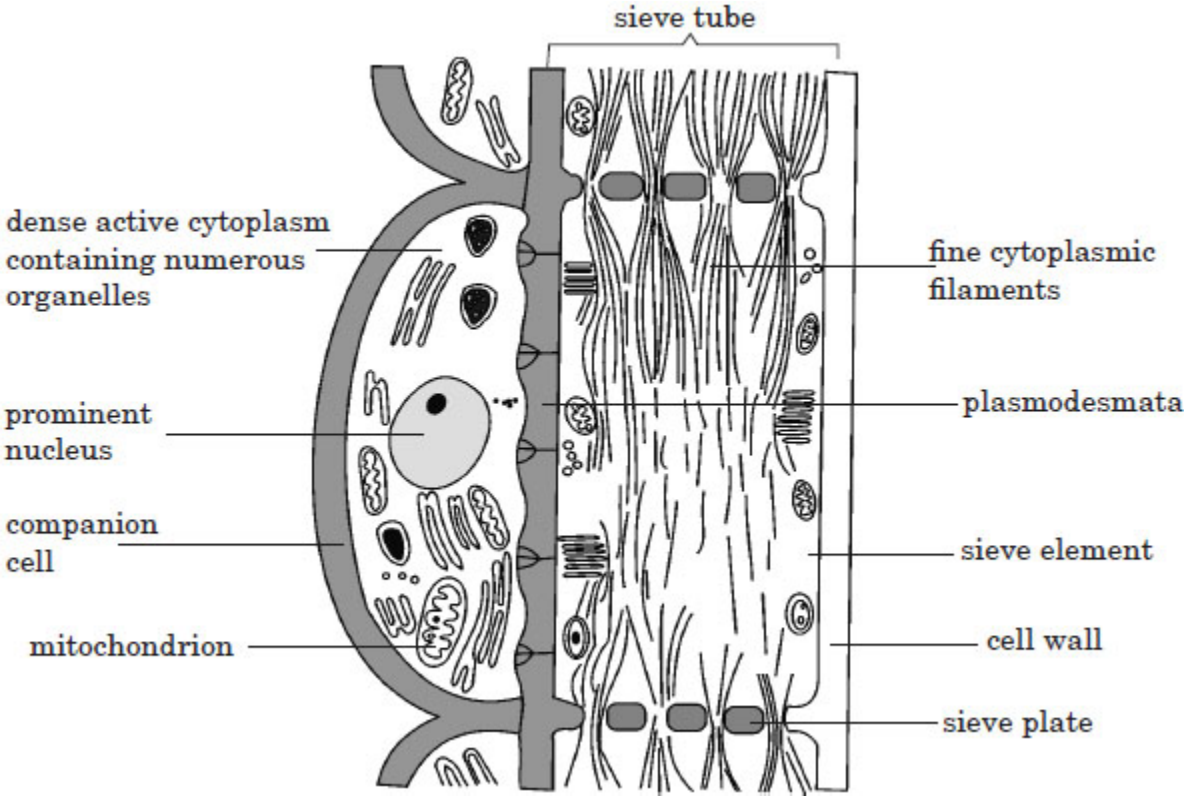


Fig. 4.7: Structure of the phloem

Structural and functional differences between xylem and phloem

Table 4.1: Structural differences between xylem and phloem

Xylem	Phloem
• Xylem is made of dead tissue.	• Phloem is made of living tissue.
• In xylem, cross walls between adjacent cells is absent.	• Cross walls are perforated into sieve pores.
• Xylem walls are lignified.	• Phloem walls are thin and not lignified.
• Xylem are made of hollow tubes.	• Phloem is made of sieve elements.

Table 4.2: Functional differences between xylem and phloem

Xylem	Phloem
• Transports water and mineral salts.	• Transports manufactured food substances from the leaves to all other parts of the plant.

Sieve tubes

The sieve tubes are made up of cells called **sieve elements** arranged end to end with each other. Sieve elements are separated from each other by structures called **sieve plates** which have pores or perforations in them. Phloem sieve tubes, unlike xylem tissue are living tissue. They have fine cytoplasmic strands that run through from one element to another. However, the cytoplasm of sieve elements does not have a nucleus and several other cell organelles.

Companion cells

Each sieve element has an accompanying cell known as a **companion cell.** This cell has a dense cytoplasm, a prominent nucleus and other cell

organelles. These take up the roles of those organelles that should have been in the sieve elements.

Activity 4.3: The ringing experiment to show that substances are translocated through the phloem

Apparatus and materials

- Tree or shrub with many branches.
- Sharp knife.

Procedure

1. Remove completely a ring of bark with its phloem from two branches. The xylem tissue which makes up the bulk of the stem is left intact.
2. The set-up is left undisturbed for four weeks.

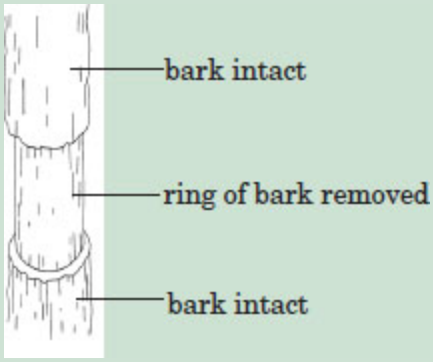


Fig. 4.8: A ring of bark is removed from a woody shoot leaving the xylem

Question

1. What observations were made in the stem after four weeks?
2. Explain these observations.

Discussion

When the ring of bark is removed, the phloem beneath it is also removed. After several weeks, a swelling above the cut ring is noted. This swelling is due to the accumulation of food substances that were being transported from the leaves but could not get across the debarked part of the stem. As a result, there is no swelling on the lower part of the ring.

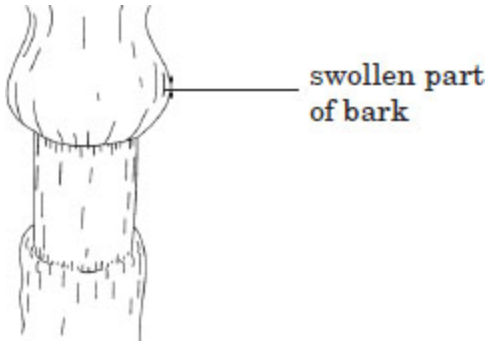


Fig.4.9: Swollen tissue above the cut part after four weeks.

Note: This ringing procedure is sometimes employed to kill some unwanted trees before they are cut down. Do not use it on a tree that has economic value to your community. Discuss with your friends how the bark of medicinal trees can be harvested without killing these important trees.

Transport of substances in the phloem

As we mentioned earlier the phloem transports manufactured food substances from the leaf cells and the storage tissues to all other parts of the plant. This is by a process called **translocation.**

The food substances move from the leaf cells into the sieve tubes by active transport. The energy for this process is produced by the companion cells.

The substances accumulate in the sieve tubes of the phloem of the leaf. They draw water from adjacent cells by osmosis into the sieve tubes. This causes an increase in hydrostatic pressure in the sieve tubes resulting to the movement of materials to areas of storage or use. The materials can also be transported in the sieve tubes by cytoplasmic streaming.

The materials are moved along the cytoplasmic filaments from one sieve tube cell to the next through the pores on the sieve plate. This process uses energy that is produced by the companion cells.

How substances are transported in the xylem and the phloem

In order to carry out the life processes, that we mentioned in Unit 3, a cell needs and takes in various substances. In carrying out these processes, the cell produces certain substances as well. Some of these are waste products and others are substances that the cell does not need but are useful to other

cells in a tissue. Such useful substances are usually taken out of the cell to the other cells that need them. Therefore substances are always moving into and out of cells.

The way substances move into or out of the cell depends on certain properties of the substances such as size of molecules and the type of substance.

There are three main physiological processes by which substances move in and out of cells. These are **diffusion, osmosis** and **active transport.**

Diffusion

Let us carry out the following activity to show diffusion.

Activity 4.4: To demonstrate diffusion using ink and perfume

Materials

- Bottle of perfume or ink.
- Beaker
- Water and pipette

Procedure

1. Fill a beaker half-full with water
2. Add a drop of ink into the water. What do you observe? Add another drop of ink. What do you observe?
3. Open a bottle of strong perfume. What do you observe after a few minutes?

Discussion

From the activity, you may have noticed that the ink spreads until the water becomes uniformly coloured.

You also realised that after the perfume bottle was opened, you could smell the perfume after sometime.

The particles of the ink spread from one point to the entire beaker until the water was uniformly coloured. In the same way, the particles of the perfume spread from the open bottle into the air in the whole class.

This process where particles move from one point and spread to other regions is called **diffusion.**

Activity 4.5: To demonstrate diffusion using potassium manganate (VII) crystals and ink in water

Materials

- For each group; beakers, water, potassium manganate (VII) crystals, ink, pipette or dropper.

Procedure

1. Put about 50 cm^3 of water in a beaker. Select a large crystal of potassium manganate (VII) and drop it carefully in the water. Observe what happens.

Questions

1. Explain the observation made when the crystal of potassium manganate (VII) is dropped in the water.

Activity 4.6: To demonstrate diffusion using a visking tubing

Materials

- Visking tubing, starch solution, dilute iodine solution, beakers, string.

Procedure

1. Measure and cut a visking tubing 8 cm in length.
2. Tie up one end tightly with a string, about 1cm from the tip. Fill the visking tubing with starch solution and then tie up the other end.
3. Note the colour of the solution. Immerse this visking tubing into a beaker filled with dilute iodine solution.
4. Leave it to stand for 15 minutes.
5. Make observations of the colour changes and complete the table below.

Before	After 15 minutes	Conclusion

• Colour of the starch solution inside the visking tubing.		
• Colour of the iodine solution in the beaker.		

Questions

1. Why did the colour of the starch solution change after the visking tubing was immersed in a solution of iodine?
2. Why was there no change in the colour of the iodine solution in the beaker after 15 minutes?
3. The visking tubing seems to allow some molecules to pass through and not others. What is the name given to membranes that have this characteristic?

Discussion

The colour of the starch solution changed from white to blueblack because iodine molecules moved into the visking tubing which brought about the change.

The colour of iodine remained brown because starch molecules did not move from the visking tube to the beaker.

The membrane is permeable to the iodine molecules.

Diffussion is the movement of particles of a substance from a region of high concentration of the particles to a region of low concentration of the particles. The difference in the concentration of particles in the two regions is called a **concentration gradient** or **diffusion gradient.**

Diffusion occurs in liquids and gases. Diffusion does not take place in solids. Diffusion of certain particles also takes place through the cell membrane, cell walls and cell cytoplasm.

When particles move from a region of high concentration to a region of low concentration, they are said to diffuse **along a concentration gradient.** As long as a concentration gradient is maintained, the movement of particles continues until they are evenly distributed in the available space.

Examples of diffusion

1. When a drop of ink is placed into a glass of water, the ink particles spread in the water until all the water is uniformly coloured as seen in Activity 4.5.
2. We are able to smell perfume that other people have worn because the particles of perfume diffuse from them through the air to our organs of smell, the nose.

Factors affecting the rate of diffusion

The rate of diffusion of particles is the time taken for the particles to diffuse within an available (fixed) space until they are evenly distributed. Several factors affect the rate of diffusion. They include:

Temperature

When the temperature of particles is increased, their kinetic energy also increases and the particles move faster. Therefore, the higher the temperature, the faster the particles will diffuse. The lower the temperature the lower the rate of diffusion.

Concentration of substance

A greater difference in concentration of particles between two regions, results in a steeper concentration gradient and vice versa. Diffusion is faster when the concentration gradient is high.

The difference in concentration of substances determines the rate of diffussion. Where the difference in concentration of substances is big, the rate of diffussion is high because this increases the concentration gradient.

Size of molecules

Small particles diffuse faster than large particles. This is bacause small particles are light and pass through air or water easily.

Osmosis

Let us carry out the activity below to learn about osmosis.

Activity 4.7: To demonstrate osmosis using a visking tubing

Materials

Visking tubing, concentrated sucrose/sugar solution, beaker filled with distilled water, string.

Procedure I

1. Measure and cut an 8cm length of visking tubing.
2. Tie one side of the visking tubing tightly with a string 1 cm from the end.
3. Fill the visking tubing about three-quarter full with the concentrated sugar solution.
4. Tie up the other end of the tubing tightly with a string.
5. Immerse the visking tubing with the sugar solution into a beaker full of distilled water. Note the level of water in the beaker.
6. Leave the setup to stand for several hours then note the amount of solution in the visking tubing and the level of water in the beaker.

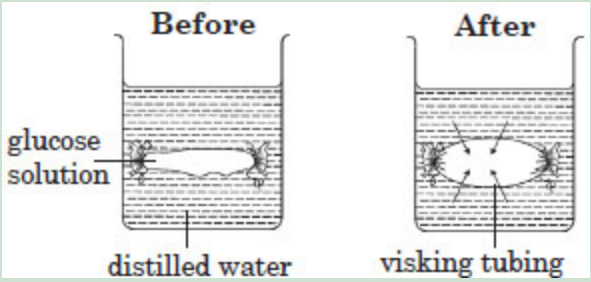


Fig. 4.10: The results of osmosis

Questions

1. What happens to the following after several hours?

(a) Contents of the visking tubing?

(b) Level of the water in the beaker.

Procedure II

1. Repeat procedure I, but this time, fill the visking tubing with distilled water then tie tightly until it is firm and bulging.
2. Immerse the visking tubing into a beaker of concentrated sugar solution and leave it to stand for several hours.

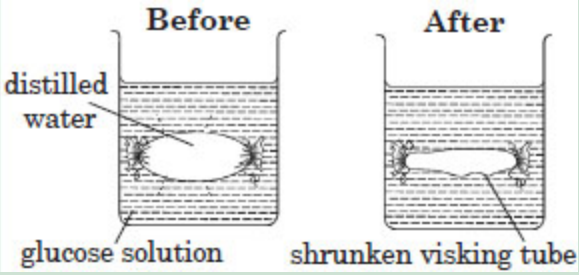


Fig. 4.11: The results of osmosis

Questions

1. What happens to the contents of the visking tubing after several hours?
2. Does it still feel firm to the touch? Does it still appear bulging? Explain your observations.

In our activity of demonstrating osmosis, water also moves from a region where it is in high concentration to a region where it is in low concentration. Therefore, osmosis is a kind of diffusion. However, the term osmosis is used only when we are referring to diffusion of water molecules through a semi-permeable membrane. In our experiment, the visking tubing acts as a semi- permeable membrane.

Osmosis is the movement of water molecules from a region of high concentration of water molecules to a region of low concentration of water molecules through a semi-permeable membrane.

We have seen that diffusion is the movement of particles from a region of high concentration to a region of low concentration.

Solute, solution and solvents

When a solid is dissolved in water, we get a **solution.** The solid that is dissolved in this solution is called the **solute.** The liquid that dissolves the solid is known as the **solvent.** Thus:

Solute + Solvent = Solution

The concentration of a solution depends on the amount of solute dissolved. **A dilute solution** has more water (Solvent) molecules as compared to solute molecules.

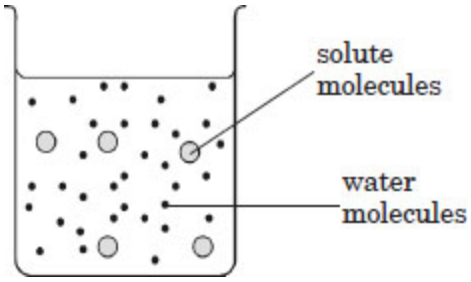


Fig. 4.12: A dilute solution

A concentrated solution has more solute molecules than water molecules. Suppose, a dilute solution were separated from a concentrated solution by a semi-permeable membrane in a beaker. Water molecules will move from the dilute solution to the concentrated solution.

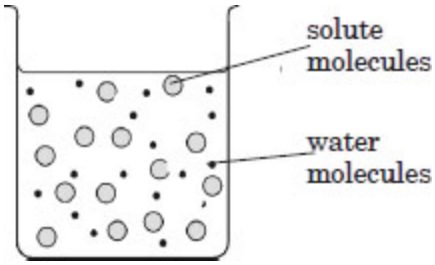


Fig. 4.13: A concentrated solution

This is because the dilute solution has more water molecules than the concentrated one. Water molecules pass easily through the channels or pores of the cell membrane mainly because they are very small. Solute molecules are too large to pass through the pores.

Activity 4.8: To demonstrate osmosis in a living tissue

Materials

Fresh arrow roots/cassava, sweet potatoes, *Mbatata,* Irish potatoes, strong salt solution, distilled water, scalpel, large beaker or small basin.

Procedure

1. Take a large Irish potato and peel it. You could also use arrowroot, cassava or sweet potato.
2. Cut off a piece so that it stands at least 6cm high.
3. Cut and scoop out a deep hollow portion in its middle and pour the strong salt solution halfway up the hollow portion.

4. Mark the level of the salt solution using a scalpel.
5. Place the potato in a beaker or basin containing distilled water and let it stand for several hours then note the level of solution in potato.
6. Repeat the experiment with boiled pieces of irish potato or cassava.

Questions

1. Is the level of the strong salt solution still the same at the end of the experiment?
2. Explain what happens to cause the change in level of the salt solution.
3. Compare these results with those obtained when boiled Irish potato is used.

Activity 4.9: To demonstrate osmosis using Irish potato tubes/cylinders

Materials

- Irish potato, cork borer, ruler marked in millimetres, scalpel or razor blade, 3 test tubes, board to cut on, labels for beakers, concentrated sucrose solution, distilled water.

Procedure

1. Select large Irish potatoes.
2. Using a cork borer, bore holes into the potato tuber and bore out long cylinders each 60mm in length.
3. Put concentrated sucrose solution in one test-tube and distilled water in another. Leave the third test tube empty. Label the test tubes.
4. Put the potato cylinders into the three test-tubes and leave them over-night.
5. Measure the change in length of the potato cylinders in each test-tube.
6. Record your results in a table like the one shown below.

Test tube contents			
	Sucrose	**Distilled water**	**Empty**
Length of cylinder before experiment	30mm	30mm	30mm

Length of cylinder after experiment			

Activity 4.10: To demonstrate osmosis using leaf petioles

Materials

Leaf petioles, salt solution, distilled water, petri-dishes, labels, scalpel.

Procedure

1. Cut petioles from three leaves.
2. Split each petiole lengthwise and place the two strips from the same leaf in water, salt solution and an empty petri dish respectively.
3. Leave them for 30 minutes.
4. Draw the appearance of the petioles after 30 minutes in each solution.

Questions

- Explain the appearance of each stalk/petiole in the solution it was immersed.
- Explain why it was necessary to cut a split on petioles in this experiment.

Discussion

The inner cut surface of a strip of petiole is described as the inner side. Its cells are exposed. The outer surface of the petiole is covered by a thick cuticle. When a strip of petiole is immersed in water, the cells in the inner side (exposed cells) take up water by osmosis much faster than the cells on the outer (covered by cuticle) surface. These cells expand more causing a curvature towards the outside (outwardly).

When the strip is immersed in the salt solution, the cells on the inner side lose water much faster than the outside. The cells in the inner side shrink more and hence the strip of petiole curves inwardly. The strips in the empty petri dish do not change. Usually this is used for comparison purposes and is referred to as the **control experiment.**

Active transport

The type of movement of molecules and ions that we have considered so far are those where molecules move down or along a concentration gradient. These movements are called **passive transport.** Molecules and ions can also move from an area of low concentration to that of higher concentration. They are said to move **against a concentration gradient.** Such a process requires the use of energy and is called **active transport.**

In active transport, the cell must use its own energy to move the molecules against a concentration gradient. Such energy is supplied by the mitochondria in the cell. Therefore active transport takes place only in living cells.

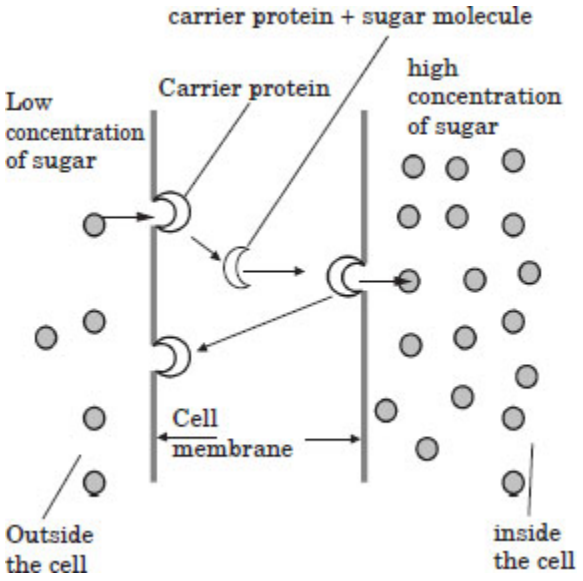


Fig 4.14: Active transport across the cell membrane

Active transport involves carrier protein molecules. They pick up molecules of a substance from one side of the cell membrane and transports them across.

Activity 4.11: To show dyed water moving up the xylem

Apparatus and materials

- Boiling tube, dilute solution of red ink or dye, cotton wool, bean seedling.

Procedure

1. Set up the apparatus by placing a bean seedling in a dilute solution of red ink in boiling tube. Colour the solution with red ink or eosin stain.

2. Leave the set up for three or four hours then remove the plant and cut sections of the root, stem and leaf.
3. Examine under low power of the microscope or with a hand lens.

Questions

1. Which tissues are stained red by the dye?
2. Suggest a control for this experiment.

Discussion

The sections of the root, stem and leaf will be seen to carry the dye or ink. If only the xylem vessels are stained red by the dye we can conclude that water travels up the plant in the xylem vessels.

This conclusion would be strengthened if we cut sections of a second plant of the same species to confirm that the xylem vessels are not normally coloured. This would be the control experiment.

We have already noted that water in the soil is absorbed by the roots and then transported through the xylem to all parts of a plant.

In very tall trees, water is transported to the leaves which may be more than 100 metres above the level of the ground. This water moves against the force of gravity. A number of forces have been suggested to explain the movement of water in the xylem to such great heights. These forces include:-

Capillarity

Capillarity is the tendency of water to rise inside a narrow tube. This is because water molecules have the ability to cling to the surface of the tube. Water rises more in tubes with small diameters than in wide tubes.

In plants, xylem forms narrow tubes through which water moves. Water rises in the xylem because of strong forces of attraction between the water molecules and the cell walls of the tubes or xylem vessels. However, capillarity can raise water up to a height of only a few centimetres. It is therefore not enough to raise water up to great heights in tall trees.

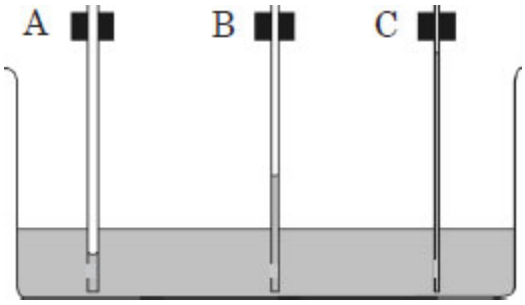


Fig. 4.15: An experiment to demonstrate capillarity

Cohesion and adhesion

Water molecules have the ability to attract each other. This force by which water molecules attract each other is known as **cohesion force.** The water molecules also have a strong attraction to the walls of the xylem vessels or tubes. The forces of attraction between unlike molecules are called **adhesion forces.** Due to these two forces, water molecules next to the wall of the xylem tube "creep up" along the wall due to adhesion and pull along molecules that are not near the wall by cohesion. This is similar to the "tug of war" in which people on a line hold themselves firmly on the ground as they pull on the rope. Cohesive and adhesive forces prevent the column of water from breaking. Like capillarity, these two forces are not enough to raise water to the height of tall trees.

Root pressure

This is another force that moves water up the plant. Root pressure moves water from living root cells into the xylem. When the stem of a plant that is well supplied with water is cut off near the ground level, sap flows from the cut-stem. If a glass tube is attached to the cut end of the stem with a rubber tubing, the sap rises in the tube as shown in Fig. 4.15. The sap can rise up to a height of one metre.

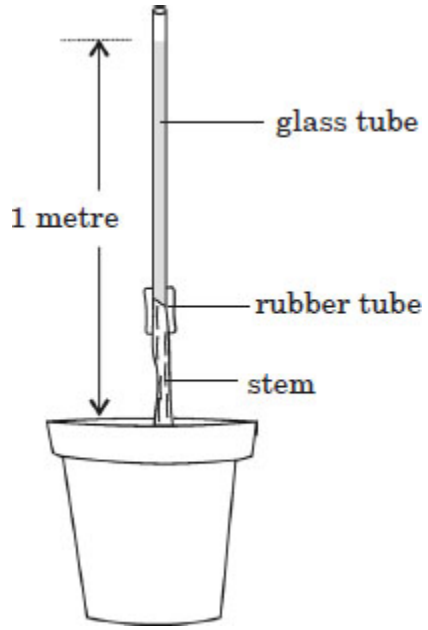


Fig. 4.16: An experiment to demonstrate root pressure

The pressure that holds up the column of water against the pull of gravity is called **root pressure.**

Root pressure is due to an increase of osmotic pressure. Such pressure is caused by accumulation of solutes in the xylem of roots. In the root, the endodermis moves solutes by active transport into the xylem. As a result, the osmotic pressure of sap in the root xylem increases. This causes water from the soil to diffuse into the root xylem by osmosis, causing an increase in pressure. This pressure in the root xylem causes water to move upwards in the xylem of the stem.

As mentioned before, root pressure can only raise water to a height of about one metre. In addition, if a plant is growing in soil with little water, the maximum height that root pressure will raise water will be less than one metre. Therefore, root pressure alone cannot help to transport water to great heights in tall trees.

Transpiration pull

Transpiration pull is another force that transports water through the plant. This process begins in the leaf and sets up conditions that cause water to be drawn all the way from the roots in a continous stream. Water evaporates into the air spaces from the surrounding mesophyll cells in the leaf as shown in Fig 4.16. This causes the mesophyll cells next to the air space

(cell B) to have a higher solute concentration than the cells further away from the air space (cell A). As a result, water moves by osmosis from cell A to cell B. The concentration in cell A therefore increases. If cell A is next to a xylem tube as shown in Fig. 4.16, then the water in the xylem moves by osmosis into the cell. Water in the xylem is drawn upwards by cohesion and adhesion forces to replace it.

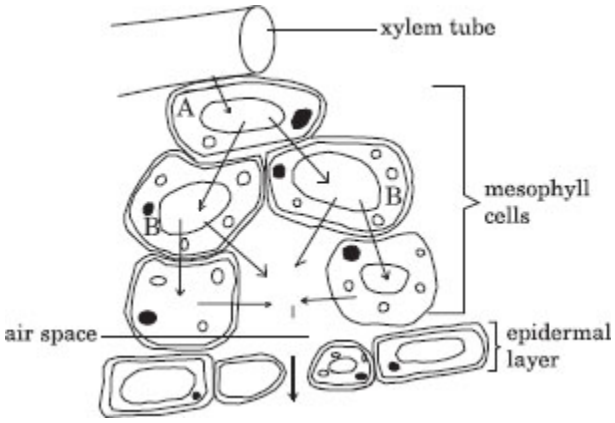


Fig. 4.17: To show detailed movement of water from xylem through cells to air spaces in the leaf.

Significance of diffusion, osmosis and active transport

(a) Absorption of water and mineral salts by plants

Soil particles are usually surrounded by a film of water except when there is drought. Root hair cells absorb water from the soil by osmosis. The cell sap in the vacuole of the root hair cell has a high concentration of salts and sugars. It is therefore hypertonic to the water found between the soil particles. Due to this concentration gradient, water molecules move by osmosis from the soil through the semi-permeable membrane of root hair cells into the cell sap.

The root hair cells will take up water as long as their concentration of salts is higher than that in the soil. The cell wall pressure is not large enough to prevent osmosis.

(b) Active uptake of mineral salts

As mentioned earlier, the concentration of salts in the cell sap of a root hair cell is higher than that of soil water. Soil water is a **dilute solution** of mineral ions such as potassium, magnesium, nitrates and phosphates. This means that a root hair must take up these mineral ions by **active transport** against their concentration gradients. Plants need minerals salts for normal growth and development. For example, they need magnesium to synthesise chlorophyll, and nitrate ions to synthesise proteins.

(c) Transportation of manufactured foods

Translocation is the transport of organic substances from one part of the plant to another. It takes place in the phloem tissue in plants.

Transpiration stream

Meaning of transpiration

Transpiration is the **evaporation** of **water from the plant surface mainly through the leaf.**

When water is lost from the surface of cell wall of spongy mesophyll cells, water is then drawn from the adjacent cells by osmosis. The adjacent cells continue to draw water from the xylem. This creates a sucking effect of water from the xylem which is known as **suction.**

Continous flow of water from the xylem through the mesophyll cells and out of the stomata is called **transpiration stream.**

Transpiration stream together with cohesion and adhesion forces draws water up the plant through the xylem.

When the xylem in the root draws water from the adjacent cortex cells, the cortex cells draw water from the root hair cells by osmosis. This results in absorption of water from the soil through the root hair cells.

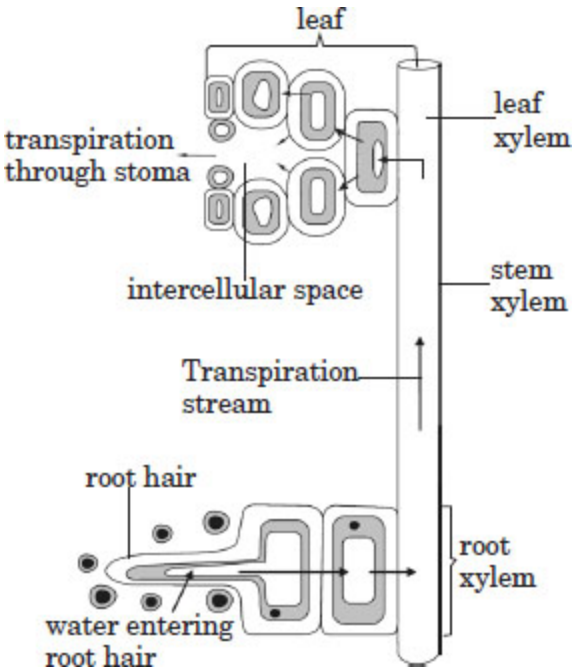


Fig. 4.18: Transpiration stream

Suction

- Have you ever taken a soft drink using a straw? What do you usually do?
- Do you usually push in air, or do you pull out or suck air out of the straw? How does the soda in the bottle behave when you suck air out of the straw?
- From the example probably you have noticed that as you suck air up a straw, the soft drink moves from the bottom of the bottle up the straw. This is called **suction.**

Activity 4.12: To show that water is given off by the leaves during transpiration

Apparatus and materials:

Two potted plants *(one with leaves, the other with its leaves removed)* two polythene bags, strings.

Procedure

1. Set up the potted plants and cover each with a polythene bag. Tie the polythene bag round the stem as shown in the following figures.

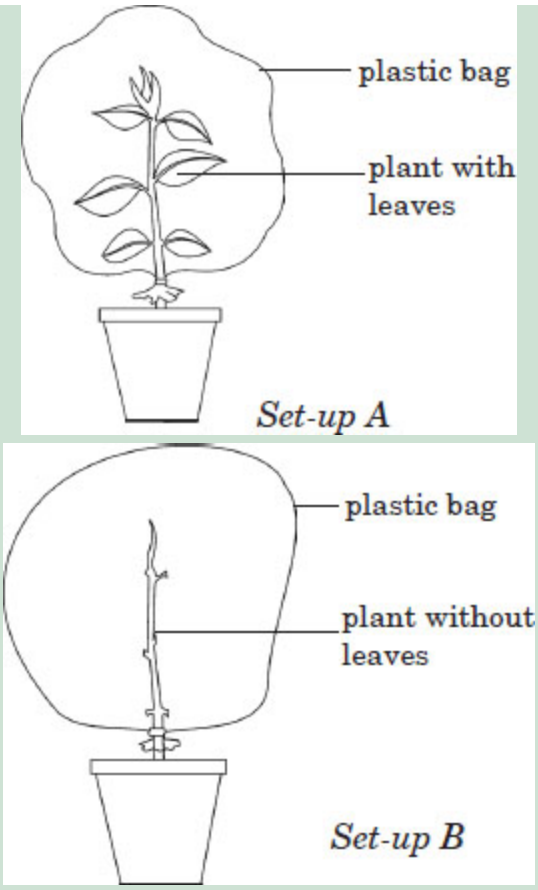


Fig. 4.18: Set-up of experiment to show that water is given off by leaves during transpiration.

2. Leave the two set-ups in a sunny place.
3. Collect and test any liquid which collects in the plastic bag with anhydrous copper sulphate or anhydrous cobalt chloride paper.

Questions

1. What observation was made in set-ups A and B after several hours?
2. What conclusion can be made from the above observations?
3. Which is the control experiment and why?
4. What changes are observed on the anhydrous cobalt chloride paper?

Discussion

The anhydrous dry cobalt chloride paper is used to confirm that the liquid collected is water. If the anhydrous cobalt chloride paper which is blue turns

pink, then water is present which means transpiration is taking place. If water collects in the plastic bag in set-up A but not in set up B, we can conclude that water is given off mainly by the leaves of a plant. Set up B is the control. It proves that without leaves, no transpiration occurs.

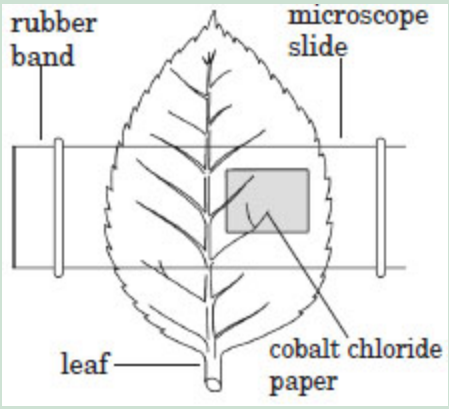
Activity 4.13: To compare transpiration on lower and upper leaf surfaces

Apparatus and materials

Anhydrous cobalt chloride papers, two glass slides, rubber bands or paper clips or cellotape. Plant that is still anchored in soil.

Procedure

1. Identify an intact leafy shoot, a plant that is still growing will do.
2. Select a leaf, and attach equal size pieces of anhydrous cobalt chloride paper on both sides of the leaf. You can use the cellotape, slides and rubber bands or clips to secure the paper in position as shown in the figure below.
3. Record the time, and observe each piece of cobalt chloride paper.
4. Note how long it takes for each paper to change colour.
5. Make your conclusion.



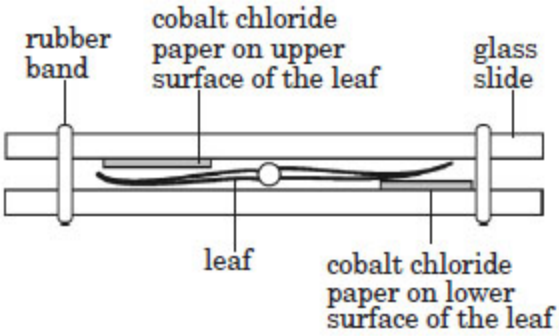


Fig. 4.20: Experiment to compare transpiration on lower and upper leaf surfaces.

Questions

1. What is the colour of anhydrous cobalt chloride paper?
2. What is the colour change observed during the experiment?
3. Which paper took longer to change: the one on the upper surface of the leaf or the one on the lower surface?
4. Explain your answer in 3 above.

Discussion

Anydrous (dry) cobalt chloride paper is blue. Hydrated (wet) cobalt chloride paper is pink. Evaporation of water from the leaves (transpiration) occurs through the stomates located on the leaf surface. In a typical land plant, there are more stomates on the under side of the leaf than on the upper side. The more the number of stomates, the more the amount of water lost by transpiration. The cobalt chloride paper on the under surface of the leaf therefore changes colour from blue to pink faster/sooner than the cobalt chloride paper on the upper surface of the leaf.

Importance of transpiration

Transpiration is important to a plant for the following reasons:

1. Cooling of plants

In hot climates or on hot days, direct sunlight causes the surface of the plants to heat up. In such situations, transpiration is important because it

cools the plant as the water is evaporating, the plant is getting cooled.

2. **Distribution of mineral salts throughout the plant**

   When transpiration occurs, it causes water to flow through a plant. This is because when water evaporates through the stomata, more water is drawn from the leaf cells to replace it. This causes **transpiration stream.** As the water flows through the plant, it carries with it the mineral salts dissolved in it which are distributed throughout the plant.

3. **Uptake of water**

   The water lost by transpiration is replaced by water absorbed from the soil.

Factors affecting the rate of transpiration

Rate of transpiration is the speed at which a plant loses water through transpiration.

The factors affecting transpiration rate include:

- Temperature
- Air movements
- Humidity
- Light intensity.

Activity 4.14: Use of a potometer to investigate the effect of external conditions on the rate at which water enters a leafy shoot

Apparatus and materials

Leafy plant freshly uprooted or freshly cut for example a tomato plant, bean, or any other suitable plant, basin of water, scalpel, means of timing such as stopwatch or wristwatch, potometer, polythene bag.

Procedure

1. Immerse the potometer in the basin of water making sure it is completely filled with water.

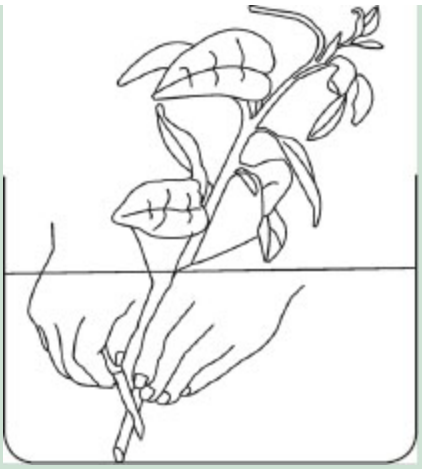


Fig. 4.21(a): Cutting a leafy branch under water

2. Put the plant into the water and cut through the stem under water as shown below.
3. Attach the freshly cut end of the stem into the potometer still under water.
   - Why is the stem of the plant cut under water?
4. Remove the plant and potometer from the water and mount them in a fixed position. The end of the capillary tube should rest in a beaker of water.
5. After setting up the potometer as shown, carry out the following activities and record the results in a table.

   (a) (i) Place the potometer with the shoot in a windy place outside the classroom.

   (ii) Introduce an air bubble into the capillary tube by removing the beaker of water at the end of the tube.
   - What happens to the bubble?

   (iii) Measure the distance moved by the bubble for five minutes and record your results in a table like the one shown below.

Conditions	Distance moved by bubbles (cm)	Time (min)
Windy		
Still air		
Hot sun		

Cool place		

Table 4.1: External factors affecting transpiration

(iv) Calculate the rate of water uptake as follows:

$$\text{Rate of water uptake} = \frac{\text{Distance moved by the bubble (cm)}}{\text{Time taken in min}}$$

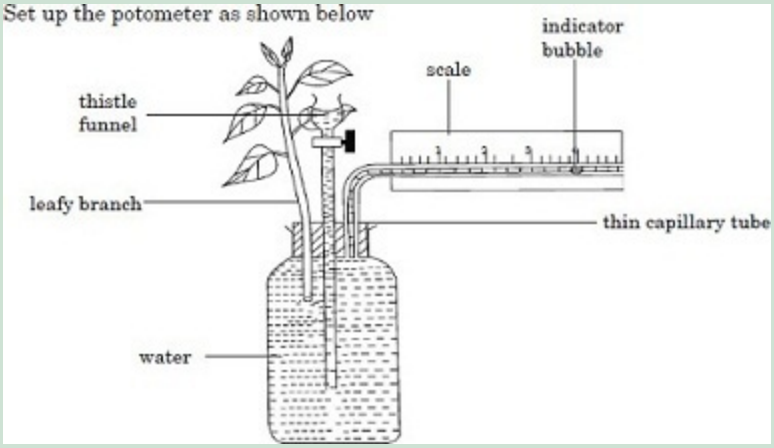


Fig. 4.22(b): Experiment to show external factors affecting transpiration

(b) Repeat the procedure but this time place the plant where the air is still for instance in the classroom. Record the distance covered by the bubble and calculate the rate of water uptake by the same shoot.

(c) (i) Place the set-up outside in the hot sun and again in a cool place for example, inside the classroom.

(ii) Calculate the rate of water uptake in each case using the procedure described in (a) above.

(d) (i) Put the plant in a humid environment that is by covering the leaves with a polythene bag and leaving it without the polythene bag to compare.

(ii) Calculate the rate of water uptake in each case.

Questions

1. Explain what the potometer measures;
   (a) Directly.
   (b) Indirectly.

2. What conclusion can you draw from your results where the following environmental conditions were investigated
    (a) Wind.
    (b) Humidity.
    (c) Temperature.
3. Evaporation alone cannot account for the movement of water through a plant. What other forces might be involved?

Discussion

The potometer measures directly the rate of uptake of water. It also indirectly measures the rate of transpiration since evaporation of water from the leaf leads to the replacement of this water through uptake.

In windy conditions, the rate of transpiration is higher than in still air. In hot environments, the rate of transpiration is higher than in cold conditions. In humid conditions, the rate of transpiration is lower than in dry conditions.

When setting up the leafy shoot in the potometer, the stem is cut under water to prevent the introduction of an air bubble into the xylem tissue because it blocks the conduction of water.

The plant uses up water for photosynthesis and it also loses water by transpiration. These two factors contribute to its uptake from the soil.

Let us now discuss how the various factors affect transpiration.

Temperature

The temperature of the surrounding of a plant is an indication of the amount of heat present around the plant. On a hot day, **Fig. 4.19(i),** the temperature is high because there is a lot of heat in the atmosphere. This causes faster evaporation of water from the leaf and therefore transpiration is very fast. On cold days. **Fig 4.19(ii),** the temperature is low because there is very little heat in the environment. As a result of this, little evaporation of water from the leaf occurs causing transpiration to occur very slowly.

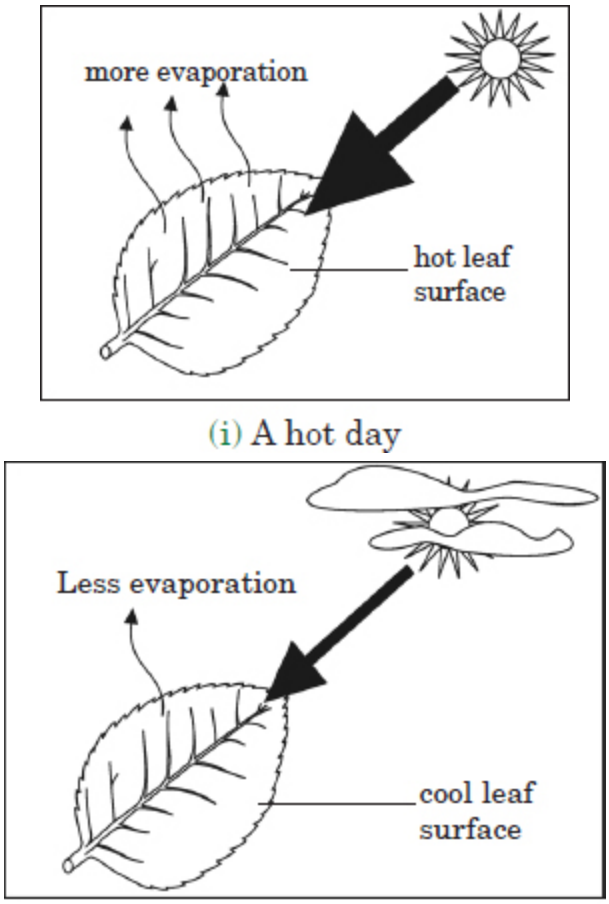


Fig. 4.23: Effect of temperature on rate of transpiration

Humidity

Humidity is the amount of water vapour in the air. If this amount of water is a lot then humidity is high. If it is little, then the humidity is described as being low. When the humidity is high, the air becomes saturated with water vapour. Under these conditions there is very little space available in the air for water vapour from the leaf to occupy.

This means that transpiration reduces or even stops. However, when the air is dry, that, is humidity is very low, there is plenty of space for water vapour being transpired from the leaf to occupy. Therefore the rate of transpiration is high.

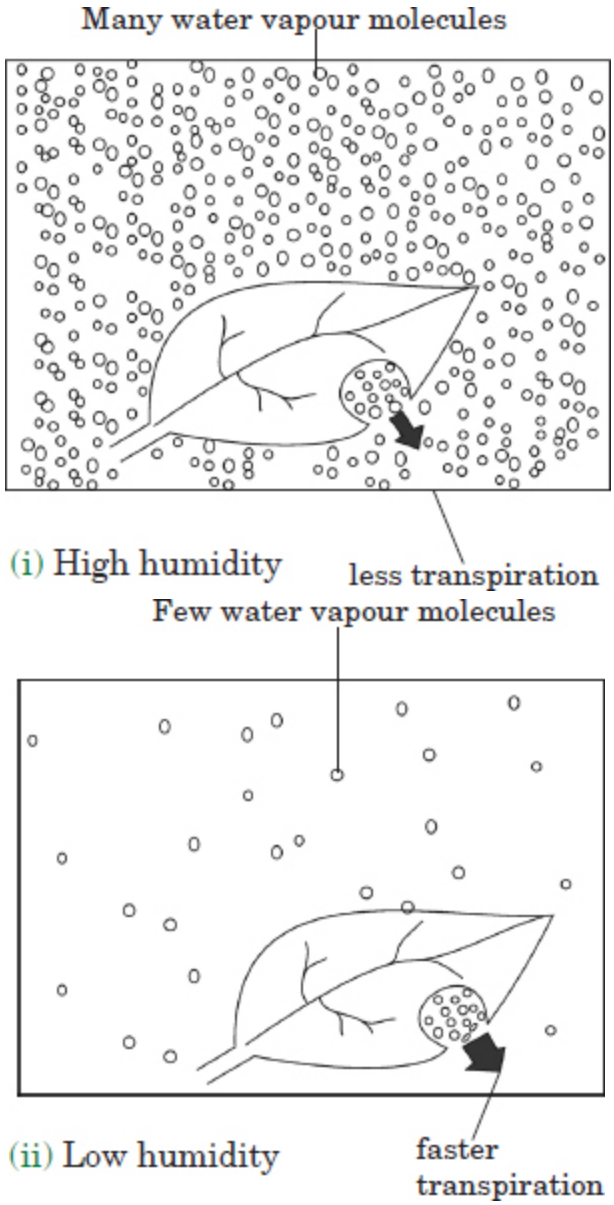


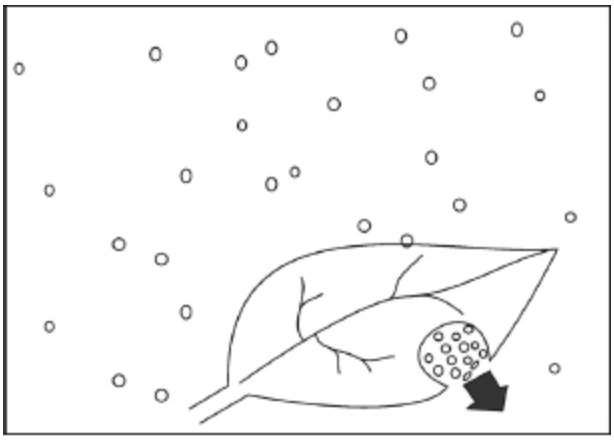
Fig. 4.24: Effect of humidity on rate of transpiration

Air movement

Moving air carries with it moisture that has evaporated from the leaf surface. This prevents the air surrounding the stomates from becoming saturated with water vapour from the leaf.

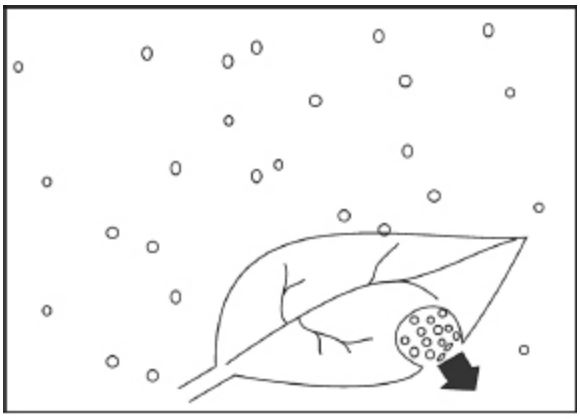
Sometimes, the environmental conditions around the plant can be described as windy like when the air is moving quickly. The air can also be still when there is no wind.

In a windy environment, increased movement of air prevents any moisture from accumulating on the surface of the leaf, Fig. 4.21(i). This creates room for vapour transpiring from the leaf. It also increases the diffusion gradient of water vapour between intercellular spaces in the leaf and the air. The rate of diffusion of water vapour from the leaf increases, thus increasing the rate of transpiration.



(i) Windy conditions

When there is no wind, the air above the leaf surface quickly becomes saturated with water vapour hence reducing transpiration, Fig. 4.21(ii). The rate of transpiration decreases with increased humidity.



(ii) Still air

Fig. 4.25: Effect of wind on rate of transpiration

The situations just described can be compared with what happens in your class at break time. Everybody usually wants to leave the classroom. If the first students to leave just hang around the door, this will create crowding at the door and make it difficult for the others to leave. However, if those who

leave first go away completely, then there is room for those behind to pass and everybody moves fast.

Generally, the rate of transpiration is highest in hot, windy and dry conditions and it will be lowest in cold, non-windy and wet conditions.

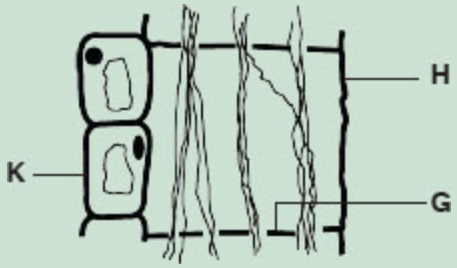
Light intensity

Light intensity is the strength of light received by the earth's surface. It varies in the course of the day depending on the position of the sun. For example, at dawn, there is very little light, and the light intensity is low. As the sun rises in the sky, the strength of sunlight increases. At noon, the sun's intensity, is high and therefore light intensity is very high. As the sun sets, the strength of light decreases causing a low light intensity.

Light intensity affects transpiration because it has an effect on the opening of stomates. The rate of transpiration is high when there is high light intensity because the stomates open more. When the intensity of light is low, the rate of transpiration is reduced because stomates open less. Stomates close in darkness, so at night very small amounts of water are lost.

Revision Exercise 4

1. The diagram below represents a plant tissue.

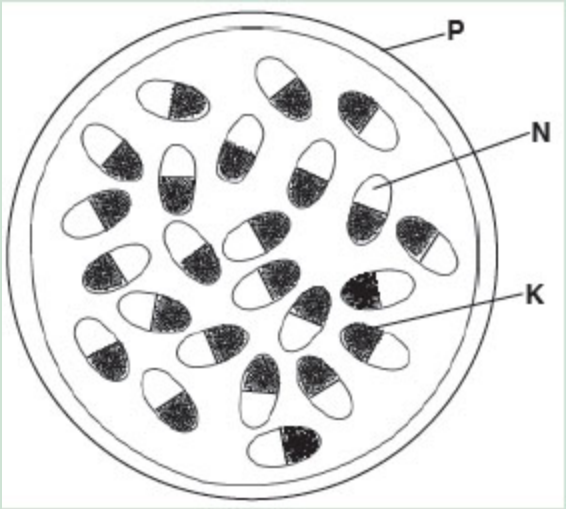


(a) (i) Identify the parts labelled G, H and K.

(ii) State the functions of the vessel shown above.

(b) Name food substances that are transported in plants by the above structures.

2. The diagram below represents a section through the stem of a plant.



(a) Name the structures labelled K, P, and N.

(b) State the class to which the plant belongs to giving reasons.

3. Explain the following observations.

The freshly cut stump of a tree will continue releasing water for sometime after the tree has been cut down.

4. Explain why plants growing in an enclosed greenhouse have a lower rate of transpiration than plants growing in the open.

5. In an experiment, the bark of a stem was ringed as shown in figure M. Figure N shows the results after several weeks.

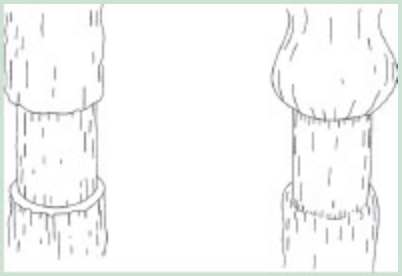


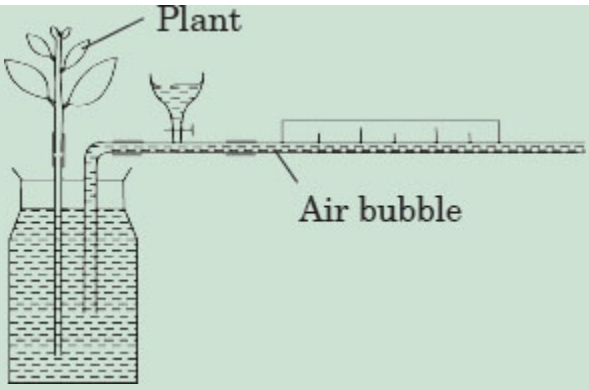
Figure M Figure N

(a) Account for the results obtained after several weeks.

(b) (i) From the results of this experiments, explain why trees that have been ringed dry up after sometime.

(ii) Suggest a possible aim of this experiment.

6. A student set up an experiment shown below using a freshly obtained leafy shoot. The shoot was cut and mounted on the capillary tube under water.



(a) Suggest a possible aim of this experiment.

(b) Explain why the leafy plant was cut and mounted under water.

(c) Give the name for the apparatus used in the above experiment.

(d) State the environmental factors that would influence the movement of the air bubble along the scale.

7. Define the following terms:

(a) Osmosis.

(b) Diffussion.

Unit 5

Human digestive system

Specific Objectives

By the end of this unit, you should be able to:

(a) State the functions of carbohydrates, proteins, lipids, vitamins, mineral salts and water in the body.

(b) State the chemical composition of different food substances.

(c) State different digestive enzymes and the food substances they work on.

(d) List products of chemical digestion.

(e) Describe properties of enzymes.

(f) Carry out investigations in enzymes.

(g) Describe the absorption of food substances.

(h) Describe the adaptations of the small intestines to their function.

(i) State the functions of the large intestines.

(j) State the fate of digested food.

(k) Explain problems associated with the digestive system.

Introduction

In Form Two, we learnt about food nutrients and what makes a balanced diet.

In this unit, you will learn about the function of nutrients in the food, chemical digestion (molecular structure of food substances), enzymes (characteristics and properties of enzymes) absorption of food substances, assimilation, adaptations of the small intestine in its function and finally problems associated with the digestive system.

We have seen that plants make their own food in a process called photosynthesis. Animals however do not make their own food. They depend

on organic substances that make up the body of other organisms.

Nutrients in food

In Form Two, we discussed nutrients in food and what makes a balanced diet.

In this section, we shall learn about functions of carbohydrates, proteins, lipids, vitamins, mineral salts and water in the body.

Functions of carbohydrates

Carbohydrates are important chemical compounds to all living things. They have several functions which include;

1. As a source of energy

Some carbohydrates such as glucose are broken down to provide energy in the cell. Energy is used for various life processes such as locomotion, growth among others.

2. As part of the structure in plant cells

A carbohydrate like cellulose forms part of the cell wall in plants. Cellulose makes the cell wall firm.

3. As roughage in humans

Foods of plant origin such as vegetables and fruits are rich in cellulose or fibre. They provide bulk and resistance to the muscles in the alimentary canal. This allows easy movement and digestion of food in the gut and prevents constipation.

Functions of proteins

1. Proteins are structural compounds of animal tissues

Proteins form part of the structure of animal tissues. They are found in the form of:

- **Keratin** in hair, horns and feathers.
- **Collagen** in tendons and ligaments.
- **Myosin** in muscles.

2. Proteins are functional units in plants and animals

Proteins perform many functions in animal bodies. Some functional proteins include:

Enzymes

These are proteins that speed up the reactions in plant and animal cells. Reactions like photosynthesis and respiration proceed with the help of enzymes.

Haemoglobin

This protein is found in red blood cells of vertebrates. Its function is to transport oxygen from the lungs to other parts of the body.

Hormones

These proteins regulate life processes in animals. An example of an animal hormone is **insulin.** It regulates the sugar level in the body.

Antibodies

These are proteins that provide the body with immunity against diseases. They assist the body to destroy disease-causing microorganisms.

Fibrinogen

This protein is important in the clotting of blood. Blood cannot clot without fibrinogen. Clotting of blood prevents excessive bleeding from wounds or injury.

3. Proteins are storage products

Plants store their excess proteins in seeds. Such proteins are used by the seeds during germination.

Mammals store some of their protein in form of **casein** in milk. This is a source of protein called albamen for their young ones. Similarly, a protein called a humen is stored in eggs and is used for the growth of the embryo.

Functions of lipids

Lipids are large, naturally occuring organic compounds. They are insoluble in water but they readily dissolve in alcohol. Fats are usually solids at room

temperature. When heated, fats can melt to liquid. Oils can be turned to solids when cooled enough.

1. **As a source of energy**

   Lipids store energy just like carbohydrates. However, lipids store more energy than carbohydrates.

2. **Lipids form part of the structure of the cell membrane**

   Cell membrane is composed of a type of lipid called a *phospholipid.*

3. **As a storage compound**

   Plants store lipids as oil in seeds and in some fruits such as coconuts, avocado pear, castor seeds, groundnuts, simsim seeds, maize and macadamia nuts. Animals store lipids in the form of fat in a special tissue known as *adipose tissue.* Stored lipids can always be used by the plants and animals for respiration when need arises.

4. **For insulation**

   Lipids are used by animals for insulation against excessive heat loss. The insulatory lipid is in the form of solid, insoluble fat found beneath the skin in vertebrates. This layer helps to keep the animal warm.

5. **As protective compounds**

   The fat found around body organs like the heart and the kidneys acts as a protection against mechanical injury by cushioning the organs against physical impact.

6. **As a source of metabolic water**

   Chemical reactions that take place in cells are referred to as **metabolic reactions.** Some of these reactions produce water as a by-product. In the camel, the fat stored in the hump can be used as a source of water. This occurs when the fat is broken down during respiration to release energy. The water formed as a by product enables the camel to go for long periods without drinking water.

7. **As a store of vitamins**

   Vitamins A, D, E and K are soluble in fat. The human body is able to store these vitamins in fat found in the liver.

Name of vitamin	Use in the body
A	• It maintains healthy epithelial growth • It promotes growth • It improves proper vision
D	• It strengthens bone and teeth • It enables absorption of calcium and phosphorus
E	• Involved in cell metabolism • It strengthens muscles
K	• It helps in blood clotting by formation of prothrombin
C	• Maintenance of healthy cells, tissues and blood vessels. • It promotes absorption of iron • It promotes healing of wounds and prevents infections • For formation of cement and collagen fibres in the teeth
B_1	• Involved in cell respiration • It promotes nerve activity
B_2	• It is needed for maintaining healthy tissues
B_3	• Involved in energy release in cells

Table 5.1: Vitamins and their uses in the body

Functions of water

The following are some ways in which our bodies use the water that we drink or take in with our food.

1. Digested food can only be absorbed when it is dissolved in the water in the ileum.

2. Excretory materials like carbon dioxide and urea are removed from the body when dissolved in water.
3. Oxygen is absorbed into the body after it dissolves in the moisture lining of the lungs.
4. Water gives organisms form.
5. Water dilutes harmful substances in our bodies and helps in their removal from the body. We must always take in a lot of fluids or water during any one of the following situations.
    - when one has a high fever
    - when one has diarrhoea
    - when one is vomiting
    - when one is sweating
    - when one is bleeding

    Thirst is always a sign that the body needs water.
6. Water is used to transport substances in the cell and in the blood.

Functions of mineral salts

Table 5.2: Some important minerals, their sources, uses and deficiency signs

Name of mineral	Sources	Use in the body	Deficiency signs
Calcium	Milk, cheese, nuts, green vegetables	• Formation of strong bones and teeth. • Needed for muscle contraction. • Clotting of blood (pregnant and breastfeeding mothers need more)	• Rickets • Osteomalacia (bone disease in which bones are painful and they fracture easily)
Phosphorous	Milk and milk products like cheese, eggs, spinach	• Formation of strong bones and teeth	• Weak bones and teeth
Iron	Liver, meat, egg yolk, green vegetables	• Formation of haemoglobin in red blood cells and myoglobin in muscle (pregnant women and young people need more).	• Anaemia (iron deficiency
Sodium	Common salt	• Keeps nerves in good working order	• Muscle cramps, weakness, dullness
Potassium	Meat, fish, cereals, vegetables	• Proper functioning of nerves and muscles as well as enzymes.	• Muscular weakness, paralysis and drowsiness.
Magnesium	All foods	• Strong bones and teeth. • Proper functioning of muscles and nerves.	• Muscle tremors • Convulsions
Iodine	Eggs, sea foods, vegetables, iodised salt	• Formation of thyroxine.	• Goitre (swelling of thyroid gland in the neck.)

Chemical composition of food substances

(a) Carbohydrates

These are chemical compounds made up of the elements carbon, hydrogen and oxygen. Their general formula is $(CH_2O)_n$. Common examples of carbohydrates are **sugars** and **starch.** Carbohydrates are classified into three main groups:

- Monosaccharides.
- Disaccharides.

- Polysaccharides.
- Monosaccharides.

A monosaccharide is a single sugar unit. The general formula of a monosaccharide is $(CH_2O)_n$ where n can be 3, 5 or 6. Some examples of monosaccharides include glucose, fructose, galactose.

Monosaccharides

- They are single sugar units, their general formula is $(CH_2O)_n$.
- They are classified according to the number of carbon atoms present example trioses has three (3) carbon atoms and pentoses has five (5) carbon atoms.
- They are used in respiration to release energy and used in the manufacture of disaccharides and polysaccharides.
- They are reducing sugars.

Disaccharides

- They are made by joining two monosaccharides in a process known as **condensation.** A molecule of water is removed in the process.
- Examples include:
  Lactose = glucose + galactose
  Sucrose = glucose + fructose
- They are sweet tasting.
- They are readily soluble in water.
- They have a general formula $^{C}12^{H}22^{O}11$.

Polysaccharides

- They are made by joining many monosaccharides.
- They are non-reducing sugars.
- They are not sweet, insoluble or slightly soluble in water.
- They are non-crystalline.
- They have a general formula; $C_x(H_2O)_y$

(b) Proteins

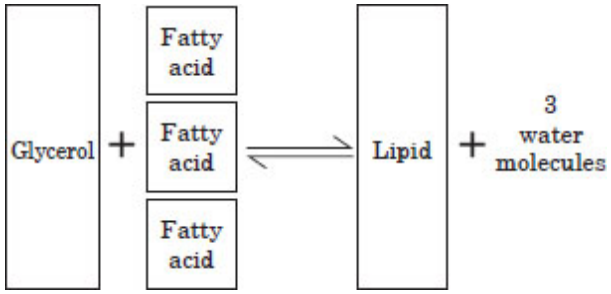
Proteins are complex compounds. They are made up of the elements carbon, hydrogen and oxygen. In addition, they have nitrogen. Some proteins may

also contain sulphur or phosphorus. These elements make up units called **amino acids. Amino acids are the building units of proteins.** Several amino acids are joined together by peptide bonds to form proteins. There are about twenty different types of amino acids which occur naturally in plants and animals. These amino acids combine differently in a chain to form different types of protein.

(c) Lipids

Lipids are fats and oils. The elements found in lipids are the same as those found in carbohydrates namely, carbon, hydrogen and oxygen. However, lipids have much fewer oxygen atoms than hydrogen atoms as compared with carbohydrates. For example, in glucose which is a carbohydrate, there are two hydrogen atoms for every oxygen atom. In a lipid, there are twenty two hydrogen atoms for every oxygen atom. Fats are lipids commonly found in animal tissue. An exception is the whale which has oil. Oils are lipids commonly found in plants.

The building units in a lipid molecule are fatty acids and glycerol. One glycerol molecule combines with three fatty acid molecules in a condensation reaction to form a lipid known as a triglyceride. Three water molecules are given out. This reaction can be reversed by hydrolysis where the triglyceride (lipid) is split to glycerol and three fatty acid molecules.



There are different types of fatty acid molecules but only one type of glycerol. The type of lipid formed depends on the types of fatty acid molecules that it contains.

Digestive enzymes

Digestion is the process by which food substances from complex compounds are broken down to simple compounds that can be absorbed by

the body. The process takes place along a digestive system and it involves the use of teeth as well as enzymes (digestive enzymes).

(a) Salivary amylase

Saliva is produced by the salivary glands. It contains the enzyme **salivary amylase** or **ptyalin.**

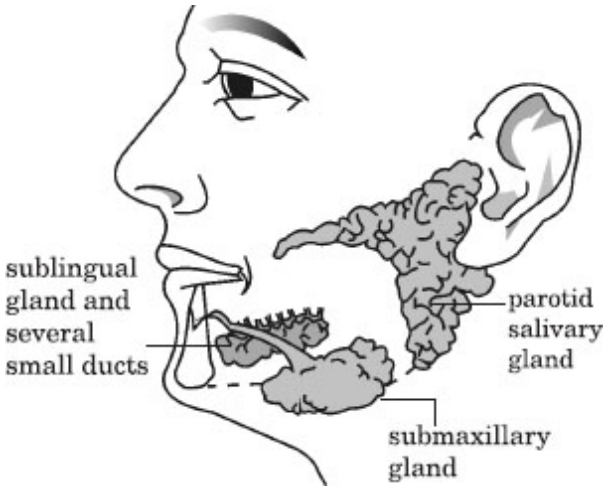


Fig. 5.1: Diagram showing the salivary glands.

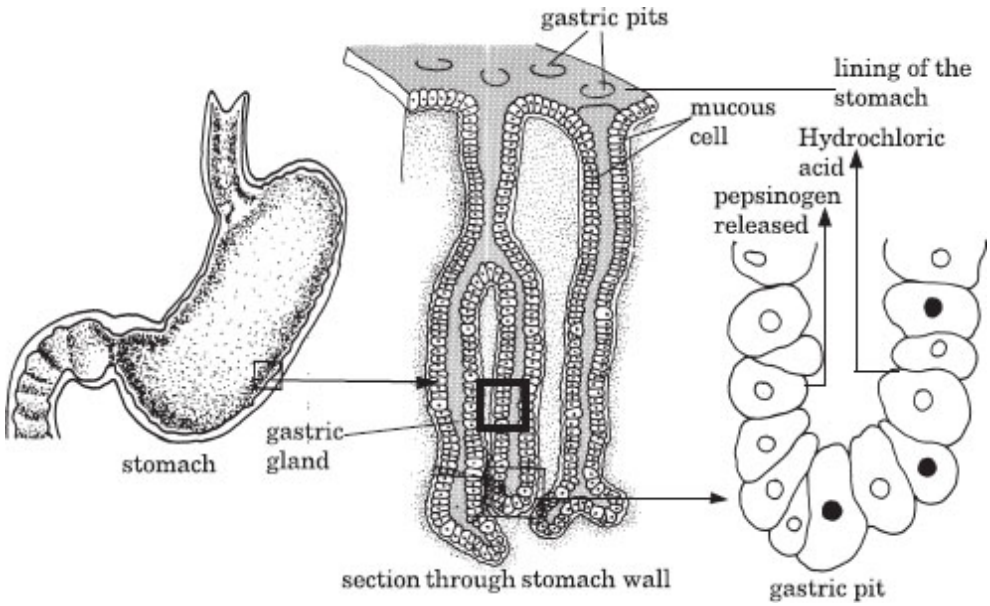


Fig. 5.2: Secretion of gastric juice in the stomach

Salivary amylase converts starch to **maltose.** Ptyalin works best at a pH of about 6.8. This is the pH of saliva.

(b) Pepsin

It is an enzyme which catalyses the breakdown of proteins into smaller polypeptides through hydrolysis.

Pepsin is secreted as an **inactive** form called **pepsinogen** by special cells in the gastric gland. The gastric gland has mucus. The muus protects the enzyme producing cells from being digested. Once in the stomach, pepsinogen is converted to active pepsin due to presence of hydrochloric acid.

$$\text{Proteins} \xrightarrow{\textit{pepsin}} \text{smaller polypeptides}$$

(c) Rennin

Its function is to make liquid milk to **curdle.** This is described as the **coagulation** of milk. It does this by converting a soluble milk protein called **caseinogen** into an insoluble form called **casein.** Pepsin can only act on milk protein when it is converted to casein.

Coagulation of milk by rennin is also important because the solid milk stays in the stomach longer for digestion to occur. Rennin is found mainly in young mammals and may be absent in adults. This is because the diet of young mammals mainly consists of milk.

(d) Pancreatic juice

Pancrease secretes pancreatic juice. Pancreatic juice contains the enzymes *pancreatic lipase, pancreatic amylase, trypsin* and *chymotrypsin.* These enzymes digest the following food substances:

1. Lipase converts lipids into **fatty acids** and **glycerol.**

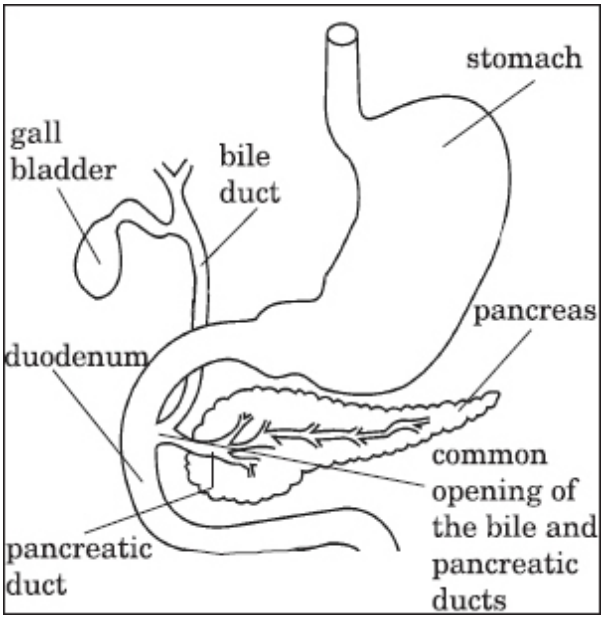


Fig. 5.3: Diagram showing opening of the bile and pancreatic ducts into duodenum.

2. Pancreatic amylase breaks down any undigested starch into maltose. (Remember that some starch is digested in the mouth)
3. Trypsin breaks down proteins to peptides. It is released in the inactive form called **trypsinogen.**
4. Chymotrypsin breaks down proteins to peptides. Its inactive form is chymotrypsinogen. Trypsinogen and chymotrypsinogen are both activated by an enzyme called **enterokinase.**

Pancreatic juice also contains **sodium bicarbonate** (sodium hydrogen carbonate). This creates an **alkaline medium** of pH 8.8. This medium is suitable for the action of enzymes found in pancreatic juice. It also neutralises the acidic content of food from the stomach.

Enzymes	Function
Trypsin	Hydrolyses proteins to peptides.
Chymotrypsin	Hydrolyses proteins to peptides.
Lipase	Hydrolyses lipids to fatty acids and glycerol.
Pancreatic amylase	Hydrolyses starch to maltose.
Sodium	Neutralises the acid in the chyme. Creates an alkaline

bicarbonate	medium for the action of the pancreatic enzymes.
Bile: bile salts	Emulsification of lipids.

Table 5.3: Digestive enzymes and their functions.

Peptidase, maltase, sucrase and lactase

The ileum is the second part of the small intestine. The ileum has two main functions.

1. To complete breakdown of food.
2. It is the site for absorption of digested food into the blood.

The epithelial lining of the small intestine has special cells called goblet cells that secrete mucus.

This mucus protects the intestinal wall from protein digesting enzymes. Secretory cells in the intestine wall also release **intestinal juice** or **succus entericus.**

Intestinal juice is a slightly alkaline liquid with a pH of about 8.3. It contains water, mucus and enzymes. Intestinal juice increases the volume of the fluid in the gut. It also creates the right pH for the intestinal enzymes to function well.

Intestinal juice contains the following digestive enzymes: **peptidase, sucrase, lactase, maltase** and **lipase.**

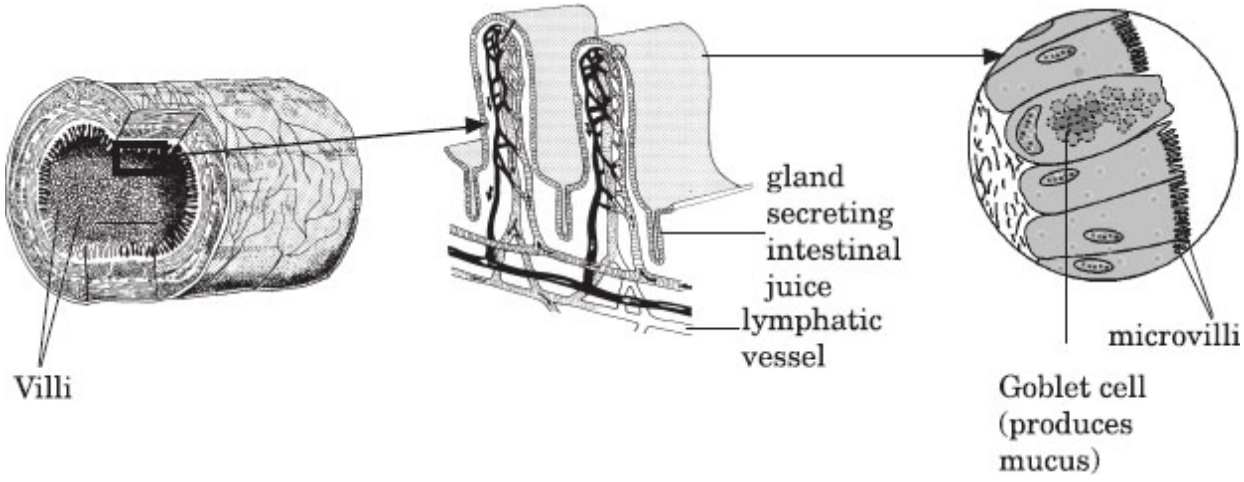


Fig. 5.4: Detailed structure of the small intestine showing the villi

The table below shows the substances digested by these enzymes and the products of digestion.

Enzymes	Food substrate	Final product
Sucrase	Sucrose	Glucose and fructose
Maltase	Maltose	Glucose
Lactase	Lactose	Glucose and galactose
Peptidase	Polypeptides	Amino acids
Lipase	Lipid	Fatty acids and glycerol

Table 5.4: Contents of intestinal juice and products of digestion in the ileum

The products of digestion are small enough to be absorbed across the ileum walls to the blood.

Products of chemical digestion

We have discussed different digestive enzymes and food substances they work on. The following is a list of products of chemical digestion.

(a) Monosaccharides

In Form Two, we learnt that the end products of digestion are simple and soluble. The monosaccharides are the simplest and final form of digestion. The following are end products of carbohydrate digestion;

- Glucose.
- Fructose.
- Galactose.

(b) Amino acids

In chemical digestion of proteins, the final products are amino acids. They are the simplest and soluble form of a protein.

(c) Fatty acid and glycerol

Fatty acid and glycerol are simplest and final products of lipid digestion. When a lipid molecule is digested, it forms three fatty acid and a glycerol.

Properties of enzymes

Enzymes are substances that are protein in nature and they help in speeding up reactions in plants and animals cells. There are two types of enzymes; **Intracellular** and **extracellular** enzymes. Intracellular enzymes are produced and only work and remain active within a cell for example, catalase. Extracellular enzymes (exo-enzymes) functions outside the cell from which it originates examples include pancreatic amylase. Enzymes have the following properties.

1. **Protein in nature**

   Enzymes are made up of proteins.

2. **Specific in their action**

   Each enzyme is specific in its action. This means that it speeds up a **particular** chemical reaction. This is because each enzyme has a **binding site** on its surface onto which only certain substrate molecules can bind (attach) in order to speed up the reaction.

   For instance, the enzyme lipase can only act on lipids and not on maltose. In the same way, the enzyme maltase can only act on maltose and not on lipids.

3. **Specific pH**

   Enzymes work best in either alkaline, acid or neutral conditions.

   In each of these conditions, a particular enzyme will work best at a specific pH value. For example, the enzyme pepsin works best in an acidic medium of pH 2.0. If the pH value is lower than this, then pepsin will not work well.

4. **Enzymes work best within narrow temperature ranges**

   Enzymes work best at a certain temperature. High temperature denatures enzymes and very low temperatures inactivates enzymes. Let us carry out the following activity to determine the effect of temperature on enzymes.

Activity 5.1: To investigate the effect of temperature on enzyme activity

Materials

Starch solution, 1% ptyalin enzyme, iodine solution, Benedict's solution, two beakers, test tubes, thermometer, means of heating.

Procedure

1. Place 2 cm^3 each of starch solution into three different test tubes labelled 1-3.
2. To each test tube, add 1cm^3 of ptyalin enzyme.
3. Immerse the 1st test tube into a beaker of cold water *(preferably with ice-cubes)*
4. Put the second test tube in a water-bath maintained at 37°C.
5. Boil the contents of the third test tube.
6. Test the contents of each test tube with iodine and Benedict's solutions. Observe and record your results.

Discussion

Enzymes work best at an optimum temperature of 37°C. Boiling denatures enzymes. Very low temperatures make enzymes inactive.

Enzymes are sensitive to temperature changes. If the temperatures are very low, for example 0^{o}C, the enzymes do not work. They are said to be **inactive.** Temperatures above 45^{o}C are too high for **most** enzymes.

This is because such temperatures alter or change the structure of the enzyme and destroy the binding site. We say that the enzyme becomes **denatured.** A denatured enzyme cannot function.

5. Enzymes are catalysts

Activity 5.2: To investigate the catalytic nature of an enzyme in living tissue.

Investigations on enzymes in the liver tissue

Living tissue contain enzymes in their cells, whose activity can be observed. Carry out the following investigative project to study the effect of enzymes found in liver tissue on hydrogen peroxide.

Here is a guide on what you must do during the project.

(a) Read about enzymes found in living tissues like the liver.

(b) Read about how to extract enzymes.

(c) Plan your investigations carefully.
(d) Carry out the investigations using scientific methods
(e) Record your observation and data.
(f) Analyse the data recorded.
(g) Draw conclusions.
(h) Write a complete report for your teacher to mark.

Materials

Starch solution, iodine solution, Benedict's solution, test tubes, 1% ptyalin enzyme, beaker of water (water bath) maintained at 37°C, white tile, dropper, thermometer.

Procedure

1. Put 2 cm^3 each of starch solution into two test tubes and label them as 1 and 2.
2. Into test tube 1, add 5cm^3 of starch solution.
3. Into test tube 2, add 5cm^3 of starch solution then 1cm^3 of a solution of the enzyme ptyalin.
4. Place the two test tubes into the water bath maintained at 37°C for 10 - 15 minutes.
5. Using a pipette or dropper, place one drop of the contents of test tube 1 onto the tile then add a drop of iodine solution. Repeat this procedure with contents of test tube 2.
6. Take the remaining contents of test tube 1 and 2, add 2cm^3 of Benedict's solution to both and boil. Record your observation and conclusions as shown in the table like 5.5

Test tube	Test with iodine		Test with Benedict's solution	
	Observation	Conclusion	Observation	Conclusion
Test tube 1 (starch alone)				
Test tube 2 (starch + ptyalin)				

Table 5.5: Effect of ptyalin on starch

Question

1. Why was the water bath maintained at 37°C?

Discussion

Ptyalin converts starch to maltose. Maltose is a reducing sugar and Benedict's solution changes colour from blue to orange when boiled with maltose.

Absorption of food substances

We learnt that the end products of digestion include: glucose, amino acids and glycerol

These substances together with vitamins pass through the walls of the small intestines into the blood circulatory system.

All amino acids are absorbed into the capillaries at the villi of the small intestines by diffusion and active transport.

Monosacharides are also absorbed into the capillaries at the villi by diffusion and active transport.

Some fatty acids are absorbed into the capillaries while some are absorbed into the lacteals at the villi.

Some vitamins are absorbed in the stomach and they then enter into the blood capillaries in the stomach walls.

Some vitamins are absorbed into the capillaries in the villi. Some fat soluble vitamins are absorbed in the lacteals of the villi. Some vitamins such as vitamin B_{12} and vitamin K that are synthesised in the colon are absorbed into the walls of the colon and then into the blood capillaries.

Adaptations of the small intestines to their functions

Absorption of food takes place in the last part of the small intestines known as the **ileum.** The structure of the ileum is well suited to its two functions.

1. The ileum is long to increase the surface area for absorption.

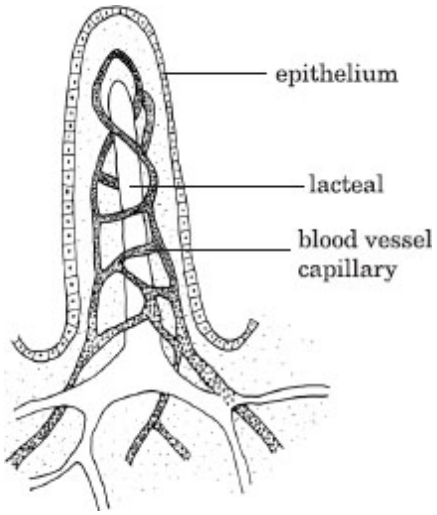


Fig.5.5: Longitudinal section through a villus.

2. The inner walls of the ileum are highly folded. They have many finger-like projections called **villi** (singular villus) which increase their surface area.

   Each villus is about 1mm long. Each square millimetre of small intestine has up to forty villi. This means that there are over 5 million villi in the small intestine. The surface area of each villus is increased even more by the folding of the membrane of each villus cell into microscopic **microvilli.** There are about 5,000 microvilli per cell which are visible only through an electron microscope. Thus, the **folds, villi** and **microvilli** greatly increase the surface area of the lining of the ileum for absorption of digested food.
3. Each villus has a network of blood capillaries and a **lacteal** in the centre. The presence of many blood vessels in one villus and the fact that there are over 5 million villi in the small intestine means that the intestine is served with millions of blood capillaries. The blood capillaries from the villi joins to form a blood vessel known as the **hepatic portal vein** which takes blood to the liver. This large number of blood capillaries results in a large amount of absorbed digested food materials being carried away from the small intestines in a very short time.
4. The small intestine also has a **thin epithelial lining** which is one cell thick. It allows rapid diffusion of digested food material from the intestinal space (lumen) into the blood vessels.

5. Epithelial cells have numerous mitochondria in them to provide energy for active transportation during absorption of digestive food.
6. Contraction of muscles in the walls of the small intestine causes continuous movement of the fluid-like material in the lumen of the small intestine. These movements mix the enzymes with food substances thoroughly and expose the villi to digested food. This speeds up the process of digestion as well as absorption of the digested food material.

Functions of the large intestines

The large intestine is sometimes called the **colon.** It is about 1.5 metres in length and is composed of the **caecum** with the **appendix,** the **colon** and the rectum. The walls of the large intestine have no villi. They have mucus secreting glands.

Functions

1. The main function of the large intestines is the absorption of water. This makes the contents of the large intestine to become more solid. At this point, this material is known as **faeces.**
2. The mucus secreting cells produce mucus to lubricate the passage for easy movement of faeces.
3. Faeces is composed of undigested roughage material, food which may not have been digested (undigested material), dead cells from the lining of the alimentary canal, unwanted mineral salts, bile pigments, living and dead bacteria. Some of the bacteria produce vitamin K which is useful to the body. The rectum stores these faeces until powerful peristaltic waves cause the sphincter muscles in the rectum to relax and the faeces are released in a process known as defaecation. Faeces may take 12 - 24 hours and even up to three days or more to pass to the rectum. A sphincter muscle at the entrance to the rectum prevents faeces from entering the rectum until it is ready for elimination.

Two sphincter muscles control elimination of faeces. When the rectum is distended with faeces, its muscles contract and the inner anal sphincter relaxes. The relaxation of the inner anal sphincter is not under our control. The relaxation of the outer anal sphincter is under our control. It remains in contracted condition until we decide to have it relaxed in order to defaecate.

In the large intestines, the caecum is large in diameter. It has an appendix.

Functions of the liver related to digestion

The liver is the second largest organ in the body. It has several functions. We will study only the functions related to digestion here.

Do you know any functions of the liver in digestion?

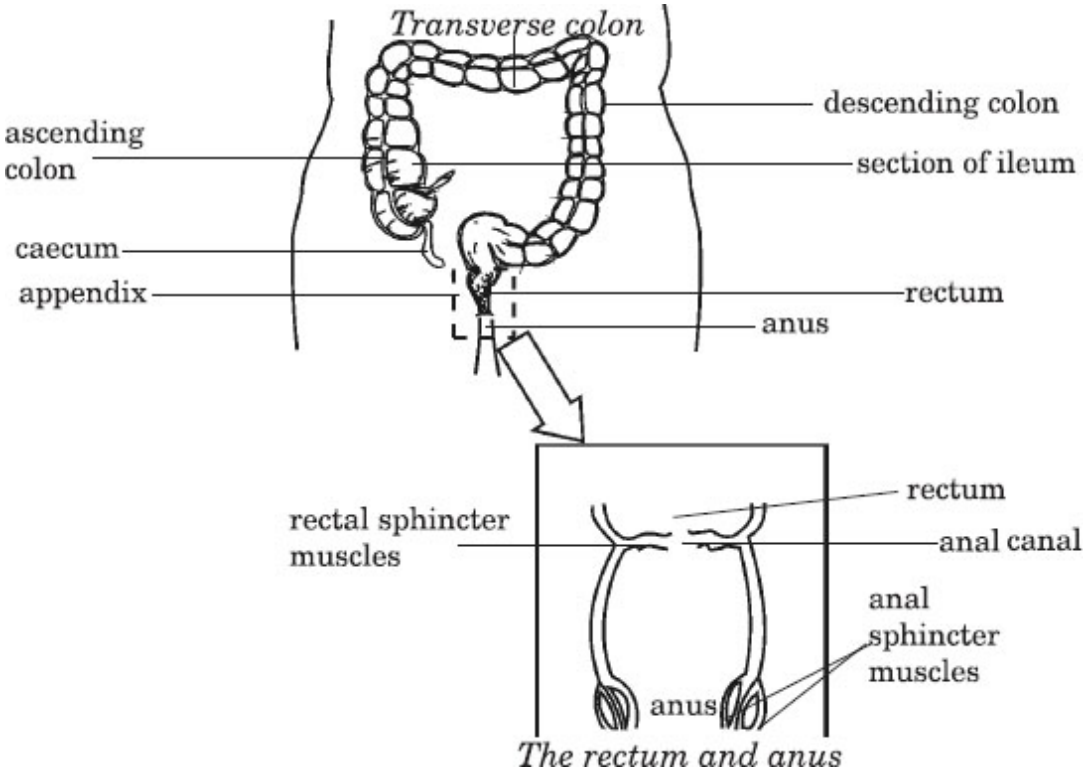


Fig. 5.6: Diagram showing the large intestine.

Control of proteins

(a) Deamination

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

reactions in what is called the **ornithine cycle.** The resulting urea is taken to the kidney via the blood and is eliminated from the body in urine. The equation below gives a summary of the substances that enter the ornithine cycle and what is produced.

$$2NH_3 + CO_2 \longrightarrow CO(NH_3)_2 + H_2O$$

Ammonia + carbon dioxide ⟶ urea + water

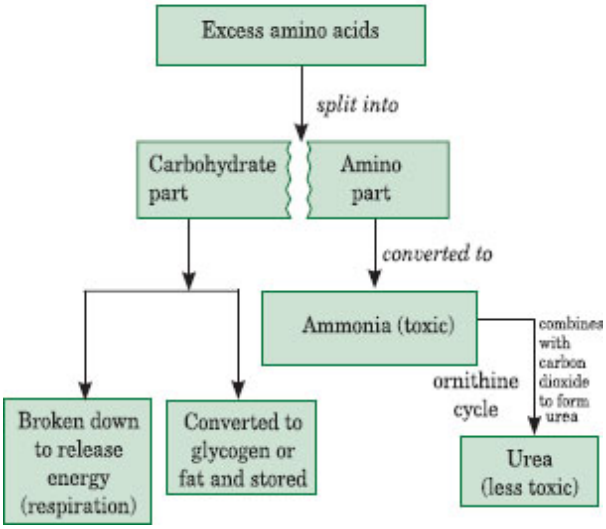
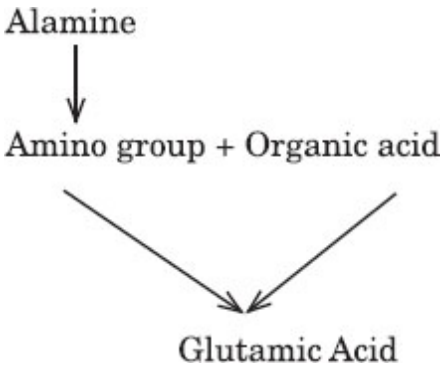


Fig. 5.7: The process of deamination

(b) Transamination

This is a process whereby the liver makes amino acids that are deficient in the diet. It does this by transferring amino groups from one available amino acid to an organic molecule like a sugar or an acid to form the required amino acid. For instance glutamic acid can be made by removing an amino group from alamine and combining it with an organic sugar.



Transamination therefore means the transfer of an amino group from one amino acid to another substance so as to form another amino acid.

This process enables the liver to provide an important amino acid that may be lacking in the body.

(c) Control of lipids

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

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

Gallstones may block the bile duct and prevent the secretion of bile into the small intestine. Do you remember the function of bile in digestion? Remind yourself.

(d) Control of sugar

Under the influence of insulin, the liver converts excess glucose to glycogen for storage when blood sugar levels are above normal. Under the influence of glucagon, it converts the stored glycogen to glucose when blood sugar levels are below normal.

(e) Production of bile

The liver produces bile. Bile is passed to the duodenum through the bile duct. Bile is a greenish liquid. It contains bile salts like sodium bicarbonate and bile pigments. The role of the bile salts is to split up fat in the digestive system into tiny droplets in a process called **emulsification.**

(f) Storage

The liver acts as a storage organ. It stores fat soluble vitamins like vitamins A, D, E and K. It also stores some water soluble vitamins like vitamins B and C. The liver stores minerals like iron and potassium as a result of breakdown of old blood cells. The liver also stores blood. There is a large number of blood vessels found in the liver.

Problems associated with the digestive system

Can you identify various problems involving the digestive system that students in your school face? What happens when one eats the following:

(a) Very cold food.

(b) Dirty food.

(c) Food that has been kept for long in an open space.

From your discussion, you may have realised that, human beings are faced with problems in their digestive system due to various reasons. Such problems involves:

(a) Vomiting.

(b) Stomachaches.

(c) Diarrhoea.

(d) Heart burns among others.

In this section, we will examine some of these problems.

1. Ulcers

This is a problem whereby the alimentary canal develops some small wounds or broken parts of its walls. These small wounds are found on the inner lining of the walls of the alimentary canal called the epithelial walls.

Ulcers can also be found in the gullet, the stomach and the small intestines.

Ulcers can be caused by:

- Infections by a certain bacteria that attacks the walls of the intestines.
- Over production of acids in the stomach. The stomach corrodes the stomach walls.
- Use of some drugs such as strong painkillers.
- Eating spicy foods that increase acidity in the stomach.
- Stress that result to overproduction of stomach acids.

Ulcers causes pains in the abdomen especially after eating meals.

They also produce a burning effect in the stomach due to contact of stomach acids with the open tissues.

Ulcers can also cause bloating, nausea and loss of appetite. Ulcers can be controlled by:

(i) Eating diets with less acids and spices

(ii) Using anti-acid drugs to neutralise the acidity.

(iii) Treatment with antibiotics to eliminate the bacteria.

(iv) Controlling emotional stress.

(v) Avoiding excessive use of strong painkillers.

2. Constipation

This is a disorder where an individual takes too long before emptying the bowels. In some cases, one can take up to a week be before defecating. In this case, faeces stay longer in the alimentary canal making it to harden. This is because the alimentary canal absorbs most of the water from the faeces. Constipation is as a result of reduced peristaltic movements in the alimentary canal.

Causes of constipation

- Eating food with less fiber. For instance eating processed food for a long time without eating vegetables and fruits.
- Lack of water in the diet.
- Eating too much dairy products.

Symptoms

- Taking too long before defecating defecating only once or twice a week.
- Difficulties when passing out faeces
- Pain during defecation.
- Swollen abdomen

Control of constipation

- Eat food rich in fibres such as vegetables, fruits and whole grains.
- Increase water intake.
- Do exercise to induce movement of bowels.

3. Diarrhoea

This is a disorder where an individual passes loose or watery stool.
It is caused by:

- Food poisoning
- Allergy to certain food substances
- Drug abuse such as the use of alcohol
- Some diseases such as diabetes, cholera and typhoid can cause diarrhoea.

Control

Diarrhoea can be controlled by:

- Treatment of disease infections using appropriate antibiotics. You must visit a doctor for the correct antibiotics
- Oral rehydration where an individual is given rehydration solution orally and frequently so as to replace lost fluids.

4. Heart burn

This is a burning feeling on the lower part of the chest followed by a sour or bitter taste on the throat. It is as a result of passage of acidic materials from the stomach to the gullet when the sphincter muscle at the entrance of stomach opens.

Heartburns are caused by the following:

- Overeating.
- Eating too fast.
- Eating when lying down or when bending
- Pregnancy
- Stress
- Eating spicy food.
- Smoking and use of alcohol.
- Drinking coffee and other carbonated drinks.
- Eating acidic foods such as citrus, tomatoes and onions.

Control

- Avoid taking alcohol and smoking
- Avoid eating too salty or spicy food
- Eat when seated at an upright posture

- Avoid stress
- Avoid carbonated and acidic drinks.

5. Nausea and vomiting

Nausea is an uncomfortable feeling that comes before vomiting.

Vomiting is a reaction whereby the muscles at the joint between gullet and stomach opens resulting to food in the stomach being forced violently back to the mouth.

Nausea and vomiting can be caused by:

- Some diseases such as typhoid and cholera.
- Reaction to bad smells such as the smell of human waste.
- Motion sickness when travelling in fast moving cars.
- Stress
- Food poisoning
- Allergy to some food products.
- Early stages of pregnancy
- Coughing and cold.

Control

- Avoid heavy meals
- Take drinks between the meals not after the meals.
- Take a sweet, non-acidic drink when having a feeling of nausea.

6. Indigestion

This is a disorder where the food eaten takes long to be digested thereby making the abdomen to be overly full.

Symptoms

- Abdomen often over full.
- Accumulation of gases in the abdomen hence causing bloating.
- Discomfort or pain in the abdomen.

Control

- Use food with low fat content
- Doing exercise

- Use of antacids.

Revision Exercise 5

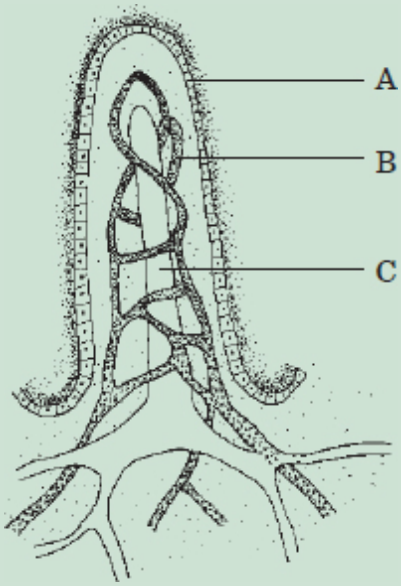
1. (a) Define the term digestion.

(b) What is the role of hydrochloric acid in the stomach?

(c) What prevents this acid from corroding the stomach walls?

(d) Name the enzymes produced in the stomach and give their functions.

2. Study the diagram below and answer the questions that follow.



(a) Name the structure above.

(b) Where is it found?

(c) Name the parts labelled A, B and C.

(d) How is part A structurally suited to its function?

3. (a) Which three elements do carbohydrates and proteins have in common?

(b) Which element is always found in protein but is not found in carbohydrates?

(c) Name the building units of proteins.

4. Name the functions of carbohydrates.

5. Name the deficiency diseases caused by the absence of the following vitamins in the diet.

(a) Vitamin A

(b) Vitamin B

(c) Vitamin C

(d) Vitamin D

6. (a) Human salivary glands produce salivary amylase. Name one other organ in the human body that produces amylase.

(b) What is the role of amylase in humans?

7. Name five roles of the liver

8. Name three substances stored in the liver.

9. State four problems associated with the digestive system.

10. What is the function of the large intestines?

Unit
6

Human circulatory system

Specific objectives

By the end of this unit, you should be able to:

(a) State the functions of the circulatory system.
(b) State the types of blood cells.
(c) Describe the structure of blood vessels.
(d) Relate structure of blood cells to their function.
(e) Explain the role of haemoglobin in oxygen transport.
(f) Compare the structure of arteries, veins and capillaries.
(g) State the relationship between structure and function of each type of blood vessel.
(h) Describe the blood clotting process.
(i) Describe the structure of the heart.
(j) Explain how the heart works.
(k) Explain the effects of physical activity on the pulse rate.
(l) Describe the lymphatic system.
(m) Explain the importance of the lymphatic system.
(n) State problems associated with the circulatory system.
(o) Explain ways of preventing problems associated with the circulatory system.

Introduction

In unit 2, we looked at the various ways in which substances are transported in plants. In this unit, we will learn about transport of substances in a human body.

We will study about the importance of the circulatory system, the structure and function of the heart and blood vessels.

We will also learn about blood clotting, problems associated with the circulatory systems and the functions of the lymphatic system.

Functions of the circulatory system

Activity 6.1

1. In your groups, identify and list down various substances that are transported in the body of an animal.
2. Discuss reasons why each of those substances is important and the reason why each should be transported.
3. From your discussion, state the importance of the circulatory system.

From your discussion, you may have realised that the circulatory system in humans plays a very important role. The functions of the human circulatory system include:

1. **Transport of oxygen**

   Oxygen is breathed in from air and absorbed in the lungs. All cells in our bodies require oxygen for respiration. Oxygen therefore must be transported continuously from the lungs to all the body cells.

2. **Transport of carbon dioxide**

   During respiration, carbon dioxide is produced. Carbon dioxide cannot be stored in the cells because it can poison or cause damage to the cells. Therefore, it must be transported from all the cells of the body and be eliminated through the lungs in exhaled air.

3. **Transport of soluble food substances**

   All body cells require soluble food substances such as glucose, amino acids, vitamins and mineral salts for carrying out body processes and for growth. These substances as we saw in the previous topic are absorbed in the small intestines after digestion. The substances therefore must be transported from the intestines to all cells of the body where they are used.

4. **Transport of hormones**

Hormones are chemical substances that regulate body processes. Some hormones are produced in one part of the body and regulate a process taking place in another part of the body. The hormones therefore must be transported from the glands where they are produced to the parts of the body where they work.

5. **Distribution of body heat**

   The circulatory system transports heat from organs such as the liver (which produces most heat) to all other parts of the body.

6. **Defence against infections**

   The blood transports white blood cells around the the body to sites of infection to help fight against infections.

Types of blood cells

There are two types of blood cells.

(a) Red blood cells

(b) White blood cells

There are two types of white blood cells. These are **phagocytes** and **lymphocytes.**

Structure and function of blood cells

Let us carry out the following activity to examine the structure and function of blood cells.

Activity 6.2: To observe blood cells through a microscope.

Materials

- Light microscope
- Permanent slides of blood cells

Procedure

1. Set the microscope into focus
2. Place the permanent slide on the stage and clip it.

3. Examine the slide through low power objective lens and then medium power objective lens.
4. Identify the blood cells in the slides.

Questions

1. Describe the shape of the red blood cells under the low power lens and under the high power lens.
2. What is the colour of the red blood cells?
3. Is the nucleus visible in the red blood cells.
4. Examine the white blood cells and note their shape.
5. Note that the white blood cells appear to have a nucleus. Is the shape of the nucleus in all the white blood cells the same?
6. Draw a sketch of the red blood cells and white blood cells.

Discussion

From the activity, you may have noticed that the red blood cells have a round shape. They do not have a nucleus and they are red in colour.

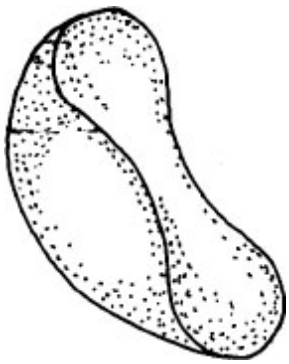
White blood cells have an irregular shape. They have a nucleus and the shape of the nuclei in all white blood cells is not the same.

Structure and function of red blood cells

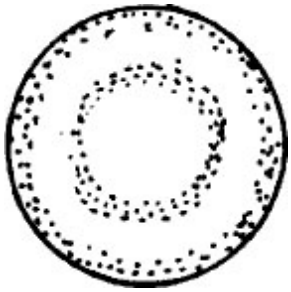
Structure

Red blood cells are very tiny cells. They are **disc shaped** and **biconcave** and appear as discs which are thinner in the centre than around the edges.

The small size of red blood cells increases their surface area to volume ratio for the diffusion of oxygen. Their cytoplasm contains a red iron-containing pigment called **haemoglobin.** Red blood cells have no nucleus. This creates space for more cytoplasm and therefore more haemoglobin to be packed in them. Red blood cells are also very many in number.



(i) Red blood cell cut in half to expose its biconcave shape



(ii) Disc shape of a red blood cell observed from the top.

Fig. 6.1: Structure of the red blood cell

There are about five million red blood cells in every cubic millimetre (mm^3) of human blood. However the number of red blood cells varies depending on any of the following factors:

- Altitude; the higher the altitude the more they will be.
- The state of health of a person; people with severe anaemia or malaria have much fewer red blood cells in their blood.

Red blood cells are made in the bone marrow of the bones of the sternum and ribs. They stay alive for four months and are destroyed in the liver and spleen. Iron from destroyed cells is reused in the body to make haemoglobin in new red blood cells.

Functions of the red blood cells

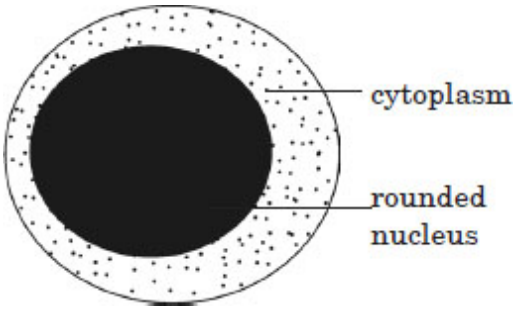
The main function of the red blood cells is to transport oxygen from the lungs to the body tissues.

The red blood cells also play an important role in the transport of carbon dioxide. Most of the carbon dioxide from the tissues enters the red blood cells where an enzyme called **carbonic anhydrase** speeds up the dissolving of carbon dioxide to form carbonic acid. This acid dissociates to form

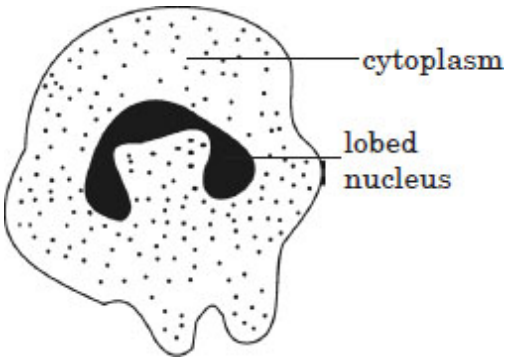
hydrogen ions and hydrogen carbonate ions. The hydrogen carbonate ions leave the red blood cell and enter the plasma where they are eventually transported to the lungs. In the lungs, the reverse reaction takes place and the hydrogen carbonate ions are converted back to carbon dioxide. This is released to the air when breathing out.

White blood cells

The white blood cells are larger than red blood cells, they are colourless and are fewer in number. There are about 6000 per cm^3 of blood. This number increases during infections but reduces in the case of HIV infections. White blood cells have a nucleus. There are two main types of white blood cells namely **lymphocytes** and **phagocytes.** The figures below shows the two types of white blood cells. White blood cells fight disease germs in the body.



(i) A lymphocyte



(ii) A phagocyte

Fig. 6.2: Types of white blood cells

Phagocytes

Phagocytes have a large lobed nucleus and a cytoplasm containing granules. They can change their shape as they actively **seek, engulf** and **digest** disease causing germs therefore protecting the body from infection.

They can squeeze through capillary walls in order to reach infected tissue. They are made in the bone marrow of long bones.

Lymphocytes

Lymphocytes have large rounded nuclei. Their cytoplasm is non-granular.

They protect the body from disease by recognising foreign proteins (antigens) in disease causing germs that invade cells.

They are also able to recognise any chemicals that these germs produce. Lymphocytes respond by producing chemical substances called **antibodies** to destroy the antigen or germs.

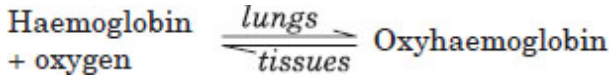
The following table shows the differences between red and white blood cells.

Red blood cells	White blood cells
Bi-concave in shape	Irregular in shape
Have no nucleus	Have a nucleus
Have haemoglobin	Do not have haemoglobin
Very many in number	Fewer than red blood cells.
Smaller in size	Larger in size
Made in bone marrow of short bones.	Made in the bone marrow of long bones and in lymph nodes.
Transports oxygen as	Defend the body against infections.

Table 6.1: Differences between red and white blood cells.

Role of haemoglobin in oxygen transport

Haemoglobin found in these cells readily combines with oxygen when the blood passes through the lungs to form **oxyhaemoglobin.** When the blood reaches a region with low oxygen levels like in the tissues, the oxyhaemoglobin readily gives up the oxygen it was carrying. It then reverts back to haemoglobin. The cells take up the oxygen and haemoglobin is free to be used again to carry more oxygen.



Haemoglobin can combine even more readily with carbon monoxide gas than with oxygen to form carboxyhaemoglobin. However, carboxyhaemoglobin does not split readily to release haemoglobin. This prevents adequate oxygen from being supplied to the tissues. This makes carbon monoxide a dangerous gas because a person who has inhaled even small quantities of it especially in a room with poor ventilation can die of suffocation.

Structure and function of arteries, veins and capillaries

Let us carry out an activity to compare structures of arteries, veins and capillaries.

Activity 6.3: To compare the structure of arteries, veins and capillaries

Apparatus and materials

Charts, Photographs, Textbooks

Procedure

1. You are provided with charts or photographs of arteries, veins and capillaries
2. Examine the thickness of the three vessels
3. Examine the size of the lumen of each.

Questions

1. Which vessel has the;
   (a) thickest walls
   (b) thinnest walls
2. Compare the thickness of the wall of the artery and that of the vein.
3. Compare the lumen of the artery to that of the vein.
4. Note the size of the capillary in comparison to the other two.

Discussion

From the activity, you may have noticed that arteries have thicker walls than the veins. The capillaries have walls that are very thin. The vein has a larger lumen than the artery.

Arteries

The heart pumps blood into vessels called **arteries.** Arteries carry blood to various parts of the body. Due to the pumping action of the heart, blood from the heart enters the arteries at high pressure. Therefore, the structure of the arteries enables them to withstand the high pressure of blood flowing in them. Arteries have the following properties.

- Thick muscular walls to withstand and maintain higher pressure of blood.
- An outer fibrous coat for strength and protection.
- A thick layer of muscle and elastic fibres which contract and relax to adjust their diameter as the blood flows through them. Arteries have an inner lining of cells known as an **endothelium.**
- A narrow lumen to maintain the pressure of blood inside them.

Most arteries are located deep within our bodies.

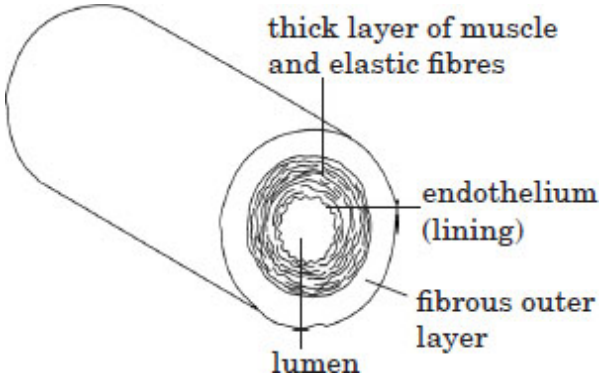


Fig. 6.3: Structure of an artery

The size of the lumen in arteries can be adjusted by nerve control of the muscles in their walls. For example, the amount of blood passing through arteries can be adjusted during exercise, so that more blood flows to the legs and less blood to the small intestines. This is very important because it ensures that blood is properly utilised by parts of the body that need it most. Pumping of the blood can be felt on an artery if pressure is put on it with a finger. This is known as the **pulse.**

It is this pressure which makes blood in arteries to flow in only one direction. All arteries carry **oxygenated blood** except the pulmonary artery which carries deoxygenated blood.

Arteries branch out to form narrower vessels called **arterioles.** The arterioles branch further within the tissues into finer vessels called **capillaries.**

Capillaries

They are numerous in number and form a dense network in all the tissues in the body. They have very thin walls made up of only one cell layer.

These characteristics make the capillary region a suitable point of exchange of substances between the blood and the tissues. Their thin walls allow for rapid exchange of substances.

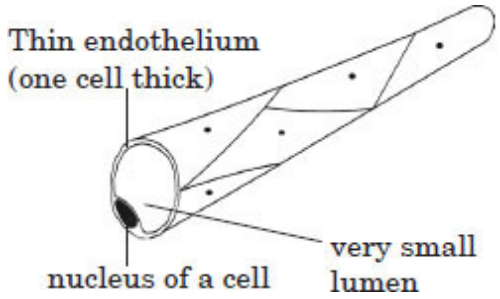


Fig. 6.4: Structure of a capillary

The dense network creates a large surface area over which the exchange takes place and the narrowness of the capillaries allows a high pressure buildup within them.

This ensures faster movement of substances out of them. Capillaries join to form larger vessels known as **venules.** Venules link up to form **veins.**

Veins

Veins carry blood under low pressure from the tissues towards the heart. They have thin walls which are composed of a thin outer fibrous coat, a thin middle layer of muscle elastic fibres and an inner layer of cells called the endothelium. Veins have pocket valves at intervals in their walls which allow blood to flow only in one direction towards the heart. They carry **deoxygenated** blood except the pulmonary vein which carries oxygenated blood.

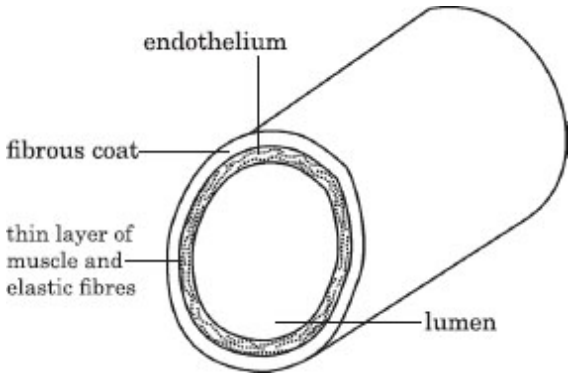


Fig. 6.5: Structure of a vein.

Portal veins have capillaries at both ends. They are unique veins that carry blood from one organ to another for example the **hepatic portal vein** which carries blood from the small intestine to the liver.

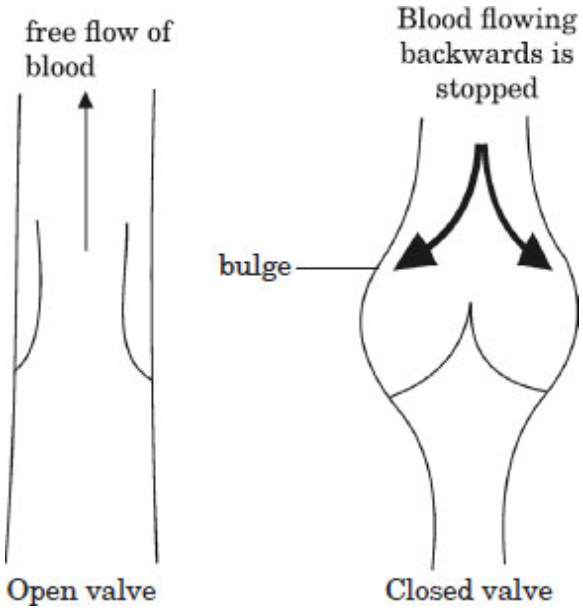


Fig. 6.6: How the valves work

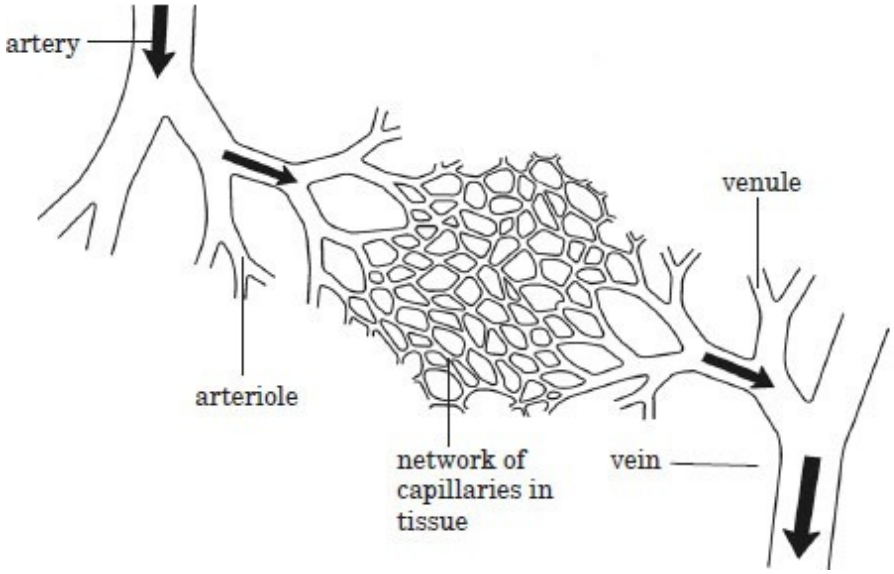


Fig. 6.7: Relationship between arteries, capillaries and veins.

Arteries	Veins	Capillaries
Carry blood away from the heart.	Carry blood towards the heart.	Carry blood from arteries to veins.
Carry blood rich in oxygen except the pulmonary artery.	Carry blood low in oxygen concentration except the pulmonary vein.	Oxygen and food substances diffuses into the tissue fluid from them.
Blood is under very high pressure.	Blood is under low pressure.	High pressure of blood for filtration of substances.
Have a pulse.	Have no pulse.	Have no pulse.
No valves except at the points where arteries leave the heart.	Have valves.	No valves.
Have thick muscular elastic walls.	Walls are thin, less muscular and inelastic.	Are one cell thick.
Have a narrow lumen.	Have a larger lumen.	Have very narrow lumen (microscopic).
Are located deep in the body.	Are located nearer the skin in the body.	Are located in all tissues.

Table 6.2: Relationship between arteries, veins and capillaries

Blood clotting process

The process of blood clotting

Figure 6.8 below summarises the process of blood clotting. When blood vessels are damaged, for example a cut on the skin, the damaged tissue and platelets release a chemical called **thromboplastin** (thrombokinase). This substance converts a blood protein called prothrombin to enzyme thrombin. Thrombin in turn changes soluble blood protein fibrinogen into insoluble fibrin, a mesh of **fibres** which traps red blood cells. This generates a clot which shrinks as it forms hence pulling the edges of the wound together and assists in its sealing. It dries up to form a scab which protects the wound, giving the tissue beneath time to heal. Vitamin K is needed for prothrombin to be formed in the liver.

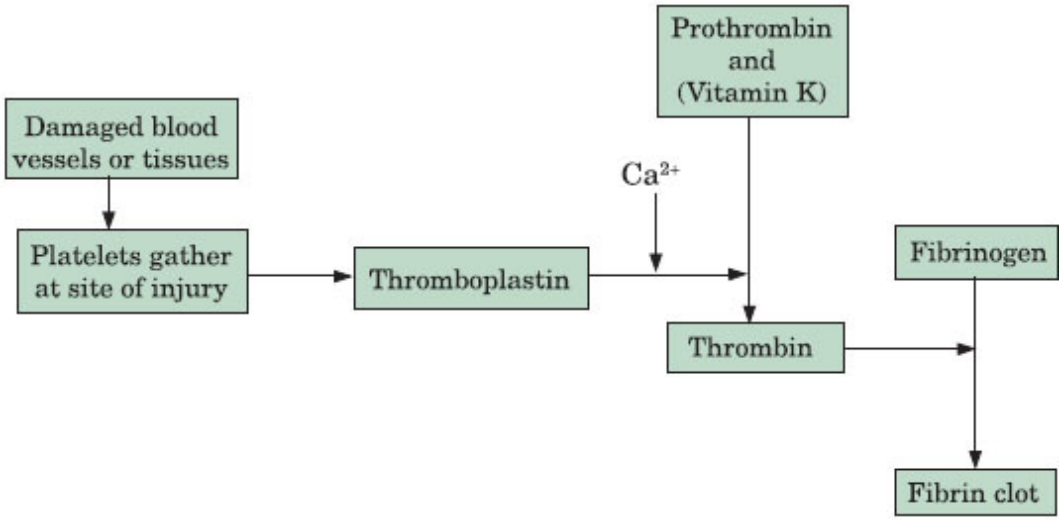


Fig. 6.8: The process of blood clotting

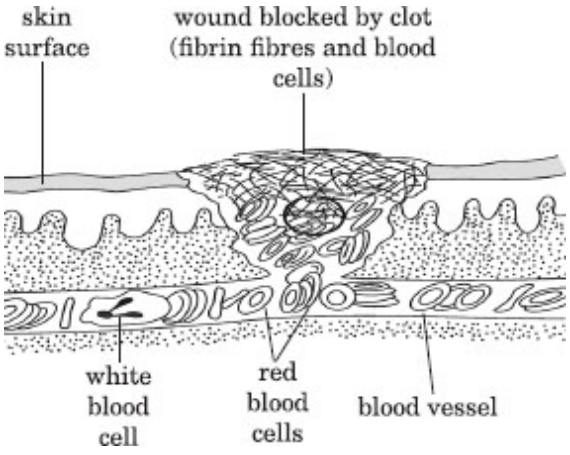


Fig. 6.9: A blood clot

If a clot forms internally, a condition known as *thrombosis* occurs. We have seen that thrombosis can be fatal if the clot formed enters and blocks

fine capillaries that provide oxygen and nutrients to vital organs like the brain or heart.

Structure of the heart

Let us carry out the following activity to determine the structure of the heart.

Activity 6.4: To examine the structure of a sheep/goat's heart

Apparatus and materials

Sheep's heart with all parts and vessels intact, hollow tubing, flat wooden board, forceps.

Procedure

1. Place the heart on the dissection board and examine it closely.
   (a) Identify the following parts. (Use Figs. 6.3 and 6.4 to guide you).
      - Various blood vessels
      - Pericardium (membrane covering the heart).
      - The heart chambers
      - Any fat.
   (b) Suggest the names of the vessels and chambers.
      - What is the purpose of pericardium and the fat?
2. Using the scalpel, scissors and the forceps, carefully remove the pericardium and the fat.
3. Cut and expose the internal structure of the heart as shown along the doted lines.

Questions

1. Identify the atrioventricular valves that is bicuspid and tricuspid. Note the:
   - Tendons
   - The muscle thickness of both the left and right lower chambers and compare their size.
2. Explain the function of the valve tendons.

3. Account for the differences in muscle thickness of the left and right lower chambers.
4. Name the wall between the right and left chambers. Suggest its importance.

Discussion

The main observable features of the heart are:

- The thick muscular walls of the ventricles, the left ventricle walls are thicker than the right ventricle walls.

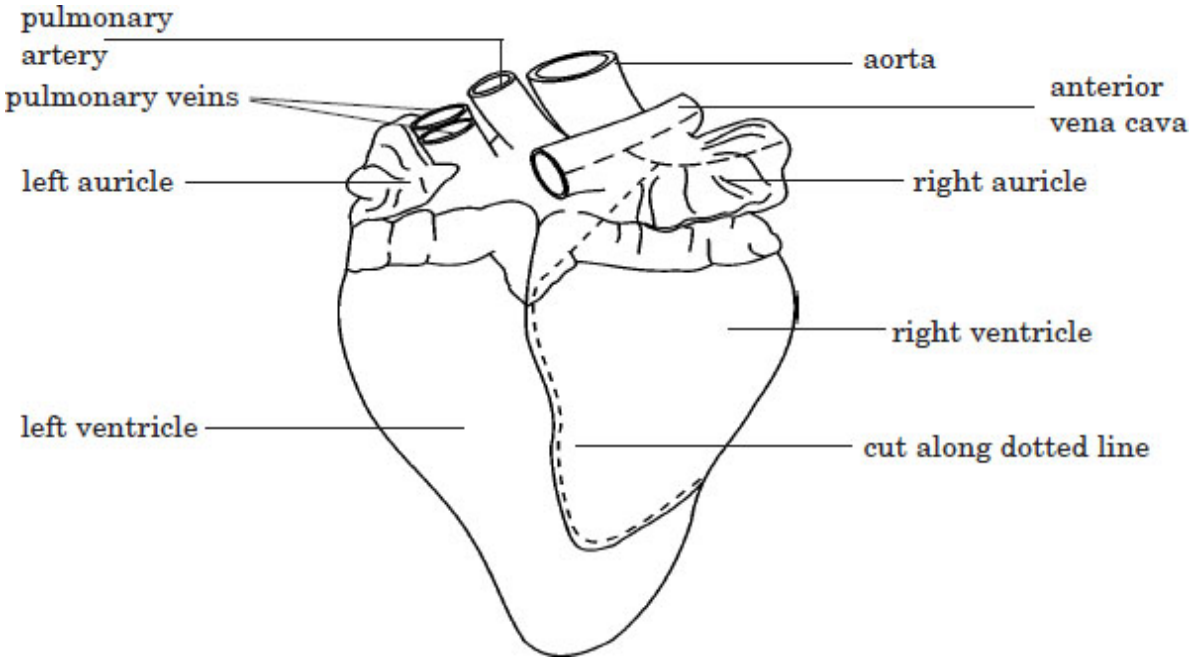


Fig. 6.10: To expose the sheep's heart from the right side

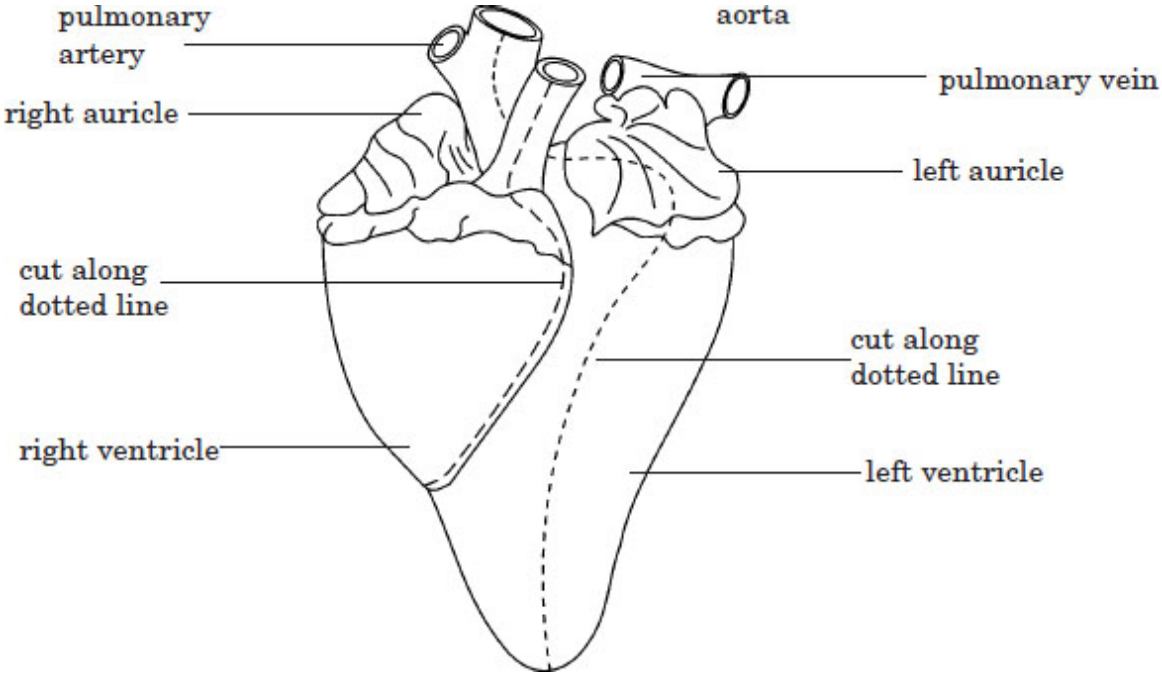


Fig. 6.11: To expose the sheep's heart from the left side

- The thin walls of the auricles as compared with the ventricles.
- The tricuspid valve between the right ventricle and the right auricle.
- The bicuspid valve between the left ventricle and the left auricle.
- The "heart-strings" attached to the valves and the walls of the ventricles.
- Coronary artery on the surface of the heart.

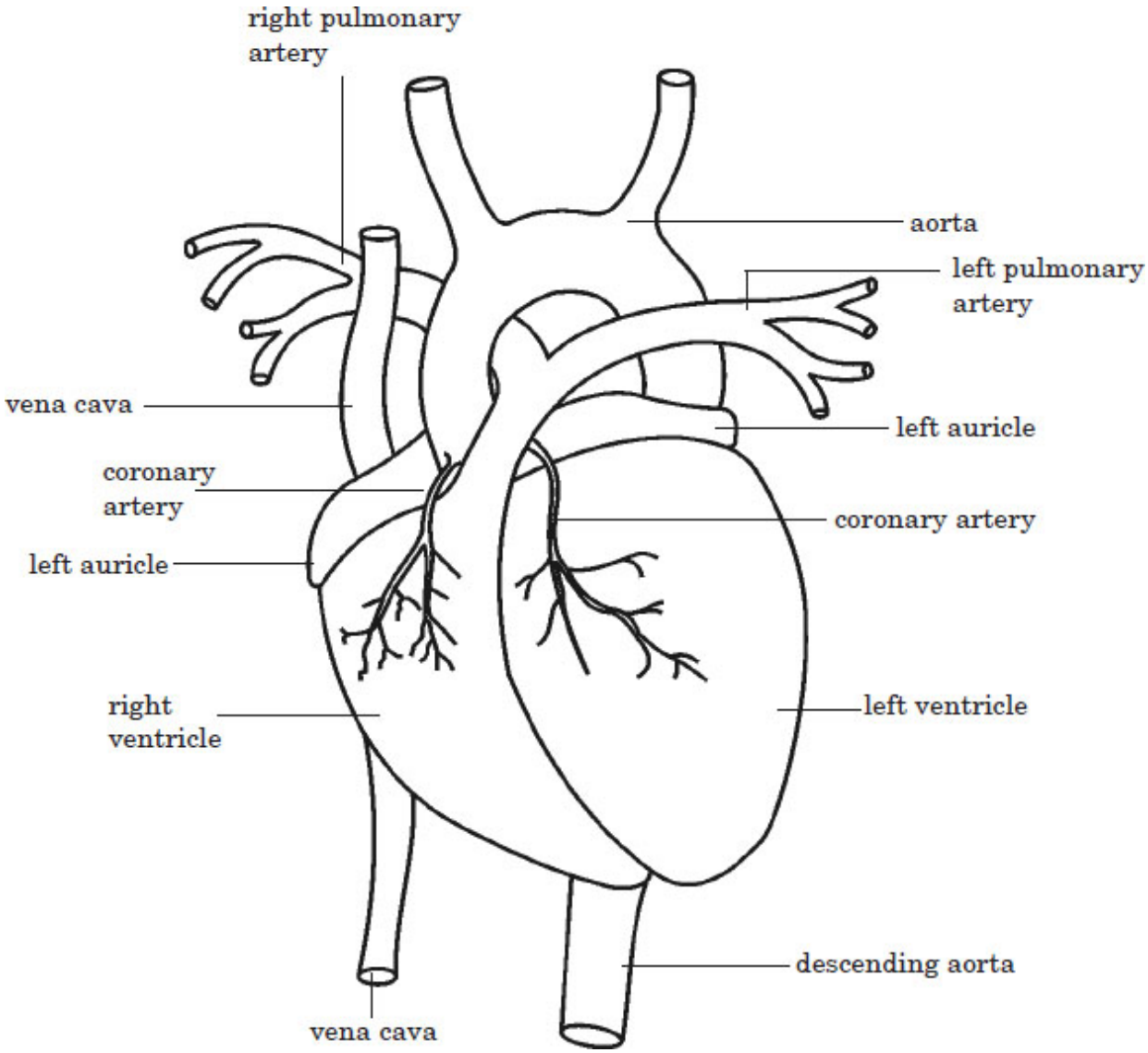


Fig. 6.12: External structure of the mammalian heart

The heart is a muscular organ about the size of the fist. It lies inside the chest cavity between the two lungs. Internally, the heart is surrounded by a tough membrane called the **pericardium** which covers and protects it. It is divided into two sides, the left and the right side which are completely separated by a wall called the **septum.** The septum prevents blood on the right side from mixing with blood that is on the left side. Each side consists of a small upper chamber called the **atrium** (plural atria) and a larger lower chamber called the **ventricle.** This makes the mammalian heart a four-chambered organ.

The atria (also called *auricles*) are thin walled and receive blood into the heart which they pump to the ventricles.

Identify the two blood vessels that bring blood into the atria.

The ventricles are thick walled and pump blood out of the heart.

Identify the two blood vessels that take blood away from the two ventricles.

The heart is made of special muscle called **cardiac** muscle. This muscle is special in two ways: It can contract continuously without fatigue. The heart can beat for a lifetime without taking a rest. Cardiac muscle is also **myogenic,** which means that its contractions are started by the muscle itself and not by nerves as is the case with other muscle tissue in the body.

Four flap like valves control the direction of blood flow inside the heart.

Two of these valves are called the **atrio-ventricular** valves. They allow the blood to flow only from the atria to the ventricles. The one found in the right side of the heart is called the **tricuspid valve** because it has three flaps. In the left side of the heart is the **bicuspid valve.** It is also known as the mitral valve.

The other two valves found in the heart are the **semilunar valves.** When open, they allow blood to move from the ventricles into the arteries and away from the heart.

How the heart works

Circulation of blood in the heart

The right atrium receives blood coming from the body tissues through the **vena cava.** This blood has very little oxygen dissolved in it because most of the oxygen has been taken up for respiration by the tissues. This blood is described as **de-oxygenated** blood. It is however rich in carbon dioxide and appears **dull red** in colour.

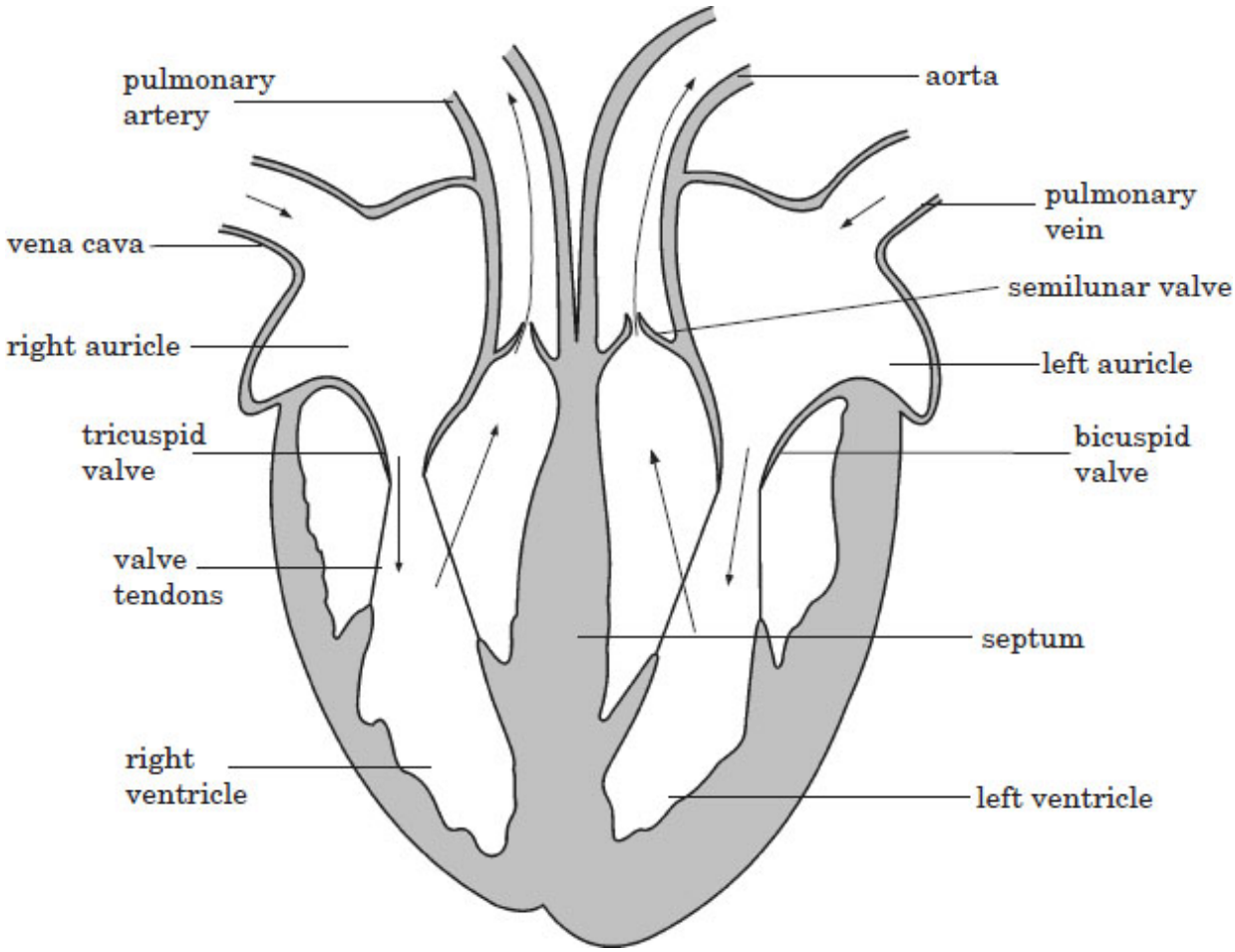


Fig. 6.13: Internal structure of the mammalian heart showing blood circulation

The right atrium then pumps the blood into the right ventricle via the tricuspid valve. When full, the right ventricle pumps blood into the **pulmonary artery.** Semi-lunar valves at the opening of this artery prevents back flow of blood into the right ventricle. At the same time the triscuspid valve prevents any back flow of blood into the right atrium. Tendons (heart strings) hold the valves in a closed position preventing them from turning into the atrium. The pulmonary artery carries blood to the lungs.

In the lungs, the blood picks up oxygen and gives up carbon dioxide. It is now said to be **oxygenated** and is **bright red** in colour. It goes to the left atrium of the heart via the **pulmonary vein.** This portion of the circulatory system where blood flow to the lungs from the heart and back is called the pulmonary circulation.

The left atrium pumps blood into the left ventricle via the bicuspid valve. The left ventricle pumps blood to all parts of the body except the lungs. This blood leaves the left ventricle through the aorta. Semi-lunar valves that open into the aorta prevent back flow of blood.

The left ventricle walls are much thicker than the right ventricle walls in order to develop a high enough pressure to pump blood to all parts of the body. The circulation of the blood from the heart to the tissues and back is called **systemic circulation.**

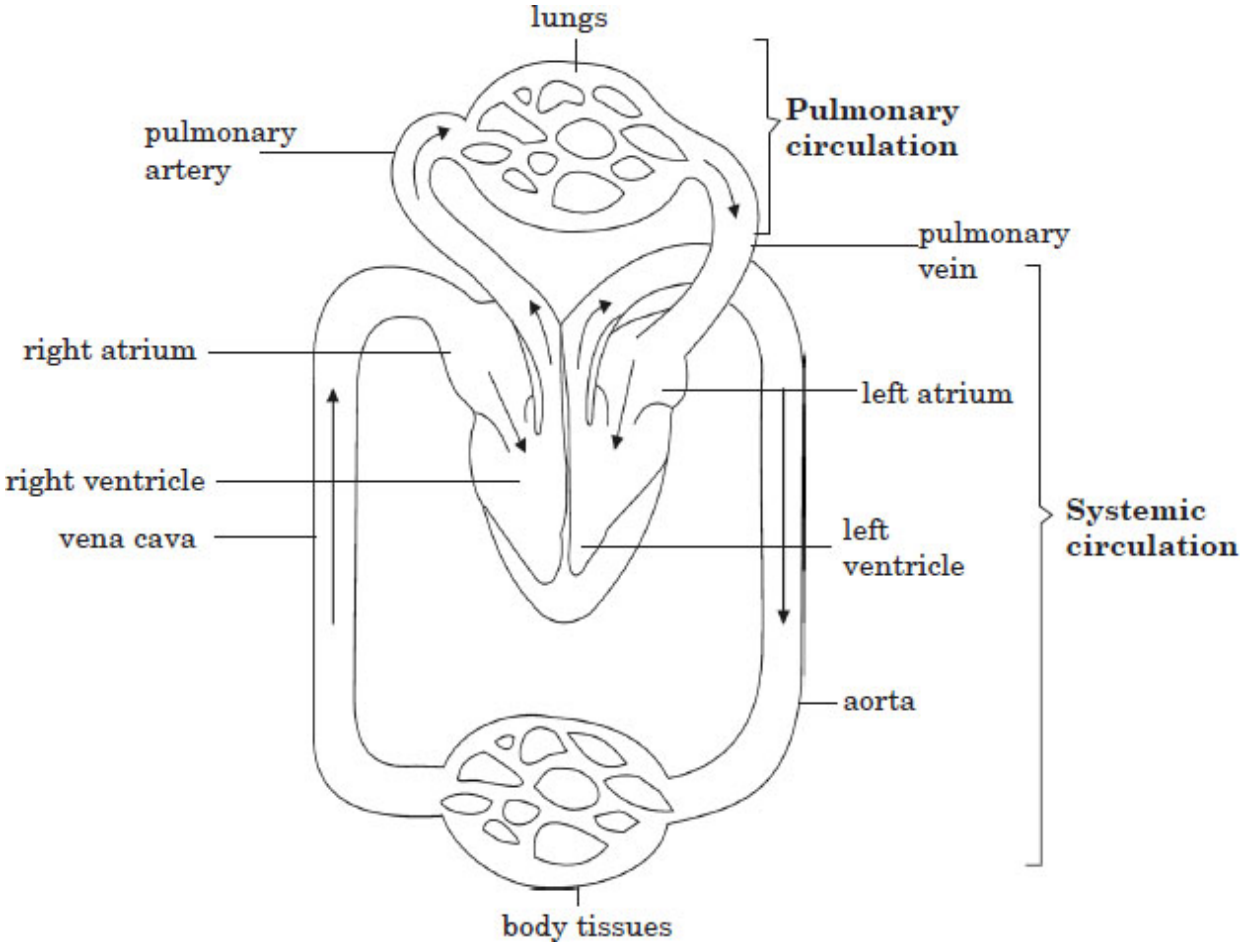


Fig. 6.14: Double circulation in a mammal

Table 6.3: Summary of the structure and function of the heart and associated blood vessels

Part	Adaptation	Functions
Cardiac muscle	Is myogenic	Contracts and relaxes on its own without fatigue.
	Has numerous mitochondria	Generates energy for muscle contraction
	Has interconnected muscle fibres	Spreads wave of excitation throughout the heart muscles.
	Has a pace maker (sinoatrial node (SAN)	Initiates contractions of the heart muscle.
Valves • Biscuspid • Tricuspid • Semilunar	Flaps of tissue Pocket like	Prevent flow of blood into the auricles when ventricles contract. Prevent the blood in the arteries from flowing back into the heart.
Chambers Atria (auricles)	Right; cavity surrounded by thin cardiac muscle.	Receive blood from the vena cava and pumps it into right ventricle.
	Left; cavity surrounded by thin cardiac muscle.	Receive blood from the pulmonary vein and pushes it to the left ventricle.
	Chambers surrounded with thick cardiac muscles.	Right ventricle pumps blood through the pulmonary artery to the lungs while the left ventricle pumps blood through the aorta to the rest of the body. The left ventricle is thicker than the right because of this.
Vessels *Arteries,* Aorta, Pulmonary artery, *Veins:* Vena cava, Pulmonary vein	Thick muscular and elastic walls, narrow lumen.	Lead the blood away from the heart.
	Wider lumen, have valves, thin muscular wall.	Lead the blood back to the heart.
Coronary artery.	As for arteries	Supplies the cardiac muscle with oxygenated blood.
Coronary *vein.*	As for veins	Returns blood to the heart from the cardiac muscle.
Pericardium	Tough and secretory	Prevents the heart from overstretching and secretes pericardial fluid to lubricate the heart against the membrane.
Fat layer	Spongy	Protects and cushions the heart.
Valve tendons	Inelastic	Prevent the atrioventricular valves from turning inside out into the auricles

The mammalian heart therefore acts as a **double pump.** The left side sends blood rich in oxygen to the rest of the body and the right side sends blood poor in oxygen to the lungs.

The heart tissue itself receives food nutrients and oxygen via a vessel known as the **coronary artery** which branches from the aorta and spreads through the heart muscle.

The function of the heart is to receive and pump blood. The heart receives blood when its muscles relax. It pumps blood when its muscles contract. These two processes take place in repeated sequence or cycle known as the **heart** or **cardiac cycle.**

The cardiac cycle has two alternating phases known as **systole** and **diastole.** During systole, the muscles of the heart chambers contract to pump out blood. During diastole, muscles of the heart chamber relaxes for them to receive blood. Table 6.3 gives a summary of the structure and functions of the heart and associated blood vessels.

Effect of physical activity on pulse rate

Have you ever noticed what happens to your heartbeat when you run very fast? Carry out the following activity to find out.

Activity 6.5: To record the pulse rate at the wrist before and after vigorous activities.

Apparatus and materials

- Wrist watch showing minutes.

Procedure

1. Working in pairs, take the pulse by placing three fingers firmly on your partner's wrist. Do not press too hard.
2. Shift the position of these fingers until you feel some movement against your fingers. This is the pulse.

Fig. 6.15: Taking the pulse

3. Count the number of times you feel these beats in a minute and record them in a table like the one shown below.

Table 6.4: Recording the pulse

Activity	**Pulse rate (beats per minute)**		
	1	2	Average
Standing			
Walking			
Running			

Repeat this procedure.

4. Ask your partner to walk round the classroom block. Take the pulse again and record. Repeat and record.

Questions

1. From the results shown in the table, in which activity was:
   (a) the pulse rate lowest?
   (b) the pulse rate highest?
2. What is the normal heart beat/pulse of a person at rest?
3. What is the advantage of an increased heart beat when an activity becomes vigorous.
4. What other situations can cause the pulse rate to increase?

Discussion

The normal average heartbeat of an adult at rest is 72 beats per minute. This is also known as the **pulse rate** and it increases during a vigorous activity.

An increased heartbeat helps to circulates blood with oxygen and glucose needed to produce energy for the vigorous activity in the muscle tissue faster and takes away carbon dioxide and other wastes away from the tissue. The pulse rate also increases during situations such as fear or excitement.

The lymphatic system

A lymphatic system is a special system of vessels connected to the tissues to transport excess tissue fluid back to the blood after exchange of substances between cells and tissue fluid.

The lymphatic system is a system of tiny, thin walled vessels called **lymphatic vessels.**

They are numerous and pass between cells in the body tissues. The small lymphatic vessels join up into larger lymphatic vessels. These make up an extensive lymphatic system throughout the body. The lymph vessels have valves which ensure lymph moves in one direction.

Excess water and tissue fluid in the blood circulatory system passes into the lymphatic vessels, where it is called **lymph.** It is carried in the lymphatic vessels to the subclavian veins in the neck where it passes back into the blood.

Many lymph vessels are found in muscle tissue. The contractions of muscle tissue squeeze the lymph vessels and pushes the lymph forward in the lymphatic system.

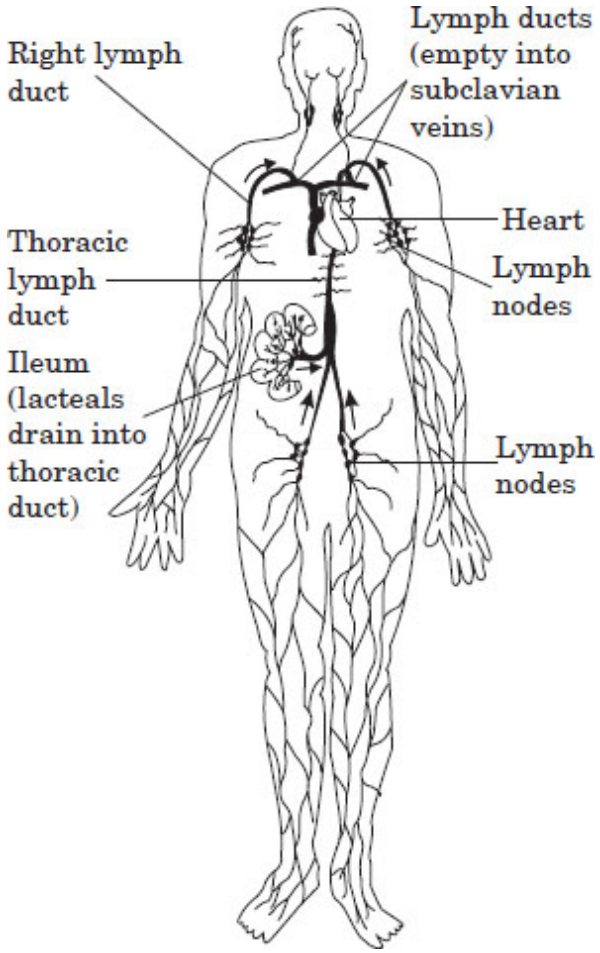


Fig. 6.16: Diagram showing the human lymphatic system

Importance of lymphatic system

- Transports excess tissue fluid back to the blood.
- It contains white blood cells called lymphocytes which protect the body against diseases and infections.

At regular intervals along the lymph vessels are swellings called **lymph nodes.** They contain a special type of white blood cells called **leucocytes** which destroy bacteria in the lymph.

The small intestines has small lacteals which form part of the lymphatic system.

Table 6.5: Differences between lymphatic and blood circulatory system

Lymphatic system	Blood circulatory

	system
1. It involves only one circuit where tissue fluid flows from intracellular spaces into lymphatic vessels. The lymphatic vessels join to form the thoracic duct that drains the fluid back to blood at the subclavian vein at the neck region.	1. It involves complete circulation of blood from heart to all body organs of the body and back to the heart.
2. The tissue fluid flows in one direction only.	2. Blood flows in two directions to the organs through arteries and out of the organs through the veins.
3. System has no pumping mechanism as it is not connected to the heart. It relies on pressure created by connecting muscles surrounding the lymph vessels.	3. Has heart to provide the pumping mechanism.
4. Involves transport of substances in lymph that is slightly yellow in colour.	4. Involves blood that is red in colour.
5. Uses lymphatic vessels.	5. Uses blood vessels.
6. Lymph lacks red blood cells and plasma proteins.	6. Blood has red blood cells and plasma proteins.
7. Mostly involved in defence mechanism against pathogens.	7. Involved in transport of substances in all tissues of the body.

Problems associated with circulatory system

The descriptions we have given so far apply to a normally functioning heart and blood vessels. However, there are certain diseases and conditions which may interfere with the proper functioning of the heart and blood vessels. Name some heart diseases or conditions that you know. We shall discuss some of the diseases of the heart and blood vessels in this section.

(a) Heart attack

This also khown as **coronary heart attack.** It is the condition whereby the heart tissue becomes damaged and stops functioning. This occurs when a blood clot occurs in the coronary artery which supplies the heart with oxygen and nutrients. As arteries age, the body reacts by depositing an insoluble fat called cholesterol and calcium in their walls. This causes the artery walls to thicken and harden. They become less elastic forcing the heart to work harder in order to pump the blood efficiently throughout the body. This causes an increase in blood pressure and subsequently causes a heart attack.

(b) High blood pressure

High blood pressure is a condition whereby the pressure of blood flowing in the blood vessels is higher than normal. This can be caused by a variety of factors such as smoking, overweight, anxiety, stress, alcohol, diabetes and excess salt in food.

(c) Varicose veins

These are enlarged veins and their branches found near the surface of the skin in the lower parts of the leg. When the valves in these veins do not work properly, blood tends to build up inside the veins. The walls of the veins become stretched, lose their elasticity and are unable to regain their normal size.

Ways of preventing problems associated with the circulatory system

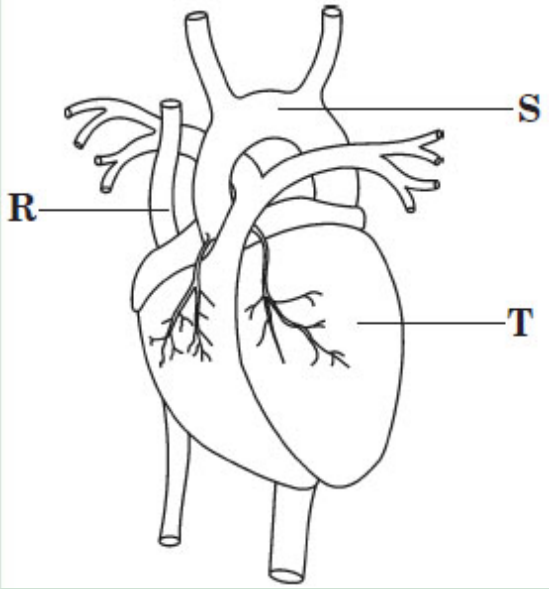
1. No smoking! Cigarettes contain nicotine. Nicotine makes arteries to constrict. Constriction of the arteries raises blood pressure causing the heart to beat faster.

2. Reduce the amount of high cholesterol foods by eating less fatty or red meat, instead one should eat white meat such as fish that has no cholesterol and eat more fresh fruits and vegetables.
3. Reduce salt intake to prevent high blood pressure.
4. Exercise regularly to strengthen the heart and improve the circulation of blood.
5. Avoid obesity because it causes the heart to overwork and causes high blood pressure.
6. Learn to be organised to avoid stress.
7. Avoid alcohol consumption.

Most of the ways above point at our lifestyles. Avoid drugs which have no medicinal value. Eat only a recommended diet. Exercise your body to burn out excess calories. Observing all these will see you living a healthy life.

Revision Exercise 6

1. List the functions of the circulatory system.
2. Name the blood cells.
3. What is the role of haemoglobin?
4. (a) Describe how blood clotting occurs.
(b) What is the importance of blood clotting.
5. List the importance of lymphatic system.
6. The diagram below represents the internal structure the heart.



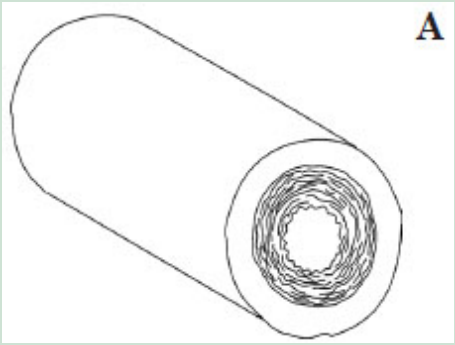
(a) Name the parts labelled S, T and R and state their functions.

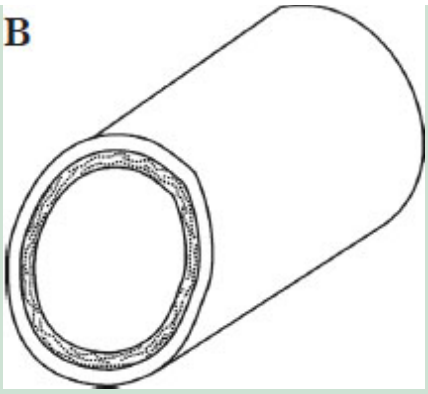
(b) Explain how the following structural concepts of the heart assist in its function.

(i) The left ventricle wall is more muscular than the right ventricle walls.

(ii) The heart has valves.

7. The diagrams below represent a transverse section through blood vessels A and B.





(a) Name vessels A and B.

(b) Describe how blood vessels A and B are adapted to their function.

8. List the problems associated with the circulatory system.

Unit 7

Human respiratory system

Specific objectives

By the end of this unit, you should be able to:

(a) Describe tissue respiration.
(b) Distinguish between aerobic and anaerobic respiration.
(c) Explain the importance of gaseous exchange in organisms.
(d) Explain how gaseous exchange takes place in the lungs and tissues.
(e) Explain how breathing is regulated.
(f) Explain the effects of exercise on breathing.
(g) Explain how carbon monoxide poisoning occurs.
(h) Perform First Aid for carbon monoxide poisoning.
(i) State ways of preventing carbon monoxide poisoning.
(j) Explain the effects of smoking on the lungs.
(k) Draw and label respiratory systems of fish and insects.
(l) Explain how respiration in fish and insects takes place.
(m) Explain how respiratory structures in fish, insects and humans are adapted for their function.

Introduction

In this unit, we will learn about tissue respiration and how the gases involved in respiration move in and out of the cells.

We will also learn about carbon monoxide poisoning and effects of smoking on human health. We will then learn about the adaptations of respiratory structures of different animals.

Tissue respiration

Respiration is the breakdown of organic substances to release energy. There are two types of tissue respiration. These are:

(a) Aerobic respiration

(b) Anaerobic respiration

Respiration takes place in cell organelles known as **mitochondria.** Let us review the structure of the mitochondrion in Fig 7.1 below.

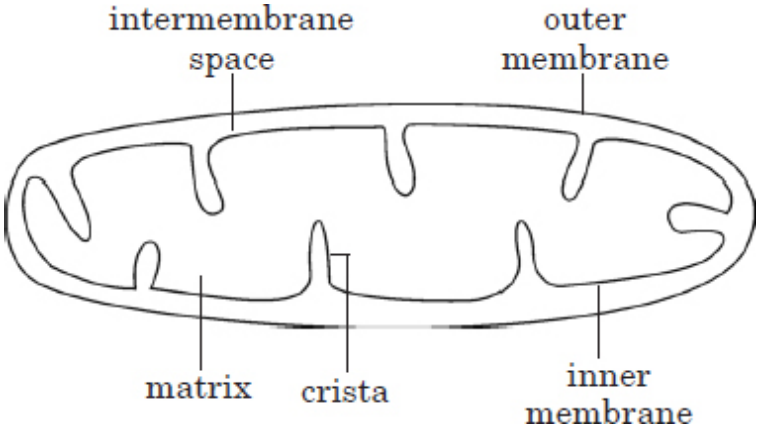


Fig. 7.1: Structure of a mitochondrion

Mitochondria are found in nearly all cells. They are most abundant in cells that require a lot of energy like sperm cells which need energy to swim and muscle cells. Mitochondria contain the enzymes and other special molecules required for respiration. These are located inside or on the surface of the inner membrane which is deeply folded to create a large surface area.

Aerobic and anaerobic respiration

There are two kinds of tissue respiration depending on whether oxygen is required or not. Respiration that requires oxygen in order to take place is known as **aerobic respiration. Anaerobic** respiration takes place in the absence of oxygen.

The first steps of both aerobic and anaerobic respiration are the same. They involve splitting glucose into **pyruvic acid.** This process is known as **glycolysis** which means sugar-splitting (usually one molecule of glucose is split into two molecules of pyruvic acid). It takes place in the cytoplasm and does not require the presence of oxygen. Only little energy is produced during this process.

Aerobic respiration

This type of respiration takes place in the presence of oxygen. Aerobic means with air. The food substrate broken down to produce energy is glucose. This is a complex step by step process which is catalysed by several enzymes. It begins when the pyruvic acid formed during glycolysis enters the mitochondria and undergoes further breakdown to produce more energy. The breakdown process is known as **Krebs cycle.** It eventually produces **carbon dioxide, water** and **energy.**

The following equations summarises the processes of aerobic respiration:

Glucose + oxygen ⟶ carbon dioxide + water + energy

$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$ + energy

Most organisms respire aerobically because it is efficient and produces a large quantity of energy. This is because the glucose is completely broken down to release most of its energy.

Sixty per cent of the energy released in the process of respiration is in form of heat energy which is lost or is used to warm the body. Some energy is used immediately by the cell. The rest is converted into a storable form of energy molecule known as **Adenosine triphosphate** or **ATP.**

ATP is a combination of a complex organic molecule called **adenosine** and **three phosphate groups.** They are joined end to end as shown below.

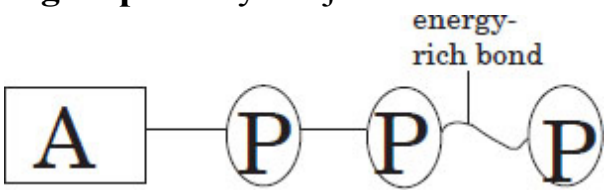


Fig. 7.2: Adenosine triphosphate (ATP)

A stands for **A**denosine and **P** for phosphate. The last link between the two phosphates is shown with a wavy line because it is an **energy-rich bond.** This is where a large amount of the energy is stored. When the third phosphate group is removed, the stored energy is released leaving adenosine with two phosphate groups in a molecule called **Adenosine diphosphate (ADP).**

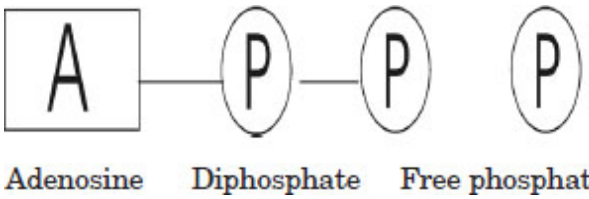


Fig. 7.3: Adenosine diphosphate (ADP) and a free phosphate

Note:

In order to store energy, adenosine diphosphate is converted to adenosine triphosphate by using energy released from respiration to add the third phosphate group. Thus:

$$ADP + P + Energy \longrightarrow ATP$$

In order to release the energy for use, ATP is split to ADP and a free phosphate.

$$ATP \longrightarrow ADP + P + energy$$

This process is summarised in Fig. 7.4.

I. The energy produced by respiration of glucose is used to attach a third phosphate group to ADP to form ATP.
II. When the third phosphate group is detached from ATP, the energy released is used for cell activities.
III. The ADP is returned for reuse. The energy from a single glucose molecule can form 36 molecules of ATP.

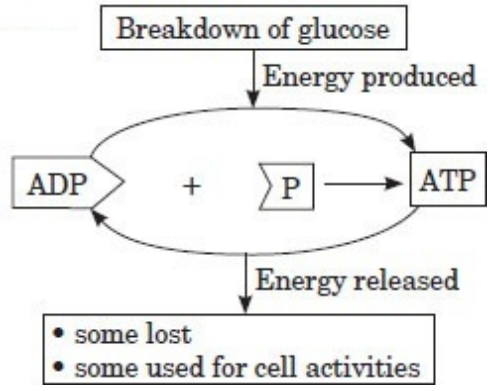


Fig. 7.4: Summary of formation of ATP

The energy produced during respiration can be measured in units called **joules** (J) or **kilojoules** (kJ).

For every molecule of ATP formed, 30.6 kJ of energy is used (stored). This means that for every molecule of ATP broken to ADP and P, 30.6 kJ of energy is released.

Activity 7.1: To show that heat is produced during respiration

Apparatus and materials

Vacuum flasks, thermometers, bean seeds, disinfectant, cotton wool, two clamp stands.

Procedure

1. Soak some bean seeds for a day or two in order to allow them to germinate.
2. Take a second set of the bean seeds and boil or heat to kill them. Wash both sets of beans with the diluted disinfectant.
3. Put each group of beans into sterilised vacuum flasks. (Do not fill the flasks to the brim).

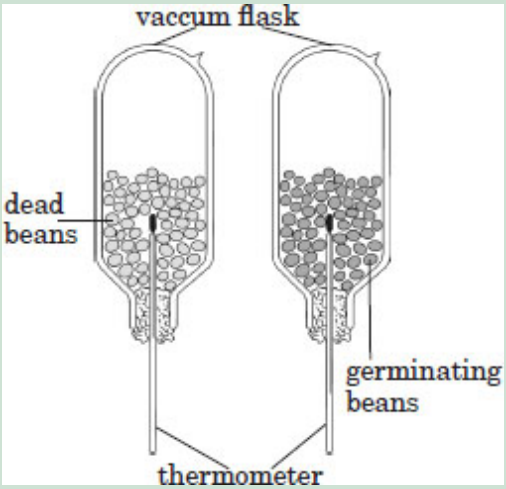


Fig. 7.5: Apparatus to show that heat is produced during respiration

4. Put a thermometer into each flask and hold it in place with cotton wool stuffed at the mouth of the flask.
5. Note the temperature of the flask.
6. Using a clamp stand, support each flask upside down and leave them for five days.

7. After the five days, note the new temperature in each flask.

Questions

1. In which flask was the temperature higher?
2. Why were the bean seeds disinfected before the experiment?
3. Why were the flasks
   - Put upside down?
   - Half filled with beans?
4. Was all the energy released as heat energy?
5. Where did the heat energy come from?

Discussion

Germinating seeds break down stored carbohydrates in the process of respiration in order to get energy that they require for growth. Some of the energy is released as heat. You will have temperature rise in the flask containing germinating seeds. You may have also noticed that the boiled seeds did not produce heat as indicated by the thermometer. Before the experiment, the seeds were disinfected in order to kill bacteria that would cause decay of the beans. The flasks were also inverted in order to prevent loss of heat. Warm air rises up and if the flasks are not in an upside down position, warm air in the flask would rise and lead to heat loss from the germinating seeds. This is to allow carbon dioxide to diffuse out since it is heavier than oxygen and thus allow oxygen to diffuse in.

Anaerobic respiration in plants and animals

Anaerobic respiration takes place in both plants and animals. Organisms that respire anaerobically are called **anaerobes.** In these organisms, food substrates are broken down to release energy without the use of oxygen. Some anaerobes are so sensitive to oxygen that they get poisoned by its presence. They are called **obligate anaerobes** because they can only respire anaerobically. Other anaerobes, however, can respire both aerobically and anaerobicaly. When oxygen is present in their immediate environment, they

use it to respire but when it is absent they can still respire without it. Such anaerobes are called **facultative anaerobes.**

Anaerobic respiration in plants

Activity 7.2: To show the gas produced during fermentation of sugar by yeast

Apparatus and materials

Sugar, yeast, water (boiled then cooled), limewater (calcium hydroxide), some oil for example corn oil, boiling tube, rubber band with hole in it to fit a delivery tube, delivery tube and test tube.

Procedure

1. Take the water and add some sugar to it to make a sugar solution.
2. Add some yeast to it and stir.
3. Set up the apparatus as shown in Fig. 7.6, then leave them aside in a warm place for one hour.

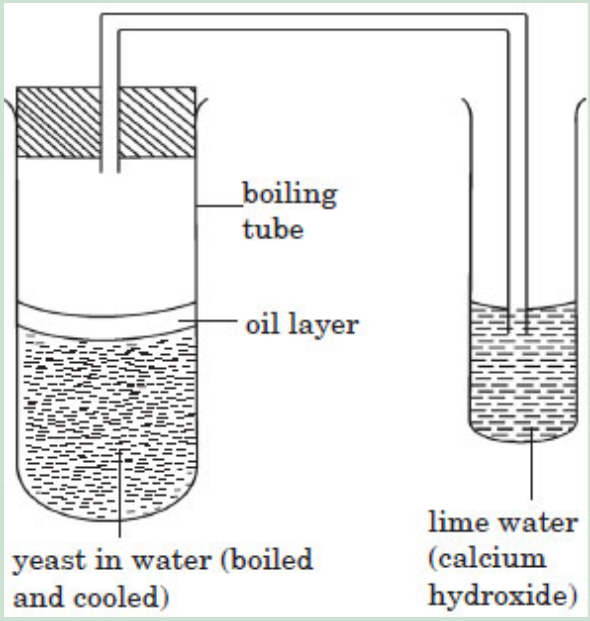


Fig. 7.6: Experimental set up to show the gas produced during fermentation

4. State your observation.

Questions

1. Why is the water first boiled then cooled before the yeast is put in the sugar solution?
2. Why is a thin layer of oil poured over the yeast and sugar solution?
3. What do you observe in the boiling tube after one hour?
4. Explain your observation in (3) above.
5. Describe a control for this experiment.

Note

You can also change/replace the boiling tube with a conical flask in the drawing.

Discussion

The water was first boiled to expel any dissolved oxygen to prevent aerobic respiration from taking place. Yeast being a living organism would be killed or its enzymes denatured with hot water. This is the reason for first cooling the water before the yeast is added to it. As the yeast respires in the absence of oxygen, it uses up some of the sugar and produces a gas and ethanol. The gas causes a lot of frothing in the boiling tube and some of it goes up the delivery tube and makes the lime water appear turbid (a white precipitate is formed). It is calcium carbonate.

In anaerobic conditions in plants, the pyruvic acid initially formed in glycolysis is broken down to **carbon dioxide and ethanol.** This process is also known as **alcoholic fermentation.**

Alcoholic fermentation takes place only in the cytoplasm and does not take place in the mitochondria. It produces very little energy because the glucose is not completely broken down to release all the energy contained in it. The ethanol formed still stores some energy. This process is therefore not very efficient at energy production.

Note:

Higher plants respire aerobically However, whole plants or their parts may respire anaerobically for a short time when necessary, for example, during temporary water logging when the plant is submerged in water.

Anaerobic respiration in animals

Activity 7.3: To demonstrate anaerobic respiration in animals

Apparatus and materials

School athletic track.

Procedure

1. Run around the athletic track twice.
2. Stop at designated area and rest.

Questions

1. State your experience after the exercise.
2. Compare the breathing rate before and after the exercise.
3. Explain what happened that enabled you to resume the previous state before the exercise.

Some animals also respire anaerobically. Tapeworms, for example, are able to survive in the small intestine where there is a very low concentration of oxygen because they are able to respire anaerobically. In mammals, the skeletal muscle cells can also respire anaerobically. However they do so only when they fail to get enough oxygen for the work they are doing, for example, during heavy or strenuous exercise.

When glucose is broken down anaerobically in animal cells, **only lactic acid** and **energy** are produced. Lactic acid is toxic when it accumulates in animal cells. It causes *muscle fatigue.* Therefore, it is usually further broken down to less toxic substances like water and carbon dioxide. This happens when oxygen becomes available. The amount of oxygen needed to eliminate lactic acid by respiration is referred to as **oxygen debt.** We continue to breathe heavily or **pant** after a race or any strenuous exercise so as to supply this oxygen to the muscle cells. This is what happened to you in the Activity 7.3.

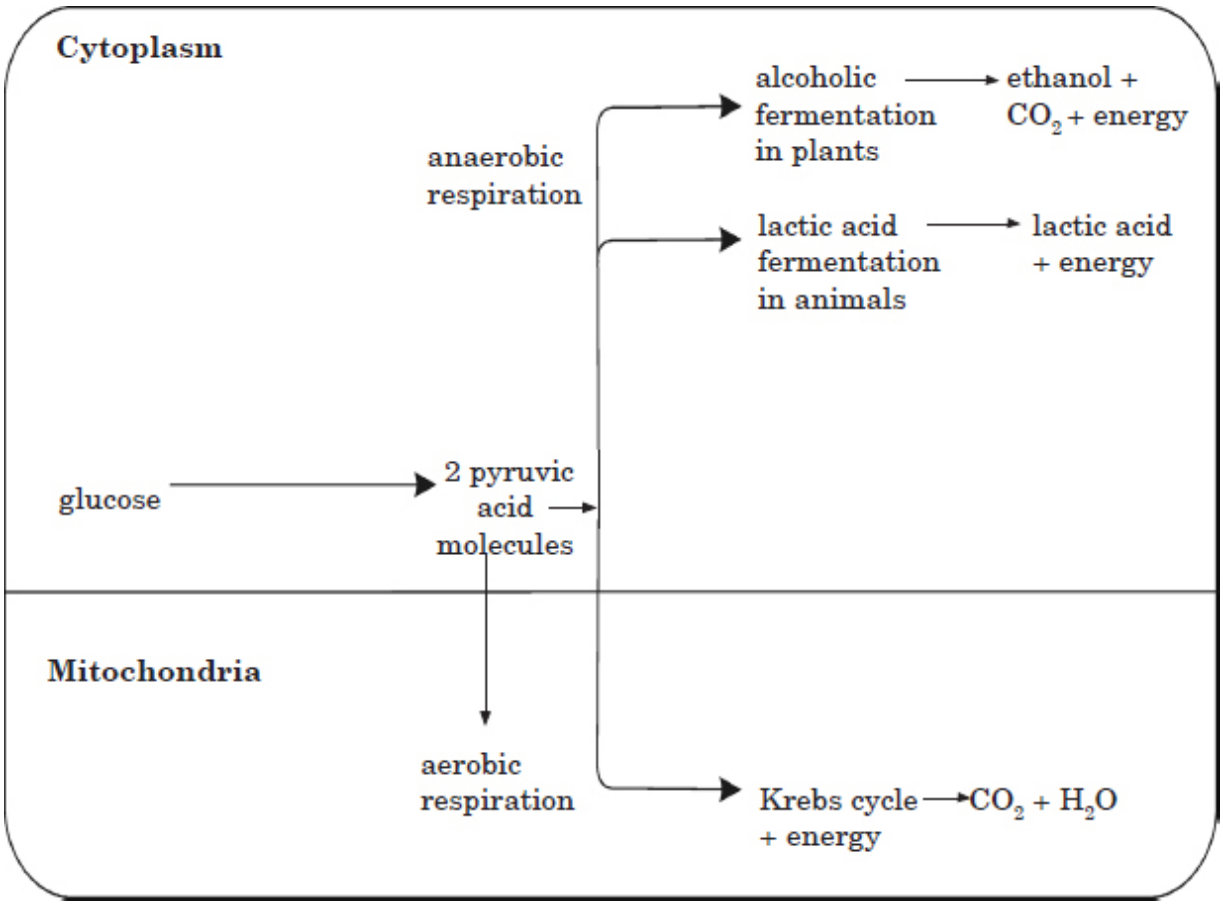


Fig. 7.7: A summary of cellular respiration

Importance of gaseous exchange in organisms

Living things carry out two important life processes that require the exchange of gases.

Plants need to take in or release oxygen and carbon dioxide at one time or another during respiration and photosynthesis. Animals, on the other hand, always take in oxygen and release carbon dioxide during respiration.

Gaseous exchange, therefore is:

(a) Exchange of respiratory gases in animals.

(b) Exchange of photosynthetic and respiratory gases in plants.

The environment that organisms exchange gases with is air for some organisms and water for others. Air is the main source of oxygen and carbon dioxide. Organisms that live on land exchange these gases directly with air. Oxygen and other gases from the air diffuse into lakes, rivers and oceans.

The air dissolved in water is used for gaseous exchange by organisms that live in water. Therefore gaseous exchange is necessary because:

- Organisms are able to obtain useful gases from their environment.
- Organisms are able to get rid of waste gases into their environment.

How gaseous exchange takes place in the lungs and in the tissues

In Form 2, you learnt about ventilation of the lungs. In this section, we will learn about what happens to the air in the alveolus of the lungs.

Gaseous exchange at the alveolus takes place between the phases of inhalation and exhalation. Alveolus is a suitable point for gaseous exchange because:

- It is supplied with blood which carries the gases being exchanged.
- It has a very thin wall across which gases diffuse between it and the blood.
- It is lined with a thin film of moisture to dissolve the diffusing gases.
- A ventilation process brings in and takes away air containing the gases being exchanged.
- We saw earlier that the lungs also have a very large number of alveoli to increase their surface area for gaseous exchange.

Gaseous exchange in lungs

We learnt in Form Two that gaseous exchange in humans takes place in the aleveolar spaces in the lungs. Oxygen in air in the alveolar space is at a higher concentration than that in the blood capillaries.

It therefore first dissolves in the water layer in the alveolar lining, then diffuses across the alveolus and then the capillary walls into the red blood cells.

This becomes oxygenated blood which is carried to the heart by the pulmonary vein. Fig. 7.8 shows gaseous exchange at the alveolus.

Carbon dioxide in the blood diffuses across the capillary and alveolus walls into the alveolar space and is eventually expelled during exhalation.

We have learnt earlier that a diffusion gradient is essential for rapid gaseous exchange in the alveolus.

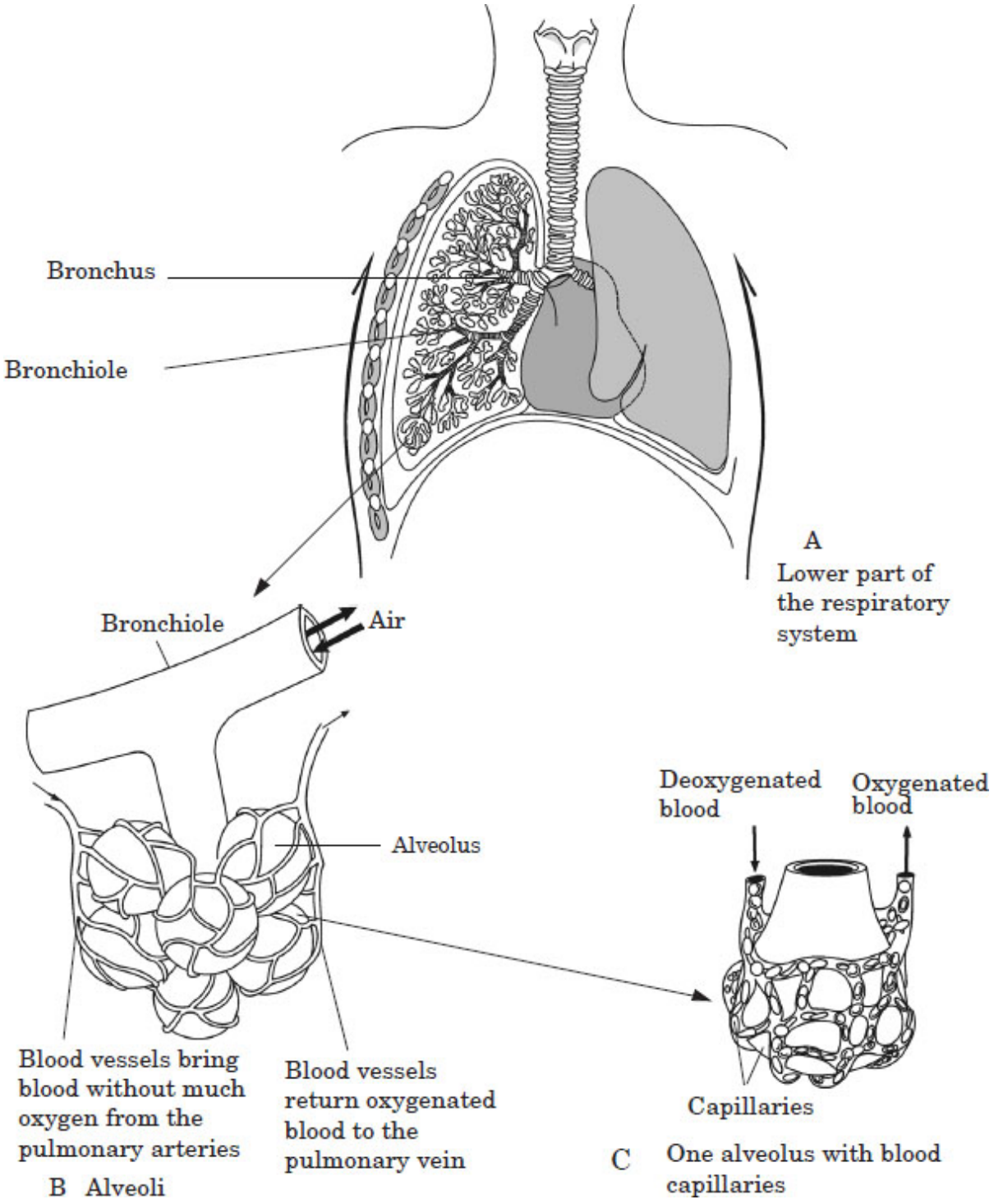


Fig. 7.8: Lower part of the human respiratory system

Gaseous exchange in the tissues

Tissues are made up of cells. Surrounding the cells is a fluid called **tissue fluid.** This tissue fluid has a higher concentration of oxygen than the cells. Therefore oxygen diffuses from the tissue fluid into the cells.

Similarly carbon dioxide in the cells is at higher concentration than in the surrounding tissue fluid. Therefore carbon dioxide diffuses out of the cells into the tissue fluid.

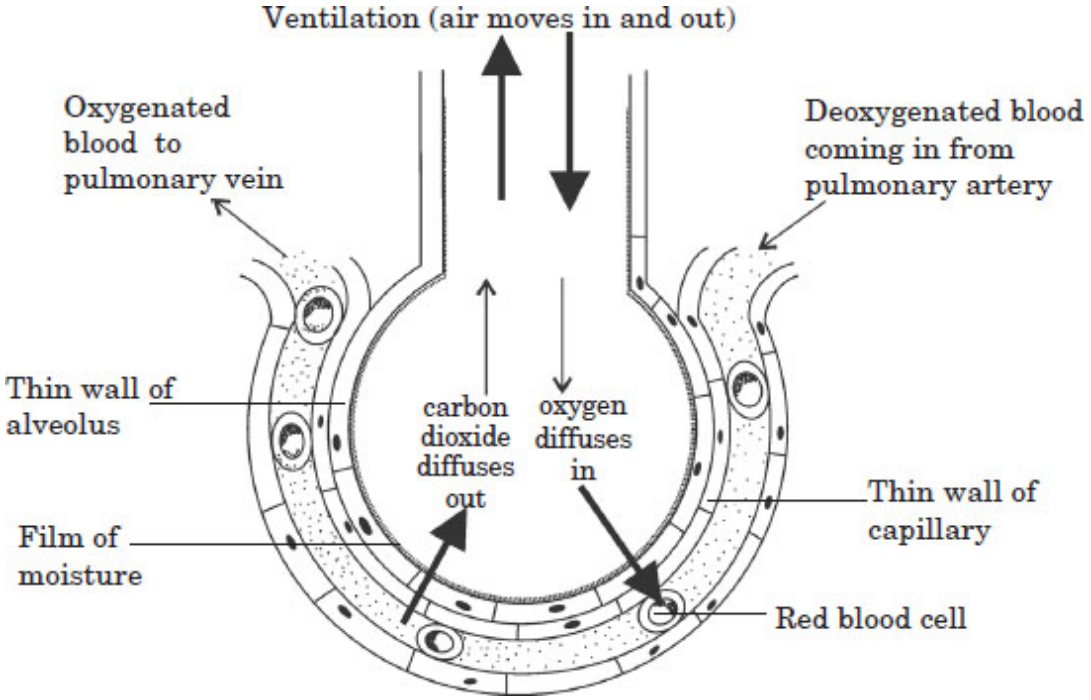


Fig. 7.9:Gaseous exchange at the alveolus

Comparing gaseous exchange in lungs and tissues

While gaseous exchange in lungs alveoli is between the air and the blood cells, gaseous exchange in the tissues is between the tissue fluid and cells.

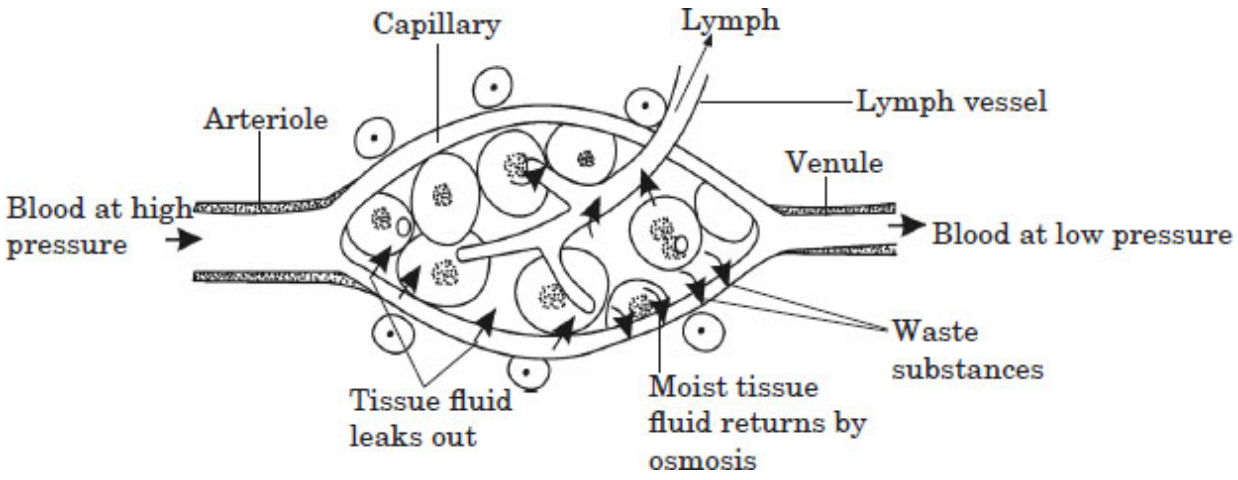


Fig. 7.10: Formation of lymph

In the lungs, oxygen must dissolve in the moist lining of the alveolus before diffusion can occur.

How breathing is regulated

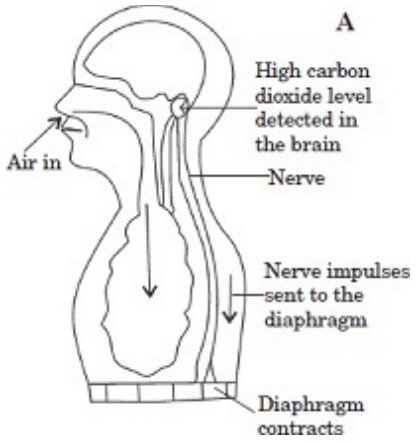
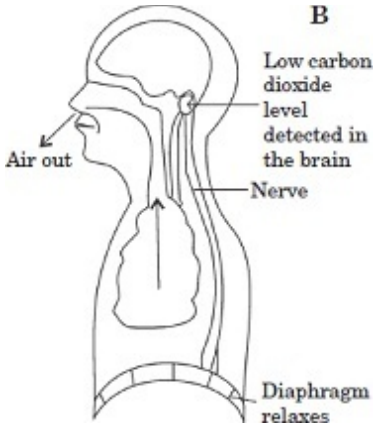
Breathing is regulated by a section of the brain known as medulla oblongata. This control centre constantly monitors the levels of carbon dioxide and oxygen in the bloodstream and adjusts your breathing rate to maintain balance. Breathing involves two processes; **inhalation** and **exhalation.** The table below gives a summary of how breathing in human beings is regulated.

Effects of exercise on breathing

Have you noticed what happens to your breathing when you run? Carry out the following activity to find out.

Table 7.1: Summary of the process of breathing.

Inhalation	Exhalation

	
• A high level of carbon dioxide in the blood passes through the medulla oblongata (part of the brain).	• A low level of carbon dioxide in the blood passing through the medulla oblongata.
• Nerve impulses are sent from the brain to the diaphragm and rib. External intercostal muscles contract. The internal intercostal muscles relax.	• Nerve impulses from the brain to the diaphragm stop temporarily and rib external intercostal muscles and diaphragm muscles relax. Internal intercostal muscles contract.
• The diaphragm flattens and inhalation occurs.	• The diaphragm become dome-shaped and exhalation occurs.
• The lungs become ventilated and some carbon dioxide in the blood quickly diffuses out into the alveolus.	• At this point, the concentration of carbon dioxide begins to increase.
• This lowers the level of carbon dioxide in the blood.	• This causes an increase in the level of carbon dioxide in the blood and the sequence of the events repeats itself to lower it.

Activity 7.4: To investigatge the effect of exercise on the rate of breathing

Apparatus and materials

Stop watch or clock, students themselves.

Procedure

1. Count the number of breaths (breathing in and out) for 5 minutes of the student while he/she is standing. From this, count calculate the breathing rate per minute. Record the rate in a table like the one below.

Activity	Breathing rate per minute
Standing for 5 min	
After skipping 20 times	
Two minutes rest after skipping	
Four minutes rest after skipping	
Six minutes rest after skipping	

2. Let the student skip twenty times with the rope and immediately find the breathing rate. Record this rate in a table.
3. At the end of two, four and six minutes rest, record the breathing rate again.
4. Draw a graph of your results.
5. Repeat steps 1 to 4 with another student.

Questions

1. How does the exercise affect the breathing rate?
2. Is there any difference in the breathing rates between the first student and the second student? Suggest a reason for any variation.

Discussion

You may have observed that the following were the effects of exercise on:

(a) Rate of breathing

Exercises increase the rate of breathing. Physical activity such as walking, dancing and running also increase the rate of breathing.

(b) Depth of breathing

Vigorous and prolonged exercises does not only increase the rate of breathing but also increases the depth of breathing.

(c) Carbon dioxide

During exercise, the rate of respiration increases to produce energy. As a result there is a higher accumulation of carbon dioxide in the blood.

(d) Oxygen concentration

As a result of exercises, there is an increase in the amount of oxygen used for respiration. This causes an increase in the rate of breathing

(e) Residual air

The volume of residual air remains the same.

Carbon monoxide poisoning

Haemoglobin combines with oxygen to form oxyhaemoglobin. Haemoglobin also has a higher affinity for carbon monoxide gas.

Carbon monoxide is produced when fuels are not fully burned or where fuels are burnt in insufficient oxygen for instance, in a poorly ventilated room. Carbon monoxide is also produced by engines.

Carbon monoxide combines readily with haemoglobin when inhaled to form a compound called **carboxyhaemoglobin.** Unlike oxyhaemoglobin which splits in the cells to release oxygen, carbon xyhaemoglobin does not easily split. In this case, it does not release oxygen for use by the cells.

Carboxyhaemoglobin continues to circulate in blood depriving body cells oxygen. Lack of enough oxygen results to less energy. Prolonged exposure to carbon monoxide can cause death

Due to lack of energy, body processes stops taking place and a person may die due to suffocation. This is called **carbon monoxide poisoning.**

First Aid for carbon monoxide poisoning

For one to know that an individual is suffering from carbon monoxide poisoning, the following symptoms are observed in addition to the fact that the individual is in a poorly ventilated room where fuel is not being fully combusted.

- *The person develops severe headache.*
- *The person has nausea and in some times abdominal pains.*
- *The person feels dizzy and has a dry cough.*

To help such a person, the following first aid steps should be taken, immediately.

(i) Take the person out of the room and make him lie comfortably on an open space.

(ii) If air circulation is not sufficient, increase the circulation by fanning using a flat object such as an exercise book or if inside a house put on the fan. If the person is having difficulties breathing carry out artificial respiration by use of mouth to mouth resuscitations.

(iii) Take the person to the nearest health facility for treatment as soon as you can.

Ways of preventing carbon monoxide poisoning

1. Make sure that the house where cooking or heating is being done is well ventilated.
2. Ensure that chimneys are working and are freely allowing exhaust air out of the house or an enclosed space.
3. Avoid keeping a low burning stove or charcoal burner in a poorly ventilated room.
4. Do not run generators or small engines inside a house or enclose spaces.
5. Ensure that at night, any charcoal burner with charcoal still burning is kept outside the house or inside the chimney.

Effects of smoking on the lungs

Smoking has the following effects on the human body namely; Respiratory infections, addiction, causes cancer, and harms the foetus when a pregnant woman smokes.

(a) Respiratory infections

Cigarette smoke contains substances that irritate the respiratory tract hence increasing mucus production. Cigarette smoke destroys the cilia

on the respiratory tract; bacteria and harmful particles are not removed from the respiratory tract, the result is increase in infection incidences. Smoke and mucus accumulate in bronchus resulting in bronchitis.

(b) Addiction

Nicotine is addictive leading the person to depend on the smoking habit.

(c) Cancer

Smoke from cigarettes contains tar which contains carcinogens. Carcinogens encourage cancerous cells to develop in the lungs. This can lead to **lung cancer.**

(d) Harm to foetus

The harmful effects of tobacco smoke on the pregnancy is as a result of the carbon monoxide and nicotine the mother and foetus are exposed to. Carbon monoxide combines with foetal haemoglobin leading to retarded foetal growth and results in stillborn or miscarried foetus. It also hinders mental development in the foetus.

Respiratory systems of fish (gills)

In bony fish, the respiratory structures are the **gills.** The bony fish have four gills on each side of the body. The gills are located inside a cavity in the head region known as the **operculum cavity.** Refer to Fig. 7.11. Each side of the fish has an operculum cavity which has an opening to the outside of the fish known as the **opercular opening.** The gills are protected by a thick **gill cover** or **operculum** on both sides of the body near the head. This is a fold of skin made stiff by a bony plate.

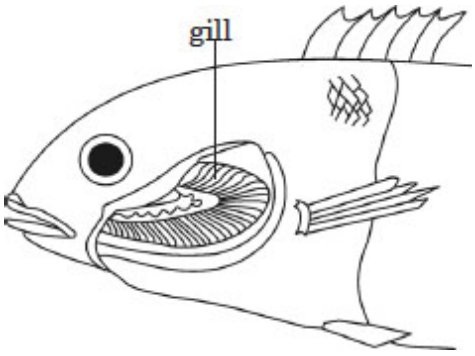


Fig. 7.11: Position of the gills after removing the operculum.

Activity 7.5: Examine the gills of a bony fish

Apparatus and materials

A freshly killed fish, pair of scissors, gills of a bony fish, scalpel, hand lens, microscope.

Procedure

1. Place the fresh fish on the dissection board. Lift the operculum. Look towards the anterior part of the head through the operculum and check if you can see through to the mouth cavity.
2. Push a glass rod between the gills and check where it comes out from.
3. Use a pair of scissors to cut out the operculum of the fish. Cut the operculum near its point of attachment to the body. Note the following about the gill:
   - Location
   - Structure
   - Arrangement.
4. Now cut out a complete gill from the gill chamber with the pair of scissors.
5. Place the gill in water in a dish. Note what happens to the filaments.
6. Examine the gill filaments with the hand lens or under low power of the microscope. Draw the structure of the gill and label the gill rakers, gill bar and gill filaments.

Discussion

When the gill is removed and held in the hand, it can be observed that the filaments stick together. When filaments are stuck together, the surface area is reduced. When the gill is placed in water, the filaments spread out and expose a larger surface area. The gill of bony fish consists of a set of long, curved bony structures called **gill bars** as shown below.

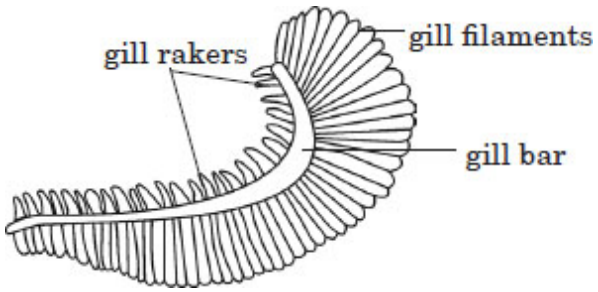


Fig. 7.12: Parts of a gill

A large number of long thin-walled and moist gill filaments project from each gill bar. The curved shape of the gill bar allows for more filaments to fit on it. The filaments are richly supplied with blood due to the presence of many capillaries. The respiratory surface of the gill on the gill filaments is a layer of cells, exposed to the surrounding water on one side and to blood vessels on the other. The thin surface allows rapid diffusion of carbon dioxide and oxygen between water and the blood.

The gill bar has bony teeth-like structures called **gill rakers** on the opposite side of the gill filaments. The gill rakers face the mouth and prevent food and other solid materials in water from reaching the delicate filaments.

Gaseous exchange in the fish occurs between the gill filaments and water. This means that there has to be contact between water and the gill filaments. Such contact is brought about by ventilation processes of inspiration and expiration which continuously bring in and remove water from the gills. This water gets into the mouth, passes over the gills and leaves through the opercular cavity.

Inspiration: Flow of water into the mouth cavity

The following processes bring water into the mouth cavity.

- The mouth opens.
- Muscular contraction in the mouth lowers the floor of the mouth. This increases volume in the mouth cavity and decreases the pressure inside it.
- The water outside is at a higher pressure and it rushes in through the open mouth.

- Each operculum on the side of the fish bulges outwards due to the muscular action. This increases the volume in the operculum cavity and lowers the pressure there.

Water from the mouth is sucked into the opercular cavity. This is the region of gaseous exchange. Meanwhile, the free edge of the operculum remains pressed against the body wall of the fish. This prevents water outside the fish from entering through the operculum cavity.

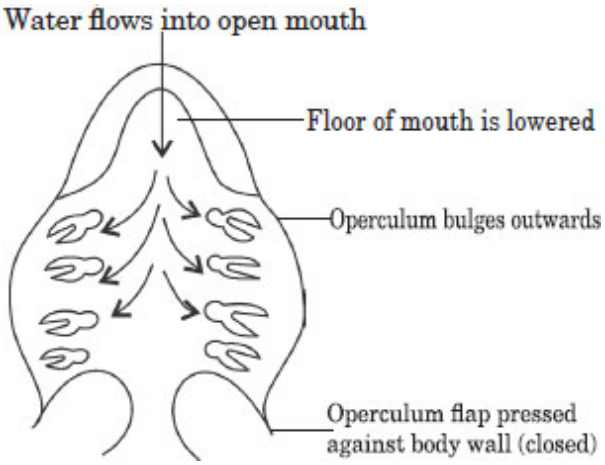


Fig. 7.13: Inspiration in fish

Expiration: Flow of water over the gills

During expiration:

- The mouth closes.
- The floor of the mouth is raised. This reduces the volume (space) in the mouth cavity and increases the pressure.
- The operculum presses inwards by muscular action, decreasing the volume in the operculum cavity but increasing its pressure.
- The free edge of the operculum moves away from the body wall of the fish to open the operculum cavity.
- Water rushes from the operculum cavity and flows out of the fish via the operculum opening.

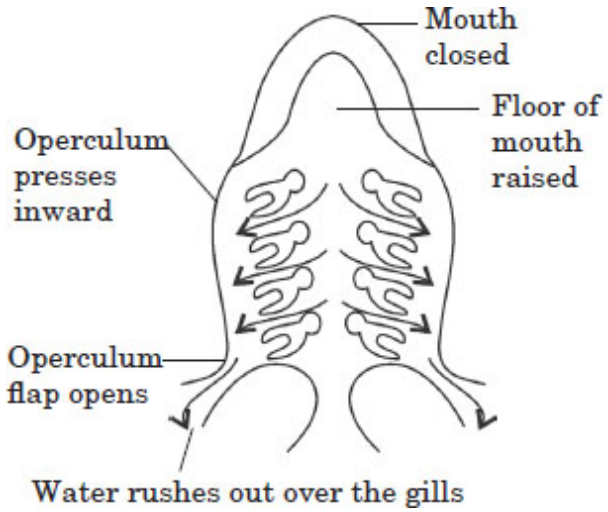


Fig. 7.14: Expiration in fish

Exchange of gases between water and gill filaments

Gaseous exchange in fish takes place on the gill filaments as water passes over the gills.

Blood in the capillaries in gill filaments has a lower concentration of oxygen than the water entering the mouth. Therefore, oxygen diffuses from the water flowing over the gill filaments into the blood through the thin walls of the capillaries.

On the other hand, blood in the capillaries has a higher concentration of carbon dioxide than the water entering the mouth cavity. Therefore, carbon dioxide diffuses from the blood through the walls of the capillaries into the water flowing over the gill filaments.

In order to have maximum gaseous exchange between the blood in the gill filaments and the flowing water, a steep concentration gradient must be maintained across the respiratory surface.

This is achieved by the flow of water and blood in opposite directions. This system in which blood flows over the gill filaments in the opposite direction with the incoming water is called the **counter current system.**

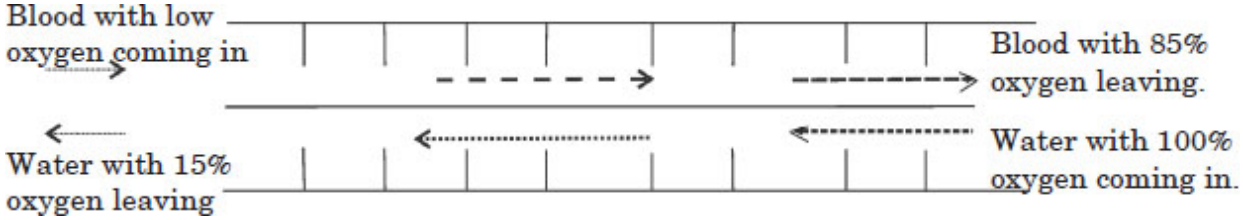


Fig. 7.15: Counter current exchange of gases

Respiratory system in insects

The respiratory system in insects is called the *tracheal system.* It consists of *spiracles, trachea* and *tracheoles.*

The following figure shows the tracheal system of a grasshopper. Identify the parts of this system.

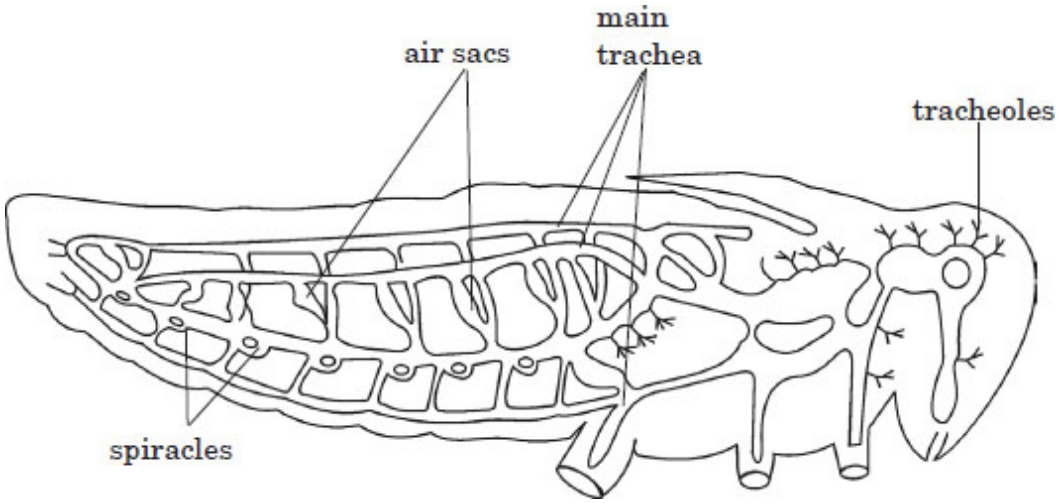


Fig. 7.16: The tracheal system in a grasshopper

Activity 7.6. To examine the distribution of spiracles on a grasshopper or locust

Apparatus and materials

Live grasshopper/locust/cockroach, hand lens.

Procedure

1. Hold the grasshopper in your hands. Use a hand lens to observe the small openings on the sides of the body. These are called **spiracles.** Count the spiracles on both sides of the body and note their position.
2. Now place the grasshopper in a glass container and cover it. Observe the movement of the abdomen from the side of the glass container. Note what happens to the spiracles.

Questions

1. How many spiracles did you count?
2. Where were they located?
3. Describe the movements of the abdomen.
4. How do the movements of the abdomen affect the spiracles?

Discussion

You will notice that the spiracles are found only on the sides of the thorax and abdomen. There are no spiracles on the head. The following figures show spiracles and a detailed structure of part of the tracheal system of an insect.

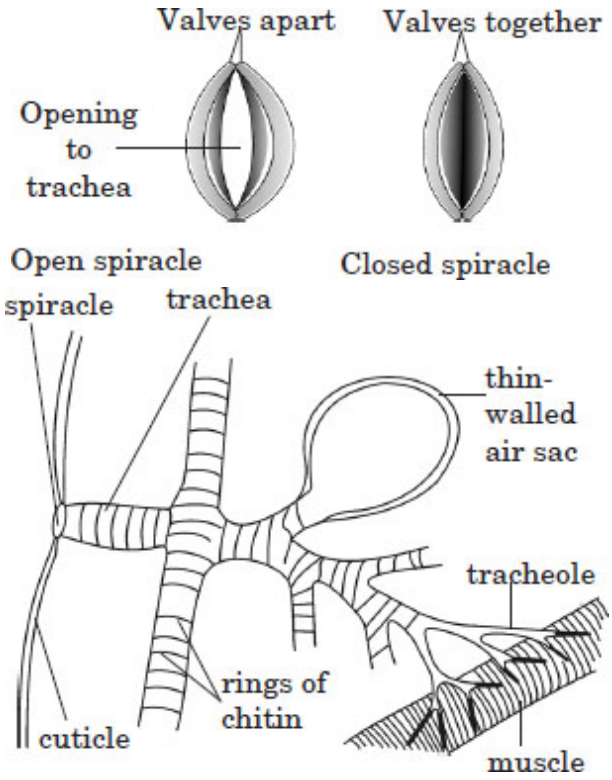


Fig. 7.17: Part of the tracheal system of an insect.

Each spiracle has a muscular valve, which can be opened or closed to regulate the flow of air. There are also hairs in the spiracle which prevent excessive loss of water by evaporation from the tissues.

The spiracles open into large tracheal tubes called **tracheae** *(singular trachea)*. These tubes are strengthened with spiral bands of **chitin** to keep them open at all times. There are several large **air sacs** which are connected to the tracheal tubes.

The tracheae are subdivided into microscopic tubes (with a diameter of about 0.1mm) called **tracheoles.** Tracheoles penetrate the body tissues and are in direct contact with all the living cells. They lack the spiral bands of chitin and their ends are filled with a fluid. These ends act as respiratory surfaces between the cells and the tracheoles.

In small insects, simple diffusion is enough to meet their gaseous exchange requirements. In large active insects like grasshoppers, wasps and bees breathing movements which ventilate the tracheal system are necessary to increase the efficiency of gaseous exchange.

Inspiration in a grasshopper

During inspiration or breathing in, air enters the body of the insect. Inspiration takes place when the internal muscles in the abdomen of the grasshopper **relax.**

This makes the abdomen and the tracheal system to expand and increase in volume. The pressure in the tracheal system decreases as compared to that of the atmosphere.

This causes air to be sucked into the tracheal tubes via the spiracles in the thorax which are open at this time, Fig. 7.18. This air travels through to the tracheoles.

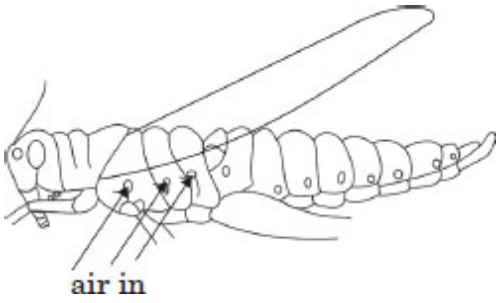


Fig. 7.18: Inspiration in the grasshopper.

Expiration in a grasshopper

Expiration is breathing out. In order to expel the used air, internal muscles in the abdomen of the grasshopper **contract** and compress the abdomen.

This causes a compression of the tracheal system. The reduced volume and increased pressure in the tracheal system forces air out of the system through the spiracles.

In the grasshopper, the four anterior (front) spiracles close while six pairs of posterior spiracles open so that air flows from the front to the rear end and then out of the insect as shown in Fig. 7.20.

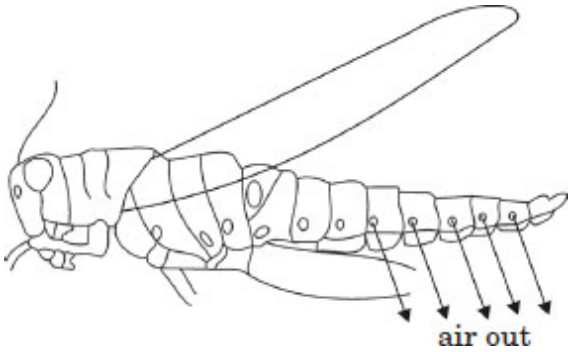


Fig. 7.19: Expiration in a grasshopper.

Gaseous exchange

Oxygen from the air dissolves in the fluid in the tracheoles and diffuses directly into the cells. Carbon dioxide which is at a higher concentration in the cells than in the tracheoles diffuses from the cells into the fluid in the tracheoles. It is removed from the insect during expiration. Note that gases are not transported by blood in the insects.

Adaptations of gills, tracheal system and lungs

We have learnt that gaseous exchange takes place over respiratory surfaces of organisms. These respiratory surfaces include gills, lungs and tracheal system. A respiratoty surface has a number of characteristics that make it efficient for gaseous exchange. These are discussed below.

(i) Thin walls for faster diffusion of gases across it.

(ii) It is moist to dissolve gases as they diffuse across it.

(iii) It has a large surface area for maximum gaseous exchange.

(iv) In animals with a transport system, the respiratory surface has a rich supply of blood capillaries to quickly transport gases to and from the cells.

Let us now see how the following respiratory structures are adapted to the function of gaseous exchange.

(a) Gills

Gaseous exchange in fish occurs over the gill filaments. The gill filaments are thin to reduce the distance through which gases diffuse. Gills are highly vascularised for easy transportation of gases. Gill filaments are numerous and bear gill lamellae that increase the surface area for gaseous exchange.

(b) Tracheal system

The tracheal walls are spirally thickened with chitin which keeps it open and allows faster air diffusion if the air pressure inside is reduced.

The tracheal system is extensive spreading to every tissue near each cell hence reducing the distance air has to diffuse to get to the respiring cells. Tracheoles are very small and numerous hence increasing the surface area for gaseous exchange.

Tracheoles walls are thin hence reducing the distance of diffusion and increasing the rate of diffusion. The removal of the fluid from the ends of the tracheoles speeds up the rate at which oxygen diffuse along it.

c) Lungs

Lungs provide numerous alveoli to provide a large surface area for efficient gaseous exchange. Alveoli wall and blood capillary wall are made of squamous epithelium cells which are thin to provide a shorter diffusion distance for faster gaseous exchange. The alveoli are highly vascularised to maintain a high concentration gradient for diffusion of oxygen and carbon dioxide.

The alveoli inner surfaces are covered by a thin layer of water film to dissolve oxygen for faster diffusion of gases into the blood hence ensuring efficient gaseous exchange.

Revision Exercise 7

1. (a) What is respiration.
   (b) Name and differentiate between the types of respiration.
2. What is the importance of gaseous exchange in organisms.
3. Describe how breathing is regulated.
4. What is carbon monoxide poisoning?
5. State ways of preventing carbon monoxide poisoning.

6. What are the effects of smoking?
7. Describe the adaptations of the following to gaseous exchange;
   (a) Gills.
   (b) Lungs.

Unit 8

Locomotion

Specific objectives

By the end of this unit, you should be able to:

(a) State the types of skeletons.

(b) Describe the structures and functions of bones.

(c) Draw and label locomotory structures in fish and birds.

(d) Describe locomotion in fish and birds.

(e) Explain how fish and birds are adapted for locomotion.

Introduction

In this unit, we will learn about types of skeletons and types of joints. We will also learn about locomotion in fish and birds.

Types of skeletons

We learnt in Form Two that a skeleton is a supportive framework in an animal's body.

There are three types of skeletons. They include;

(a) Endoskeleton.

(b) Exoskeleton.

(c) Hydrostatic skeleton.

Endoskeleton

An endoskeleton is a skeleton found inside the body of an organism. It is found in vertebrates.

Exoskeleton

An exoskeleton is a skeleton found on the outside of the body of some animals. It is found in invertebrates like crabs, insects, spiders and

millipedes.

Hydrostatic skeleton

This is a skeleton by which support is provided by a fluid enclosed in a cavity under pressure.

It is found in some invertebrates like earthworms.

Structure and functions of parts of bones

In Form Two, we learnt that the human skeleton is made up of bones. Bones are made up of the following parts;

- Cartilage tissue.
- Bone marrow.
- Spongy bone.
- Compact bone.

(a) Cartilage tissue

Cartilage is a dense, flexible connective tissue found in many areas of the body.

It is made of living cells called **chrondrocytes.** Chrondrocytes produce the collagen which make up the cartilage. Cartilage does not have blood vessels hence it heals and grows very slowly.

Functions of cartilage

(i) It covers the end of the bones where joints form. It absorbs shock and prevents friction.

(ii) It connects ribs to the sternum.

(iii) It forms the flexible part of the ears and the nose.

(b) Bone marrow

Bone marrow is a connective tissue that fills the spaces in the spongy bone. It contains many blood capillaries and it is the site of formation of blood cells.

(c) Spongy bone

This is the interior region of a bone. It is less dense and it contains many spaces in between the collagen fibres. The spaces are filled with another

tissue called the **bone marrow.** In the long bones, the spongy bone forms a cavity where bone marrow is filled.

(d) Compact bone

This is the hard outer shell of the bone. It is made of compacted collagen fibres with no spaces in between them. The hardening of the fibres makes the bone to be very dense, strong and rigid for support. Its surface is used for attachment of muscles.

Note: Compact bones, spongy bone and bone marrow are collectively referred to as the **bone tissue.**

Locomotory structures in fish and birds

In this unit, we will learn about the locomotory structures and locomotion in birds and in fish.

Locomotory structures in fish

Let us carry out the following activities to study locomotion in fish.

Activity 8.1: To observe and identify external features of a finned fish

Material

- Tilapia fish or any other available finned fish.
- Dissection board or plate.
- Scalpel.

Procedure

Precaution: Handle the fish carefully because the spines are sharp and can prick you.

1. Hold the fish in your hands. Is its body flexible and able to bend or is it stiff? How does the flexibility of the region near the head compare with that of the tail region?
2. Hold the fish with head pointed towards you as if the fish was moving towards you. Describe the shape of the body of the fish.
3. Place the fish on a dissecting board.

4. Pass your hand carefully from the head to the tail end and back again to the head region. How do you feel? How are the scales arranged? What is the importance of this arrangement of scales?
5. Look at the fins. Try to gently spread out the fins. What do you note? Note the position of each of the fins on the body of the fish. Note the fins that are paired and those that are not paired.
6. Locate the operculum. What is its function?
7. Examine the eyes of the fish. Is there an eyelid to cover the eye?
8. Locate a line of pores along the side of the fish. What is the name of the line and what is its function?
9. Draw and label the external structure of the fish.

Discussion

From the activity. You may have noted that the fish has fins. The fins helps in controlling movement of fish in water. There are several types of fins some of these fins are found singly (unpaired) and others are found in pairs (paired). Fish use fins as structures of locomotion.

The following are the types of fins and their locations in fish such as *Tilapia.*

(a) Unpaired fins

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

Note: The dorsal fin and ventral fin are sometimes referred together as **median fins.**

(b) Paired fins

- **Pectoral fins** – are found on the sides of the fish near the operculum.

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

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

The vertebral column is flexible to allow efficient movement.

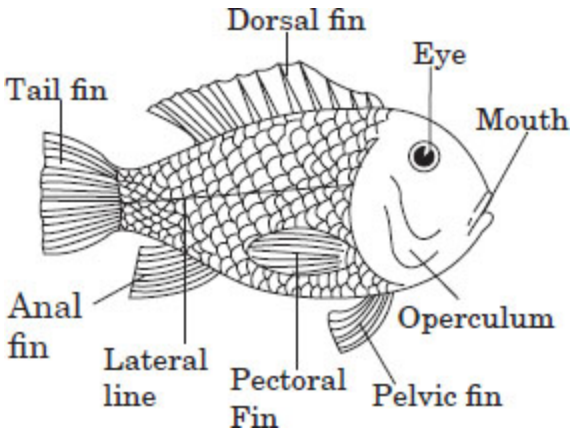


Fig. 8.1: External features of Tilapia.

Activity 8.2: To observe movement of fish

Materials

- An aquarium
- Live fish in a ventilated glass jar

Procedure

1. Observe the fish in the aquarium or in the glass jar carefully.
2. Note the action of the fins that leads to:
   - Forward movement.
   - Braking.
   - Change of direction.
   - Movement to the bottom of the container.
   - Stopping and balancing.
3. Draw the fish showing the position of the fins at each experiment observed.

Locomotion in fish and birds

Locomotion in fish

Locomotion of a fish in water is by swimming. Swimming involves forward movement and control of the body position in water as the fish moves.

Forward movement is also known as **propulsion.** Propulsion is caused by the tail. The tail is almost half the length of the body of the fish.

This is significant because the tail is able to create enough force to enable the fish to push forward. This propulsion is achieved when the tail pushes sideways against the water. The sideways movement is caused by muscles which are arranged in segmented blocks called **myotomes** that are located on either side of the vertebral column.

The muscles contract alternately causing the flexible vertebral column to swing sideways thus enabling the tail to push against the water. When the muscle blocks on the left contract while those on the right relax, the body bends to the left side. When the blocks on the right contact and those on the left relax, the body bends to the right.

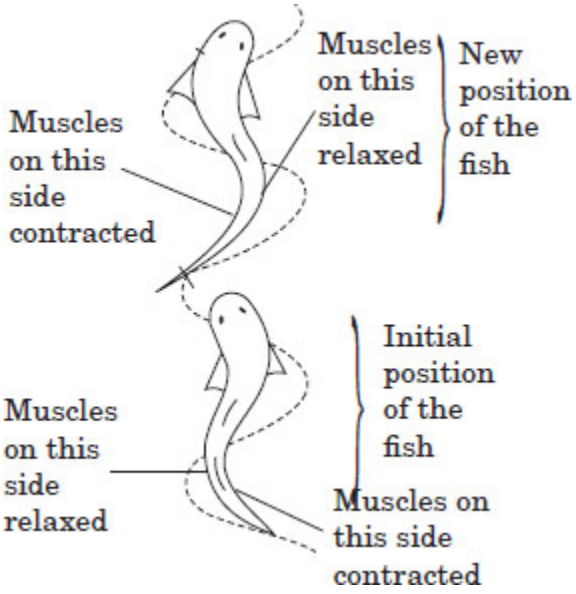


Fig. 8.2: Movement of fish in water

The total effect of this body movements is a forward thrust of the fish in water. The fish uses the dorsal fins and the ventral fins to prevent yawing. Yawing is the sideways movement of fish in water.

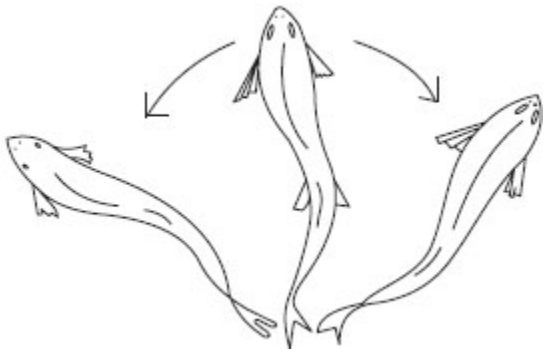


Fig. 8.3: Yawing in fish

A fish may want to change its level in water, that is, ascend or descend. This is known as **pitching.** In order to do that, it uses the paired fins, that is, the pectoral and pelvic fins, as shown in the figures below.

Fig. 8.4: Paired fins spread out to slow or stop the fish (braking).

In order to **steer** itself, (change direction), the fish uses the paired fins (pectoral and pelvic fins).

As the fish moves forward, it uses its fins to control the position of its body in water. The paired fins lie flat on the body surface to maintain the streamlined shape of the body. In order to brake (stop moving forward) the fish spreads out the pectoral and pelvic fins at 90° to the body as shown in the figure below. This creates resistance and enables the fish to stop.

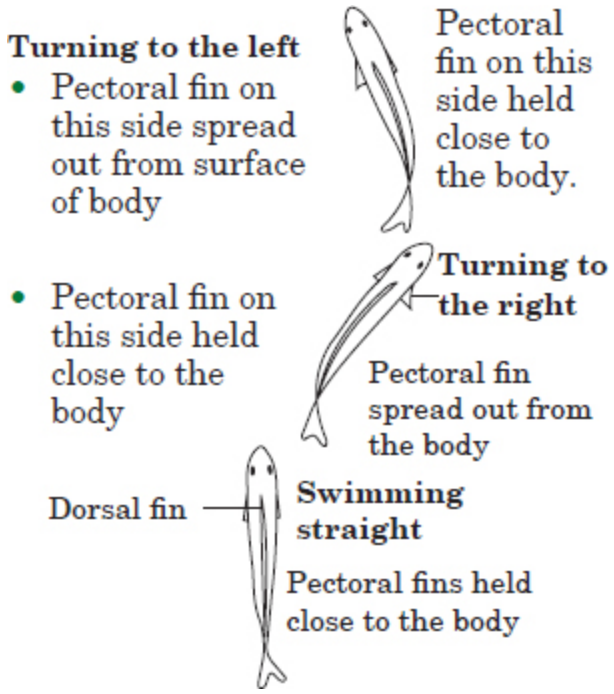


Fig. 8.5: Pectoral and pelvic fins help to steer the fish.

The paired fins also help the fish prevent unnecessary pitching caused by water currents.

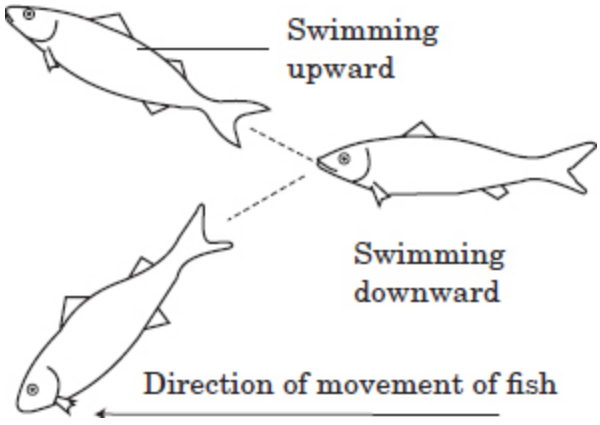


Fig. 8.6: Paired fins, pectoral and pelvic fins control the pitch of the fish.

Swim bladder can also be used by fish to change its level in water. It is a saclike structure that can fill up with air. The air can also leave the swim bladder. When the swim bladder fills up with air, the fish becomes lighter that is, more buoyant. As a result of this, the fish rises in water. When the swim bladder is deflated, the fish becomes heavier or less buoyant. As a result, the fish sinks deeper in the near ventral edge.

Adaptations for locomotion in fish

1. The fish has a streamlined body so that it cuts through water rapidly.
2. The scales overlap facing backwards. This arrangement of scales allows the fish to move through water easily.
3. The body of the fish is covered with mucus this reduces friction between the body of the fish and water during movement.
4. Fish have other features known as **fins.** The fins help in controlling movements of fish in water.

Locomotory structures in birds

Birds are vertebrates with four limbs. The forelimbs have feathers and are modified to form wings. Wings enable birds to fly. Their hind limbs form legs with scales and claws. They are used for walking or hopping. The figure below shows some parts of a bird.

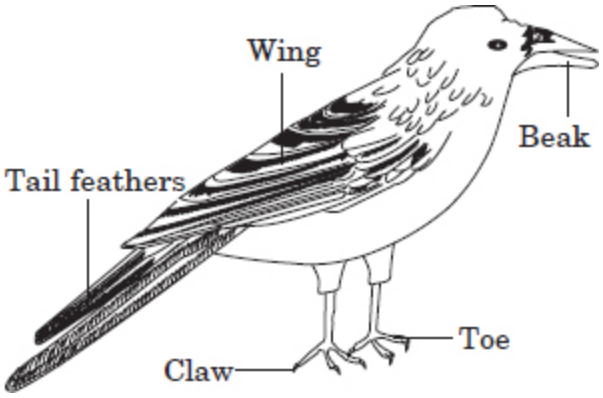


Fig. 8.7: Parts of a bird

Activity 8.3: To draw and label feathers of birds

Materials

- Feathers – down feathers
  – flight feathers
- Hand lens

Procedure

1. Study each type of feathers provided.
2. Identify the following feathers:

- Down feathers.
- Flight feathers.

3. Draw and label:
   - A down feather.
   - A flight feather.
4. Suggest which part of the body of a bird each feather is located.

Types of feathers

Feathers are external features found only in birds. They are produced from the skin. There are four types of feathers: *Down feathers, flight feathers* (quill feather), *covert feather* and *filoplume feather.* In this sub-topic, we will look at the first two.

Flight feathers

They are broad and flat feathers. They prevent air from passing through them.

Fig. 8.8: Flight feather

Down feathers

There are small fluffy feathers close to the body of the bird. They trap a layer of air near the body surface.

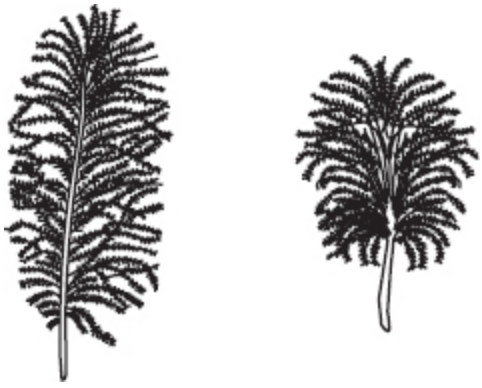


Fig. 8.9: Down feathers

Locomotion in birds

There are three types of flight movements in birds: Gliding, flapping and soaring.

(a) Flapping flight

Wings are flapped up and down. When wings are flapped up, the movement is called **upstroke.** When the wings are flapped down, it is called **downstroke.** The flapping of the wings is controlled by muscles that hold the bones of the wings to the pectoral girdle. These are the ***Pectoralis minor*** and the ***Pectoralis major.***

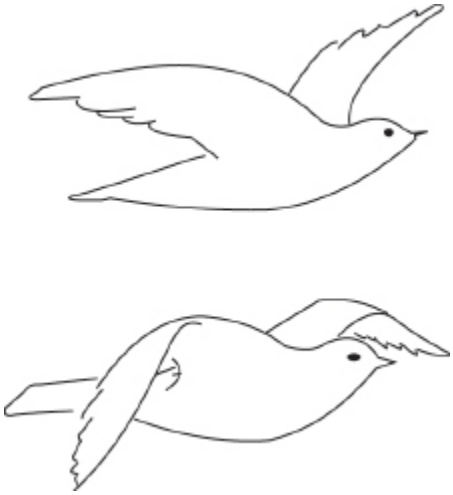


Fig. 8.10: Flapping flight of birds

During upstroke, the ***Pectoralis minor*** contracts, pulling the wing upwards. The wing is raised. At this time the ***Pectoralis major*** is relaxed.

During down stroke the ***Pectoralis major*** contracts pulling the wing downwards. The resistance of air to downward movement of the wing produces an upward force that pushes the body of the bird upwards. At this time the ***Pectoralisis major*** is relaxed. The wing is slice shaped. Therefore, during the upward thrust it also cuts forward through the air enhancing movement.

(b) Gliding flight

In gliding flight, the wings are out-spread and used as aerofoils. The bird slides down a "couloir" of air loosing height and gaining forward momentum.

Fig. 8.11: Gliding flight

(c) Soaring flight

The bird spreads out its wings in soaring movements to allow upwards thermal air currents or gusts of wind to lift the bird allowing it to gain height without moving its wings.

Fig. 8.12: Soaring flight

Adaptation of birds for locomotion

These are features that suit a bird for flying.

1. The bird has fore limbs called *wings.* Wings have feathers which create a large surface area for flight.
2. Birds have big muscles called *pectoral muscles* that attach the wings to the body of the bird for efficient movement of the wing. These muscles lower the wings. Smaller pectoral muscles raise the wings.
3. The sternum or breastbone of the rib cage forms a wide bone which is called a *keel.* It is for the attachment of the pectoral muscles.
4. Birds have *hollow bones* to make them light in weight for flight.
5. The skeleton is *rigid* and *firm* for attachment of flight muscles. Most bones are fused together.
6. Birds have a *streamlined body.* This makes it possible for them to move in air with less resistance to air currents.
7. Birds have keen *eyesight.*
8. Birds have *no teeth.* This enables them to reduce their body weight.
9. Birds have *no earlobes.* This enables them to reduce air resistance during flight.

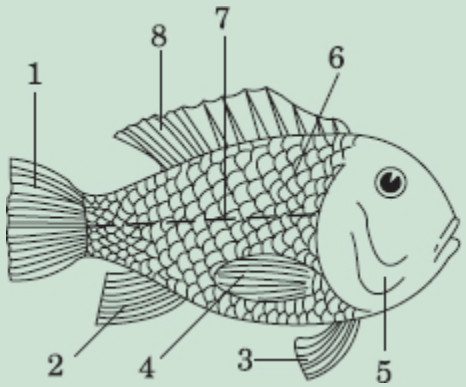
10. Birds have a very efficient respiratory and transport systems.

Adaptation of a bird's skeleton to flight

1. The skeleton is *rigid.* This makes it form a framework which is very firm. The bones are fused together. Examples of fused bones are the vertebrae of the vertebral column.
2. The bones are *hollow.* This reduces the weight of the bird.
3. The sternum or breastbone forms an extension called the *keel.* This creates a large surface for attachment of the pectoral muscles.
4. The coracoid or collar bone is well developed to transmit forces between left and right wings.

Revision Exercise 8

1. The following diagram represents a finned bony fish.



(a) Identify the structures numbered 1 –8.

(b) Explain how a fish is adapted for locomotion.

2. Name the fins which;

(a) controls braking in fish.

(b) control yawing.

(c) control pitching.

3. (a) Describe the adaptation of a bird for flight.

(b) Name three types of feathers found in birds

4. Give a function of each of the following parts of a bone:

(a) Cartilage

(b) Bone marrow
(c) Spongy bone
(d) Compact bone.

Unit
9

Reproduction

Specific objectives

By the end of this unit, you should be able to:

(a) Describe the structure and function of chromosomes.
(b) Describe the processes of mitosis and meiosis.
(c) Label the parts of the human reproductive system.
(d) State the functions of the parts of human reproductive system.
(e) Describe the process of fertilisation and conception.
(f) Explain the role of hormones in the menstrual cycle.
(g) Describe the structure and function of the placenta.
(h) Describe the process of birth.
(i) Explain the importance of breastfeeding.
(j) Explain the meaning of contraception.
(k) State the methods of contraception.
(l) Explain the problems associated with reproduction.

Introduction

In Form One, we learnt that reproduction is one of the characteristics of living things. Reproduction is the process by which living things produce new individuals of their species.

In this unit, you will learn about chromosomes, mitosis and meiosis. You will also learn the human reproductive system and its functions. You will get to understand the role of hormones in the menstrual cycle, the process of birth and methods of contraceptives. Finally you will get to understand the problems associated with reproduction.

The process of reproduction is very important. It enables the survival of species on earth. Through reproduction, organisms produce new members of their species. Without reproduction, organisms would all die due to the absence of replacements by young or new organisms. As a result, they would eventually become extinct.

Structure and function of chromosomes

Activity 9.1: To examine chromosome structure in prepared microscope slides

Materials

- Prepared microscope slides of chromosomes in cells.
- Microscope.

Procedure

1. Place the provided microscope slide of chromosomes in cells on the microscope stage.
2. Adjust the lower power objective lens to position and observe.
3. Repeat with the medium and high power objective lens.

Questions

1. What do you observe inside the nucleus?

In Form One, we learnt that cells contain a nucleus which controls and regulates all the activities of the cells and heredity, (passing on characteristics from parents to offspring). The nucleus is able to do all these because it has structures called chromosomes. Chromosomes are thread like structures in the nucleus of plant and animal cells.

All cells are formed from already existing cells by a process of cell division. When a cell is not dividing to form new cells, its chromosomes are not visible under the light microscope. It is said to be at rest. The chromosomes become visible only during cell division. This is because before the cell divides, each chromosome thread coils up to form a compact

chromosome. When stained, such chromosomes are visible under the light microscope as shown in the diagram below.

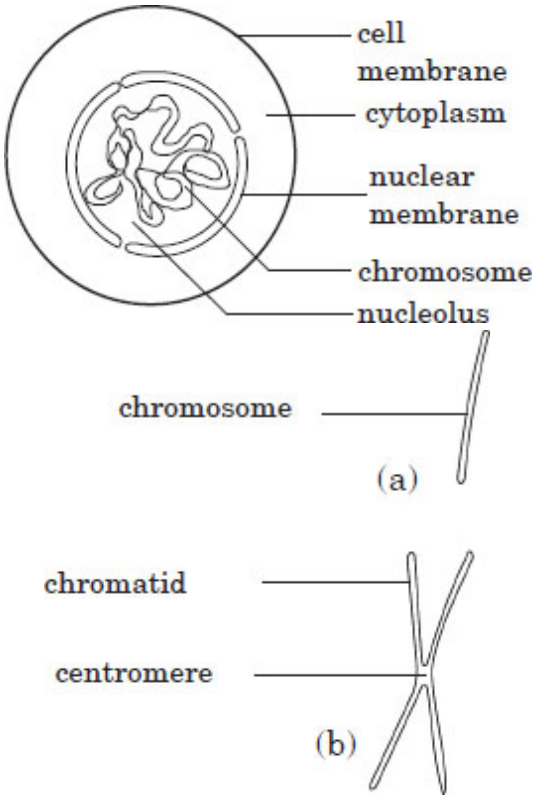


Fig. 9.2: A chromosome and chromatids

The thread-like chromosomes coil up tightly to form thicker, shorter and more compact chromosomes. Just before cell division, they also appear to have split along their lengths to form two similar strands joined at their centres.

These two strands are called **chromatids** and they are joined at a point called the **centromere** as shown in Fig. 9.2.

Note:

(i) The coiling is not visible

(ii) When the two strands are attached at the centromere, they are chromatids of the same chromosome. When they are separate, they are each called a chromosome.

The two chromatids are exact copies of each other. During the process of cell division, the two chromatids separate with each going into a separate cell as we shall see later.

The number of chromosomes in the nucleus of a plant or animal cell varies according to the species. For example, in humans, it is 46 in the body cells in 23 pairs. Chromosomes are present in the nucleus in pairs. These pairs are called **homologous pairs.**

Homologous pairs of chromosomes have the same length and shape but with different genetic composition.

Chromosome numbers also vary according to the type of cells in the organisms. The difference in number of chromosomes in the same organisms depends on if the cell is a normal body cell or a reproductive cell. Reproductive cells are called **gametes;** examples are sperms and ova in humans.

The body cells are sometimes called **somatic cells.** These are cells like nerve cells, blood cells, bone cells and muscle cells, in humans.

In every organism that forms reproductive cells or gametes, the number of chromosomes in the nuclei of the gametes is always half of that in the body or somatic cell. For example, in humans, the body cells have 46 chromosomes, then the sperms or ova have 23 chromosomes.

We shall now look at how cells divide.

Mitosis

We have learnt that all cells are formed from already existing cells. This is possible because some cells are capable of dividing to form new cells. Cell division is the general term used when existing cells divide to form new cells. In reproduction, cell division is very important because it is responsible for the formation of new individual organisms.

Mitosis is the process by which the nucleus of the body or somatic cell first divides into two daughter nuclei.

Activity 9.2: To examine stages of mitosis using squashed young onion root tip

Materials

- Germinating onions
- 1M hydrochloric acid

- Test-tube
- Microscope
- Microscope slide
- Water
- Orcein dye
- Tile
- Scapel
- Glass rod
- Cover slip
- Blotting paper
- Forceps

Procedure

1. Cut off 0.5 cm from the end of a root tip of the onion.
2. Place it in a little 1M hydrochloric acid which has been heated to 60^{o}C in a test-tube.
3. Leave for 10 minutes.
4. Remove the piece of root tip using forceps and wash it in water.
5. Place it on a microscope slide and remove excess water.
6. Place a small drop (0.5 cm diameter) of orcein stain on the tip just enough to prevent it from drying up. Orcein dye is used to stain chromosomes to make them visible.
7. Tap the root tip gently with a glass rod until no particles are seen. Remove any particles big enough to be seen. What is left should be a suspension of separated cells.
8. Lower a cover slip and leave for 10 minutes.
9. Use blotting paper to absorb any excess liquid. Avoid lateral movement of the slide.
10. Examine the preparation carefully under the high power objective lens of the microscope.

Questions

1. Can you see any chromosomes?
2. What is the appearance of the chromosome?
3. Are they all of the same size?
4. Are they single structures?
5. Have they taken up the stain all over?
6. Try to count the number of chromosomes in the cell in your preparation. What is the number in the onion?
7. Can you see some chromosomes that appear to split lengthwise into two?
8. Can you see separated chromatids?
9. Do you notice cells at different stages of mitosis?

   Look out for cells that you think are at interphase. Describe the appearance of such cells.
10. Identify two cells that are in each of the following stages of mitosis: prophase, metaphase, anaphase and telophase. Give one reason why you are able to identify a cell in each of these phases.
11. Draw one cell in each of these phases and arrange the drawings in their correct sequence of the process of mitosis. Label as many structures as you are able to identify.

Discussion

The nuclei in the cells you have observed are undergoing mitosis. The chromosomes are not separately visible in the nucleus of a cell which is not dividing. When the cell is about to divide, the chromosomes first appear as a tangled mass of fine threads in the nucleus. Cells in onion or plant root tips are usually dividing by mitosis.

Some chromosomes may appear as if they are split lengthways into identical halves called chromatids. You may have noticed some are chromosomes arranged in a more or less regular manner. Some chromatids may appear to be separate from their partners and at opposite directions of the nucleus. You may also notice two sets of chromosomes with membranes around them.

You may notice that the arrangement of the chromosomes in different cells corresponds to the phases in mitosis. Chromosomes will appear thick,

short and replicated in prophase. In metaphase, they are aligned along the equator. In anaphase, the chromatids separate and move away from each other to opposite ends. In telophase, the chromatids have reached the poles of the cell as chromosomes. The nuclear membranes have reformed and the cell divides into two.

Importance of mitosis

Mitosis is important because it is responsible for the following:

- The process of asexual reproduction. This is due to the formation of new cells which retain the same number and exact copies of chromosomes as the parent cell.
- Mitosis is also the cause of growth when new cells formed increase in number and contribute to the growth of an organism.
- It is also important because when cells are damaged or die in the body, they are replaced when existing cells divide by mitosis to provide additional cells.

Most animal cells are capable of dividing by mitosis when the need arises. Plant cells however are not all capable of dividing by mitosis. Only a specialised group of plant cells called **meristem** cells are able to do so. In single celled organisms like amoeba and other actively dividing cells, the process of mitosis is cyclic. This means that when the daughter cells formed mature, they too undergo mitosis. In specialised tissue like nerve tissue, division of cells stops once the cells mature.

This is why certain injuries to the spinal cord and the brain which is made up of nerve cells sometimes leave the patient paralysed permanently. This is because some of the nerves when severed, cannot be replaced. The existing nerve cells are too specialised to undergo mitosis to form replacement nerve tissue.

Each daughter nucleus ends up with a set of chromosomes, which are identical. After the nucleus divides, the cytoplasm then divides. This results in two cells that can exist independently.

A simple way of understanding mitosis is by first following what generally happens to the chromosomes in the nucleus before following it up with what is also going on in the entire cell.

Normally, chromosomes only become clearly visible during cell division. The following is an outline of the main events that involve only the chromosomes in an imaginary cell with two chromosomes. Note that we will ignore the structure of the rest of the nucleus and the cell contents.

(i) Each chromosome duplicates itself by dividing into two strands called chromatids before the cell divides. The chromatids lie side by side and are joined together at a point called a centromere.

(ii) These chromatids then separate from each other.

(iii) Each chromatid is then called a chromosome and it goes into one of the new daughter cells.

This way, it is possible for one set of chromosomes to be apportioned into each daughter cell that is formed when cells divide by mitosis. This means that each daughter cell can retain the original number of chromosomes in its nucleus.

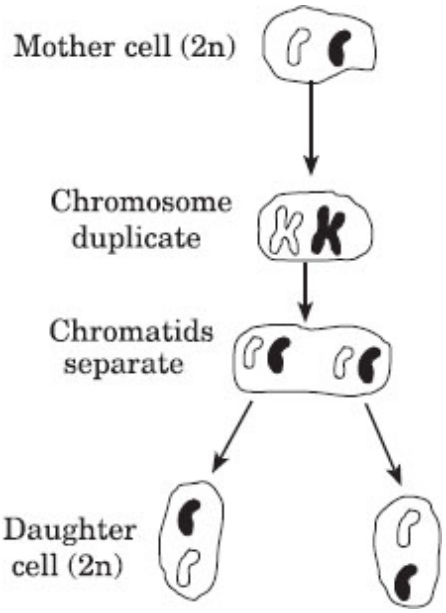


Fig. 9.3: A generalisation of the process of mitosis.

Meiosis

Meiosis is a type of cell division which reduces the number of chromosomes in a cell by half in order to form gametes (sperm and ova).

Activity 9.3: To examine stages of meiosis in the anthers of a flower

Materials

- Immature anthers that are still enclosed inside the flower buds for example, lily
- Acetic orcein dye; ten parts dye to one part HCl slides and cover slips
- Mounted needles
- White tile and hand lens
- Glass rod
- Filter paper tissue means of warming
- Forceps.

Procedure

- Take a flower bud and remove the enveloping sepals and petals. Expose the anthers. Do this on a white tile using a needle and forceps.
- Use a hand lens to help you identify the anthers.
- Remove one anther and place it onto a clean microscope slide.
- Add two drops of acidified acetic orcein dye.
- Squash the anther with a glass rod for a while, and leave for a minute for the strain to penetrate the tissue.
- Place a cover slip and press downwards gently.
- Examine the slide and look out for cells that have nuclei that is under division.
- Try to locate and identify the chromosomes in different cells.

Questions

1. Are there chromosomes that appear to have replicated?
2. What similarities and differences do you notice in various cells with reference to:
   (a) The chromosomes?
   (b) Positions of the chromosomes?
   (b) Phases?
3. Identify cells that are in the following phases of division.

(a) Metaphase: (chromosomes aligned along the equator) is this alignment the same as it was in mitosis. If so, state how?

(b) Do the same for anaphase and telophase.

Discussion

Meiosis takes place in the reproductive organs to produce gametes. In a flower, it would be in the anthers and ovaries. In animals, it would be in the gonads.

Meiosis is very different yet similar to mitosis as you are about to learn. However as you probably noticed in the practical, certain phases like metaphase, anaphase and telophase appear in meiosis with some similarities as well as differences to similar phases in mitosis.

The original cell first divides into two cells. Each cell then divides further into two cells forming a total of four cells. Each of the four cells has half the number of chromosomes as the original. The four daughter cells are therefore **haploid.** These cells are similar but not identical. The process of meiosis occurs in two cell divisions.

For example, in humans, the full set of 46 chromosomes is halved to 23 during meiosis when sperms and eggs form.

When the egg and sperm unite, they each contribute 23 chromosomes and the resulting embryo will have the normal 46 chromosomes (23 pairs).

Meiosis also allows exchange of portions of chromosomes when the cells are dividing. This leads to genetic variation in offspring.

Meiosis occurs when gametes (reproductive cells) are formed. These gametes are formed in special organs that make reproductive cells.

In humans, the reproductive cells are formed in the gonads; the testes in the male and ovaries in the female. In forming gametes, special somatic cells in the gonads undergo meiosis. In the testis, the resulting daughter cells are called **sperms** or **spermatozoa** and in the ovaries they are called **ova** or **eggs.** In meiosis, two divisions of the nucleus and the cell occur. These are first meiotic division and the second meiotic division. Just as we did in mitosis, we will first look at the outline of events that happen only to the chromosomes in an imaginary cell with two chromosomes.

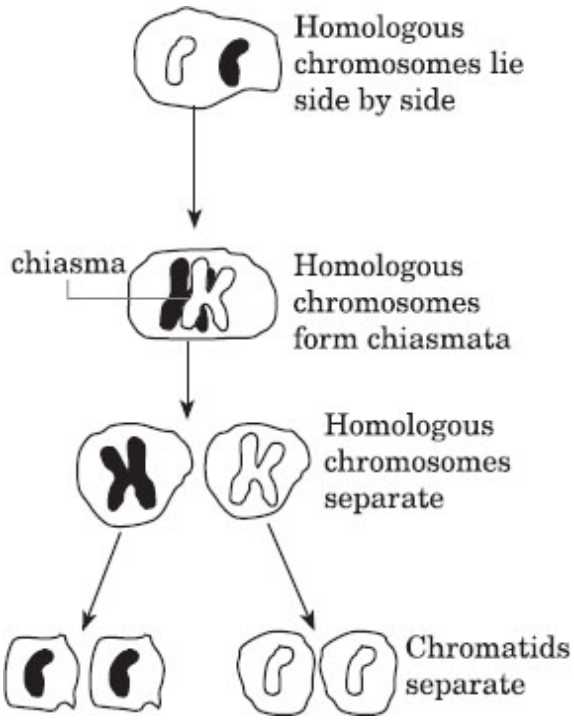


Fig. 9.4: A generalisation of the process of meiosis

(i) The chromosomes inside the nucleus split into two chromatids and the homologous chromosomes pair up.

(ii) The homologous chromosomes separate, and the first meiotic cell division occurs.

(iii) The chromatids separate to form chromosomes and the second meiotic division takes place in a process similar to mitosis.

This is how it is possible to form a total of four daughter cells during cell division, each with half the number of chromosomes that the parent cell had that is, the haploid number. Let us now study the whole process of meiosis as it involves the whole cell.

The stages of meiosis

The stages of meiosis form a cycle of events which can be divided into the following.

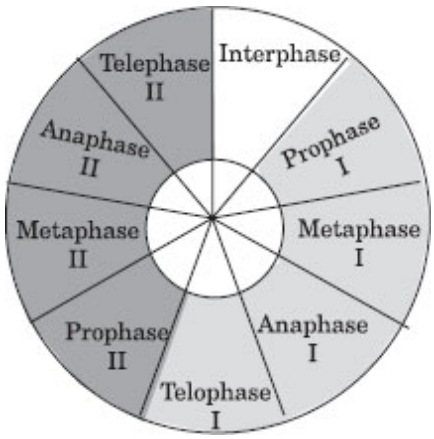


Fig. 9.5: The cycle of meiotic division and stages that occur during meiosis

1. First meiotic division *(Meiosis I).*
   - Prophase I
   - Metaphase I
   - Anaphase I
   - Telophase I
2. Second meiotic division *(Meiosis II).*
   - Prophase II
   - Metaphase II
   - Anaphase II
   - Telophase II

The symbols I and II represent the first and second meiotic divisions. The interphase stage occurs between the two cell divisions.

Interphase

In interphase, as shown in mitosis, the cell is not dividing. The chromosomes are not visible. The chromosomes and cell organelles replicate.

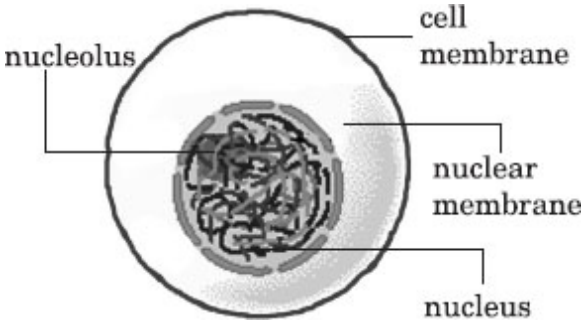


Fig. 9.6: Meiotic interphase

Prophase I

Prophase I starts when the chromosomes contract and shorten becoming more clearly visible. The nucleolus disappears. The homologous chromosomes pair up. Each pair is called a **bivalent.** After that, each chromosome is seen to be clearly made up of two chromatids which are not clearly visible during interphase as shown in the following to diagram.

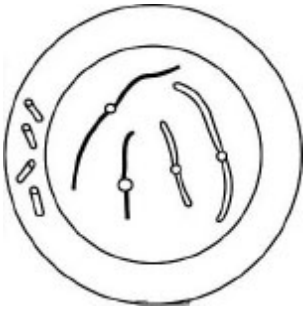


Fig. 9.7: Chromosomes visible

Chromatids of homologous chromosomes may then wrap around each other and become joined at certain points called **chiasmata** (singular: Chiasma).

One (or both) of the chromatids of the two homologous chromosomes may break at these points and link up with the chromatid of the other chromosome in the bivalent at points called **chiasmata.** Formation of chiasmata ensures that the portions of chromosomes are exchanged in a process called **crossing over.**

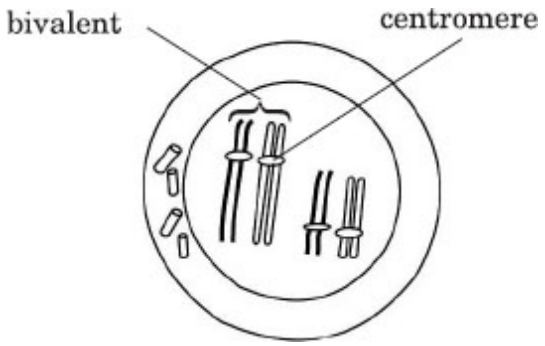


Fig. 9.8: Chromosomes split into chromatids.

Metaphase I

In metaphase, the spindle is fully developed. The bivalents (pairs of homologous chromosomes) move to the equator of the spindle and arrange themselves as pairs. (Note: Some have exchanged portions).

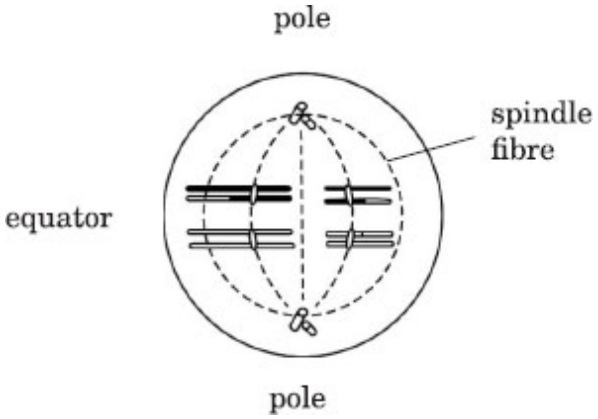


Fig.9.9: Metaphase I

Anaphase I

As the spindle fibres which are attached to the centromeres contract. The homologous chromosome (bivalent pairs) are pulled apart and separated because of the action of the spindle fibres. One chromosome in each pair of chromosome is pulled towards one pole and the other pair to the other pole. **Note:** Each chromosome is replicated to form chromatids.

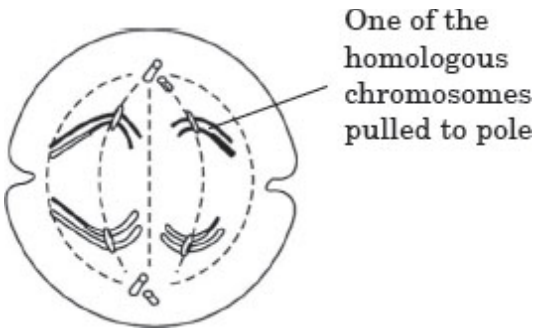


Fig. 9.10: Anaphase I

Telophase I

The spindle disappears. The nuclear membrane may reform around the two sets of chromosomes. When the chromosomes reach the poles, the cell divides into two new cells each with half the number of chromosomes as the original cell This is shown in the diagram below.

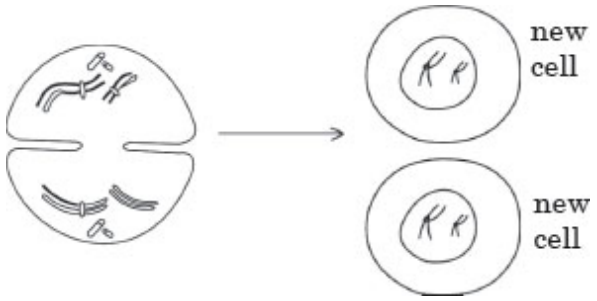


Fig. 9.11: Cell divides into two new cells

Sometimes the nuclear membrane does not form around the two sets of chromosomes at the poles and prophase II follows immediately. At other times the daughter cells go into a short 'resting' interphase. At this point, let us note that the first meiotic division separates the homologous chromosomes into two daughter cells.

Prophase II

At this point, the appearance of the chromosomes are as would be expected in prophase during mitosis that is, replicated into chromatids.

Metaphase II

The centrioles replicate and a new spindle is formed in each new cell. The chromosomes (with their chromatids) arrange themselves singly on the equator of the cell. The spindle fibres attach themselves to the centromere of each chromosome.

Note: The chromatids are still attached to each other at the centromeres as shown below.

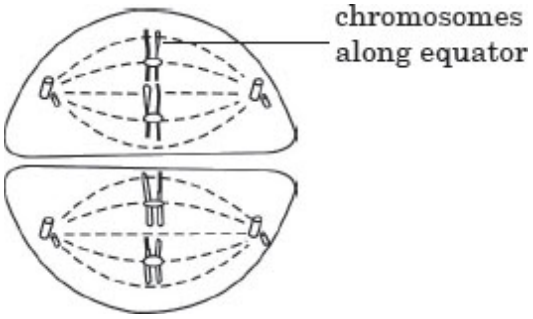


Fig. 9.12: Metaphase II

Anaphase II

Chromatids of each chromosome separate and are pulled to opposite poles of the cell.

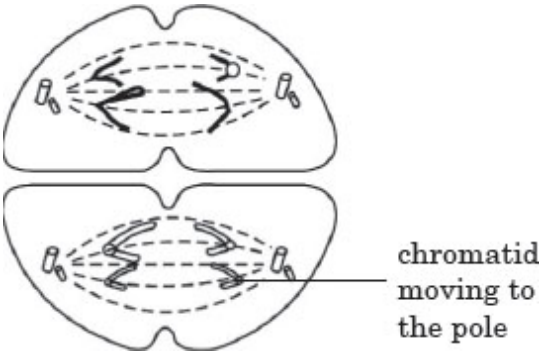


Fig. 9.13: Anaphase II

Telophase II

The cells constrict along the middle and four new cells form. The nuclear membranes and nucleoli reform. The chromatids are now known as chromosomes. They unwind and soon become thin and indistinct. The spindle disappears. The daughter cells have half the number of chromosomes of the original parent cell.

Note that at this point, the second meiotic division separates the chromatids from each other into new cells (just like in mitosis). The result is four new cells each with half the number of chromosomes of the original parent cell.

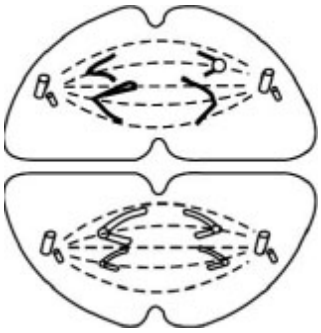
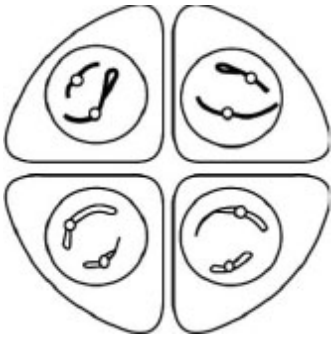


Fig. 9.14(a): Early telophase: The chromatids separate and move to the opposite poles



(b) Late telophase:Each cell divides into two resulting to four haploid daughter cells.

Fig 9.14: Stages of telophase

The four daughter cells formed at the end of the process of meiosis are not gametes. These cells undergo the process of differentiation to form specialised cells called gametes.

In animals, for example in humans, the daughter cells become specialised to form sperms in males and ova or eggs in females.

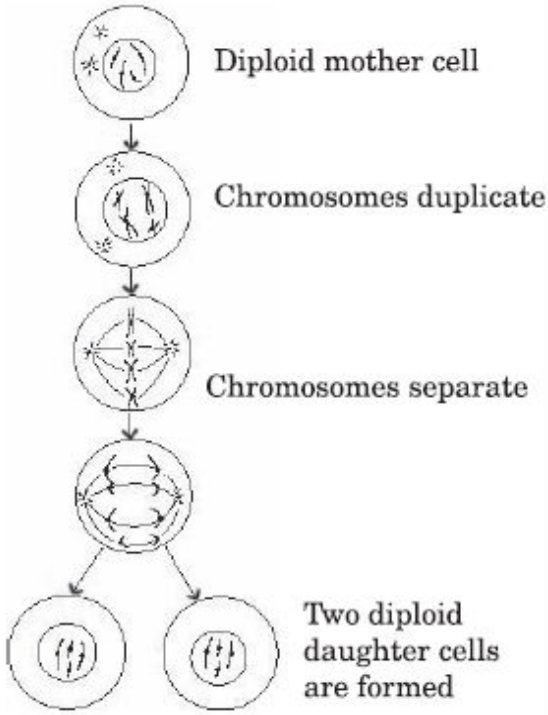
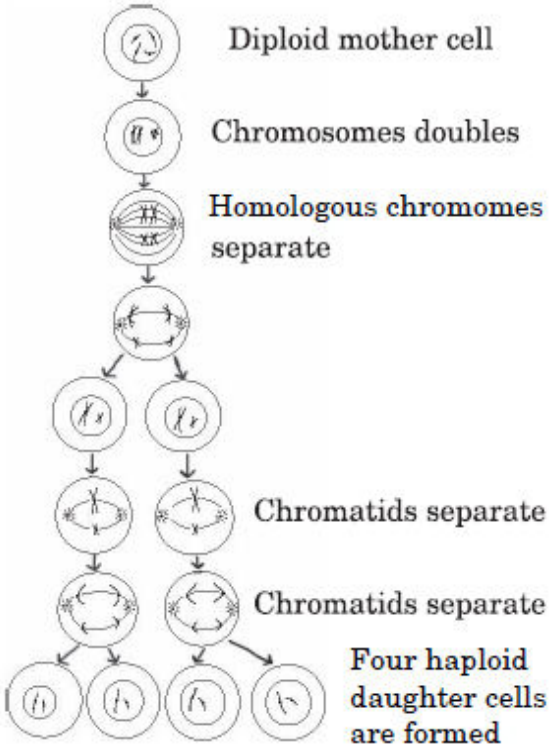
In flowering plants, the daughter cells eventually form specialised structures called ovules in the female part of the flower and pollen grains in the male part of the flower.

Table 9.1: Comparison of mitosis and meiosis

Mitosis	Meiosis
Two daughter cells formed.	Four daughter cells formed.

Daughter cells are identical to the parent.	Daughter cells are not identical to the parent.
The number of chromosomes are retained.	The number of chromosomes are retained.
Homologous chromosomes do not pair up.	Homologous chromosomes pair up in prophase I.
Chiasmata does not form and no crossing over occurs.	Chiasmata form and crossing over may occur.

Table 9.2: Summary of mitosis and meiosis

Mitosis	Meiosis
 *Summary of mitosis.*	 *Summary of meiosis.*

The significance of meiosis includes;

(i) Large numbers of possible arrangement of chromosome pairs at metaphase I, which increases the possible combinations of chromosomes in the gamete cells produced.

(ii) Crossing over during prophase, this enables the exchange of corresponding segments between two homologous chromosomes.

Structure and function of the human reproductive system

In males, these structures are suited to produce the male gametes and introducing them into the female's reproductive system. In females, the structures are suited to making female gametes and receiving male gametes. The reproductive structure in humans just like in other mammals is closely associated with part of the urinary system. These systems together are sometimes referred to as the **urino-genital system.**

Structure of the female reproductive system in humans

Study the structure of the female reproductive system as shown in Fig. 9.15.

The main structures that make up this system are the ovaries, oviducts or fallopian tubes, uterus, cervix and the vagina.

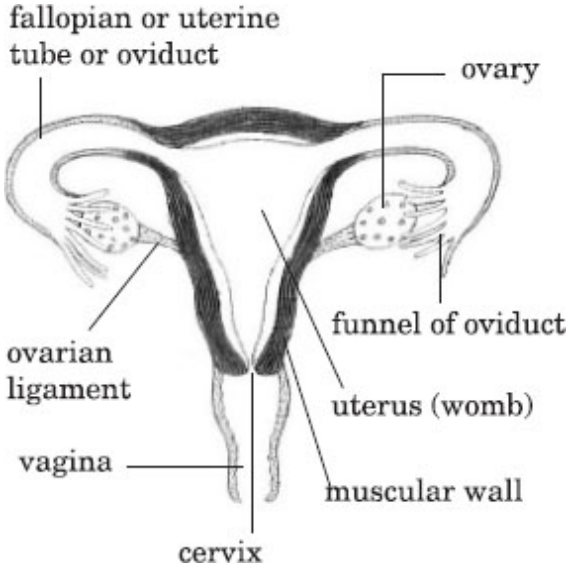


Fig. 9.15: The female reproductive system

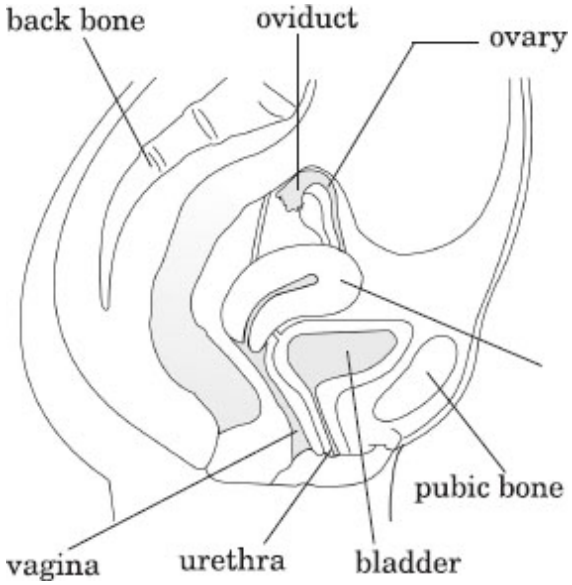


Fig. 9.16: Longitudinal section of a female reproductive system

Functions of parts of the reproductive systems

The female reproductive system

Ovaries

There are two ovaries in the mammalian female. They are located one on the left side of the uterus and the other on the right. They are suspended in the abdominal cavity by ligaments. Female gametes which are also known as eggs or ova are made here.

Inside the ovaries are egg cells at different stages of development. A baby girl is born with egg cells that are just starting to develop. Each month after puberty, one of these cells completes its development into an ovum.

During development, each egg cell is in the form of a graafian follicle. The **graafian follicle** is a fluid-filled structure containing one egg cell surrounded by a few cells known as follicle cells.

In humans, one egg is usually released once every month from alternating ovaries. The ovaries also secrete female sex hormones, oestrogen and progesterone.

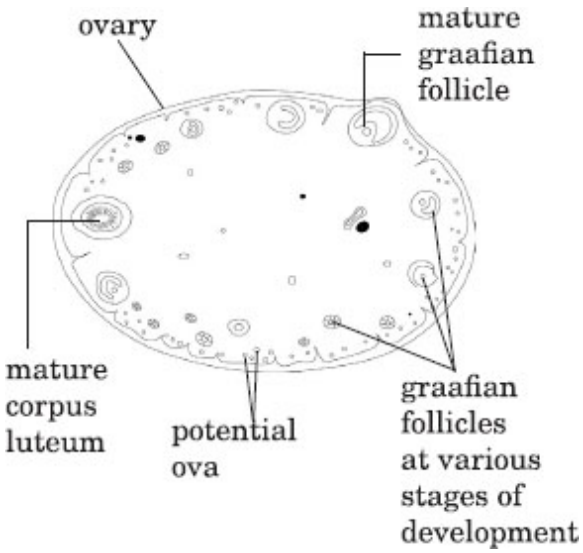


Fig. 9.17: Section through ovary with ova at various stages of development

Oviducts or fallopian tubes

These are tubes which lead from the ovaries to the uterus. It is through these tubes that the ova travels from the ovaries to the uterus.

Each tube has an open ended funnel shaped part which lies next to the ovary. Note that it is not attached to the ovary. The lining of the oviducts has ciliated cells. The movements of the cilia transports an egg cell towards the uterus. Fertilisation takes place in the oviducts.

Sexually transmitted infection of the oviducts may result in their becoming scarred and blocked. This may cause sterility. If a fertilised egg implants itself in the oviducts, a tubal or ectopic pregnancy occurs. If the situation is not diagnosed and treated early the tube ruptures and severe internal bleeding occurs which can cause death.

Uterus or womb

This is a hollow thick walled muscular organ with the size and shape of an inverted pear. It has a space inside it known as the ***uterine cavity.*** The outer layer of the uterus wall has thick muscles that contract strongly during birth. The inside layer of the uterus wall is made up of many blood vessels. It is called the **endometrium.** The uterine cavity leads to a canal, the cervical canal which extends to form a ring of muscle in the cervix. The cervix opens into the space of the vagina.

A fertilised egg implants itself in the thickened endometrium. The uterus contains a developing embryo during pregnancy until birth. It also enlarges during this time to occupy a large space in the abdomen. It shrinks rapidly immediately after childbirth.

Cervix

This is the narrow entrance to the uterus from the vagina. It is also sometimes referred to as the mouth of the uterus. It has a ring of muscle to close it and also a mucus plug.

During pregnancy, the mucus plug seals the cervix and prevents entry of harmful microrganisms into the uterus. The ring of muscles remains contracted to keep the baby in the uterus. During birth, the ring of muscles relaxes to allow the baby to pass through to the world.

Vagina

It is a muscular tube, leading from the cervix. The penis is placed here during sexual intercourse. It stretches during childbirth to allow the passage of the baby. The vagina opens to the outside through the vulva a general name for the external genital organs.

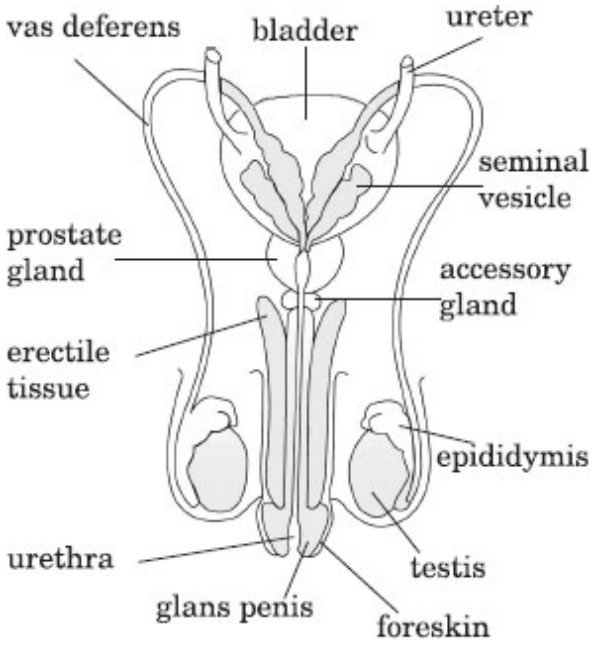
Table 9.3: Summary of the human female reproductive system

Part	Function
Ovaries	Produce eggs
Vagina	Receives sperms
Oviducts (F.T)	Where fertilisation occurs
Uterus	• Supports development of embryo • Expels developed foetus at birth
Ovaries	Produces oestrogen

The male reproductive system

The male reproductive system consists of the following main structures. The testes, (singular testis), scrotum or scrotal sac, seminiferous tubules, vas defferens (singular vas deferentia), epididymis, urethra, penis, Cowper's

gland, prostrate gland, seminal vesicles. Study *Fig. 9.18(a)* and *Fig. 9.18(b)* which shows the male reproductive structures.



(b) front view

Fig. 9.18(a): The male reproductive system

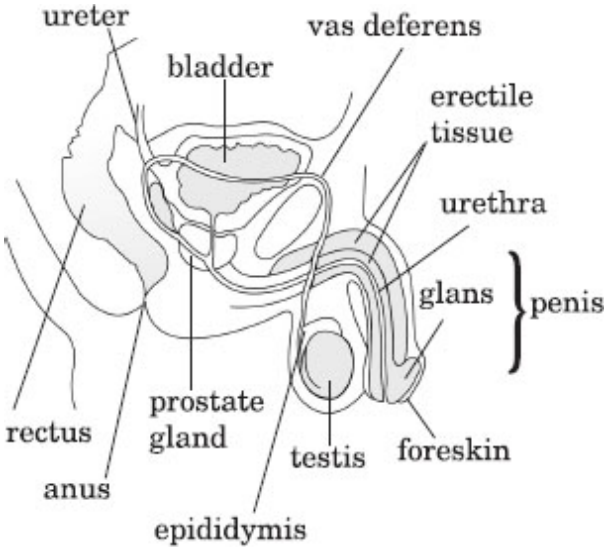


Fig. 9.18(b): side view of a male reproduction system

Functions of parts of the male reproductive system

Testes

There are two testes in the male reproductive system. They are the male gonads where male gametes or sperms are made. They also have a second function. They produce the male sex hormone testosterone.

The scrotal sac or scrotum

The testes are positioned outside the abdomen in a sac of skin called the scrotal bag or scrotum. The scrotum is suspended immediately beneath the base of the penis. The function of the scrotum is to support and protect the testes. It also ensures that the testes are located at a lower temperature than that of the body. This is because sperms require temperatures slightly lower than that of the body for their production. High temperatures reduce the lifespan of sperms.

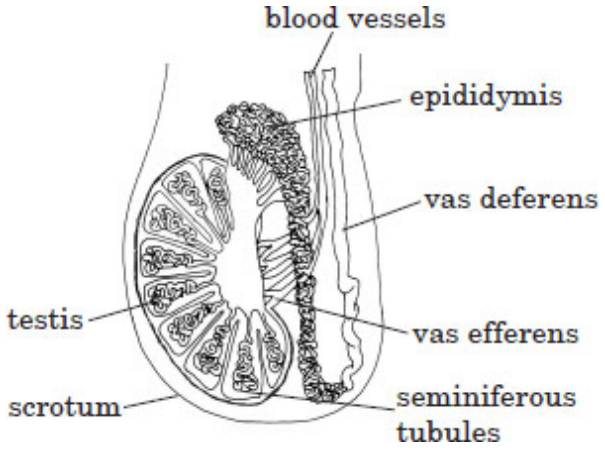


Fig. 9.19: Internal structure of the testes

Seminiferous tubules

Each testis contains in it tightly coiled seminiferous tubules. The walls of these tubules have specialised cells that produce sperms or spermatozoa. Other specialised cells located in between the seminiferous tubules are known as *interstitial cells* which produce and secrete the hormone testosterone.

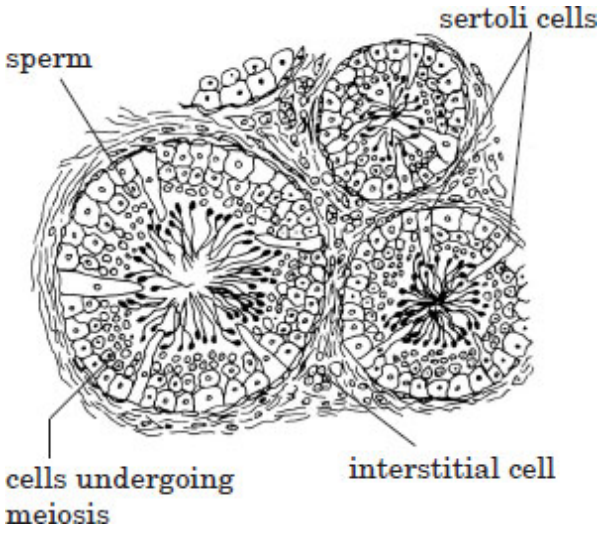


Fig. 9.20: Cross-section of seminiferous tubules with sperms

In the seminiferous tubules, cells known as *sertoli cells* provide nourishment to the developing sperms.

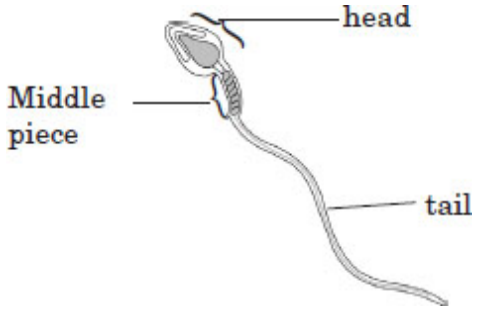


Fig. 9.21: A sperm cell

Vas efferentia

These are tiny tubes that direct the sperm from the seminiferous tubules to the epididymis.

Epididymis

This is a coiled tube in which the sperms continue to develop and mature. They are stored here for some time. It is a muscular tube.

Vas deferens (Plural; vas deferentia)

This is a straight muscular tube which directs sperm to the urethra. Before it joins the urethra, it combines with the duct leading from the seminal vesicle forming the ejaculatory duct.

Urethra

This is a tube that *directs urine* from the bladder as well as *sperm* from the vas deferentia out of the male body via the penis at different times.

Therefore, the urethra plays a role in both the urinary and reproductive systems of the human male. It is therefore said to be urino-genital in function.

Penis

The penis is a part of the reproductive system as well as part of the urino-genital system. This is because it contains a tube the urethra, which terminates into it. It conveys urine and sperms at different times. As part of the reproductive system, its role is to deposit sperm into the vagina of the female. This is possible due to the presence of specialised tissue known as *erectile tissue.*

This tissue has spaces that fill up with blood during sexual excitement causing the penis to become rigid and erect a process known as *erection.* This way, it can penetrate and deposit sperms into the vagina. The tip of the penis is called the *glans.* It has sensory neuron endings that are stimulated by friction to cause the expulsion of sperm with fluid known as *semen* through the process of ejaculation.

There is a foreskin or a prepuce which covers the glans. This skin maybe removed during circumcision.

Circumcision should be done by qualified persons preferably medical doctors to prevent injury that can cause excessive bleeding which may lead to death.

The instruments used should be sterile and they should NOT be used on more than one person before sterilising due to the possibility of infection with HIV and AIDS.

Accessory glands

The seminal vesicles, a pair of cowper's glands and prostrate gland are sometimes referred to as accessory glands.

- *Prostrate gland*

This gland secrets mucus and a slightly alkaline fluid that is released during ejaculation. It makes sperms more active and neutralises the acidity of the vagina.

- *The cowper's glands* secrete a clear, sticky slightly alkaline fluid which cleans the urethra prior to ejaculation by neutralising any urine present.
- *The seminal vesicles* produce mucus secretion which aids sperm movement. The resultant combination of secretions and sperm is called *semen.*

  Semen is made up of sperms, sugars that nourish the sperms making them more active, mucus that forms a semi-fluid liquid that the sperms can swim in, alkaline substances to neutralise the acidic conditions in the urethra and vagina and hormones which help sperms reach the ovum by causing muscular contractions of uterus and oviducts.

Fertilisation and conception

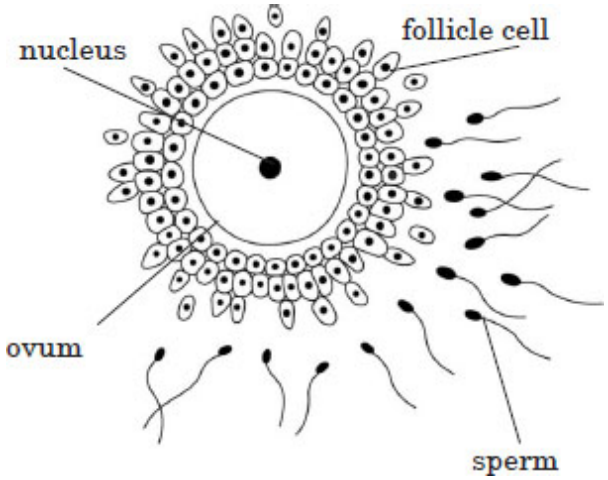
We have learnt that fertilisation in humans takes place internally. For fertilisation to take place, the egg (ovum) must meet with a sperm. Sperms are first deposited in the vagina of a female in a process called **copulation** or **sexual intercourse.**

Fertilisation

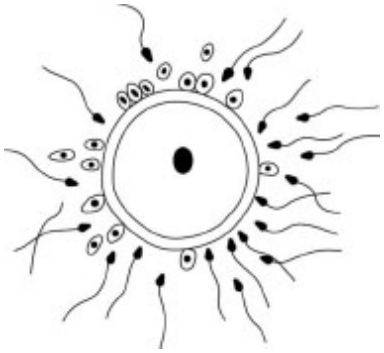
Fertilisation is the fusion of the male and female gametes. Once the sperms are ejaculated from the penis into the vagina, they swim and are also propelled through the cervix, uterus and into the oviducts where they may meet an egg. This normally occurs in the upper part of the oviduct.

When the sperms and an ovum meet, the head of a sperm sticks onto the ovum. The action of the sperm causes the follicle cells surrounding the egg to disperse. Eventually, the nucleus of one sperm passes into the cytoplasm of the ovum along with the head and middle piece leaving the tail outside.

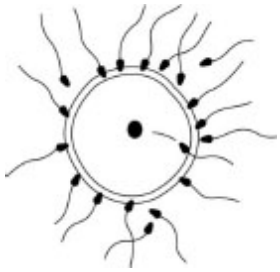
The sperm *nucleus* fuses with the nucleus of the ovum. *This fusion of the sperm and ovum nuclei is known as fertilisation.* The egg membrane changes its structure after one sperm penetrates it to prevent other sperms from entering the ovum. The fertilised ovum is called a *zygote.*



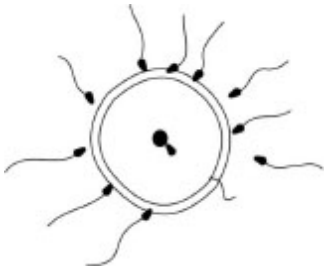
(i) Sperms meet ovum



(ii) Follicle cells dispersed



(iii) Sperm head penetrates egg membrane



(iv) Sperm and ovum nuclei fuse

Fig. 9.22: The process of fertilisation

Twins

There are two types of twins namely fraternal and identical twins. The fraternal twins are as a result fertilisation of two ova by two different sperms. The identical twins are as a result of splitting of one zygote after fertilisation.

Implantation

After fertilisation, a zygote is formed. The zygote moves down the oviduct. Movement of ovum is aided by the beating of cilia found on the oviduct. As it moves down the oviduct, it undergoes a series of cell division to form a hollow mass of cells known as the **blastocyst.** It develops fingerlike projections called **villi** which attaches it to the endometrium. It is then referred to as an **embryo.** The embryo uses the villi to absorb nutrients from the endometrium.

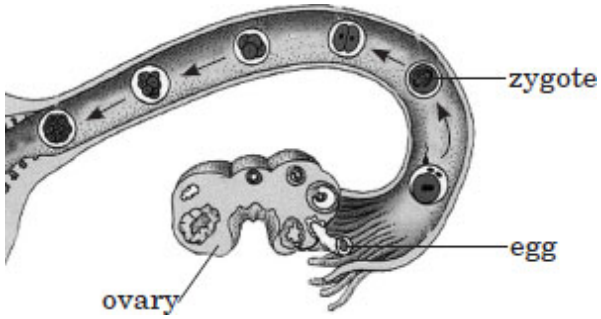


Fig. 9.23: Zygote travelling through the oviduct to the uterus

The role of hormones in menstrual cycle

Mensturation is the shedding of the uterine lining and blood through the vagina in females. Menstruation only takes place when fertilisation does not occur. All these events are under the influence of hormones.

As we will learn, these events are cyclic which means that the whole sequence repeats itself once every month in what is called the **menstrual cycle.** In this cycle, the uterus is prepared for implantation. If fertilisation does not occur, the new uterus lining and the egg are discharged from the uterus.

The average length of the menstrual cycle is 28 days. It can however be as short as 24 days or as long as 35 days. The first day of the menstrual period can be regarded as day 1 of the menstrual cycle. During this time, the

endometrium is shed from the uterus through the cervix and vagina together with some blood. After this event, four other main events occur

1. The healing and repair of the uterine lining (endometrium).
2. Ovulation; the release of ovum from the graafian follicle.
3. Thickening of the uterine lining in preparation for implantation
4. Menstruation occurs again if fertilisation does not occur.

1. The healing and repair of the endometrium (uterine lining)

After the endometrium has been shed from the uterus, the pituitary gland releases the ***Follicle Stimulating Hormone*** **(FSH).** This hormone stimulates the development of follicles in the ovary. One of these follicles develops into a Graafian follicle. Each egg in the ovary becomes surrounded by a layer of cells called follicle cells. When the follicle stimulating hormone (FSH) is released, it causes one of these follicles to undergo some change. It forms a space, accumulates some fluid, increases in size and develops into a structure called **a Graafian follicle.**

The ovary secretes ***oestrogen.*** When the oestrogen level rises in the blood to a certain point, it causes two events. One is the growth and replacement of the uterine lining shed during the previous menstruation with new tissue. This helps repair the lining of the uterus.

The second effect of oestrogen is that at its highest level in the blood, it triggers the anterior pituitary gland to release ***Luteinising Hormone.*** The luteinising hormone (LH) stimulates ovulation and the formation of corpus luteum. It also causes the Graafian follicle to change into a yellow body or a **corpus luteum.**

2. Ovulation

Ovulation is the release of the ovum from the ovary. The level of luteinising hormone rapidly rises in the blood. It triggers the process of ovulation at about the 14^{th} day of the cycle. For ovulation to take place, a mature graafian follicle moves to the surface of the ovary. It forms a bulge on the ovary surface. It then ruptures and releases the ovum as shown below.

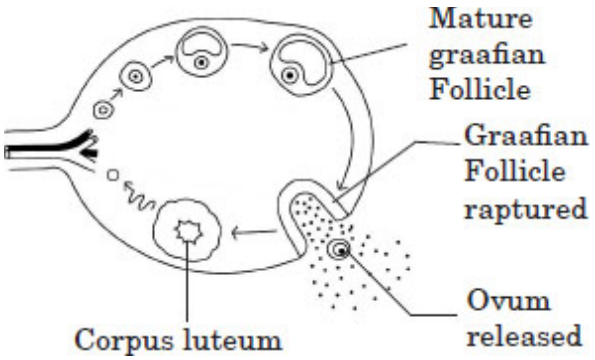


Fig. 9.24: Ovulation

3. Thickening of the endometrium

The graafian follicle secretes both oestrogen and progesterone. The progesterone causes further thickening of the endometrium during which it is enriched with blood capillaries. This is in preparation for an embryo to be implanted. By this time, the level of progesterone is quite high.

This high level of progesterone inhibits further production of the follicle stimulating hormone and also luteinising hormone from the pituitary gland. Less follicle stimulating hormone means less oestrogen from the ovary, a low level of oestrogen will cause the pituitary gland to stop releasing luteinising hormones. The high levels of progesterone ensure that the thick endometrium layer in the uterus is maintained and no new follicle develops.

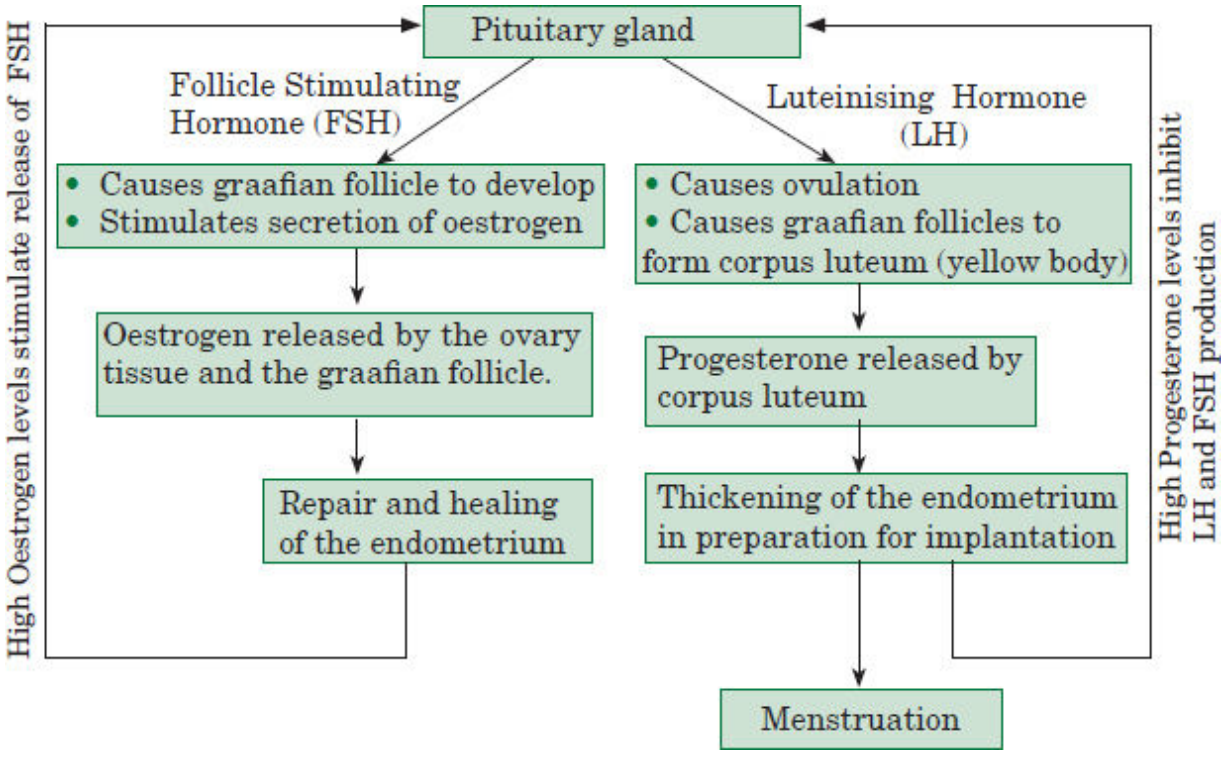


Fig. 9.25: Effects of hormones during menstruation

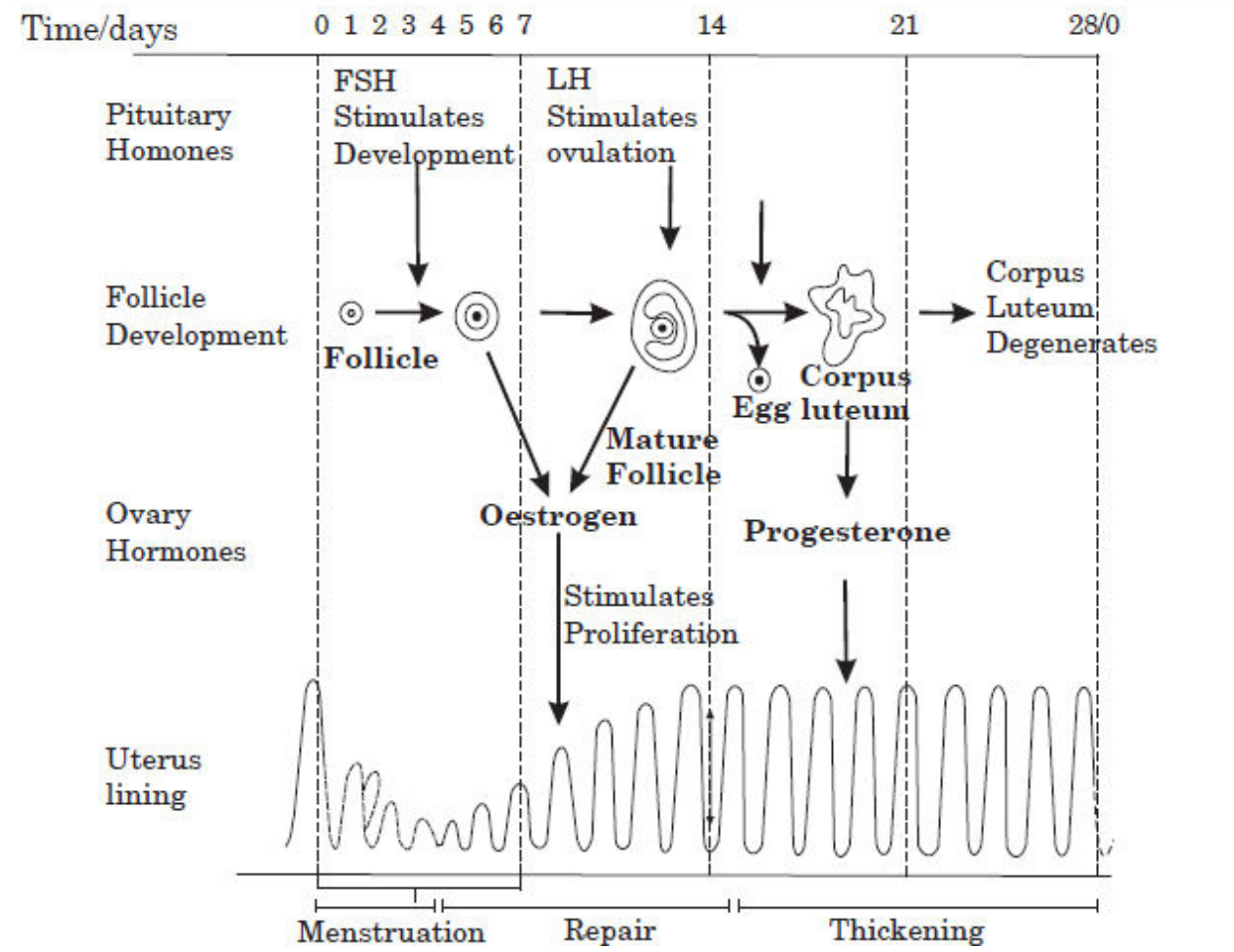


Fig. 9.26: Events in the ovaries and uterus as co-ordinated by hormones.

4. Menstruation

If the egg is not fertilised, the corpus luteum lasts for about 10 to 12 days and then it degenerates because the level of oestrogen is low causing the corpus luteum to degenerate and the secretion of progesterone stops.

The endometrium lining can no longer be maintained or protected so the capillaries break up and the endometrium is lost from the uterus with some blood. The pituitary gland starts to secrete follicle-stimulating hormone again because the levels of progesterone go down. The pituitary gland is no longer inhibited to secrete follicle stimulating hormone and the cycle repeats itself. Fig. 9.25 and 9.26 is a summary of the effects of hormones during menstruation.

The structure and function of the placenta

The villi that develops from the blastocyst represent the beginning of the placenta. The placenta is an organ that enables the transport of nutrients and oxygen from the mothers circulation to the growing embryo and waste materials like carbon dioxide away from the developing embryo to the maternal circulation. The developing embryo is referred to as a foetus after about 10 weeks.

The placenta is made up of tissues and a large number of blood vessels. It has a disc like shape. The capillaries in the placenta unite to form a vein and two arteries which run in the umbilical cord from the placenta to the abdomen of the foetus.

Note that only one of the two arteries is shown in *Fig. 9.27.* There are villi which protrude from the placenta into the lining of the uterus wall which is thick and also has a rich supply of blood.

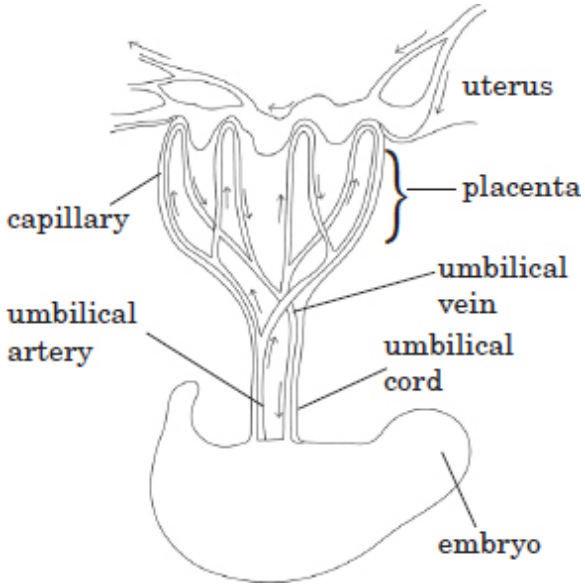


Fig. 9.27: Relationship between blood supply of embryo, placenta and uterus

There are membranes which separate the blood vessels of the mother and the foetus. These membranes are thin and hence allow dissolved oxygen, glucose and amino acids and salts in the mother's blood to diffuse into the blood vessel of the placenta. They also allow waste products such as carbon dioxide and nitrogenous wastes to pass from the placental blood vessels into the vessel of the mother.

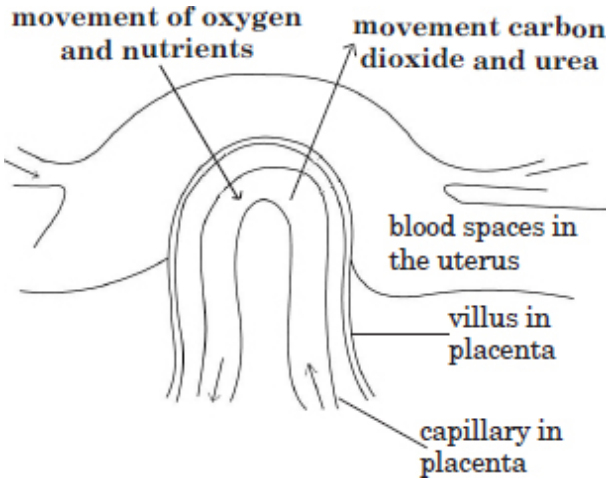


Fig. 9.28: Exchange of nutrients and wastes between blood and the placenta

Blood from the embryo is directed to the placenta capillaries through umbilical arteries. It has a high level of carbon dioxide and wastes like urea.

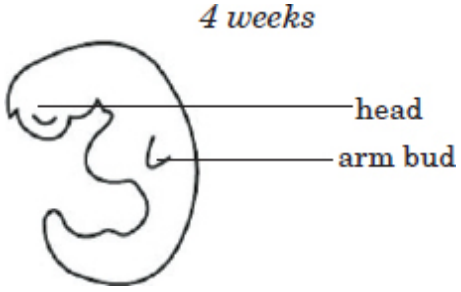
Blood rich in nutrients and oxygen which have diffused into the placenta from the mothers circulatory system are directed to the foetus through the umbilical vein.

The placenta forms the link between the circulatory systems of the foetus and the mother.

The membranes are selective in that they allow only certain materials to pass into the foetal circulation.

In this way, they prevent some harmful materials from reaching the foetus. However, substances such as drugs, alcohol and nicotine can pass through hence pregnant women are always advised not to take such harmful substances.

Another role of the placenta is to produce hormones such as progesterone and oestrogen which assist in maintaining the pregnancy and preparing the body for birth.



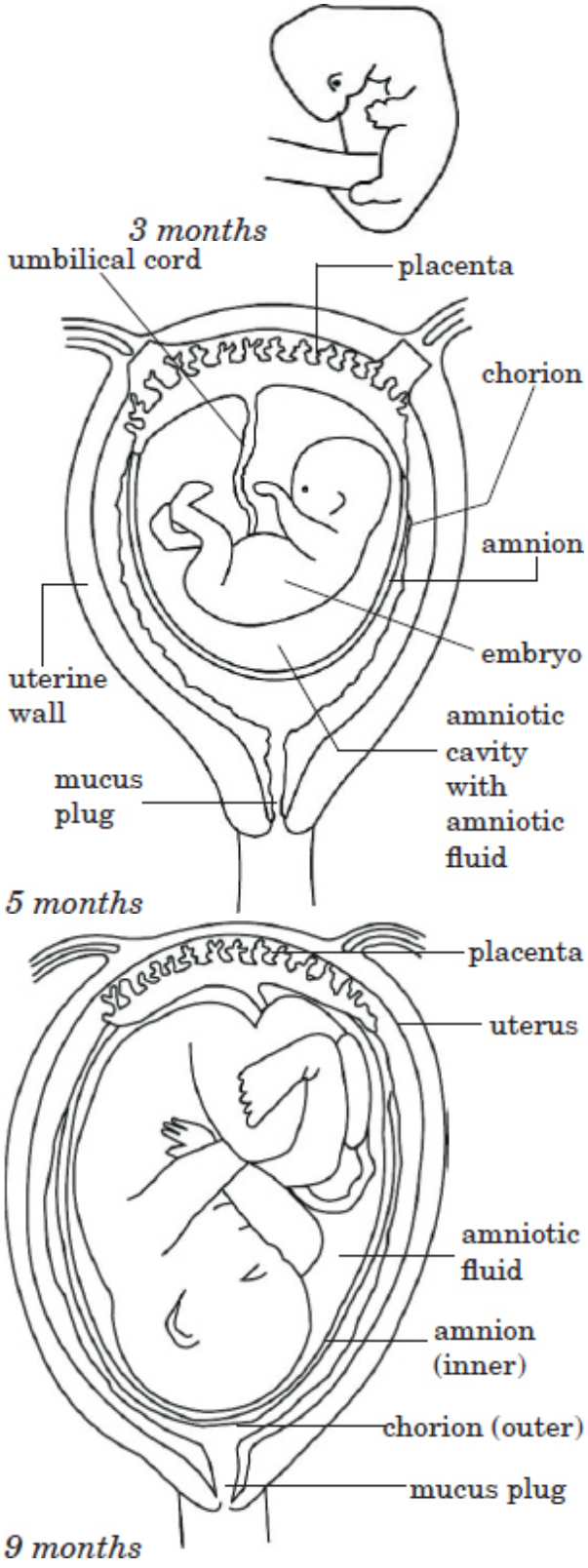


Fig. 9.29: A human foetus growing in the uterus

Gestation period

This is the period within which the embryo grows and develops into a human being. In humans, pregnancy lasts for about 38–40 weeks. In a mouse, it is 20 days, while in an elephant it is 21 months. After implantation, one part of the blastocyst develops into the embryo while the outer layer of cells of the blastocyst develops into two membranes called the **chorion** and **amnion.** These membranes surround and protect the growing embryo until birth.

The amnion being the innermost of the membranes completely surrounds the foetus like a balloon within a balloon.

A fluid called **amniotic fluid** fills up the amnion. It surrounds the foetus and keeps it moist, gives it a stable environment and cushions it from physical damage and shock. Fig. 9.29 shows the growth and development of the embryo.

The process of birth

In the last stages of pregnancy, progesterone hormone levels in the mothers blood drops. This stimulates the pituitary gland to release another hormone called **oxytocin**. Oxytocin flows in the blood to the uterus where it stimulates the muscles of the uterine wall to contract.

The waves of contraction of these muscles results to pain commonly called **labour pain.** The contractions provides a force that starts to push the foetus from the uterus to the cervix.

At the same time, the muscles of the cervix relaxes making the cervix to open and widen to allow the foetus to pass through. As the foetus moves to the cervix, the amnion and chorion walls breaks releasing the amniotic fluid through the cervix.

The foetus is pushed downwards through the cervix into the birth canal. The birth canal is elastic and it widens allowing the baby to be born.

The baby comes out through the vulva with its head first. After birth, the umbilical cord is cut by use of a clean sterilised razor to separate the baby from the placenta. The baby takes its first breath and the lungs become functional. The placenta is then eliminated from the mother's womb as the afterbirth.

Caesarean delivery

In some cases, pregnant women are not able to give birth normally. This may be due to several factors including the foetus not being in the right position or the cervix failing to widen enough to allow the baby pass through. This neccesitates a delivery through an incision in the abdominal wall and uterus.

The importance of breastfeeding

All mammals have one characteristic in common; they are able to provide parental care to their young ones. This involves provision of food and protection. Feeding involves provision of milk to the young one until it is strong enough to feed on its own.

In humans, provision of milk to the young ones is called **breastfeeding.** It starts from the first day by suckling the young one on **colostrum.** Colostrum is the first milk produced by the mammary glands. It is yellowish in colour and rich in **proteins** and **lactose.** It also contain high concentration of antibodies which provides natural immunity to the child

Mother's milk is usually rich in protein, fats, lactose, calcium and vitamins.

According to WHO (World Health Organization) every child should be breastfed for the first six months of its life without being given any other food. WHO observed that in doing so, children grow healthy and infant mortality is reduced.

Importance of breastfeeding

1. Milk contains all the nutrients needed for growth and for development of the baby.
2. Colostrum provides passive natural immunity to the infant ensuring that the infant is able to resist disease infections in its early stages as its body develops.
3. Colostrum also contain substances that cleans and activates the alimentary canal of the infant to enable it carry out digestion.
4. Milk contains a lot of calcium that enhances growth and development of strong bones and teeth.

5. It reduces infant mortality by ensuring that the infants grow without any nutritional deficiency diseases.
6. Breastfeeding in some instances is known to delay the onset of menstruation for the mother hence delaying pregnancy. This is because breastfeeding triggers the production of **oxytocin hormone** which inhibits thickening of the endometrium. When breastfeeding is intense some women are known to stay for up to a year before the normal menstruation begins again. Without menstruation a woman cannot conceive because no egg is being released. However, breastfeeding should **not** be used as a birth control method because its effect in delaying menstration occur in only few women.

Contraceptions

Contraception is the prevention of conception by natural or artificial means. Contraception is important because it allows the mother to space the birth of the children. This gives the mother enough time to regain her strength and energy and to take care of the newborn. The following are some of the methods of contraceptions.

(a) Abstinence

In this method, sexual intercourse is avoided. Its failure rate is zero, it is very effective.

(b) Vasectomy

The vas deferens of the male is cut so that sperms cannot reach the vagina. It has no side effects and is difficult to reverse.

(c) Condoms

These are made of thin rubber. In males they are put on the erect penis just before sexual intercourse. They are 90% effective, have no side effects but may tear or slip off after ejaculation. Female condoms have one closed and one open end and they fit into the vagina.

(d) Diaphragm cap

The diaphragm is a rubber which is dome shaped and fits over the cervix. It must be fitted by a doctor. It is used with a spermicide. A spermicide kills sperms. It is effective for a very short time and has a high failure rate. It

occasionally causes abdominal pain. It must be left in place for some length of time after intercourse. It is 85% effective. It should be checked for a proper fit every six months by a doctor.

(e) Contraceptive pill

The pill contains hormone oestrogen and progesterone. It prevents the development of the egg and ovulation from taking place by interfering with the production of FSH hormone during the menstrual cycle. It is very reliable but has many side effects such as fluid retention, weight gain, nausea, increased risk of blood clotting and headaches.

(f) Intra-uterine device (IUD)

In this method, small copper, plastic or steel devices are put into the uterus through the vagina by a doctor, and left there. They prevent implantation. The device may come out and may cause bleeding or discomfort. It is highly effective.

(g) Tubal ligation

This involves the cutting of the oviduct in females. This hinders the movement of the ova through the oviduct. This ensures no fertilisation takes place. This is a permanent method hence it is highly effective.

(h) Norplant

This is the placement of a contraceptive pill just beneath the skin on the upper side of the arm of the woman. The contraceptive are released continually for a period of upto five years. The norplant can be removed by a qualified medical person when the woman wants to bear children. It is a very reliable and effective method.

Problems associated with reproduction

Sterility

This is the inability of an individual to reproduce. It is the permanent inability to produce offspring. The problem may be inherited or it may develop due to external factors. It may involve the following:

- Poorly developed reproductive organs
- Failure of reproductive organs to produce gametes.

Sexually transmitted infections (STI's) and sexually transmitted diseases (STD's)

STI stands for Sexually Transmitted Infections. STD stands for Sexually Transmitted Diseases.

Examples of common STIs/STDs include:

- Gonorrhoea
- Syphilis
- Chlamydia
- Genital herpes
- Trichomoniasis
- Candidiasis
- Genital warts
- Hepatitis B
- HIV and AIDS
- Chancroid

Sexually transmitted diseases are also called **venereal diseases.** They are associated with serious health effects if untreated. In the following sub-unit, the most common STDs and STIs are discussed in detail.

1. Gonorrhoea

(a) Cause

Gonorrhoea is caused by a bacteria known as *Neisseria gonorrhoea.* The bacteria affects urethra in males and the vagina in females.

(b) Mode of transmission

- Having sexual intercourse with infected persons.
- At birth for newborn babies if the mother is suffering from the disease.

(c) Signs and symptoms

In females:

1. Pain in the lower abdomen.
2. Menstrual problems.

3. Discharge of pus from urethra.

In males:

1. Yellowish discharge from urethra.
2. Pain while passing out urine.

(d) Effects

1. Blockage of sperm ducts or oviduct which leads to sterility.
2. Destruction of red blood cells thereby causing anaemia.
3. Destruction of the liver cells causing jaundice (yellowing of eyes and skin).

(e) Prevention and control

1. Abstaining from sex before marriage.
2. Early diagnosis and treatment using antibiotics.
3. Health education to the community to avoid spread.
4. Engaging in safe sex through the use of condoms with one faithful partners.

2. Syphilis

(a) Cause

Syphilis is caused by a bacterium called *Treponema pallidum*. Like gonorrhoea, it also affects the urethra and the vagina and is more serious than gonorrhoea.

(b) Transmission mode

1. Through sexual intercourse with an infected person.
2. At birth to newborn babies by infected mother.

(c) Signs and symptoms

Syphilis occurs in three phases. Each phase is characterised by different signs and symptoms as follows.

(i) First phase

Painful sore appears on the cervix or the tip of penis (chancre).

(ii) Second phase

- Rashes appear on the skin
- Falling of hair
- Mild fever
- Enlarged lymph nodes.

The patient is highly infectious at this stage.

(iii) Third phase

- This is a fatal stage where infection reaches the nervous system and body organs destroying them.
- Can cause paralysis, blindness and/or madness.
- Death may eventually occur.

(d) Effects

1. Heart diseases.
2. Blindness and insanity.
3. Paralysis.
4. Death.

(e) Prevention and control

(i) Engaging in safe sex for example by use of condoms.

(ii) Abstaining from sex before marriage.

(iii) Health education to create awareness in the community.

(iv) Treatment with antibiotics for example, penicillin.

3. Genital herpes

(a) Cause

This is caused by a *Herpes* virus.

(b) Transmission mode

(i) Through sexual intercourse with an infected person.

(ii) At birth from an infected mother to the newborn baby.

(c) Signs and symptoms

(i) Sores on the lips.

(ii) Painful blisters on the genitals.

(iii) Genital ulcers which may heal or recur.

(d) Effects

(i) Causes damage to the eyes of the newborn at birth.

(ii) Damages the central nervous system leading to mental retardation in children.

(e) Prevention and control

(i) Abstaining from sex before marriage.

(ii) Engaging in safe sex through the use of condoms for couples.

(iii) Treatment using antibiotics.

4. Trichomoniasis

(a) Cause

Trichomoniasis is caused by a protozoa Trichomonas vaginalis.

(b) Mode of transmission

Through sexual intercourse with an infected person.

(c) Signs and symptoms

(i) Painful sores on the vaginal walls.

(ii) Smelly discharge from the vagina.

(iii) Burning sensation while passing out urine.

(iv) Itchy penis with lesions.

(d) Prevention and control

(i) Abstaining from sex before marriage.

(ii) Engaging in safe sex for couples by use of condoms.

(iii) Treatment using antibiotics.

5. Candidiasis

(a) Cause

Candidiasis is caused by a fungus called *Candida albicans.* Candidiasis are of two types:

(i) *Oropharyngial candidiasis* - This occurs when the fungi attacks the mouth. It is commonly known as oral thrush.

(ii) *Vaginal candidiasis* - This occurs when the fungi attacks the vagina.

(b) Mode of transmission

Through sexual intercourse with an infected person.

(c) Signs and symptoms

(i) Flarry white patches on the skin.

(ii) Red inflammed skin under the patches.

(iii) Severe irritation of the vagina (itching of the vagina)

(iv) Vaginal discharge in infected females.

(d) Prevention and control

(i) Abstaining from sex before marriage.

(ii) Treatment with antifungals.

6. Hepatitis B

(a) Cause

Hepatitis B is caused by hepatitis virus.

(b) Mode of transmission

(i) Through sexual intercourse with an infected person.

(ii) Through blood transfusion with infected blood.

(c) Signs and symptoms

(i) Dark coloured urine.

(ii) Yellow-orange faeces.

(iii) Jaundice.

(iv) Inflammed liver which swells and stops functioning.

(v) Pain in the stomach.

(vi) Muscle ache, fatigue, nausea, vomiting and diarrhoea.

(d) Prevention and control

(i) Abstaining from sex before marriage.

(ii) Engaging in protected sex for couples through the use of condoms.

(iii) Treatment using drugs.

7. Chlamydia

(a) Cause

Chlamydia is caused by a bacteria. The disease is similar to gonorrhoea in many ways and it is difficult to distinguish between the two.

(b) Mode of transmission

Through sexual intercourse with an infected person.

(c) Signs and symptoms

(i) Inflammation of the pelvis.

(ii) Pain and discomfort.

(iii) May lead to infertility.

(d) Prevention and control

(i) Abstaining from sex before marriage.

(ii) Treatment using antibiotics such as penicillin.

8. Genital warts

(a) Cause

Genital warts is caused by Human Papilloma Virus (HPV).

(b) Mode of transmission

Sexual intercourse with an infected person

(c) Signs and symptoms

(i) Bump-like growths on the genitals and anus.

(ii) Itching sensation or discomfort around the genital.

(iii) Bleeding may occur.

(d) Prevention and control

(i) Removal of the warts using liquid nitrogen or a chemical which is usually applied on the warts.

(ii) Treatment using drugs.

(iii) Abstaining from sex before marriage.

(iv) Practising protected sex for couples by using a condom.

9. HIV and AIDS

Meaning of HIV

HIV is an abbreviation which stands for Human Immuno-deficiency Virus.

H - Human - this means that the virus affects human beings.

I - Immuno-deficiency - this refers to the fact that the virus destroys the body's immune system allowing the individual to become infected by germs which normally the body could resist. Immuno-deficiency is the combination of two words - *immune* and *deficiency* which means the body's immune system is weak and therefore the body becomes readily infected by disease causing germs.

V - Virus - the germ that infects is of a special type called virus.

AIDS

AIDS is an abbreviation which stands for Acquired Immune Deficiency Syndrome.

A - Acquired - this means anything that is got from another person.

I - Immune - this refers to the body's defense system which protects us from diseases.

D - Deficiency - this refers to the fact that the immune system is not functioning properly thus reducing the body's ability to fight diseases.

S - Syndrome - this is a group of signs and symptoms which are found together in a person who has a particular disease.

Therefore, AIDS is the result of a person's immune system becoming weak that the person is no longer able to fight diseases. The person becomes ill with one or more diseases like pneumonia, tuberculosis, among others.

(a) Cause

AIDS is caused by a virus called HIV (Human Immunodeficiency Virus). The virus is found in body fluids such as blood and semen or vaginal fluid.

(b) Mode of transmission

(i) Through sexual intercourse with an infected person (most common mode).

(ii) Blood transfusion with infected blood.

(iii) From infected mother to child during birth.

(iv) By sharing unsterilised surgical/piercing instruments such as syringes, blades, needles, scissors, among others with infected people.

(c) Signs and symptoms

(i) Chronic diarrhoea for more than a month.

(ii) Sudden loss of weight.

(iii) Constant, persistent and severe coughs which occur longer than a month.

(iv) Inflammation of the lymph nodes.

(v) Opportunistic diseases such as tuberculosis, pneumonia and brain diseases.

(d) Effects

Loss of immunity which leads to death.

(e) Control and prevention

(i) Abstaining from sex before marriage.

(ii) Having protected sex by using condoms.

(iii) Being faithful to one partner.

(iv) Using anti-retroviral drugs (ARVs), they slow down the spread of the virus in the body.

(v) Screening blood for HIV before transfusion.

(vi) Avoid sharing surgical instruments and equipment such as syringes and/or sharing them.

The following is a summary of some major points relating to HIV and AIDS, STIs and STDs.

- Abstinence from sex is the only effective way to avoid getting STIs, STDs and HIV and AIDS.

- Practising sex only after marriage and with only one partner whose status you know.
- Having a regular physical examination to test for STIs and STDs.
- Notifing your partner about your STI or STD condition so that he/ she can go for treatment and avoid reinfection.
- Proper use of condoms to help reduce the chances of STD infection.

Maternal mortality

Maternal mortality is also called maternal death. It refers to all deaths of women that are related to child bearing. The deaths occur either during the period of pregnancy or at the time of giving birth.

The major causes of maternal deaths include:

(i) Excessive bleeding during birth.

(ii) Infections during pregnancy especially by malaria.

(iii) High blood pressure during pregnancy

(iv) Unsafe abortion.

(v) Complications during birth.

(vi) Complications brought about by HIV and AIDS infections.

Prevention

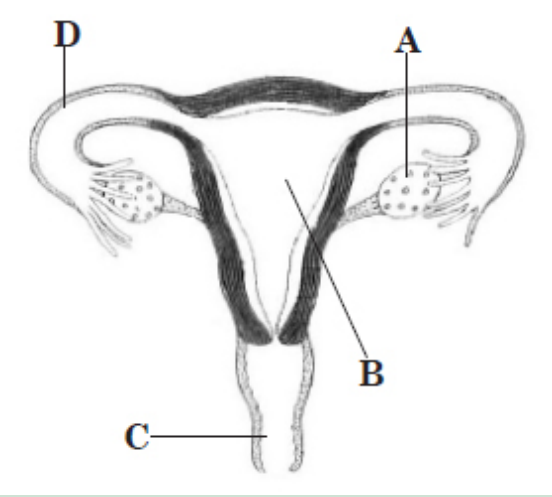
1. All pregnant mothers should seek prenatal care in the health centres as soon as they discover that they are pregnant.
2. Avoid giving birth at home where qualified medical personnel are not available.
3. Proper diet during pregnancy
4. HIV positive mothers should seek help from health facilities during their pregnancy to enhance their safety and that of their babies during birth.

Revision Exercise 9

1. What is reproduction?

2. Give the differences between mitosis and meiosis.

3. The diagram below shows a human reproductive system.



a) Identify the structures labelled A – D.

b) Name the hormone produced in A.

c) What is the function of the part labelled B?

4. State the accessory glands in the male reproductive systems and name their functions?

5. Describe the role of semen.

6. Describe the role of the placenta.

7. What is the importance of breastfeeding?

8. (a) What is a contraception?

(b) Name the different methods of contraception.

9. Name four Sexually Transmitted Infections (STI's)

10. Give ways of preventing the spread of Sexually Transmitted Infections.

Unit 10

Human diseases

Specific objectives

By the end of this unit, you should be able to:

(a) Describe signs and symptoms of selected diseases caused by protozoa, bacteria, fungi and viruses.

(b) Describe modes of transmission of these diseases.

(c) Explain how these diseases can be prevented and controlled.

(d) Investigate, control and preventive measures of diseases at household and community levels.

Diseases caused by bacteria

1. Pneumonia

Causes

Pneumonia is an infection of the lungs. It is caused by bacteria called *Pneumococcus* which is spread through the air. Infection proceeds from the mouth down into the lungs. As a result of the infection, a fluid is produced which collects in the alveoli. The lungs become solid and have no air. This prevents exchange of gases in the lungs.

Symptoms

- Sudden chills and high fever.
- Rapid shallow breathing and sometimes wheezing.
- Cough with yellow, greenish colour or mucus with some blood.
- Chest pains.

Treatment and control

(i) Patient should consult a doctor for adequate treatment.

(ii) Overcrowded places should be avoided and good ventilation in living rooms should be provided.

2. Tuberculosis

Causes

Tuberculosis is caused by bacteria called *Mycobacterium tuberculosis*. The source of infection may be droplets containing bacteria sprayed from the air passages during breathing or sneezing, or infected dry sputum in particles of dust. Tuberculosis bacteria may attack any part of the body but they usually invade the lungs causing pulmonary tuberculosis. Another source of infection is by drinking raw milk from a cow suffering from **bovine tuberculosis.**

Symptoms

- Tuberculosis of the lungs starts with a dry cough followed by the spitting of blood fever, and sweating at night as the infection progresses.
- If there is no treatment, loss in weight occurs and finally death of the patient.

Treatment and control

(i) The patient should consult a doctor for adequate treatment.

(ii) Overcrowding increases the risk of spread of tuberculosis.

(iii) Avoid taking raw milk. Boil all milk or drink pasteurised milk.

(iv) Immunisation of children with B.C.G. vaccine.

3. Cholera

Cholera is an acute infection of the intestinal tract caused by bacterium called *Vibrio cholerae.* The bacteria are capable of living in water for a long period of time until they find a suitable host.

Cholera is a common problem in places where there is poor sanitation, especially where disposal of faeces is in such a way that water sources and food get contaminated. This happens especially in crowded conditions where there are poor toilet facilities or where there is poor sewage treatment.

As a result, drinking untreated water contaminated by human waste spreads the bacteria that causes cholera. Houseflies too, may transmit the bacteria from faeces to food.

Uncooked food, fruits and vegetables can easily be contaminated especially if washed in contaminated water or if human excreta are used as fertiliser for the crops.

Effects of the parasite on the host

Once food contaminated in this way is ingested, the bacteria undergoes an incubation period of one to six days. They then multiply rapidly in the small intestine and produce highly poisonous substances. These toxins are responsible for the severe symptoms of cholera which occur suddenly.

Severe diarrhoea results to nausea, severe vomiting, abdominal pain, acute thirst and muscle cramps. Severe dehydration occurs due to loss of water from the body. It is followed by collapse, shock and in many cases death.

Adaptive characteristics of the parasite

Bacteria causing cholera can survive in areas of low oxygen concentration like that found in the small intestines.

Prevention and control

Infected patients should be isolated and they, together with people they are in contact with, should be given the appropriate medication by qualified medical practitioner (personnel).

During an outbreak of cholera, all infected people should be isolated and vaccinations given to those under threat of possible infection. Movement of people should be controlled.

Cholera patient attendants should not handle food for other people.

Prevention of cholera involves measures to ensure environmental and personal hygiene. These measures include:

(i) Construction of proper toilets or pit latrines especially in crowded areas.

(ii) Discouraging the practice of "*flying toilets*" (defaection in plastic bags which are then thrown into waste dumps or roof tops) by the inhabitants of slum areas where the toilets are far or few.

(iii) Education and awareness campaigns on proper use of latrines, importance of washing hands after defecation.

(iv) Boiling water or simple measures of treating water with chlorine tablets to ensure untreated water is safe for drinking.

Note:

Treatment of cholera aims at replacing fluids and maintaining the balance of mineral ions in the body. This is done through giving oral rehydration salts or saline drips together with suitable antibiotics administered by qualified medical practitioner.

Typhoid

Typhoid is caused by bacteria called *Salmonella typhi*

Mode of transmission

Just like in cholera, typhoid is a common problem in areas where there is poor sanitation leading to contaminated water and food.

Unhygienic handling of food or food products by healthy looking persons infected with *Salmonella typhi* is another method of transmission of the bacterium.

Such people are called *carriers*. This is because they have the disease organisms in their bodies but show no signs of the disease. If they do not wash their hands thoroughly after defecation they can easily spread the disease.

The disease may also be spread through flies which feed on infected excreta and deposit it on human food. Foods most readily contaminated with typhoid causing organisms include milk products, cooked meats, salads and fruits.

Effects of the parasite on the host

Salmonella typhi has an incubation period of two weeks. It causes fever, headaches, abdominal pain and diarrhoea because it attacks the walls of the intestines. This causes ulcers and in extreme situations the breakdown of the intestinal wall. This may lead to death.

Adaptive characteristics of the parasite

The bacteria causing typhoid *(Salmonella typhi)* can survive in areas of low oxygen concentration like that found in the small intestines.

Prevention and control

The control measures include:

1. Isolation of the patients to avoid spread of the disease by contact. Proper treatment by qualified medical doctor should be sought.
2. Sterilising clothes that the patient has used using disinfectants or by boiling.
3. Food handlers in institutions, like hospitals, schools and restaurants should go for regular check-ups and treatment if found infected.
4. Proper disposal of faeces in toilet and pit latrines and not in the bush to avoid spreading the bacteria.
5. Thorough water treatment and purification in town or city water supplies to kill the bacteria.
6. Boiling water and thorough cooking of food to kill the bacteria.
7. Good hygiene like washing hands properly every after visiting the toilet. Thorough washing of fruits and vegetables with clean water.
8. Vaccinations in the case of outbreaks of the disease that is epidemics.
9. Proper medical treatment by a qualified doctor in the case of infection by the disease.
11. Proper sewage treatments should be done in towns to kill or destroy the bacteria.
12. Households and areas around them should be kept clean to prevent flies from breeding in them.

Diseases caused by viruses

- Common cold
- Flu
- Measles
- Chicken pox
- AIDS

1. Common cold

Common cold is caused by a virus. It is transmitted through droplets infection.

Symptoms

- Running nose.
- Sneezing
- Fever

Control and treatment

(i) Taking prophylactic drugs.

(ii) Being in well ventilated rooms

(iii) Avoid overcrowded areas.

2. Flu

This is also called influenza. It is caused by a virus called **influenza virus.** It is spread through the air via air breathed out by infected people. It can also be spread by touching items with the virus and then touching the mouth.

Symptoms

Symptoms are seen 1–7 days after infection. They include:

- Sneezing and sore throat
- Fever and chills
- Body aches
- Dizziness
- Headaches
- Lack of energy
- Nausea and vomiting.

Control and prevention

(i) Use of drugs that lower the fever.

(ii) Use of cough drops

(iii) Drinking hot drinks

(iv) Use of anti-viral drugs in severe cases.

3. Measles

Measles are caused by viruses.
There are two viruses that cause measles. These are:

(i) *Rubella virus* — causes the German measles.

(ii) *Rubeola virus* causes the ordinary or red measles.

Symptoms of the disease appear 10 – 14 days after infection.

Symptoms

- Fever
- Cough
- General body weakness
- Reddened eyes
- Running nose
- Loss of appetite.
- Rashes on the face which then spreads to the rest of the body. The rashes don't itch.
- Headaches.
- Swollen and soft lymph nodes
- In pregnant women, painful joints and the disease can cause deformity in the unborn baby.

Control

Immunisation of the child.

Note: *After recovery from a measles infection, survivors of the measles get natural active immunity. They can never be afected by the disease again.*

4. Chicken pox

This is a skin disease caused by a virus called – *Varicella zosta.*

The disease is highly contagious and easily transmitted through air droplets. Contact with infected person transmits the disease.

Symptoms

Symptoms appear 14–15 days after infection. They include:

- Rashes on the skin.

- A lot of itching on the skin rashes
- Mild fever.

Control and prevention

Through immunisation of children.

Note: *This is a disease whereby if one gets infected and recovers, the body attains antibodies to prevent any further infection. This is called natural active immunity.*

5. Acquired Immuno-Deficiency Syndrome (AIDS)

AIDS stands for acquired immunodeficiency syndrome and is caused by *Human immuno-deficiency virus* (HIV). The virus belongs to a group of viruses called *retroviruses*. It infects and destroys certain white blood cells called **T- helper lymphocytes** which are involved in the defence of the body against disease and infections. This virus attacks the immune system so that the body is defenceless against infections from diseases. There is no known cure for AIDS.

There are four phases in this infection

1. In the first phase after infection, the body produces HIV antibodies. There is a short flu-like illness, skin rash may develop and swollen lymph glands.
2. In the second stage, there are no symptoms of infection. This stage can last from a few weeks to 13 years or more.
3. In the third stage, the person may contract a variety of conditions known as *opportunistic infections*. At this stage, the infection may not be major or life threatening. Oral and genital herpes are common at this stage. Loss of weight occurs at this stage also.
4. In the fourth phase, opportunistic infections occur, body organs get diseased and secondary cancers can form. Cancer of the lymphatic system, pneumonia, severe diarrhoea and tuberculosis are some of the opportunistic diseases. These diseases result from the weakening of the immune system.

Note: Even though HIV is sexually transmitted, it can also be transmitted by non-sexual ways for example

- Sharing of hypodermic needles with an infected person.
- Blood transfusions if the blood is infected.
- Infected mother to newborn babies during birth in the birth canal.
- Mother to child through breastfeeding.
- Mother to foetus through the placenta.

Control and management of HIV and AIDS

There are different strains of HIV. The virus keeps changing itself (mutating) and this is one of the main reasons why developing an effective vaccine against HIV is a challenge. The most effective method of avoiding sexually transmitted HIV is abstinence from sexual intimancy.

Care and management of people with HIV infections

Anti retroviral treatment

This treatment uses a combination of drugs that can slow down or inhibit the spread of HIV in a person's body.

It delays or prevents the onset of AIDS and prolongs life. This care can be difficult because many people cannot stand the side effects of the drugs. The costs of the treatment can be high but efforts are being made to make them available more cheaply.

Role of behaviour change in the transmission of HIV

We know that there are several ways in which HIV can be transmitted. Irresponsible sexual behaviour is the main mode of transmission. Preventing the spread of HIV involves working towards behaviour change. This involves evaluating of one's life and a deliberate decision made with commitment to change and avoid risky behaviour that exposes one to the probability of contracting the virus. This could mean for example, abstinence from sex for unmarried people, faithfulness for marriage partners whose status you know. Proper use of condoms where partner are HIV positive whereas the other one is not.

Use of condoms

A condom is a rubber sheath worn on the penis or inserted in the vagina before sexual intercourse. There are male condoms as well as female condoms. When used properly, condoms may prevent the transmission of

sexually transmitted infections such as gonorrhoea, syphilis and HIV and AIDS. However, sexual abstinence is the only way that provides 100% protection against STIs and AIDS.

Voluntary counselling and testing

Voluntary counselling and testing encourages individuals to get to know their HIV status at centres called VCTs'. (Voluntary counselling and testing centres). This is important because through the counselling offered at VCTs, one is able to make decisions that allow them to change their behaviour to reduce the risk of contracting HIV and AIDs and or spreading it to others.

For those who may already be infected, VCT's enable one to access care and support services like counselling, information on how to stay healthy, treatment for opportunistic diseases, and information to help them make informed decisions on child bearing and marriage. For those who are HIV negative, the knowledge helps them to plan for their future, get an opportunity to detect sexually transmitted and other diseases. It is very important to:

- Have proper food and nutrition.
- Avoid stressful situations.
- Have a positive attitude that fosters living a positive lifestyle.

Diseases caused by fungi

1. Ringworms
2. Thrush
3. Athlete's foot

1. Ringworms

This is a fungal disease caused by a fungus called *Tinea*. The fungus is transmitted through:

(a) Direct contact of infected heads

(b) Using infected combs or shaving equipments.

(c) Sharing head brushes and hats.

Symptoms

- Round gray patches on the head and face.

- Itching on the grey patches.
- Hair loss on the patches.

Control

(i) Treatment using fungicide creams and tablets.

(ii) Hygiene in and care of hair.

(iii) Avoid sharing of combs, brushes and hats.

2. Thrush

This disease is caused by a fungus called It can occur in the mouth, vagina, intestines among other places. It is mainly transmitted through sexual intercourse though it may also arise due to changes in acidity in the vagina in females during pregnancy or diabetes. Newborn babies can be infected in the mouth at birth and through the vaginal canal.

The symptoms include, fluffy white patches on the infected area with red inflammed skin under the patches. This causes severe irritation. The control and treatment involves treatment with appropriate drugs administered by a doctor.

3. Athlete's foot

This is a fungal disease that affects feet in human beings. The disease usually occurs due to:

(a) Wearing closed shoes for a long time.

(b) Keeping the feet wet for prolonged period of time.

(c) Excessive sweating in the feet.

The disease is common in areas with warm wet weather.

Signs

- Itching in the foot.
- Pains in between the toes.

Prevention and control

(i) Proper drying of feet after bath.

(ii) Use of sandals in public showers.

(iii) Change socks frequently.

(iv) Treatment with antifungal drugs such as powders and creams.

Diseases caused by protozoa

1. Malaria
2. Sleeping sickness.

1. Malaria

Malaria is caused by a parasite called *Plasmodium.*

Mode of transmission

Plasmodium is a parasite found in the blood of infected people, it is transmitted into humans by a vector, the female anopheles mosquito.

Only the adult female anopheles mosquito transmits malaria. When it bites a person infected with malaria, it passes saliva down the tube to prevent the blood from clotting, before it sucks up the blood. The infectious *Plasmodium* remains in its salivary glands where it can survive for some time. When this mosquito bites a person who is not infected, it pierces through the skin and injects the *Plasmodium* present in its saliva into the blood stream of the person and the person becomes infected.

Effects of the parasite on the host

Once the *Plasmodium* reaches the liver cells, it multiplies. It then breaks out of the liver cells, invades red blood cells and reproduces in them causing them to burst. When red blood cells burst, toxins from the *Plasmodium* are also released. Anaemia occurs as a result of the breakdown of red blood cells.

The toxins and the damaged red blood cells cause the symptoms of malaria. Sometimes *Plasmodium* parasites cause a more severe and often fatal form of malaria by entering the brain cells. These causes **celebral malaria.** This celebral malaria causes some kind of madness.

Some common symptoms of malaria include *chillis, fever, sweating at night* and *headaches.* In some cases, there is vomiting, loss of appetite, muscle aches and a general feeling of weakness.

Prevention and control of malaria

Mosquitoes lay their eggs in stagnant water. The eggs hatch and then develop into larvae which develops to pupae. The larva and pupa breath through spiracles on the surface of the water. Therefore any action that

disrupts the life cycle of the mosquitoes also prevents the eventual spread of *Plasmodium* and thus controls malaria.

Prevention of malaria involves killing mosquitoes, destroying their larvae and preventing the invasion of red blood cells by the *Plasmodium.* This can be done through the following ways;

(i) Draining swamps or stagnant water in ditches, holes or tins. This prevents egg laying by mosquitoes by destroying their breeding grounds. Plants whose leaf structure can hold water such as, bananas, should be planted as far away as possible from the houses.

(ii) Spraying or pouring oil on stagnant water that cannot be drained. The oil blocks the spiracles of pupa suffocating the larva and the pupa. If the oil has an insecticide, then it would also kill any females coming to land and lay their eggs in the water.

(iii) Introducing fish such as *Gambusia* (which eat mosquito larvae) into ponds or lakes.

(iv) Clearing bushes near and around residential areas because they are hiding places for mosquitoes.

(v) People who live in malaria prone regions should sleep under treated mosquito nets. These nets have been treated with insecticides that they keep mosquitoes away.

(vi) Using insecticides to kill mosquitoes.

(vii) Preventive medicine should be taken when travelling to malaria prone regions. However they should be administered by a doctor to prevent their abuse which contributes to the resistance of plasmodium to different drugs.

(viii) Treating sick people with anti malarials at doses prescribed by a qualified doctor.

2. Sleeping sickness

This is a disease caused by protozoa called *Trypanosoma rhodesience*. The protozoa is spread by tsetse flies through their bites. The disease affects humans and wild animals.

Symptoms

- Drowsiness during the day.

- Fever and headaches.
- Lack of sleep at night.
- Anxiety and mood changes.
- Uncontrollable sleepiness during the day.
- Sweating.
- Swollen lymph nodes all over the body.

Control and treatment

(i) Use of drugs to treat infected people.

(ii) Tsetse fly control by:

- Bush clearing.
- Trapping.
- Use of pesticides.

(iii) Developing corridors between forests and inhabited areas.

(iv) Releasing sterile males

Diseases caused by parasitic worms

1. Elephantiasis

Elephantiasis is a disorder of the lymphatic system. It is caused by a microscopic roundworm called filaria worm *Wuchereria bancrofti*.

The filarial worm is a parasite, it lives in the circulatory and lymphatic systems.

It is transmitted into the body by a bite from the **culex mosquito.**

The worm enters the lymphatic vessel and blocks them. This causes the tissue fluid to accumulate in that part of the body because it cannot drain away. The affected part swells to very huge proportions.

Symptoms

- Massive swelling on legs and arms.
- In some cases swellings occur on the scrotum and breasts.

Control and prevention

(i) Mosquito control.

(ii) Treatment using appropriate drugs.

2. River blindness

This is a parasitic disease caused by infection of a roundworm *Onchocerca volvulus*. It is also known as *Robles'* disease. It is the worlds second leading infectious cause of blindness.

The parasite is transmitted to humans through bites of a black fly of the *Simulium* type. It causes severe itching which can destroy the tissues of the eye. It can be controlled by treating the people infected with antibiotics.

Control and treatment

- Observing personal hygiene
- Food treatment
- Treatment of water before it is pumped to homes
- Providing health services to the people
- Proper disposal of human and animal wastes.

Control and preventive measures of diseases at household and community levels

The following are ways that can be used to control problems with rapid population.

1. Water treatment

This is the process of removing the undesirable properties of raw water to make it safe for human consumption.

Water treatment kills disease causing organisms for example, liver flukes and bacteria therefore preventing the spread of diseases. There are several water treatment methods including filtration, use of chemicals, boiling and aeration.

2. Disposal of human and domestic wastes

Poor sewage disposal can be responsible for the spread of diseases such as typhoid, cholera and amoebiasis. Human waste includes human

faeces, human urine and household washing water. There are several methods of handling sewage including;

(a) *Conserving systems* which include pit latrines, chemical latrines and bore hole latrine. The conserving systems do not use water to flush away the sewage. They should be located away from water supplies to avoid contamination of water.

(b) *Water carriage systems:* the sewage is flushed away and the septic tanks receive it through pipes. The septic tank is a distant away from the house and disinfectant are not used in the system because they kill the bacteria needed for decomposition of sewage. Modern sewage works involve the town authorities to control the disposal of sewage.

3. Personal hygiene

Personal hygiene is the practice of keeping a persons cleanliness and grooming of the external body parts to reduce risk of infections.

Proper personal hygiene increases immunity of the body. There are several common personal hygiene practices. They include:

(a) Washing hands with soap and water prevents the spread of infections like common colds and gastro enteritis.

(b) Use of a brush to wash and clean the nails.

(c) Washing hands after using the toilet, after handling body secretions like mucus, after handling gabbage bins and when you get home from a journey.

(d) Washing the body daily to eliminate body odour and bacteria. The bath towel must not be shared to avoid spreading infections.

(e) Brushing teeth after every meal is a good personal hygiene practice. This prevents tooth decay.

(f) Other personal hygiene care include clipping fingernails, covering all cuts, burns and sores.

4. Pest control

This is the management of organisms involved in spreading diseases such organism include tsetse flies mosquitoes and worms. Control of the

vectors prevents the spread of infections.

5. Food treatment and preservation

This is the practice of processing food to prevent spoilage spread of disease, and food poisoning. The methods used for food treatment and preservation include smoking, salting, drying, freezing, canning, pasteurisation, radioactive and chemical preservation.

6. Health services

This is the responsibility of the health ministry. The health ministry deals with the hospital boards and Medical Officers. Public health inspectors check shops and restaurants that sell food to make sure that the highest standards of hygiene are maintained. This helps to reduce the spread of diseases.

- The sanitary inspectors check on water supply, sewage, refuse disposal and rodent extermination to prevent disease spreading.
- Maternity services offer ante-natal clinics, training about pregnancy, care of babies, diet and rest.
- Doctors report notifiable diseases and treat patients to prevent spread of infections. Doctors also carry out immunisation programmes.

Revision Exercise 10

1. Name four diseases caused by bacteria.
2. Describe the signs and symptoms of the following diseases.
   (a) Typhoid
   (b) Malaria
3. Describe the five modes of transmission of HIV and AIDS.
4. Discuss the control and preventive measures of sexually transmitted diseases.

Unit
11

Human population

Specific objectives

By the end of this unit, you should be able to:

(a) Describe human population growth in Malawi and in the world.

(b) State the factors that affect the human population growth.

(c) Explain how birth rate, fertility rate, death rate, urbanisation, migration and age structure affect human population and growth.

(d) Identify problems associated with rapid population growth.

(e) Explain how the problems associated with rapid population growth can be controlled.

Introduction

In this unit, we will learn about human population growth and factors affecting human population growth, such as, birth rate, death rate, population age structure, urbanisation and migration. We will also learn about problems associated with rapid population growth and their control.

Meaning of population

What do you understand by the term population? Do you know what is the current population of Malawi?

Population refers to the total number of organisms of a particular species living in a given place. In this case, we can say that it involves the total number of people living in Malawi. For instance in 2009 the population of Malawi was estimated to be 15 million.

Population growth

Population growth refers to the increase in the numbers of individuals in a given area over time. For instance in your family, do you have the same number of people as they were when you were in primary school? You may realise that your family has increased by several people due to babies being born. This has resulted to in increase in population of Malawi.

Let us carry out the following activity;

Activity 11.1: To plot graphs of population growth

You are provided with the following table that shows the estimated population of Malawi from 1959 to 2009.

Year	Estimated population in millions
1959	3.6
1969	4.5
1979	5.9
1989	8.8
1999	11.0
2009	15.0

Table 11.1: Population of Malawi

Table 11.2: shows estimated world population from 1900 to 2010.

Year	Estimated population in millions
1900	1 billion
1930	2 billion
1960	3 billion
1975	4 billion
1987	5 billion
1999	6 billion
2010	7 billion

Table 11.2: Estimated world population growth from 1900 to 2010

1. The graph of Malawi population against time in years, has been provided (Graph 11.1).

2. Using another graph paper, plot a graph of world population over time in years.
3. Study the two curves made.

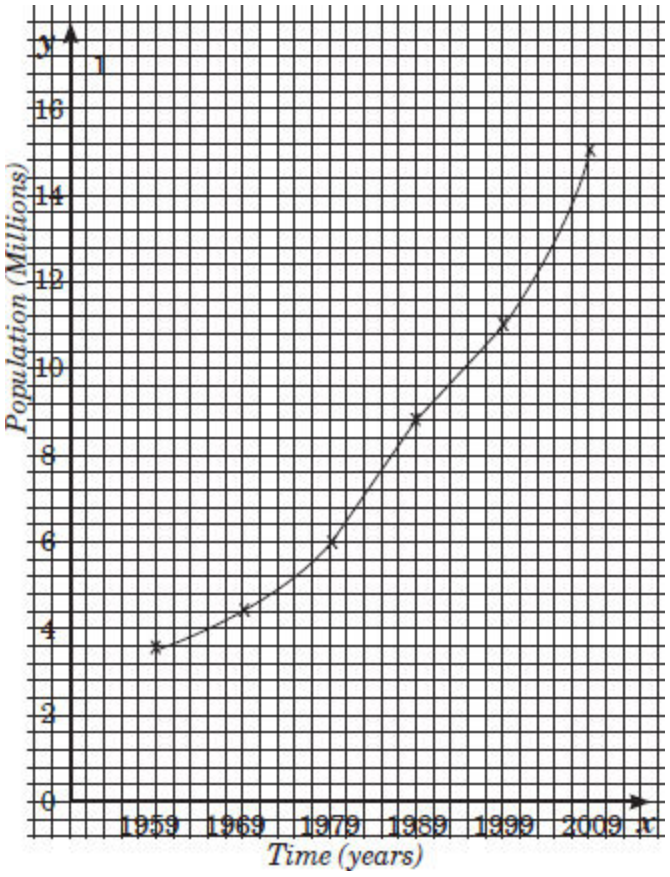
Questions

1. Compare the shape of the curve of Malawi population to the curve of the world population. Describe their shapes.
2. What similarities and differences can you note in the two curves?

Discussion

From the exercise, you probably plotted curves like the ones illustrated on Graph 11.1.

Graph 11.1: Estimated population growth in Malawi between 1959 to 2009.



Population growth curves

These are graphs that show the relationship between population and time. They show how population of a given nation or place grows over time.

Conclusion

You may have realised from the two graphs that there is a similarity in the shapes of the curves. In the initial years, the two curves have a gentle slope and in the later years, they have steep slopes. This shows that in the recent years, both populations have grown at a greater rate. You may also have realised that the two graphs tend to acquire the shape of a letter J thus they are refered to as **J- curves** that demonstrate growth in a population.

The J-curve

A J-curve is a curve that assumes the shape of letter J when population of a given place is plotted against time.

From the J-curve, one can note that in the initial years, population was increasing slowly but in the later years population increased rapidly. For instance, the world's population is seen to increase slowly up to 1960s. After that, the population increased rapidly.

This rapid increase in population is called an *exponential growth.* The same is observed in the population growth for Malawi. The population is seen to increase rapidly after 1989 more than the way it had increased before 1989.

From the study of history, it has been noted that the world's population has continued to increase with economic and technological developments. In the same way as Malawi continues to develop, its population also continues to grow.

Let us now study the various factors that influence population growth rates. The significance of this exponential increase of a population on resources and services should match the increase. ***For example*** With a high human population, it is important that a country builds more schools, hospitals, houses and create jobs. Therefore the country uses more resources especially financial resources to enable it build and create more services for its people.

Self assessment activity:

Name some resources and services in your school that you would expect would have to change to match an increase in the population in your school.

Factors affecting human population growth

From the previous sub-unit, we have seen that population of both the world and of our country Malawi increases with time. This is called *population growth.* Population growth is affected by the following factors:

- Birth rate and fertility rate — these are usually affected by the level of education of the parents, value given to children, cost of living, infant mortality rate, average age of marriage, availability of birth control methods and religious beliefs.
- Death rate is affected by nutrition, diseases and the availability and quality of medical services.
- Population age structure.

Activity 11.2: To discuss factors that affect population growth

In your group, discuss the following

1. The average number of children born per family per year in your locality.
2. The average number of children per family in your locality.
3. Explain how your findings in (1) and (2) above influences population growth of Malawi.

From your discussion group, you may have realised that several factors influence growth of a population. They include:

(a) Level of education of parents.

(b) Importance of children to the community.

(c) Infant mortality.

(d) Cost of living.

(e) Average age of marriage.

(f) Availability of birth control.

(g) Religious believes.

(a) Education of the parents

The level of education of the parents influences the average number of children born in a given family. In most places, people who are less educated tend to give birth to many children while educated families tend to give birth to fewer children because the parents want to provide to few children more adequately. Therefore population growth tends to be greater in the rural areas where the level of education is lower than in the urban areas where the level of education is higher.

(b) Importance of children to the community

Malawi like all other African cultures value children. Birth of a child is celebrated by the whole community and in some cases social status is placed on the number of children an individual has. This has encouraged increased child bearing hence an increase in population.

(c) Infant mortality

Infant mortality refers to the number of infants of one year or younger die per year in every 1000 live births in a population. When infant mortality is high, it means that fewer individuals are added into the population. Over the years improved healthcare in Malawi has greatly reduced infant mortality. This has in turn increased birth rate in the population leading to increase in population growth.

(d) Cost of living

Cost of living in urban areas is higher than in the rural areas and this is one reason why growth of population in urban areas is lower. Families in urban areas tend to give birth to the number of children they are capable of adequately providing for with the income they get. In the rural areas, where the cost of living is lower and food is readily available, the number of children born is not restricted.

(e) Average age of marriage

This is the average age at which young people enter into marriage and start child bearing. In most countries in Africa, the average age is

between 18 and 20 years. This means that young people enter into marriage at a very early age and hence they will likely give birth to more children in their lifetime. This ends up increasing the population of a given nation.

(f) Availability of birth control methods

Birth control method enables families to limit the number of children they will get or delay the time at which the children will be born. Where birth control methods are available, population growth is lower. In the deep rural areas of Malawi where birth control methods are not available, population growth is very high.

(g) Religious beliefs

Some religions value children and do not encourage the use birth control methods. In families or in regions where such beliefs exists population growth is higher.

(h) Death rate

Death rate refers to the number of individuals who die per every 1000 individual in a given area. It is simply the rate at which death takes place in a given population.

When death rate rises, the growth of population goes down. If at any one time, death rate in a given place becomes higher than birth rate, the overall population of a given place reduces.

You may realise that most of the deaths in our country are caused by diseases such as Malaria, HIV and AIDS, Cancer, Typhoid among others.

Other causes of death include poor nutrition leading to lower immunity against diseases. During the drought seasons especially on the southern regions, poor nutrition makes many individuals to be exposed to diseases hence increased chances of death. From 1990, HIV and AIDS pandemic has contributed to many deaths in Malawi.

(i) Population age structure

This refers to the number of individuals per age set. It describes a given population in terms of number of children, youth, young adults and adults. The Malawi population is composed of young people between

the ages of 20-40. This is the most productive age. Many individuals are giving birth hence a greater increase in population.

A greater number of young people in a population results to a higher growth rate. If a country has a higher number of older people above the age of 40 than the young people, then the increase in population would be lower. This is because at an age above 40 years individuals are less productive.

(j) Urbanisation

Urbanisation refers to the growth of urban centres that result to development of urban population.

Urbanisation results to shifting of people from rural areas to urban areas. This results to lower growth rate in rural areas because all young people of child bearing age tend to move and settle in urban areas.

At the same time, urbanisation has resulted to rapid population growth in urban areas. As we will see later, the rapid increase in urban population has resulted to competition for the limited resources available including housing.

(k) Migration

Migration involves movement of people from one place of living to another place. People settled in one place deliberately move and settle in another place. Migration occurs in two ways.

(i) Emigration

This is where people leave one place or country to go and settle in another region or country. Emigration results to a reduced population's growth in a place or country.

(ii) Immigration

This is where people enter and live in a given region or country. This results to an increased growth in the population. For instance, in the past years, an immigration of refugees from Mozambique to Malawi resulted to a rapid population growth. After Mozambique stabilised politically most of the refugees immigrated back to their country resulting to a lower population growth.

Problems related to rapid population growth

Any increase in population will always result to an effect to the resources available.

- Do you live in Lilongwe or have you ever gone to Lilongwe to visit a relative?
- How many people did you see on the streets?
- What problem did you face as you tried to walk through the streets?
- Do we have enough houses for everyone in Lilongwe?

Lilongwe like many other cities in the world, is faced with high population growth. All over the world, a high population growth rate puts pressure on available resources and services. Let us now discuss problems related to rapid population growth.

1. Depletion of resources

Rapid population growth results to depletion of available resources such as land, water, forests and power. At the same time, the remaining resources becomes limited and expensive. For instance in Lilongwe like many other African cities, water and electricity are inadequate because the power being supplied is not enough for the great population living in the city.

2. Pressure on social services

Social services are provided by the government. These services include health services, education and welfare services. The social services facilities available are not adequate for the large number of people living in a given place. An example is the long queues of patients in government hospitals seeking treatment.

3. Spread of diseases

Infectious diseases spread rapidly where people live in overcrowded areas. Diseases like HIV and AIDS easily spread in highly populated areas due to the high rate of interaction between individuals.

4. Pollution

Pollution is mainly caused by human activities where waste substances are released in quantities harmful to the environment. The higher the

population of a given area, the greater the volume of wastes produced hence the greater the rate at which the environment will be polluted. It is therefore common to find heaps of wastes and garbage in our cities especially where there are high populations.

Controlling problems associated with rapid population growth

Population growth can be controlled by:

1. ***Reducing the birth rate***

   This is by provision of birth control methods and information on contraceptive on all women at reproductive age.

2. ***Conservation of resources***

   This ensures availability of resources to sustain the population.

   Conserved water catchment areas ensure availability of water to the population.

   Conservation of forests and wildlife improves tourism resulting to more foreign exchange to a country. This provides employment and supports many livelihoods in the community. For example; conservation of Lake Malawi will ensure continuous supply of fish to the local market and for export. This will continue supporting the increasing population in the area.

3. ***Improving sanitation***

   Improved sanitation by developing proper housing systems, efficient sewarage system and waste recycling/disposal projects.

4. ***Reducing over consumption***

   For instance controlling fishing in Lake Malawi to prevent over-consumption of the fish. If all the fish were depleted, the increasing population would not get enough food.

Revision Exercise 11

1. Define the term population
2. Explain the factors that affect human population growth in Malawi

3. Identify problems associated with rapid population growth
4. Discuss how we can control problems associated with rapid population growth.

Excel & Succeed Biology for Form 3 is a new, concise and comprehensive course that has been developed in line with the syllabus for Senior Secondary Biology Education.

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The authors have served in the education sector in various capacities where they have contributed immensely in the field of Biology. They also have a wide experience in teaching and curriculum development.

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