South Sudan

Secondary Biology 2

Student's Book

Secondary Biology has been written and developed by Ministry of General Education and Instruction, Government of South Sudan in conjunction with Subjects experts. This course book provides a fun and practical approach to the subject of Biology, and at the same time imparting life long skills to the students.

The book comprehensively covers the Secondary 2 syllabus as developed by Ministry of General Education and Instruction.

Each year comprises of a Student's Book and Teacher's Guide

The Student's Books provide:

- Full coverage of the national syllabus.
- A strong grounding in the basics of Biology.
- Clear presentation and explanation of learning points.
- A wide variety of practice exercises, often showing how Biology can be applied to real-life situations.
- It provides opportunities for collaboration through group work activities.
- Stimulating illustrations.

All the courses in this secondary series were developed by the Ministry of General Education and Instruction, Republic of South Sudan.
The books have been designed to meet the secondary school syllabus, and at the same time equiping the student's with skills to fit in the modern day global society.

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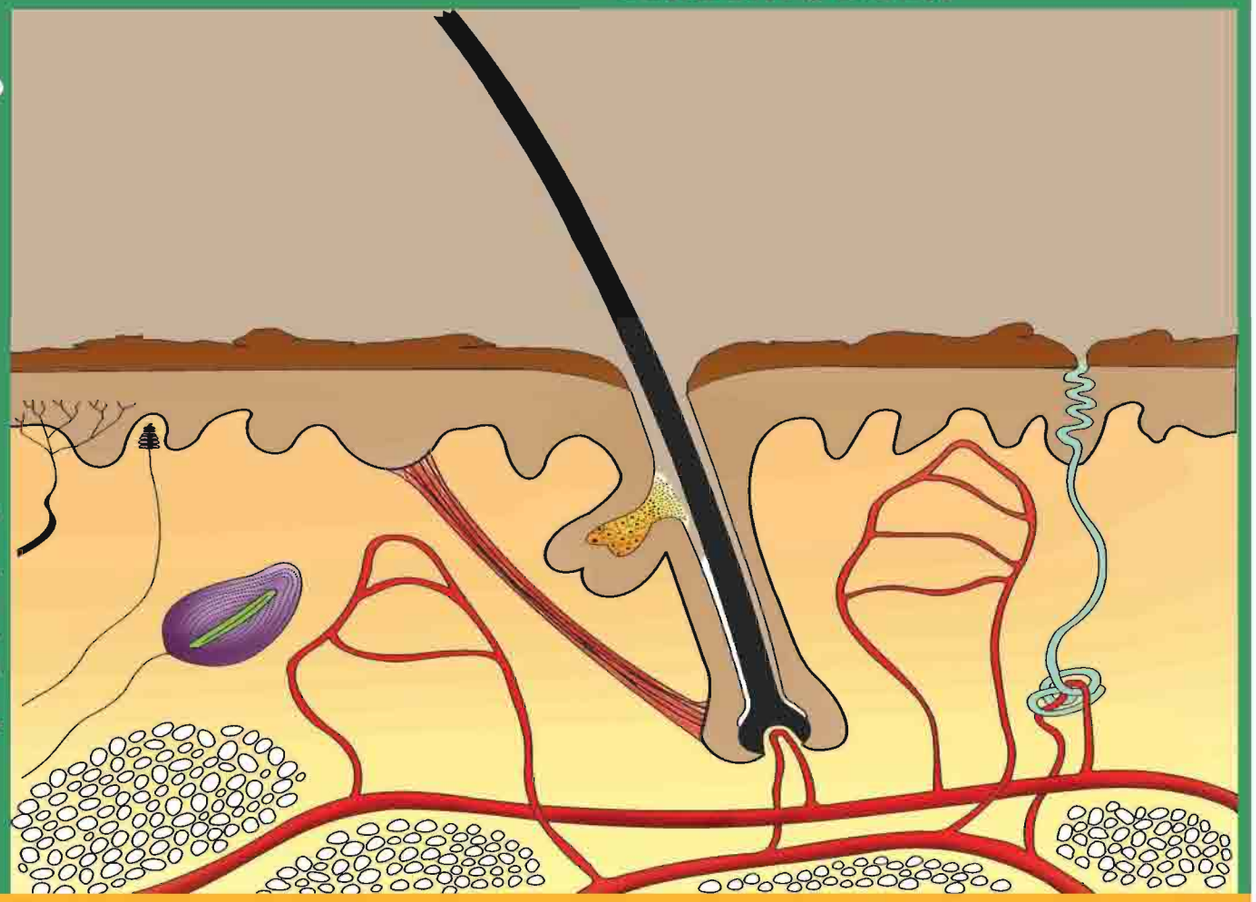

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South Sudan

SECONDARY 2

Biology

Student's Book 2

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FOREWORD

I am delighted to present to you this textbook, which is developed by the Ministry of General Education and Instruction based on the new South Sudan National Curriculum. The National Curriculum is a learner-centered curriculum that aims to meet the needs and aspirations of the new nation. In particular, it aims to develop (a) Good citizens; (b) successful lifelong learners; (c) creative, active and productive individuals; and (d) Environmentally responsible members of our society. This textbook, like many others, has been designed to contribute to achievement of these noble aims. It has been revised thoroughly by our Subject Panels, is deemed to be fit for the purpose and has been recommended to me for approval. Therefore, I hereby grant my approval. This textbook shall be used to facilitate learning for learners in all schools of the Republic of South Sudan, except international schools, with effect from 4th February, 2019.

I am deeply grateful to the staff of the Ministry of General Education and Instruction, especially Mr Michael Lopuke Lotyam Longolio, the Undersecretary of the Ministry, the staff of the Curriculum Development Centre, under the supervision of Mr Omot Okony Olok, the Director General for Quality Assurance and Standards, the Subject Panelists, the Curriculum Foundation (UK), under the able leadership of Dr Brian Male, for providing professional guidance throughout the process of the development of National Curriculum and school textbooks for the Republic of South Sudan since 2013. I wish to thank UNICEF South Sudan for managing the project funded by the Global Partnership in Education so well and funding the development of the National Curriculum and the new textbooks. I am equally grateful for the support provided by Mr Tony Calderbank, the former Country Director of the British Council, South Sudan; Sir Richard Arden, Senior Education Advisor of DfID, South Sudan. I thank Longhorn and Mountain Top publishers in Kenya for working closely with the Ministry, the Subject Panels, UNICEF and the Curriculum Foundation UK to write the new textbooks. Finally, I thank the former Ministers of Education, Hon. Joseph Ukel Abango and Hon. Dr John Gai Nyuot Yoh, for supporting me, in my previous role as the Undersecretary of the Ministry, to lead the Technical Committee to develop and complete the consultations on the new National Curriculum Framework by 29 November 2013.

The Ministry of General Education and Instruction, Republic of South Sudan, is most grateful to all these key stakeholders for their overwhelming support to the design and development of this historic South Sudan National Curriculum. This historic reform in South Sudan's education system is intended to benefit the people of South Sudan, especially the children and youth and the future generations. It shall enhance the quality of education in the country to promote peace, justice, liberty and prosperity for all. I urge all Teachers to put this textbook to good use.

May God bless South Sudan. May He help our Teachers to inspire, educate and transform the lives of all the children and youth of South Sudan.

Deng Deng Hoc Yai, (Hon.)

Minister of General Education and Instruction, Republic of South Sudan

Unit 1

Photosynthesis and plant nutrition

Learning outcomes

Knowledge and understanding	Skills	Attitude
By the end of this unit, I should be able to:		
• Understand photosynthesis and plant nutrition and the importance of photosynthesis to all living things.	• Carry out investigations to find out about the factors that limit photosynthesis • Design a simple experiment to test for the presence of starch in the leaf. • Investigate whether chlorophyll is necessary for the process of photosynthesis to occur.	• Appreciate the process of photosynthesis and how it forms part of a cycle. • Value the role of green plants in nature and its contribution to agriculture and food production.

Introduction

In senior one you learnt about diversity of living things and the cell. Are you able to recall this?

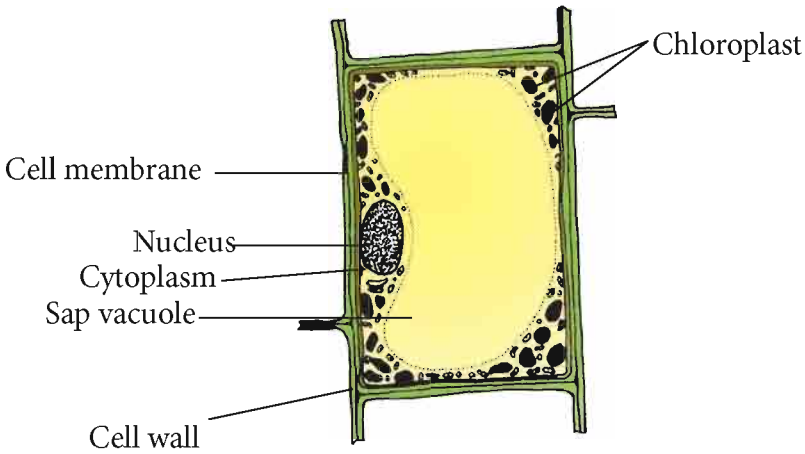


Fig 1.1 Plant cell

Are you able to describe the movement of substances across the cell? This unit will focus on photosynthesis and plant nutrition.

Now study the picture below. What can you see? What does this tell you about plant nutrition?

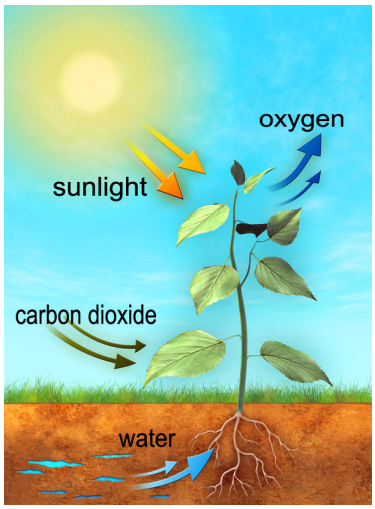


Fig. 1.2: Photosynthesis process

The picture above shows a growing plant. Plants require food in order to survive. Life of every organism depends on the food that we eat. This food can be used for various processes in the body such as provision of energy for work, growth and development, repair of worn out tissues and reproduction. The chief source of all energy is the sun. The process by which living organisms use food in the body is known as **nutrition**. Plants are able to synthesise their food from simple substance, they are known as **autotrophs**.

1.1 Photosynthesis

Unlike animals which consume the already manufactured food, green plants manufacture their own food. The process by which green plants make their own food from simple inorganic substance using energy from sunlight is known as **photosynthesis**. Plants are able to convert light energy into a form that can be used by living organisms. The process takes place in plant leaves in a cellular structure called **chloroplast**.

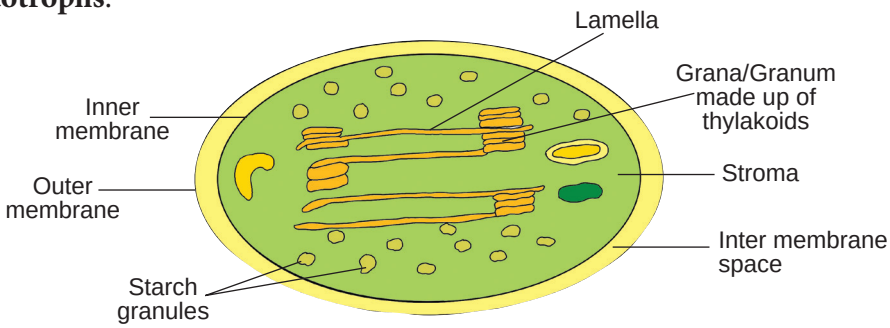


Fig. 1.3: Structure of chloroplast

The process is summarised using the following equation:

$$6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light}} C_6H_{12}O_6 + 6O_2$$

Carbon dioxide + Water → Glucose + Oxygen

Testing starch

Activity 1.1: Investigating the presence of starch in a leaf

Work in group of four

Materials

Leaves, beaker with water, boiling tube, tripod stand, wire gauze, methylated spirit (alcohol), white tile, iodine solution, pair of forceps.

Procedure

1. Half fill the beaker with water and boil the water in the beaker.
2. Dip a leaf into the hot water for 2 to 3 minutes.
3. Put a boiling tube half filled with methylated spirit into the boiling water (water bath).

Caution: Do not expose methylated spirit to a naked flame.

4. Take a leaf and dip it into the boiling methylated spirit.
5. Leave the leaf in the hot methylated spirit until all the chlorophyll is removed.
6. Take the leaf, which is now white in colour and dip it once again in the boiling water.
7. Take the leaf using a pair of forceps and spread it out carefully onto a white tile.
8. Using a dropper place a few drops iodine solution onto the leaf and note the colour of iodine.

Study questions

1. Explain the reasons for the following procedures:
   (i) Boiling the leaf in water.
   (ii) Boiling the leaf in ethanol.
   (iii) Dropping the leaf again in hot water.

My environment my life!

We should strive to conserve the environment in whatever we do. Avoid uprooting the whole plant when collecting leaves.

The facts

To find out whether the leaf is the site for photosynthesis, we test for the presence of starch in the leaf. Starch is made up of a chain of glucose molecules Presence of starch in the leaf will therefore confirm the leaf as a site for photosynthesis.

The leaf is first dipped in boiling water to kill the protoplasm and denature enzymes so as to stop further reactions within it.

Alcohol boils at a lower temperature than water so it will boil in hot water.

The hot methylated spirit is a good solvent which dissolves and extracts (removes) chlorophyll from the leaf which becomes white. It is easier to

observe colour changes on such a leaf. However alcohol also makes the leaf stiff and brittle.

Dipping the leaf in hot water again softens it so that it can be spread out easily on the tile for testing with iodine solution.

If the iodine solution changes colour from brown to blue-black then that part of the leaf has starch and therefore photosynthesis must have taken place in that part.

Conditions necessary for the process of photosynthesis

Activity 1.2: Is light needed for photosynthesis?

Work in group of four

Materials

Potted plant, aluminium foil strip or some black paper, clips, iodine solution, white tile, methylated spirit, water in a beaker, iodine

Procedure

1. You are provided with the above materials.
2. Come up with the steps and how you will show that light is necessary for the process of photosynthesis. Use the steps to do the activity.
3. Use the picture below for some hint.

Study questions

1. What do you observe when you test the leaf for starch?
2. Which part of the leaf acts as a control?
3. Explain your answer in (2) above.

Were your steps the same as the one below?

1. Cut out star shape or circle in the middle of an aluminimum foil or black carbon paper that is big enough to cover a big portion of a leaf.
2. Use a paper clip to attach this paper securely around one of the green leaves of a potted plant.
3. Leave the plant to stand in the bright sunlight for 5 to 7 hours.
4. Detach
   (a) The leaf with the foil.
   (b) A leaf with no foil or paper covering.
5. Test the leaves for starch alone.

The facts

After testing the leaf for starch, the shape that was cut out in the paper appears as blue-black coloured shape on the leaf. This is because light reached this part of the leaf causing photosynthesis to take place. Starch changed the colour of iodine solution from brown to blue-black.

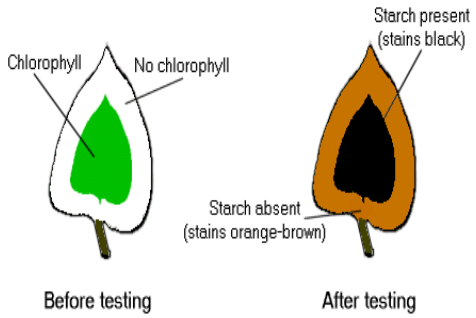


Fig. 1.4: Results on test for need for light during photosynthesis

The area under the foil or paper did not change colour to blue black because there was no starch present. The part of the plant not covered with the foil on testing with iodine, it appeared blue-black. This is because starch was present. This part of the leaf act as a control.

Activity 1.3: Is carbon dioxide needed for photosynthesis?

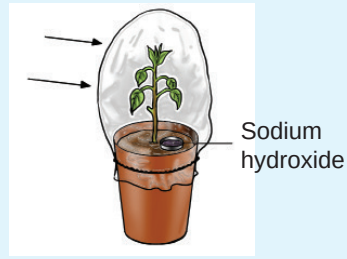
Work in group of four

Materials

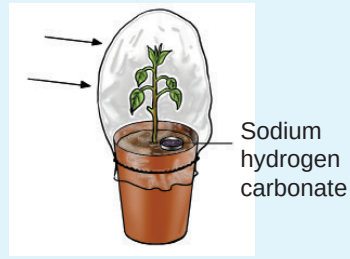
Two potted plants kept in the dark for 24hours, ink, transparent plastic bags, sodium hydroxide, oil, rubber band, methylated spirit, beaker with water, boiling tube, sodium hydrogen carbonate(sodium bicarbonate), stone

Procedure

1. Choose the correct materials that you will need in investigating if carbon dioxide is necessary for photosynthesis.
2. Come up with the steps and how you will show that carbon dioxide is necessary for photosynthesis. Follow the steps to do the activity.
3. The picture below will guide you.



Plant A



Plant B

Study questions

1. Explain the role of sodium hydroxide and sodium hydrogen carbonate?
2. What was the result of testing the leaf in set-up A and B for starch?
3. Which set-up acts as the control experiment? Explain.

Were your steps the same as the one below?

1. Plant A: Put sodium hydroxide or potassium hydroxide into a small plastic container. Place it carefully on the soil holding the plant. Take the transparent polythene bag and cover the whole plant with it. Secure the bottom by tying it with one or two elastic bands.

2. Plant B: Repeat the procedure but place sodium hydrogen carbonate (sodium bicarbonate) in the plastic container.

The facts

Sodium hydroxide absorbs carbon dioxide from air. The air in the bag in the set up A becomes free of carbon dioxide after sometime. Photosynthesis will not take place without carbon dioxide therefore no starch is formed. Hence iodine did not turn blue-black.

Set up B has a container with sodium hydrogen carbonate which breaks up to release carbon dioxide into the air in the polythene bag. Photosynthesis takes place and leaves produce starch. When tested with iodine solution, these leaves give a positive test for starch. The colour of iodine changes from brown to blue black.

Set up B acts as the control. The experiment shows that carbon (IV) dioxide is needed for photosynthesis to take place.

Activity 1.4: To determine whether chlorophyll is necessary for photosynthesis

Work in group of four

Procedure

1. You are provided with the following materials.

   Destarched variagated potted plant, tripod stand, wire gauze, methylated spirit.
2. List other materials that you will need in determining if chlorophyll is necessary for photosynthesis.
3. With your group members, discuss the steps that you will follow in determining if chlorophyll is necessary for photosynthesis.

   Hint: Use study questions for hint.
4. Follow the steps you discussed in (3) above to carry out experiment determining role of cholorophyll in photosynthesis.

Study questions

1. In the test for starch, what is the colour of the part of the leaf that was green and that part which was whitish?
2. Explain the results that you get on testing the variegated leaf for starch.
3. Which part of the leaf acts as a control?

Were your steps the same as the one below?

1. Detach a variegated leaf from the plant and draw it.
2. Label the green part and the white part.
3. Test the leaf for starch.
4. Draw the leaf after the test and label the brown parts and the blue –black part.

The facts

A variegated leaf is the one whose surface shows two colours e.g green on some parts and white on others. The green parts have cells with chlorophyll so they carry out photosynthesis and

form starch. This part will turn iodine from brown to blue-black.

The white part has cells that do not have chlorophyll. These cells will not carry out photosynthesis, so no starch will be formed. The starch test will be negative.

The green part of the leaf acts as a control experiment because it has all the conditions required for photosynthesis.

Fig. 1.5: Variegated leaf

Stages of photosynthesis

Photosynthesis occurs through a series of chemical reactions. These reactions can be divided into two main stages. The first stage requires light and is called the **light stage**. The second stage does not require light and is called the light energy and is called **dark stage**.

a) Light stage

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

i) Some is used to split water molecules into hydrogen and oxygen. This is known as photolysis of water. The hydrogen is used in the dark stage. Some of the oxygen formed is released from the leaf through the stomata. The rest is used up in the plant cells for respiration.

$$2H_2O \xrightarrow[\text{Chlorophyl}]{\text{light}} 4H + O_2$$

Water — Hydrogen atom — Oxygen

Photolysis

ii) Some of the absorbed sunlight energy is stored. This energy will also be used in the dark stage.

b) Dark stage

Is the second phase of photosynthesis which occurs in stroma and it takes place at the same time that the light stage is taking place in the grana. Carbon dioxide diffuses into stroma from the cell cytoplasma. 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**.

$$CO_{2(g)} + 4[H] \longrightarrow [(CH_2O)_n]$$

Carbon dioxide — Hydrogen atom — Simple carbohydrate

Carbon dioxide fixation

It is important to note that photosynthesis only avails carbohydrates to a plant. Carbohydrates are important sources of energy to living organisms. However, a plant needs proteins as well in order to grow and develop and a variety of other mineral nutrients for various chemical reactions to take place in its cells. A plant obtains mineral salts from the soil by active transport or diffusion through its root hairs. Examples of such mineral salts

are nitrates. The plant uses the nitrates for the manufacture of proteins. Magnesium ions from the soil are also important because they are used in formation of chlorophyll.

1.2 Importance of photosynthesis

Activity 1.5

As a class

1. All life on earth depends on photosynthesis directly or indirectly. Debate.
2. Come up with posters that supports the motion. Stick them on the class wall for future reference.

The facts

- **As a source of energy**

We are already aware that plants make their own food through photosynthesis. Also, animals depend directly or indirectly on plants for their food. Food contains energy from the sun stored as chemical energy. This energy is necessary for the normal life processes to take place.

- **Provides oxygen in air**

Oxygen is a by-product of photosynthesis. This oxygen replaces oxygen in air which is continuously used up by all living things during respiration.

- **Makes carbon available to plants and animals**

Carbon is a major and important component of chemicals in cells. During photosynthesis, the carbon part of carbon (IV) oxide from the air is incorporated into the synthesised food. This way the carbon is made available to living things.

- **Prevents accumulation of carbon (IV) oxide in the air**

Some of the carbon (IV) oxide in the air is used up during photosynthesis. A reduced level of carbon (IV) oxide in the atmosphere prevents global warming. This is the increase in global temperature caused by increasing levels of carbon (IV) oxide in the atmosphere among other factors.

- **It is responsible for the energy stored in coal and petroleum**

Plants and animals that existed on earth millions of years ago were converted into fossils. The energy they contained which they obtained as a result of photosynthesis is stored in fossil fuels such as petroleum, and coal.

Check your progress 1.1

1. Use a diagram to show where dark stage and light stage of a photosynthesis takes place.
2. There is no difference between dark stage and light stage. Argue your answer.
3. All heteroptrophs will not exist if all autotrophs are eliminated from the world. Explain.
4. With less than a hundred words, summarise the importance of photosynthesis.

1.3 Leaf as an organ for photosynthesis

Structure of a leaf

Activity 1.6
Observing the transverse section of a leaf

Work in a group of four

Materials

Pieces of carrot, scalpel or sharp blade, microscope slides, microscope cover slip, compound microscope, some water, dropper, mounted needle, dish e.g. petri-dishes or glass dishes, a fine brush, young leaf from dicotyledon e.g. *Bidens pilosa,* peas, beans and monocotyledon like maize or grass.

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 (see activity on how to make sections for observation under the microscope).
4. Put the sections in some water in a petridish.
5. Take a slide and put a drop or two of water on it using a dropper.
6. Select the thinnest section, preferably one that is cut through the midrib, and place it into the drop of water. Use a fine brush when transferring the sections to avoid damaging them.
7. Using a mounted needle, carefully place a cover slip on the section. Make sure no air bubbles are trapped.
8. Using tissue paper, wipe off excess water from the slide before observing it under the microscope. First use low power then medium power.
9. Try to identify the following layers of tissue: upper epidermis, palisade layer, spongy mesophyll, vascular bundles, lower epidermis and stomata.
10. Use a sharp pencil to draw the outline of the layers of tissues you have seen under low power magnification. Label the layers.
11. Under the medium power, examine and draw a cell from each of the following layers: upper epidermis, palisade layer, spongy mesophyll and lower epidermis.

Study questions

1. Relate the shape of the cell in the leaves to their function.
2. What do you notice about the arrangement of the cells in the layers? Are they closely packed or loosely packed? Why do you think this is?
3. Explain the purpose of the thin cuticle.
4. The upper leaf surface darker green than the lower surface. What is the significance of this?
5. Where are stomata located in aquatic plants? Why?

The facts

The internal anatomy of a leaf under light microscope indicates the following tissues arranged as shown in Figure 1.6 below.

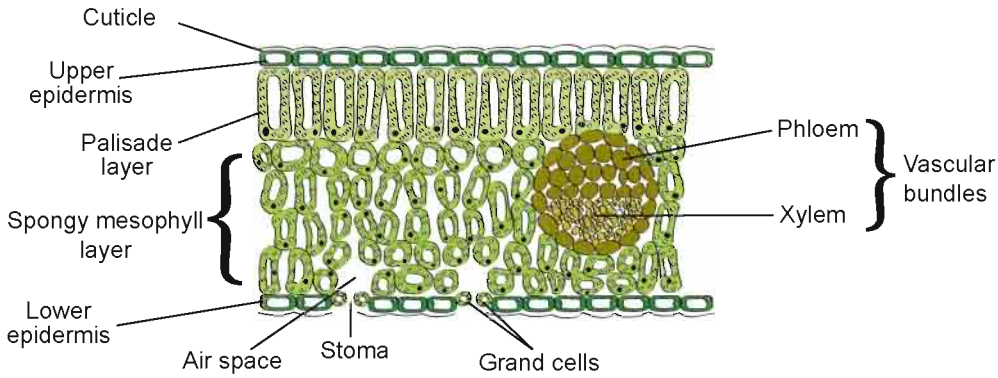


Fig. 1.6: Cross section through a leaf

Cuticle

It covers the upper surface of most leaves and makes them appear shiny. Cuticle is thin and transparent to allow light to pass through.

It has a waxy material that protects the leaf from attack by bacteria. The waxy material also acts as a waterproof layer which prevents excessive loss of water by the leaf. If the leaf loses too much water, the rate of photosynthesis will be reduced.

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, which allows them to remain transparent for light to pass through. The epidermis forms a protective layer over the cells that carry out photosynthesis.

Palisade layer

Optimum photosynthesis takes place in the palisade mesophyll. This is a layer of cells located below the upper epidermis. 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. The cells are irregular in shape and are loosely arranged. They have large air spaces between them which allow for air circulation and gaseous exchange between the cells and the air surrounding them. Spongy mesophyll cells are also lined with moisture to facilitate uptake of oxygen and release of carbon (IV) oxide. They have fewer chloroplasts than the palisade mesophyll cells. Suggest why the mesophyll is described as spongy.

Vascular tissue

The network of veins in the leaves is made up of vascular tissue. This tissue has vessels which supply water and mineral salts to the leaf. The vessels also take away manufactured food substances from the leaf to other parts of the plant. The vessels are the xylem and phloem vessels. Vascular tissue also provides support for the cells in the leaf.

Stomata

Stomata are pores within guard cells. They are found on the upper or lower epidermis or both. They allow entry of carbon (IV) oxide into the leaf for photosynthesis.

Adaptation of a leaf for photosynthesis

Activity 1.7

Identification of external features of a leaf and its adaptation for photosynthesis.

Work in pairs

Materials

A variety of leaves e.g. grass leaves, Hibiscus, bean leaves, Bougainvillea

Procedure

1. Examine using microscope 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.

   (i) breadth.
   (ii) thickness.
   (iii) colour.
   (iv) structures that supply the leaf with water and minerals.
   (v) structures that transport manufactured food from the leaf.
   (vi) the firmness of the leaf.

2. Draw and label the observable external features of the leaves.

Study questions

i. List the features that are common in all the leaves.

ii. State how the features mentioned in (i) above are an adaptation of the leaves for photosynthesis.

iii. Explain why you used microscope in examining the leaf.

The facts

In your examination of the different types of leaves, you may have noticed that they are green, broad and thin. Leaves have some special features which enable them carry out photosynthesis. They include the following.

1. Leaf lamina is thin to reduce the distance through which the gases have to diffuse from the atmosphere to mesophyll cells.

Fig. 1.7: Leaf showing lamina

2. Leaf lamina is broad and flat in shape to present a larger surface area to air facilitating faster absorption of oxygen and carbon

oxide and also allow for maximum sunlight to fall on it.

3. Leaf epidermis has stomata that allows for passage of carbon (iv) oxide into a leaf for photosynthesis and oxygen out of leaf.
4. Leaf has vascular bundles for transport of photosynthetic products (phloem), water and mineral salts(xylem).
5. Leaf has large air spaces between spongy mesophyll cells to allow for gaseous exchange between mesophyll cells.
6. Palisade cells have numerous chloroplast and located next to upper epidermis to receive maximum sunlight.

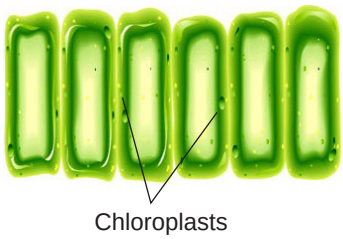


Fig. 1.8: Palisade cells

7. Extensive network of veins in leaf conduct water and mineral salts to photosynthetic cells or transport away photosynthetic products.

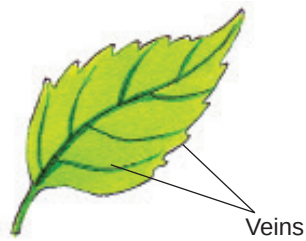


Fig. 1.9: Network of veins in a leaf

8. Leaf mosaic pattern prevents lower leaves from overshadowing by upper leaves.
9. Leaf cuticle secreted by epidermis prevents excessive loss of water by transpiration and also allows light to pass through and reach photosynthetic cells.

My environment my life!

Do not uproot the whole plant when plucking leaves.

Check your progress 1.2

1. Indicate **TRUE** or **FALSE**
   - (i) The two main roles of stomata on a leaf are gaseous exchange and transpiration.
   - (ii) Epidermal cells in a leaf are also referred to as mesophyll cell.
   - (iii) Palisade cells have the highest number of chloroplast in a leaf.
   - (iv) More light is trapped by chloroplast in the epidermal cells because they are in direct contact with sunlight.
2. Use diagram to differentiate between guard cells and surrounding epidermal cells.
3. Give biological explanation for the following:
   - (i) Leaves are well adapted for effecient diffusion of carbon dioxide.
   - (ii) Existence of cuticle on the leaf surface.
   - (iii) Location of chloroplast on the upper epidermis.

1.4 Factors affecting rate of photosynthesis

Some of the carbohydrates manufactured during photosynthesis are converted to other substances, such as proteins which are necessary for growth and development. This means that the rate at which photosynthesis takes place influences the rate of growth and development in plants.

The following factors influence photosynthesis:

- Light intensity
- Temperature
- Carbon dioxide concentration
- Water

If the level of one of the factors is reduced but the others remain the same, the rate of photosynthesis will reduce.

On the other hand, if the level of one of the factors increases, and the others remain constant, the rate of photosynthesis will also increase up to a certain point beyond which it does not increase any more. At this point other factors limit the rate of photosynthesis.

Light intensity

Activity 1.8

What is the relation of light intensity to rate of photosynthesis?

Work in group of six

Materials

Water plants e.g. Elodea and Spirogyra, beakers, glass funnels, sodium bicarbonate (to be dissolved in the water).

Procedure

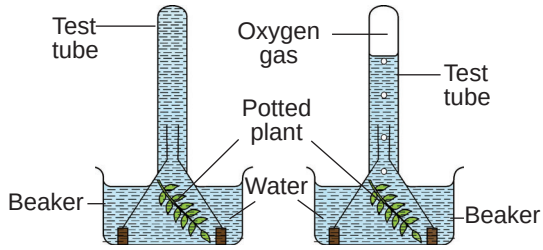
1. You are provided with the materials above.
2. Come up with the steps showing how light intensity affects the rate of photosynthesis.
3. Follow the steps to carry out the experiment showing how light intensity affects photosynthesis.

Study questions

1. Was the average number of bubbles of gas per minute the same under different light conditions?
2. Why was the average number of bubbles produced per minute different?
3. Explain the effect of light intensity on the rate of bubble formation.

Were your steps the same as the ones shown below?

1. Prepare two set-ups of apparatus as shown below.



2. Place the set-up first inside the laboratory, count the number of bubbles released in a minute by the plant. Repeat this five times, and calculate the average number of bubbles released by the plant in a minute. Note this down.

3. Repeat the counting, but with the plant in bright sunshine. Note that the experiment can also be done by exposing the same plant to varying strengths of light bulbs, e.g. 25 watts, 100 watts.

The facts

When the amount of light increases e.g. from inside the laboratory to outside in the bright sunshine, the rate of photosynthesis increases. Rate of photosynthesis increases with increase in light intensity up to level beyond this , rate of photosynthesis falls. This is because excess light damages chlorophyll.

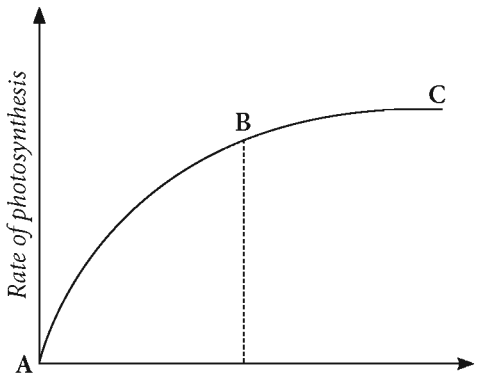


Fig. 1.10: Graph of rate of photosynthesis against light intensity

The curve between:

A and **B** – Shows that an increase in light intensity leads to an increase in rate of photosynthesis.

B and **C** – Any further increase in light intensity does not lead to an increase in the rate of photosynthesis. Instead, other factors limit the rate of photosynthesis at this point.

Temperature

Photosynthesis is an enzyme-controlled process. Any changes in the external temperature of a plant affects the activity of enzymes in the plant cells. If the temperature is very low, 0°C for example, then the enzymes are inactive and little photosynthesis occurs. If the temperature is higher than 40°C, enzymes are denatured. This means that increase in temperature increases the rate of photosynthesis up to a certain point. Any further increase in temperature beyond this point causes the denaturing of enzymes and the rate of photosynthesis falls rapidly. See the figure below.

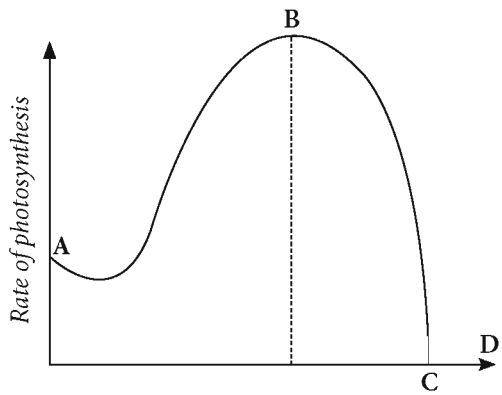


Fig. 1.11: Graph of rate of photosynthesis against temperature

AB – Increase in temperature causes a corresponding increase in the rate of photosynthesis. The rate of photosynthesis is highest at B.

BC – Any further increase in temperature causes denaturing of enzymes, so the rate of photosynthesis declines.

In general rate of photosynthesis at low and high temperatures will compare as shown below.

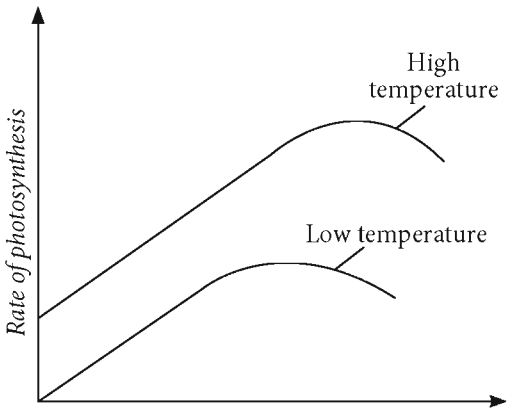


Fig. 1.12: Graph of rate of photosynthesis against low and high temperature

Carbon dioxide concentration

Activity 1.9

Do carbon dioxide concentration has effect on the rate of photosynthesis?

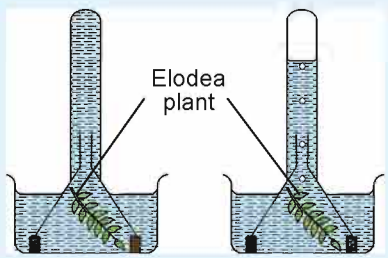
Work in group of four

Materials

Boiled and cooled water, water with sodium hydrogen carbonate dissolved in it, beakers, test-tubes, glass funnels, Elodea plants.

Procedure

1. Prepare two set-ups of apparatus as shown below.



2. Using the same Elodea plant, place boiled but cooled water in the beaker. Place the set-up in bright sunshine and count the average number of bubbles of gas that will be produced per minute. Record this.
3. Repeat the experiment using water with some sodium hydrogen carbonate in it. Count the average number of bubbles of oxygen gas released per minute and record.

The facts

Boiled water is free of gases including carbon dioxide. The rate of photosynthesis will be very low. This is seen by the fact that very few bubbles are counted per minute. Water that has sodium hydrogen carbonate has more carbon dioxide dissolved in it. The rate of bubble formation is high as more oxygen is produced. The percentage of carbon dioxide by volume of air is 0.03%. When factors such as light and temperature are held constant, increase in carbon dioxide concentration increases the rate of photosynthesis up to optimum levels. This has been experimented with green leaves where carbon dioxide concentration can be increased putting other factors constant.

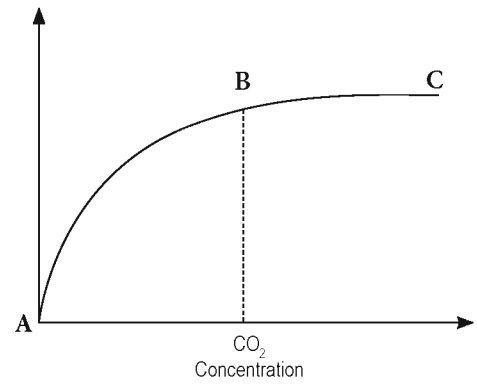


Fig. 1.13: Graph of rate of photosynthesis against carbon dioxide concentration

1.5 The essential elements

Activity 1.10

Work in group of five

Materials

Notebook, computer connected with internet, pens

What to do

1. With the guidance of your teacher, visit a nearby farm plantation.
2. During the visit, ask the resource person to show some plant that he or she suspect to be suffering from insufficient of essential element.
3. Note down the plant characteristics in your notebook.
4. Back in class, use the school library and internet to research more on essential elements.

The facts

There are sixteen essential elements necessary for good plant growth. These are: carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, sulphur, magnesium, calcium, manganese, iron, boron, zinc, copper, molybdenum and chlorine. Some of these elements are obtained from the air and water while others are supplied by the soil.

Essential elements from the air and water. Plants get most of their carbon and oxygen from the air through stomatal gaseous exchange. Hydrogen cannot be directly derived from the air, but absorbed as water from the soil by plant roots.

Essential elements from the soil: These are the macro-nutrients and micro-nutrients supplied to the plant from the soil in solution form. They must be present in their right proportions, suitable amounts and absorbable forms. The presence of certain elements in excess may interfere with the availability of the other nutrients.

Classification of essential elements

Research work

1. Using soilless cultures, devise experiments to investigate the effect of macronutrients and micronutrients.
2. Tabulate your answer using the following guidelines. Record number of leaves that are green, green with yellow patches, yellow, burnt leaves, curl leaves, height of plant, stem diameter, size of leaves and number of leaves.
3. Account for the observations you make.
4. Present your work to the rest of the class.

The facts

The essential elements are classified according to the quantities required by the plants, They include:

(a) Macro-nutrients: These are elements required by plants in large quantities. Macro-nutrients can be grouped either as primary or secondary elements.

(i) Primary macro elements: These are elements which must be present for proper plant establishment. They are

nitrogen, phosphorus and potassium (N. P. K). They are also referred to as fertilizer elements.

(ii) Secondary elements: These are required in large amounts but in lesser quantities than primary macro-nutrients. They include carbon, hydrogen, oxygen, calcium, magnesium, and sulphur.

(b) Micro-nutrients: These elements are needed in relatively small quantities. They are also referred to as trace elements. They include iron, manganese, copper, zinc, boron, molybdenum and chlorine.

Activity 1.11:

Work in group of five

Materials

- 6 small sheets with basic information regarding each macronutrient and micronutrient.
- Handout that contains all of the information from each sheet.

Procedure

1. In your groups, discuss the information on the small sheet provided by your teacher.
2. Share the information you gained during group work with the rest of the class through your group leader.
3. Confirm gained information by reading handout provided by your teacher.
4. Tabulate all the information gained about macronutrients and micronutrients in plants.

The facts

The macro-nutrients

a) Nitrogen

Debate:
Nitrogen plays no role in plants.

The Role of Nitrogen:

- It promotes vegetative growth (foliage growth e.g. leaves).
- It improves the quality of leafy crops such as cabbages, kales, etc.
- It forms part of chlorophyll and, as such, it encourages healthy green leaves, i.e. leaves become dark green.
- It is important in the formation of proteins in plants, i.e. tends to increase the protein content in all crops.
- In cereal crops, it increases the size of grains and their protein content, eg. finger millet.
- It regulates the availability and utilisation of phosphorus and potassium.

Effects and symptoms of nitrogen deficiency

- Leaves chlorosis, i.e. they lose chlorophyll and become yellow green or pale-green. This is associated with the formation of anthocyanin (purple-green in colour) in crops like tomatoes, maize etc.
- Reduced in plant growth leading to short, stunted crops.
- It may lead to early leaf fall.
- It can cause premature ripening of the fruit crops.
- Die back (browning and death of plant shoots stating at the tips.

Fig. 1.14: Leaf affected by nitrogen deficiency

b) Phosphorus

Activity 1.12: Role of phosphorous in plants

In groups of four

Materials

- Manila paper, maker pen, pencils, scissor, ruler, handouts.

Procedure

1. Read handouts provided by our teacher.
2. Using the information you acquired and materials provided. Design advertisement promoting role of phosphorous in plants.
3. Compare your advert with the rest of the class members.

The facts

The Role of Phosphorus

- It promotes root establishment and development especially secondary roots.
- It hastens leaf development and encourages greater growth of shoots.
- It improves crop quality, i.e. palatability particularly in horticultural, forage and cereal crops.
- It hastens maturity of crops.
- It is necessary for flowering, seeding and fruiting of crops, i.e. stimulates flowering and seed formation.
- It strengthens stems in cereal crops thus preventing lodging.
- It is an important in the formation of proteins.
- It influences cell division and is essential in various metabolic processes.
- It stimulates nodule formation in the legumes.
- It is necessary for the metabolism of carbohydrates e.g. during respiration.
- It increases plant resistance to disease attack and contributes to the general hardiness of crops.

Effects and symptoms of phosphorus deficiency

- Stunted growth and delayed maturity.
- There is poor grain, fruit and seed formation. Dead spots may be observed on the fruits and seeds.
- Stalk is unusually thin. The stems are weak in cereals.
- There is poor root development.
- Lateral buds remain dormant.
- Leaves change colour from green to blue or purplish-green as a result of increased anthocyanin. This is followed by premature leaf-fall.
- Tubers of crops like Irish potatoes become small and few.
- Appearance of rusty-brown spots in potato tubers.

Fig. 1.15: Leaf affected by phosphorous deficiency

c) Potassium

Debate!!
Potassium plays a vital role in plants.

The Role of Potassium:

- It is essential for nitrogen metabolism and protein synthesis.
- It increases plant vigour and disease resistance. The plant stalks are strengthened making them less prone to lodging and to bacterial/ fungal infections.
- It promotes root development.
- It helps in synthesis of sugars and starch and their translocation.
- It helps in plant metabolism.
- It is essential for chlorophyll formation.
- It regulates the availability and use of nitrogen and phosphorus. It assists in the uptake of nitrates.
- It increases the size of grains and seeds.
- It is necessary for the neutralisation of organic acids in plants.
- It acts as an activator for different enzymes.
- It enhances plant tolerance to cold and other adverse weather conditions.
- It increases crop quality e.g. in cut flowers.

Effects and symptoms of Potassium deficiency

- Plants lodge before maturing.
- Leaves of crops develop a burnt appearance on the tips and margins, i.e. they are scorched. Scorching starts with older leaves die back occurs.
- Leaves curl.
- Upper leaf surface lose chlorophyll and become yellow or chlorotic. Premature leaf fall.
- Stunted plant growth with stems having shorter internodes.
- Fruit or seed is somewhat shrivelled wrinkled
- Plants like beans, potatoes and sugar beet are prone to rust attack.

Fig. 1.16: Leaf affected by potassium deficiency

d) Magnesium

Activity 1.13:

Imagine you are a radio presenter.

You are assigned to investigate on the role of magnesium, calcium and sulphur to a plant. This information has to be accurate because it will be used in helping farmers around by Ministry of Agriculture.

- How will you go about it?

The facts

The Role of Magnesium:

- It is important in chlorophyll formation, i.e. It is responsible for maintaining the green colour in plants.
- It promotes the formation of fats and oils in oil crops like groundnuts, soya beans, sunflower etc.
- It enhances the nitrogen fixing power of the legumes.
- It activates the synthesis and translocation of carbohydrates and proteins in plants.
- It aids in the absorption and translocation of phosphorus.

Effects and symptoms of Magnesium deficiency

- There is loss of green colour in plants between the leaf veins which starts from the bottom leaves and gradually moves upward. This is called interveinal chlorosis.
- Leaves curve upwards along the margins and become brittle.
- Leaves are abnormally thin.
- Stalks become weak.
- Plants develop long unbranched roots.

Fig. 1.17: Leaf affected by magnesium deficiency

e) Sulphur

The Role of Sulphur:

- It is essential for protein synthesis.
- It increases the oil content in oil crops such as groundnuts, soya beans etc.
- It is essential in the formation of some vitamins, e.g. Vitamin B1.
- It is essential for the activation and activities of certain enzymes, e.g. co-enzyme A.
- It influences nitrogen fixation by legumes.
- It aids in the formation of cells.
- It is essential in chlorophyll formation.
- It is essential for carbohydrate metabolism.

Effects and symptoms of Sulphur deficiency

- Leaves become completely chlorotic, especially the lower (older) leaves.
- Stems become very thin and woody.
- Growth of plant in stunted.
- Reduce nodulation legumes.

Fig. 1.18: Leaf affected by sulphur deficiency

f) Calcium

The Role of Calcium:

- It is essential for protein synthesis.
- It forms calcium acetate which helps to strengthen plant cell walls.
- It is used in the elongation of plant apical tips and roots.
- It helps in root development.
- It is essential in the formation of the middle lamellae of chloroplast in plant cells.
- It increases the protein content of mitochondria.
- It raises the soil pH thus increasing the availability of phosphorus and potassium to plants. A higher soil pH is ideal for the action of nitrifying bacteria (nitrification).
- When added to clay soils, it flocculates the soil particles thus facilitating good aeration, water infiltration and retention.
- It helps in the translocation of carbohydrates in plants.

Effects and symptoms of Calcium deficiency

- Poor growth of terminal buds and root-tips. Terminal buds die under severe deficiency. Plant exhibits stuntedness.
- Leaves become chlorotic, particularly along margins of younger leaves.
- Leaves roll up.
- The plant shed flowers and buds prematurely.

Fig. 1.19: Leaf affected by calcium deficiency

The micronutrients
(Trace elements)

Activity 1.14

What are micronutrients in plants?

In pairs

Imagine you are a journalist in your country. Maize farmers in your country are complaining of low yield for three consecutive seasons. Scientists in your region suspects deficiency in macronutrients. You are assigned to investigate further about this.

Study questions

1. How will you go about it?
2. List all the questions that you will ask.
3. Explain materials you will choose to use and why.
4. Write a report on your findings.
5. What advises will you recommend.

The facts

Some of macronutrients in plants include:

1. Boron

Boron is associated with calcium utilisation within the plant. Whenever the proportion of calcium to boron is unbalanced due to boron deficiency, the terminal bud of the plant fails to develop properly. Boron requirement in a plant is extremely small.

Effects and symptoms of boron deficiency

Boron deficiency is indicated by a change in colour at the tips of growing shoots. The terminal bud becomes light green with traces of reddish-brown. It may cause the shoot tip to die and flowering may fail to occur.

2. Copper

It is an activator or catalyst for various chemical reactions within the plant. It promotes formation of Vitamin A. It also regulates the functions of nitrogen.

Effects and symptoms of copper deficiency

Its deficiency results in foliage with a chlorotic condition showing bleached appearance. Citrus fruits show die back of new shoots and the stem is marked with a reddish brown secretion (gummy exudates). Cereals show chlorotic leaf tips and failure to set seeds.

3. Iron

Iron is essential for the formation of chlorophyll. It is also necessary in the plant respiration and metabolism processes.

Effects and symptoms of iron deficiency

Its deficiency causes leaf chlorosis i.e. paleness at the leaf tips and margins while the veins remain green. The young leaves become affected first and may curve in an upward direction e.g. in cabbage.

4. Manganese

It is associated with copper and zinc metabolism. It acts as a catalyst in plant growth processes.

Effects and symptoms of manganese deficiency

Its deficiency results in chlorosis in young leaves. The loss of colour is often followed by the development of dead tissue spots (necrosis) and dead spots may drop off giving the leaf a perforated appearance.

5. Molybdenum

It is associated with nitrogen utilisation. It is required in very little amounts.

Effects and symptoms of molybdenum deficiency

Its deficiency results in retarded plant growth and yellowing of leaves.

6. Zinc

It is associated with availability of iron and manganese which are essential in chlorophyll formation.

Effects and symptoms of zinc deficiency

Its deficiency results in reduced fruiting. The plants terminal leaves may become abnormally small.

Check your progress 1.3

1. Using a table, list all macro-nutrients and micro-nutrients and their deficiency symptoms.
2. Which nutrients do these plants lack?

a) _____

a) _____

3. Your neighbour, Chol is doing maize farming in large scale. She suspects that the maize plants are suffering from nitrogen deficiency. As a Biology student, how will you confirm whether what she is saying is true or false?

4. Describe how a plant suffering from magnesium deficiency looks like.
5. How will you apply knowledge learnt in macronutrients and micronutrients in plants to animals.
6. Plants need enough micronutrients and macronutrients. Explain
7. Design a puzzle which includes all micronutrients.

Unit 2

Nutrition in animals

Learning outcomes

Knowledge and understanding	Skills	Attitude
By the end of this unit, I should be able to:		
• Understand animal nutrition. • Understand how animals have adapted feeding methods to the food available and how a change in food available can change animal population.	• Observation and recording by drawing and annotation. • Ability to investigate the anatomy of feeding organs in insects, birds and mammals in the laboratory and relate this to what they eat.	• Become curious about feeding methods of different groups of animals.

Brain teaser

Study the jaws below carefully.

Fig 2.1: Different types of jaws

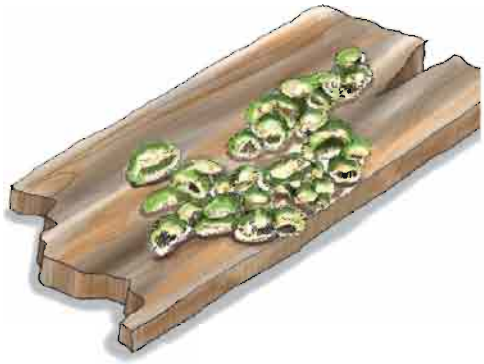
From the structures of the jaws and shapes of the teeth, suggest what sort of diet each of the animals with these jaws has.

Introduction

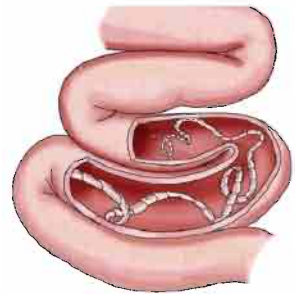
All living things may be regarded as working machines which require a continous supply of energy. This energy comes from nutrients. Therefore nutrients are required in order to carry out variety of living organisms.

Nutrition is the intake of nutrients and other substances into the body and making it part of body tissues.

Animals depend on complex organic substances for nutrition because they cannot synthesize their own food. This form of nutrition is known as **heterotropism**.



(a) Fungi on a dead wood



(b) Tapeworms in the intestines

Fig 2.2: Feeding in animals

The pictures show heterotrophic nutrition which is the concept you will learn in this unit.

2.1 Forms of nutrition in animals

Activity 2.1

1. Observe how different animals in your Payam obtain their food.
2. Relate your observations to what happens in human beings.
3. Find out the different modes of feeding in animals. Refer back to the brain teaser jaw photographs and relate these to the observations in your Payams.
4. Write short notes and present to your classmates.

The facts

Heterotrophism is the type of nutrition in which animals obtain ready-made food materials from their environment. Such organisms are called **heterotrophs**. Animals obtain nutrients by digesting organic compounds. Example of heterotrophs include: human beings, fungi such as mushrooms and some protists like plasmodium, amoeba and paramecium. All heterotrophs depend on autotrophs for their nutrition.

Nutrition in animals involves digestion of food so that insoluble complex food substances can be changed into soluble simple molecules that can be absorbed. There are three main types of nutrition in animals. These are:

- Holozoic nutrition
- Saprophytic nutrition
- Parasitic nutrition

(a) Holozoic nutrition

This type of nutrition involves organisms with a developed digestive

system. Food materials are ingested, digested, absorbed, assimilated and thereafter undigested food is egested. During these steps complex insoluble food substances are broken down to simple soluble compounds. Examples of holozoic animals are carnivores, such as eagle, lion and tigers, herbivore such as cattle, goat and antelopes and omnivores such as human beings, pig, among others.

(a) A lion

(b) A zebra

(c) A pig

Fig 2.3: Holozoic animals

(b) Saprophytic nutrition

This is the type of nutrition found in saprophytes which obtain their food from dead and decaying organic material. Examples of saprophytes include some fungi such as mushroom and mucor (Rhizopus) and bacteria. The saprophytes release enzymes which break down the decomposing food material into simple food substances that are easily absorbed into their bodies.

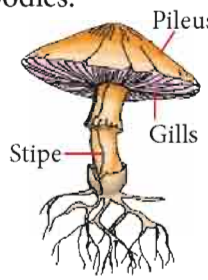


Fig 2.4: Mushroom

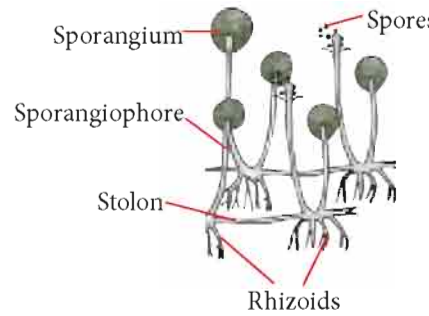


Fig 2.5: Mucor (Rhizopus)

(c) Parasitic nutrition

This is the type of nutrition found in parasites which obtain their food material from other living organisms. Parasites obtain nutrients from other live organisms which are referred to as **hosts.** The host is always on the losing side as it does not benefit from the parasite. Parasites have no intention of killing the host although sometimes a host may die due to activities of parasites. The food material is easily absorbed because it is already in simple form.

Parasites living inside organisms are called **endoparasites,** for example, tape worm and liver fluke. Parasites which live on the outside of an organism such as, ticks and lice are called **ectoparasites.** All these suck food materials and blood from the organism.

Check your progress 2.1

1. What is heterotrophic nutrition?
2. How can you preserve bread for longer without it growing mould?
3. Unscramble the following to form terms related to modes of feeding.
   A. raspaeit
   B. ropehytsap
   C. torophaut
   D. sibiomsys
4. Suggest ways a farmer can use to control parasites in livestock.

2.2 Structure and functions of humans teeth

Activity 2.2

Investigating the human teeth

Work in a group of four

Materials

- Teeth and jaw models
- Charts and diagrams

Procedure

1. Observe a jaw model or chart showing arrangement of teeth.
   - What can you see?
   - What is the colour of the teeth?
   - How many types of teeth can you observe?
   - Do you have all your teeth present? What happened if some are missing?
   - What is the importance of keeping a good dental hygiene?
2. Compare your observations with the teeth, jaw models and the diagrams on the charts.
   - Draw the teeth you have observed
   - Relate each teeth structure to its function.
3. Share your findings with the rest of the class.

The facts

Human beings feed on a mixed diet of animal flesh and vegetable matter. They therefore, have differentiated teeth. The different types of teeth found in mammals have different functions, for example, chewing, biting and grinding. When teeth are of different types and sizes, the dentition is termed **heterodont** while similar teeth in structure and size, the dentition is termed as **homodont**.

The structure of each type of teeth is adapted to its specific function. The teeth are used to break down large pieces of food to smaller pieces to increase the surface area for digestive enzymes to act. Like other mammals, humans have two jaws, each with a set of teeth. The number, size and shape of these teeth are determined by the omnivorous diet of human beings. Each type of tooth has a basic structure and function.

The different types of teeth in human being dentition are incisors, canines, premolars and molars.

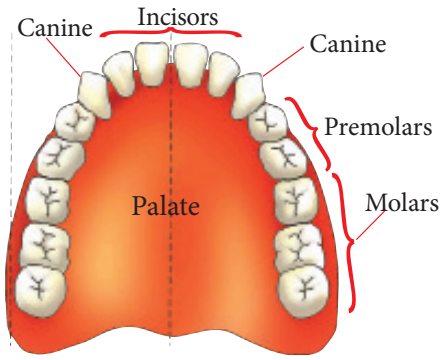


Fig 2.6: Upper jaw showing human dentition

(a) Incisors

They are located at the front of the jaws. They are shaped like a wedge or chisel, see fig 2.7. This creates a flat surface with a sharp edge that makes incisor teeth suited for cutting and biting.

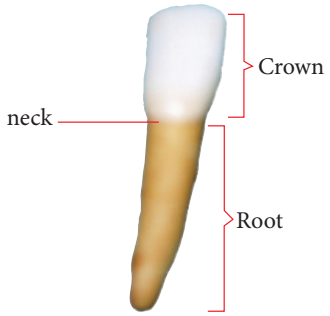


Fig 2.7: An incisor

(b) Canines

They are located on the left and right of the incisors. Canines are pointed teeth as shown in fig 2.8. Their basic function is to pierce and hold food. In human beings, canines are poorly developed as they are not needed for holding onto prey.

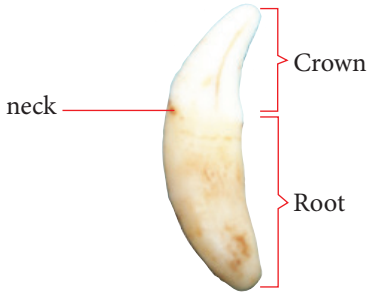


Fig 2.8: A canine

(c) Premolars

They are located after the canines, towards the back of the jaw. They have broad top surfaces usually with two projections called cusps that give them a ridged appearance. Fig 2.9 illustrates a premolar tooth. They are used to crush and grind food.

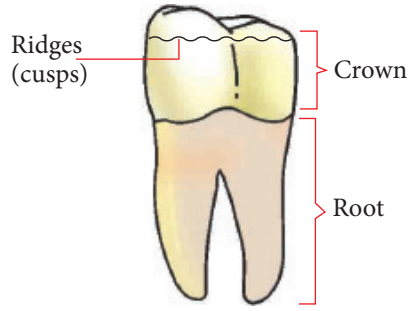


Fig 2.9: A premolar

(d) Molars

They occupy the back of the jaw, in the cheek. They too have broad top surfaces with four or five cusps, which form a ridged surface as shown in fig 2.10. They are also used to crush and grind food.

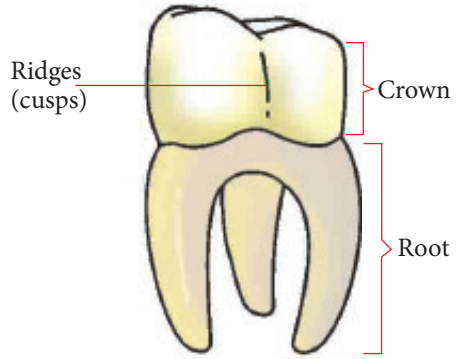


Fig 2.10: Molar tooth

Human beings have two sets of successive teeth. The first set is known as the **milk** set or **deciduous** teeth. They form in the jaw before birth. In a new-born baby, the teeth are not visible above the gum. They erupt out of the gum at about five months. At two years, the baby has all the teeth

in the milk set, usually 20. Milk teeth are shed from the age of about seven years. They are replaced by a second set of teeth which are larger and more permanent. These are permanent teeth. An adult has 32 permanent teeth. The last molars to appear are called **wisdom** teeth. They erupt any time between 17 and 25 years.

Structure of the tooth

Activity 2.3

Investigating the structure and function of human teeth

Work in a group of 4.

Procedure

1. Observe carefully the models, charts and diagrams showing the structure of human teeth and rabbit teeth.
   - How does the human and rabbit teeth differ?
   - How are they similar?
2. Label the different parts shown and suggest their functions.
3. Compare your drawings with the rest of the class.

Study questions

1. How is the shape and structure of each tooth related to its function?
2. Is the arrangement of the teeth affecting their functions?

The facts

A tooth has three regions. These are the **crown**, **root** and **neck**. The crown projects above the gum, the root is fixed in a socket in the jaw-bone and the neck is the narrow part which lies between the root and the crown.

When a tooth is cut longitudinally into two, we can observe and study the internal parts. The internal structure of a tooth is shown below.

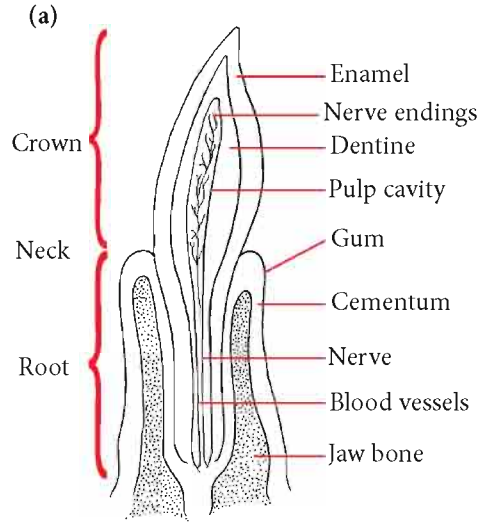


Fig 2.11: Longitudinal section of a canine tooth

Enamel

The enamel is the outer part of the tooth. It is the hardest substance in the human body. It is made up of non-living tissue. The function of enamel is to:

- Protect the inner parts of the tooth from infection by bacteria and other micro-organisms. It also protects the inside of the tooth from mechanical damage by hard food material such as bones.
- Provide a hard biting surface.

Dentine

This is the part of the tooth found immediately beneath the enamel. It is not as hard as the enamel. It is made up of living cells. The dentine:

- Forms the bulk of the tooth.
- Replaces worn out enamel.
- Prevents the teeth from cracking.

Pulp cavity

It is found at the centre of the tooth. The pulp cavity contains numerous blood capillaries and sensory nerves. These enter the pulp cavity through a small opening at the bottom part of the root. The blood capillaries supply nutrients and oxygen to the cells of the pulp cavity. They also transport waste material and carbon dioxide from the tooth. The sensory nerve fibres have nerve endings that make the tooth sensitive to temperature and pain. Special cells in the pulp cavity produce dentine which forms the bulk of the tooth.

Cement

It is similar to bone in structure. It lines the root and holds the tooth in its socket in the jaw.

Periodontal membrane

This membrane is found between the cement and the jaw bone in the socket of the tooth. It contains cells that secrete cement. It also allows the tooth to move slightly to avoid breaking during chewing.

Check your progress 2.2

1. Match the tooth with its function.

Tooth	Function
(a) 	Crush and grind food
(b) 	Grinding food
(c) 	Cutting and biting food
(d) 	Piercing and holding food

2. Explain how the arrangement of teeth in the mouth is related to the function of the teeth.
3. Why toothache if decay reaches dentine?
4. Why do tooth have hard enamel?

Common dental diseases

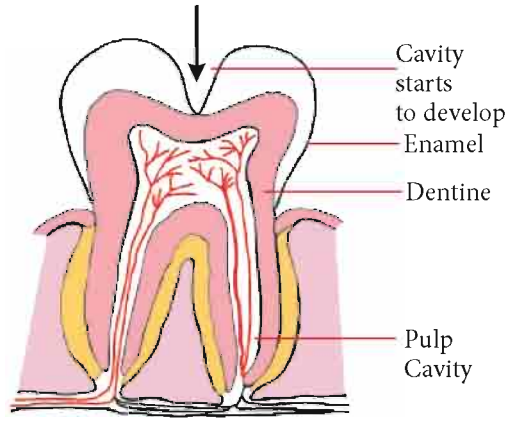
The mouth cavity is a habitat for bacteria and other micro-organisms. These

micro-organisms feed on the food particles that remain trapped between the teeth after eating. Bacteria and their activities can be a source of disease to both the teeth and the gum. Bacteria cause two major dental diseases; **dental caries** and **periodontal** disease. Lack of proper care of the teeth also contributes to this problem.

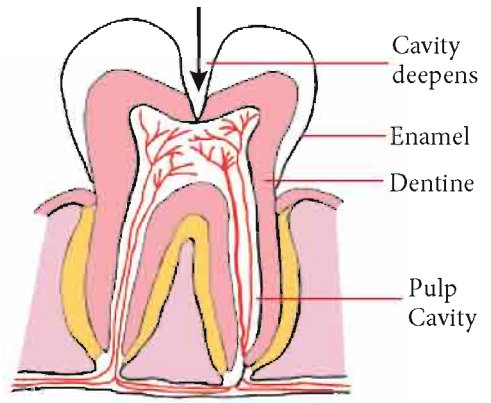
Dental caries

This is also called **dental cavities**. It is a dental disease that is caused by plaque found on the surface of the teeth and also between the teeth. Plaque is made up of bacteria mixed with saliva. The bacteria feed on sugary substances in the food left between the teeth, in order to produce energy for them. An acid is formed as a by-product of this process. This acid slowly dissolves or corrodes part of the tough tooth enamel. This is the beginning of the formation of a tiny hole called a **cavity**, which does not cause any pain.

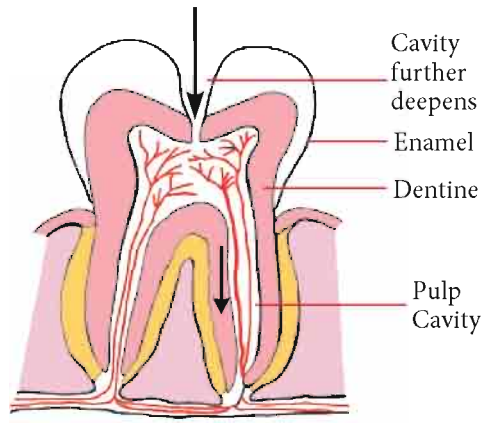
The cavity traps more food and bacteria. Further bacterial action on the food causes the cavity to become deeper, exposing the dentine. At this point some pain is felt. If the cavity becomes deep enough to reach the pulp cavity, severe pain is felt due to exposure of the nerve endings. At this point, this pain is called a **toothache**. Dental cavities can form in the grooves on the top surface of teeth, e.g. molars. They can also form at the junction between the neck and the root of any tooth.



(a) A cavity begins to form in enamel



(b) Cavity deepens to reach dentine



(c) Cavity further deepens to reach pulp cavity

Fig 2.12: Stages in the formation of dental cavity

Health check!

It is advisable to clean teeth a minimum of two times a day.

Care of teeth

Most dental diseases can be prevented with proper care of the teeth and gums. This would require a proper diet and good oral hygiene and other measures. The following are some useful measures in preventing dental diseases.

(i) A diet rich in calcium and vitamin D is important in the growth of strong and healthy teeth. This is especially important in pregnant mothers, breast-feeding mothers and children.

(ii) Brushing the teeth regularly, particularly after meals and before going to sleep to remove food particles and to reduce the accumulation of plaque. Food particles that are stuck between the teeth can also be removed by inserting a strong nylon thread into the gaps between the teeth and pulling the thread upwards. Thread used in this way is called **dental floss**.

(iii) Avoiding sweet and sugary food in order to prevent multiplication of bacteria on the teeth.

(iv) Eating food that contains enough fibrous material to stimulate blood circulation in the teeth due to the chewing process. Efficient blood circulation supplies the teeth with the necessary nutrients required for maintenance of strong and healthy teeth. Examples of food rich in fibrous material are nuts, sugarcane, pear and raw carrots.

(v) The teeth should not be used to remove bottle tops or crack nuts. Such use of teeth could cause cracks in them. Food particles and bacteria could occupy the cracks and cause dental cavities.

(vi) Occasionally, when brushing is not possible, the mouth should be rinsed thoroughly with water to remove food particles between the teeth.

(vii) Taking water with minute quantities of fluoride and using toothpaste with small amounts of fluoride could prevent dental cavities. Fluoride helps in the formation of hard, strong teeth.

(vii) Regular visits to a dentist will help in the detection of cavities and diseases of the gum at an early stage.

Activity 2.4: Research Activity

Work in a group of four

1. Devise an experiment to investigate the effects of hydrochloric acid, lemon juice and fizzy drinks on egg shells.
2. Share your finding with the rest of the class.

Check your progress 2.3

1. The outer layer of the crown of a tooth is resistant to attack by bacteria.
   (a) Name the outer layer.
   (b) State the minerals and the vitamins needed in the diet for the healthy development of this layer.
   (c) Explain how bacteria can gain entry through this layer into the tooth and cause dental decay.
2. How do the functions of teeth contribute to the process of digestion?

2.3 The digestive system

Activity 2.5: Dissection of a rabbit to observe the digestive system and compare it to the human digestive system

Materials

- Charts and models of the human digestive system
- Rabbit (preserved or just killed)
- Dissecting instruments
- Cotton
- Dissecting board or tray
- Pins

Procedure

1. Place the rabbit on its back on the dissection board and stretch out the body by tying the limbs to the sides of the board with a pin.

Caution: Gloves must be worn while performing dissection. This reduces the risk of infectious diseases

2. Wet the fur and then pinch up the skin in the middle of the abdomen.
3. Insert the point of your scissors, cut skin upwards along the midline to the neck, downwards near the reproductive opening and outwards along the four limbs.

Safety warning: Be careful when using sharp objects like scissors and surgical pins to avoid cutting and pricking yourself.

4. Separate the skin from the underlying muscle with your scalpel and pin it out on either side of the body. cortex, medulla, pelvis, renal artery, renal vein and urethra.
5. Draw and label the structures you have identified.
6. Open up the abdominal cavity by holding your scissors horizontally and carefully cutting through the muscle layers along the mid-ventral line, forwards to the start of the breastbone and backwards to near the reproductive opening.
7. Cut across the body muscle immediately behind the ribs and towards the rear of the abdominal cavity.
8. Pin back the body flaps.
9. Locate the following organs: liver, stomach, small intestine (much coiled), caecum colon or large intestine, rectum, bladder (bag-like).
10. Without disturbing the organs, make a drawing of the abdominal cavity.

11. Observe the charts and models of human digestive system.

Remember! Wash your hands frequently and before leaving the laboratory. Avoid unconcious gestures such as scratching the face

- Name all the parts of the digestive system.
- What are the functions of parts of the digestive system named?

12. Compare your diagram drawn of the digestive system of the rabbit and the charts and models of the human digestive system.

The facts

Human beings take in solid or liquid food material. The teeth mechanically break down food into smaller pieces. Such food is easy to swallow. However, it is still complex and the body cells cannot use it in this form. It needs to be broken down further. This complex food is broken down by enzymes. The breaking down process changes the food materials from complex compounds to a simple compound which can easily be absorbed by the human body. This process is known as **digestion**. It takes place along the digestive system.

Discussion corner

1. Draw human digestive system and state the function of each part.
2. Role play digestive system: each learner to be part of the system, stand in correct order and each describes his or her function.
3. Role play disestion by enzymes and absorption: Long chain (of learners holding hands), broken up by enzymes (release hands) small enough to be absorbed (pass through spaces between chairs/other students), enzymes as catalysts (not used up).

You will remember that an organ system is a group of different organs working together to carry out a particular function. The digestive system is such a system. The main function of the digestive system is to break down complex food material into simple soluble substances that the cells can use. Both mechanical and chemical breakdown of food take place in the digestive system.

The parts that make up the digestive system are the alimentary canal, liver, pancreas, gall bladder and salivary glands.

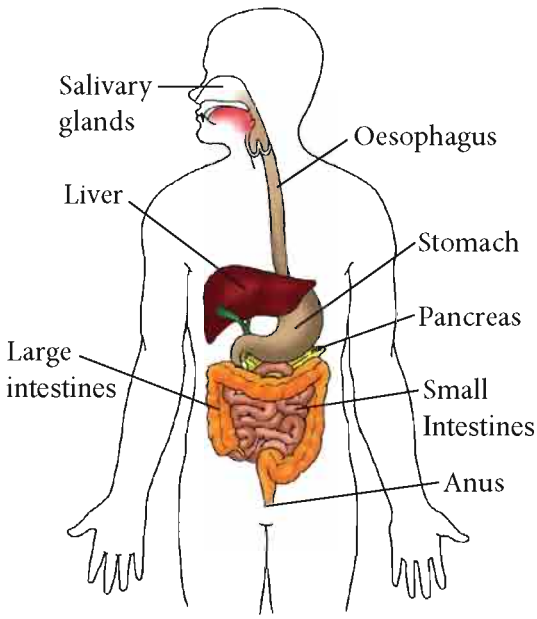


Fig 2.13 Human digestive system

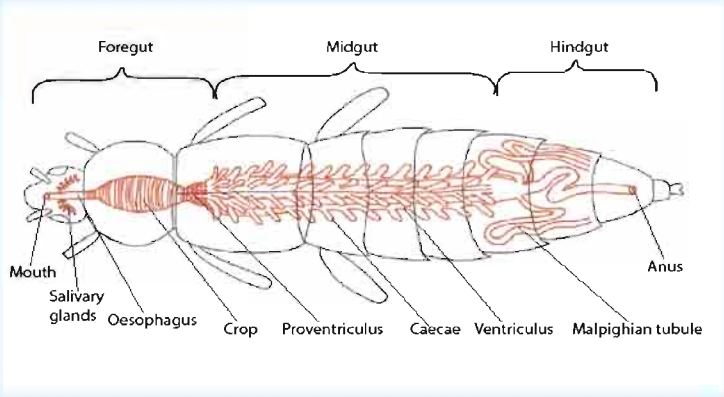
Anatomy of the digestive system in insects

Activity 2.6

To study digestive system of insect

In pairs

1. Look at the picture below. What can you see?



2. Compare this with the digestive system of human being as learnt earlier.
3. Note down the similarities and differences.

The facts

An insect uses its **digestive system** to extract nutrients and other substances from the food it consumes. Most of this food is ingested in the form of **macromolecules** and other complex substances (such as **proteins**, **polysaccharides**, **fats**, and **nucleic acids**) which must be broken down by **catabolic reactions** into smaller molecules (i.e. **amino acids**, **simple sugars**, etc.) before being used by cells of the body for energy, growth, or reproduction. This break-down process is known as **digestion**.

The insect's digestive system is a closed system, with one long enclosed coiled tube called the **alimentary canal** which runs lengthwise through the body. The alimentary canal only allows food to enter the mouth, and then gets processed as it travels toward the **anus**. The alimentary canal has specific sections for grinding and food storage, **enzyme** production.

Anatomy of feeding organism in birds

Many birds possess a muscular pouch along the **esophagus** called a **crop**. The crop functions to both soften food and regulate its flow through the system by storing it temporarily. The size and shape of the crop is quite variable among the birds. The avian **stomach** is composed of two organs, the **proventriculus** and the **gizzard** that work together during **digestion**. The proventriculus is a rod shaped tube, which is found between the esophagus and the gizzard, that secretes **hydrochloric acid** and **pepsinogen** into

the **digestive tract**. The acid converts the inactive pepsinogen into the active **proteolyticenzyme**,**pepsin**, which breaks down certain specific **peptide bonds** found in **proteins**, to produce a set of **peptides**, which are **amino acid chains** that are shorter than the original dietary protein. The **gastric juices** (hydrochloric acid and pepsinogen) are mixed with the stomach contents through the muscular contractions of the gizzard. The gizzard is composed of four muscular bands that rotate and crush food by shifting the food from one area to the next within the gizzard. The gizzard of some species of herbivorous birds, contains small pieces of grit or stone called **gastroliths** that are swallowed by the bird to aid in the grinding process, serving the function of **teeth**. The use of gizzard stones is a similarity found between birds and **dinosaurs**, which left gastroliths as **trace fossils**.

The partially digested and pulverized gizzard contents are passed into the **intestine**, where **pancreatic** and **intestinal enzymes** complete the digestion of the digestible food. The digestion products are then absorbed through the intestinal **mucosa** into the blood. The intestine ends via the large intestine in the vent or **cloaca** which serves as the common exit for renal and intestinal excrements as well as for the laying of eggs. However, unlike mammals, many birds do not excrete the bulky portions (roughage) of their undigested food (e.g. feathers, fur, bone fragments, and seed husks) via the cloaca, but regurgitate them as **food pellets**.

nutrientabsorption. **Sphincters** control the food and fluid movement between three regions. The three regions include the foregut (stomatodeum) the midgut (mesenteron) and the hindgut (proctodeum)

In addition to the alimentary canal, insects also have paired **salivary glands** and salivary reservoirs. These structures usually reside in the thorax (adjacent to the fore-gut). The salivary glands produce saliva; the salivary ducts lead from the glands to the reservoirs and then forward through the head to an opening called the **salivarium** behind the **hypopharynx**; which movements of the mouthparts help mix saliva with food in the buccal cavity. Saliva mixes with food, which travels through salivary tubes into the mouth, beginning the process of breaking it down.

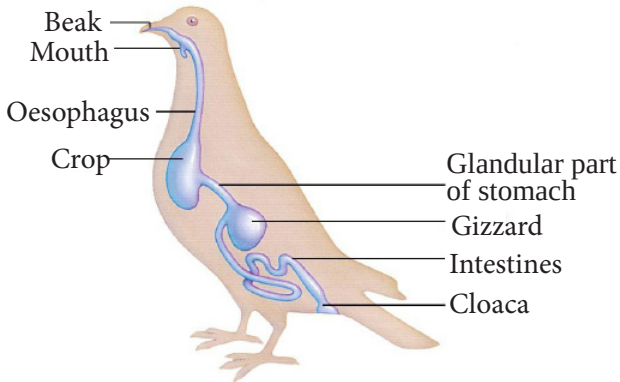


Fig 2.14 Bird's digestion system

Check your progress 2.4

1. Compare digestive system in birds to that of human beings
2. Draw and label insect digestive system.
3. What is the difference between a complete digestive system and an incomplete digestive system? How are these types of digestive systems related (or not) to extracellular digestion?
4. What are some of the evolutionary advantages among animals with a complete digestive tract?

Unit 3

Transport, respiration and gaseous exchange

Learning outcomes

Knowledge and understanding	Skills	Attitude
By the end of this unit, I should be able to:		
• Understand the process of transport, gaseous exchange, excretion and homeostasis in animals.	• Investigate open and closed circulatory systems in animals, explain diffusion and mass flow in liquids. • Relate the microscopic structures of kidney, lungs, skin, to their functions.	• Show curiosity to know about functions of the different organ systems in animal body.

Introduction

In senior one you learnt about movement of substance into and out of the cell. Can you recall forces behind the movement of substance into and out of the cell.

Now, look at the picture below. What can you see? Relate this to what we are about to learn in this unit.

Fig. 3.1 Hot water system in a house

In addition to the exchange of materials between an organism and its environment, there is need for materials to be transported within the organism. Oxygen and nutrients need to be transported from their place of uptake to the respiring cells; carbon dioxide and other waste products must be removed. Therefore, the body needs a transport system to carry nutrients and oxygen to the cell and at the same time carry waste substances from the cells.

3.1 Understanding transport in animals

Unicellular organisms obtain or release substances to the environment by diffusion. However multicellular animals have a **circulatory system** which consists of **vessels**, a **transporting medium** and a **pumping organ.**

The transporting medium flows through vessels and is pumped to all parts of the body by one or more pumping organs. Cells and tissues obtain useful substances from this transporting medium. They also release their waste substances into it. There are two types of circulatory systems in animals: **closed** circulatory system and **open circulatory system.**

Comparison between open and closed circulatory system

Activity 3.1

Work as a group

Procedure

1. Use the fig 3.2 and 3.3 in the book to differentiate between open and closed circulatory system.
2. Use school library and internet to research more about open and closed circulatory system.

The facts

In an **open circulatory system**, the blood does not stay inside the vessels all the time because they are open ended. Instead, the blood is pumped out of the vessels by a heart or pumping organ into a space within the body known as the **haemocoel.** This means that blood is in direct contact with the cells. The cells exchange materials directly with the blood. This blood eventually flows back into the heart due to the movement of the body muscles of the organism.

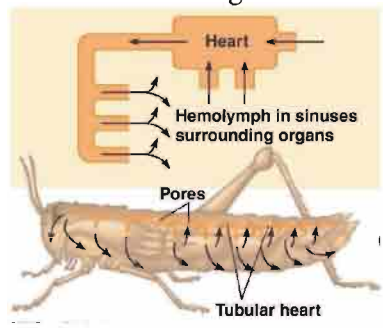


Fig. 3.2 Open circulatory system

In a **closed circulatory system**, the blood does not leave the vessels which link up to form a continuous system, as shown in Fig. 3.3. It circulates within these vessels due to the pumping action of the heart which is part of the system. In this way, food and waste substances from the tissues enter the blood which is contained in the vessels.

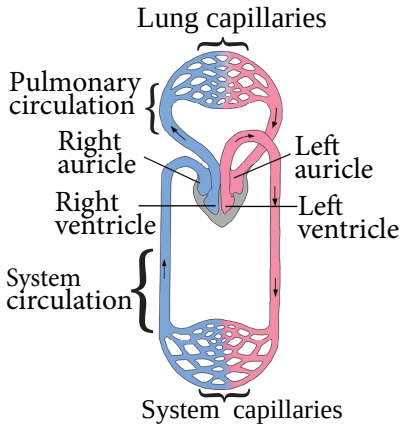


Fig. 3.3 Closed circulatory system

The open circulatory system works best in organisms with a small body cavity e.g. insects. It is not efficient for large organisms such as vertebrates. Insects' circulatory systems consist of a long tubular heart along the back side (dorsal) of the organism. When the heart contracts, blood in it is forced out at its front end. The blood then flows into the haemocoel or body space where exchange of materials with the tissues takes place. It then re-enters the heart through openings called **ostia**.

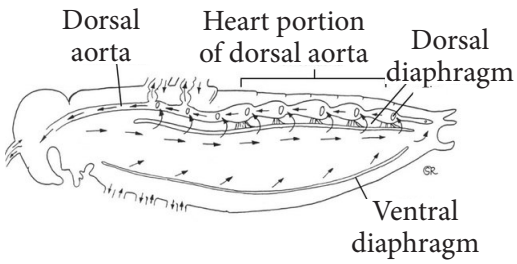


Fig. 3.4 Closed circulatory system in a grasshopper

Closed circulatory system is found in annelids and vertebrates like mammals. It has an advantage over the open circulatory system because the pressure of blood in it is high.This means that blood circulates faster, and hence transports substances to and from the tissues faster than in the open circulatory system.

Mammalian circulatory system

The mammalian circulatory system consists of a **heart** which keeps pumping in order to circulate **blood** through a well-defined network of **vessels** around the body. There are three kinds of blood vessels; **arteries**, **veins** and **capillaries**.

Structure and function of the heart, arteries, veins and capillaries

Structure of the heart

Activity 3.2

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

As a class

Materials

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

Procedure

1. Your teacher will dissect the heart of a sheep..
2. Observe keenly as he or she is dissecting.

Study questions

1. Why was he or she using a sharp scapel?
2. On observation you realised that the heart was covered with layers of fat. Explain the main reason for this.
3. Are you able to identify parts of the heart? If yes, relate the structure of each part to their function.

The main observable features of the heart are:

- the thick muscular walls of the ventricles, the left ventricle walls being thicker than the right ventricle walls.
- the thin walls of the auricles compared with 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.

The heart of a goat is a muscular

Activity 3.3:

Relating observable features of the heart to their functions.

In group of five.

Materials

- Chart with the structure of the heart.
- Handouts with information on heart.

Procedure

1. Your teacher will assign each group some parts of the heart for discussion.
2. Using the chart provided, observe each part asign by your teacher.
3. Relate the structure of each part with its function. Use handout provided for guidance.
4. Share your results to the rest of the class through your group leader.

The facts

Heart 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 that 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. 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 **atrioventricular** valves, which allow the blood to flow

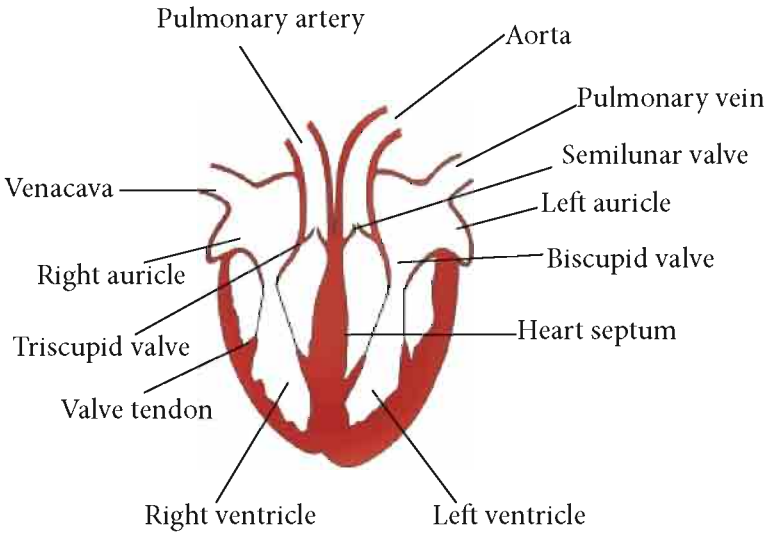


Fig 3.5 internal structure of the heart

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.

Circulation of blood in the heart

Activity 3.4: Investigating circulation of blood in the body

In groups of five

Procedure

1. Using charts, illustrations or computer animations provided, examine the circulation of the blood in the heart.
2. Trace the path taken by the red blood cell in a complete circuit.
3. Share your findings with the class.

Study questions

1. What did you realise about path taken by blood?

The facts

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 (IV) oxide and appears **dull red** in colour.

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 prevent back flow 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 (IV) oxide. 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**.

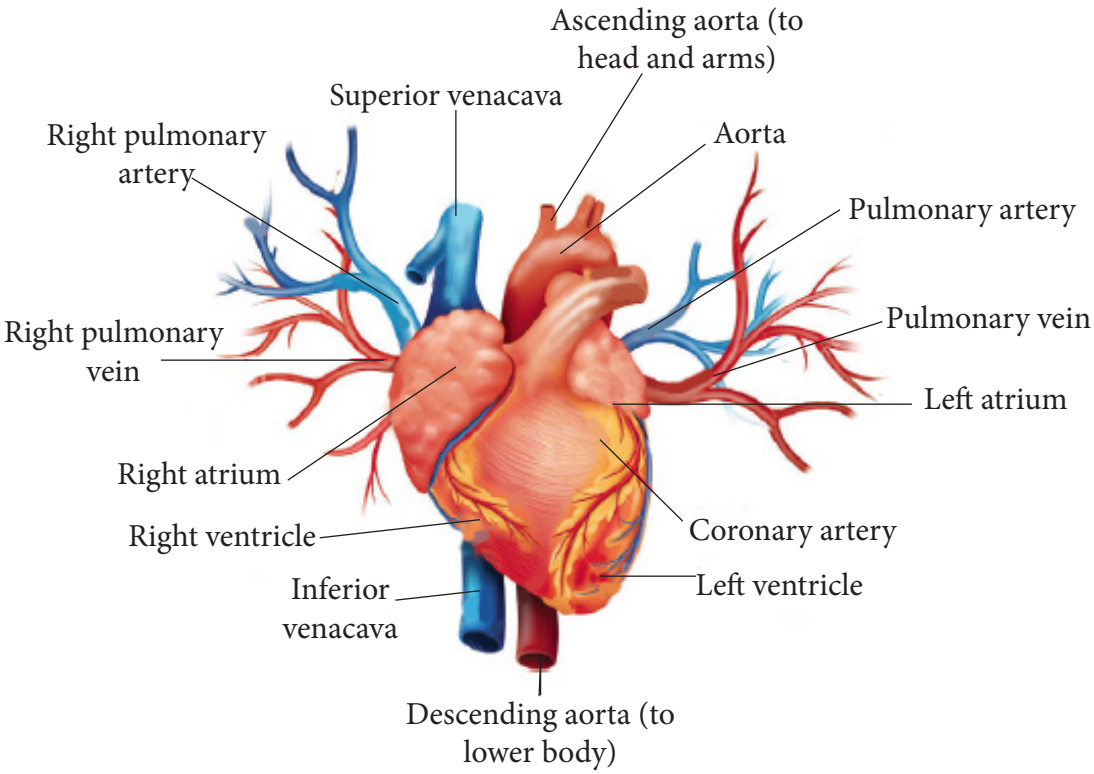


Fig 3.6 External structure of the heart

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.

Pulse rate

Activity 3.5: Investigating pulse rate at the wrist before and after rigorous activities.

Materials

- Stop watch
- Sphygomanometer

Procedure

1. You are provided with the Materials above.
2. Come up with the steps on how you will investigate pulse rate.
3. Use the steps to investigate pulse rate at the wrist before and after rigorous activities.
4. Record your results in a tabulated way.

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

Study questions

1. Explain why the pulse can only be felt in few places, commonly joints.
2. Why do veins have valves?
3. Why do minor cuts bleeds although no arteries or veins have been damaged?

The facts

Were your steps the same as the ones shown below?

1. Take your pulse by placing three fingers on your partner's wrist. Shift the position of these fingers until you get some beating movement against your fingers.
2. Count the number of times you feel these beats in a minute and record them in a table.
3. Repeat this procedure.
4. Ask your partner to walk around the classroom block. Take the pulse again.

The facts

The normal average heartbeat of an adult is 72 beats per minute. This is also known as pulse rate. It increases during rigorous activity. An increased heartbeat 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 from the tissue.

Pulse rate can only be felt in a few places, commonly joints.

Check your progress 3.1

1. Fill in the table below.

Part	Adaptation	Functions
Cardiac muscle	_____	Contracts and relaxes on its own without fatigue. Generate energy for muscle contraction. Spread wave of excitation throughout the heart muscles.
Valves • Biscuspid • Tricuspid • Semilunar	Flaps of tissue Pocket like	_____
_____	Thick muscular and elastic walls, narrow lumen.	Lead the blood away from the heart.
Pericardium		Prevents the heart from overstretching and secretes pericardial fluid to lubricate the heart against the membrane.
_____	Inelastic	Prevent the atrioventricular valves from turning inside out into the auricles

2. Draw and label the structure of the heart.
3. Which is the most powerful chamber in the heart and why?
4. Using illustrations and examples, distinguish between single and double circulatory system.

3.2 Blood vessels

Activity 3.6

Observing prepared slides of blood vessels

Work in a group

Materials

- Microscope
- Prepared or permanent slides of blood vessels
- Diagrams and charts

Procedure

1. Set up the microscope.
2. Mount the prepared slides and observe.
3. Make drawings of your observations.
4. Using illustrations and examples, distinguish between single and double circulatory system.

Study questions

1. How many types of blood vessels did you observe?
2. Compare the structures of the blood vessels.
3. How are the blood vessels suited for their functions?

The facts

Blood vessels are tube like structures which form continuous channels through the body. They transport blood to and from the heart to the body tissues. There are three major types of blood vessels: **arteries**, **veins** and **capillaries**. The figure below illustrates the relationship between these three main vessels.

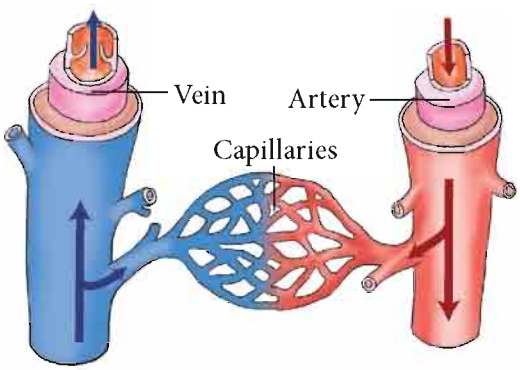


Fig 3.7: Relationship between arteries, capillaries and veins

Arteries

The heart pumps blood into vessels called arteries. Arteries carry blood away from the heart 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.

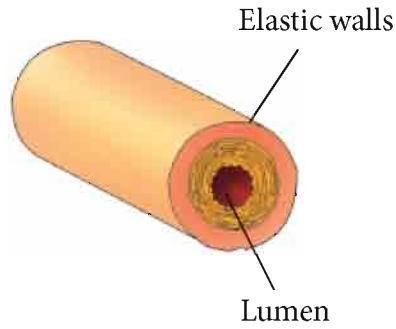


Fig 3.8: Artery

Arteries have the following properties.

- Thick muscular walls to withstand and maintain higher pressure of blood and also for protection.
- A thick layer of muscle and elastic fibres which contract and relax to adjust their diameter as 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.
- Arteries are located deep within our bodies.
- All arteries **carry oxygenated** blood except the pulmonary artery which carries deoxygenated blood.

The size of the lumen in arteries can be adjusted by 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 supplied to 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.

Arteries branch out to form narrower

vessels called **arterioles**. The arterioles branch further within the tissues into finer vessels called **capillaries**.

Capillaries

Capillaries are fine branching blood vessels that form a dense network between the arterioles and venules.

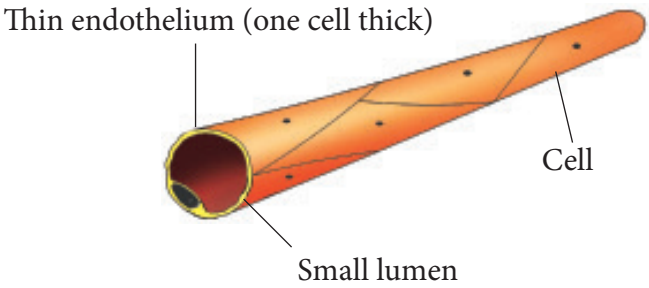


Fig 3.9: Capillary

Capillaries have the following properties.

- They have thin walls to allow for rapid exchange of substances.
- They form a dense network which creates a large surface area over which the exchange of substances takes place.
- Their walls are narrow to allow high pressure build-up within them. This ensures faster movement of substances out of them.
- They have very thin walls made up of only one cell layer for faster exchange of materials.

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 and elastic fibres and an inner layer of cells, 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.

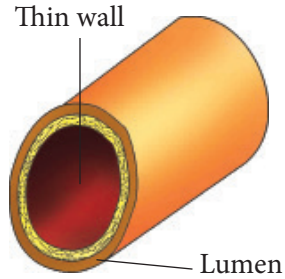


Fig 3.10: Vein

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.

Check your progress 3.2

1. Which blood vessels carry blood away from the heart?
2. Blood vessels which absorbs strong pressure pulses contain more of _____tissue.
3. What features do veins have that arteries do not have? Use a table.

Composition of blood

Activity 3.7

Investigating the components of blood

Work in a group

Materials

- Light microscope
- Micrographs of blood smear
- Diagrams and charts

Procedure

1. Set up the microscope with assistance from your teacher.
2. Mount the micrographs of blood smear.
3. Make drawings of your observations.
4. Compare your drawing with the charts.

Study questions

1. What is the composition of blood?
2. Compare the structures of the blood components.
3. Are there any structural adaptations in the components of blood?

The facts

Blood is the body fluid which transports materials in mammals. It is a liquid tissue that contains

suspended substances as well as dissolved substances. Blood has three major functions:

- A medium of transport of materials to and from other tissues.
- Regulation of body temperature and of materials in the body.
- Protection against disease germs

The mammalian blood is composed of **cellular components** suspended in a pale yellow watery medium known as **plasma**. The cellular components of blood are the **blood cells** and the **platelets**. There are two main types of **blood cells: red blood cells** also known as erythrocytes and the **white blood cells** also known as leucocytes.

Plasma

Activity 3.8

Imagine you are a radio presenter. You have a morning show, and your co-presenter informs you in the evening that next morning show will be discussing plasma.

Study questions

1. How will you go about it?
2. What are the key points that you should know?
3. How is this topic going to be helpful?

The facts

Plasma makes up about 55 per cent of the total volume of blood. The other 45 per cent of the blood is made up of the red blood cells, white blood cells and the platelets. Blood plasma is clear and pale yellow in colour when separated from the cellular parts of blood. Ninety per cent of blood plasma is made up of water. The remaining ten per cent consists of a variety of substances that are dissolved in the water. These substances dissolved in plasma include:

- **Food substances** - glucose, amino acids and fatty acids.
- **Vitamins** and **mineral salts** from digestion. The mineral salts are in and hydrogen carbonate ions.
- **Waste substances** - carbon dioxide and urea.
- **Hormones** - adrenaline and insulin among others.
- **Enzymes** and **antibodies**.
- **Proteins** - albumin, fibrinogen and globulins.

Did you know?

Blood plasma without fibrinogen is called **serum**.

Functions of blood plasma

The plasma transports substances dissolved in it from one part of the body to another.

i. Transportation of carbon dioxide

Carbon dioxide is formed from reactions that release energy in the cells. Carbon dioxide can be toxic to the cells at high concentrations and must be removed before it accumulates.

About 5 – 10% of carbon dioxide from the tissue is transported in solution as **carbonic acid**. The water in plasma acts as the solvent.

Carbon dioxide water + carbonic acid

$$CO_2 + H_2O \longrightarrow H_2CO_3$$

The plasma also carries carbon dioxide in form of hydrogen carbonate ions formed from breakdown of carbonic acid in the red blood cells. Most of the carbon dioxide is transported in this way.

ii. Transportation of waste substances

End products of metabolic wastes in the body such as urea, carbon IV oxide and urine are transported to various excretory organs for elimination from the body.

iii. Transportation of heat

Transport of heat by the blood helps distribute it evenly within the body tissues. Most heat originates from an organ like the liver in which many heat-producing chemical reactions occur.

iv. Transportation of hormones

The blood plasma serves as a medium in which hormones are transported from the glands that produce them, to specific target organs on which they act.

v. Transportation of antibodies

Antibodies are chemical substances that protect the body from disease causing

micro-organisms. They are transported in the plasma.

vi. Transportation of nutrients

Many of the products of digestion such as glucose and amino acids are dissolved in the plasma before they are transported from the small intestines to the liver either for storage or for further transport to cells in body organs.

Red blood cells (Erythrocytes)

Discussion corner

- What are red blood cells?
- Explain why the number of red blood cells increases.
- To what role do the special shape of red blood cells play in relation to their function?

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

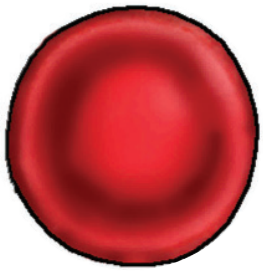


Fig 3.11: Red blood cell

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. 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 red bone marrow of the bones of the sternum and ribs. They circulate for about 100–120 days in the body before their components 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 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, while haemoglobin is free to be used again to carry more oxygen.

Haemoglobin + oxygen $\xrightarrow{tissue}$ oxyhaemoglobin

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 (Leucocytes)

Activity 3.9

In pairs

Materials

Manila paper, scissors, maker pen, stick glue, handout.

Procedure

1. Draw different types of white blood cell.
2. Under each cell, list the roles it plays.
3. Use stick glue to stick on class walls.

The facts

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 infection. White blood cells have a nucleus and fight disease germs in the body.

There are two main types of white blood cells namely lymphocytes and phagocytes. Others are neutrophils, monocytes, eosinophils and basophils.

i. Phagocytes

Phagocytes are made in the bone marrow of long bones. They have a large lobed nucleus and a cytoplasm containing granules.

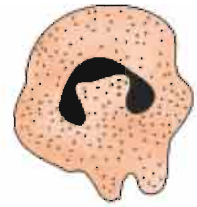


Fig 3.12: Phagocyte

They can change their shape as they actively seek, engulf and digest disease - causing micro-organisms. Therefore, protecting the body from infection. They can squeeze through capillary walls in order to reach infected tissue.

ii. Lymphocytes

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

Fig 3.13: Lymphocyte

They protect the body from disease by recognising foreign proteins (antigens) in disease-causing micro organisms that invade cells. They are also able to recognise any chemicals that these micro-organisms produce. Lymphocytes respond by producing chemical substances called **anti-bodies** to destroy the antigen or germs.

iii. Neutrophils

Neutrophils are the most common type of white blood cell in the body. Neutrophils are medium-sized white blood cells with irregular nuclei and many granules. They kill germs by means of a process known as phagocytosis or "cell-eating.

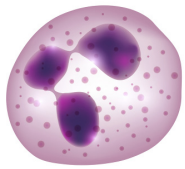


Fig 3.14: Neutrophil

iv. Monocytes

Monocytes are the largest of the types of white blood cells. They have few granules in the cytoplasm when seen under the microscope. Monocytes turn into macrophages when they exit the bloodstream.

As macrophages, monocytes do the job of phagocytosis (cell-eating) of any type of dead cell in the body, whether it is a somatic cell or a dead neutrophil.

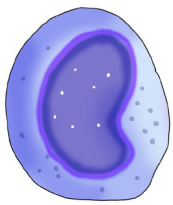


Fig 3.15: Monocyte

v. Eosinophils

There aren't that many eosinophils in the bloodstream—only about 40-400 cells per mm3 of blood. They have large granules that help in cellular functions. Eosinophils are especially important when it comes to allergies and worm infestations. High eosinophil counts are associated with allergic reactions.

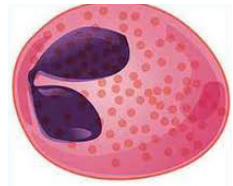


Fig 3.16: Eosinophil

vi. Basophil

Basophils are the least frequent type of white blood cell, with only 0-100 cells per mm^3 of blood. Basophils have the ability to secrete anticoagulants and antibodies that have function against hypersensitivity reactions in the bloodstream.

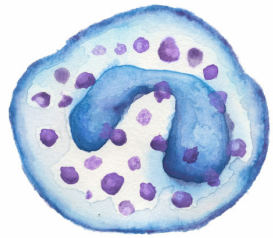


Fig 3.17: Basophil

Platelets

Blood platelets are also known as **thrombocytes**. They are fragments from larger cells. They are very small and have no nucleus.

Fig 3.18: Platelets

Platelets are formed by the pinching off of bits of cytoplasm from large cells inside the bone marrow.

Although these bits of cytoplasm contain no nuclei, they are surrounded by a membrane. About 300,000 platelets are found in 1 cm^3 of blood. They live for about seven days. Platelets are involved in blood clotting when an injury occurs on the skin.

Check your progress 3.2

1. Which of the following statements is true concerning human blood?
   - A. Blood is not a tissue.
   - B. The blood of all normal human beings contains red and white cells, platelets and plasma.
   - C. Some people lack the ability to produce plasma.
   - D. Proteins are not normal components of blood.
2. Write true or false for the following statements.
   - A. Mature red blood cells lack nuclei.
   - B. Red blood cells contain hemoglobin.
   - C. Deoxyhemoglobin carries oxygen.
   - D. Red blood cells lack mitochondria.
   - 3. The _____ produces red blood cells which transports____ and _____.
4. Of what advantage is it, for a red blood cell to:
   - (i) have a biconcave disc shape?
   - (ii) have haemoglobin?
   - (iii) Lack a nucleus?
5. What is the main function of white blood cells?
6. A student in Magwi Secondary School took a blood smear from the fingertip and examined it under a microscope.
   - (a) Which was the most abundant cell type that he observed ? describe one cell and state its function.
   - (b) A number of cells that he observed a large nucleus lobed and their outline looked like that of the amoeba. What name did he give such cells?
   - (c) Whats the function of the cells that he observed in (b) above?
7. What can one attribute the main causes of the circulatory system to man?
8. A footballer fell down during a match and bruised his knee. Drops of blood were seen to flow through the bruise for 20 minutes and then were seen to stop. Describe the processes which brought about the cessation of blood flow at the injury.
9. How does the structure of arteries and veins relate to their functions?
10. How do the heart and lungs work together to pick up and deliver oxygen to the cells.
11. Blood samples were taken from groups of people living in different altitudes and the number of red blood cells in each mm^3 of blood determined. The results of the survey are shown in the following table:

Height above sea level (m)	Red blood cells (per mm^3 of blood)
0	5,000,000
400	5,750,000
1500	6,500,000
1800	7,000,000
4400	8,000,000

(i) Plot a graph of altitude against the number of red blood cells per mm^3 of blood.

(ii) Explain the significance of increase in number of red blood cells as altitude increases

(iii) Explain what athletes going to compete in high altitude areas should do in order to increse O_2 absorption capacity during the competitions.

3.3 Lymphatic system

Activity 3.10

Investigating the lymphatic system

Work in a group

Procedure

Using computer simulations and charts identify the location of lymph nodes, lymph vessels and glands.

Study questions

1. What is the function of the lymphatic system in the body?
2. How does the lymphatic system complement the blood circulatory system?

The facts

Blood entering the arteriole end of a capillary network has a higher pressure compared to that leaving the venule end. This pressure forces water and small solutes in the blood to pass through the capillary wall and to form a fluid outside the capillaries.

This fluid surrounds the cells in the tissues and is called **tissue fluid**. Blood cells and large proteins do not pass through capillary walls. Tissue fluid is similar to plasma but with less protein in it. It is from this fluid that cells obtain their nutrients and oxygen by the process of diffusion. Waste materials and secretory products from the cells diffuse into it. Tissue fluid eventually drains back into the blood at the venule end of the capillary where the pressure is lower.

Most of the tissue fluid does not re-enter the capillaries but instead makes its way into another system of capillaries known as the **lymphatic capillaries**. Inside this system the fluid is now called **lymph**.

The lymphatic capillaries link up to form another transport system made up of lymph vessels: lymph veins and lymph capillaries. These vessels are thinner than blood vessels and have many internal valves. They also have swellings along their length called **lymph nodes.** Lymph nodes contain **lymphocytes**.

Lymphocytes are white blood cells which defend the body against infection by producing antibodies. The antibodies kill micro-organisms that cause the disease. Examples of such micro-organisms are bacterium, virus and fungi.

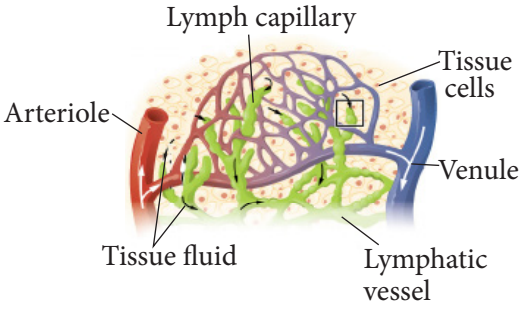


Fig 3.19: Lymphatic capillaries

An antibody is a protein produced in the blood that fights diseases. Just like blood circulatory system which transports blood, lymphatic system transports lymph. The lymphatic system is a network of tubes throughout the body that drains fluid (called lymph) from tissues and empties it back into the bloodstream. Lymph is filtered through the spleen, thymus and lymph nodes before being emptied into the blood. Blood vessels tend to seep fluid into surrounding tissue. The lymphatic system drains off any extra fluid to stop the tissues from puffing up.

The lymphatic system consists of a fluid (lymph), vessels that transport the lymph and organs that contain lymphoid tissue.

Lymph

Lymph is a fluid similar in composition to blood plasma. It is derived from blood plasma as fluids pass through capillary walls at the arterial end. As the interstitial fluid begins to accumulate, it is picked up and removed by tiny lymphatic vessels and returned to the blood.

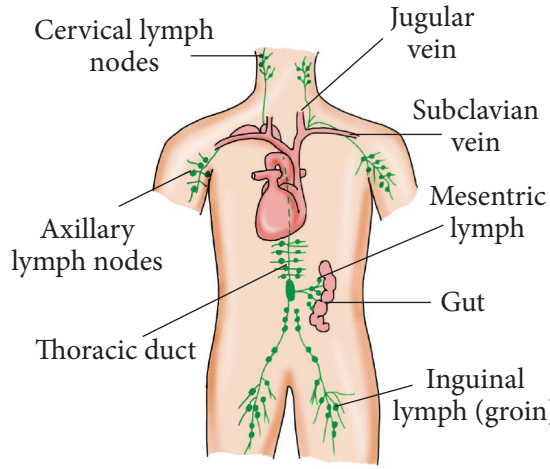


Fig 3.20: Lymphatic system

Lymphatic vessels

Lymphatic vessels, unlike blood vessels, only carry fluid away from the tissues. The smallest lymphatic vessels are the lymph capillaries, which begin in the tissue spaces. Lymph capillaries are found in all regions of the body except the bone marrow, central nervous system and tissues, such as the epidermis, that lack blood vessels.

Lymphatic organs

Lymphatic organs are characterised by clusters of lymphocytes and other cells in branching connective tissue fibres. The lymphatic organs include:

- Lymph nodes
- Tonsils
- Spleen
- Thymus

Lymph nodes

Lymph nodes are small bean-shaped structures found in particular locations in the body. Such places include neck,

armpits and between the lungs. Lymph nodes contain white blood cells which fight infections.

Tonsils

Tonsils are the two lymph nodes located on each side of the back of the throat.

They help to prevent the body from infection.

The spleen

The spleen is located in the upper left abdominal cavity, just beneath the diaphragm, and posterior to the stomach. It is similar to a lymph node in shape and structure but it is much larger. The spleen is the largest lymphatic organ in the body.

The thymus

The thymus is a soft organ with two lobes that is located inside the ribcage, just behind the breastbone. It is relatively large in infants and children but after puberty it begins to decrease in size so that in older adults it is quite small.

Functions of the lymphatic system

The lymphatic system has multiple interrelated functions:

i. It is responsible for the removal of interstitial fluid from tissues.

ii. It transports white blood cells to and from the lymph nodes into the bones.

iii. It absorbs and transports fatty acids and fats as chyle from the digestive system,

iv. It transports dendritic cells, to the lymph nodes where an immune response is stimulated.

Check your progress 3.3

1. The spleen is a lymph organ that filters blood and also acts as a reservoir for_____.
2. Both lymph and venous blood flow are heavily dependent on
   - A. the pumping action of the heart
   - B. Skeletal muscle contractions and differences in thoracic pressures due to respiratory movement
   - C. Contraction of the vessels themselves
   - D. Two-way valves
3. Draw and label the lymphatic system.

Immune response

Viruses, bacteria and other micro-organisms that cause diseases are called **pathogens**. They are found everywhere around us: in water, in soil, in the food we eat, the air we breathe, on our bodies, and even inside the body. When pathogens enter the body, they reproduce in large numbers and produce toxins or poisons that affect the normal cell functions. This makes us ill.

The skin, mucus, stomach acid, etc prevent most pathogens from getting to our cells. But this is not enough.

Pathogens still enter our bodies. The body has the ability to distinguish between substances that are part of itself and those that are foreign. This is because different organisms have different types of proteins within them. When the body recognises foreign protein in molecules or organisms that enter it,

it produces antibodies or special cells that destroy or inactivate the foreign material or organism. The production of antibodies and special cells that inactivate a foreign substance is called the **immune response.** This prevents disease, or in case of disease, it helps in healing. The ability of the body to fight infection by producing **antibodies** or cells that destroy pathogens is called **immunity.**

Various tissues in our lymphatic system make up the immune system. The immune system includes all the parts of the body that are involved in the recognition and destruction of foreign substances. It is made up of the following:

Bone marrow which produces white blood cells White blood cells especially phagocytes and lymphocytes. Various tissues of the lymphatic system such as lymph nodes tonsils, thymus and spleen which accommodate lymphocytes.

Natural and artificial immunity

Immunity may be active or passive

- In **active immunity** the body produces its own antibodies or natural killer cells (killer T cells) to attack a particular antigen.
- In **passive immunity** a person receives antibodies from another individual or animal. It is like donated immunity.

Active immunity

It may develop as a result of having had a disease. The organism makes its own antibodies as a result of contact with the antigen from the disease-causing pathogen. Once the organism recovers from the disease,

it can produce antibodies very quickly should the pathogen invade it again. This makes the organism **immune** in the sense that it cannot fall sick due to invasion by the same pathogen. Since this happened naturally it is also known as **active natural immunity.**

Active immunity can also be induced by introducing antigens into the body of an organism through the use of a **vaccine**. A vaccine contains antigens composed of living, dead, or weakened pathogens. They are used to stimulate the body to recognise certain disease antigens and to respond to them. They usually do not cause the disease. This is **active artificial immunity.**

Passive immunity

This is immunity that comes from using antibodies produced in one organism to protect another organism from a specific disease. These antibodies are usually extracted from the **serum** of an animal that has recovered

from the disease. Such immunity does not last long. Serum refers to plasma without the soluble protein

fibrinogen. Passive immunity is also found in newborn babies when they get the antibodies through breast

milk or across the placenta in the uterus before they are born. Such immunity gives protection to newborn

babies for a few months until their own natural body defense system begins to function.

Importance of vaccination against disease

We have seen that vaccines are antigens that are artificially introduced into the body of an organism to start an immune response. This gives protection to the organism against certain diseases, sometimes for life. The antigens are introduced into the body by injection or orally by mouth in a process called **immunisation** or **vaccination**. In children, some diseases are life threatening and the Ministry of Health has prepared a proper programme of immunisation to protect them from such diseases. It is necessary that all children are vaccinated against **polio, diphtheria, tetanus, whooping cough** and **tuberculosis.** You must have been vaccinated as a child. Here is a quick way of finding out. Look for the scar on the outer part of your left arm.

See if your neighbour has a similar one. This scar comes from immunising children with BCG vaccine. Are your younger brothers and sisters vaccinated? What about other children in your locality? Find out and mention the importance of vaccination to parents whose children you suspect are not vaccinated. Sometimes, people who go to a foreign country are immunised against **yellow fever.** In the case of an outbreak of a disease e.g. cholera or typhoid, mass vaccinations are carried out to prevent many deaths from taking place.

Check your progress 3.5

1. Fill the passage below
_____is a type of immunity that is found in foetus and young children. The _____ of the mother crosses though the_____ into the foetus. Babies get the antibodies from the mothers milk through _____. This immunity lasts for a few months after birth. The mothers _____ protect the baby from infections before it is able to manufacture its own antibodies.
2. Passive immunity is not important to human body. Discuss.

Gaseous exchange in protozoa

Protozoa

Protozoa are single celled organisms. Examples of protozoa include *Amoeba, Plasmodium* and *Trypanosoma***.**

These are microscopic organisms. They are mainly found in water or in the body fluids of other organisms.

The respiratory surface of protozoa is the *cell membrane.* Gaseous exchange occurs across the cell membrane directly by diffusion. Due to respiration, the concentration of carbon (IV) oxide inside the uni-cellular organism is higher than that in the surrounding water. Therefore, carbon (IV) oxide diffuses out of the organism into the surrounding

Fig 3.21: Amoeba

The concentration of oxygen is higher in the surrounding water than inside the organism. This gas is continuously used for respiration in the organism. Oxygen therefore diffuses from the surrounding water into the organism.

3.4 Aerobic and anaerobic respiration

Activity 3.11

Demonstration of anaerobic respiration in animals

Work in a group

Materials

School athletic track.

Procedure

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

Study 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.

The facts

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. The equations for this reaction are as follows:

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 (IV) oxide. 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 Activity 3.3.

Glucose $\longrightarrow$ lactic acid + energy

$C_6H_{12}O_6 \longrightarrow 2C_3H_6O_3$ + energy

Comparison of aerobic and aerobic respiration

Aerobic respiration	Anaerobic respiration
Requires oxygen to take place.	Does not need oxygen in order to take place.
There is complete breakdown of glucose molecule.	There is incomplete breakdown of glucose; leading to the formation of intermediate compounds.
Large amount of energy released from each molecule of glucose.	Much less energy released from each molecule of glucose.
The by-products formed are carbon dioxide and water.	The by-products formed are carbon dioxide and ethanol in plants and lactic acid in animals.
Occurs in the cytoplasm and in the mitochondrion.	Occurs only in the cell cytoplasm.

Check your progress 3.6

1. When lactic acid builds up in the blood, a person is said to be in oxygen debt. This debt must eventually be paid. Suggest how the debt is paid.
2. Give the difference between aerobic and anaerobic respiration.

Unit 4

Excretion and Homeostasis

Learning outcomes

Knowledge and understanding	Skills	Attitude
By the end of this unit, I should be able to:		
• Understand the processes of transport, respiration, gaseous exchange, excretion and homeostasis in animalsx	• Investigate open and closed circulatory system in animals, explain diffusion and mass flow of liquids • Relate the microscopic structures of kidney, lungs, skin, to their functions.	• Show curiosity to know about functions of the different organ systems in animal body.

Introduction

We use fuel, for example diesel and petrol to run machines such as engines of vehicles. Are these waste products produced by a running engine? Look at the picture below.

Fig 4.1 Waste from vehicle through exhaust pipe

The facts

What is happening in the picture? What are the components of the smoke? What would you think would happen to the engine of the vehicle if the products being removed were left to accumulate? Assuming the vehicles were human being, answer the above questions. From the answers above, what do you think you will learn in this unit?

After an organism takes in nutrients (food) for growth and carry out other activities, the nutrients are utilised in the process of metabolism which in return releases waste products which are supposed to be removed from the body immediately. If these waste substances which are of no use to an organism are allowed to accumulate in the cells, they will adversely affect the normal metabolic activities. The chemical environment of organisms need to be regulated in order for their life processes to occur normally without interruption.

Excretion is the processes by which waste products of cellular metabolism and used hormones are removed from the body of an organism. Excretory organs therefore regulate the chemical makeup of blood and body fluids by removing metabolic waste products.

4.1 Main excretory products in animals

Activity 4.1

Investigating excretion of carbon dioxide from the

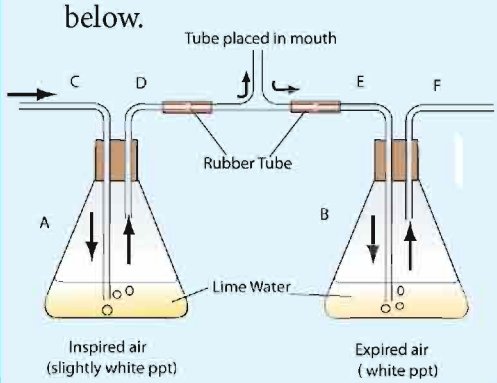
Work in groups

Requirements

Conical flasks, lime water, corks, drinking straws.

Procedure

1. Set up the apparatus as shown below.



3. Breathe into the solution through the straw as shown above for 3 minutes.
4. Record your observations.

Study questions

1. Explain your observation in this experiment in relation to human beings.
2. What is the importance of this experiment?

The facts

The main cellular wastes include: carbon dioxide, water, nitrogenous wastes and mineral salts. When we breath out carbon dioxide is produced. It turns the lime water milky.

(a) Carbon dioxide

Carbon dioxide is a product of cellular respiration. It is carried in blood as carbo-amino acid. It is excreted through gaseous exchange.

(b) Excess water

Water is a product of dehydration synthesis as well as a product of cellular respiration.

(c) Nitrogenous wastes

Nitrogenous wastes including urea, urine, ammonia and uric acid are produced from breakdown of excess amino acids. The process by which excess amino acids are broken down is called deamination. Ammonia is a highly toxic compound that requires a lot of water to excrete. Therefore, only fresh water organisms are able to excrete it. In other organisms such as mammals, marine fish and adult amphibians; ammonia is reacted with carbon dioxide and converted to urea. Urea is less toxic and requires less water to excrete and is therefore the main nitrogenous waste substance excreted in mammals. Uric acid is insoluble and requires very little water to excrete. It is the main nitrogenous waste substance excreted by birds, insects and reptiles.

Other waste products

Bile pigments are produced from breakdown of haemoglobin of dead red blood cells. Mineral salts such as sodium chloride accumulate during metabolism. If these waste products accumulate to high levels, they could be toxic to the organism's body and cause cell death. Other than the metabolic wastes, excess water and mineral salts are also removed from bodies of higher organisms like human beings. Used hormones and drugs are also excreted from the human body.

Excretion of metabolic waste products in plants is not a problem since:

- Plants manufacture the organic materials they require depending on the need, hence waste products do not accumulate to toxic levels.
- Plants accumulate waste products in some organs such as old leaves which are shed off.
- Plants recycle some of their waste products therefore counter the problem of accumulating them. Carbon dioxide from respiration is used in photosynthesis while ammonia from metabolism of amino acids is re-used to synthesize more amino acids.

Check your progress 4.1

1. Nitrogenous wastes are products of breakdown of
   A. Lipids
   B. Mineral salts
   C. Proteins
   D. carbohydrates
2. Which of the following nitrogenous waste products is most toxic?
   A. Uric acid
   B. Ammonia
   C. Urea
3. Carbon dioxide is produced by the process of
   A. Gas exchange
   B. Photosynthesis
   C. Respiration
   D. Deamination
4. Fill the blank spaces in the paragraph that follows with suitable terms.
   Excretion involves the removal of ..... waste products from the body. The liver carries out ..... resulting to the formation of nitrogenous wastes including ..... , urea and ..... Fresh water

organisms excrete ..... as their main nitrogenous waste. Cellular respiration results to the formation of carbon dioxide as a waste product that is removed through the lungs.

5. Why is uric acid the least nitrogenous waste?
6. Explain why plants do not have a problem excreting nitrogenous waste.

4.2 Excretion in unicellular organisms

Activity 4.2

Discuss in groups

Procedure

1. Define the term diffusion and osmosis.
2. Differentiate between unicellular and multicellular.
3. Explain why diffusion alone is sufficient for removal of nitrogenous waste in protoctists such as amoeba.

The facts

Metabolic wastes in protozoa such as amoeba and paramecium include carbon dioxide, ammonia and mineral salts. Ammonia is the main nitrogenous waste for the unicellular and multicellular aquatic organisms as well. Despite the fact that ammonia is highly toxic; it is also very soluble in water. For fresh water amoeba, plenty of water is available therefore ammonia dissolves in the excess water and is washed away into the contractile vacuole including other waste materials present in the cytoplasm. The contractile vacuole then moves to the plasma membrane, makes contact with it and bursts to release its content to the environment. A contractile vacuole is a small sac lined with a thin membrane. Carbon dioxide (CO_2) and some ammonia simply diffuse across the cell membrane of the amoeba down their concentration gradient.

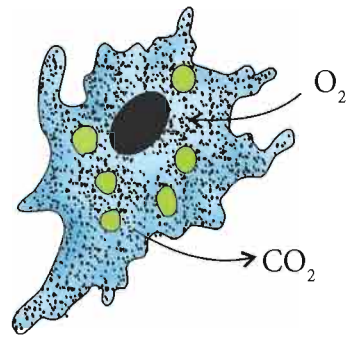


Fig 4.2: Excretion through the cell membrane in amoeba

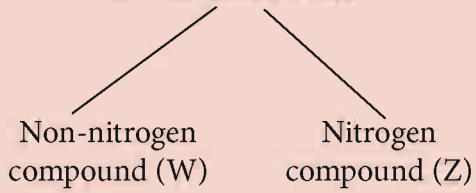
The cell membrane is adapted for removal of gaseous metabolic waste since it is:

- Thin to reduce distance of diffusion, hence rapid movement of ammonia (NH3) and carbon dioxide out of the cell.
- Moist to dissolve the gaseous waste which diffuse faster in solution form.

Check your progress 4.2

1. Amoeba has a very large surface area to volume ratio. Explain the significance of this in the process of excretion.
2. Explain how water balance is maintained in fresh water Amoeba.
3. Explain what would happen if a marine water amoeba is transferred fresh water.

4. Proteins are very important in our bodies. However, excess amino acids from protein digestion cannot be stored. Study the diagram below and answer the questions that follow.



(i) Name the process illustrated below.
(ii) In which organ does the process (i) above occur?
(iii) Name the compound Z and W.

Did you know?

Drinking water that has not been treated or boiled and is contaminated will result to a waterborne disease called *Amoebic dysentery*.

4.3 Structure and function of excretory organs in higher organisms

Activity 4.3

As an individual

What to do

1. Research and fill out the table using appropriate words

Organism	Excretory organ	Type of excretory product removed
Earthworms	_____	Water, mineral salts, ammonia and _____
_____	Malpighian tubules	_____
Mammals	_____	_____

2. Share your result with the rest of the class. Are your findings the same?

The facts

Insects have open circulatory system, blood therefore flows in open body cavities and is in direct contact with body tissues. The Malpighian tubules are bathed by the blood hence dissolved waste products including excess water, mineral salts and nitrogenous wastes called potassium urates enter into the excretory tubules. Potassium urate reacts with water and carbon dioxide and water to form uric acid and potassium hydrogen carbonate. The latter is absorbed back into the blood while the former is deposited into the Malpighian tubules which open into the gut where waste products are released.

Uric acid which an insoluble solid nitrogenous waste is eliminated along with other wastes from the body through the anus.

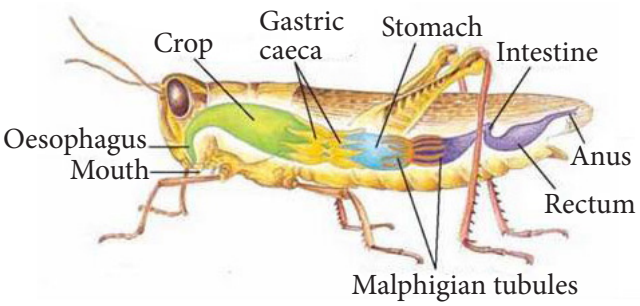


Fig 4.3: Excretory system in a grasshopper

The respiratory surfaces of insects that remove carbon dioxide as a metabolic waste are adapted by having:

- The tracheoles have tracheole fluid to dissolve carbon dioxide which diffuses rapidly in solution form.
- Highly branched tracheal system to increase surface area over which the respiratory gas diffuses out of the body.

Excretion in higher animals

a) Excretion in fish

Fish utilize kidneys primarily for removal of nitrogenous waste products but also use the gills to get rid of ammonia. The digestive tract and the skin are also used to get rid of metabolic wastes. The waste products include nitrogenous waste, excess water and mineral salts. Type of the major nitrogenous waste product eliminated will however depend on the environment where the fish lives.

Fresh water bony fish like Tilapia excrete ammonia since they have abundant water to remove the highly toxic compound.

Marine fish excrete a non-toxic compound called trimethylamine oxide which requires little water to excrete.

Fish excrete carbon dioxide through the gills. The gill as a respiratory surface possess the following adaptive features:

- Have numerous gill filaments to increase surface area for diffusion of carbon dioxide.
- The gill filaments are covered with moisture and mucus which dissolve carbon dioxide hence it diffuses faster in solution form.
- The gill filaments also have dense capillary network to supply blood to the gills hence maintaining a steep diffusion gradient between the blood and water therefore ensuring rapid diffusion of carbon dioxide out of the blood.
- The gill filaments are also thin to reduce distance of diffusion of carbon dioxide.

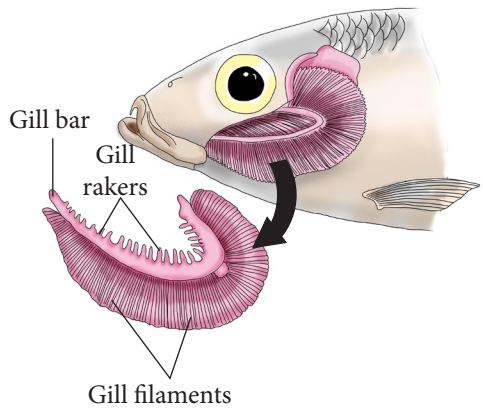


Fig 4.4 Structure of gills

b) Excretion in birds and reptiles

These organisms use the kidneys to get rid of nitrogenous wastes which are extracted from the blood and then excrete it as **uric acid** through the ureters. The uric acid is then shed into the intestines and deposited with the faecal matter.

c) Excretion in amphibians

Amphibians excrete nitrogenous wastes in the form of ammonia, uric acid and urea. They have kidneys which remove nitrogenous wastes from blood, combine it with water to form urine that is channeled out of the body through the cloaca when the bladder if full.

Apart from the lungs, amphibians like frogs use their skin remove carbon dioxide.

The skin as a respiratory surface is:

- Thin to reduce distance of diffusion and enable efficient removal of carbon dioxide.
- Moist to dissolve respiratory gases which diffuse faster in solution form.
- Highly vascularised to ensure efficient diffusion of carbon dioxide out of the lungs.

Mammals, fish, reptiles and amphibians use the lungs to remove carbon dioxide; a product of cellular respiration. The lungs are adapted for this function in the following ways:

- Numerous alveoli (the site of gaseous exchange in the lungs) to increase surface area over which carbon dioxide diffuses.
- Thin epithelial lining of the alveoli to reduce distance of diffusion hence rapid diffusion of carbon dioxide.
- Moisture lining on the alveoli to dissolve carbon dioxide to enable faster diffusion in solution form.
- Dense capillary network to ensure maximum diffusion of carbon dioxide from blood.

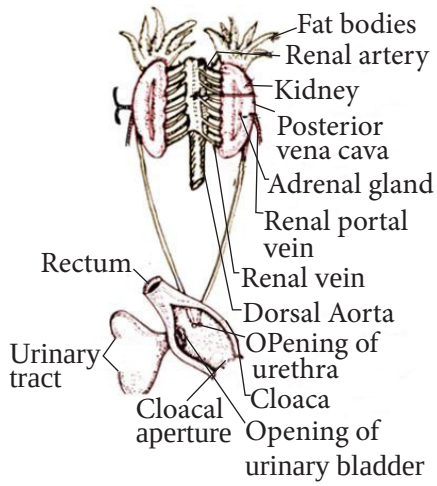


Fig 4.5: Excretory system in amphibians

d) Excretion in human beings

The main excretory organs in humans include: lungs, kidneys, skin and liver. Refer to table 4.1. The skin excretes excess water, mineral salts and traces of urea through sweat while the lungs remove carbon dioxide. The liver plays an important role of deaminating excess amino acids to form urea. The amine part of the amino acid is removed as ammonia while the carbon skeleton is converted to glycogen and stored in the liver or muscles for later use. Since ammonia is highly toxic, it is reacted with carbon dioxide to form urea which is shed into the blood and transported to the kidney for excretion. The kidneys remove the nitrogenous wastes from blood.

The urinary system

The urinary system is a group of organs that remove urine from the body. It consists of the kidneys, ureters, urinary bladder and associated blood vessels. The kidneys are dark red bean-shaped structures located at the back of the abdominal cavity. They are supplied with oxygenated blood that carries nitrogenous waste by the renal artery.

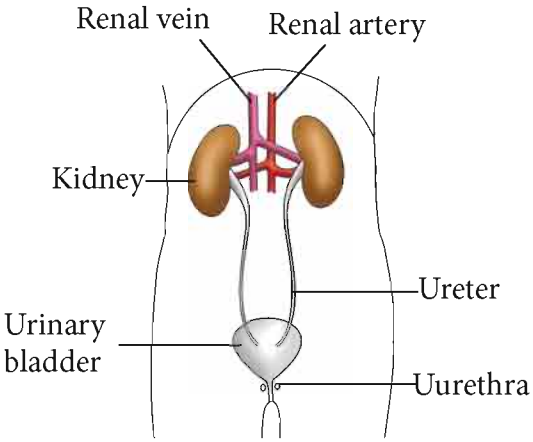


Fig 4.6: Urinary system in human beings

The renal artery branches to the afferent arteriole that takes the blood into the kidneys' functional units called the nephrons. The kidneys perform two main functions of the kidneys are: excretion and regulation of concentration of various substances in the body, thus homeostasis. The ureters carry urine from the kidneys to the urinary bladder to be stored temporarily. The urethra carries urine from the bladder to the outside of the body.

Structure of the Kidneys

Activity 4.4

To examine and draw the mammalian kidney

Work in a group of four

Material

Sheep kidney

Procedure

1. Examine the whole kidney.
2. Note the various tubes attached to it.
3. What is the external colour of the kidney?
4. Draw and label the external structure of the kidney.

Activity 4.5

To make longitudinal section of the kidney

Work in a group

Materials

Fresh kidney of sheep/goat/cow, sharp razor, knife or scalpel, small dissecting board, hand lens or dissecting microscope.

Procedure

1. Place the kidney on the dissecting board.
2. Use the scalpel to cut the kidney along its length at the middle.
3. Identify the following parts: cortex, medulla, pelvis, renal artery, renal vein and urethra.
4. Draw and label the structures you have identified.

The facts

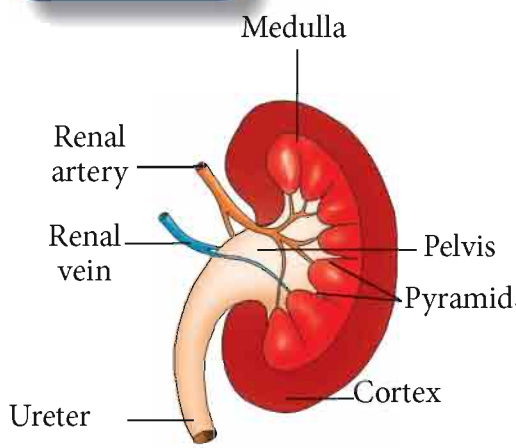


Fig 4.7: Cross-section of the kidney

A longitudinal section of the kidney reveals three distinct regions: a dark red outer region called **cortex**, light red middle region called the **medulla** and an inner region called pelvis. The medulla projects into the pelvis as cone-shaped structures called pyramids.

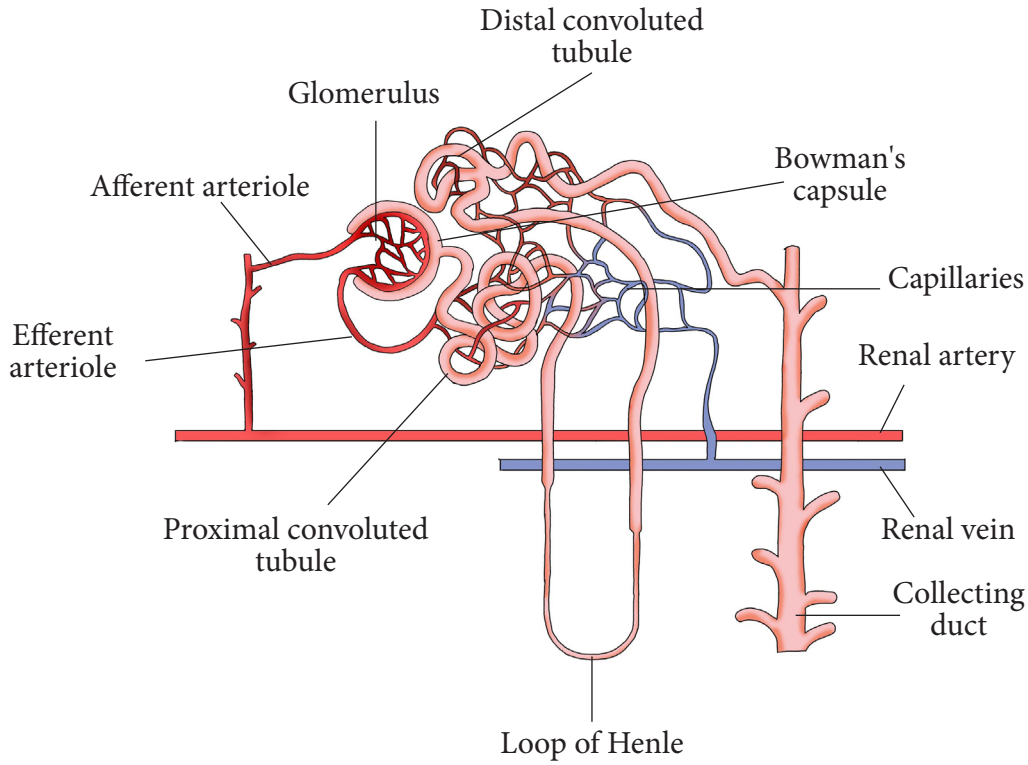


Fig 4.8: Structure of nephron

Structure and function of the nephron

Filtration of blood and urine formation occurs in the nephron. Each nephron consists of a single glomerulus, renal capsule, renal tubule and blood capillaries. Afferent arteriole brings in oxygenated blood into the nephron. It then branches into smaller capillaries called glomerulus. The capillaries coalase to form efferent arteriole that takes blood away from the glomerulus. The efferent arteriole then branches into capillaries that transverse the renal tubules before rejoin to form the renal vein that takes deoxygenated blood away from the kidneys.

The process of urine formation occurs in two main stages: filtration and selective reabsorption.

a) Filtration

Blood flowing through the glomerulus is under high pressure. In addition to this, the efferent arteriole leaving the glomerulus is narrower than the afferent arteriole creating more pressure build up at the glomerulus. As a result of the high pressure, fluid part of blood containing small sized molecules such as water, mineral ions, urea, glucose and amino acids filter through the small pores of the capillaries and enter into the renal capsule (Bowman's capsule). This is termed as ultrafiltration. Molecules of large size like blood cells and plasma proteins do not filter through the small glomerular pores. About 180 liters of filtrate are by the kidneys during a 24 -hour period.

b) Selective reabsorption

The filtrate in the renal capsule referred to as glomerular filtrate flows to the proximal convoluted tubule where:

- All amino acids and glucose are reabsorbed back into the blood stream in a normal human.
- Some water and mineral salts are also reabsorbed.

This is called selective reabsorption.

Amino acids, glucose and mineral salts are taken up by active transport while water is reabsorbed passively by osmosis. The proximal convoluted tubule is adapted for selective reabsorption in the following ways:

- It is highly coiled to slow down rate of flow of filtrate to allow more time for more reabsorption.
- It is also long to increase surface area for reabsorption of substances
- The epithelial cells have dense mitochondria to provide ATP energy for the active uptake of solutes back into the bloodstream.
- Have villi and microvilli that further increase surface area for reabsorption.
- Thin walled to reduce distance of diffusion and ensure maximum reabsorption of solutes and water molecules back into the bloodstream.

The filtrate then flows to the loop of Henle where most of the water molecules are reabsorbed back into the bloodstream. The loop of Henle is located in the medulla of the kidneys. Mineral salts are actively removed from the filtrate into the medullary tissues; resulting to high osmotic pressure in these tissues. Water molecules are therefore reabsorbed via osmosis from the ascending loop of Henle into the blood stream as the filtrate flows to the distal convoluted tubule.

At the distal convoluted tubule, reabsorption of mineral salts including sodium and chloride ions occur. Apart from reabsorption, tubular secretion of ions also occur.

Table 4.1 Summary of excretory products in %

Substance	Plasma %	Glomerular filtrate %	Urine %
Water	91-93	91-93	95
Uric acid	0.003	0.03	2
Glucose	0.1	0.003	0.05
Protein	8.0	0.1	-
Amino acids	0.05	-	-
Sodium	0.3	0.05	-
Chloride	0.37	0.3	0.5

Reabsorption of sodium ions occurs under the influence of aldosterone hormone secreted by the adrenal glands located above each kidney. Aldosterone hormone is secreted when a drop in blood pressure is detected; resulting to reabsorption of sodium ions back into the blood stream. Tubular secretion that occurs at the distal convoluted tubule involves pH regulation. The pH of plasma is maintained within a narrow range of 7.2-7.4. If the pH drops below 7.2, hydrogen ions (H+) are actively secreted from the blood into the lumen of distal convoluted tubule resulting to an increase in pH of plasma. On the other hand, if the pH rises above 7.4, hydrogen carbonate ions (HCO3-) are actively secreted from blood into the lumen of the distal convoluted tubule; resulting to a drop in pH of plasma.

The filtrate then flows to the collecting duct where reabsorption of water occurs depending on the dehydration state of the body. If the osmotic pressure of blood is high, the hypothalamus stimulates the pituitary gland in the brain to secrete Antidiuretic hormone (ADH) also called vasopressin which diffuses into the blood to the kidneys. ADH causes the kidney tubules, especially the collecting duct to be more permeable to water. Hence, water molecules are reabsorbed before the filtrate flows as urine to the pelvis. Several nephrons empty their urine into a common collecting duct. The composition of the filtrate varies greatly as the filtrate flows from the proximal convoluted tubule to the collecting duct.

Check your progress 4.3

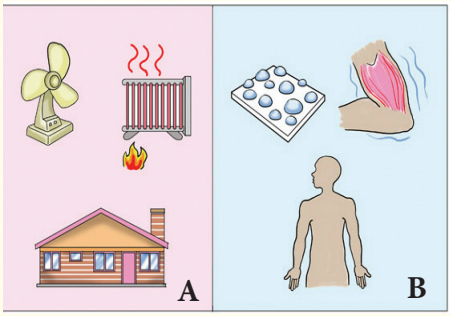
1. Which structure do insects use for excretion
   - A. Nephridian pore
   - B. Flame cells
   - C. Malpighian tubules
   - D. Coelom
2. Marine fish excrete
   - A. Urea
   - B. Ammonia
   - C. Uric acid
   - D. Trimethylamine oxide
3. Organisms that face water shortage excrete uric acid because
   - A. It is small in amount
   - B. It insoluble and requires less water to excrete
   - C. It dissolves to form harmless compounds
   - D. It passively diffuses out of the body
4. What is the functional unit of the kidney?
   - A. Glomerulus
   - B. Kidney tubules
   - C. Nephron
   - D. Cortex
5. The kidneys play an important role in homeostasis because
   - A. Breakdown toxic metabolic wastes in the body
   - B. Remove carbon dioxide from the body
   - C. Regulate the concentration of various substances in the body
   - D. Control glucose level in the body

6. In the kidneys, filtration of blood occurs in the
   A. Medulla
   B. Cortex
   C. Ureter
   D. Loop of Henle
7. During filtration, small substances are filtered into the ……
   the filtrate that flows to the proximal convoluted tubule is called ……..
   All ……..
   and …….
   Are reabsorbed back into the blood stream through …….
   The proximal convoluted tubule has abundant ……..
   to supply energy for the selective reabsorption of these substances. Most water is reabsorbed at the

4.4 Homeostasis

Discussion corner

Study the diagram below on temperature control. The illustrations in **A** shows what happens in a home scenario. The illustrations in **B** shows what happens in the body.



With a friend, think about how temperature is regulated in a home. Compare that to what happens in the body. Which other things require regulation in our bodies?

Activity 4.6

Work in groups

Requirements

4 basins with warm water, 4 basins with ice cold water, thermometer and stopwatch.

Procedure

1. Prepare a table as shown in table 4.3.
2. Record initial body temperature of four of the group members in the table. Two members of the group will do the measuring and recording of body temperature of the group participants.
3. Let the four students immerse their feet in ice cold water for twenty seconds and record their body temperature.
4. Let the four students then immerse their feet in very warm water for twenty seconds and record their body temperature.
5. Work out the differences in body temperature of the students from the initial when their feet were immersed in ice cold water and very warm water and record your results in another table.

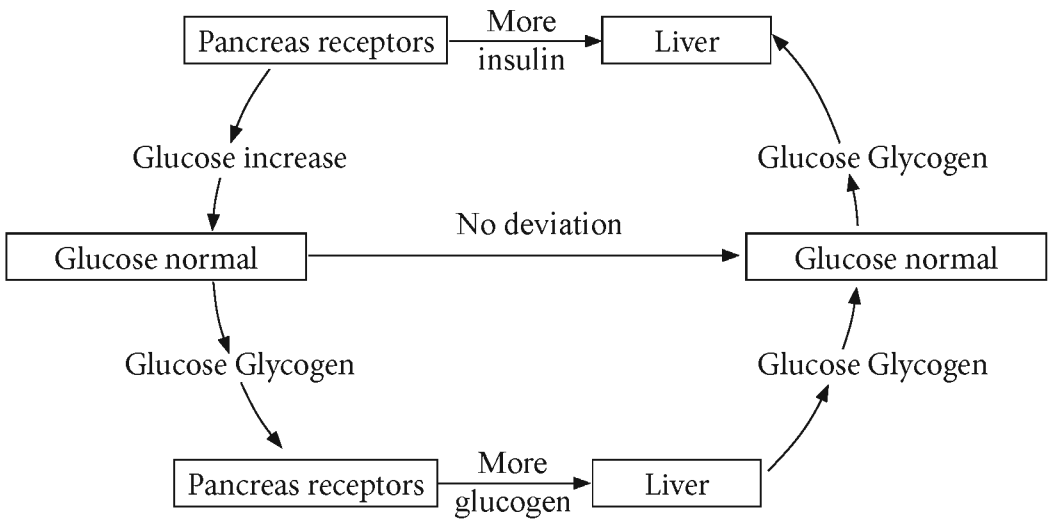
Student	Initial body temperature (°C)	Body temperature after immersing feet in ice cold water (°C)	Body temperature after immersing feet in ice cold water (°C)
1.			
2.			
3.			
4.			

The facts

The Internal body conditions of animals need to be maintained within narrow ranges to ensure that metabolic functions go on uninterrupted. These internal conditions include; blood glucose level, pH, temperature and osmotic pressure of body fluids. Homeostasis therefore refers to the maintenance of a constant internal body environment.

As mentioned earlier, the regulation of pH and osmotic pressure of body fluids is carried out by the kidneys. The liver regulates the sugar levels in the blood under the influence of hormones secreted by the pancreas. Normal blood sugar level is about 90 milligrams per 100 ml of blood; but should not exceed 140mg/100 ml of blood two hours after a meal containing carbohydrates. The figure below shows how sugar in the body is related.

The regulation of body temperature is termed as **thermoregulation**. Mammals are able to maintain their internal body within narrow limits; they are therefore termed as homoiotherms or endotherms. Animals like reptiles and fish are not able to regulate their body temperature, hence they are termed as poikilotherms or ectotherms. Their body temperature fluctuates with that of the external environment; they therefore employ behavioral mechanisms to counter the effects of extreme external



temperatures. When environmental temperature is high, these ectotherms move to places like crevices or a shade where temperatures are lower. When temperatures are low, they would move to bask on rocks or areas with higher temperatures. The normal human body temperature is between 36.5 °C – 37.50 C. This is the optimum temperature range within which enzymes act best and metabolic functions proceed without disruption. The organs involved mammalian thermoregulation include: the brain, liver and skin. An increase in body temperature above normal would result to denaturing of enzymes and interruption of biological processes. The hypothalamus in the brain detects the rise in temperature as blood passes by the brain and sends impulses to specific structures of the skin resulting to lowering of body temperature to normal.

The skin responds through the following physiological mechanisms:

Activity 4.7

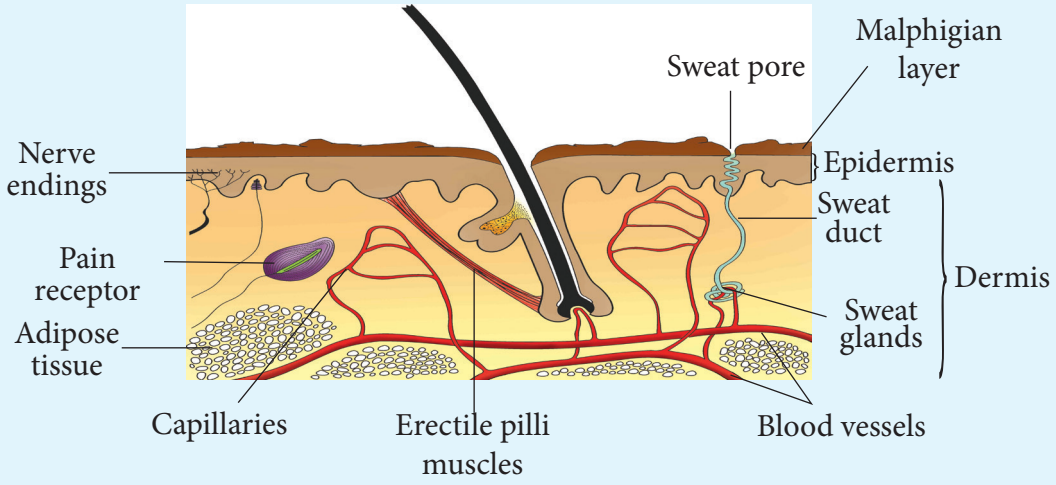
To observe prepared slides of mammalian skin

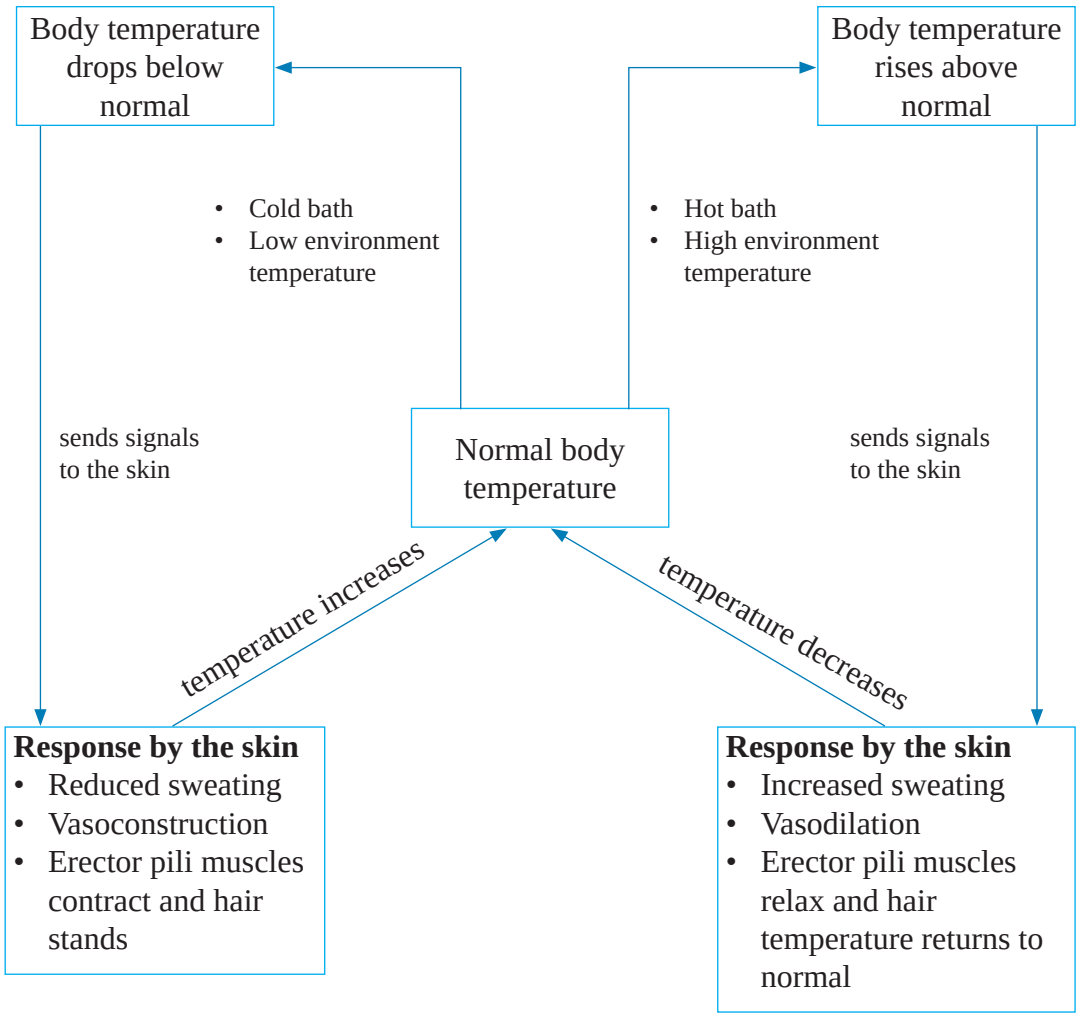
Requirements

Prepared slide of a vertical section of a mammalian skin, microscope.

Procedure

1. Place the slide under the microscope.2. Examine the slide first under low power and then under high power.
3. Identify the two main parts of the skin i.e. the epidermis and the dermis.
4. Note the malpighian layer with its clear nuclei. It appears granular.
5. Note also that the cells of the malpighian layer are pigmented towards the outer surface.
6. Locate other parts of the skin such as hair follicle, sebaceous glands, sweat gland , hair.
7. Draw and label what you observe. Refer to figure below for assistance in labelling.





Check your progress 4.4

1. Which of the following is an example of homeostasis?
   - A. Removal of faecal matter through the anus
   - B. Exhaling carbon dioxide
   - C. Regulation of pH of plasma
   - D. Urination
2. Which row describes the level of glucose in blood going to the liver from the gut and glycogen in the liver after a starchy meal

	Blood going to the liver	Glycogen in the liver
A	Increase	Decrease
B	Decrease	Increase
C	Increase	Increase
D	Decrease	Decrease

3. What is true for a marathon runner after at the end of a race?
   - A. Sweating only
   - B. Sweating and vasodilation
   - C. Vasodilation only
   - D. Vasodilation and vasoconstriction

4. A student was seated in a room that was at 36 °C for about an hour. What would be the effect on the blood temperature and sweating after drinking several cups of hot coffee.

5. Explain why a snake would be able to use more of its food intake for growth compared to a mammal.
6. Describe how animals like the polar bear living extremely cold places are adapted to their environment

Unit 5

Organisms interaction with their environment and the effect of climate change

Learning outcomes

Knowledge and understanding	Skills	Attitude
By the end of this unit, I should be able to:		
• Understand how organisms interact with each other and with their environment	• Develop investigation skills by accessing a wide range of sources • Ability to use mathematical models e.g. for predictions. • Develop ability to classify the organisms according to their food Materials. • Develop the skills of field visit in various ecological zones	• Appreciate interdependency of organisms on one another and on their environment. • Appreciate South Sudan ecosystems • Value the diversity of life found in South Sudan

Introduction

Look at the pictures below. Can you explain what is happening in each picture?

What is the importance of the pictures below?

What does this tell you about what you will learn in this topic?

A

B

C

Fig 5.1 Interaction of organisms within the environment

Living organisms exist in different environmental conditions depending on how best suited they are for that particular habitat. In their existence, organisms interact with both living and non-living factors in the ecosystem. The study of the interactions between organisms and their environment is termed as ecology. The physical or non-living factors in the ecosystem are called abiotic factors; while the living factors are called biotic factors. The study of ecology can be divided further into two subfields; synecology and autecology. Synecology deals with the study of different interaction of groups of organisms with their environment while autecology deals with the study of interaction of a single species with its environment.

5.1 Definition of terms

Activity 5.1

Work in groups

Procedure

1. With the guidance of your teacher, take a tour to the area around your school.
2. Identify the different areas that you find organisms living; thus, grassland, water pond, trees, decomposing log of wood among others.
3. Draw a table and note down the different organisms that exist in the different areas you have identified.
4. Identify the types of food that you will see organisms in the different habitats feeding on.
5. Investigate the physical factors around you and note them down. Identify the type of soil in the different habitats and the type of plants that grow in them. Do you notice any relationship between soil type and the type of plants growing in these habitats?
6. Discuss the information you have collected in your group and present your work to the rest of the class.

The facts

An **ecosystem** is a self-sustaining unit that comprises of both biotic and abiotic factors. An ecosystem contains resources that support the different organisms living in it. The maximum number

of organisms that an ecosystem can support without depleting its resources is called the **carrying capacity**. In the different ecosystem, there are specific areas where different organisms live. These are termed as **habitats**. In a given habitat such as a water pond, you will find different organisms inside. For instance, algae, small green plants, aquatic arthropods and fish. Each of these organisms occupies a specific location of the habitat. The specific role that a specific organism plays in its interactions with the other organisms in the habitat is called a **niche**. In studying the interactions between organisms and their habitats, living and non-living factors must be considered. **Biotic** factors include all living organisms and their effects in the environment both directly and indirectly. **Abiotic** factors are the physical or non-living factors such as: water, soil, humidity, wind, atmospheric pressure, organic and inorganic nutrients. Some habitats may comprise fewer species than others. A **species** refers to a group of organisms that can interbreed freely and produce fertile offspring. A group of organisms of the same species comprise a **population**. A community on the other hand comprises of different species of organisms, both plants and animals living in the same geographical location. Different communities that have similar characteristics for the environment they live in constitute a **biome**. Biomes consist of climax communities that are defined by dominant type of plant life. For example, one biome may consist of communities of grass only i.e. grassland. In South Sudan, the main biomes include: grassland, savanna and shrubland. An **ecological zone** comprises of large geographical area having different species and communities.

The ecological zones of south Sudan and the Biomes associated with them are shown in the table provided.

Ecological Region	Biome
Northern Acacia Bushlands and Thickets	Tropical and subtropical Grasslands, Savannas, and Shrublands
East Sudanian Savanna	Tropical and Subtropical Grasslands, Savannas, and Shrublands
Northern Congolian Forest-Savanna Mosaic	Tropical and Subtropical Grasslands, Savannas, and Shrublands
Sahelian Acacia Savanna	Tropical and Subtropical Grasslands, Savannas, and Shrublands
Victoria Basin Forest-Savanna Mosaic	Tropical and Subtropical Grasslands, Savannas, and Shrublands
Saharan Flooded Grasslands	Flooded Grasslands and Savannas
East African Montane Moorlands	Montane Grassland

Check your progress 5.2

1. The diagram below shows trees and organisms associated with them. What does this represent?

   A. Biome
   B. Species
   C. Habitat
   D. Niche
2. Several species living together comprise a:
   A. Home
   B. Community
   C. Population
   D. Biome
3. Which of the following is odd one out?
   A. Wind
   B. Salinity
   C. Predation
   D. Humidity
4. Which is an example of population?
   A. All the species of animals in Europe
   B. All plants and animals in an ecosystem
   C. Aquatic animals in a water pond
   D. All pine trees in a forest
5. A part of the earth in which living organisms are found is called
   A. Autecology
   B. Biosphere
   C. Ecosystem
   D. Biome
6. A ..... comprises of both biotic and abiotic factors and can only contain a given number of organisms. Organisms possess ..... that enable them to exist in given environments. An ecological ..... refers to the specific role that an organism plays in a given habitat. Several species in a given ecosystem make up a ..... that constitutes .....
7. Distinguish using examples a population and a community.

5.2 Factors in an ecosystem

Activity 5.2

Work in groups

Procedure

1. Obtain soil from three different ecological areas near you and bring the samples to the laboratory.
2. Note down the type and the density of the plants growing in these areas.
3. Determine the pH of the soil samples you have obtained.
4. How does soil pH and type or health of plants compare?
5. Present your work to the rest of the class.

Activity 5.3 Predators and prey

You will be provided with a video of a geographical program by your teacher.

Procedure

1. Keenly observe and note down the body features possessed by animals like gazelles, zebras and antelopes that feed on vegetation.
2. Observe and note down the body features of carnivores like lions or cheetahs. Take note of how the carnivores are able to capture their prey and how the prey manages to get away from the predators.
4. In groups of five, discuss the information you obtained from the video watched.
5. Present your work to the rest of the class.

The facts

Living organisms are affected by living and non-living factors. Ecological modelling can be used to study ecological system and enable understanding of the effects of biotic and abiotic factors in an ecosystem. Ecological modelling therefore refers to the construction and analysis of mathematical models of ecological processes for example, population dynamics. The study pf prey-predator interactions for instance using mathematical modelling shows natural oscillations on the number of prey and predators.

An ecologist Alfred J Lotka developed simple equations for predator- prey interactions that could enable prediction of interacting populations over a given period of time. This is termed as the Lotka- Voltera model.

$$\frac{dN(t)}{dt} = N(t)(r\alpha P(t))$$

$$\frac{dt}{dP(t)} = P(t)(c\alpha N(t)-d)$$

where:
N is prey population, **P**- predator population size **r** is rate of prey growth; **α** is the prey mortality per capita, **c**- efficiency of conversion from prey to predator **d**- exponential death rate for predators in the absence of prey **t**- time.

Mathematical models are important in the sense that:

- They improve understanding of natural ecosystem and reveal dynamics of populations based on natural processes like fluctuations in species populations.
- Generate observable phenomena across species and ecological units.
- Enables ecologists to predict insights about natural processes for example, the change in populations of species in an interaction like the prey-predator association.

The biotic factors as mentioned earlier include all the living organisms in an ecosystem. The relationships that exist between these living organisms include: predation, parasitism, saprophitism, commensalism, symbiosis and competition.

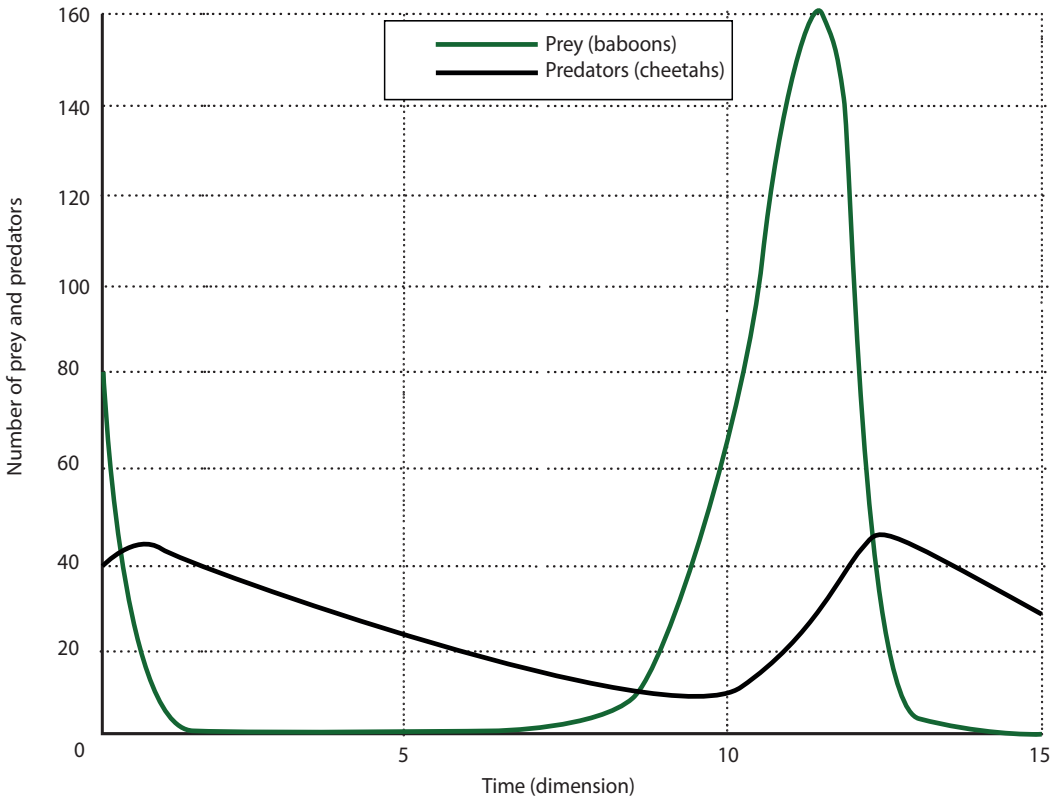


Fig 5.2: Lotka–Volterra model of cheetah–baboon interactions. Starting with 80 baboons (green) and 40 cheetahs, this graph shows how the model predicts the two species numbers will progress over time.

Activity 5.4

In pairs

1. Use school library to find out more about predation and parasitism. Write down main points and share with the rest of the class. Where possible provide pictures and draw graphs to support your points.
2. Design posters at your free time to differentiate between symbiosis and mutualism. Pin design posters on your class wall.

i) Predation

In this type of relationship, an organism (predator) feeds on another living organism (prey); either partly or wholly. Most predators feed on more than one type of prey. The prey feeds on plant material. Both predator and prey have developed adaptive features to suit to this type of relationship.

The predators have adaptations that enable them to capture and eat the prey. These features include:

- Strong sense of smell and sight to enable then detect the prey.

- Strong limbs and muscles to enable them run fast and capture the prey.

Fig 5.3: Predator

- Sharp claws and canine teeth to enable then hold onto the prey and tear flesh.
- Body colour that blends with that of the environment enabling them to camouflage with the its surrounding; hence making it difficult for the prey to notice them as they approach.
- Some predators like snakes, spider, shrews, jelly fish and male platypus produce venom to enable them paralyze and kill the prey.

The prey on the other hand are adapted to get away from the predators in the following ways:

- Have streamlined bodies and possess ability to run very fast hence get away from their predators.
- Have body colour that matches that of their surroundings to blend and camouflage.
- Some like..... resemble distasteful organisms hence they are not fed on by predators.
- Others like buffalos herd in groups enabling them to fight off the approaching predators.
- Their eyes are placed on the sides of the face to increase the field of view even as they feed to enable them detect the predator easily.

In the natural setting, it has been observed that a balance on the population of predators and prey is maintained within some limits. When the number of prey increase due to abundance of vegetation, the number of predators increase as well. On the other hand, shortage of food for prey due to factors such as drought causes a drastic drop in their population resulting to a decline in the number of predators. This type of relationship produces a prey-predator cycles.

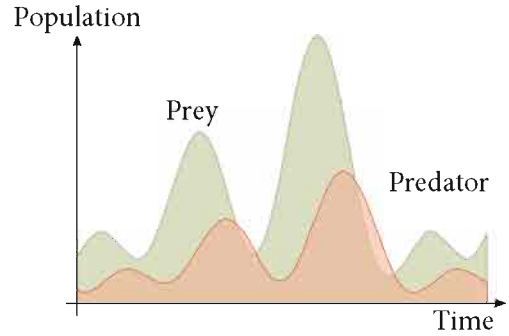


Fig 5.4: Variations in number of predator and prey over a period of years

Herbivores as well have adaptive features to ensure successful feeding on plant material.

- Browsers like giraffes have long necks to reach the twigs at the top of trees.
- Some like goats have rough tongues to rasp on thorny vegetation.

- Browsers also have long tongues to collect as much food from the plant as possible.
- They possess gaps called diastema to enable them separate freshly cut vegetation from the chewed vegetation to ensure they collect as much food as possible.

ii) Parasitism

In this type of biotic relationship, an organism (parasite) feeds on another living organism (host) and obtain nutrients from it; eventually causing harm to it. The parasite and host live in very close association the host however does not benefit in this association. Some parasites live inside the host and are called endoparasites. They include: tapeworms, *Escherichia coli*, *Entamoeba histolytica* and *Plasmodium* which causes malaria. Ectoparasites like the head louse live on the outside of the body. Major parasitic infections in South Sudan include: malaria, Trypanosomiasis, Dengue, schistosomiasis and Lishmaniasis. Tapeworms for instance live in the intestines of human beings and other mammals like pigs. Both parasite and host have developed adaptive features to enable them survive.

Adaptations of parasite.

- Some like tapeworms have hooks that enable them to anchor firmly on the intestine walls to prevent them from being swept away by the peristaltic wave. They also secrete mucus and other substances onto the body wall to prevent them from being digested by host enzymes. In addition, they have flattened bodies to increase surface area for absorption of digested food substances. Their tissues are also tolerant to low concentration of oxygen to increase chances of survival. They also produce large number of eggs to increase chances of survival.

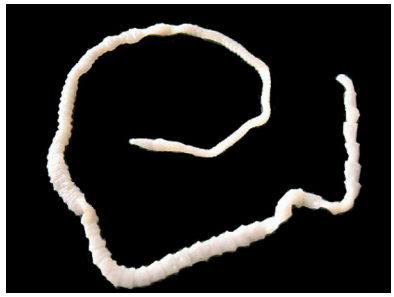


Fig 5.5: Tapeworm

- Schistosoma parasites have two hosts to increase chances of survival. Their larvae and eggs secrete lytic enzymes to soften tissues of the host at the point entry to enable easy penetration. The males carry the female in a groove to ensure that the eggs laid are fertilized. The parasite also has many larval forms including miracidium, cercaria and metacercaria to increase their chance of survival.

Fig 5.6: Schistosoma

- They secrete enzymes to digest tissues of the parasites.
- Induced early maturity to produce offspring before the parasite manages to cause major harm.

iii) Symbiosis

Symbiotic relationships can be categorized as either mutual or commensal.

iv) Mutualism

Mutualism is a type of association that exists between two organisms which both benefit from this relationship without harming each other. A typical example of this type of association exists in lichen; a plant-like composite of blue-green algae and fungal mycelia.

Fig 5.7: Lichen

This association in lichen enable it to colonise places with harsh environmental conditions where other plants cannot grow; a very important aspect of development of succession in ecosystems. The fungus obtains minerals and water deep from the substratum while the algae photosynthesizes.

Mutualism is also observed in nitrogen-fixing bacteria *Rhozobium* and leguminous plants such as beans, peas and clovers. The bacteria convert free nitrogen in the atmosphere into nitrogenous compounds like ammonia that are utilized by plants to make proteins. The bacteria on the other hand obtains sugars from the plant.

Fig 5.8: Leguminous plant

v) Commensalism

Activity 5.5

In pairs

1. Discuss in details about commensalism. Provide pictures, tables, graphs and other illustration supporting your findings. Make school library and internet (if available) your main source of reference.
2. Share your findings with the rest of your class members. Ask for more clarification from your teacher.

The facts

This is a type of symbiotic association in which only which one organism benefits from another organism without hurting it. For example, the egret feeds on ticks from herbivores like cattle but do not cause harm to the herbivore.

Fig 5.9: Egret feeding on cattle

vi) Competition

> Discussion corner
>
> Competition plays a very important role in the survival of living organism in an ecosystem. Debate!

The facts

Competition occurs when two or more organisms are in need of the same resource. This mainly comes about when the lifestyle of the organisms or their niches overlap. If the competition is between members of the same species, it is called intraspecific competition. And if the competition is between members of different species, it is called interspecific competition. Plants compete for space, nutrients and sunlight. An example of intraspecific competition can be seen in bean plants as they grow in the field. The effect of this competition can best be ascertained if the crops are planted at different densities. Physiological parameters such as plant height, size of leaves and spread of roots can be determined. At harvesting, the dry matter yield per unit area can also be determined and compared. Animals on the other hand compete for space, food and mates. An example of interspecific competition in animals is seen between white ants and black whose niches are very closely associated but do not overlap completely; but they associate enough to bring competition for some resources. White ants search for food under the grounds and build termite mounds to breed while the black ants search for food under the rocks and decomposition logs of wood.

Fig 5.10: Termite mound

vii) Synergism

A type of association between different species where these organisms benefit from the association but then it is not obligatory and the different populations can survive on their own. For example, aerobic bacteria can be seen on the surfaces of algae. The photosynthetic algae produce oxygen as a by-product. The bacteria move to an area with higher oxygen concentration but can respire using oxygen obtained from the surrounding environment.

Factors that determine survival of an organism in an environment

Activity 5.6

In groups

Procedure

1. Your teacher will divide you into various groups and assign each group each abiotic factor.
2. Research more about the abiotic factor assigned (use school library, other textbooks and internet if available).
3. Let your secretary note down the main points that you will discuss.
4. Design posters supporting your points (where necessary).
5. Back in class, share your findings with the rest of the class. Pin your design posters on the class wall.

Abiotic factors

Abiotic factors determine the type of organisms that survive in a given environment. For example, South Sudan deserts like the Nubian and Libyan and Bayuda deserts very little water and temperatures vary from very hot to very cold.

Fig 5.11: Desert

Only plants adapted to such conditions like the cactus survive; other plants like corn cannot survive. Plants therefore only grow in environments that have physical factors that suit them. The distribution of plants affects the animals that would be found in these environments.

i) Light

Sunlight is the ultimate source of energy in an ecosystem. Organisms therefore obtain energy directly or indirectly from the sun. Plants are able to utilize sunlight energy to synthesize organic food substances whereas animals obtain chemical energy from plants or other animals. In plants, the intensity and duration of sunlight determine flowering, rate of photosynthesis and transpiration. Rate of photosynthesis and transpiration are higher when light intensity is high as well. In animals, relative lengths of day and night affect reproduction, hibernation and migration. Penetration of light in aquatic ecosystems also affect the distribution of organisms. The **photic zone** (where light penetrates) support autotrophs while the **aphotic zone** (depths of water that light does not penetrate) only support heterotrophs and few chemotrophs.

Light intensity can be measured using a **photographic light meter** while depth of light penetration in water is measured using a **seechi disc**.

ii) Temperature

The temperature on the earth's surface varies with altitude and latitude. Geographical features like lakes and oceans around an ecosystem also affect the temperature of an area. Temperature is an important abiotic

factor that influences metabolic reactions in the organism's body since it directly affects enzyme action. For this reason, temperature affects enzyme-catalyzed physiological processes such as: photosynthesis, respiration and germination.

Very high temperatures denature enzymes thereby hindering enzyme -catalyzed reactions in the body of living organisms. Deserts experience extremely high and low temperatures and therefore support very little life forms that have suitable adaptive features. Temperature is measured using maximum-minimum thermometer.

Fig 5.12: Thermometer

ii) Water

Water is an abundant and important component of bodies of plants and animals. Water plays the following important functions in the bodies of living organisms:

- Provides habitats for many living organisms, both unicellular and multicellular.
- A transport medium for dissolved food substances.
- A solvent medium in which biological reactions take place.
- Maintenance of body temperatures by absorbing heat for vaporization.
- Important component in biological reactions like photosynthesis and hydrolysis of food.

Water can be made available to the ecosystem through precipitation. Precipitation refers to release of water from the atmosphere in forms such as rain, snow, fog and dew. Areas like the East Montane Forests in South Sudan that receive adequate rainfall support many plants as well as many herbivores. Many carnivores are in turn supported by this type of ecosystem.

Fig 5.13: Tropical forest

Arid and semi-arid areas receive very little rainfall though the year and therefore support very few plants as well as animals with suitable adaptive features

Amount of rainfall is measured using a rain gauge.

Fig 5.14: Raingauge

iv) Soil

Soil comprises of both organic and inorganic components. The type of soil

determines the minerals available to the plants growing in these soils. Soil types are classified according to the mineral composition, organic matter content, pH and size of soil particles. Sandy soils have large particles, followed by silt soil then clay that have very small particles. Water drains very quickly in sand soils and slowly in clay soil. Sandy soils however have better aeration compared to clay soils. Soil aeration is an important factor that affects microbial activity especially of saprophytes that bring about decomposition and recycling of nutrients. Therefore, the best soils for plant growth would be a mixture of clay and larger particles. The prominent black cotton soils of South Sudan are very fertile and support growth of many different types of plants.

Soil pH affect mineral availability to the plants. Most minerals are available at pH values of between 6 and 7 hence soils with pH range support more plants; ultimately affecting the distribution of herbivores and carnivores. Some plants like conifers however thrive well in acidic soils.

These properties of soil that influence the distribution of living organisms are called **edaphic factors**.

v) Humidity

This refers to the water vapour content in the atmosphere. Humidity influences the rate of transpiration in plants as well as evaporation of water from body surfaces of animals. Areas with high humidity support more plant growth compared to dry areas with low humidity.

Relative humidity can be measured using the wet and dry bulb hygrometer however comparison of relative humidity can be done using anhydrous cobalt chloride paper.

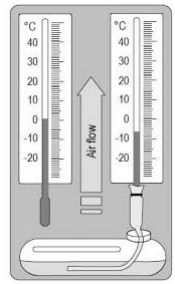


Fig 5.15: Hygrometer

vi) Wind

Wind refers to moving air in the form of current. Wind affects process such as transpiration, pollination and dispersal of seeds and fruits. In animals, wind influences migration, evaporation of water from body surfaces and predation. Strong winds however cause damage to plants resulting to breakage of trees. Plants that grow in areas with very strong winds experience stunted growth.

Wind speed is measured using an anemometer while direction of wind is measured using a wind sock or a wind vane.

(a)

(b)

Fig 5.16: (a) Windsock (b) Anemometor

vii) Atmospheric pressure

Atmospheric pressure refers to weight exerted by the air column in the atmosphere. It is therefore dependent on the altitude of an area. This physical factor affects processes like transpiration in plants and gaseous exchange in animals. Areas of a high altitudes like the East Africa Montane moorlands and Shrub land in South Sudan experience lower atmospheric pressure and consequently higher transpiration rates. This minimizes the number of plants that grow in these areas ultimately influencing the animals that would inhabit the area. On the other hand, areas of lower altitudes like the Victoria Basin Forest- Savanna mosaic of South Sudan experience higher altitudes and consequently experience lower transpiration rates and thus would have more life forms compared to the areas of higher altitudes.

Ecological succession

Discussion corner

1. Imagine a forest that has been destroyed by a forest fire. All the plants that lived there are gone. Will the burned-up forest remain lifeless forever?
2. Discuss the impacts of pesticides and pollution in an ecosystem.

Even though ecosystems appear stable, they do undergo changes with time. Living organisms present in the ecosystem may at times alter the environment. The change brought about may be more suitable enabling other new species to inhabit the environment. The process by which communities present in an environment are eventually replaced by new communities is termed as succession. Succession can be categorized as either primary or secondary succession.

i) Primary succession

It occurs in areas where the lands were initially not inhabited by any living organisms. For instance, on rocks or sand dunes in the deserts. The rocks may be weathered in the course of time through natural processes. Only organisms that adapted to these harsh conditions can survive. For example, Lichens which further breakdown the small rock particles and add soil content. These organisms which thrive in areas that were previously lifeless are referred to as pioneer organisms. Organisms like mosses may grow subsequently covering the lichens and cause death and decomposition of lichens. This further adds more soil content making the environment more favorable for other organisms. Eventually, more organisms inhabit the environment until it achieves climax community.

ii) Secondary succession

Secondary succession on the other hand comes about as a result of complete destruction of the previous climax community that existed in a particular area through processes such as: forest fires and clearing of forests for human occupation. New succession will begin after some period of time resulting

to another climax community. For example, the forest fires of South Sudan's Savanna ecosystem destroy trees as well as other species; eventually secondary succession occurs in the course of time. The distribution of organisms in an ecosystem is also affected by the climate changes other than the biotic and normal physical factors. Climate change in South Sudan has resulting from longer dry spells has led to drying up of seasonal streams hence reducing fish yield. In addition, longer dry spells due to effects of global warming have also resulted to deforestation and resource-based conflicts between pastoralist and farming communities.

Check your progress 5.2

1. Biotic factors in an environment includeA. The chemical and physical factors in an environment.
   B. All living organisms in an ecosystem
   C. Edaphic factors
   D. Competition among living organisms
2. The abiotic factors in an environment
   A. The chemical and physical factors in an environment.
   B. All living organisms in an ecosystem
   C. Edaphic factors
   D. Competition among living organisms
3. Which of the following is not affected by light in an ecosystem?
   A. Photosynthesis
   B. Transport
   C. Flowering
   D. Migration
4. In an ecosystem, the most severe competition develops among the organisms that
   A. Belong to different species
   B. Parasitize on different organism
   C. Occupy the same ecological niche
   D. Are active only during the day
5. Amoebic dysentery is caused by organisms that live in the intestines of human beings. This is an example of
   A. Commensalism
   B. Synergism
   C. Competition
   D. Parasitism
6. An abiotic factor that affects the ability of pioneer organisms to thrive in an ecosystem is the
   A. Type of substratum
   B. Species of bacteria
   C. Species of algae
   D. Competition between algae and fungus
7. List the physiological factors that are affected by the availability of water in an ecosystem
8. Name the type of association in which one organism benefits and the other is not affected.

9. Bacteria that live in the human intestines derive nutrients from digested food and on the other hand synthesize vitamins that are absorbed into the blood stream of the human being. This association is called?
10. State a word that best suits the following description
    a) A certain moth species resembles a bee
    b) The lion has body colour that blends well in the savanna grassland
11. Suggest reasons for the following observations
    a) Zebras are mostly found in open grassland while giraffes are found in wooded areas.
    b) Increase in rainfall may ultimately lead to increase in number of predators
12. Which types of biomes are found in the following ecological zones of South Sudan?
    a) Sahara flooded grassland
    b) Victoria Basin forest-savanna mosaic
13. Describe the effect of wind on the plants and animals
14. What is ecological succession?
15. Explain why lichens are commonly pioneer organisms in lifeless environments. Revision exercise 5.2

5.3 Classification of organisms

Discussion corner

1. "All food come from plant"
   Debate.All animals sources of energy is directly or indirectly comes from the sun. Debate.
2. Look at the pictures below.

A

B

C

What do they feed on?

Remember!

Only collect the number of specimen you require and do not harm any organisms. After the exercise, return the organisms to their habitats.

Activity 5.7

Individually.

1. At your free time, take a walk in your Payam. Observe what different organisms (both wild and domestic) feed on.
2. Record your results in a table like this:

Animal	What it feeds on

3. Share your findings with the rest of the class. Are your findings the same for specific animals.

The facts

Living organisms can be grouped into two main categories depending on the mode of acquisition of nutrients; **autotrophs** and **heterotrophs**. Autotrophs are organisms are able to make their own organic food substances using simple inorganic substances. They include plants algae and some bacteria. These organisms possess photosynthetic pigments like chlorophyll and are therefore able to trap light energy or utilize chemical energy to synthesize organic food substances. Hence photosynthetic autotrophs utilize light energy while chemosynthetic autotrophs like bacteria obtain energy by breaking down chemical substances. This mode of nutrition is termed as autotrophism and these organisms are called producers in an ecosystem. Heterotrophic organisms obtain food substances by feeding on plants or other animals. Heterotrophic organisms are grouped into: secondary, tertiary or quaternary consumers. Animals that feed directly on plant materials or vegetation are called **herbivores**. They include rabbits, gazelles, zebras, deer, sheep and cattle and are classified as primary consumers. Those that feed on flesh only are called **carnivores**. They include cheetahs, lions, wolves, hyenas and leopards and are classified ae secondary consumers. While those like human beings which feed on both flesh and plant material are called **omnivores**; they can be classified as either primary or secondary consumers. Quaternary consumers feed on tertiary consumers. Scavengers like vultures and hyenas feed on dead animals that they find. **Saprophytes** are those organisms that obtain nutrients by breaking down the remains of dead plants and animals; they include bacteria and fungi. **Detritivores** also called detrivores are organisms that feed on dead plants, animals and even faecal matter. They include dung beetles, earthworms, sea cucumbers and earthworms.

Energy flow in an ecosystem

As mentioned earlier, the sun is the ultimate source of energy in an ecosystem and primary producers like plants are able to utilize this energy to synthesize organic food substances like glucose. The energy from plants is then transmitted to other consumers in the form of chemical energy through a nutrition sequence. Several organisms in the nutrition sequence where each organism is fed on by another subsequent organism makes up a food chain. This is a linear representation of energy flow in an ecosystem.

Discussion corner

In groups discuss and write five food chains comprising of common organisms in your surrounding environment.

Other examples of food chains include:

1. Photosynthetic algae ⟶ mosquitoe larvae ⟶ prawns ⟶ sea gull
2. Kales ⟶ rabbit ⟶ wild dog
3. Grass ⟶ chicken ⟶ snake ⟶ owl ⟶ dog

The arrows in the food chain points the organism feeding on the other and also represents energy flow from one organism to the other in the food chain. Each feeding level in a food chain is called a **trophic level**.

Discussion corner

By giving an example, discuss the impact of population decrease or increase at one trophic level to the other.

The amount of energy reduces from one trophic level to the other along the food chain. This is necessitated by loss energy through the following ways:

- Respiration where some of the energy is lost in the form of heat.
- Thermoregulatory mechanisms where some of the energy is lost by endothermic organisms as they regulate their body temperature.
- Excretion- some energy is lost through passing out of excretory wastes from the body.
- Egestion- some undigested food is passed out of the organism's body through faecal matter.
- Carnivores discarding some parts of the animals they do not feed on like bones.

Generally, most of the energy is lost from one trophic level to another in the form of heat. A small fraction of the energy also remains stored in the new tissues formed.

Several food chains that are interconnected make up a food web. In a food web, an organism can occupy more than one trophic levels. The final organisms in a food web are always decomposers.

Example of food web

The energy flow in an ecosystem can also be diagrammatically represented using ecological pyramids such as: pyramids of numbers and the pyramid of energy. Due to loss of energy along the food chain, the number of organisms along the food chain decreases in the subsequent trophic levels. This can well be illustrated in a normal pyramid of numbers.

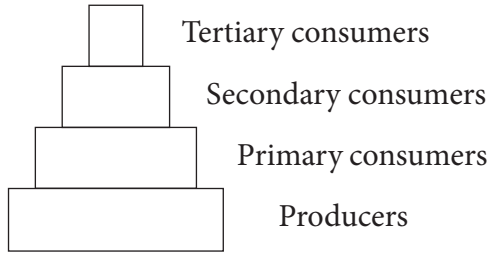


Fig 5.19 An illustration of pyramid of numbers based on the number of organisms at each trophic level

Discussion corner

Discuss the reason for odd shaped pyramids of numbers but normal shaped pyramids of biomass.

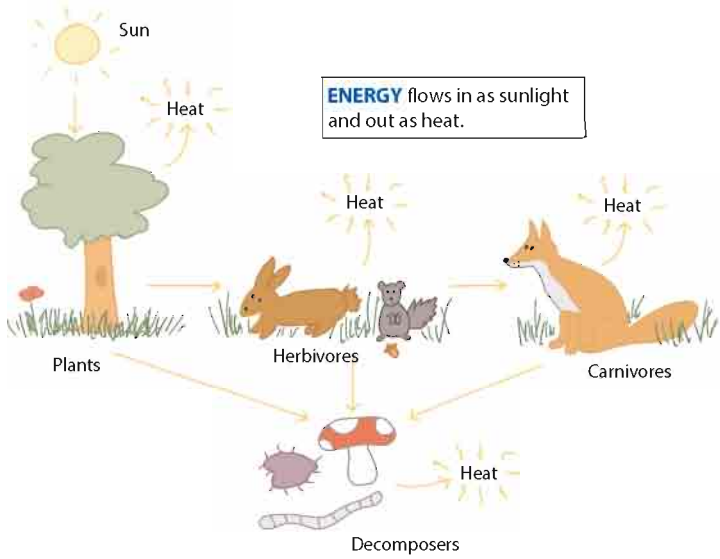


Fig 5.17 The efficiency of flow along a given food chain

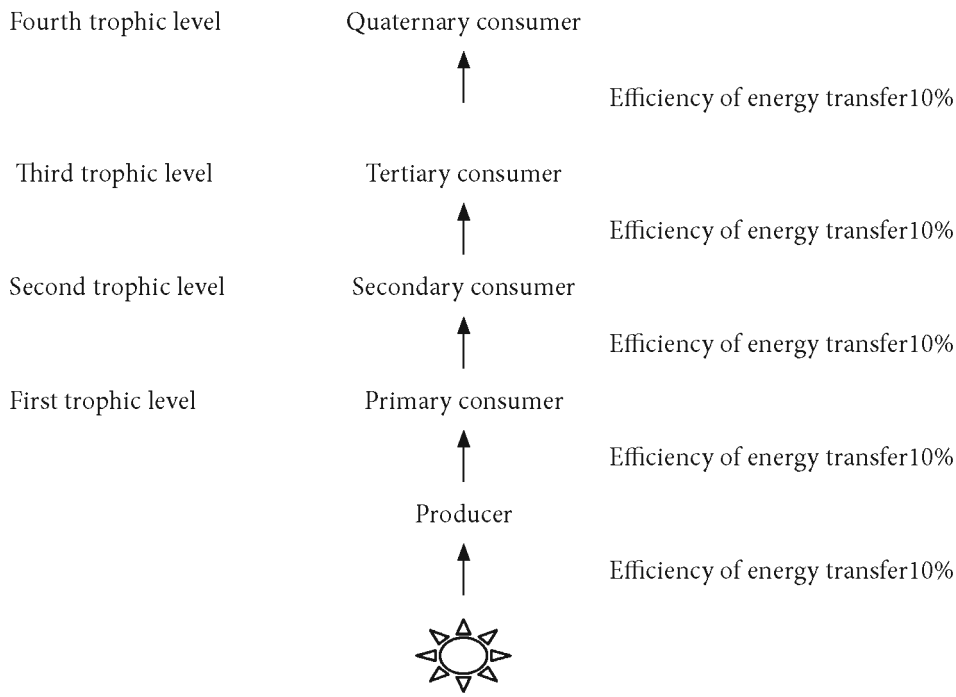


Fig 5.17 A generalized food chain indicating energy transfer efficiency from one trophic level to another. Only about 1 % of solar energy reaching the earth's surface ends up in primary productivity. The energy transferred from primary producers to other trophic levels varies between 5-20%.

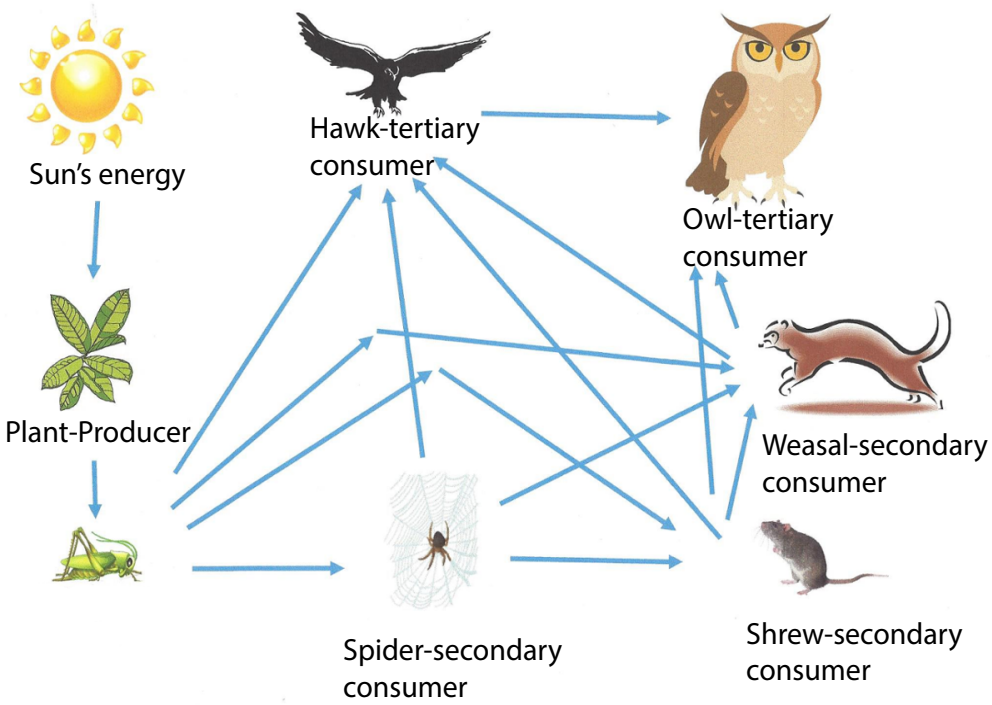


Fig 5.20: Food web

Some pyramids of numbers may however be inverted. For instance a case where some primary consumers feed on one producer. For example, several aphids feed on a cabbage. The aphids are then eaten by birds which are eventually fed on by cats.

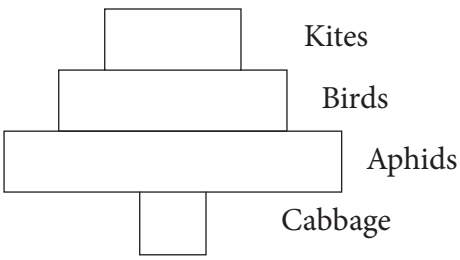


Fig 5.21 an inverted pyramid of numbers

The amount of available energy in the ecosystem can be show using a pyramid of energy. The producers form the base of the pyramid of energy since they contain the greatest amount of energy. The least amount of energy is present in the highest level consumer which occupy the top most level of the pyramid of energy.

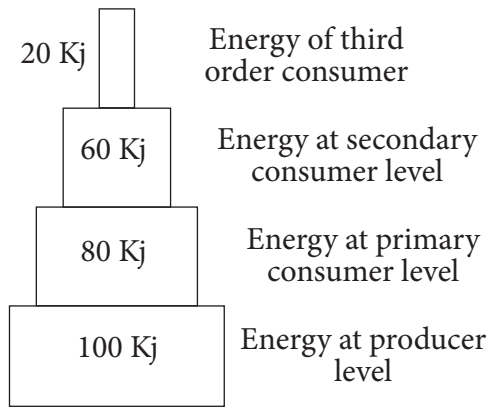


Fig 5.22 a pyramid of energy. At each trophic level, the amount of energy available for the next trophic level is only about 10%

Due to the decrease in the amount of energy from one trophic level to another, the total mass of living organisms that can be supported at each trophic level decreases. This information can be represented on a pyramid of biomass using the total dry weight or relative mass at each trophic level.

My environment my life!

Discharging of harmful wastes into the environment through pollution of habitants can result to death of living organisms resulting to decrease of biodiversity of life forms.

Discussion corner

During class debate session. Discuss the following motions.

'We see vast herds of some creatures such as wildebeest but much smaller populations of predators such as lions.

'The world could support a bigger human population of vegetarians than meat eater.'

5.4 Nutrient cycles

Discussion corner

1. Describe your daily activity cycle.
2. Take a walk, around the school, find examples of something that is part of a cycle.

In all ecosystems, there is cycles of important nutrients between living organisms and their environment. Living organisms incorporate certain substances from the environment into their bodies. For example, carbon present in carbon dioxide in the atmosphere is incorporated into plants' bodies through photosynthesis. The carbon is then passed to other consumers through feeding. When these organisms die, their bodies are broken down by decomposers and the nutrients are returned back into the environment.

The carbon cycle

Activity 5.8

Investigating the process of carbon cycle

In groups of five

Materials

Plant water, bromothymol, two clear bags, clean water in a beaker, straw.

Procedure

1. Fill the two bags with water half way.
2. Add two bags of bromothymol in each clear bag. Observe the colour.
3. Close the bags immediately after adding bromothymol.
4. Using a straw, blow air inside the bags. Observe the colour.
5. Add water plant in one of the bags and put in an area where there is sunlight. Check the colour of the two bags.

Study questions

1. Explain changes of colour in each steps in the experiment above.
2. Relate your observation to carbon cycle process.

Carbon existing in the form of carbon dioxide makes up about 0.03 % of air.

Carbon is incorporated into tissues of plants through the process of photosynthesis. This occurs during carbon dioxide fixation where carbon dioxide is reacted with hydrogen ions resulting to formation of glucose. Glucose is then translocated in the form of sucrose to other parts of the plant and stored as starch. Herbivores feed on plant material and obtain carbon compounds like starch and sucrose from them. Carbon is returned back into the atmosphere through cellular respiration by the process of gaseous exchange.

When plants and animals die, the carbon containing compounds are stored in fossils over a long period of time. Combustion of fossil fuels including coal, oil and natural gas from decomposition of dead bodies of plants and animals also release carbon dioxide back into the atmosphere.

Nitrogen cycle

Activity 5.9: Nitrogen cycle

In a group of four

Materials

Maker pen, manila paper, hand out, pencil, stick glue.

Procedure

1. With the nitrogen you got in unit one, discuss with your friends how nitrogen cycle would look like.
2. Draw and label it using materials provided.
3. Stick your drawing on the class wall after approval by your teacher.

Can you recall what we discuss about nitrogen in unit one. What is its importance to plants? What about plants?

Although nitrogen is the most abundant gas in the atmosphere; about 78%,

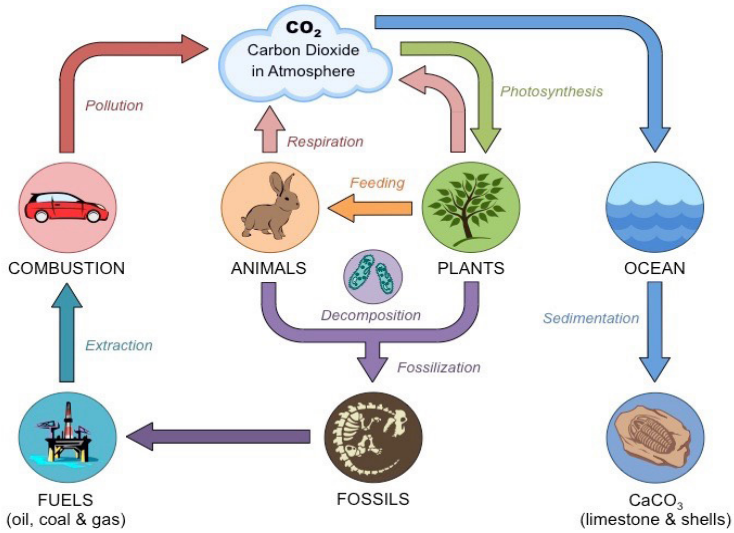


Fig 5.23 Carbon cycle

living organisms are not able to utilize free nitrogen in the air. Plants however are able to use compounds of nitrogen such ammonia, nitrites and nitrates to make proteins. Herbivores obtain the nitrogenous compounds from plants through feeding and pass them to carnivores that feed on them.

Free nitrogen in the atmosphere can be availed to plants through the process of nitrogen fixation. This can happen through biological fixation or non-biological fixation.

a) **Non- biological** fixation which occurs during thunderstorms. Energy from lighting is used to combine nitrogen and oxygen resulting to formation of nitrous gas that reacts with water in the atmosphere forming nitric acid. In the soil, nitric acid reacts with ions resulting to formation of nitrates which are absorbed by plants.

b) **Biological fixation**- this occurs through action of:
   i) Free-living microorganisms organisms such as bacteria (*Clostridium* and *Azotobacter*) and fungi (*Chlorella*, *Anabaena* and *Nostoc*).
   ii) Symbiotic bacteria like *Rhizobium* in root nodules of leguminous plants.

When plants and animals die, their bodies are decomposed by saprophytic bacteria and fungi releasing ammonium compounds into the soil. The ammonium compounds are converted into nitrites (NO_2-) by *Nitrosomonas* and *Nitrococcus* bacteria. Nitrobacter bacteria then convert nitrites to nitrates (NO_3-). The conversion of ammonium compounds to nitrites and nitrites

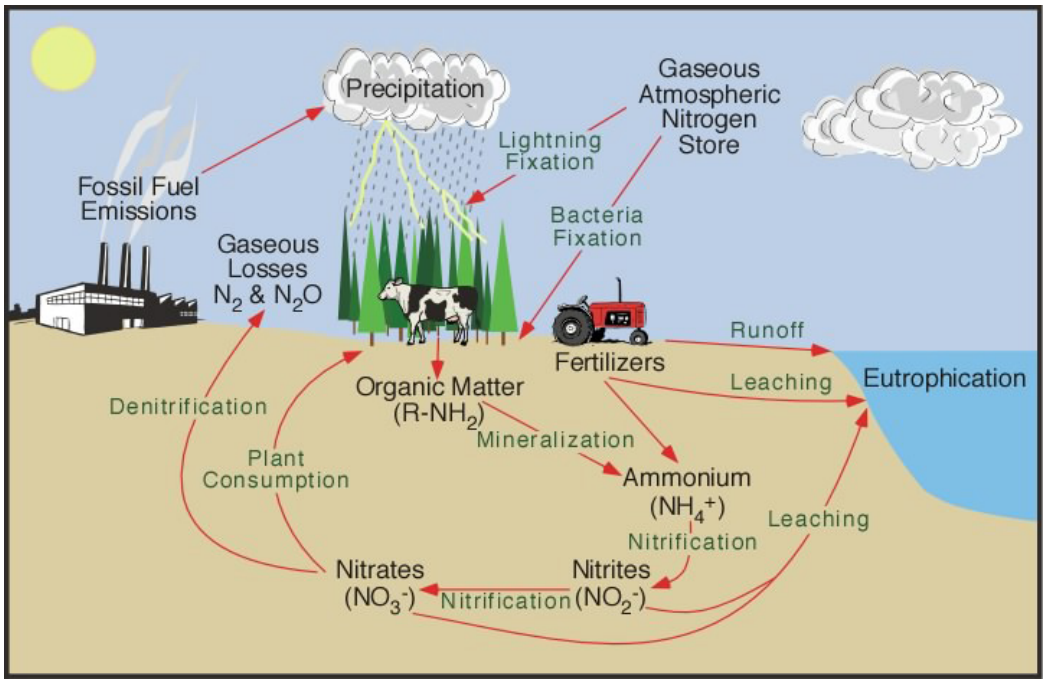


Fig 5.24: Nitrogen cycle

into nitrates is called **nitrification** and is carried out by nitrifying bacteria mentioned.

Available nitrates can be converted back into ammonia and nitrites through the process of denitrification that is carried out by denitrifying bacteria; *Psedomonas denitrificans* and *Thiobacillus denitrificans*. This process is disadvantageous since it depletes the soil of available nitrates should be made available to the plants.

Water cycle

Discussion corner

'Water is life'. Debate on this motion.

Activity 5.10

Investigating the process of water cycle in groups.

Materials

Spoon, salt, 2 glass bowls (1 small and 1 big), ice cubes, hot water in a cup, clear foil.

Procedure

1. Pour hot water in a big bowl.
2. Using a spoon, add salt into the water in a bowl.
3. Put small glass bowl in water in the big bowl.
4. Cover big glass bowl with clear cling foil.
5. Put pieces of ice on cling foil for 10 minutes and record your observation.

Study questions

1. What does each apparatus represent in real life water cycle?
2. Can you manage life without water cycle. What is its importance?

The cycling of water between the surface of water and the atmosphere is called water cycle. This is almost entirely a physical process. Water is availed to the earth through precipitation in the form of rain, snow, fog and dew. Water

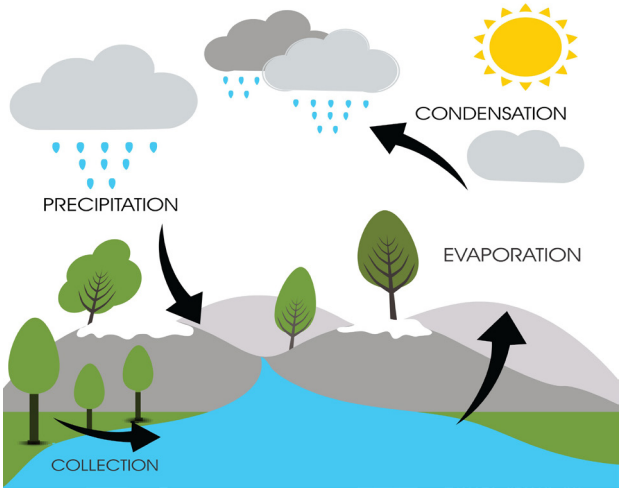


Fig 5.25 Water cycle

enters water bodies or percolates into the earth's surface. Plants absorb water from the soil through their roots where some of the water is broken down in the process of photosynthesis but restored during cellular respiration. Water in the plants' bodies is returned to the atmosphere through transpiration. Animals take water through drinking and lose water from their bodies through evaporation.

Check your progress 5.3

1. Which is the ultimate source of energy in an ecosystem?
   - A. Plants
   - B. Sun
   - C. Primary producers
   - D. Consumers
2. Trophic level is
   - A. Food chain
   - B. Feeding level in a food chain
   - C. Available food in a food chain
   - D. Energy in an ecosystem.
3. Which pathway shows the flow of energy from the sun
   - A. Stored in plants chemical energy in carbohydrates trapped by chlorophyll
   - B. Trapped by chlorophyll chemical energy in carbohydrates stored in plants
   - C. Chemical energy in carbohydrates stored in plants trapped by chlorophyll
   - D. Carnivores stored in plants trapped by chlorophyll
4. What do scavengers feed on?
   - A. Flesh
   - B. Dead animals
   - C. Producers
   - D. All of the above
5. At the beginning of every food chain are
   - A. Primary consumers
   - B. The sun
   - C. Producers
   - D. Carnivores
6. What are carnivores? Name three examples of carnivores in the ecosystems near you.
7. Complete the paragraph given using appropriate statements

   …….. are organisms that are able to manufacture organic food substances using simple inorganic substances. Heterotrophs obtain nutrients by feeding on other organisms. ……. Convert light energy to chemical energy and pass it to other …….. levels. The energy flowing in ecosystem can be represented using a …… The top most consumer in the food chain contains the …… amount of energy.

8. What is the nature of energy flow from the sun in an ecosystem?

9. Study the food chain provided and answer the questions that follow

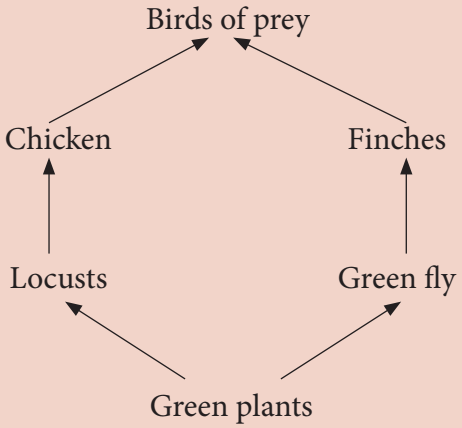
   Green plants grasshoppers birds

   i) Which organism has the highest biomass?

   ii) What would be the likely effect of reduction of number of birds on the number of grasshoppers?

   iii) Draw a pyramid of energy to represent the information in the food chain provided

10. Study the food web provided and answer the questions that follow



   i) Which organism would have the highest numbers?

   ii) Which trophic level is occupied by the birds of prey?

   iii) Which organism(s) would decrease in number in case of a fire outbreak?

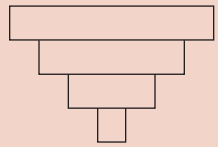
   iv) Which organism would increase in number if the number of chicken decrease drastically?

11. The diagram below shows a food chain in an ecosystem

Grass ⟶ hens ⟶ dog ⟶ ticks

Which pyramid of numbers best represents this information?

A



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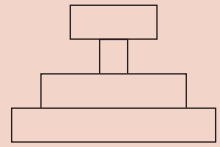

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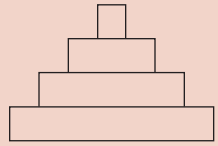

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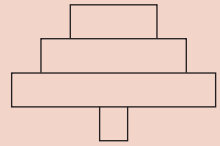

12. Which process incorporates carbon in carbon dioxide into the ecosystem?

13. Energy and biomass content in an ecosystem can be represented in a pyramid because?

14. Distinguish between a nitrogen fixation and nitrification.

15. Describe the water cycle.

Glossary

Aerobes: organisms that use oxygen in respiration

Aerobic respiration: the type of respiration that takes place in the presence of oxygen

Anaerobes: organisms that do not use oxygen to respire

Agglutination: the clumping together in suspension of antigen-bearing cells, macro-organisms or particles in the presence of specific antibodies.

Anaerobic respiration: the type of respiration that takes place without oxygen

Assimilation: a combination of two process which are; absorption of digested food from intestines to blood stream and a second process is the alteration of absorbed food by the liver and cells into other compounds

ATP: Adenosine Tri Phosphate

Autotrophism: the type of nutrition where organisms make their own food from simple substances such as carbon dioxide and water

Autoimmune: a condition arising from an abnormal immune response to a normal body part

Auxins: a family of plant hormones produced at the growing regions of the plant

Biodegradable: these are substances that can be broken down by living things

Biome: is a community of plants and animals that have common characteristics for the environment they exist in.

Competition: the interaction between organisms of the same or different species in which both are harmed

Conservation: the use of natural resources without wasting them for social and economic development

Cooperation: the kind of interaction in which organisms of the same species live together and share work between themselves

Dissection: the cutting up of body parts of an animal or plant for the

purpose of careful examination so that analysis can be done

DNA: (**Deoxyribonucleic acid):** a molecule that carries most of the genetic instructions used in the development, functioning and reproduction of cells of all living organisms

Ecosystem: a community of organisms interacting with each other and with their environment

Ecotourism: tourism industry that focuses on ecology and conservation of the environment (by conducting trips to the rainforest, African savannas, etc)

Effectors: structures that aid animals to react to stimuli i.e. they carry out a response; they can be glands or cells

Egest: the expelling of undigested material through the anus

Egg: female gamete

Emulsification: physical breaking down of fats into small droplets for easy digestion

Enamel: the hardest part of the teeth that covers the surface

Endangered species: species of plants and animals that are at risk of going extinct because their numbers are too few to have successful breeding

External environment: the immediate surroundings of an organism

Fossil fuel: fuels formed from the remains of plants and animals that lived in an earlier era such as coal, petroleum, natural gas

Food testing: a process used to check that a food is safe and does not contain harmful contaminants.

Fruit: seed bearing structure formed from a flower after fertilisation

Gamete: a reproductive cell containing a haploid or half number of chromosomes

Gene: It's the unit of inheritance located on DNA

Habitat: an area where an organism is usually found

Haploid: half number of chromosomes in a cell

Health: a state of well-being resulting from complete physical, mental and social well-being

Herbicides: chemicals used to kill weeds

Heterotrophism: the type of nutrition where organisms get ready-made food from

the environment

Hormone: an organic chemical substance, which is produced in small quantities and transported by blood to target organs where it exerts its effects

Host: an organism which provides food and sometimes shelter to the parasite

Hygiene: practices that bring about safe and healthy environment that prevents diseases through cleanliness

Immune system: a protect ion mechanism comprising of biological structures and processes that defend the body against pathogenic microorganisms

Infection: invasion into the body and multiplication of pathogenic microorganisms.formed on a modified shoot

Inspection: careful examination of something

Insulin: a hormone produced by the pancreas and responsible for lowering blood sugar

Intensive farming: farming on a small piece of land using modern techniques

Interdependence: depending on each other for either food or shelter

Internal environment: the immediate surroundings of the cells, which is mainly tissue fluid

Macronutrients: nutrients which provide energy needed in large quantities for metabolism of an organism such as carbohydrates, proteins, fats, calcium, etc

Micronutrients: nutrients required by an organism in small quantities for physiological functions such as vitamins, iron, zinc, copper, e.t.c

Oxygen debt: oxygen deficit that develops when an aerobic organism or tissue cannot increase its oxygen uptake sufficiently to match the increased demand for energy **Parthenocarpy**: formation of fruits without fertilisation

Population density: the number of organisms in a given place per unit area

Preservation: the protecting of the environment by the act of saving it from damage

Renewable resources: able to be replaced by nature e.g. forests are renewable natural resources

Reproduction: a process by which living organisms give rise to new individuals of the same kind

Speciation: the gradual process of formation of new species due to evolution person

Stimulus: any change in the environmental conditions which can bring about a change in the activity of an organism e.g. chemical change, light

Sustainable development: the development that does not damage the environment either by using all the resources or polluting the environment.

Sustainable resources: the resources that can be renewed as in the case of agricultural products

Wildlife: wild animals and plants, which are not domesticated