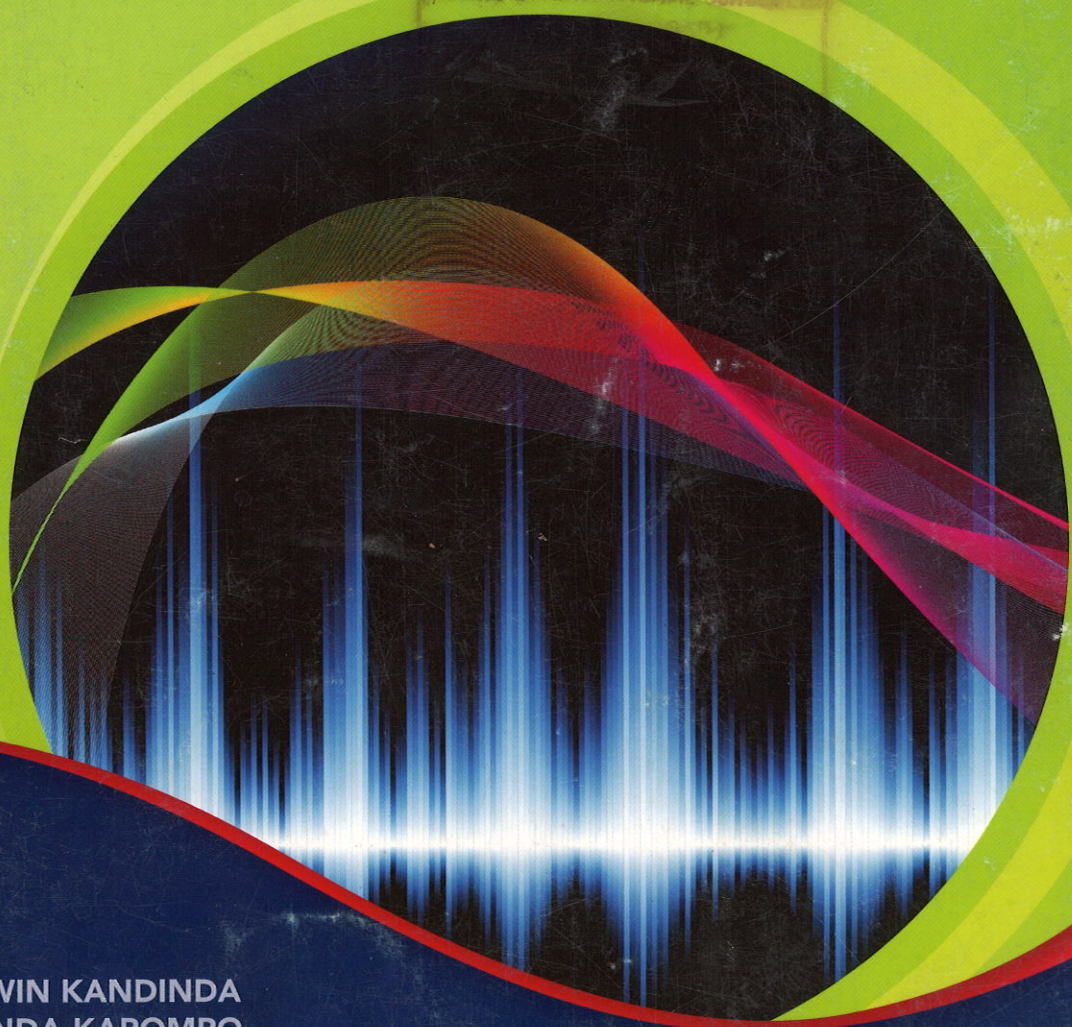
OXFORD

Progress in 9

Integrated Science

LEARNER'S BOOK

EAGLE INTERNATIONAL SCHOOL



BALDWIN KANDINDA
KABANDA KAPOMPO
ARTHUR SIKAPIZYE
with GARY MANN

OXFORD

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Progress in Integrated Science

Grade 9

LEARNER'S BOOK

BALDWIN KANDINDA
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EAGLE INTERNATIONAL SCHOOL LTD
(KITWE ROAD)
21 MAY 2015
DEPUTY MANAGER/HEAD'S OFFICE
P.O. BOX 41374
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Contents

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How to use this book

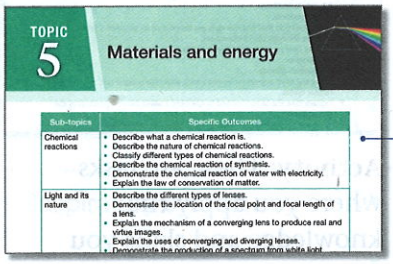
Welcome to the *Progress in Integrated Science* series for Grades 8–12!

This series is based on the *Junior Secondary Syllabus for Integrated Science* issued by the Ministry of Education. All the knowledge, skills and values expressed in the document are addressed in *Progress in Integrated Science* Grade 9 Learner's Book so that you can feel confident about your success in this subject.

These two pages will help you understand how the book works.

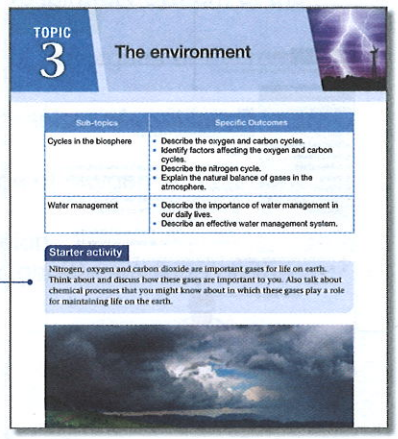
The book is divided into topics so that you can easily see what content will be covered in your Integrated Science class.

On the first page of every topic, you will find:


TOPIC 5 Materials and energy

Sub-topics	Specific Outcomes
Chemical reactions	• Describe what a chemical reaction is. • Describe the nature of chemical reactions. • Classify different types of chemical reactions. • Describe the chemical reaction of synthesis. • Demonstrate the chemical reaction of water with electricity. • Explain the law of conservation of matter.
Light and its nature	• Describe the different types of lenses. • Demonstrate the location of the focal point and focal length of a lens. • Explain the mechanism of a converging lens to produce real and virtue images. • Explain the uses of converging and diverging lenses. • Demonstrate the production of a spectrum from white light.

A box that shows you which **sub-topics** and **specific outcomes** will be covered during the topic.


TOPIC 3 The environment

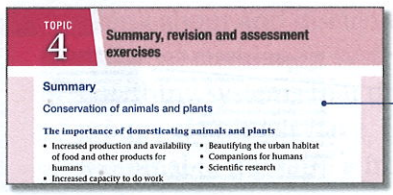
Sub-topics	Specific Outcomes
Cycles in the biosphere	• Describe the oxygen and carbon cycles. • Identify factors affecting the oxygen and carbon cycles. • Describe the nitrogen cycle. • Explain the natural balance of gases in the atmosphere.
Water management	• Describe the importance of water management in our daily lives. • Describe an effective water management system.

Starter activity

Nitrogen, oxygen and carbon dioxide are important gases for life on earth. Think about and discuss how these gases are important to you. Also talk about chemical processes that you might know about in which these gases play a role for maintaining life on the earth.

Starter activity: This prepares you for the topic you are starting.

At the end of each topic, you will find:


TOPIC 4 Summary, revision and assessment exercises

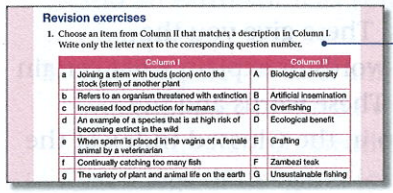
Summary

Conservation of animals and plants

The importance of domesticating animals and plants

- Increased production and availability of food and other products for humans
- Increased capacity to do work
- Beautifying the urban habitat
- Companions for humans
- Scientific research

A **topic summary** that helps you quickly revise key learning points from the topic.


Revision exercises

1. Choose an item from Column II that matches a description in Column I. Write only the letter next to the corresponding question number.

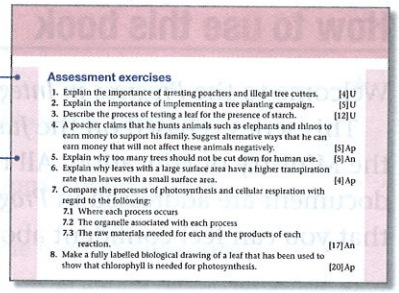
	Column I		Column II
a	Joining a stem with buds (scion) onto the stock (stem) of another plant	A	Biological diversity
b	Refers to an organism threatened with extinction	B	Artificial insemination
c	Increased food production for humans	C	Overfishing
d	An example of a species that is at high risk of becoming extinct in the wild	D	Ecological benefit
e	When sperm is placed in the vagina of a female animal by a veterinarian	E	Grafting
f	Continually catching too many fish	F	Zambezi teak
g	The variety of plant and animal life on the earth	G	Unsustainable fishing

Revision exercises that help you revise the topic's work and check your understanding.

Assessment exercises that help you prepare for tests and exams.

Bloom's taxonomy levels are referred to in the assessment exercises.

The taxonomy levels used in this book are:
K = Knowledge
C = Comprehension
Ap = Application
An = Analysis
S = Synthesis
E = Evaluation

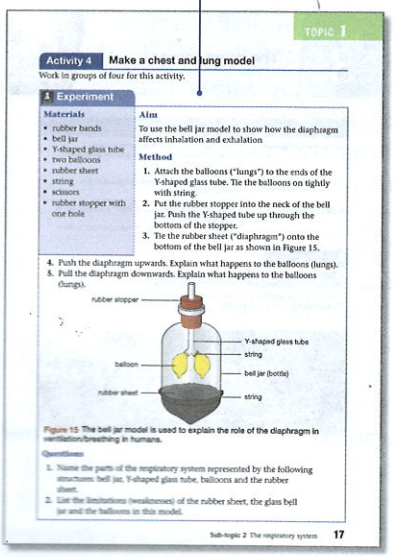


Assessment exercises

1. Explain the importance of arresting poachers and illegal tree cutters. [4]U
2. Explain the importance of implementing a tree planting campaign. [5]U
3. Describe the process of testing a leaf for the presence of starch. [12]U
4. A poacher claims that he hunts animals such as elephants and rhinos to earn money to support his family. Suggest alternative ways that he can earn money that will not affect these animals negatively. [5]Ap
5. Explain why too many trees should not be cut down for human use. [5]An
6. Explain why leaves with a large surface area have a higher transpiration rate than leaves with a small surface area. [4]Ap
7. Compare the processes of photosynthesis and cellular respiration with regard to the following:
   7.1 Where each process occurs
   7.2 The organelle associated with each process
   7.3 The raw materials needed for each and the products of each reaction. [17]An
8. Make a fully labelled biological drawing of a leaf that has been used to show that chlorophyll is needed for photosynthesis. [20]Ap

You will see the following throughout the book:

Experiments: These practical activities give step-by-step instructions for doing experiments and also indicate what the aim of the experiment is.



TOPIC 1

Activity 4 Make a chest and lung model

Work in groups of four for this activity.

Experiment

Materials
- rubber bands
- bell jar
- Y-shaped glass tube
- two balloons
- rubber sheet
- string
- scissors
- rubber stopper with one hole

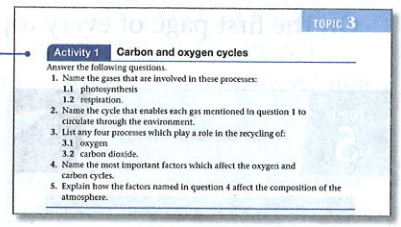
Aim
To use the bell jar model to show how the diaphragm affects inhalation and exhalation

Method
1. Attach the balloons ("lungs") to the ends of the Y-shaped glass tube. Tie the balloons on tightly with string.
2. Put the rubber stopper into the neck of the bell jar. Push the Y-shaped tube up through the bottom of the stopper.
3. Tie the rubber sheet ("diaphragm") onto the bottom of the bell jar as shown in Figure 15.
4. Push the diaphragm upwards. Explain what happens to the balloons (lungs).
5. Pull the diaphragm downwards. Explain what happens to the balloons (lungs).

Figure 15 The bell jar model is used to explain the role of the diaphragm in ventilation/breathing in humans.

Questions
1. Name the parts of the respiratory system represented by the following structures: bell jar, Y-shaped glass tube, balloons and the rubber sheet.
2. List the limitations (weaknesses) of the rubber sheet, the glass bell jar and the balloons in this model.

Sub-topic 2 The respiratory system 17



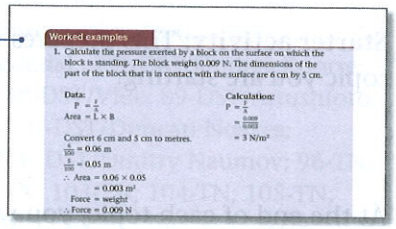
TOPIC 3

Activity 1 Carbon and oxygen cycles

Answer the following questions.
1. Name the gases that are involved in these processes:
   1.1 photosynthesis
   1.2 respiration.
2. Name the cycle that enables each gas mentioned in question 1 to circulate through the environment.
3. List any four processes which play a role in the recycling of:
   3.1 oxygen
   3.2 carbon dioxide.
4. Name the most important factors which affect the oxygen and carbon cycles.
5. Explain how the factors named in question 4 affect the composition of the atmosphere.

Activity: These are tasks where you apply the knowledge and skills you have learnt in that section. Note: We use the term "activity" to refer to written exercises and practical activities.

Worked examples: These examples with model answers show you how to do calculations step-by-step.



Worked examples

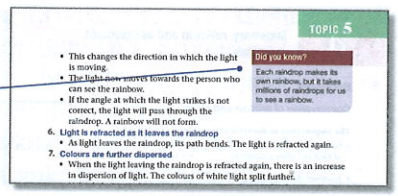
1. Calculate the pressure exerted by a block on the surface on which the block is standing. The block weighs 0.009 N. The dimensions of the part of the block that is in contact with the surface are 6 cm by 5 cm.

Data:
$P = \frac{F}{A}$
Area = L × B

Calculation:
$P = \frac{F}{A}$
$= \frac{0.009}{0.003}$
$= 3\ N/m^2$

Convert 6 cm and 5 cm to metres.
$\frac{6}{100} = 0.06$ m
$\frac{5}{100} = 0.05$ m
∴ Area = 0.06 × 0.05
= 0.003 m²
Force = weight
∴ Force = 0.009 N

Did you know? boxes: These give you more knowledge about what you are learning.

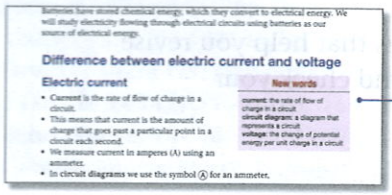


TOPIC 5

- This changes the direction in which the light is moving.
- The light now moves towards the person who can see the rainbow.
- If the angle at which the light strikes is not correct, the light will pass through the raindrop. A rainbow will not form.

6. **Light is refracted as it leaves the raindrop**
   - As light leaves the raindrop, its path bends. The light is refracted again.
7. **Colours are further dispersed**
   - When the light leaving the raindrop is refracted again, there is an increase in dispersion of light. The colours of white light split furthe

Did you know?
Each raindrop makes its own rainbow, but it takes millions of raindrops for us to see a rainbow.



Batteries have stored chemical energy, which they convert to electrical energy. We will study electricity flowing through electrical circuits using batteries as our source of electrical energy.

Difference between electric current and voltage

Electric current

New words
current: the rate of flow of charge in a circuit
circuit diagram: a diagram that represents a circuit
voltage: the change of potential energy per unit charge in a circuit

- Current is the rate of flow of charge in a circuit.
- This means that current is the amount of charge that goes past a particular point in a circuit each second.
- We measure current in amperes (A) using an ammeter.
- In circuit diagrams we use the symbol Ⓐ for an ammeter.

New words boxes: These give you the definitions of key words or explain what certain new words mean. These words and the definitions are also in the **Glossed index** at the back of the book.

TOPIC 1 The

Sub-topics

Circulatory system

Respiratory system

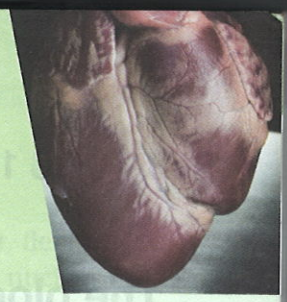
Starter activity

Work in groups of four activity.

1. Think about and d different circulatio breathing systems groups of animals mammal (a humar and an earthworm examples.
2. List the parts of ea you think are invo blood circulation, exchange of the g and carbon dioxid

TOPIC 1

The human body

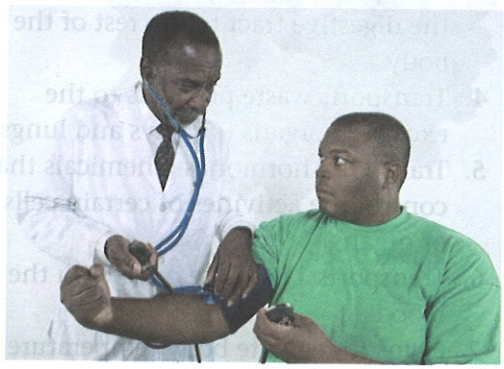


Sub-topics	Specific Outcomes
Circulatory system	• Describe the blood circulatory system. • Identify the components of blood and their functions. • Describe the internal structure of the heart. • Illustrate the movement of blood in the double circulatory system. • Identify the role of the heart, lungs and blood vessels in blood circulation. • Take the pulse rate at rest and after physical exercise.
Respiratory system	• Identify organs of the respiratory system of the human body. • Explain the functions of the organs of the respiratory system. • Demonstrate the mechanism of ventilation in the human body. • Describe the exchange of oxygen and carbon dioxide in the lungs. • Explain tissue respiration. • Explain the effect of cigarette smoking on the respiratory system.

Starter activity

Work in groups of four to five for this activity.

1. Think about and discuss the different circulation systems and breathing systems that different groups of animals have. Use a mammal (a human), a frog, a fish and an earthworm as your examples.
2. List the parts of each animal that you think are involved with blood circulation, breathing and exchange of the gases (oxygen and carbon dioxide).



A doctor checks a man's blood pressure to check that his blood circulation is in order.

SUB-TOPIC 1

The circulatory system

The blood circulatory system

The blood circulatory system in humans transports substances within our bodies. It is made up of:

- **blood:** for transporting dissolved gases, nutrients and waste products
- **blood vessels:** for transporting the blood
- **heart:** for pumping blood around the body
- **valves:** for keeping the blood flowing in only one direction around the body.

Components of blood and their functions

Blood is a salty, sticky, red liquid with a metallic smell and a slightly alkaline pH. It consists of two parts: plasma and blood cells. There are three types of blood cells: red blood cells, white blood cells and platelets.

An adult human has about five litres of blood in the body.

Blood plasma

This is the liquid part of blood. It is a yellowish fluid that contains about 90% water and 10% dissolved substances. These substances include fats/lipids, carbohydrates (glucose), salts, gases, vitamins, waste products, plasma proteins and amino acids. Plasma makes up about 55% of the blood volume.

Functions of blood plasma:

1. Transports blood cells and **antibodies**
2. Acts as a solvent for soluble substances
3. Transports absorbed nutrients from the digestive tract to the rest of the body
4. Transports waste products to the excretory organs (kidneys and lungs)
5. Transports hormones (chemicals that control the activities of certain cells or organs)
6. Transports 1% of the oxygen in the blood
7. Helps to regulate body temperature as it distributes heat through the body
8. Transports **fibrinogen** and clotting factors which play a vital role in blood clotting

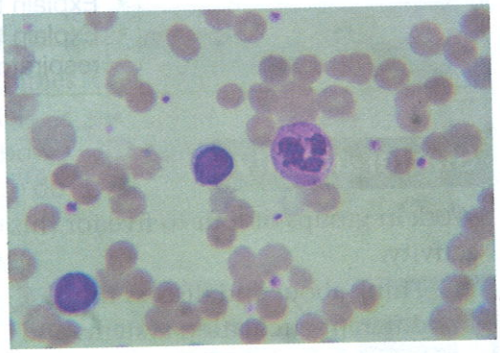


Figure 1 The composition of blood as seen under a light microscope

New words

antibodies: proteins generally found in the blood that detect and destroy invaders such as bacteria and viruses
fibrinogen: a protein in the blood plasma that is essential for blood clotting

Red blood cells

Red blood cells are the
biconcave discs that are
They are produced in re

Red blood cells norm
then destroyed in the li

Functions of red blood

1. Make the blood lo
2. Transport about 9
the blood
3. Transport about 3
in the blood
4. Play a role in bloo
5. Play a role in pH r

White blood ce

White blood cells are
white blood cells than
cells, based on their f
in shape, almost colo
produced in yellow b

Functions of white bl

1. Play a vital role i
2. Fight diseases
3. Control infectio
4. Secrete **heparin**
5. Regulate **allergi**
6. Make and distrib

New

haemoglobin: the iron-
carries oxygen
heparin: a substance f
the clotting of blood
allergy: the body's rea
environment that are h
example, pollen, dust,

Red blood cells

Red blood cells are the most numerous cells in the blood. They are flat, flexible, biconcave discs that are filled with **haemoglobin**. They do not have a nucleus. They are produced in red bone marrow.

Red blood cells normally stay in circulation for about three months. They are then destroyed in the liver and the spleen.

Functions of red blood cells:

1. Make the blood look red in colour
2. Transport about 99% of the oxygen in the blood
3. Transport about 30% of the carbon dioxide in the blood
4. Play a role in blood clotting
5. Play a role in pH regulation

Figure 2 Red blood cells are flat, biconcave discs.

White blood cells

White blood cells are the second most numerous cells in blood. There are far fewer white blood cells than red blood cells. There are five different types of white blood cells, based on their functions. They are much larger than red blood cells, irregular in shape, almost colourless and transparent, and have a nucleus. They are produced in yellow bone marrow, the spleen and the lymph glands.

Functions of white blood cells:

1. Play a vital role in immunity
2. Fight diseases
3. Control infections
4. Secrete **heparin** to prevent blood clotting
5. Regulate **allergies**
6. Make and distribute antibodies

Figure 3 A white blood cell is irregular in shape.

New words

haemoglobin: the iron-containing protein that carries oxygen
heparin: a substance found in the liver that slows the clotting of blood
allergy: the body's reaction to substances in the environment that are harmless to most people, for example, pollen, dust, insect bites

Platelets

Platelets are the least numerous cells in blood. They are not true cells, but pieces of cytoplasm from large cells found in red bone marrow. They are surrounded by a cell membrane, but have no nucleus. They contain fibrinogen and other blood-clotting factors. They stick to each other and to the surface of foreign substances in the blood, forming clumps.

Functions of the platelets:

1. Clump together to repair small gaps in damaged walls of small blood vessels temporarily to stop bleeding
2. Play an important role in the formation of blood clots

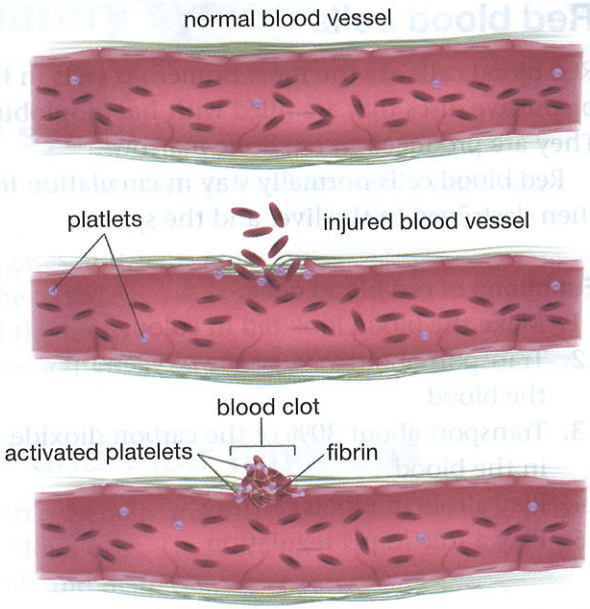


Figure 4 The role of blood platelets in blood clottin

Activity 1 Blood components and circulation

Answer the following questions.

1. Name the four essential parts of the blood circulatory system. Give the function of each part.
2. Describe the composition of blood plasma.
3. List the functions of blood plasma.
4. Name the types of cells that occur in blood.
5. List the functions of each type of cell that forms part of blood.

The heart

The heart is a hollow, muscular, four-chambered organ about the shape and size of a man's closed fist. It is situated in the thorax (chest) between the lungs and behind the breastbone (sternum). The heart is surrounded by a double membrane. The space between these membranes is filled with fluid that reduces friction as the heart beats.

Structure and fu

The heart has four sepa chambers are called at lower chambers are cal vessels are attached to from the heart. Vessels that take blood away f

New word

atrium (plural **atria**): uppe chamber of the heart, whi receives blood
ventricle: lower chamber heart, which pumps blooc heart

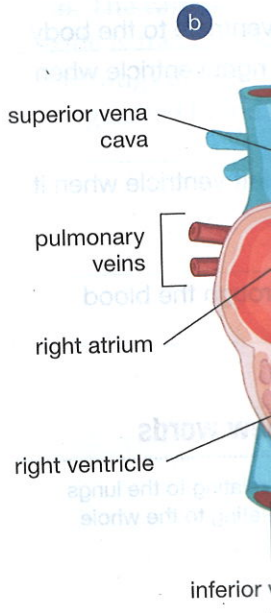


Figure 5 a) The exte of a human heart

Structure and function of the heart components

The heart has four separate chambers that are connected by valves. The upper chambers are called **atria** (**atrium** singular). Atria have thin, muscular walls. The lower chambers are called **ventricles** and have thick muscular walls. Various blood vessels are attached to the heart. They bring blood to the heart or take blood away from the heart. Vessels that bring blood towards the heart are called veins; vessels that take blood away from the heart are called arteries.

New word

atrium (plural **atria**): upper chamber of the heart, which receives blood
ventricle: lower chamber of the heart, which pumps blood from heart

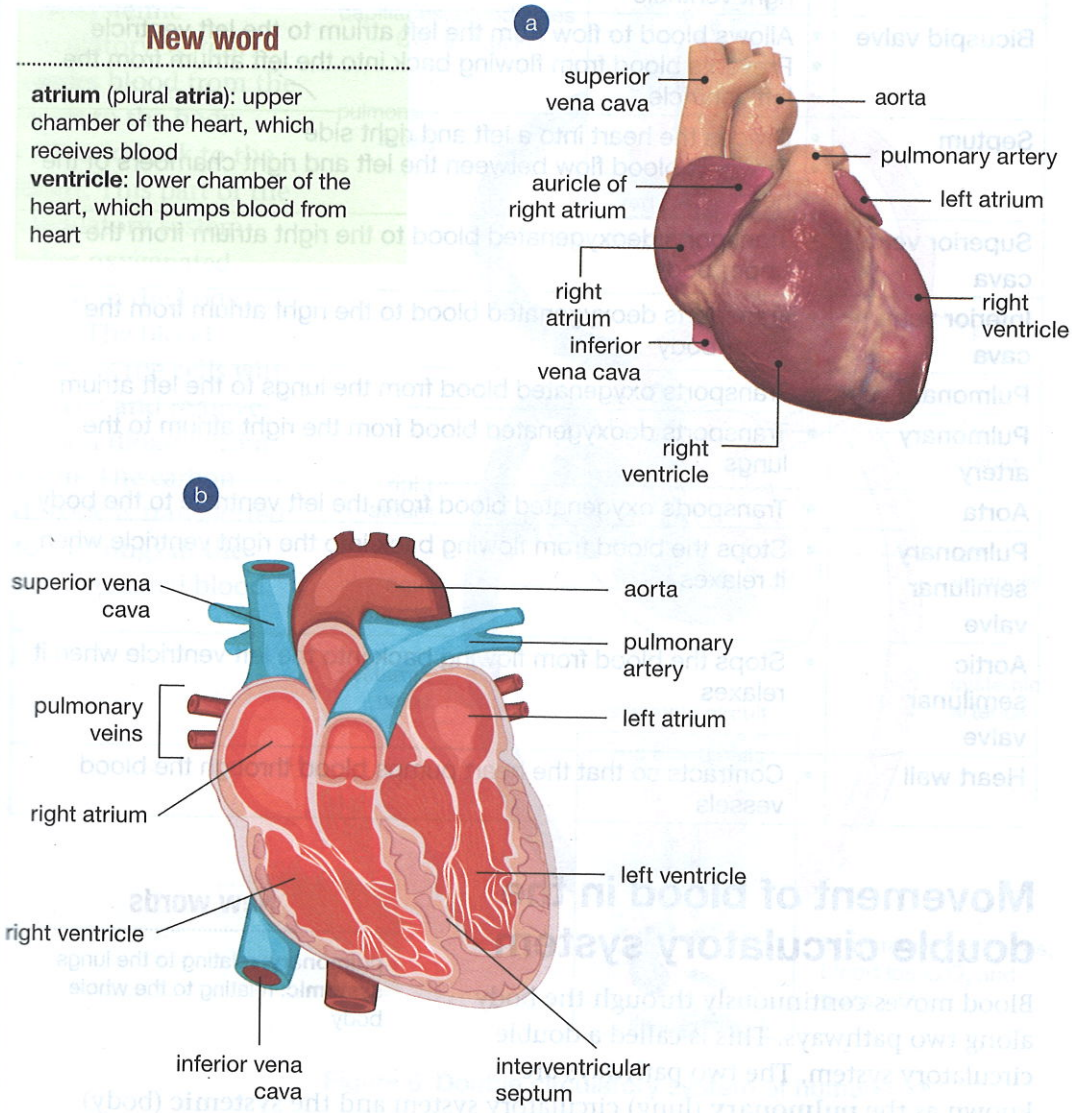


Figure 5 a) The external appearance of a human heart; b) The internal structure of a human heart

The main components of the heart and their functions

Component	Function
Right atrium	• Receives deoxygenated blood from the body
Left atrium	• Receives oxygenated blood from the lungs
Right ventricle	• Pumps deoxygenated blood to the lungs
Left ventricle	• Pumps oxygenated blood to the body
Tricuspid valve	• Allows blood to flow from the right atrium to the right ventricle • Prevents blood from flowing back into the right atrium from the right ventricle
Bicuspid valve	• Allows blood to flow from the left atrium to the left ventricle • Prevents blood from flowing back into the left atrium from the left ventricle
Septum	• Divides the heart into a left and right side • Prevents blood flow between the left and right chambers of the heart
Superior vena cava	• Transports deoxygenated blood to the right atrium from the upper body
Inferior vena cava	• Transports deoxygenated blood to the right atrium from the lower body
Pulmonary vein	• Transports oxygenated blood from the lungs to the left atrium
Pulmonary artery	• Transports deoxygenated blood from the right atrium to the lungs
Aorta	• Transports oxygenated blood from the left ventricle to the body
Pulmonary semilunar valve	• Stops the blood from flowing back into the right ventricle when it relaxes
Aortic semilunar valve	• Stops the blood from flowing back into the left ventricle when it relaxes
Heart wall	• Contracts so that the heart pumps blood through the blood vessels

Movement of blood in the double circulatory system

New words

pulmonary: relating to the lungs
systemic: relating to the whole body

Blood moves continuously through the body along two pathways. This is called a double circulatory system. The two pathways are known as the **pulmonary** (lung) circulatory system and the **systemic** (body) circulatory system.

Pulmonary circ

The pulmonary circulat
back to the heart. This
the lungs. In the lungs,
absorbed by the blood.

Systemic circulation

The systemic circulatory system carries blood from the heart to the body cells and back to the heart. This part of the circulatory system takes oxygenated blood to the body cells. The blood supplies the cells with oxygen and removes carbon dioxide from them. The carbon dioxide is transported to the lungs in the deoxygenated blood.

Pulmonary circulation

The pulmonary circulatory system carries blood from the heart to the lungs and back to the heart. This part of the circulatory system takes deoxygenated blood to the lungs. In the lungs, carbon dioxide is removed from the blood and oxygen is absorbed by the blood. The oxygenated blood then flows to the heart.

Systemic circulation

The systemic circulatory system carries blood from the heart to the body cells and back to the heart. This part of the circulatory system takes oxygenated blood to the body cells. The blood supplies the cells with oxygen and removes carbon dioxide from them. The carbon dioxide is transported to the lungs in the deoxygenated blood.

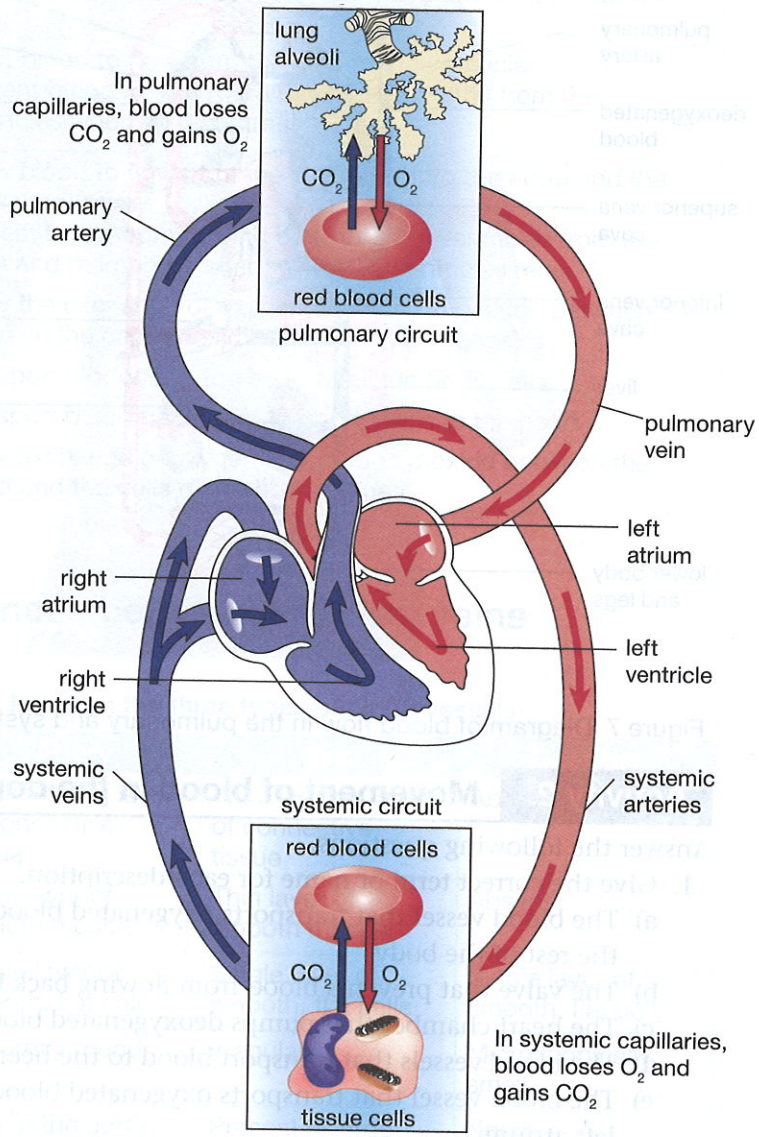


Figure 6 Double circulatory system of humans

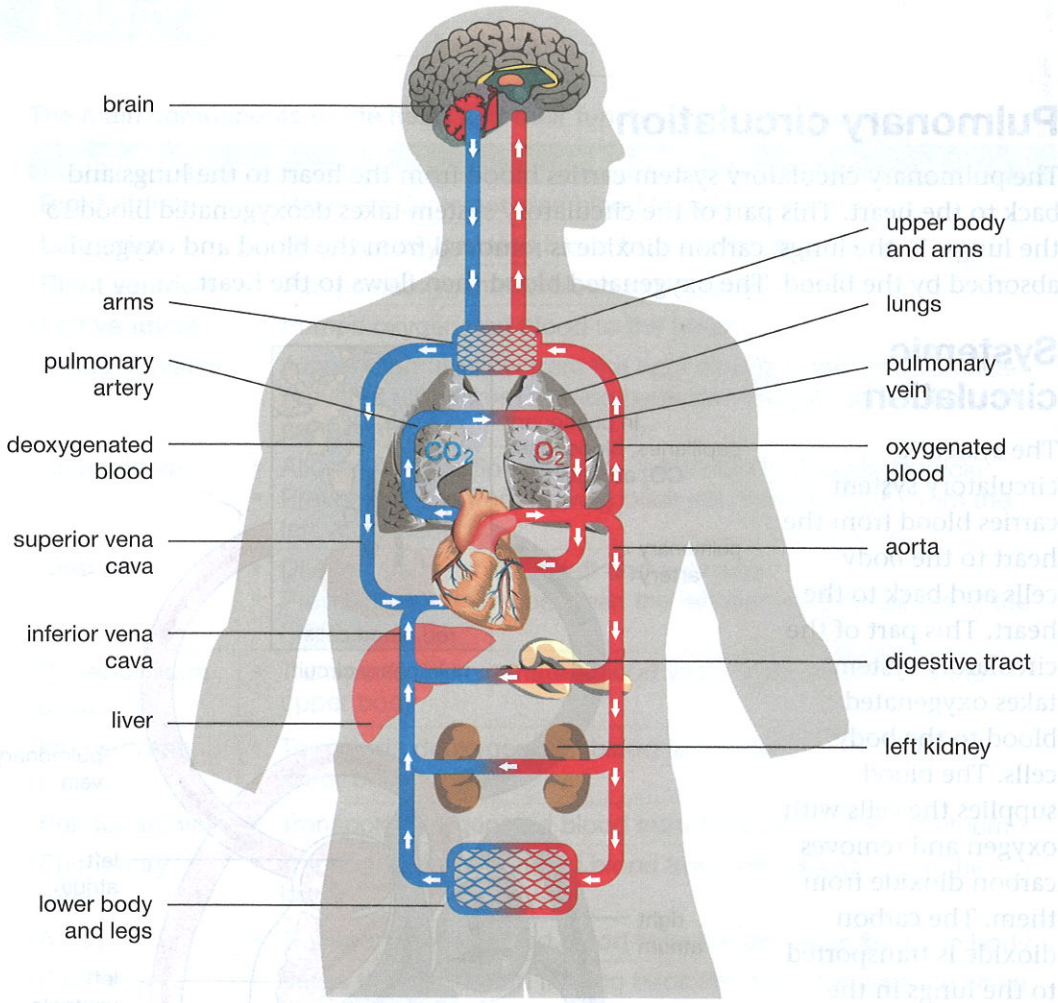


Figure 7 Diagram of blood flow in the pulmonary and systemic circulatory systems

Activity 2 Movement of blood in the double circulation

Answer the following questions.

1. Give the correct term or name for each description.
   a) The blood vessel that transports oxygenated blood from the heart to the rest of the body
   b) The valve that prevents blood from flowing back into the right ventricle
   c) The heart chamber that pumps deoxygenated blood to the lungs
   d) The blood vessels that transport blood to the heart from the body
   e) The blood vessel that transports oxygenated blood from the lungs to the left atrium
2. Explain the meaning of the term "double circulation".
3. Describe the type of blood, in terms of oxygen content, that occurs in the:
   a) pulmonary artery b) pulmonary vein.
4. In a short paragraph, describe the pathway of blood in the pulmonary circuit.

The role of the circulatory

The main structures/org

Organ	
Heart	• Pu bo
Bicuspid and tricuspid valves	• All • Pre ve
Semilunar valves	• All pu • Pre ao
Lungs	• All bl
Arteries	• Tra
Veins	• Tra
Capillaries	• All bl

Structural diffe and capillaries

The structural differen

Characteristic	
Outer layer of blood vessel wall	
Middle layer of blood vessel wall	
Inner layer of blood vessel wall	
Shape in cross-section	
Semilunar valves	
Lumen	

The role of the heart, lungs and blood vessels in the circulatory system

The main structures/organs of the circulatory system and their functions

Organ	Function
Heart	• Pumps blood through the circulatory system throughout the body
Bicuspid and tricuspid valves	• Allow blood to flow from the atria to the ventricles • Prevent blood from flowing back into the atria from the ventricles when they contract
Semilunar valves	• Allow blood to flow from the ventricles into the aorta and the pulmonary artery • Prevent blood from flowing back into the ventricles from the aorta and pulmonary artery when the ventricles relax
Lungs	• Allow the exchange of oxygen and carbon dioxide between the blood (in the capillaries) and the air (in the lungs)
Arteries	• Transport blood from the heart to all the body cells
Veins	• Transport blood back from the body cells to the heart
Capillaries	• Allow exchange of oxygen and carbon dioxide between the blood and the cells of the body tissues

Structural differences between arteries, veins and capillaries

The structural differences between the three types of blood vessels

Characteristic	Artery	Vein	Capillary
Outer layer of blood vessel wall	Thick, strong layer of connective tissue	Thin, weaker layer of connective tissue	Absent
Middle layer of blood vessel wall	Thick layer of smooth muscle	Thin layer of smooth muscle	Absent
Inner layer of blood vessel wall	Single layer of smooth, flat cells	Single layer of smooth, flat cells	Single layer of smooth, flat cells
Shape in cross-section	Uniformly round	Irregular	Microscopically small
Semilunar valves	Only in the aorta and pulmonary artery as they leave the heart	Present in large veins	None
Lumen	Narrow	Wide	Very small

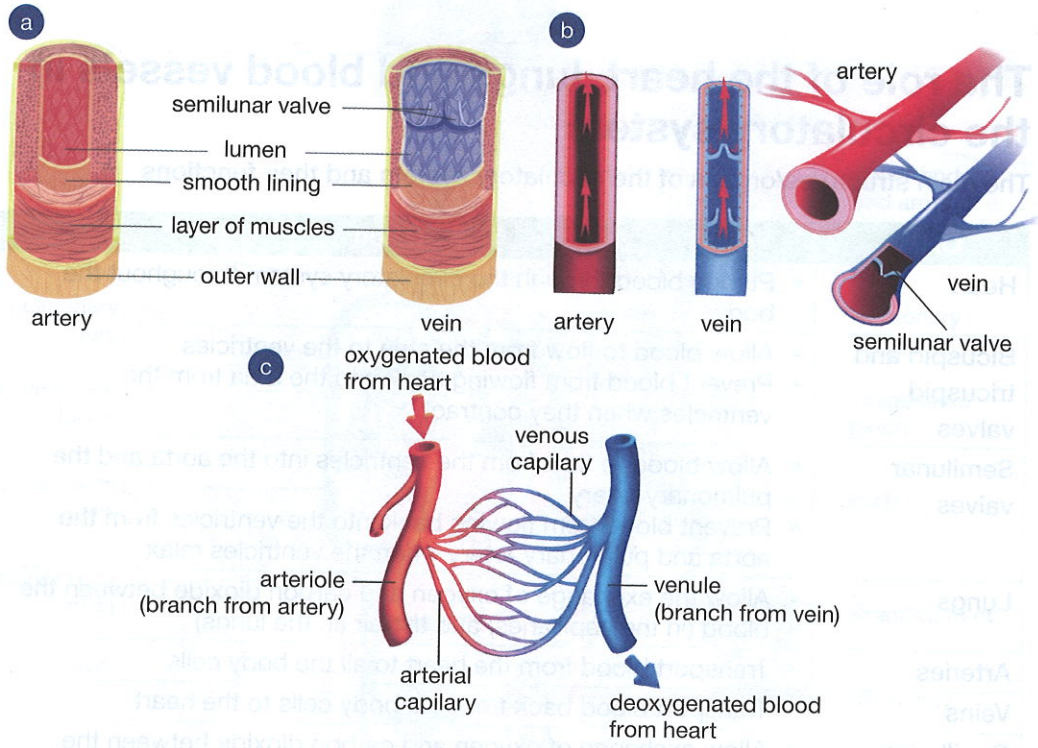


Figure 8 Diagram showing the structural differences between an artery and a vein: a) Cross-sections through an artery and a vein; b) Blood flow in an artery and a vein showing valves in the vein; c) Capillary blood flow

Pulse rates at rest and after physical exercise

- A **pulse** is the rhythmic throbbing of the arteries each time the heart beats. A pulse occurs in all your arteries, but you can feel it in the arteries that run close to the skin's surface.
- You can feel your pulse most easily in the wrist, neck, groin and the top of the foot. The most common place for reading a pulse is in the wrist or the neck.
- The average pulse rate is 70–75 beats per minute.
- Pulse rate and heart rate are directly related.
  - » The pulse rate speeds up when you are exercising.
  - » Your cells increase their oxygen demand during exercise. So the heart beats faster to move blood around your body faster when you exercise.
- Pulse rate and the time taken for your pulse rate to return to normal after exercise (recovery rate) are fairly good indicators of a person's level of fitness.
- Generally speaking, the slower the pulse rate and the shorter the recovery rate, the fitter a person is.

Figure 9 Use your first two fingers to feel your pulse towards the centre of your wrist.

Activity 3

Work outside in p

Experime

Materials

- timer (clock, w with a second or a cellphone
- pencil
- ruler
- workbook/no

3. At the end c down. Read beats in 15 s for each par
4. Both partne
5. Determine t Record your
6. Both partne
7. Determine t Record your

Results

Activit
Learner

Draw column gr

Discussion

Explain your res

Questions

1. Name the d
2. Name three
3. Identify two

Activity 3 Measuring pulse rate

Work outside in pairs for this activity.

Experiment

Materials

- timer (clock, watch with a second hand or a cellphone)
- pencil
- ruler
- workbook/notebook

Aim

To measure your pulse rate at rest and after physical exercise

Method

1. Copy the data table that is given below into your workbook.
2. Sit in your groups for no less than five minutes. During this time stay as still, quiet and relaxed as possible.
3. At the end of the rest time, each partner takes their pulse while still sitting down. Read either the wrist or neck pulse, and then count the number of beats in 15 seconds. Multiply this number by four, and record this number for each partner. This is the resting pulse rate.
4. Both partners stand up and walk briskly for two minutes.
5. Determine both pulse rates at the end of this time as you did in step 2. Record your readings in the table.
6. Both partners run for two minutes.
7. Determine both pulse rates at the end of this time as you did in step 2. Record your readings in the table.

Results

Activity	Sitting	Walking	Running
Learner	Pulse rate (beats/minute)	Pulse rate (beats/minute)	Pulse rate (beats/minute)

Draw column graphs of both sets of results on the same set of axes.

Discussion

Explain your results.

Questions

1. Name the dependent and independent variable in this investigation.
2. Name three fixed variables in this investigation.
3. Identify two ways to make this investigation more reliable.

SUB-TOPIC 2

The respiratory system

Introduction

The respiratory system is vital for the survival of all humans. This system enables three important processes to take place: breathing, gaseous exchange and cellular respiration. It is important that you understand the meaning of each term at the start of this section.

Breathing/ventilation

The movement of air into and out of the lungs is called breathing or ventilation. This includes **inhalation** (inspiration) and **exhalation** (expiration).

Gaseous exchange

In this process, carbon dioxide is moved from the blood into the air inside the lungs. At the same time, oxygen is removed from the inhaled air and moves into the bloodstream. The basic mechanism of gaseous exchange is the **diffusion** (movement) of gases across a moist membrane.

Tissue or cellular respiration

In this chemical process, cells break down energy-rich molecules of glucose, a sugar. They convert the energy in glucose into energy that is usable for life processes.

Oxygen is required for this process and carbon dioxide is a **waste product**. The cells store their energy in special high-energy molecules. Cells use this energy to power almost all their activities.

New words

inhalation: breathing in
exhalation: breathing out
diffusion: the movement of molecules from where they are in higher concentration to where they are in lower concentration
waste product: a harmful chemical that is produced in a chemical reaction and that must be removed from the body

Did you know?

You will also use the terms gaseous exchange and tissue or cellular respiration when you study how plants work. These processes are common to all living things.

Organs of th
the human b

a

nasal cavity

mouth cavity

right lung

b

Figure 10 The human
b) The detail inside a l

Organs of the respiratory system of the human body

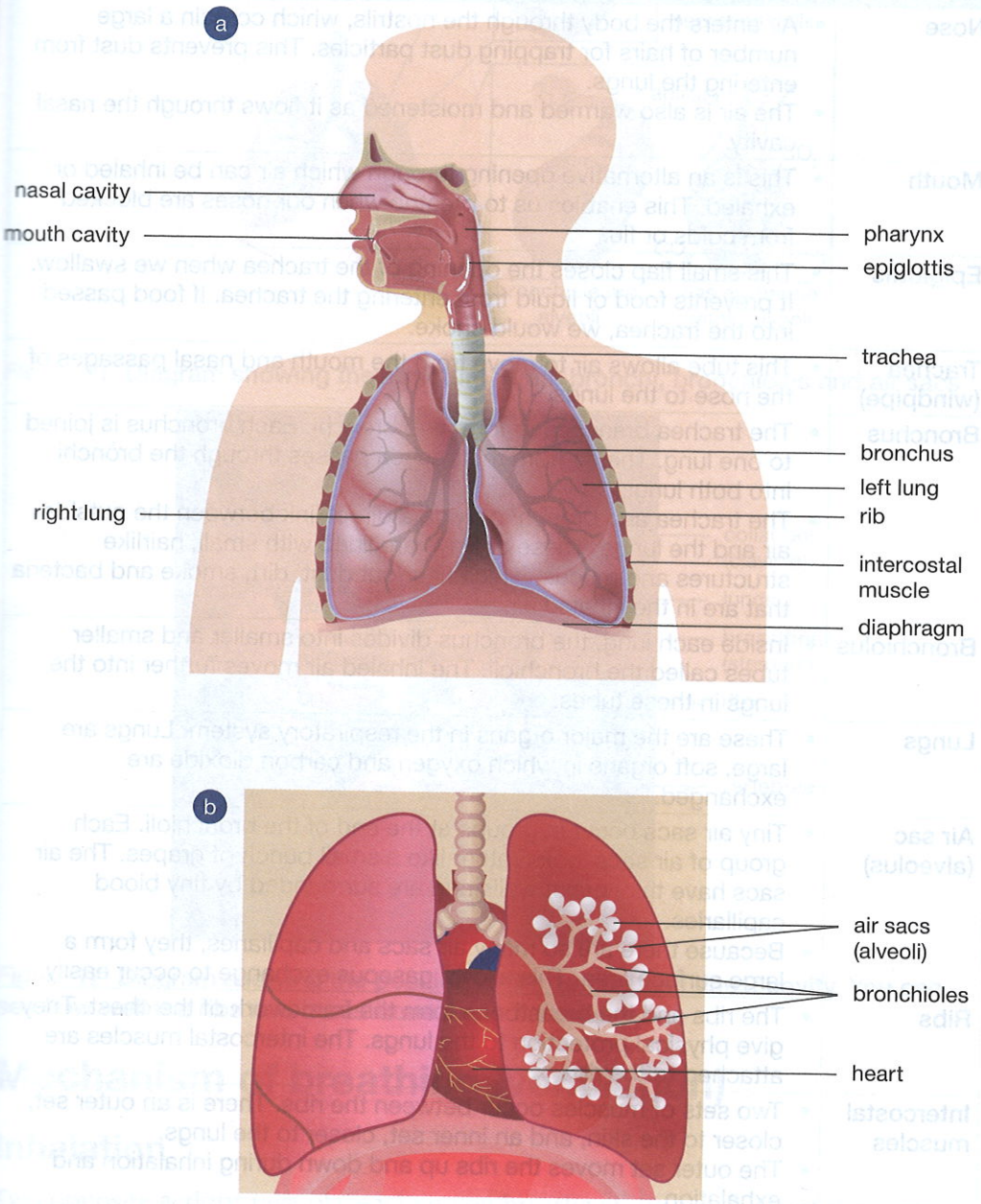


Figure 10 The human respiratory system: a) Its position in the body; b) The detail inside a lung

Functions of organs of the respiratory system

The main organs of the respiratory system, their structure and their function

Organ	Structure and function
Nose	• Air enters the body through the nostrils, which contain a large number of hairs for trapping dust particles. This prevents dust from entering the lungs. • The air is also warmed and moistened as it flows through the nasal cavity.
Mouth	• This is an alternative opening through which air can be inhaled or exhaled. This enables us to breathe when our noses are blocked from colds or flu.
Epiglottis	• This small flap closes the opening of the trachea when we swallow. It prevents food or liquid from entering the trachea. If food passed into the trachea, we would choke.
Trachea (windpipe)	• This tube allows air to move from the mouth and nasal passages of the nose to the lungs.
Bronchus	• The trachea branches to form two bronchi. Each bronchus is joined to one lung. The air from the trachea passes through the bronchi into both lungs. • The trachea and bronchi provide a direct link between the outside air and the lungs. These airways are lined with small, hairlike structures and mucus, which filter out dust, dirt, smoke and bacteria that are in the inhaled air.
Bronchiolus	• Inside each lung, the bronchus divides into smaller and smaller tubes called the bronchioli. The inhaled air moves further into the lungs in these tubes.
Lungs	• These are the major organs in the respiratory system. Lungs are large, soft organs in which oxygen and carbon dioxide are exchanged.
Air sac (alveolus)	• Tiny air sacs occur in groups at the end of the bronchioli. Each group of air sacs looks rather like a small bunch of grapes. The air sacs have thin, moist walls and are surrounded by tiny blood capillaries. • Because there are so many air sacs and capillaries, they form a large surface area. This allows gaseous exchange to occur easily.
Ribs	• The ribs and the breastbone form the framework of the chest. They give physical protection to the lungs. The intercostal muscles are attached to the ribs.
Intercostal muscles	• Two sets of muscles occur between the ribs. There is an outer set, closer to the skin, and an inner set, closer to the lungs. • The outer set moves the ribs up and down during inhalation and exhalation.
Diaphragm	• This sheet of muscle occurs between the chest and the abdomen. It is attached to the body wall and the base of the ribs. It helps air flow into and out of the lungs during inhalation and exhalation.

Figure 11 Diagram sho

Figure 12 Diagram sho
see how well the ribs a

Mechanism o

Inhalation

Two opposite actions t
During inhalation (ins
(expiration), air is pus
sacs; exhalation remov
of inhalation and exha

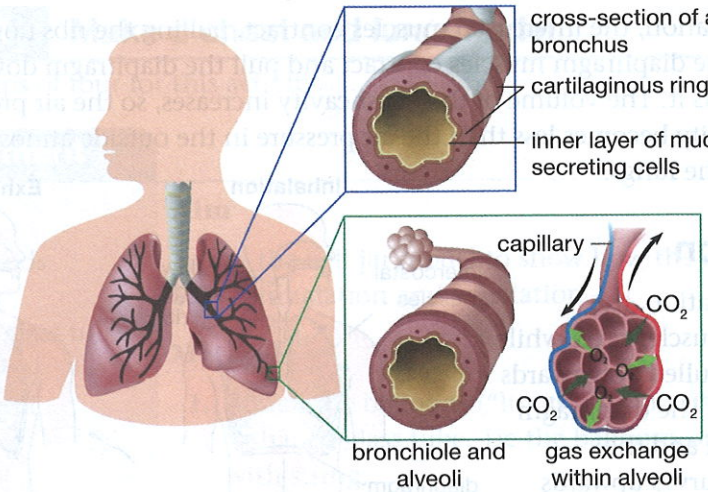


Figure 11 Diagram showing the structure of the bronchi, bronchioles and air sacs

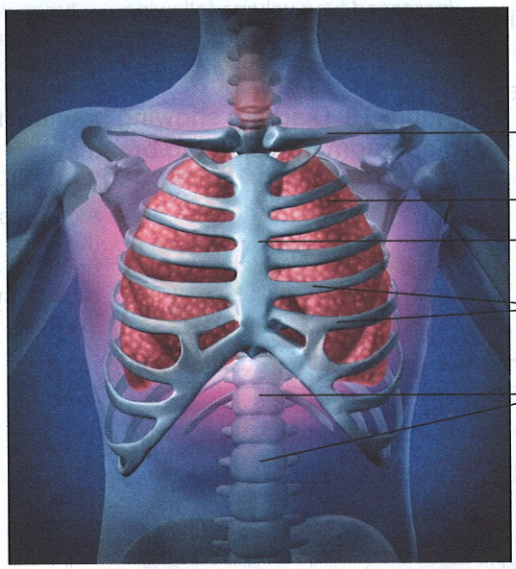


Figure 12 Diagram showing the position of the lungs in the chest cavity. You can see how well the ribs and breastbone protect the lungs.

Mechanism of breathing (ventilation)

Inhalation

Two opposite actions take place when you breathe air into and out of the lungs. During inhalation (inspiration), air is drawn into the lungs. During exhalation (expiration), air is pushed out of the lungs. Inhalation supplies oxygen to the air sacs; exhalation removes carbon dioxide from the air sacs. The continuous process of inhalation and exhaling is called breathing (ventilation).

During inhalation, the intercostal muscles contract, pulling the ribs upwards and outwards. The diaphragm muscles contract and pull the diaphragm downwards, which flattens it. The volume of the chest cavity increases, so the air pressure inside the chest cavity becomes less than the air pressure in the outside atmosphere. Air is drawn into the lungs.

Exhalation

During inhalation, the intercostal muscles relax while the ribs are pulled downwards and inwards. The diaphragm muscles relax and the diaphragm curves upwards (becomes dome-shaped). This causes the volume of the chest cavity to decrease and the air pressure inside the chest cavity increases. Air is pushed out from the lungs.

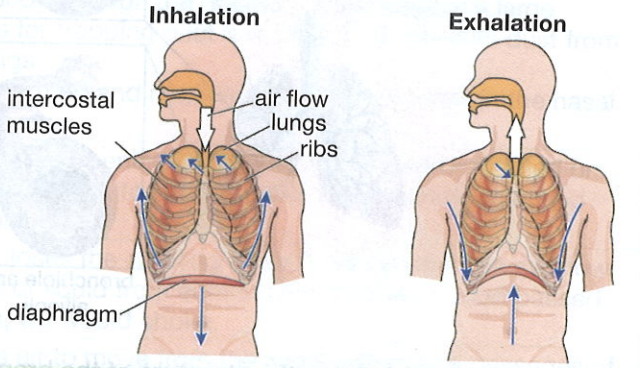


Figure 13 Diagram showing how the ribs and diaphragm move during breathing

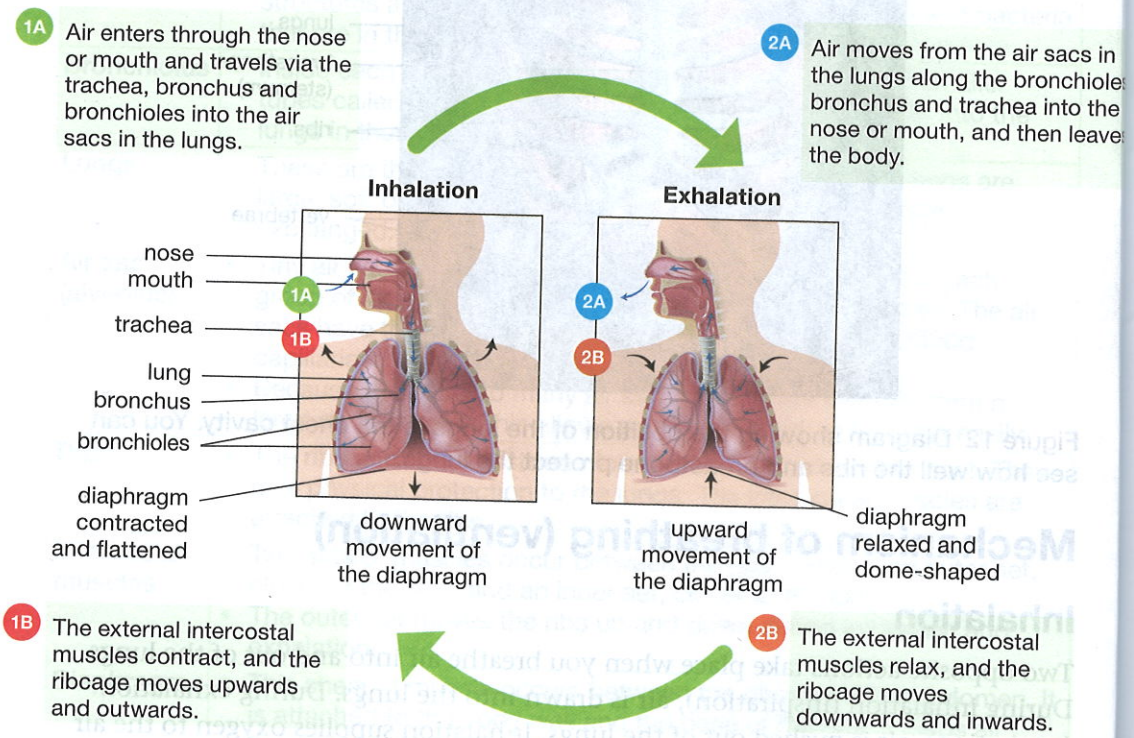


Figure 14 The movements of the diaphragm and ribcage that enable ventilation/breathing to occur

Activity 4 Ma

Work in groups of four

Experiment

Materials

- rubber bands
- bell jar
- Y-shaped glass tube
- two balloons
- rubber sheet
- string
- scissors
- rubber stopper with one hole

4. Push the diaphra
5. Pull the diaphrag (lungs).

rubber st

ba

rubber

Figure 15 The bell ja ventilation/breathing

Questions

1. Name the parts o structures: bell ja
2. List the limitation jar and the balloo

Activity 4 Make a chest and lung model

Work in groups of four for this activity.

Experiment

Materials

- rubber bands
- bell jar
- Y-shaped glass tube
- two balloons
- rubber sheet
- string
- scissors
- rubber stopper with one hole

Aim

To use the bell jar model to show how the diaphragm affects inhalation and exhalation

Method

1. Attach the balloons ("lungs") to the ends of the Y-shaped glass tube. Tie the balloons on tightly with string.
2. Put the rubber stopper into the neck of the bell jar. Push the Y-shaped tube up through the bottom of the stopper.
3. Tie the rubber sheet ("diaphragm") onto the bottom of the bell jar as shown in Figure 15.
4. Push the diaphragm upwards. Explain what happens to the balloons (lungs).
5. Pull the diaphragm downwards. Explain what happens to the balloons (lungs).

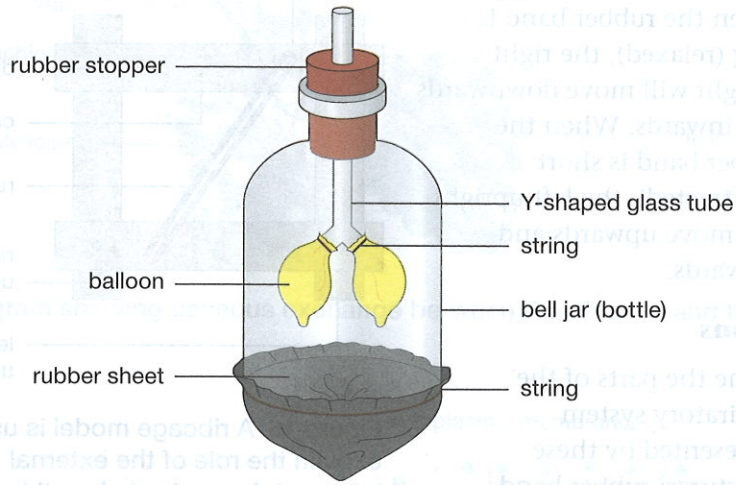


Figure 15 The bell jar model is used to explain the role of the diaphragm in ventilation/breathing in humans.

Questions

1. Name the parts of the respiratory system represented by the following structures: bell jar, Y-shaped glass tube, balloons and rubber sheet.
2. List the limitations (weaknesses) of the rubber sheet, the glass bell jar and the balloons in this model.

Activity 5 Make a model of the ribcage

Work in groups of four when doing this activity. You will make a model from a diagram.

You will see the effect that the contraction of the intercostal muscles has on the movement of the ribs and the breastbone.

Experiment

Materials

- rubber bands
- two pieces of stiff cardboard – 30 cm × 15 cm
- four drawing pins
- sticky tape

Aim

To make a model from a diagram to illustrate the movement of intercostal muscles

Method

1. Look carefully at Figure 16. Make sure you have all the materials that you need to make your model ribcage.
2. Join the cardboard strips together as shown in Figure 16.
3. Pull on the rubber band. When the rubber band is long (relaxed), the right upright will move downwards and inwards. When the rubber band is short (contracted), the left upright will move upwards and outwards.

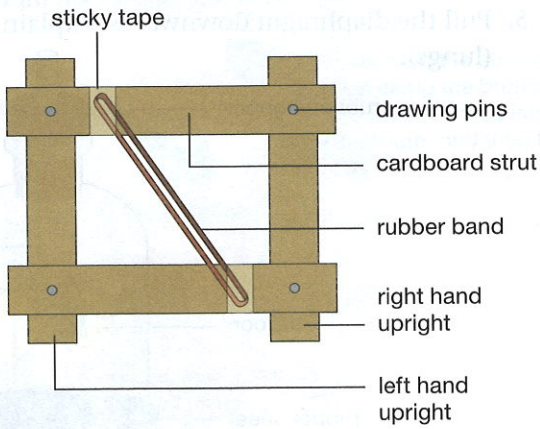


Figure 16 A ribcage model is used to explain the role of the external intercostal muscles in breathing in humans.

Questions

1. Name the parts of the respiratory system represented by these structures: rubber band, cardboard struts, left upright and right upright.
2. List the limitations of the cardboard struts, the rubber band and the absence of a rubber sheet in this model.

Gaseous excha

Gaseous exchange

In this process, carbon dio
At the same time, oxygen
bloodstream.

Blood that flows into th
content and a high carbo
the air sacs has a high oxy
diffuses (moves) out of th
dioxide diffuses out of th
exchange of gases takes p

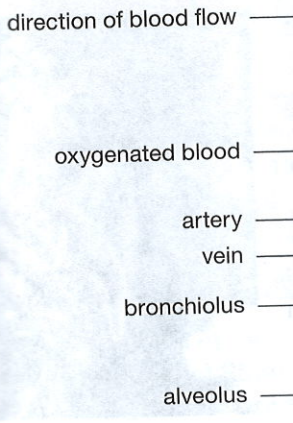


Figure 17 Diagram show
capillaries

Diffusion

Diffusion is the movem
or molecules from whe
higher concentration t
are in lower concentrat
systems, molecules diff
membranes, which are
fluid.

Gaseous exchange in the lungs

Gaseous exchange

In this process, carbon dioxide moves from the blood into the air inside the lungs. At the same time, oxygen is removed from the inhaled air and moves into the bloodstream.

Blood that flows into the capillaries around the air sacs has a low oxygen content and a high carbon dioxide content. When you breathe in, the air that fills the air sacs has a high oxygen content and a low carbon dioxide content. Oxygen diffuses (moves) out of the air sacs into the blood of the capillaries. Carbon dioxide diffuses out of the blood in the capillaries into the air in the air sacs. This exchange of gases takes place across moist membranes.

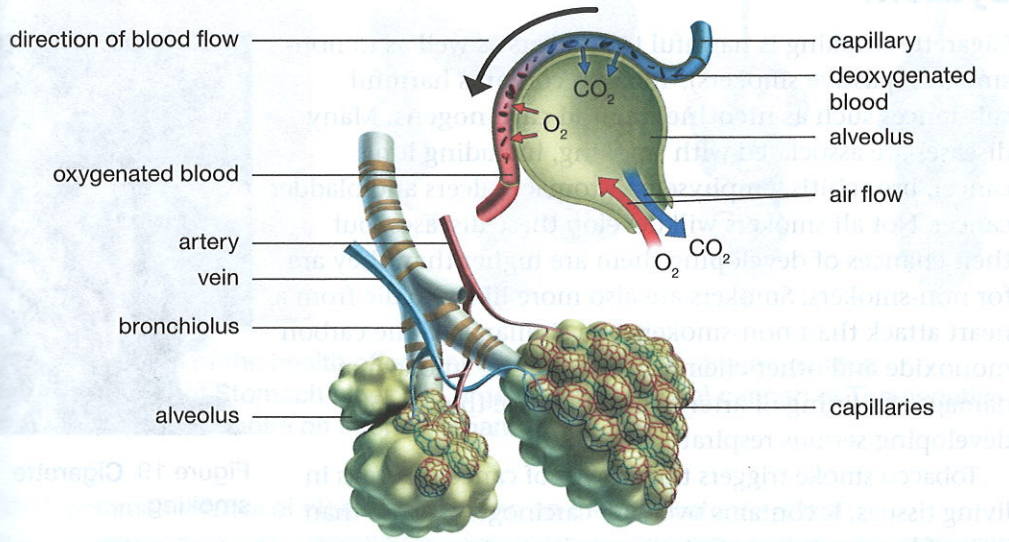


Figure 17 Diagram showing gaseous exchange between the air sacs and the capillaries

Diffusion

Diffusion is the movement of atoms or molecules from where they are in higher concentration to where they are in lower concentration. In living systems, molecules diffuse across cell membranes, which are moistened by fluid.

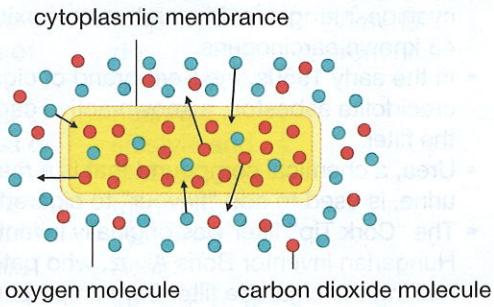


Figure 18 Diagrammatic representation of diffusion

Tissue or cellular respiration

Tissue respiration is vital for living organisms and occurs in all their cells. In this chemical process, cells break down energy-rich molecules of glucose, a sugar. This releases energy that can be used for life processes. Oxygen is required for this process. Carbon dioxide and water form as waste products of the reaction. The cells store their energy in special high-energy molecules. Cells use this energy to power almost all their life-sustaining activities.

We can summarise tissue respiration with this word equation:

oxygen + sugar → carbon dioxide + water + energy

Effect of cigarette smoking on the respiratory system

Cigarette smoking is harmful to smokers as well as to non-smokers (passive smokers). Tobacco contains harmful substances such as **nicotine**, **tar** and **carcinogens**. Many diseases are associated with smoking, including lung cancer, bronchitis, emphysema, stomach ulcers and bladder cancer. Not all smokers will develop these diseases, but their chances of developing them are higher than they are for non-smokers. Smokers are also more likely to die from a heart attack than non-smokers of a similar age. The carbon monoxide and other chemicals in cigarette smoke may damage the lining of arteries and increase the risk of developing serious respiratory diseases.

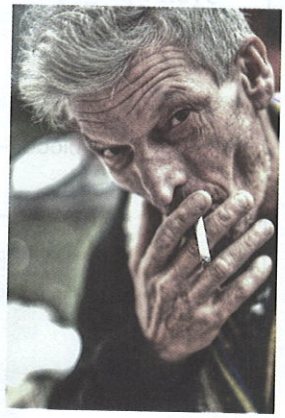


Figure 19 Cigarette smoking

Tobacco smoke triggers the growth of cancerous cells in living tissues. It contains over 400 carcinogens. More than 90% of lung cancer patients are smokers.

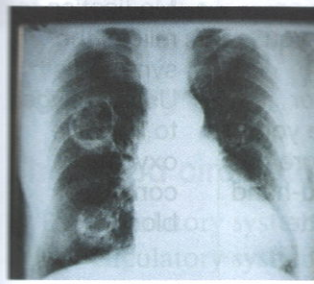
Did you know?

- Cigarettes contain arsenic, formaldehyde, lead, hydrogen cyanide, nitrogen oxide, carbon monoxide, ammonia and 43 known carcinogens.
- In the early 1950s, the Kent brand of cigarettes used crocidolite asbestos, a known active carcinogen, as part of the filter.
- Urea, a chemical compound that is a major component in urine, is used to add "flavour" to cigarettes.
- The "Cork Tip" filter was originally invented in 1925 by Hungarian inventor Boris Aivaz, who patented the process of making the cigarette filter from crepe paper. All kinds of filters were tested, although cork is unlikely to have been one of them even though the name suggests that cork was used.

New words

nicotine: a colourless, oily and poisonous substance found in tobacco
tar: solid remains of partly burnt tobacco
carcinogen: a chemical that is known to increase the risk of a person developing cancer

a



c

Figure 20 Some of the he
b) Emphysema; c) Stoma
effect of cigarette smoke

Some common effects of

Respiratory disease	Cause effec
Bronchitis	• Viral or bacteria infectio • Smokin • Results increas product phlegm which m become infected bacteria

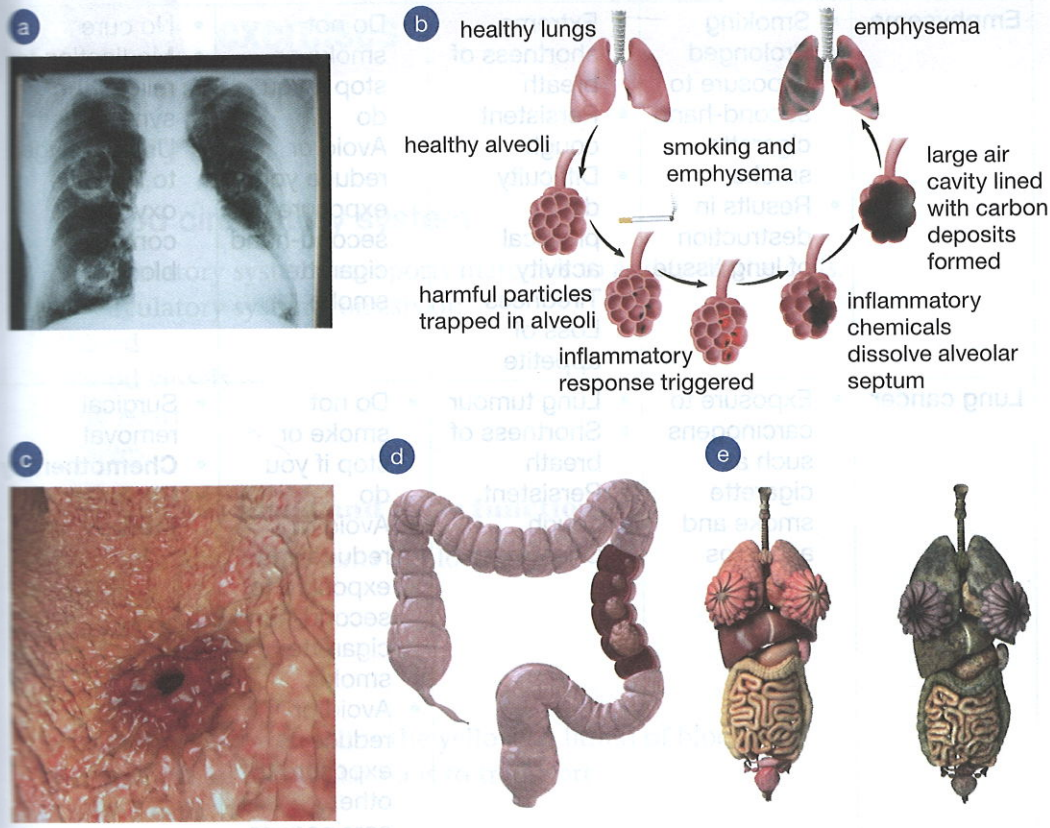


Figure 20 Some of the health effects of cigarette smoke: a) Lung cancer; b) Emphysema; c) Stomach ulcer; d) Large intestine (colon) cancer; e) The negative effect of cigarette smoke on internal organs

Some common effects of cigarette smoking on the respiratory system

Respiratory disease	Cause and effect	Symptoms	Prevention	Treatment
Bronchitis	• Viral or bacterial infection • Smoking • Results in increased production of phlegm, which may become infected by bacteria	• Inflamed bronchi • Excessive amounts of phlegm • Wheezing • Shortness of breath • Persistent cough • Chest pain	• Do not smoke or stop if you do • Maintain a healthy lifestyle and diet to boost the immune system • Avoid contact with people with bronchitis	• Stop smoking • **Antibiotics** for bacterial bronchitis

Emphysema	• Smoking • Prolonged exposure to second-hand cigarette smoke • Results in destruction of lung tissue	• Extreme shortness of breath • Persistent cough • Difficulty doing physical activity • Tiredness • Loss of appetite	• Do not smoke or stop if you do • Avoid or reduce your exposure to second-hand cigarette smoke	• No cure • Medication to relieve the symptoms • Use of oxygen to improve oxygen content of blood
Lung cancer	• Exposure to carcinogens such as cigarette smoke and asbestos	• Lung tumour • Shortness of breath • Persistent cough • Chest pain	• Do not smoke or stop if you do • Avoid or reduce your exposure to second-hand cigarette smoke. • Avoid or reduce exposure to other carcinogens	• Surgical removal • **Chemotherapy** • **Radiation therapy**

New words

antibiotic: a substance that can destroy bacteria that cause infections or infectious diseases
chemotherapy: the treatment of diseases using chemicals with a toxic effect on the micro-organisms causing the disease or that selectively destroy cancerous tissues
radiation therapy: the treatment of diseases, especially cancer, by exposure to a radioactive substance

Activity 6 Poster on the effects of smoking

Work in groups of three for this activity.

Make a poster to show the effects of smoking on the overall health of a person. Your poster should be no smaller than A2 in size and no bigger than A1 in size.

Activity 7 Reasons to stop smoking

Work in pairs for this activity.

Make a bulleted list of the information you would use to convince someone to stop smoking or not to start smoking.

TOPIC 1 Summ exerc

Summary

The blood circulato

- The circulatory system
- The circulatory system
  - » blood
  - » blood vessels
  - » the heart
  - » valves.

Components of blood

- The four main compo
  - » plasma
  - » red blood cells
  - » white blood cells
  - » platelets.
- Plasma is mostly wate
- The function of blood
  - » blood cells
  - » metabolic wastes
  - » nutrients
  - » hormones
  - » various types of pro
  - » heat.
- Red blood cells contai
  - » transporting oxyge
  - » transporting carbo
  - » help with pH regul
  - » help with the clotti
- The functions of the
  - » destroying harmful
  - » playing a vital role
  - » regulating allergies
  - » making and distrib
  - » secreting heparin t
- Platelets help with bl is damaged.

TOPIC 1

Summary, revision and assessment exercises

Summary

The blood circulatory system

- The circulatory system transports materials to and from the cells.
- The circulatory system consists of:
  - » blood
  - » blood vessels
  - » the heart
  - » valves.

Components of blood and their functions

- The four main components of blood are:
  - » plasma
  - » red blood cells
  - » white blood cells
  - » platelets.
- Plasma is mostly water. It is the yellowish liquid of blood.
- The function of blood plasma is to transport:
  - » blood cells
  - » metabolic wastes
  - » nutrients
  - » hormones
  - » various types of proteins
  - » heat.
- Red blood cells contain haemoglobin. Their functions include:
  - » transporting oxygen
  - » transporting carbon dioxide
  - » help with pH regulation
  - » help with the clotting of blood.
- The functions of the white blood cells include:
  - » destroying harmful bacteria and viruses
  - » playing a vital role in immunity
  - » regulating allergies
  - » making and distributing antibodies
  - » secreting heparin to prevent clotting of the blood.
- Platelets help with blood clotting to stop the flow of blood when a blood vessel is damaged.

Summary, revision and assessment exercises continued

Internal structure of the heart

- The heart is a hollow, muscular organ with four chambers:
  - » the two upper chambers are the atria
  - » the two lower chambers are the ventricles.
- Valves between the atria and ventricles stop blood from flowing backwards.
- Pulmonary arteries carry blood away from the heart to the lungs.
- Pulmonary veins carry blood back to the heart from the lungs.
- The superior and inferior vena cavae carry blood back to the heart from the body.
- The aorta carries blood away from the heart towards the rest of the body.

Movement of blood in the double circulatory system

- Blood flows along two separate paths:
  - » pulmonary circulation – heart → lungs → heart
  - » systemic circulation – heart → body → heart.
- The pulmonary circulatory system transports deoxygenated blood to the lungs for gaseous exchange so that it can be oxygenated.
- The systemic circulatory system transports oxygenated blood to the body to supply cells with oxygen and remove carbon dioxide from them.

The role of the heart, lungs and blood vessels in the circulatory system

Refer to the first table on page 9.

Structural differences between arteries, veins and capillaries

Refer to the second table on page 9.

Pulse rates at rest and after physical exercise

- The pulse is the rhythmic throbbing of the arteries each time the heart beats.
- The pulse is caused by the contraction of the left ventricle in the heart.
- The pulse rate is the number of pulses or heart beats per minute.

The respiratory system

- The respiratory system allows three important processes to happen:
  - » Breathing: This is the movement of air into and out of the lungs.
  - » Gaseous exchange: Carbon dioxide moves from the blood into the air inside the lungs. Oxygen moves from the inhaled air into the bloodstream. This supplies oxygen to the body cells and removes carbon dioxide from them.
  - » Cellular respiration: The chemical process that breaks down glucose in the presence of oxygen to release energy.

Functions of the orga

Refer to the table on page

Mechanism of breath

- Ventilation/breathing
- During inhalation:
  - » The diaphragm and
  - » This causes the ribc
  - » This causes the lung
- During exhalation:
  - » The diaphragm and
  - » This causes the ribc
  - » This causes the lung

Gaseous exchange in

- Gaseous exchange occ capillaries that surrou
- Oxygen in the air in t carbon dioxide in the
- Diffusion is the move to a region of lower c

Tissue or cellular res

- Respiration is the che produce usable energ

Effect of cigarette sm

- Cigarette smoking is contains harmful sub monoxide.
- Smoking contributes types of cancer, bron

Functions of the organs of the respiratory system

Refer to the table on page 14.

Mechanism of breathing (ventilation)

- Ventilation/breathing consists of two processes: inhalation and exhalation.
- During inhalation:
  - » The diaphragm and intercostal muscles contract.
  - » This causes the ribcage to expand and increase in volume.
  - » This causes the lungs to expand and air is drawn into them.
- During exhalation:
  - » The diaphragm and intercostal muscles relax.
  - » This causes the ribcage to contract and decrease in volume.
  - » This causes the lungs to contract and air is forced out of them.

Gaseous exchange in the lungs

- Gaseous exchange occurs between the air in the air sacs and the blood in the capillaries that surround them.
- Oxygen in the air in the air sacs diffuses into the blood. At the same time, carbon dioxide in the blood diffuses into the air of the air sacs.
- Diffusion is the movement of molecules from a region of higher concentration to a region of lower concentration.

Tissue or cellular respiration

- Respiration is the chemical reaction between oxygen and glucose in the body to produce usable energy, with carbon dioxide and water as waste products.

Effect of cigarette smoking on the respiratory system

- Cigarette smoking is harmful to smokers and non-smokers. Cigarette smoke contains harmful substances such as nicotine, tar, carcinogens and carbon monoxide.
- Smoking contributes towards, or causes a variety of diseases, such as various types of cancer, bronchitis, stomach ulcers and emphysema.

Summary, revision and assessment exercises continued

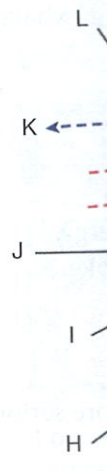
Revision exercises

Various options are provided as possible answers to the following questions. Choose the correct answer and write only the letter (A to D) next to the question number.

1. Which two organs form part of the circulatory system?
   A Brain and heart
   B Lungs and heart
   C Nose and mouth
   D Lungs and brain
2. The cells that contain haemoglobin are called:
   A Plasma
   B Platelets
   C White blood cells
   D Red blood cells.
3. The blood cells that transport oxygen are called:
   A Red blood cells
   B Platelets
   C White blood cells
   D Plasma.
4. The structure in which red blood cells are produced is the:
   A Spleen
   B Liver
   C Heart
   D Pancreas.
5. A function of platelets is to:
   A Fight against diseases
   B Control bleeding
   C Carry oxygen
   D None of the above.
6. The two upper heart chambers are called the:
   A Atria
   B Valves
   C Ventricles
   D Arteries.
7. The chamber that receives oxygenated blood from the lungs is the:
   A Right atrium
   B Right ventricle
   C Left atrium
   D Left ventricle.
8. The destination of blood leaving the right atrium is the:
   A Lungs
   B Brain
   C Rest of the body
   D Heart.
9. The blood vessels that carry blood towards the heart are the:
   A Veins
   B Arteries
   C Capillaries
   D Ventricles.
10. The structures that prevent blood from flowing in the wrong direction are the:
    A Heart
    B Valves
    C Arteries
    D Ventricles.
11. The process responsible for producing usable energy is:
    A Gaseous exchange
    B Ventilation
    C Cellular respiration
    D Breathing.
12. The structure throug
    A Lung
    C Nose
13. Another name for th
    A Windpipe
    C Epiglottis
14. Place the following
    inhalation:
    bronchus, bronchio
15. Describe the proces
16. Explain why an inc
    in the pulse rate.

Assessment exe

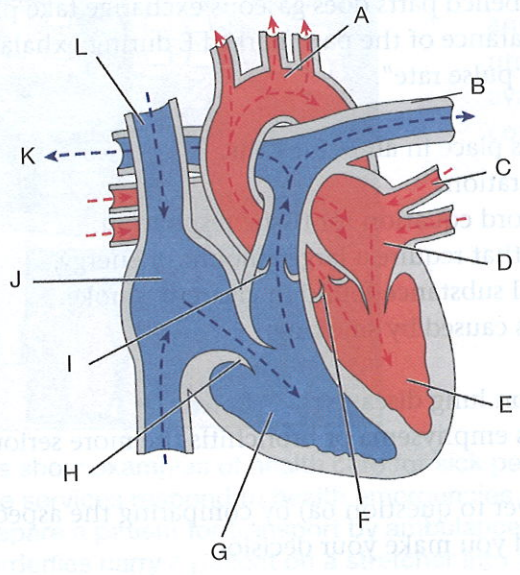
1. There are different
   a) List three types
   b) State their func
2. Name the liquid pa
3. Study the diagram
   that follow.



12. The structure through which air enters the body is the:
    A Lung
    B Epiglottis
    C Nose
    D Trachea.
13. Another name for the trachea is:
    A Windpipe
    B Alveolus
    C Epiglottis
    D Valve.
14. Place the following structures in the order in which air will reach them during inhalation:
    bronchus, bronchioles, nasal cavity, trachea, alveolus and nose.
15. Describe the process of gaseous exchange in the lungs.
16. Explain why an increase in the amount of physical activity causes an increase in the pulse rate.

Assessment exercises

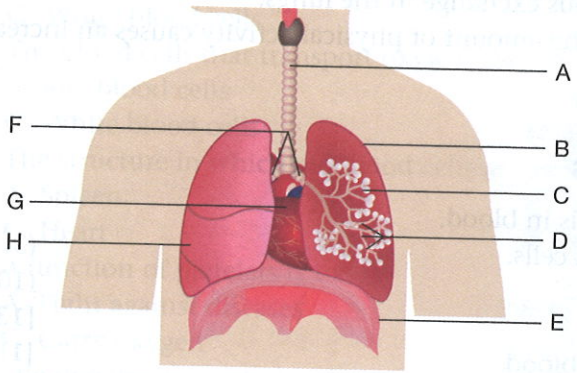
1. There are different blood cells in blood.
    a) List three types of blood cells. (3) K
    b) State their functions. (10) K
    [13]
2. Name the liquid part of the blood. [1] K
3. Study the diagram of a cross-section of the heart. Then answer the questions that follow.



Summary, revision and assessment exercises continued

a) Name the parts labelled J and L. (2) K
b) Give the function of the part labelled F. (1) K
c) Which two labels represent arteries in the diagram? (2) K
d) Give one reason why blood is pumped to the lungs. (1) C
e) State the function of the heart. (1) K
f) Compare and explain the reasons for the concentration of the gases in the blood in the left and right sides of the heart. (8) E
[15]

4. Study the diagram below, which shows a structure related to breathing and gaseous exchange. Answer the questions that follow.



a) Name the parts labelled A and C. (2) K
b) State the function of each of the parts labelled E and G. (2) K
c) In which of the labelled parts does gaseous exchange take place? (1) K
d) Describe the appearance of the part marked E during exhalation. (1) C
e) Explain the term "pulse rate". (1) K
[7]

5. Tissue respiration takes place in all living cells.
a) Define tissue respiration. (4) K
b) Write down the word equation for tissue respiration. (2) C
c) List two activities that require a large amount of energy. (2) K
d) Name one harmful substance found in cigarette smoke. (1) K
e) Name two diseases caused by smoking. (2) K
[11]

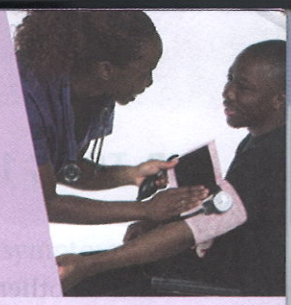
6. Answer the questions on lung diseases.
a) In your opinion, is emphysema or bronchitis the more serious lung disease? (1) E
b) Support your answer to question 6a) by comparing the aspects of each disease that helped you make your decision. (6) E
[7]

Sub-topics

Sexually transmitted infections (STIs)

These pictures show ex
a) Ambulance services
b) Nurses prepare a pa
c) Hospital orderlies ca
d) Patients with all kinc

TOPIC 2 Health



Sub-topics	Specific Outcomes
Sexually transmitted infections (STIs)	• Identify the common sexually transmitted infections. • Explain the transmission of sexually transmitted infections. • Describe the prevention of sexually transmitted infections. • Explain the impact of HIV and AIDS on the population.

Starter activity

Work in groups of three or four for this activity.

1. Think about the health care centres in your community. Look at the pictures for some ideas. Talk about the kinds of health problems they treat.
2. Discuss the types of HIV and AIDS support programmes that are available in your community.

These pictures show examples of health care for sick people:

a) Ambulance services respond to health emergencies day and night.
b) Nurses prepare a patient for transport by ambulance to a hospital.
c) Hospital orderlies carry a patient on a stretcher into a hospital.
d) Patients with all kinds of health problems visit a health care centre.

SUB-TOPIC 1

Sexually transmitted infections (ST

Like all other body systems, the human reproductive system can be infected by **viruses** and **bacteria**. This infection can result in diseases being passed from one person to another during sexual contact. Infections transmitted through sexual contact are called sexually transmitted infections, or STIs.

Some common STIs are gonorrhoea, syphilis, genital warts, and HIV and AIDS. These infectious diseases can damage the reproductive system and other body systems.

New words

virus: a pathogen smaller than a bacterium and that can only reproduce when it is in a living cell
bacteria: one-celled organisms that live on, in and around most living and non-living things; almost all are microscopic; some are harmful and others are useful
mucous membrane: moist skin lining the nose, mouth, throat and other hollow organs of the body that are open to the outside
genitals: the external sexual organs of animals
symptoms: the signs of a disease that may be seen or felt by an infected person

Transmission of STIs

There are several bacteria and viruses that cause these diseases.

Bacterial infections

The bacterial infections include gonorrhoea and syphilis.

Gonorrhoea

This is a disease caused by bacteria that live in warm, moist areas of the body. These bacteria mainly infect the **mucous membranes** of **genitals**. This means that the bacteria are spread by having unprotected sexual contact with an infected person.

Symptoms

- If **symptoms** are present, they can be seen within three to seven days after sexual contact with an infected person.
- Unlike other STIs, the symptoms are not always obvious. Females may never know that they have gonorrhoea. Symptoms may not be present or may be so slight that they go unnoticed. If present, symptoms will disappear without treatment, but the disease will remain in the body.
- **Newborns** can be infected during birth by infected mothers, resulting in eye infections that can lead to blindness.

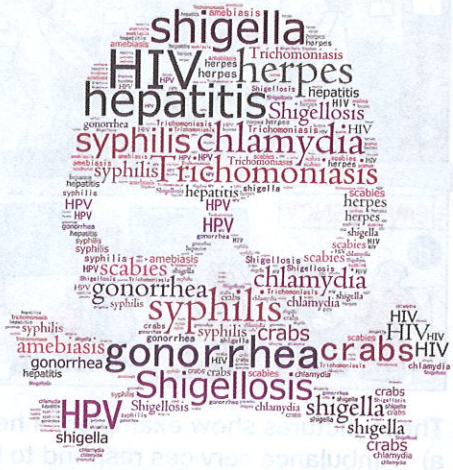


Figure 1 The various sexually transmitted infections are dangerous and some cause death.

- In males, gonorrhoea
the penis.
- In females, it causes
Sometimes females s
- Gonorrhoea can lead
urethra and fallopian

Syphilis

Syphilis is the most dan
via a mucous membran
contact such as kissing

Once the bacterium
whole body. Syphilis is
children of an infected

Symptoms

The symptoms of syph
- **In the first stage** of t
three weeks after bei
the disease continue
- **In the second stage**,
muscle or joint pain
being sick. The most
the appearance of a
or the limbs.
- **The third stage** is sy
- **In the fourth stage**,
infect the tissue of o
heart, blood vessels
system. Soft, tumou
inflammation that
occur. They usually
bone and liver, but

New words

newborn: a baby from birth
weeks old
pus: a thick, yellowish-wh
that forms in infected bod
infertility: unable to have
inflammation: red, swolle
and hot area of the body

- In males, gonorrhoea usually causes painful urination and a **pus** discharge from the penis.
- In females, it causes vaginal discharge, but most often there are no symptoms. Sometimes females suffer from abdominal pain and painful urination.
- Gonorrhoea can lead to **infertility** in males and females by blocking the urethra and fallopian tubes (oviducts) respectively.

Syphilis

Syphilis is the most dangerous sexually transmitted infection. It enters the body via a mucous membrane. It is easily spread from person to person during intimate contact such as kissing or contact with sexual organs.

Once the bacterium enters the body, it enters the bloodstream and infects the whole body. Syphilis is life-threatening to males and females, and to any future children of an infected person.

Symptoms

The symptoms of syphilis develop in stages.

- **In the first stage** of the disease, a lump or sore appears on the genitals one to three weeks after being infected. The sore usually heals without treatment, but the disease continues to develop in the body.
- **In the second stage**, the disease usually produces symptoms that include muscle or joint pain, nausea, loss of appetite, fever and a general feeling of being sick. The most common symptom is the appearance of a rash on the body and/or the limbs.
- **The third stage** is symptom-free.
- **In the fourth stage**, the bacteria begin to infect the tissue of organs such as the heart, blood vessels and central nervous system. Soft, tumour-like balls of **inflammation** that vary greatly in size also occur. They usually affect the skin, bone and liver, but can occur anywhere.

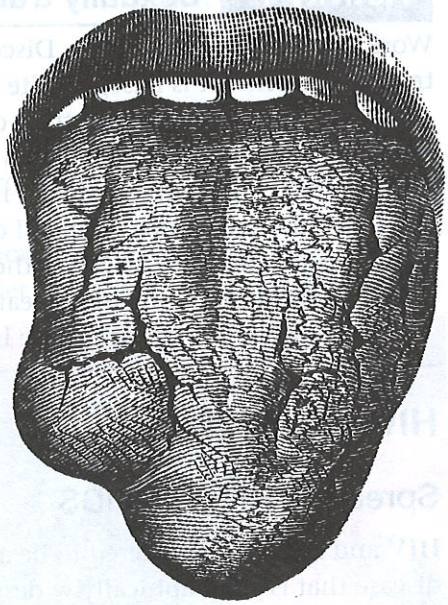


Figure 2 A tongue showing tumours (mass of cells from unusual growth) and syphilitic ulceration

New words

newborn: a baby from birth to four weeks old
pus: a thick, yellowish-white liquid that forms in infected body tissues
infertility: unable to have a child
inflammation: red, swollen, painful and hot area of the body

Viral infections

The viral infections include genital warts, and HIV and AIDS.

Genital warts

Genital warts can be caused by different viruses. The viruses that cause genital warts differ from those that cause warts on other parts of the body.

Genital warts are caused only by sexual contact with a person who is infected. They are usually highly **contagious**.

These warts are most often found on the genitals and between the buttocks. They also appear under the foreskin of an uncircumcised penis. An infected person can pass on the virus before any warts have appeared.

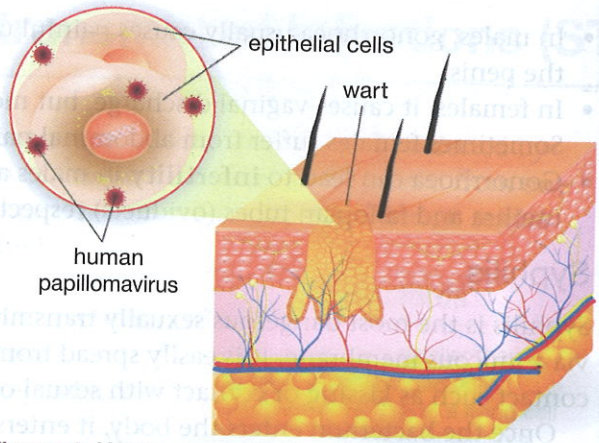


Figure 3 Warts occur in the skin on various parts of the body.

New word

contagious: able to be transmitted by contact with an infected person or object

Activity 1 **Sexually transmitted infections (STIs)**

Work in pairs for this activity. Discuss the statements, and then indicate which are true. If a statement is false, rewrite it so that it is true.

1. A person can have more than one STI at the same time.
2. A pregnant woman can spread an STI to her unborn child during birth.
3. One STI can eventually result in the death of a person.
4. Once the symptoms of an STI disappear, this disease is cured.
5. A person can have an STI without realising it.
6. Complications from an untreated STI can leave a person infertile.
7. Condoms are totally effective in preventing the spread of STIs.

HIV and AIDS

Spread of HIV and AIDS

HIV and AIDS is considered to be a **pandemic**. It is an **epidemic** of an infectious disease that is geographically widespread, and occurs throughout the world. It has claimed the lives of many Zambians, especially young people. The risk of HIV and AIDS infection is more than 50% for people aged 15 to 24 because they are usually sexually active and may also be using drugs.

What is HIV and AID

- HIV and AIDS is a disea **immune system**. The protect the body again therefore damages the virus is called the hum virus (HIV).
- It infects mainly the w **CD4 T-cells** and **macr** either destroys these ce ability to work properl
- Over time, infection w immune system. This likely to get other infe

HIV and AIDS treatr

- If not treated, most pe illness within five to te initial HIV infection a
- There is no cure or vac drugs slows down the increases life expectan Without treatment, th 11 years.

Transmission of

HIV is mainly transmitte

1. **sexual transmission** partner, including a
2. **exposure to infected** blood transfusions, a handling a needle af was used on an infec person, or when drug addicts share needles
3. **mother-to-baby transmission:** this ca happen during pregn birth or breastfeeding mother is infected.

Figure 4 The

What is HIV and AIDS?

- HIV and AIDS is a disease of the human **immune system**. The virus infects cells that protect the body against infection. It therefore damages the immune system. This virus is called the human immunodeficiency virus (HIV).
- It infects mainly the white blood cells called **CD4 T-cells** and **macrophages**. The virus either destroys these cells or affects their ability to work properly.
- Over time, infection with HIV weakens the immune system. This makes the person more likely to get other infections as well.

New words

HIV: Human Immunodeficiency Virus
AIDS: Acquired Immune Deficiency Syndrome
pandemic: spread throughout a country, continent or the whole world
epidemic: spreads quickly to many people
immune system: the system that protects the body and fights infection
CD4 T-cells: white blood cells that start the body's response to infection
macrophage: a type of white blood cell that is part of the body's defence mechanism

HIV and AIDS treatment

- If not treated, most people infected with HIV develop signs of HIV-related illness within five to ten years of being infected. However, the time between the initial HIV infection and an AIDS diagnosis can be up to 15 years.
- There is no cure or vaccine against HIV and AIDS. Treatment with antiretroviral drugs slows down the rate at which the disease progresses. This treatment increases life expectancy, but the medication is expensive and has side effects. Without treatment, the average life expectancy after HIV infection is about 9 to 11 years.

Transmission of HIV

HIV is mainly transmitted in three ways:

1. **sexual transmission:** this results from unprotected sex with an infected partner, including anal and oral sex
2. **exposure to infected blood or blood products:** this can happen through blood transfusions, a doctor, nurse or cleaner being accidentally pricked when handling a needle after it was used on an infected person, or when drug addicts share needles
3. **mother-to-baby transmission:** this can happen during pregnancy, birth or breastfeeding if the mother is infected.

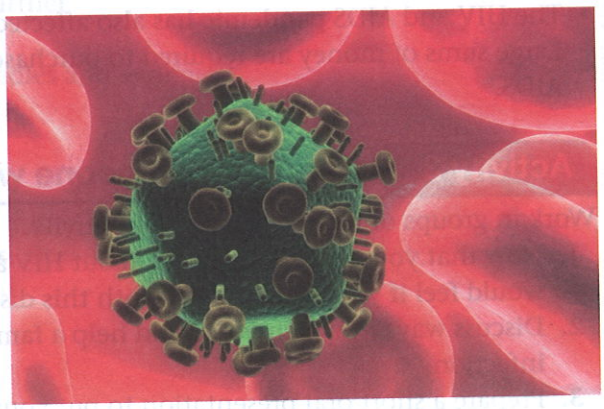


Figure 4 The HI virus

The prevention of STIs

There are ways to limit your risk of contracting a STI, including HIV. Prevention requires making responsible lifestyle decisions:

1. Correct and consistent use of male condoms.
2. Limiting the number of sexual partners. Each new person increases the risk.
3. Be tested to determine your own and your partner's HIV status. Also ensure that you are free of other types of STIs.
4. Choose not to have casual sex, then you won't have to worry about contracting STIs.
5. Implement education programmes to prevent behaviours that lead to infection.
6. Abstain from sexual activity before marriage.

Activity 2 HIV and AIDS

Answer the following questions.

1. What is the difference between AIDS and HIV?
2. Identify three ways in which HIV is transmitted.
3. State three ways of preventing HIV and AIDS infection.

Impact of HIV and AIDS on the population

The whole Zambian population is affected by the HIV and AIDS pandemic, although some groups are more at risk than others.

- HIV and AIDS causes poverty. If the breadwinner of a family gets too sick to work, the family goes hungry or the children must leave school and work to support the family.
- The death rate is highest among people aged 25 to 39. This has increased the number of orphans, which puts pressure on the extended family to provide for the orphans. Grandparents now have to fulfil the roles of parents. Many of these orphaned children become "street kids". Street children usually beg for money or food, or have casual sex to earn the money they need to survive.
- The HIV and AIDS pandemic has also affected the health services in Zambia. Large sums of money are required to purchase the drugs used to treat HIV and AIDS.

Activity 3 Caring for someone with HIV and AIDS

Work in groups of four to five for this activity.

1. Now that you understand more about HIV and AIDS, think about how you would feel if you were infected with this disease.
2. Discuss ways in which you could help a family member or friend who has this infection.
3. Prepare a short oral presentation to put your ideas to the class.

TOPIC 2 Summ exerc

Summary

Sexually transmitte

- A sexually transmitted sexual contact.
- The teenage populatio
- Common STIs are gono

Transmission of STI

- Anyone who has sexua
- Gonorrhoea is caused b is transmitted through
- Syphilis is caused by ba body organs and syster
- Genital warts are cause contagious.
- Acquired Immune Defi weakens the body's im
- HIV infection is spread transfusion with infect during pregnancy or ch
- An infected person can

Prevention of STIs

- STIs, including AIDS, c
- Ways of avoiding an ST
  - Correct and consiste
  - Have only one faithf
  - Avoid casual sex
  - Avoid sharing contai
  - Abstain from sexual

Effects of HIV and A

- It can cause poverty.
- It increases the numbe
- It places pressure on he

TOPIC 2

Summary, revision and assessment exercises

Summary

Sexually transmitted infections (STIs)

- A sexually transmitted infection (STI) is spread from person to person through sexual contact.
- The teenage population has the highest rate of infection.
- Common STIs are gonorrhoea, syphilis, genital warts, and HIV and AIDS.

Transmission of STIs

- Anyone who has sexual contact with another person is at risk of getting an STI.
- Gonorrhoea is caused by bacteria that live in warm, moist areas of the body. It is transmitted through sexual contact. It often shows no symptoms.
- Syphilis is caused by bacteria and is one of the most dangerous STIs. It infects body organs and systems. It is transmitted through sexual contact.
- Genital warts are caused by a virus that is spread sexually. They are highly contagious.
- Acquired Immune Deficiency Syndrome (AIDS) results from a virus, HIV, which weakens the body's immune system.
- HIV infection is spread through sexual contact, sharing contaminated needles, transfusion with infected blood and from an infected mother to her child during pregnancy or childbirth.
- An infected person can show no symptoms, but still spread the disease.

Prevention of STIs

- STIs, including AIDS, can be prevented.
- Ways of avoiding an STI:
  - Correct and consistent use of condoms
  - Have only one faithful sexual partner
  - Avoid casual sex
  - Avoid sharing contaminated needles and syringes
  - Abstain from sexual contact.

Effects of HIV and AIDS

- It can cause poverty.
- It increases the number of orphans.
- It places pressure on health services.

Summary, revision and assessment exercises continued

Revision exercises

Various options are provided as possible answers to the following questions. Choose the correct answer and write only the letter next to the corresponding question number.

1. Which two diseases are STIs?
   A Gonorrhoea and malaria
   B Syphilis and gonorrhoea
   C Warts and tuberculosis
   D Tuberculosis and malaria
2. Which sexually transmitted infection has these symptoms:
   i) skin rash
   ii) sores on the genitals?
   A Warts
   B Gonorrhoea
   C Syphilis
   D AIDS
3. Which two sexually transmitted diseases are caused by bacteria?
   A Gonorrhoea and genital warts
   B Syphilis and AIDS
   C Syphilis and gonorrhoea
   D AIDS and genital warts
4. Sexually transmitted infections are mainly transferred from one person to another by:
   A Sharing the same utensils
   B Using contaminated needles
   C Blood transfusion
   D Sexual contact.
5. Which method cannot be used to prevent sexually transmitted infections?
   A The correct and consistent use of condoms
   B Having one faithful partner
   C Avoiding casual sex
   D Using contraceptive tablets
6. Which deadly disease attacks the body's ability to protect itself from germs?
   A Syphilis
   B AIDS
   C Gonorrhoea
   D Genital warts
7. For a person to become infected with HIV, which condition needs to occur?
   A HI virus enters their bloodstream
   B Born with AIDS
   C Become a blood donor
   D None of the above
8. Give the correct term to describe a contagious disease that has spread over a wide geographical area.
   A Epidemic
   B Pandemic
   C Infection
   D Plague
9. Two high-risk behaviours related to AIDS are intravenous drug use and:
   A Kissing
   B Sharing a tooth brush
   C Having sex with an infected person
   D Being bitten by a mosquito.

10. Being faithful to one p
    A Illegal sex
    C Oral sex
11. Which item is placed
    the spread of AIDS?
    A Syringe
    C Clothes
12. Which situation is no
    population?
    A Poverty
    C Pressure on health

Assessment exer

1. a) Explain the term "
   b) Describe three way
   transmitted from
   c) Name a sexually t
      i) bacteria
      ii) viruses.
   d) List two symptom
      i) syphilis
      ii) gonorrhoea.
   e) Give two consequ
   transmitted disea

2. a) Write down the n
      i) HIV
      ii) AIDS
   b) Name the virus t
   c) State three ways
   d) List ways of prev
   e) Describe three in
   Zambian popula
   f) It is possible for a
   person makes ce
   could be. Then li
   each one.

10. Being faithful to one partner results in:
    A Illegal sex
    B Safe sex
    C Oral sex
    D Anal sex.
11. Which item is placed onto the penis before having sex to help prevent the spread of AIDS?
    A Syringe
    B Condom
    C Clothes
    D Soup
12. Which situation is not caused by the effect of HIV and AIDS on the population?
    A Poverty
    B Increase in the number of orphans
    C Pressure on health services
    D Lack of school places

Assessment exercises

1. a) Explain the term "sexually transmitted infections". (1) K
   b) Describe three ways by which sexually transmitted infections are transmitted from one person to another. (3) C
   c) Name a sexually transmitted disease caused by:
      i) bacteria
      ii) viruses. (4) K
   d) List two symptoms of each disease:
      i) syphilis
      ii) gonorrhoea. (4) K
   e) Give two consequences of being infected with a sexually transmitted disease. (2) AP
   [14]
2. a) Write down the names that the following acronyms stand for.
      i) HIV
      ii) AIDS (2) K
   b) Name the virus that causes AIDS. (1) K
   c) State three ways in which one can get infected with the HI virus. (3) K
   d) List ways of preventing HIV and AIDS. (4) Ap
   e) Describe three impacts of HIV and AIDS on the Zambian population. (3) C
   f) It is possible for a person never to contract AIDS or any other STI if that person makes certain responsible decisions. Decide what these decisions could be. Then list your decisions and give your reasons for selecting each one. (12)Ap
   [25]

TOPIC 3 The environment

Sub-topics	Specific Outcomes
Cycles in the biosphere	• Describe the oxygen and carbon cycles. • Identify factors affecting the oxygen and carbon cycles. • Describe the nitrogen cycle. • Explain the natural balance of gases in the atmosphere.
Water management	• Describe the importance of water management in our daily lives. • Describe an effective water management system.

Starter activity

Nitrogen, oxygen and carbon dioxide are important gases for life on earth. Think about and discuss how these gases are important to you. Also talk about chemical processes that you might know about in which these gases play a role for maintaining life on the earth.

The natural

The gases that surr
hundred kilometre
called its **atmosph**
and are held aroun

The natural bala
the earth's atmosp

- 78% nitrogen
- 21% oxygen
- 0.04% carbon di
- small amounts o
  methane, hydro
  helium and othe
- a variable amou
  vapour, usually

From the composit
atmosphere, you c
are fixed amounts
except for water va
are reused and recy
this recycling did
on earth would no

Cycles in th biosphere

- Resources on the
  For life to contin
  period of time,
  used by living o
  recycled. These
  circulate betwee
  and living organ
- The most impor
  cycles are the:
  - carbon cycle
- These cycles hav

SUB-TOPIC 1

Cycles in the biosphere

The natural balance of gases in the atmosphere

New word

atmosphere: a mixture of gases that surrounds a planet or star

The gases that surround the earth for several hundred kilometres above the land and sea are called its **atmosphere**. The gases occur in layers and are held around the earth by gravity.

The natural balance of gases in the earth's atmosphere is:

- 78% nitrogen
- 21% oxygen
- 0.04% carbon dioxide
- small amounts of ozone, methane, hydrogen, argon, helium and other "noble" gases
- a variable amount of water vapour, usually about 1%.

From the composition of the atmosphere, you can see that there are fixed amounts of gases in it, except for water vapour. These gases are reused and recycled constantly. If this recycling did not happen, life on earth would not be possible.

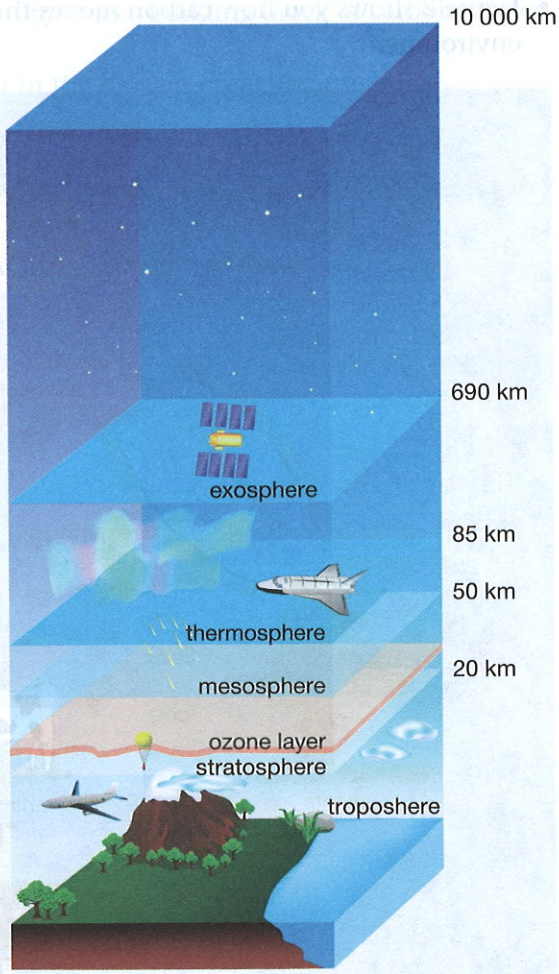


Figure 1 The atmosphere of earth is a layer of gases surrounding the planet and held by the earth's gravity.

Cycles in the biosphere

- Resources on the earth are limited. For life to continue over a long period of time, many nutrients used by living organisms are recycled. These nutrients circulate between the biosphere and living organisms.
- The most important nutrient cycles are the:
  - » carbon cycle
  - » oxygen cycle
  - » nitrogen cycle.
- These cycles have sequences of events that enable the earth to support life.

The carbon cycle

- The carbon cycle refers to the movement of carbon as it is recycled and reused in the biosphere.
- Carbon is used in different processes in living organisms and in the environment.
- Carbon is important to plants and animals as a building block for carbohydrates, fats and proteins.
- Photosynthesis and cellular respiration are important in the carbon cycle.
- Figure 2 shows you how carbon moves through plants, animals and the environment.

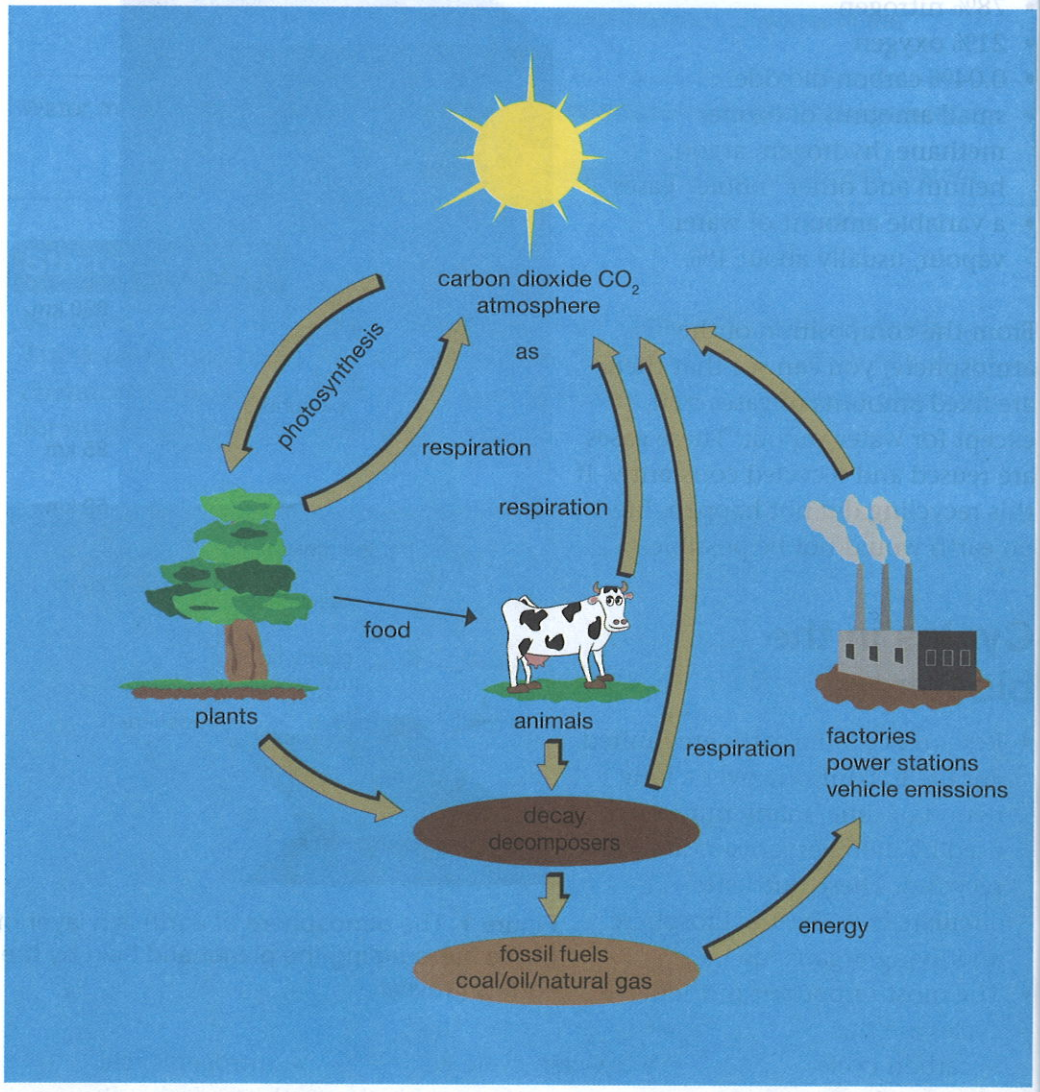


Figure 2 The carbon cycle

The oxygen cycl

- The oxygen cycle refe
in the biosphere.
- Oxygen is used in diff
environment.
- Plants are the main pr
of photosynthesis. Th
and life itself.
- Oxygen is important t
fats and proteins.
- Cellular respiration is
oxygen.
- Atmospheric oxygen f
atmosphere. The ozon
protects life.
- The flow chart in Figu
animals and the envi

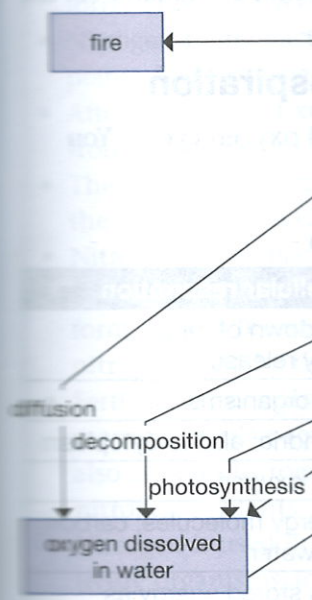


Figure 3 The oxygen cy

Factors affectin

- Many factors affect t
are:
  - the amount of free

The oxygen cycle

- The oxygen cycle refers to the movement of oxygen as it is recycled and reused in the biosphere.
- Oxygen is used in different processes in living organisms and in the environment.
- Plants are the main producers of oxygen in the atmosphere through the process of photosynthesis. This is responsible for the earth's life-supporting atmosphere and life itself.
- Oxygen is important to plants and animals as a building block of carbohydrates, fats and proteins.
- Cellular respiration is also important in the oxygen cycle because it uses oxygen.
- Atmospheric oxygen forms ozone (O_3) and the ozone layer within the atmosphere. The ozone layer absorbs harmful ultraviolet (UV) radiation and so protects life.
- The flow chart in Figure 3 shows you how oxygen moves through plants, animals and the environment.

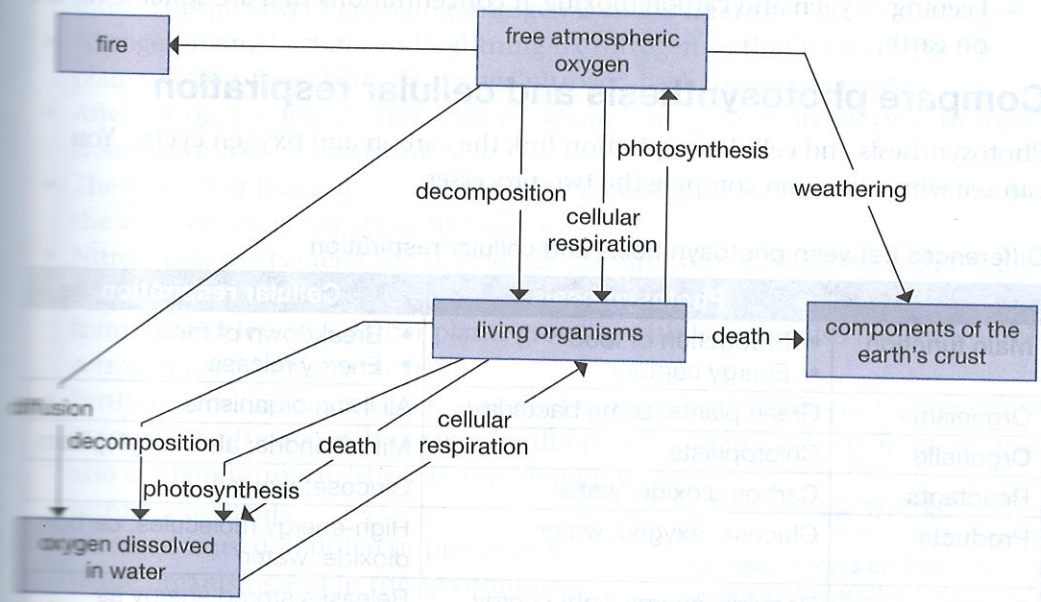


Figure 3 The oxygen cycle

Factors affecting the carbon and oxygen cycles

- Many factors affect the carbon and oxygen cycles. Two of the most important are:
  - the amount of free oxygen in the atmosphere

» the amount of carbon dioxide in the atmosphere.

- These two atmospheric gases influence the two processes that are so important to life on earth:
  - » photosynthesis
  - » cellular respiration.
- Photosynthesis affects the carbon and oxygen cycles because:
  - » It uses carbon dioxide to make sugar in the form of glucose.
  - » Therefore it reduces the amount of carbon dioxide in the atmosphere.
  - » It releases oxygen into the atmosphere as a by-product as it makes glucose.
  - » Therefore it increases the amount of oxygen in the atmosphere.
- Cellular respiration affects the carbon and oxygen cycles because:
  - » It uses oxygen to break down glucose so that living organisms can use the energy stored in the sugar.
  - » Therefore it reduces the amount of oxygen in the atmosphere.
  - » It releases carbon dioxide into the atmosphere as a by-product as it breaks down glucose.
  - » Therefore it increases the amount of carbon dioxide in the atmosphere.
- Photosynthesis and cellular respiration work together by:
  - » regulating the amount of oxygen and carbon dioxide in the atmosphere
  - » keeping oxygen and carbon dioxide at concentrations that are suitable for life on earth.

Compare photosynthesis and cellular respiration

Photosynthesis and cellular respiration link the carbon and oxygen cycles. You can see why when you compare the two processes.

Differences between photosynthesis and cellular respiration

	Photosynthesis	Cellular respiration
Main function	• Production of food • Energy capture	• Breakdown of food • Energy release
Organisms	Green plants; some bacteria	All living organisms
Organelle	Chloroplasts	Mitochondria; also in cytoplasm
Reactants	Carbon dioxide; water	Glucose; oxygen
Products	Glucose; oxygen; water	High-energy molecules; carbon dioxide; water
Energy	Requires energy (light energy from sunlight); stores it in high-energy molecules in food.	Releases stored energy as high-energy molecules
Oxygen and carbon dioxide	Carbon dioxide is absorbed and oxygen is released.	Oxygen is absorbed and carbon dioxide is released.
Chemical reaction	Carbon dioxide and water combine in the presence of sunlight to produce glucose and oxygen.	Glucose is broken down into water, carbon dioxide and high-energy molecules.

Activity 1 Ca

Answer the following q

1. Name the gases th
   a) photosynthesis
   b) respiration.
2. Name the cycle th circulate through t
3. List any four proce
   a) oxygen
   b) carbon dioxide
4. Name the most im carbon cycles.
5. Explain how the f atmosphere.

The nitrogen cy

- Living organisms ca form. This process
- Nitrogen-fixing bac plants. Denitrifying
- After nitrogen is fix from plants and/or
- The process of fixin the atmosphere is
- Nitrogen-fixing bac other plants. These form, for the legun nitrogen fixed by t
- Fertilisers containi manure are nitroge also contain nitrog nitrogen to plants.
- Nitrogen is used in living organisms a
- Nitrogen is import it is a building bloc necessary for the g

Figure 4 shows you w how it moves throug environment.

Activity 1 Carbon and oxygen cycles

Answer the following questions.

1. Name the gases that are involved in these processes:
   a) photosynthesis
   b) respiration.
2. Name the cycle that enables each gas mentioned in question 1 to circulate through the environment.
3. List any four processes that play a role in the recycling of:
   a) oxygen
   b) carbon dioxide.
4. Name the most important factors that affect the oxygen and carbon cycles.
5. Explain how the factors named in question 4 affect the composition of the atmosphere.

The nitrogen cycle

- Living organisms cannot use nitrogen gas. It must first be changed into a usable form. This process of changing nitrogen is called **fixation**.
- Nitrogen-fixing bacteria and lightning fix nitrogen so that it can be used by plants. Denitrifying bacteria change nitrogen back to its gaseous state.
- After nitrogen is fixed, plants can absorb and use it. Animals get their nitrogen from plants and/or other animals.
- The process of fixing nitrogen, its use by plants and animals, and its return to the atmosphere is called the nitrogen cycle.
- Nitrogen-fixing bacteria live in nodules (swellings) in the roots of legumes and other plants. These bacteria change atmospheric nitrogen into **nitrates**, a usable form, for the legumes. Other plants growing with legumes also benefit from the nitrogen fixed by these bacteria.
- Fertilisers containing nitrogen are called nitrogen-rich fertilisers. Compost and manure are nitrogen-rich organic fertilisers. Some man-made chemical fertilisers also contain nitrogen. These fertilisers supply nitrogen to plants.
- Nitrogen is used in different processes in living organisms and in the environment.
- Nitrogen is important to plants and animals as it is a building block of proteins. Proteins are necessary for the growth and repair of cells.

Figure 4 shows you where nitrogen is fixed, and how it moves through plants, animals and the environment.

New words

fixation: process of changing nitrogen into a usable form
nitrate: naturally occurring form of nitrogen that can be absorbed by plants
nitrite: naturally occurring form of nitrogen that bacteria change to nitrates
ammonia: naturally occurring form of nitrogen that can be absorbed by plants

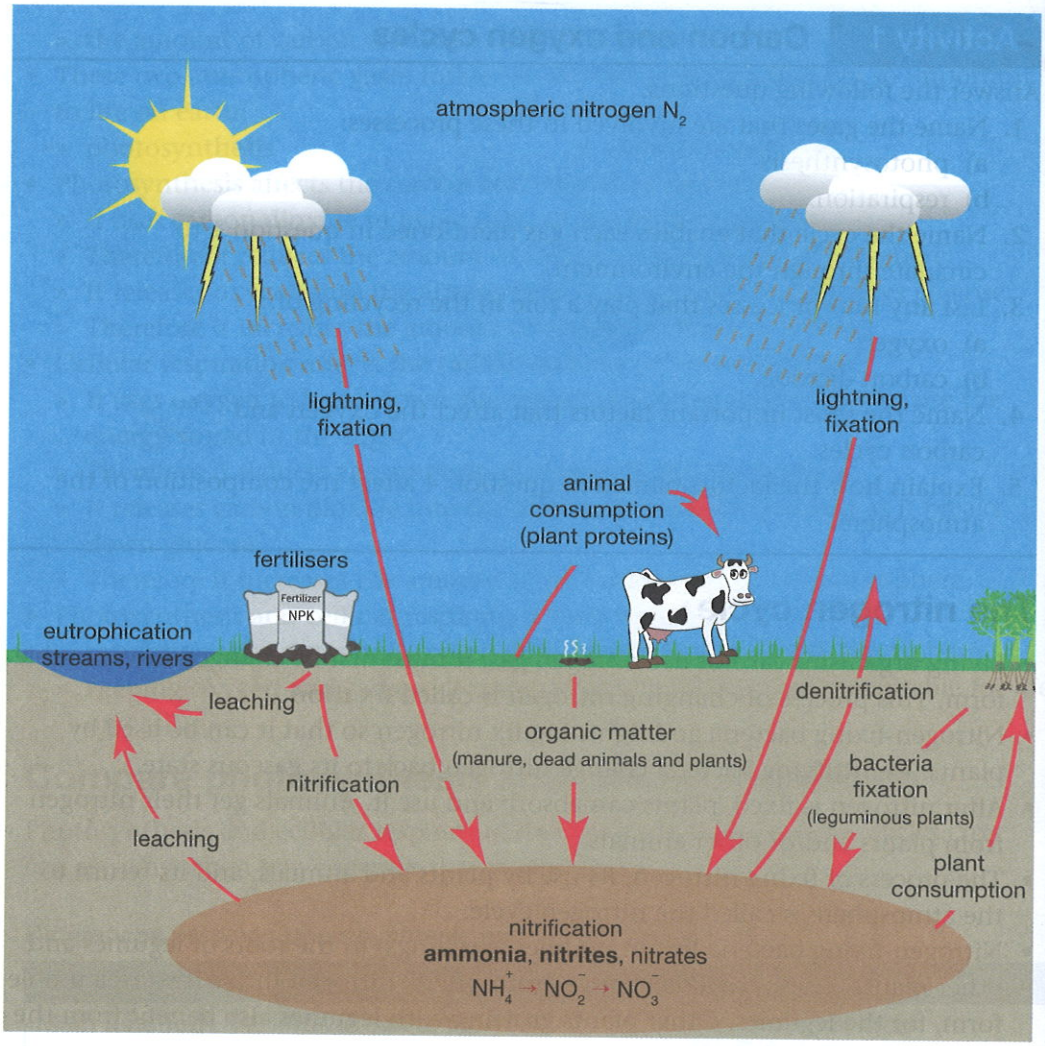


Figure 4 The nitrogen cycle

Activity 2 The nitrogen cycle

Answer the following questions.

1. Name and briefly explain the role lightning plays in the nitrogen cycle.
2. Name the group of micro-organisms that plays an important role in the nitrogen cycle.
3. Explain the role of the following organisms in the nitrogen cycle:
   a) nitrogen-fixing bacteria
   b) denitrifying bacteria
   c) plants.
   d) root nodule bacteria
   e) decomposition bacteria
   f) nitrate bacteria

The importanc

Water is essential for all
3% of all the water on t
and glaciers and canno
At present, humans u
Humans use water for:

- drinking
- household use
- industry

The demand for water
are becoming more im
Water management
should have sufficient
environment must be a
is called integrated wat
An integrated water

1. **Social equity**
   All people have eq
   health.
2. **Economic efficien**
   The financial and
   possible as much
3. **Ecological sustai**
   Aquatic ecosystem
   ensure that they w

Water resour

- Water resources are
  humans.
- Humans need fresh
- Fresh water is a ren
  decreasing. This is a
  largest source of fre
  for their use from g
- Fresh water should
  spread illnesses and
- The availability of
  issue.

SUB-TOPIC 2

Water management

The importance of water management

Water is essential for all life on the Earth. Fresh water is a limited resource; only 3% of all the water on the earth is fresh. Most fresh water is trapped in ice caps and glaciers and cannot be used.

At present, humans use less than 0.1% of the available fresh water on the earth. Humans use water for:

- drinking
- household use
- industry
- recreation
- agriculture
- environmental activities.

The demand for water is continually increasing. Good water management systems are becoming more important.

Water management requires good decisions and plans of action. All humans should have sufficient water for their needs. At the same time, the natural environment must be affected as little as possible. This type of water management is called integrated water resources management.

An integrated water resources management system helps ensure that there is:

1. **Social equity**
   All people have equal access to enough water of good quality for human health.
2. **Economic efficiency**
   The financial and water resources that are available give as many users as possible as much benefit as possible.
3. **Ecological sustainability**
   Aquatic ecosystems are water users. They must be given enough water to ensure that they work correctly.

Water resources

- Water resources are sources of water that are useful or could be useful to humans.
- Humans need fresh water for daily use.
- Fresh water is a renewable resource, but the world's supply of groundwater is decreasing. This is a disturbing situation. However, groundwater is the second largest source of fresh water on the earth. It is also easy for humans to get water for their use from groundwater.
- Fresh water should be clean and uncontaminated. Contaminated water can spread illnesses and diseases.
- The availability of clean water is both an environmental and a public health issue.

- Climate change has a big influence on the world's water resources because climate and the water cycle are closely linked.
- Water demand is already greater than the supply in many parts of the world. Many more areas could soon have the same problem.

Sources of fresh water

- The potential sources of fresh water for humans include:
  - » surface water
  - » under river flow
  - » groundwater.
- Desalination is another possible source of fresh water. This is an artificial process that changes salty water, usually sea water, into fresh water. This process is very expensive and it is not used much.

Surface water

- Surface water is water in rivers, lakes, dams or freshwater wetlands.
- It is replaced by **precipitation** and is lost through flow into the oceans, evaporation, transpiration and **seepage** deep into the ground.
- The total amount of surface water available at any time is affected by:
  - » the amount of water that can be stored in lakes, wetlands, dams and man-made reservoirs
  - » how easy it is for the water to seep into the soil
  - » how easy it is for the water to run off the ground rather than seeping into the soil
  - » when rain has occurred
  - » the rate of evaporation
  - » human activity.

New words

precipitation: any form of water, such as rain, hail, dew or snow, that falls to the earth
seepage: slow movement of water into the ground

Figure 5 Surface water: a) The Zambezi River has plenty fresh water, but most Zambians live too far from the river to benefit from it. Water is often scarce during the dry season.
b) Okavango Delta wetland

Under river flow

- This water flows in th
river bed.
- For rivers that occur i
than the water flow ir

Groundwater

- Groundwater is fresh
- Water that occurs wit
groundwater.
- Water naturally becor
surface water.
- Water is lost from gro
or lakes.
- Groundwater is taken
is mostly used in fact
areas.

Figure 6 Groundwater

Under river flow

- This water flows in the ground and between the rocks below the surface of a river bed.
- For rivers that occur in large valleys, this underground flow may be far greater than the water flow in the river.

Groundwater

- Groundwater is fresh water that is in the spaces between soil particles and rocks.
- Water that occurs within **aquifers** below the **water table** is also part of groundwater.
- Water naturally becomes part of the groundwater because of seepage from surface water.
- Water is lost from groundwater from wells, springs and seepage into the oceans or lakes.
- Groundwater is taken out of the ground on a daily basis in Zambia. This water is mostly used in factories, on farms and for drinking, especially in the rural areas.

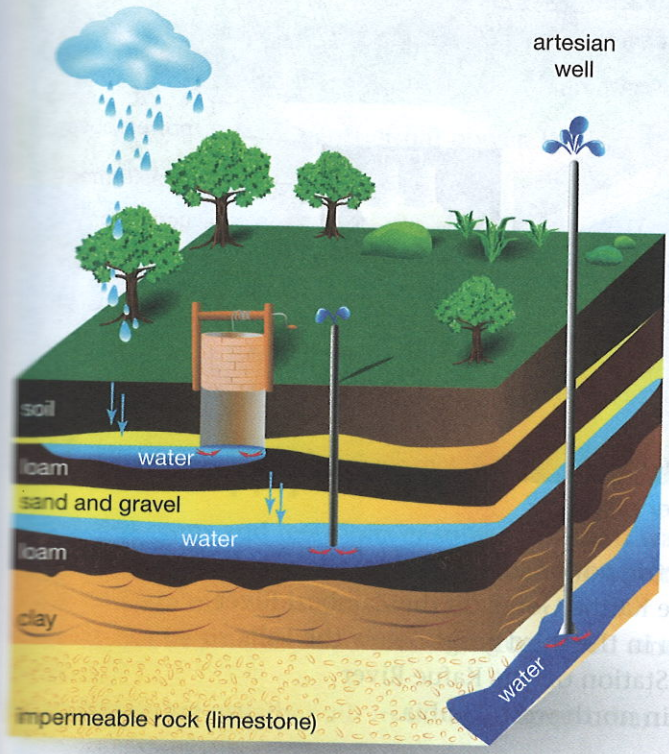


Figure 6 Groundwater

New words

aquifer: a porous layer of rock, such as sandstone, containing a large amount of water that can be used to supply wells or springs
water table: the upper surface of an area filled with groundwater

Electricity generation

Hydroelectricity

- Water can be used to generate electricity, which is known as hydroelectricity.
- Hydroelectricity is a renewable source of energy.
- Hydroelectricity is clean power. It produces no wastes and does not produce greenhouse gases.
- Hydroelectricity uses the energy of running water to make electrical energy.
- Most hydroelectric stations are located in dams where water is stored.
- The flow of the water from the dam is controlled by opening and closing the gates of pipes to the dam.
- Pipes take water at high pressure to turbines. The pressure of the water pushes against the blades of the turbines and makes them spin.
- The rotating turbines are connected to generators that make the electricity.
- The electricity travels through transformers and power lines to the consumer

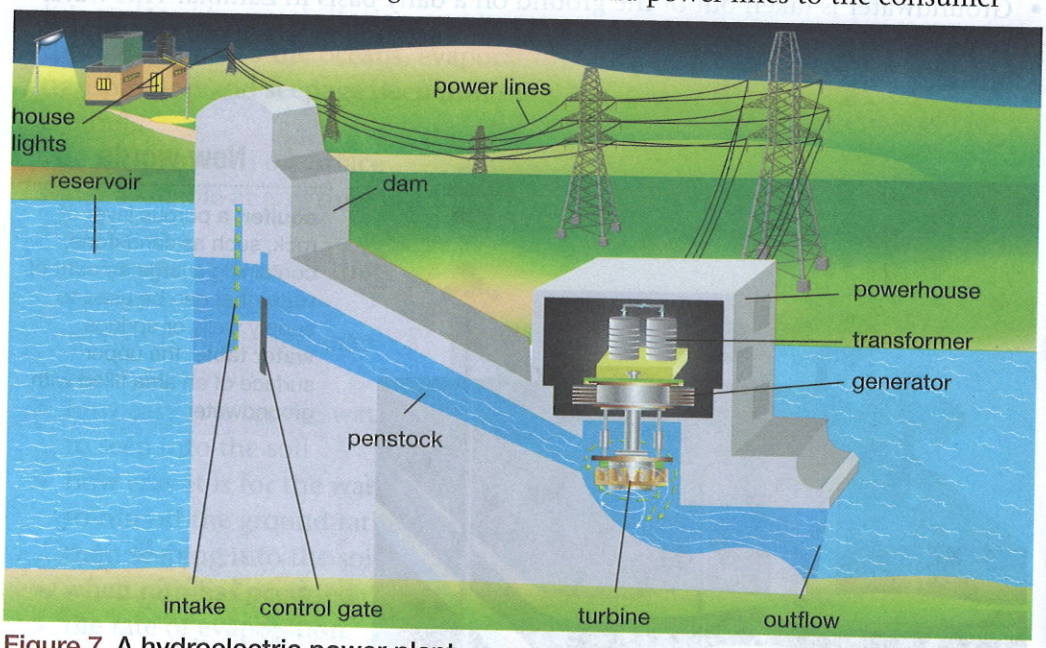


Figure 7 A hydroelectric power plant

Zambia has several hydroelectric power stations such as:

- Kariba Power Station in the Kariba Gorge on the Zambezi River
- Victoria Falls power station in the third gorge below the Falls
- Kafue Gorge Upper Power Station on the Kafue River
- Zengamina Power Station in north-west Zambia.

New power stations have been planned for:

- the Batoka Gorge Dam on the Zambezi River
- the Kabompo Gorge in north-west Zambia.

Zambia's present electricity
increase in demand has m

Geothermal electrici

- In the Rift Valley of Afri
  kilometres below the ea
- These reservoirs are a so
- Wells are drilled into the geothermal reservoirs to reach the hot water.
- Geothermal power plants use steam from this water to turn turbines to generate electricity.
- The warm water is returned to the reservoirs to extend the life of the heat source.
- Parts of Zambia are now being explored for the possibility of ge
  Kafue Basin.

Effective water

- The most important as
  - there is a constant s
  - the quality of the wa
    sick.

Constant supply

- Building dams and res
- Dams can be massive s
  Kariba Dam on the Za
- Dams can be smaller s
  dams.
- Reservoirs are usually
  the local area.
- Storing water in dams
  supply of water when
- Stored water must be

Zambia's present electricity supply comes mostly from hydroelectricity. An increase in demand has made the country look at other energy sources.

Geothermal electricity

- In the Rift Valley of Africa, reservoirs of high-pressure hot water occur a few kilometres below the earth's surface.
- These reservoirs are a source of geothermal energy.
- Wells are drilled into the geothermal reservoirs to reach the hot water.
- Geothermal power plants use steam from this water to turn turbines to generate electricity.
- The warm water is returned to the reservoirs to extend the life of the heat source.
- Parts of Zambia are now being explored for the possibility of geothermal power. Wells have already been drilled in the Kafue Basin.

Figure 8 The Olkaria II geothermal power plant in Kenya

Effective water management

- The most important aspects of managing water are to make sure that:
  - there is a constant supply of water
  - the quality of the water is good enough for humans to drink without getting sick.

Constant supply of water

- Building dams and reservoirs ensures a constant water supply.
- Dams can be massive structures that dam the water flow in big rivers, such as Kariba Dam on the Zambezi River.
- Dams can be smaller structures that store small amounts of water, such as farm dams.
- Reservoirs are usually built in urban or semi-urban areas to store water for use in the local area.
- Storing water in dams and reservoirs makes it possible to ensure an adequate supply of water when there is little or no precipitation.
- Stored water must be purified before humans use it.

Figure 9 The Kariba dam

Water purification

Reasons for purifying water

1. Contaminated water can cause epidemics. Cholera, salmonella, typhoid fever, dengue fever, hepatitis A, rotavirus, yellow fever and diarrhoea are water-borne diseases.
2. Apart from vruses and bacteria, algae, fungi and parasites can also make people sick.
3. Toxins and unwanted chemicals from industrial and mining operations must be removed.
4. Heavy metals such as mercury, arsenic, copper and lead can cause long-term nerve damage.
5. Water is also purified to improve the taste, smell and appearance of the water.

Treating water in a water purification plant

1. The treatment used to purify water depends on how clean the source of water is. Figure 11 on page 51 shows a common water purification process.
2. Water is pumped from a source. It passes through a grid to remove floating objects, such as sticks or bottles.
3. The water settles in a settling tank where small suspended particles sink to the bottom.
4. The water then passes through a filter to remove bacteria. Chlorine is added to the filtered water to kill bacteria that might have passed through the filter. The amount of chlorine depends on the source of the water and how contaminated the source of water is.
5. The purified water is pumped to a reservoir on high ground or to a water tower. The reservoir is tightly closed to ensure that no **pathogens** enter the water. The height of the reservoir creates the water pressure needed to deliver water to the user. The water is stored in the reservoir before it is taken to the user.

On a small scale, boiling water destroys most pathogens.

New word

pathogen: something that can cause disease

Figure 10 A large scale water purification plant

Activity 3 Imp

Answer the following q
1. List three ways in
2. List three sources o
3. Define the followin
   a) hydroelectricity
   b) groundwater
   c) turbine
   d) pathogen.
4. Geothermal energy
   a) Explain what ge
   b) Explain how it
   c) Name the geolo humans to acce
   d) Name three pla produce electric

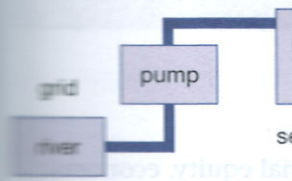


Figure 11 Purification

Activity 4 Effe

Answer the following q
1. Name the two mos
2. Explain how we er
3. Name four exampl
4. Explain the use of

Activity 3 Importance of water management

Answer the following questions.

1. List three ways in which people use water.
2. List three sources of water.
3. Define the following terms:
   a) hydroelectricity
   b) groundwater
   c) turbine
   d) pathogen.
4. Geothermal energy is an alternative source of electricity.
   a) Explain what geothermal energy is.
   b) Explain how it is possible to generate electricity from geothermal energy.
   c) Name the geological conditions in an area that make it possible for humans to access geothermal energy.
   d) Name three places or areas on the earth that use geothermal energy to produce electricity.

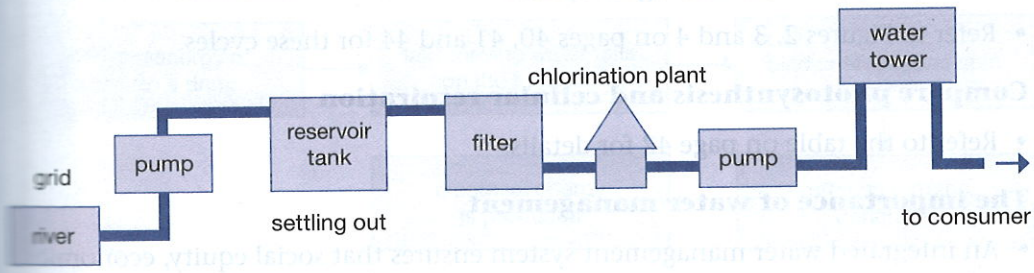


Figure 11 Purification of water

Activity 4 Effective water management

Answer the following questions.

1. Name the two most important aspects of effective water management.
2. Explain how we ensure a constant supply of water for human use.
3. Name four examples of water-borne diseases.
4. Explain the use of chlorine in the water purification process.

TOPIC 3

Summary, revision and assessment exercises

Summary

The natural balance of gases in the atmosphere

- Nitrogen: 78%
- Oxygen: 21%
- Carbon dioxide: 0.04%
- Water vapour: variable, but usually about 1%
- Ozone, methane, hydrogen, argon, helium: very small amounts of each

Cycles in the biosphere

- Resources on the planet are limited and nutrients are recycled.
- The most important nutrient cycles are:
  - » the carbon cycle
  - » the oxygen cycle
  - » the nitrogen cycle.

Carbon, oxygen and nitrogen cycles

- Refer to Figures 2, 3 and 4 on pages 40, 41 and 44 for these cycles.

Compare photosynthesis and cellular respiration

- Refer to the table on page 42 for details.

The importance of water management

- An integrated water management system ensures that social equity, economic efficiency and ecological sustainability are achieved.

Water resources

- These are sources of water that are useful or potentially useful to humans.
- Uses of water:
  - » drinking
  - » household use
  - » industry
  - » recreation
  - » agriculture
  - » environmental activities.

Sources of fresh water

- Freshwater sources for humans include:
  - » surface water
  - » under river flow
  - » groundwater.
- Fresh water is in rivers, lakes, dams or freshwater wetlands.
- Fresh water is replaced by precipitation.
- Fresh water is lost through flow into the oceans, evaporation, transpiration and seepage into the deeper layers of the ground.

Summary, revision continued

- Under river flow is water t
  the surface of a riverbed.
- This underground flow ca
- Groundwater is fresh wate
  and rocks.
- Water becomes part of the
- Water is lost from groundw
  lakes.

Electricity generation

Hydroelectricity

- Water can be used to gene
- Hydroelectricity is a renew
- It produces no wastes or g
- The flow chart outlines th

potential energy of water in a dam

- Most electricity produced in

Geothermal electricity

- In some areas, high-pressu
  surface.
- Wells are drilled into thes
- Geothermal power plants

Effective water manage

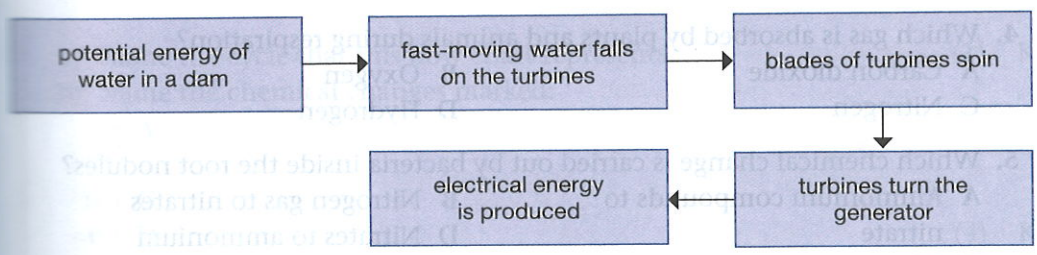
- The most important aspe
  - » there is a constant supp
  - » the quality of the wate
    sick.
- A constant water supply i
- Water supplied to towns
- The treatment used to pu
- Refer to Figure 11 on pag

- Under river flow is water that flows in the ground and between the rocks below the surface of a riverbed.
- This underground flow can be greater than the water flow in the river.
- Groundwater is fresh water that occurs in the spaces between the soil particles and rocks.
- Water becomes part of the groundwater due to seepage from surface water.
- Water is lost from groundwater from wells, springs and seepage into oceans or lakes.

Electricity generation

Hydroelectricity

- Water can be used to generate hydroelectricity.
- Hydroelectricity is a renewable, clean source of energy.
- It produces no wastes or greenhouse gases.
- The flow chart outlines the process of hydroelectric power generation.



- Most electricity produced in Zambia comes from hydroelectricity.

Geothermal electricity

- In some areas, high-pressure hot water reservoirs occur below the earth's surface.
- Wells are drilled into these geothermal reservoirs to reach the hot water.
- Geothermal power plants use steam to turn turbines to generate electricity.

Effective water management

- The most important aspects of managing water ensure that:
  - there is a constant supply of water
  - the quality of the water is good enough for humans to drink without getting sick.
- A constant water supply is provided by building dams and reservoirs.
- Water supplied to towns and cities goes through water treatment plants.
- The treatment used to purify water depends on how clean the source of water is.
- Refer to Figure 11 on page 51 for a system of purifying water.

Summary, revision and assessment exercises continued

Revision exercises

Various options are provided as possible answers to the following questions. Choose the correct answer and write only the letter (A to D) next to the corresponding question number.

1. In which form do plants absorb nitrogen from the soil?
   A Nitrates B Nitrogen
   C Protein D Urea

2. Which of these do plants use to produce food?
   A Carbon dioxide B Sunlight
   C Water D All the above

3. Name the process used by green plants to produce food.
   A Photosynthesis B Respiration
   C Decomposition D Nitrification

4. Which gas is absorbed by plants and animals during respiration?
   A Carbon dioxide B Oxygen
   C Nitrogen D Hydrogen

5. Which chemical change is carried out by bacteria inside the root nodules?
   A Ammonium compounds to nitrate B Nitrogen gas to nitrates
   C Nitrates to nitrogen gas D Nitrates to ammonium compound

6. Which gas do nitrogen-fixing bacteria in the soil absorb to form nitrates?
   A Oxygen B Carbon dioxide
   C Nitrogen D Hydrogen

7. Which method is used to purify water on a large scale?
   A Filtration B Distillation
   C Boiling D Chlorination

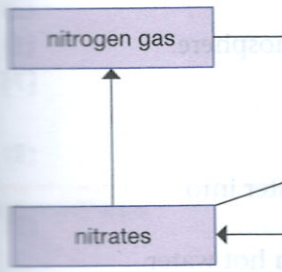
8. Which substance is used to purify water?
   A Chlorine B Nitrogen
   C Oxygen D Ammonia

9. Name the type of electricity produced by water turning a turbine.
   A Dynamo electricity B Geothermal electricity
   C Hydroelectricity D Solar electricity

The height of the reser
A Water pressure
C Electric pressure

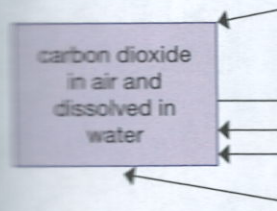
Assessment exerc

Study the flow chart a



a) Name the cycle tha
b) Name the chemica
i) A
ii) B
iii) C
iv) D
c) State the percentag
d) Give the importan
e) Explain why nitrog

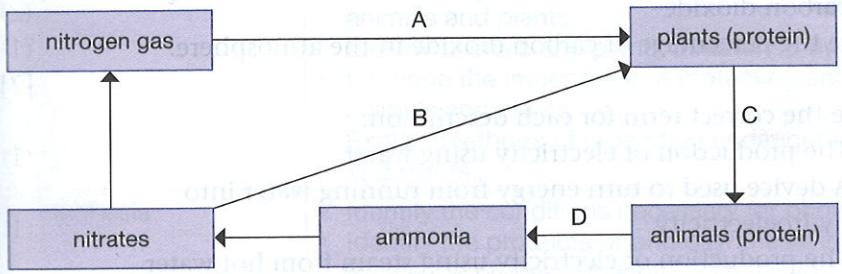
2. Study the diagram an



10. The height of the reservoir used in water purification contributes to:
    A Water pressure
    B Air pressure
    C Electric pressure
    D Blood pressure.

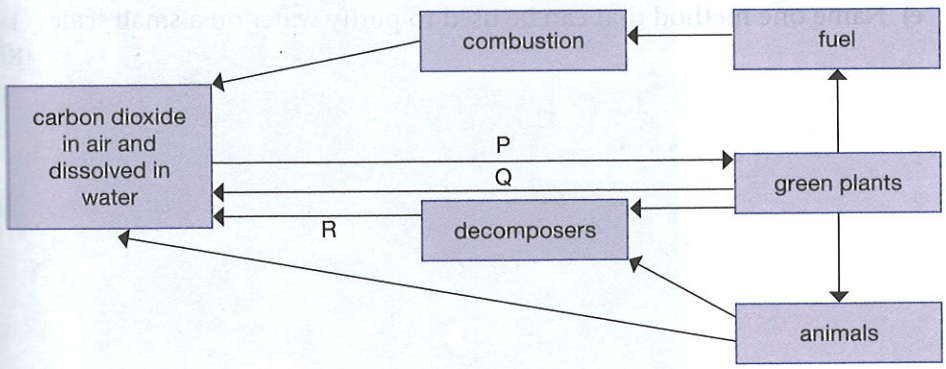
Assessment exercises

1. Study the flow chart and answer the questions that follow.



a) Name the cycle that this flow chart represents. (1) K
b) Name the chemical changes marked:
   i) A
   ii) B
   iii) C
   iv) D (4) K
c) State the percentage of nitrogen in the atmosphere. (1) K
d) Give the importance of nitrates. (1) C
e) Explain why nitrogen is essential for life on earth. (3) Ap
[10]

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



Summary, revision and assessment exercises continued

a) Name the cycle that this flow chart represents. (1) K

b) Name the processes labelled:
   i) P
   ii) Q
   iii) R (3) K

c) Give one use of these gases:
   i) oxygen
   ii) carbon dioxide (2) K

d) State the percentage of carbon dioxide in the atmosphere. (1) K

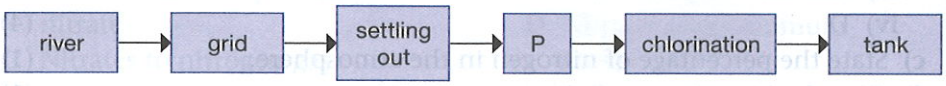
[7]

3. a) Give the correct term for each description:
   i) The production of electricity using water (1) K
   ii) A device used to turn energy from running water into hydroelectricity (1) K
   iii) The production of electricity using steam from hot water reservoirs under the earth (1) K

b) Draw a flow chart to show how electricity is generated at a hydroelectric power station. (7) Ap

[10]

4. Study the flow chart and answer the questions that follow.



a) Name the process that this flow chart represents. (1) K

b) Name the process marked P. (1) K

c) List three sources of water. (3) K

d) State the importance of water management in our daily lives. (2) K/C

e) Name one method that can be used to purify water on a small scale. (1) K

[8]

Sub-topics

Conservation of animals and plants

Photosynthesis

Transpiration

Starter activity

Work as a class or in gro
Discuss how you thin
had not domesticated ar

TOPIC 4

Plants and animals

Sub-topics	Specific Outcomes
Conservation of animals and plants	• Explain the importance of domesticating animals and plants. • Explain ways of improving domestic breeds of animals and plants. • Identify animals and plants threatened by extinction. • Describe the importance of protecting endangered animals and plants. • Explain methods of protecting endangered animals and plants.
Photosynthesis	• Identify the conditions necessary for photosynthesis. • Identify the products of photosynthesis in a leaf. • Relate the process of photosynthesis to respiration.
Transpiration	• Describe the process of transpiration. • Investigate the factors that affect the rate of transpiration. • Explain the importance of transpiration in plants.

Starter activity

Work as a class or in groups of four for this activity.

Discuss how you think everyday life might have been different if humans had not domesticated any animal or plant species.

SUB-TOPIC 1

Conservation of animals and plants

The importance of domesticating animals and plants

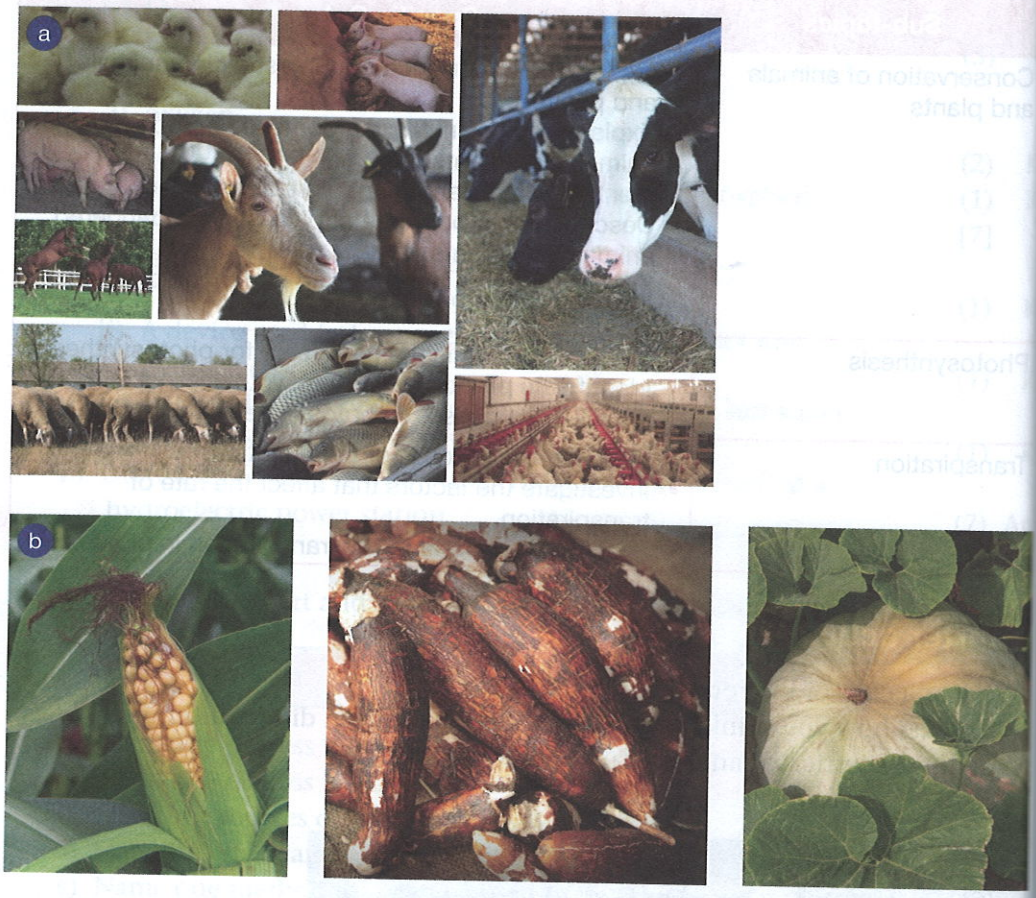


Figure 1 A variety of domesticated (a) animal and (b) plant species

For thousands of years humans have lived closely with animals and plants. **Domestication** has changed **species** of plants or animals for the benefit of humans, through many generations of selective breeding. Domesticated organisms can no longer survive in the wild and are dependent on humans.

There are six main reasons or benefits for domesticating wild organisms.

New words

domestication: changing a species of plants or animals for the benefit of humans through many generations of breeding
species: a group of living organisms that share common characteristics and are grouped as alike

1. **Increased production and availability of food for humans**
   - Animals that have been domesticated for food are called livestock or farm animals.
   - Plants that have been domesticated for food are called crops.
2. **Increased production and availability of non-food products for humans**

   Examples are:
   - wool from sheep
   - silk from silkworms
   - cotton from the cotton plant
   - linen from the flax plant
   - coir from the coconut palm
   - leather from animal skins.
3. **Increased capacity to do work**

   Examples are:
   - horse
   - donkey
   - oxen
   - Indian elephant
   - llama
   - camel.
4. **Beautifying the urban habitat**

   Plants used for this purpose are known as ornamental plants. They are grown in hothouses, as house plants or outside in gardens.
5. **Providing companions for humans**

   Examples are dogs, cats and birds. These animals are often called pets.
6. **For scientific research**

   Examples are:
   - fruit fly
   - certain monkey species
   - certain mice species
   - certain rat species.

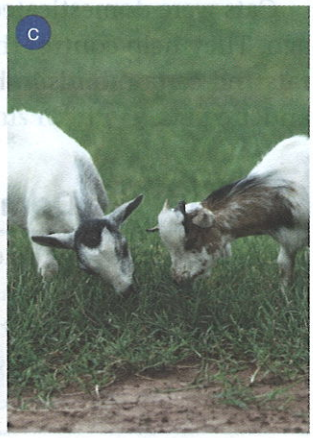


Figure 2 Examples of domesticated plants and animals: a) Silkworms; b) Cotton plant; c) Goats; d) Cattle.

Cattle were domesticated about 10 000 years ago. They provide meat, milk, skins manure and and do work. They are disease-resistant and do well in their environment.

Dogs were domesticated from wolves about 12 000 years ago. They reduce the chances of other predators entering human settlements, warn humans of approaching dangers, help with hunting and are pets.

Cats were domesticated about 3 000 years ago. They help control the numbers of mice, rats and certain birds in human settlements, and are pets.

Figure 3 An indigenous African cow

Activity 1 Domesticated animals and modern humans

Answer the following questions.

1. Write a paragraph in which you explain what the term "domesticated" means and how you think this process started in human history.
2. Plants and animals were domesticated for the benefit of humans. Discuss this statement in a few sentences.

Improving domestic breeds

Why we improve breeds of animals and plants

There are several reasons for improving breeds.

1. **Increased yield**
   This results in:
   - bigger fruit
   - more fruit
   - more lean meat per animal
   - more product (such as wool, milk or mohair) per animal.
2. **Resistance to pests**
   Improved resistance to:
   - infection by viruses, bacteria and fungi
   - attack by insects.
3. **Resistance to drought**
   This enables plant crops to:
   - grow in areas where they could not previously be grown
   - withstand certain aspects of global warming.

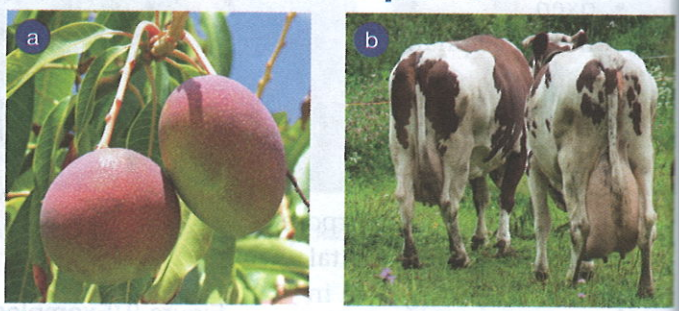


Figure 4 Improved breeds of plants and animals: a) Larger fruits; b) Increased milk production

4. **Increased germination ra**
   - Most seeds germinate a produce new plants. Th the amount of seeds th bought and planted, so costs.

Ways of improving d

There are several ways of imp

1. **Cross-pollination**

Ripe pollen grains are transfe another flower on a different plants.

Figure 5 Cross-pollination

2. **Grafting**

A bud, or a stem with many from a plant with **desirable** onto a stock (stem) of a plan stock provides water and oth the grafted bud. The new pla with the stock and the bud plants are used for grafting.

New

desirable trait: a useful or advan organism

graft: to join a bud or stem from another plant

4. **Increased germination rate**
   - Most seeds germinate and produce new plants. This reduces the amount of seeds that must be bought and planted, so reducing costs.

5. **Increased nutritional value**
   This causes an increase in:
   - the amount of nutrients per fruit
   - the types of nutrients that occur in the fruit.

Ways of improving domestic breeds

There are several ways of improving breeds of plants and animals.

1. Cross-pollination

Ripe pollen grains are transferred from the anthers of a flower to the stigmas of another flower on a different plant of the same species. This results in stronger plants.

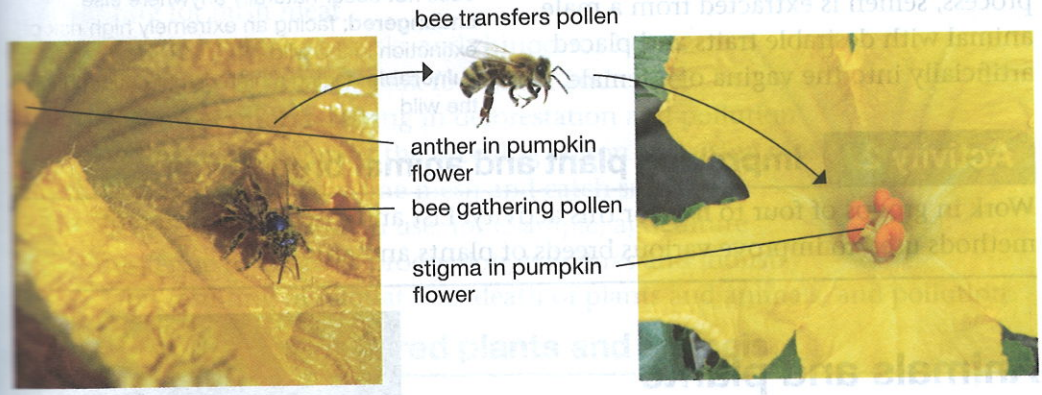


Figure 5 Cross-pollination

2. Grafting

A bud, or a stem with many buds (called a scion), is taken from a plant with **desirable traits**. The scion is **grafted** onto a stock (stem) of a plant with different traits. The stock provides water and other nutrients from the soil to the grafted bud. The new plant benefits from the traits of both the stock and the bud plant. Only closely related plants are used for grafting.

Figure 6 An example of grafting

New words

desirable trait: a useful or advantageous known characteristic of an organism
graft: to join a bud or stem from one plant to the stock (stem) of another plant

3. Cross-breeding

Cross-breeding produces new plants and animals by crossing two **varieties** of the same species. For example, a good crossbreed is between the Large White pig and a Landrace pig. The Large White pig is large, lean and hardy, and produces many piglets. A Landrace pig has fast early growth and is a little fatter. The resulting piglets have traits of both parents.

Figure 7 Cross-bred pigs, Landrace crossed with Large White, are farmed commercially in Zambia.

4. Artificial insemination

This is a quicker, but more expensive way of achieving cross-breeding. In this process, semen is extracted from a male animal with desirable traits and placed artificially into the vagina of a female.

New word

variety: a slightly different form of a species
endemic: occurring in a specific area and does not occur naturally anywhere else
endangered: facing an extremely high risk of extinction in the wild
vulnerable: facing a high risk of extinction in the wild

Activity 2 Improving plant and animal breeds

Work in groups of four to five for this activity. List and discuss the different methods used to improve various breeds of plants and animals.

Animals and plants threatened by extinction

There are about 8 017 different species of living organisms in Zambia. Of these, 615 are **endemic**. The black rhinoceros is a critically **endangered** mammal. Wild dogs and Ansell's shrew are endangered. Elephant, hippopotamus, cheetah, Kafue lechwe and black lechwe are **vulnerable**.

Figure 8 Some of the most endangered organisms in Zambia: a) Black rhinoceros; b) Shoebill stork; c) African wild dog

Some threatened species

The most endangered animal in Africa is the black rhinoceros. The black rhinoceros population was almost destroyed during the 1970s and 1980s as a result of poaching for horns.

The endangered wild dog exists only in Zambia and five other countries.

Other threatened species in Zambia include roan antelope, oribi, suni, honey badger, pangolin, various species of bats and vultures, bateleur eagle, shoebill stork, wattled crane, African skimmer and the Zambezi teak tree.

Zambezi teak is one of the world's best commercial timbers. Traditionally, the timber was used for canoes and building poles. It is threatened due to logging, clearing land for agriculture and frequent fires.

Human activities that threaten species

Plants and animals are threatened with extinction due to human activities such as:

- poaching for bush meat
- illegal trade in elephant tusks and rhinoceros horn
- illegal logging of Zambezi teak for timber and curios
- charcoal production resulting in deforestation and pollution
- overfishing, fishing during the breeding season and using mosquito nets and gill nets that have a very fine mesh and catch small fish
- land conversion for human use, for example, agriculture
- pollution due to charcoal production, wild fires and industry
- wild fires resulting in habitat loss, death of plants and animals, and pollution.

Activity 3 Endangered plants and animals

Answer the following questions.

1. Name at least two species that are endangered in your local area.
2. Name at least ten other species that are endangered in Zambia.
3. Explain which human activity or activities have played a role in making each of the species you have named in questions 1 and 2 endangered.
4. List possible solutions or alternatives that could be implemented to try to save these species from extinction.

Figure 9 Some human activities that can cause the extinction of, or endanger, plants and animals: a) Illegal wildlife trade in rhinoceros horn; b) Illegal logging for Zambezi teak; c) Charcoal production

Importance of protecting endangered species

A species is endangered when it is threatened with extinction. In the past, extinction of animals took place naturally. The extinction of the dinosaurs is a good example.

Today, the extinction of most organisms is no longer due to natural causes. For about the last 100 years, organisms have disappeared faster than ever before. Most organisms now become extinct because of human activities such as those listed on page 63. We must protect and save endangered species so that future generations can benefit from their presence and value.

Benefits of protecting endangered species

All organisms play a role in nature and have value. Humans benefit from them. These benefits are ecological, medicinal, agricultural, economic and social.

Ecological benefits

Variation within a species affects how the species survives with changes in its environment. When variation is reduced, the chances of extinction increase. By conserving **biological diversity**, we preserve and maintain ecosystems. We depend on ecosystems such as estuaries, grasslands, wetlands and forests to purify the air, clean the water and supply us with food. When species become endangered, we know that their ecosystems have been negatively affected.

Ecosystems have scientific, educational and aesthetic value due to their range of flora and fauna. Their destruction would result in desert land.

Conservation of species and their ecosystems could also result in economic and social development for local communities in the form of ecotourism. This is important in less developed countries.

Medicinal benefits

Plants are an important source of medicines. About 40% of all medicines used today contain natural medicinal compounds that are extracted from plants. Antibiotics, such as penicillin, are obtained from fungi. Known plants and plants that have not yet been discovered may have potential as a source of new medicines. Only about 5% of known plant species have been screened for their medicinal values.

Agricultural benefits

There are about 80 000 edible plant species in the world. We use only 20 of these species, for example, wheat, maize and rice, to provide 90% of the world's food. Undomesticated plant species can benefit modern agriculture as a source of new crops, when used in cross-breeding to improve existing crops and as new, natural, biodegradable pesticides.

New words

variation: the different forms of plants and animals
biological diversity: the variety of plant and animal life on earth

Economic benefits

Many plants and animals have economic benefits. Zambezi teak forests, for example, have been greatly reduced as a result of disturbance by man. These forests must be conserved for their economic value as they supply one of Zambia's most valuable commercial timbers. However, the forests are in danger of being destroyed for timber, both to supply Zambia and to earn foreign exchange.

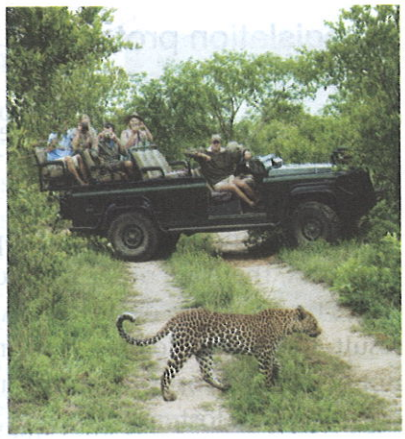


Figure 10 An economic benefit: ecotourism

Social benefits

Zambia's national heritage of biological diversity is an invaluable and irreplaceable resource. When ecosystems function normally and biological diversity is maintained, we have various social benefits. These include:

- energy capture due to photosynthesis
- chemical cycling of oxygen, carbon, nitrogen and water (see Topic 3, pages 40–44)
- replenishing groundwater
- water purification
- maintaining existing soil
- making new soil
- flood protection
- ecotourism
- recreational use
- spiritual value or use.

Activity 4 Conserving endangered organisms

Work in groups of four to six for this activity.

1. Choose a name for your group in your local language of an endangered organism that lives in your area.
2. Discuss the importance of conserving this organism.

Ways to protect endangered animals and plants

There are several ways of protecting endangered organisms.

1. Protect the natural habitat

Habitat destruction is a great threat to all organisms. In areas where endangered species are present, habitat destruction can cause a species to become extinct quickly. By protecting habitats, communities of organisms can be protected together. This requires less conservation intervention to ensure the survival of the species. Game parks, game management areas (GMAs), forest reserves and other protected areas of land are often the only habitats left untouched by destruction.

2. Legislation protecting endangered species

These laws should be well policed and applied correctly. Both are time-consuming and costly to implement. In many less developed countries, there are other more urgent issues that must be dealt with. As a result, if the laws do exist, they might not be applied correctly and countless organisms are lost.

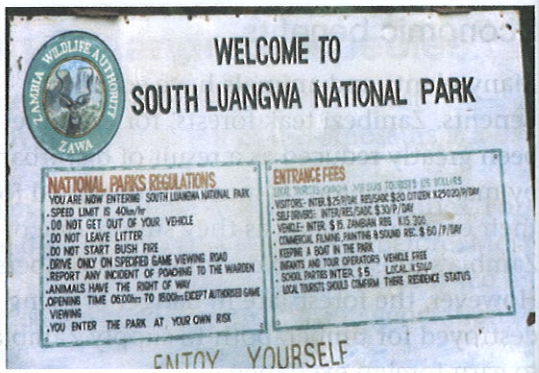


Figure 11 Protection of the natural environment: a national park

Figure 12 Educating learners about planting indigenous trees

3. Education

An environmental education programme for all schools is a good way to make learners aware of the importance of conservation. A programme could start with young children and continue until their final year of high school. The programme should be independent of any school subject so that all learners benefit. It could also be conducted within local communities to educate adults.

This programme could address issues such as:

- local deforestation for personal use including for firewood, construction material and indigenous or herbal medicines
- the importance of reforestation
- the effect of making and burning charcoal
- poaching and the bush meat trade
- environmentally friendly fishing methods and techniques
- closed seasons for hunting, fishing and the harvesting of plants
- alternative means of generating an income such as tree planting, fish farming, bee-keeping, poultry farming, carpentry and metal works.

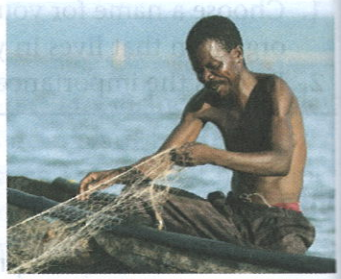


Figure 13 A fisherman uses the correct net for fishing.

4. Captive breeding and release programmes

Breeding programmes produce captive populations of organisms to ensure that they do not become extinct. Some of them are released into their natural habitats to increase the wild population numbers and to increase the diversity within wild populations.

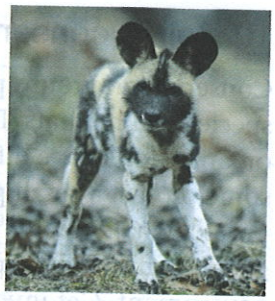


Figure 14 A young African wild dog pup from a captive breeding programme

5. Reduce the threat of invasive species

The spread of **alien** species affects indigenous species populations around the world. **Invasive** species compete with indigenous species for resources and habitats. Alien animal species may prey on the indigenous species. This might force some indigenous species towards extinction. To reduce the threat of invasive species, plant indigenous plants in your garden and help protect indigenous animals in your area.

New words

alien: from another country or continent
invasive: alien organisms that spread out of control

6. Recycle, reuse and reduce

By recycling and reusing as many things as possible, we can reduce our impact on the environment. If we reduce the amount of energy we use, we can reduce our impact on our natural resources.

7. Use fewer herbicides and pesticides

Herbicides and pesticides can be dangerous pollutants that affect living organisms at many levels. Many of these products take a long time to break down and build up in soils or in food chains. This harms organisms and those that feed on them. Some types of animals, such as amphibians, are more vulnerable to these chemical pollutants than others. They suffer greatly because of the high levels of herbicides and pesticides in their habitat.

8. Slow down when driving

Many indigenous animals live in built-up or developing areas. They face various human dangers. Roads are a danger to wildlife living in developed areas. Roads may divide a habitat and be a constant threat to animals crossing from one side to the other. Thousands of animals are killed each year by cars, trucks and other motor vehicles. So, when you are driving, slow down and look out for wildlife.

9. Help prevent or reduce bird collisions

Millions of birds die each year as a result of flying into windows. You can help reduce the number of collisions by placing stickers on the windows in your homes and offices. Other simple steps to reduce possible collisions are moving bird feeders away from buildings, and closing blinds and curtains during the brightest part of the day.

10. Join a conservation group

Conservation groups protect endangered species and habitats. Different organisations have different objectives: some protect a small plot of land or protect whales, while others establish good environmental policies in local government. Get involved locally. You can support well-organised efforts for certain animals, species and habitats. Through such groups, you can voice your concerns about endangered species in your areas.

11. Share your enthusiasm for wildlife and nature

Inspire others to learn about nature, enjoy watching wildlife, and value protecting habitats and species that we share on this planet.

Figure 15 Get involved with organisations such as Greenpop.

Activity 5 Protecting endangered plants and animals

Work in pairs for this activity.

1. Design and make a poster to show actions that can save endangered species in your community. Your poster must not be smaller than A3 size.
2. Display your posters throughout the school as well as in your local community.

Activity 6 Endangered species

Answer the following questions.

1. Name some of the plants and animals in your area that are endangered.
2. List the reasons why people living in your area cut down trees or kill animals that are endangered.
3. Suggest what could be done to stop these people from cutting down trees and killing animals that are endangered.
5. Suggest what could be done to stop the fishermen in your area from catching young or small fish.
6. If fishing were banned for a period of time, suggest what the fishermen could do to earn a living.

SUB-TOPIC 2 Photosynthesis

All living organisms need energy to stay alive. Some organisms, such as animals, depend on plants and/or other animals for this energy. Green plants use the sun's energy to produce their own food from which they get energy.

Photosynthesis is the process in which green plants use the sun's energy to turn carbon dioxide and water into glucose. They obtain:

- carbon dioxide from the air around the plant
- water from the soil.

Green plants contain **chlorophyll**, which is a green pigment that occurs inside the chloroplasts. Chlorophyll traps the energy from the sun.

The leaves use the trapped energy to turn the raw materials, carbon dioxide and water, into glucose (a sugar). This is the food for plants from which they get energy.

Photosynthesis also produces oxygen, which is released into the atmosphere through the stomata.

We can summarise the process of photosynthesis as a word equation:

$$\text{carbon dioxide} + \text{water} \xrightarrow[\text{sunlight}]{\text{chlorophyll}} \text{glucose} + \text{oxygen}$$

Plants change the glucose into starch, cellulose and other chemical compounds such as lipids and proteins. The plant uses these compounds for growth and other activities, such as reproduction.

New words

photosynthesis: a process in which green plants use the sun's energy to turn carbon dioxide and water into glucose
chlorophyll: the green pigment found in green plants

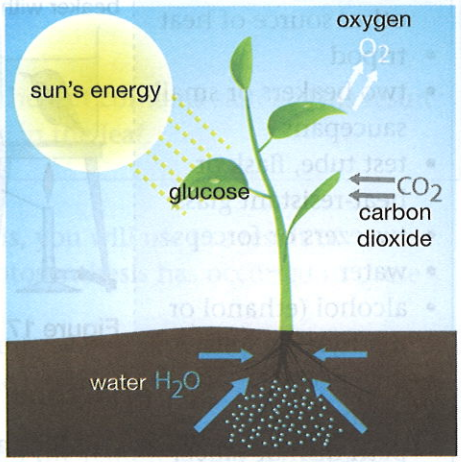


Figure 16 The materials used and produced during photosynthesis

Identifying conditions necessary for photosynthesis

Plants change glucose into starch, which they store in their cells for later use. If a plant cell contains starch, we know that the plant has been photosynthesising.

We will test for starch in plant cells in all the experiments that follow to identify the conditions necessary for photosynthesis.

Activity 7 Show that starch is produced in leaves during photosynthesis

Work in groups of four or five for this practical investigation.

Experiment

Materials

- plant such as a geranium
- Bunsen burner or other source of heat
- tripod
- two beakers or small saucepans
- test tube, flask or heat-resistant glass
- tweezers or forceps
- water
- alcohol (ethanol or methylated spirits)
- dropper
- iodine solution
- petri dish or saucer

Note

The alcohol removes the chlorophyll from the leaf.

Aim

To show that starch is present in a green leaf that has been photosynthesising

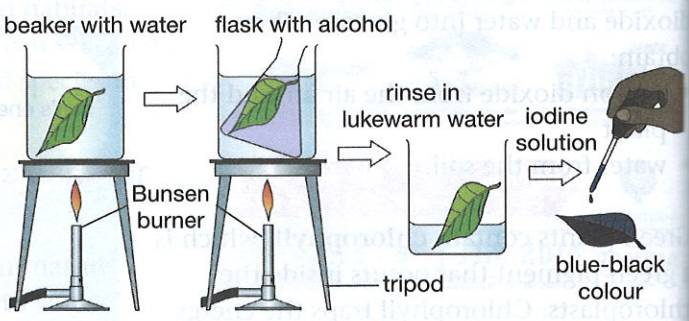


Figure 17 Experimental set-up for the starch test

Method

1. Pick a soft, green leaf from a plant that has been in sunlight for a long time. This ensures that photosynthesis has occurred in the leaf.
2. Place the leaf into a beaker of boiling water for 5 minutes. This will break down the cell walls.
3. Turn off the flame. Remove the leaf from the boiling water. Gently dry the leaf.

Caution

Use forceps or tweezers to remove the leaf from the hot water or alcohol.

4. Place the leaf in a beaker with alcohol.
5. Place the beaker with the leaf and alcohol into a larger beaker with boiling water. The water bath is hot enough to heat the alcohol to its boiling point.
6. Remove the leaf from the alcohol once it has turned white. Rinse the leaf in warm water to soften it.
7. Remove the leaf from the water and dry it.

Caution

Do this part of the experiment away from the flame. Ethanol catches fire very easily.

Continued

8. Place the leaf in a shallow dish. Test for starch by adding two or three drops of iodine solution.
9. Notice the colour change of the leaf.

Observations

The leaf turns a blue-black colour when you apply the iodine solution to it.

Result

This observation is a positive result for the starch test.

Conclusion

The blue-black colour of the leaf shows that the leaf contains starch. This result shows us that photosynthesis has taken place in the leaf.

When you do investigations on photosynthesis, you will use the result of Activity 7 as an indication whether or not photosynthesis has occurred in these situations.

- When we do investigations for photosynthesis, we use two plants.
  - **Control plant**: We give this plant all the requirements it needs for photosynthesis to occur.
  - **Experiment plant**: We give this plant all the requirements it needs for photosynthesis except the factor for which we are testing.
- We destarch a plant by placing it in a dark cupboard for 48–72 hours. During this time, the stored starch is changed to glucose and is used as food and energy within the cells. We destarch the plants so we know they have no starch at the start of each experiment.

Activity 8 Testing for starch

Answer the following questions.

1. Explain the steps that you use to test for starch in a green leaf.
2. Describe the colour change to the iodine solution when starch is present.
3. Explain why we use a water bath when we boil a leaf in alcohol or methylated spirits.

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Activity 9 Show that chlorophyll is needed for photosynthes

Work in groups of four or five for this practical investigation.

Experiment

Materials

- plant with **variegated leaves**
- all the materials for Activity 8

Aim

To show that chlorophyll is needed for photosynthesis

New word

variegated leaf: a leaf that is partly green and partly white

Method

1. Destarch the pot plant by placing it in a dark cupboard for about 24 hours.
2. Remove one leaf and test for starch as described in Activity 7. (The result should be negative to show that the leaf does not contain any starch.)
3. Place the plant in sunlight for about 48 hours.
4. Remove one leaf and test for starch as described in Activity 7.

Note

The part of the leaf with chlorophyll is your control and the part without chlorophyll is your experiment.

Observations/Result

Draw up a table for recording the results of your observation clearly and easily. Then record your results. Give your table a heading. Write the heading on the left-hand side. Start with: "Table showing ..."

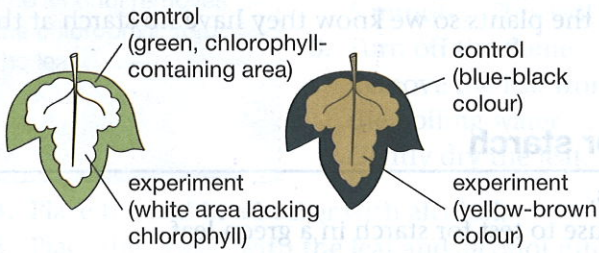

Figure 18 Expected observations for Activity 9

Conclusion

Draw a conclusion with an explanation based on your results.

Activity 10 Show

Work in groups of four or

Experiment

Materials

- pot plant with soft green leaves
- aluminium foil or cardboard
- all the materials for Activity 8

3. Without removing i aluminium foil or bl control and the cove
4. Place the plant in su
5. Remove the leaf tha
6. Remove the foil strip

Observations/Result

Design a table for record results. Remember to giv

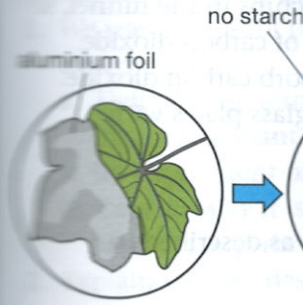

Figure 19 Experimental

Conclusion

Draw a conclusion with

Activity 10 Show that light is needed for photosynthesis

Work in groups of four or five for this practical investigation.

Experiment

Materials

- pot plant with soft green leaves
- aluminium foil or cardboard
- all the materials for Activity 8

Aim

To show that light is needed for photosynthesis

Method

1. Destarch the pot plant.
2. Remove one leaf and test for starch as described in Activity 7. (The result should be negative.)
3. Without removing it from the plant, cover part of one leaf with aluminium foil or black paper. The uncovered part of the leaf is your control and the covered part of the leaf is your experiment.
4. Place the plant in sunlight for about 48 hours.
5. Remove the leaf that has the aluminium foil strip.
6. Remove the foil strip and test for starch as described in Activity 7.

Observations/Result

Design a table for recording your results of this observation. Then record your results. Remember to give your table a heading.

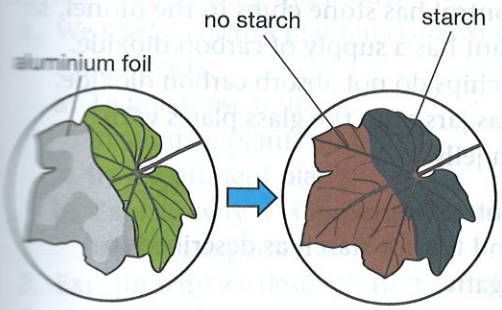

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Figure 19 Experimental set-up and expected observations for Activity 10

Conclusion

Draw a conclusion with an explanation based on your results.

Activity 11 Show that carbon dioxide is needed for photosynthesis

Work in groups of four or five for this practical investigation.

Experiment

Materials

- two pot plants with soft, green leaves
- two bell jars with glass plates
- two rubber stoppers with holes
- small beaker
- sodium hydroxide solution
- sodium bicarbonate solution
- funnel with soda lime
- funnel with small stone
- petroleum jelly
- all the materials needed for Activity 7

Aim

To show that carbon dioxide is needed for photosynthesis

Method

1. Destarch the plants.
2. Set up the experiment and control plants as shown in Figure 20 on page 75.
   - » The experiment has marble chips (soda lime) in the funnel and a beaker of sodium hydroxide in the small beaker to absorb carbon dioxide. This plant has no carbon dioxide supply.
   - » The control has stone chips in the funnel, so the plant has a supply of carbon dioxide. Stone chips do not absorb carbon dioxide.
3. Seal the gas jars onto the glass plates with petroleum jelly.
4. Place the plants in sunlight for about 48 hours.
5. Remove one leaf from each plant and test for starch as described in Activity 7. (The result should be negative.)

Tip

Make sure you remember which leaf is the experiment and which is the control!

Observations

Draw a fully labelled biological drawing of both leaves *after* you have done the starch test.

Result

Draw up a table for recording the results of your observation. Then record your results. Remember to give your table a heading.

Continued

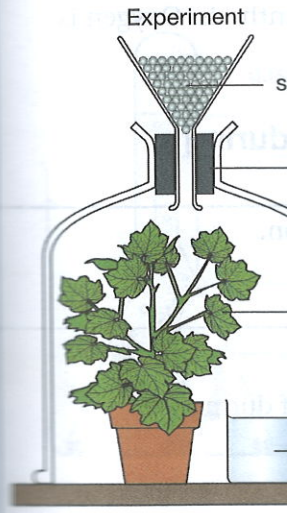


Figure 20 Experimenta

Conclusion

Draw a conclusion wit

Activity 12 Und

Answer the following q

1. We used a control p experiments.
   a) Define these ter
      i) control plant
      ii) experiment p
   b) Explain why it i in these experim
2. Explain why we de
3. Name the chemical the air in the flask photosynthesis to
4. Explain what a vari
5. Explain why crops grow well.
6. Explain why crops, yellow.

Continued

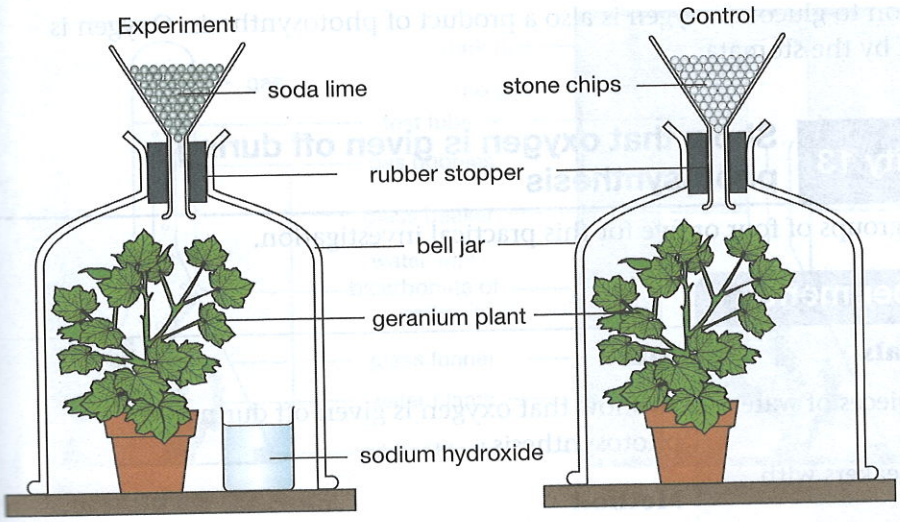


Figure 20 Experimental set-up for Activity 11

Conclusion

Draw a conclusion with an explanation based on your results.

Activity 12 Understanding photosynthesis

Answer the following questions.

1. We used a control plant and an experiment plant in all the photosynthesis experiments.
   a) Define these terms:
      i) control plant
      ii) experiment plant.
   b) Explain why it is important to use a control plant and an experiment plant in these experiments.
2. Explain why we destarch the plant before each photosynthesis experiment.
3. Name the chemical substance used to remove carbon dioxide from the air in the flask when you prove that carbon dioxide gas is needed for photosynthesis to occur.
4. Explain what a variegated leaf is.
5. Explain why crops that are growing under thick or tall trees do not grow well.
6. Explain why crops, such as maize, do not grow well if their leaves have turned yellow.

Identifying products of photosynthesis in a leaf

In addition to glucose, oxygen is also a product of photosynthesis. Oxygen is given off by the stomata.

Activity 13 Show that oxygen is given off during photosynthesis

Work in groups of four or five for this practical investigation.

Experiment

Materials

- two pieces of water plant
- two beakers with water
- sodium bicarbonate
- two test tubes
- two small funnels
- six to eight rubber blocks
- two rubber stoppers to fit test tubes
- wooden splint
- source of fire

Aim

To show that oxygen is given off during photosynthesis

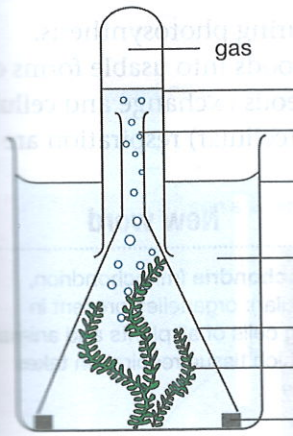
Method

1. Pour water with sodium bicarbonate into both beakers. Sodium bicarbonate and some of the water will produce carbon dioxide gas.
2. Place each water plant in a glass beaker. Turn each funnel upside down and place it on top of the plant. Rest each funnel on three or four rubber blocks (see Figure 21).
3. Place the experiment plant in a dark cupboard and the control plant in sunlight for about 48 hours.
4. If bubbles appear in one of the test tubes, carefully remove the test tube from the funnel without letting the gas escape.
5. Seal the test tube with the rubber stopper while it is still under the water. Remove the test tube from the water.
6. Place a glowing wooden splint in the gas trapped in the test tube.

Caution

Be careful when you light the wooden splint. Make sure that the splint is glowing and does not have a flame when you test the gas in the test tube.

Continued



Control

Figure 21 Experimenta

Observations

Observe what happens wh splinter.

Result

Design a table for recordi results. Remember to give

Conclusion

Draw a conclusion with a

Activity 14 Produ

Answer the following ques

1. Photosynthesis has tw
   a) Name the two proc
   b) i) Which product
      ii) In what form do
      iii) Where do plant
   c) What do plants do

Continued

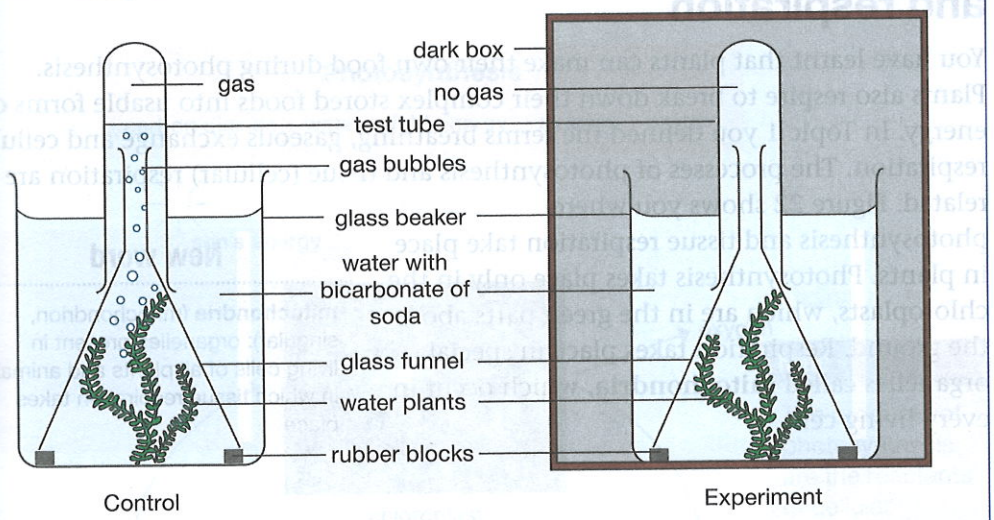


Figure 21 Experimental set-up and expected observations for Activity 13

Observations

Observe what happens when you test the gas in the test tube with the glowing splinter.

Result

Design a table for recording the results of this observation. Then record your results. Remember to give your table a heading in the correct way.

Conclusion

Draw a conclusion with an explanation based on your results.

Activity 14 Products of photosynthesis

Answer the following questions.

1. Photosynthesis has two products.
   a) Name the two products.
   b) i) Which product do plants make for storing the sun's energy?
      ii) In what form do they store this product?
      iii) Where do plants store the substance mentioned in question 1a)ii)?
   c) What do plants do with the second product mentioned in question 1a)?

Relationship between photosynthesis and respiration

You have learnt that plants can make their own food during photosynthesis. Plants also respire to break down their complex stored foods into usable forms of energy. In Topic 1 you defined the terms breathing, gaseous exchange and cellular respiration. The processes of photosynthesis and tissue (cellular) respiration are related. Figure 22 shows you where photosynthesis and tissue respiration take place in plants. Photosynthesis takes place only in the chloroplasts, which are in the green parts above the ground. Respiration takes place in special organelles called **mitochondria**, which occur in every living cell.

New word

mitochondria (mitochondrion, singular): organelles present in living cells of all plants and animals in which tissue respiration takes place

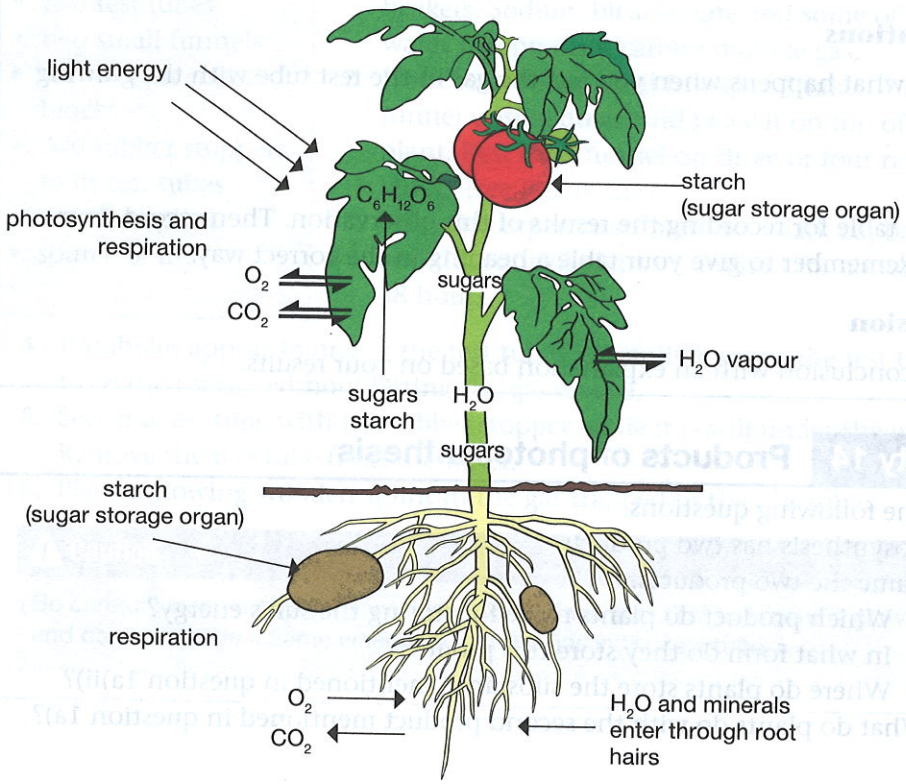


Figure 22 Diagram showing where photosynthesis and respiration take place in a plant

Figure 23 shows the materials needed by photosynthesis and cellular respiration, and how the processes are related.

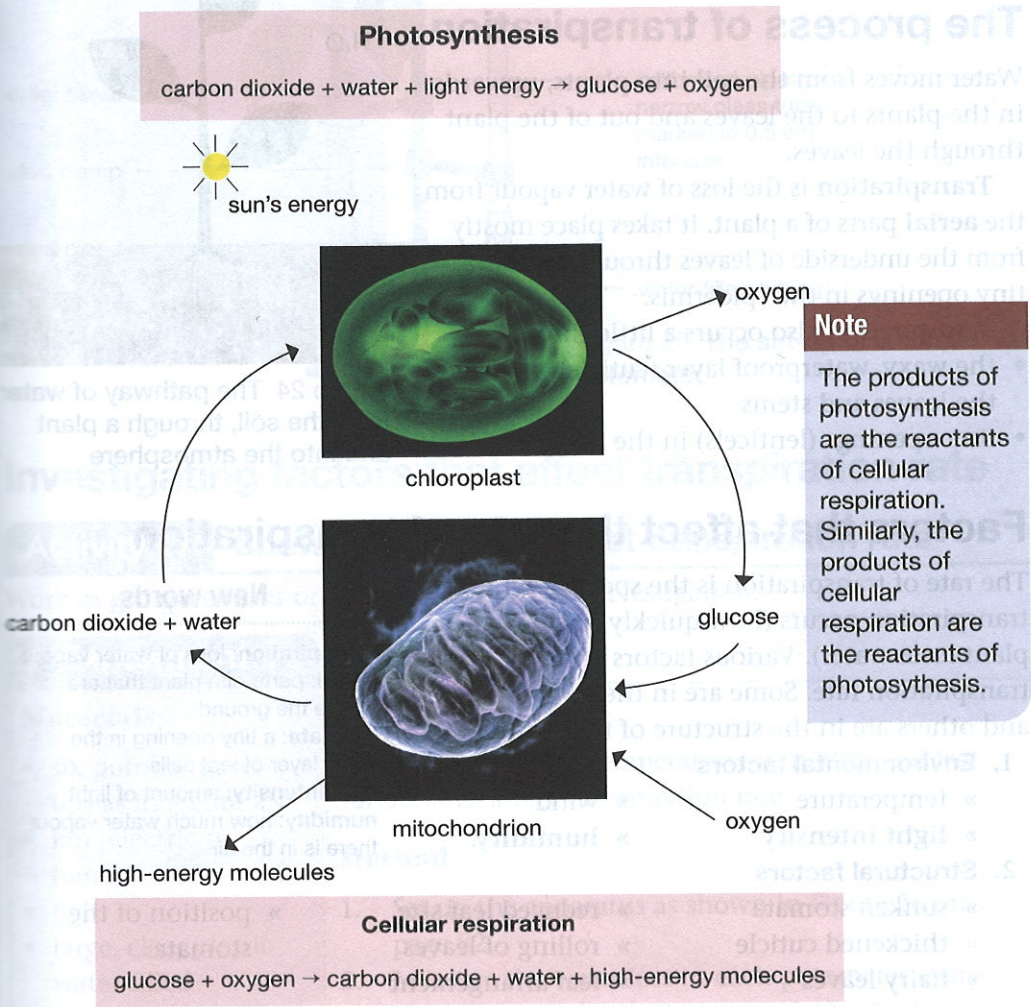


Figure 23 The relationship between photosynthesis and cellular respiration

Activity 15 Compare photosynthesis and respiration

Answer the following questions.

1. Discuss the importance of photosynthesis for both plants and animals.
2. Discuss the importance of respiration for all organisms.
3. Use a table to compare photosynthesis and respiration.

SUB-TOPIC 3

Transpiration

The process of transpiration

Water moves from the soil into plants, upwards in the plants to the leaves and out of the plant through the leaves.

Transpiration is the loss of water vapour from the **aerial** parts of a plant. It takes place mostly from the underside of leaves through **stomata**, tiny openings in the epidermis.

Transpiration also occurs a little through:

- the waxy, waterproof layer (cuticle) that covers the leaves and stems
- tiny openings (lenticels) in the bark.

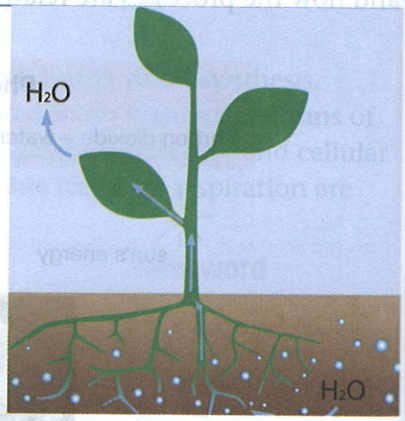


Figure 24 The pathway of water from the soil, through a plant and into the atmosphere

Factors that affect the rate of transpiration

The rate of transpiration is the speed at which transpiration occurs (how quickly or slowly a plant loses water). Various factors affect transpiration rate. Some are in the environment and others are in the structure of the plant.

1. **Environmental factors**
   - » temperature
   - » **light intensity**
   - » wind
   - » **humidity**.
2. **Structural factors**
   - » sunken stomata
   - » thickened cuticle
   - » hairy leaves
   - » reduced leaf size
   - » rolling of leaves
   - » leaf arrangement
   - » position of the stomata.

New words

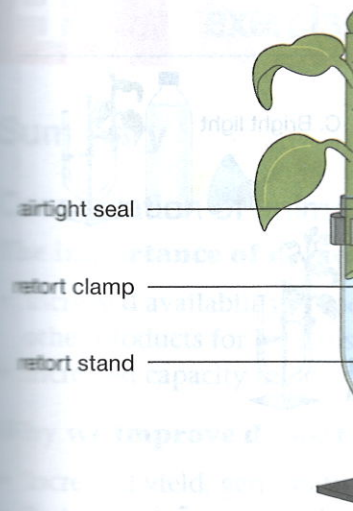
transpiration: loss of water vapour
aerial: parts of a plant that are above the ground
stomata: a tiny opening in the outer layer of leaf cells
light intensity: amount of light
humidity: how much water vapour there is in the air

We measure transpiration rate in plants with a potometer. Figure 25 on page 81 shows how to set up a potometer.

Activity 16 Structural factors affecting transpiration rate

Work in seven groups of equal size for this activity. Each group will investigate one structural factor in a plant that affects transpiration rate.

1. Plan your investigation in your groups. Decide on your approach and what your roles will be, for example, who will set up the investigation and who will record the observations.
2. Carry out your investigation.
3. Prepare an oral presentation for the rest of the class to share your information.



Investigating fact

Activity 17 Show

Work in groups of four or fi

Experiment

Materials

- six potometer set-ups as in Figure 25
- fan (electric or hand)
- light
- large, clear plastic water-filled container with large opening
- electric heater or other source of heat
- large plastic bag sprayed with water on the inside
- timing device (watch, stopwatch or cellphone)

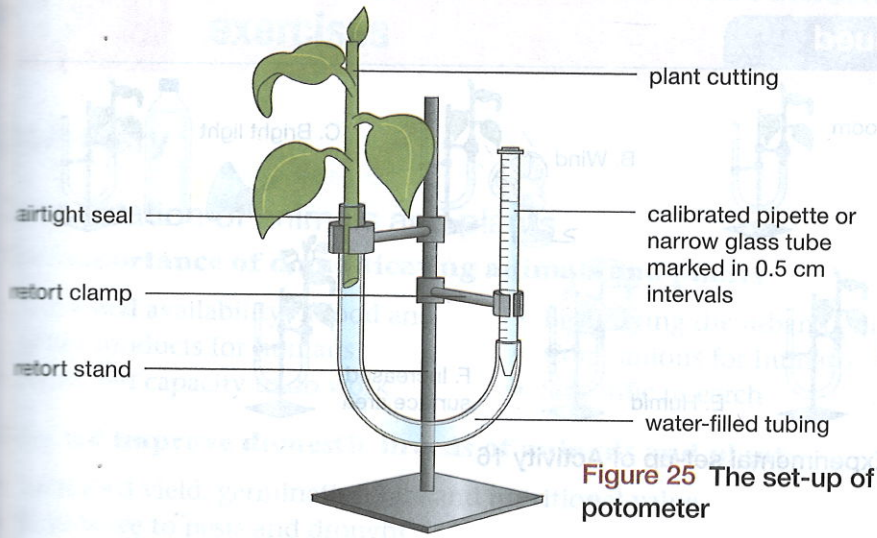


Figure 25 The set-up of a simple potometer

Investigating factors that affect transpiration rate

Activity 17 Show how factors affect transpiration rate

Work in groups of four or five for this practical investigation.

Experiment

Materials

- six potometer set-ups as in Figure 25
- fan (electric or hand)
- light
- large, clear plastic water-filled container with large opening
- electric heater or other source of heat
- large plastic bag sprayed with water on the inside
- timing device (watch, stopwatch or cellphone)

Aim

To show how wind, temperature, humidity and leaf surface area affect transpiration rate

Method

1. Set up the apparatus as shown in Figure 26 on page 82.
2. Measure the water loss in each potometer every three minutes for a minimum of 30 minutes.

Note

Make sure that:
- five plant cuttings have the same number of leaves
- the leaves are the same size on all the cuttings
- the sixth cutting has double the number of leaves that the other five have.

Continued

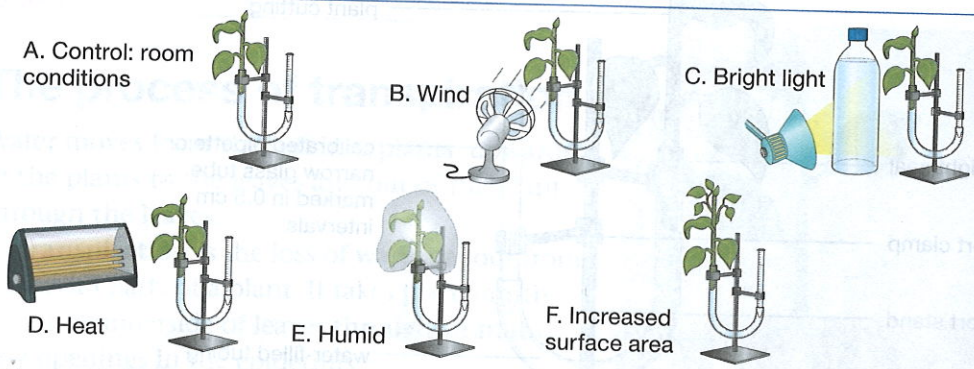


Figure 26 Experimental set-up of Activity 16

Results

Draw up a table with the complete list of factors. Record your results for each factor.

Factors that affect the rate of transpiration

Factor	Change in factor	Effect on transpiration rate
Wind speed		

Conclusion

Write a conclusion with an explanation based on your results for each potometer.

The importance of transpiration for plants

Functions of transpiration

Movement of water and mineral nutrients in the plant

- Water and nutrients are moved from the roots to the rest of the plant.
- This brings nutrients to the cells.
- Water is needed for photosynthesis in the leaves.

Cooling the plant

- The sun's energy is needed for photosynthesis, but also increases the plant's temperature. Loss of water vapour loss through the stomata cools the plant and prevents overheating.

Keeping the cells turgid

- Most of the plant body consists of water, which is replaced from the soil water when water vapour transpires from leaves.
- Transpiration keeps plant cells turgid (swollen), which helps keep plants standing upright.
- If plants absorb too much water, the excess water is released by transpiration.
- If transpiration is greater than water absorption, plants lose too much water and wilt.

Summary

Conservation of anim

The importance of dom

- Increased availability of
  other products for huma
- Increased capacity to do

Why we improve domes

- Increased yield, germinat
- Resistance to pests and d

Ways of improving domesti
- Cross-pollination
- Grafting plants

Animals and plants that

The human activities mostly
of organisms are: • poachin
production • overfishing a
for human use • pollution

Importance of protectin

- Extinction of most organi
  - pollution
  - habitat destruction
  - introduction of alien or
  - direct killing
- Endangered species must

Benefits of protecting en

ecological • medicinal •

Ways to protect endange

- Methods of protecting end
  - protect the natural habi
  - pass legislation that ma
  - educate people about en
  - captive breeding and rel

TOPIC 4

Summary, revision and assessment exercises

Summary

Conservation of animals and plants

The importance of domesticating animals and plants

- Increased availability of food and other products for humans
- Increased capacity to do work
- Beautifying the urban habitat
- Companions for humans
- Scientific research

Why we improve domestic breeds of animals and plants

- Increased yield, germination rate and nutritional value
- Resistance to pests and drought

Ways of improving domestic breeds:

- » Cross-pollination
- » Grafting plants
- » Cross breeding
- » Artificial insemination

Animals and plants that are threatened by extinction

The human activities mostly responsible for the extinction or possible extinction of organisms are: • poaching • illegal wildlife trade and logging • charcoal production • overfishing and unsustainable fishing methods • land conversion for human use • pollution • wild fires.

Importance of protecting endangered species

- Extinction of most organisms today results from human activities such as:
  - » pollution
  - » habitat destruction
  - » introduction of alien organisms
  - » direct killing
  - » commercial overexploitation
  - » poaching
  - » deforestation.
- Endangered species must be protected and saved for future generations.

Benefits of protecting endangered species

• ecological • medicinal • agricultural • economic • social.

Ways to protect endangered animals and plants

- Methods of protecting endangered organisms are:
  - » protect the natural habitat
  - » pass legislation that makes it illegal to kill or harm endangered species
  - » educate people about endangered species and nature
  - » captive breeding and release programmes

» reduce the threat of invasive species
» recycle, reuse and reduce consumption of energy and goods
» minimise the use of herbicides and pesticides
» slow down when driving
» join a conservation organisation
» share your enthusiasm for wildlife and nature.

Photosynthesis

- The substances needed for photosynthesis to take place are:
  » carbon dioxide » water » sunlight » chlorophyll.
- The products of photosynthesis are: » glucose » oxygen.
- The process of photosynthesis can be summarised as a word equation:

$$\text{carbon dioxide} + \text{water} \xrightarrow[\text{sunlight}]{\text{chlorophyll}} \text{glucose} + \text{oxygen}$$

- The starch test shows that starch is present in leaves that have photosynthesised.
- An iodine colour change from brown to blue-black shows the presence of starch.
- A plant is destarched by placing it in a dark cupboard for 48–72 hours.
- When doing the investigations for photosynthesis, give:
  » the control plant all the requirements for photosynthesis, including the factor being tested
  » the experiment plant all the requirements for photosynthesis except the factor being tested.

Relationship between photosynthesis and respiration

	Photosynthesis	Respiration
Where it takes place	• In chloroplasts in green plants	• In mitochondria in all living cells
When it takes place	• In the presence of sunlight	• All the time
Raw materials and conditions required	• Carbon dioxide, sun's energy, water and chlorophyll	• Oxygen
Products of the reaction	• Glucose and oxygen	• High-energy molecules, carbon dioxide and water
Action of the reaction	• Chlorophyll absorbs energy from the sun to change water and carbon dioxide into glucose	• Mitochondria have enzymes that break down glucose into water, carbon dioxide and energy-rich molecules

Summary, revisi continued

Transpiration

- Transpiration is the lo
- The rate of transpiratio

Factors that affect th

- Environmental factors
  » temperature »
- Structural factors inclu
  » sunken stomata
  » thickened cuticle
  » hairy leaves
- The rate of transpiratio
  » wind speed
  » light intensity

The importance of tra

- Transpiration is respon
  » the upward moveme mineral nutrients fro

Revision exercise

1. Choose an item from Write only the letter

a	Joining a stem w stock (stem) of a
b	Refers to an orga
c	Increased food p
d	An example of a becoming extinc
e	When sperm is p animal by a veter
f	Continually catch
g	The variety of pla
h	A value of protec
i	One way of prote
j	A result of fishing

Summary, revision and assessment exercises continued

Transpiration

- Transpiration is the loss of water vapour, mostly from the stomata of the leaves.
- The rate of transpiration refers to how quickly or slowly a plant loses water.

Factors that affect the rate of transpiration

- Environmental factors include:
  - » temperature
  - » light intensity
  - » wind
  - » humidity.
- Structural factors include:
  - » sunken stomata
  - » thickened cuticle
  - » hairy leaves
  - » reduced leaf size
  - » rolling of leaves
  - » leaf arrangement
  - » position of the stomata.
- The rate of transpiration is affected by:
  - » wind speed
  - » light intensity
  - » temperature
  - » humidity
  - » surface area of the leaf.

The importance of transpiration for plants

- Transpiration is responsible for:
  - » the upward movement of water and mineral nutrients from the roots
  - » cooling the plant
  - » keeping the cells turgid.

Revision exercises

1. Choose an item from Column II that matches a description in Column I. Write only the letter next to the corresponding question number.

	Column I		Column II
a	Joining a stem with buds (scion) onto the stock (stem) of another plant	A	Biological diversity
b	Refers to an organism threatened with extinction	B	Artificial insemination
c	Increased food production for humans	C	Overfishing
d	An example of a species that is at high risk of becoming extinct in the wild	D	Ecological benefit
e	When sperm is placed in the vagina of a female animal by a veterinarian	E	Grafting
f	Continually catching too many fish	F	Zambezi teak
g	The variety of plant and animal life on the earth	G	Unsustainable fishing methods
h	A value of protecting endangered organisms	H	Domestication
i	One way of protecting endangered organisms	I	Vulnerable
j	A result of fishing with mosquito nets	J	Protection of the habitat

2. Give the correct biological term for each description.
   a) Changing a living species over many generations for the benefit of humans
   b) Transferring ripe pollen grains from the anthers of a flower on a plant to the stigma of another flower on a different plant
   c) Producing new individuals by breeding two different varieties of the same species
   d) Species that occur only in one specific region or environment in the world
   e) The organelle that contains chlorophyll in green plants
   f) The reagent used to test for the presence of starch
   g) The chemical substance used to remove chlorophyll from a leaf
   h) A healthy leaf that has both green and non-green areas
   i) The loss of water vapour from the parts of a plant that are above the ground
   j) The openings on the surface of leaves through which water vapour is lost

3. Indicate whether each of the statements in Column I applies to A only, B only, both A and B or neither of the items in Column II. Write A only, B only, both A and B or neither next to the question number.

	Column I		Column II
a	Describes a plant that can grow in dry regions	A B	Increased germination rate Resistant to drought
b	A product of photosynthesis	A B	Carbon dioxide Oxygen
c	An experimental set-up supplied with all the conditions	A B	Experiment Control
d	A possible way of protecting endangered organisms	A B	Education Captive breeding programmes
e	An increase in the amount of nutrients in each fruit	A B	Increased nutritional value Increased yield
f	A product of cellular respiration	A B	Carbon dioxide Oxygen
g	Absorbs carbon dioxide from air	A B	Sodium bicarbonate Sodium hydroxide
h	The structure from which water vapour is lost from a woody plant	A B	Stomata Lenticels

Summary, revis continued

	Colu
i	Factor(s) that cause rate to increase
j	Responsible for limi plants

Assessment exe

1. Explain the import
2. Explain the import
3. Describe the proces
4. A poacher claims th to earn money to su can earn money tha
5. Explain why it is in human use.
6. Explain why leaves transpiration rate than leaves wit
7. Compare the proce regard to the follow
   a) where each pro
   b) the organelle as
   c) when the proce
   d) the raw materia
   e) the products of

8. Make a fully labelle to show that chloro

Summary, revision and assessment exercises continued

	Column I		Column II
i	Factor(s) that cause(s) the transpiration rate to increase	A B	Decreased humidity Decreased leaf surface area
j	Responsible for limiting water loss in plants	A B	Bark Cuticle

[10] U

Assessment exercises

1. Explain the importance of arresting poachers and illegal tree cutters. [4] C
2. Explain the importance of implementing a tree-planting campaign. [5] C
3. Describe the process of testing a leaf for the presence of starch. [12] C
4. A poacher claims that he hunts animals such as elephants and rhinos to earn money to support his family. Suggest alternative ways in which he can earn money that will not affect these animals negatively. [5] Ap
5. Explain why it is important not to cut down too many trees for human use. [5] An
6. Explain why leaves with a large surface area have a higher rate of transpiration rate than leaves with a small surface area. [4] Ap
7. Compare the processes of photosynthesis and cellular respiration with regard to the following:
   a) where each process occurs (2)
   b) the organelle associated with each process (2)
   c) when the process occurs (2)
   d) the raw materials needed for each (6)
   e) the products of each reaction. (5)

   [17] An
8. Make a fully labelled biological drawing of a leaf that has been used to show that chlorophyll is needed for photosynthesis. [20] Ap

TOPIC 5

Materials and energy

Sub-topics	Specific Outcomes
Chemical reactions	• Describe what a chemical reaction is. • Describe the nature of chemical reactions. • Classify different types of chemical reactions. • Describe the chemical reaction of synthesis. • Demonstrate the chemical reaction of water with electricity. • Explain the law of conservation of matter.
Light and its nature	• Describe the different types of lenses. • Demonstrate the location of the focal point and focal length of a lens. • Explain the mechanism of a converging lens to produce real and virtual images. • Explain the uses of converging and diverging lenses. • Demonstrate the production of a spectrum from white light. • Demonstrate the combination of colours of the spectrum to produce white light. • Describe the production of a rainbow. • Explain why sunsets and sunrise appear red. • Explain that the colour of an object depends on the colour of light it reflects. • Describe the effects of colour filters on light rays.
Electric current and voltage in a circuit	• Explain the difference between electric current and voltage. • Demonstrate the use of an ammeter to measure electric currents in a circuit. • Demonstrate how to measure potential difference in a circuit. • Describe the relationship between potential difference and current. • Explain the use of electric current in the local environment.
Pressure	• State what pressure is. • Identify factors affecting pressure in gases.
Energy and its conservation	• Explain what energy is. • Identify different forms of energy. • Describe how different forms of energy can be changed. • Explain the law of energy conservation. • Explain the effects of energy production on the environment. • Explain ways of conserving energy.
Communication	• Identify ways of sending and receiving information over long distances. • Describe the advantages and disadvantages of the different ways of sending messages.

Digital and analogue transmission	• Desc • Expl • Expl trans
Satellite communications	• Expl • Desc Afric

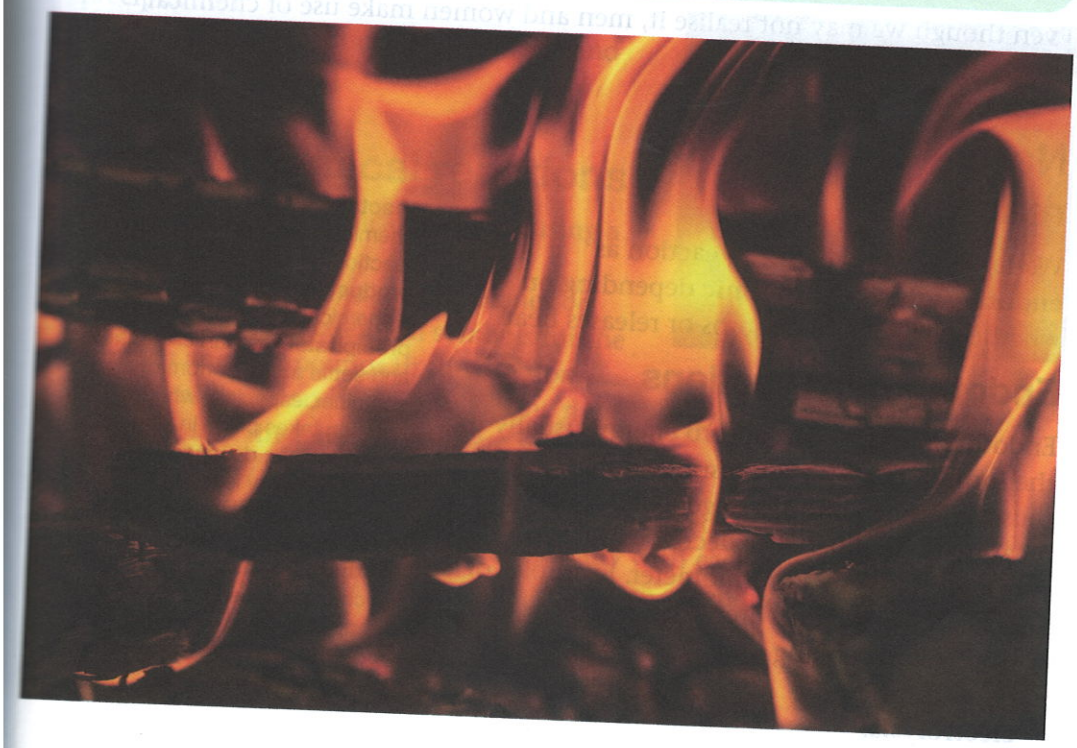
Starter activity

1. Work in groups of f piece of paper ready Science does not on all around us all the
   - adding sugar to y
   - burning firewood
   - bread dough risin
   - baking risen brea
   - rust on metal.
2. Chemical changes a changes that you th have made their list list as a class.

Digital and analogue transmission	• Describe the transmission of radio and television signals. • Explain the amplification of sound. • Explain the difference between digital and analogue transmission of information.
Satellite communications	• Explain the use of satellites in long-distance communication. • Describe the transmission of a live broadcast of an event from Africa to Europe using raw block diagrams.

Starter activity

1. Work in groups of five to six and then as a class for this activity. Have a piece of paper ready to write down your ideas.
   Science does not only happen in a science laboratory. Science is happening all around us all the time. Think about:
   - adding sugar to your tea or coffee
   - burning firewood
   - bread dough rising
   - baking risen bread in an oven
   - rust on metal.
2. Chemical changes are taking place in all of these examples. List all the changes that you think take place in each example. Once all the groups have made their lists, make a combined list of all your ideas. Discuss this list as a class.



SUB-TOPIC 1

Chemical reactions

Chemical reactions

A chemical reaction takes place when one or more substances changes into different substances. The substance that forms was not there at the start of the chemical reaction.

For example, when you burn wood, black charcoal and ash form.

Figure 1 Burnt wood or charcoal

The substances needed for a chemical reaction to occur are called the **reactants**. The new substances that are made during a chemical reaction are called the **products**.

You know that a chemical reaction is happening when you see one or more of the following:

- colour change
- temperature change
- gas produced
- **precipitate** forms.

Even though we may not realise it, men and women make use of chemical reactions every day.

Nature of a chemical reaction

We can classify a chemical reaction as **endothermic** or **exothermic** depending on whether the reaction absorbs or releases heat.

Endothermic reactions

Endothermic reactions absorb energy, usually in the form of heat, from the surroundings. This causes the surroundings to get colder. We can measure the temperature decrease of the surroundings with a thermometer. Examples of endothermic reactions are:

- baking and cooking
- photosynthesis
- **electrolysis**.

New words

reactant: a substance involved in a chemical reaction before the reaction takes place
product: a substance produced by a chemical reaction
precipitate: fine particles that form and settle at the bottom of a container, especially when a reaction takes place in a liquid
endothermic: describes a reaction in which energy is taken in (absorbed), for example, bread dough rising
exothermic: describes a reaction in which energy (heat) is given out, for example, burning wood
electrolysis: separating substances using an electric current

a

Figure 2 a) Rising brea
reactions.

Exothermic rea

Exothermic reactions t
the form of heat, to the
causes the surrounding
measure the temperatu
surroundings with a the
exothermic reactions ar

- burning
- rusting iron
- precipitation
- **neutralisation** reactic
  bases.

Types of chem

- We can represent cher
  chemical equation.
- We can write this form
  words, or using the ch
  elements and compou
- A chemical equation h
  hand side and the left-
  by an arrow, →.
  - » The substance(s) on
    substances have not
  - » The substance(s) on
    substances have reac
  - » We can write a gener

Figure 2 a) Rising bread dough and b) baking bread are both endothermic chemical reactions.

Exothermic reactions

Exothermic reactions transfer energy, usually in the form of heat, to the surroundings. This causes the surroundings to get hotter. We can measure the temperature increase of the surroundings with a thermometer. Examples of exothermic reactions are:

- burning
- rusting iron
- precipitation
- **neutralisation** reactions between acids and bases.

New words

neutralisation: a chemical reaction in which an acid and a base form a salt

chemical equation: a sentence that describes what happens in a chemical reaction

Figure 3 Rusting of metal is an exothermic reaction.

Types of chemical reactions

- We can represent chemical reactions using a **chemical equation**.
- We can write this formula using names or words, or using the chemical symbols for the elements and compounds in the reaction.
- A chemical equation has two sides. The right-hand side and the left-hand side are separated by an arrow, →.
  - The substance(s) on the left-hand side is/are called reactant(s). These substances have not yet reacted chemically with each other.
  - The substance(s) on the right-hand side is/are called product(s). These substances have reacted chemically with each other.
  - We can write a general chemical equation as: $PQ + R \rightarrow PR + Q$

    Reactants → Products

- We will study four types of chemical reactions in Grade 9:
  - » synthesis
  - » decomposition
  - » single replacement
  - » double replacement.

Synthesis

- In synthesis, two or more simple substances combine to form a more complex substance. So, two or more reactants yield one product.
- We write these reactions in general form as: $X + Y \rightarrow XY$
- Examples of this type of reaction are:
  - » copper + oxygen → copper oxide
  - » iron + sulphur → iron(II) sulphide
  - » sulphur + oxygen → sulphur dioxide
  - » iron + oxygen → iron oxide (iron rusting)

Decomposition

- In decomposition, a more complex substance breaks down into simpler parts. So, one reactant yields two or more products.
- We write these reactions in general form as: $XY \rightarrow X + Y$
- Examples of this type of reaction are:
  - » water → hydrogen + oxygen (electrolysis of water)
  - » calcium carbonate → calcium oxide + carbon dioxide

Single replacement

- In this type of chemical reaction, a single element replaces another element in a compound. So, one element changes place with another element in a compound.
- We write these reactions in general form as: $W + XY \rightarrow XW + Y$
- Examples of this type of reaction are:
  - » water + magnesium → magnesium hydroxide + hydrogen
  - » calcium + hydrogen chloride → calcium chloride + hydrogen

Double replacement

- In this type of chemical reaction, the anions and cations of two compounds change places to form two different compounds.
- We write these reactions in general form as: $VW + XY \rightarrow XW + YV$
- Examples of this type of reaction are:
  - » barium chloride + magnesium sulphate → barium sulphate + magnesium chloride
  - » lead nitrate + potassium iodide → lead iodide + potassium nitrate

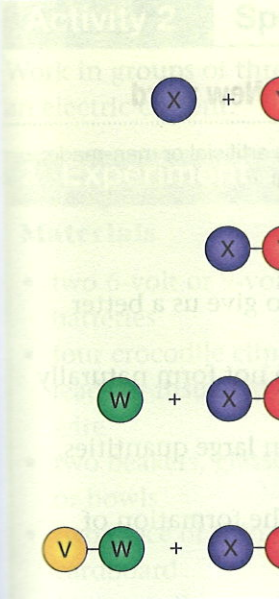


Figure 4 A diagramma

Activity 1 An

Answer the following

1. List four observati reaction has taker
2. Name the type of
3. Name the four ba Grade 9. Write th
4. Name the type of following chemic
   - a) sodium + chl Na +
   - b) zinc + hydroc Zn +
   - c) calcium carb $CaCO_3$
   - d) silver nitrate $AgNO_3$
   - e) hydrogen pe $2H_2O_2$
   - f) hydrogen + c $2H_2$ +
   - g) magnesium Mg

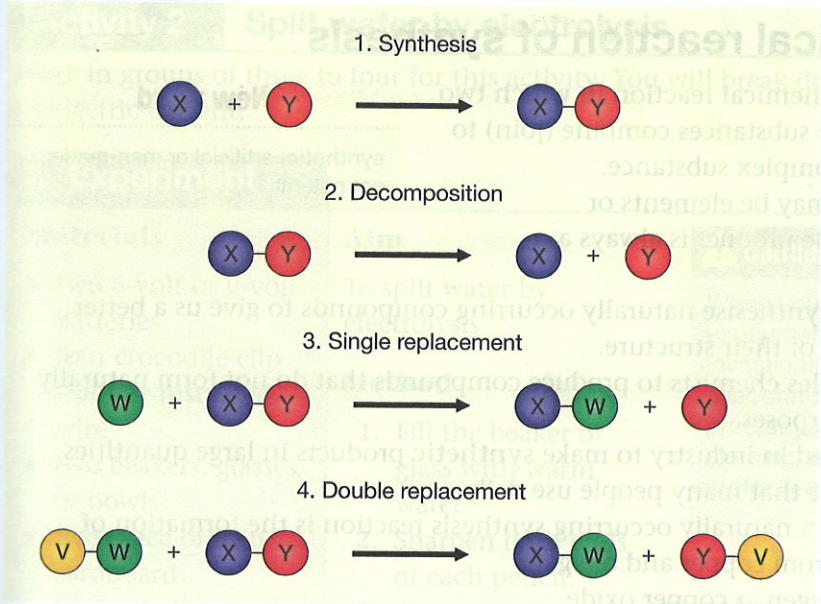


Figure 4 A diagrammatic representation of the four types of chemical reactions

Activity 1 Answer questions on chemical reactions

Answer the following questions.

1. List four observations that you can use as an indication that a chemical reaction has taken place between substances.
2. Name the type of chemical reaction that absorbs heat from its surroundings.
3. Name the four basic types of chemical reactions that you have learnt about in Grade 9. Write the general chemical formula for each type.
4. Name the type of chemical reaction that has taken place in each of the following chemical reactions:
   a) sodium + chlorine → sodium chloride
      $Na + Cl \rightarrow NaCl$
   b) zinc + hydrochloric acid → zinc chloride + hydrogen
      $Zn + 2HCl \rightarrow ZnCl_2 + H_2$
   c) calcium carbonate → calcium oxide + carbon dioxide
      $CaCO_3 \rightarrow CaO + CO_2$
   d) silver nitrate + sodium chloride → silver chloride + sodium nitrate
      $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$
   e) hydrogen peroxide → water + oxygen
      $2H_2O_2 \rightarrow 2H_2O + O_2$
   f) hydrogen + oxygen → water
      $2H_2 + O_2 \rightarrow 2H_2O$
   g) magnesium + hydrochloric acid → magnesium chloride + hydrogen
      $Mg + 2HCl \rightarrow MgCl_2 + H_2$

The chemical reaction of synthesis

- Synthesis is a chemical reaction in which two or more simple substances combine (join) to form a more complex substance.
- The reactants may be elements or compounds; the product is always a compound.
- Scientists can synthesise naturally occurring compounds to give us a better understanding of their structure.
- Synthesis enables chemists to produce compounds that do not form naturally for research purposes.
- Synthesis is used in industry to make **synthetic** products in large quantities, especially those that many people use daily.
- An example of a naturally occurring synthesis reaction is the formation of copper oxide from copper and oxygen:
  - » copper + oxygen → copper oxide.
- This reaction occurs slowly to form a layer of brown-black copper oxide. However, unlike rust, which forms when iron is exposed to moist air, copper oxide protects the underlying copper from further corrosion.

New word

synthetic: artificial or man-made; not natural

Figure 5 a) This can is made from a synthetic material, plastic. b) Copper oxide has formed naturally on this old copper kettle.

Chemical reaction of water using an electric current

- We can break down or split water (decomposition) by passing an electric current through it.
- This process is known as electrolysis.
- Water does not conduct electricity well by itself. We can speed up the process by adding table salt or sulphuric acid to the water.

Activity 2 Sp

Work in groups of th
an electric current.

Experiment

Materials

- two 6-volt or 9-vo batteries
- four crocodile clip leads or insulated wire
- two beakers, glass or bowls
- two piece of thin cardboard
- four pencils
- table salt or sulphuric acid

4. Push the pencils extend into the will hold them i
5. Alternatively, us at an angle. Ther pencil to catch t
6. Connect a croco exposed pencil le connects both pe
7. Repeat steps 1–6, acid to the water
8. Run both sets of time.
9. Observe what ha tips in the water.

Activity 2 Split water by electrolysis

Work in groups of three to four for this activity. You will break down water using an electric current.

Experiment

Materials

- two 6-volt or 9-volt batteries
- four crocodile clip leads or insulated wire
- two beakers, glasses or bowls
- two piece of thin cardboard
- four pencils
- table salt or sulphuric acid

Aim

To split water by electrolysis

Method

1. Fill the beaker or glass with warm water.
2. Sharpen both ends of each pencil.
3. Cut a piece of cardboard to fit over one beaker. Then punch two holes in the cardboard about 2–3 cm apart.
4. Push the pencils through the holes in the cardboard. The pencils should extend into the water, but not touch the bottom of the glass. The cardboard will hold them in place.
5. Alternatively, use sticky putty to attach the pencils to the sides of the glass at an angle. Then place a small, water-filled test tube over the tip of each pencil to catch the bubbles that are formed at each pencil point.
6. Connect a crocodile clip lead to each exposed pencil lead (graphite). This connects both pencils to the battery.
7. Repeat steps 1–6, but add salt or sulphuric acid to the water.
8. Run both sets of apparatus at the same time.
9. Observe what happens around the pencil tips in the water.

Caution

When you do any experiment or investigation, always wear a laboratory coat to protect yourself and your clothing, and goggles to protect your eyes.

Note

(The pencils are your electrodes. The graphite in them will conduct electricity, but will not dissolve in the water.)

Note

If you do not have crocodile clip leads, use two lengths of insulated wire. Strip 2.5 cm of insulation from each end. Wrap the wire around the graphite of each pencil and connect the wires to the battery. Tape the wires in place.

Continued

Observations/results

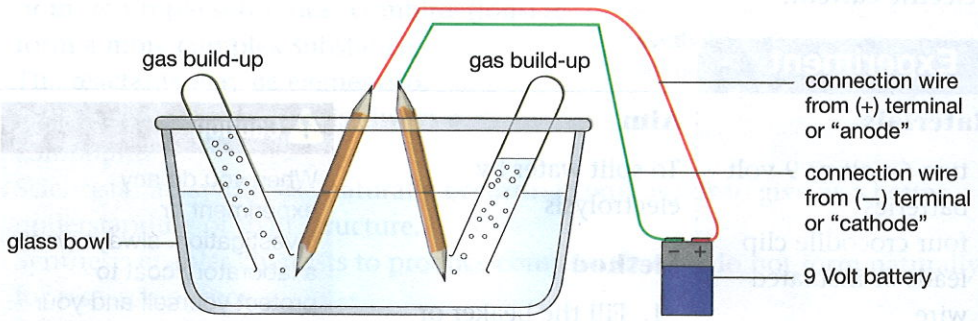


Figure 6 The experimental set-up of the electrolysis of water

Explanation of observations/results

- After the wires were connected to each battery, bubbles appeared around the pencil tips in the water/water mix.
- The bubbles are the components of water: hydrogen gas and oxygen gas. These gases have been split apart by the electric current as it travels through the water from the graphite of one pencil to the graphite of the other pencil.
- The test tube above the pencil attached to the negative terminal of the battery collects hydrogen gas.
- The test tube above the pencil attached to the positive terminal collects oxygen gas.

Questions

1. Do more bubbles collect around one pencil than around the other pencil?
2. If so, describe which pencil it is.
3. Explain your observation in questions 1 and 2.

The law of conservation of matter

- The law of conservation of matter states that matter cannot be made or destroyed during a chemical reaction. All the atoms present in the reactants must still be present in the product(s) after the reaction has taken place.
- This tells us that the total mass of the substances does not change when a chemical reaction takes place. So the mass of the reactants equals the mass of the products.

- We can write this as
  - » mass of the reacta products (on the
  - » the number of ato products.
- So, always write a ch
  - » Word equation: h
  - » Chemical symbol

Unbalanced equatio
Number of atoms on

Number of atoms on

Balanced equation:
Number of atoms on

Number of atoms on

Activity 3 Che

Work in groups of three reactants and the produ

Experiment

Materials

- iron filings
- flowers of sulphur
- beaker or heat-resistant container
- pair of tongs
- burner, hot plate or stove
- scale, preferably a digital scale that measures to two decimal places

- We can write this as follows:
  - » mass of the reactants (on the left-hand side of the arrow) equals mass of the products (on the right-hand side of the arrow)
  - » the number of atoms in the reactants also equals the number of atoms in the products.
- So, always write a chemical reaction as a balanced equation:
  - » Word equation: hydrogen (gas) + oxygen (gas) → water
  - » **Chemical symbol equation:** $H_2 + O_2 \rightarrow H_2O$

Unbalanced equation:

Number of atoms on left-hand side: Hydrogen: 2 atoms
Oxygen: 2 atoms
Total: 4 atoms

Number of atoms on right-hand side: Hydrogen: 2 atoms
Oxygen: 1 atom
Total: 3 atoms

Balanced equation: $2H_2 + O_2 \rightarrow 2H_2O$

Number of atoms on left-hand side: Hydrogen: 4 atoms
Oxygen: 2 atoms
Total: 6 atoms

Number of atoms on right-hand side: Hydrogen: 4 atoms
Oxygen: 2 atoms
Total: 6 atoms

Activity 3 Chemical synthesis and conservation of matter

Work in groups of three to four for this activity. You will investigate the mass of the reactants and the products in a chemical reaction.

Experiment

Materials

- iron filings
- flowers of sulphur
- beaker or heat-resistant container
- pair of tongs
- burner, hot plate or stove
- scale, preferably a digital scale that measures to two decimal places

Aim

To investigate the conservation of matter before and after a chemical reaction

Note

If you do not have a digital scale, use a small, sensitive, kitchen scale.

Continued

Method

1. Weigh out 4 g of iron filings and 7 g of flowers of sulphur.
2. Place the iron filings and sulphur into the test tube or beaker.
3. Place the beaker with iron filings and sulphur onto the scale and record its mass.
4. Heat the mixture of iron and sulphur over a flame until it glows.
5. Shake the mixture while you are heating it. Use tongs to hold the hot beaker.
6. Observe any change that might take place in the mixture.
7. Once you have decided that no change is going to take place or that the change that has taken place has ended, place the beaker onto the scale. Record its mass again.

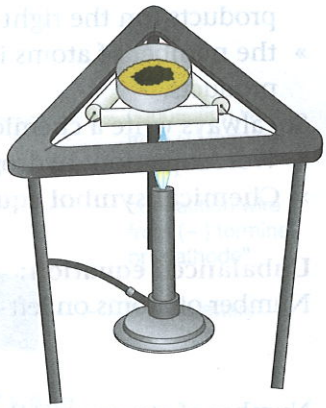


Figure 7 Iron filings reacting with sulphur

Observations/results

Record your observations or results in a table like the one below:

	Before heating	After heating
Appearance of substance(s)		
Mass of test tube containing the substance(s)		

Discussion/conclusion

- Discuss your observations on what the substance(s) look like before and after heating. State the conclusion you can make from these observations.
- Discuss the change in mass or the lack of change in mass, before and after heating. Did your results match your expected results about the law of conservation of matter?

Types of lense

There are two types of l
concave.

Convex lenses

- A **convex** lens is curv
- It is thick in the midd
- Convex lenses cause
- These lenses are also
lenses.

Concave lenses

- A **concave** lens is cur
- It is thick at the edge
- Concave lenses cause
- These lenses are also
lenses.

Activity 4 Ligh a co

Work in groups of four

Experiment

Materials

- convex lens or magnifying glass
- piece of paper
- ruler
- pencil

2. Hold the lens so th
spot of light possi
3. Measure the distar

SUB-TOPIC 2

Light and its nature

Types of lenses

There are two types of lenses: convex and concave.

Convex lenses

- A **convex** lens is curved or rounded outwards.
- It is thick in the middle and thin at the edges.
- Convex lenses cause light rays to **converge**.
- These lenses are also known as converging lenses.

Concave lenses

- A **concave** lens is curved or rounded inwards.
- It is thick at the edges and thin in the middle.
- Concave lenses cause light rays to **diverge**.
- These lenses are also known as diverging lenses.

New words

convex: curved or rounded outwards like the outside of a ball
converge: bend towards a central point
concave: curved or rounded inwards like the inside of a ball
diverge: bend away from a central point; scatter

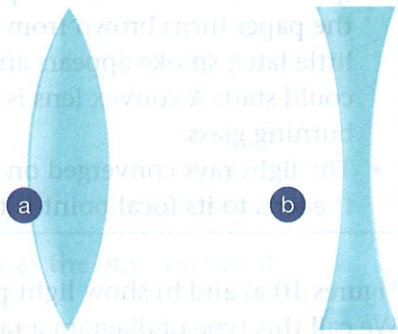


Figure 8 a) A biconvex lens; b) A biconcave lens

Activity 4 Light passing through a convex lens

Work in groups of four to five for this investigation.

Experiment

Materials

- convex lens or magnifying glass
- piece of paper
- ruler
- pencil

Aim

To see what happens to light as it passes through a convex lens

Caution

Do not look directly at the sun through the lens. This can damage your eyes.

Method

1. Take the lens or magnifying glass into the sunshine.
2. Hold the lens so that the sunlight can pass through it and form the smallest spot of light possible on the piece of paper.
3. Measure the distance between the lens and the paper.

Continued

Observations

- The sun's rays concentrate on one spot on the paper.
- After a while, smoke comes from the spot.

Figure 9 The sun's rays focus on a point when you use a biconvex lens.

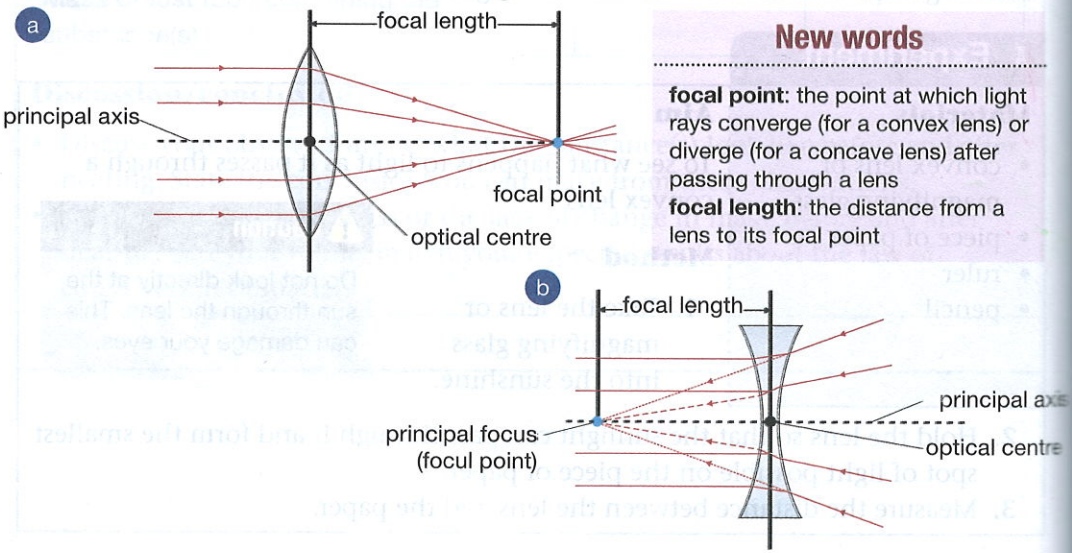
Explanation of observations

- The convex lens causes the sun's rays to converge or focus on a spot (point). After a while, the spot on the paper turns brown from heat. A little later, smoke appears and a fire could start. A convex lens is a good burning glass.
- The light rays converged on the **focal point** of the lens. The distance from the lens to its focal point is the **focal length** of the lens.

Figures 10 a) and b) show light passing through a convex lens and a concave lens. We call this type of diagram a ray diagram.

Other terms you will see in Figure 10 are:

- principal axis, an imaginary line that passes straight through the centre of the lens without bending
- optical centre, the centre of the lens through which the principal axis passes.



New words

focal point: the point at which light rays converge (for a convex lens) or diverge (for a concave lens) after passing through a lens

focal length: the distance from a lens to its focal point

Figure 10 a) Light rays passing through a convex lens; b) Light rays passing through a concave lens

Activity 5 Typ

Answer the following q

1. Identify the types
   a) A lens that is th
   b) A lens that caus
   c) A lens that caus
   d) A lens that is th
2. Name the type of l
3. Define each of thes
   a) focal point
   b) focal length.

Real and virtu

A real image:

- is formed by light ray
- can form on a surface
- is upside down (inver
- can be bigger than, sr in focus
- can be on the same o

The distance between th produce a focused imag

A virtual image:

- is formed by light ray on a flat mirror
- is not a real image an
- forms from light rays
- is upright compared t
- is bigger than the obj
- is on the same side of

A virtual image makes ar through its lens. As we l

Ray diagrams

- A ray diagram shows a
- We use ray diagrams t
  - » the same size, small
  - » real or virtual
  - » on the same side or

Activity 5 Types of lenses

Answer the following questions.

1. Identify the types of lenses described below.
   a) A lens that is thicker in the middle and thin at the edges
   b) A lens that causes light rays to diverge
   c) A lens that causes light rays to converge on a single spot
   d) A lens that is thicker at the ends and thinner in the centre
2. Name the type of lens that is referred to as a burning glass.
3. Define each of these terms:
   a) focal point
   b) focal length.

Real and virtual images

A real image:

- is formed by light rays converging at a point
- can form on a surface such as a movie screen
- is upside down (inverted) compared to the object
- can be bigger than, smaller than or the same size as the object when it is in focus
- can be on the same or the opposite side of the lens as the object.

The distance between the lens and the screen must be adjusted (changed) to produce a focused image. We move the screen or lens to do this.

A virtual image:

- is formed by light rays that appear to converge at a point, such as on a flat mirror
- is not a real image and cannot be formed on a screen
- forms from light rays that diverge from an image seen in a flat mirror
- is upright compared to the object
- is bigger than the object (magnified)
- is on the same side of the lens as the object.

A virtual image makes an image in our eyes after the rays have entered our eyes through its lens. As we look back towards the object, we see a virtual image.

Ray diagrams

- A ray diagram shows an object, a lens, light rays and an image.
- We use ray diagrams to determine whether an image formed is:
  - » the same size, smaller or bigger than the object
  - » real or virtual
  - » on the same side or the opposite side of the lens as the object.

- We use a suitable scale for ray diagrams.
- We also use ray diagrams to work out the exact size of an object. We do this by calculating the magnification.
- Magnification is the ratio of the size of the image to the size of the object.
- We calculate magnification as follows:

1. $\text{magnification} = \frac{\text{height of image}}{\text{height of object}}$
2. $\text{magnification} = \frac{\text{distance of image from lens}}{\text{distance of object from lens}}$

Produce an image using a converging lens

- Depending on the distance of the object from the lens, we can produce a real or a virtual image of the object using a converging (convex) lens.
  - » An object that is at a distance greater than the focal length of the lens will produce a real image.
  - » An object that is at a distance less than the focal length of the lens will produce a virtual image.

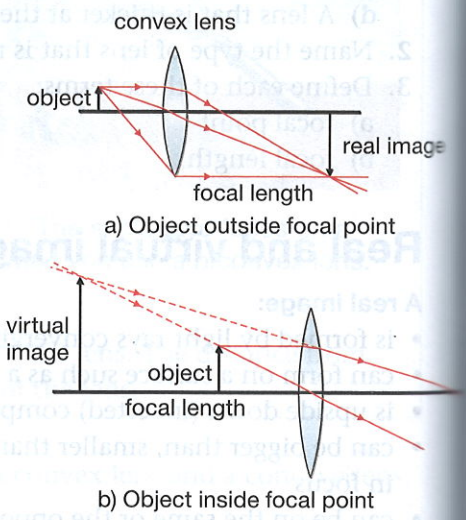


Figure 11 Ray diagrams show a) how we produce real and b) virtual images with convex lenses.

How to produce a real image using a converging lens

Ray diagrams are useful to show how to produce images from lenses. It is easiest to learn to draw ray diagrams in steps.

Step 1 Start your ray diagram by drawing Figure 12A.

Step 2 Then draw Figure 12B by adding in lines a, b and c. Make sure that:
- line a is parallel to the principal axis
- line b passes through the centre of the lens
- line c passes through the focal point on the same side of the lens as the object.

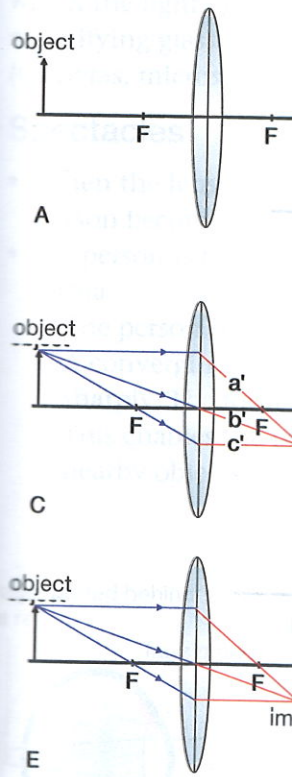
Step 3 Then draw Figure 12C by adding in lines a′, b′ and c′. Make sure that:
- the refracted (bent) lines of the light rays start from the middle of the lens
- line a′ passes through the focal point on the opposite side of the lens as the object
- line b′ continues as a straight line from the centre of the lens
- line c′ is parallel to the principal axis (is parallel to line a).

Step 4 Now draw Figure 12D. Mark the image point of the top of the object as a green dot. The three refracted rays meet at this focal point.

Note: When th
also lies on the
the mirror as th

Step 5 Now draw the

Produce a virtu



Step 1 Start your ray di

Step 2 Then draw Figur
- line a is parall
- line b passes t
- line c passes t
as the object.

Step 3 Then draw Figur
- the refracted (
of the lens
- line a′ passes t
the object
- line b′ continu
- line c′ is parall

Note: When the bottom of an object lies on the principal axis, the image also lies on the principal axis. This image will be the same distance from the mirror as the image of the top of the object.

Step 5 Now draw the whole ray diagram as shown in Figure 12E.

Produce a virtual image using a converging lens

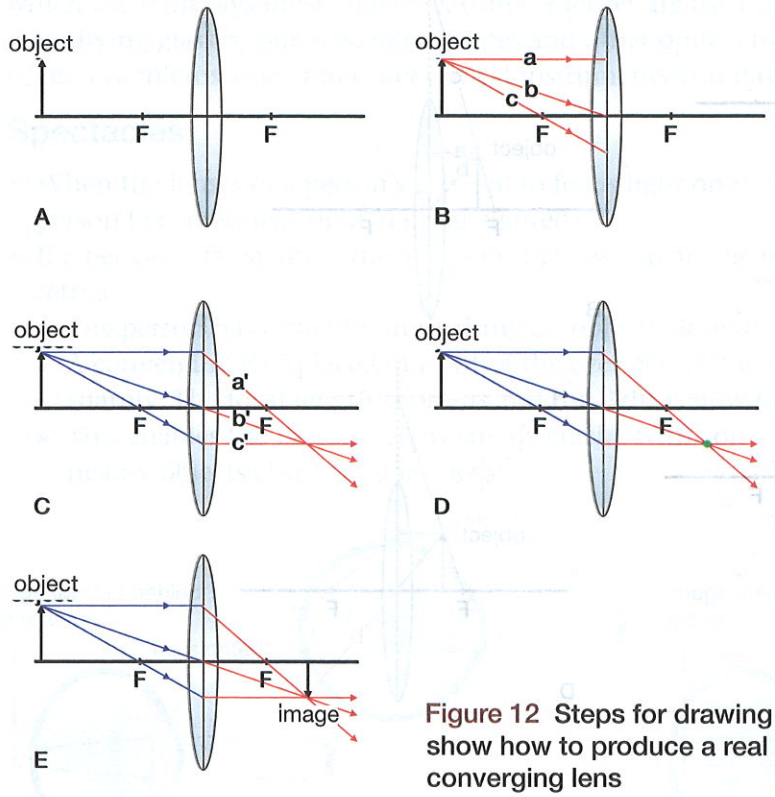


Figure 12 Steps for drawing a ray diagram to show how to produce a real image using a converging lens

Step 1 Start your ray diagram by drawing Figure 13A.

Step 2 Then draw Figure 13B by adding in lines a, b and c. Make sure that:

- line a is parallel to the principal axis
- line b passes through the centre of the lens
- line c passes through the focal point on the same side of the lens as the object.

Step 3 Then draw Figure 13C by adding in lines a′, b′ and c′. Make sure that:

- the refracted (bent) lines of the light rays start from the middle of the lens
- line a′ passes through the focal point on the opposite side of the lens as the object
- line b′ continues as a straight line from the centre of the lens
- line c′ is parallel to the principal axis (is parallel to line a).

Step 4 Now draw Figure 13D. Mark the image point of the top of the object as a green dot. The refracted rays meet at this focal point.
Note: When the bottom of an object lies on the principal axis, the image also lies on the principal axis. This image will be the same distance from the mirror as the image of the top of the object.

Step 5 Now draw the whole ray diagram as shown in Figure 13E.

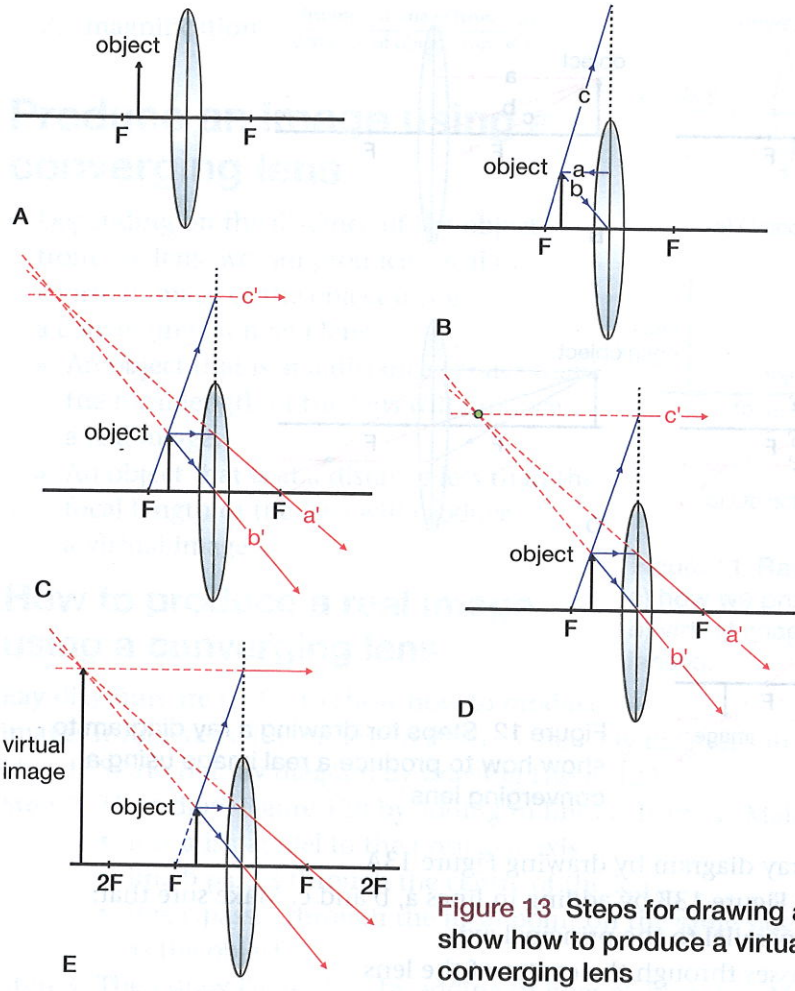


Figure 13 Steps for drawing a ray diagram to show how to produce a virtual image using a converging lens

Activity 6 Find real and virtual images using a converging lens

Work in groups of four for this activity.

Plan a simple investigation or experiment to find the real and virtual images of an object using converging lenses. Write down how you would do the investigation and what your results would be. Draw ray diagrams to help you describe your results.

Uses of conv

The two types of lens
different uses.

Uses of conve

Converging lenses ar
which the light rays
magnifying glasses, c
(Cameras, microscope

Spectacles

- When the lenses of
person becomes ne
- If a person is far-sig
retina.
  - » The person has d
  - » A converging len
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  - » This enables the
nearby objects cl

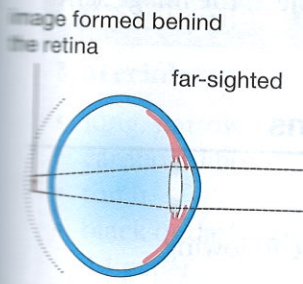


Figure 14 Correcting fa

Magnifying glasse

- A magnifying glass is
- As light passes throu
the centre of the lens
- Once you move the
reaches the object. T
in best focus.
- If you move the lens
- If you move the lens

Uses of converging and diverging lenses

The two types of lenses refract (bend) light differently. Therefore they have different uses.

Uses of converging lenses

Converging lenses are used in many different types of optical instruments in which the light rays must converge. Convex lenses are used in spectacles, magnifying glasses, cameras, microscopes and other optical instruments. (Cameras, microscopes and other optical instruments also have diverging lenses.)

Spectacles

- When the lenses of a person's eyes fail to focus light on the retina correctly, the person becomes near-sighted or far-sighted.
- If a person is far-sighted, the lenses of their eyes focus the image behind the retina.
  - » The person has difficulty in focusing on objects close to their eyes.
  - » A converging lens placed in front of the eyes bends the incoming light sharply. The focal length shortens and the light is now focused on the retina.
  - » This enables the person who wears spectacles with convex lenses to see nearby objects clearly and in focus.

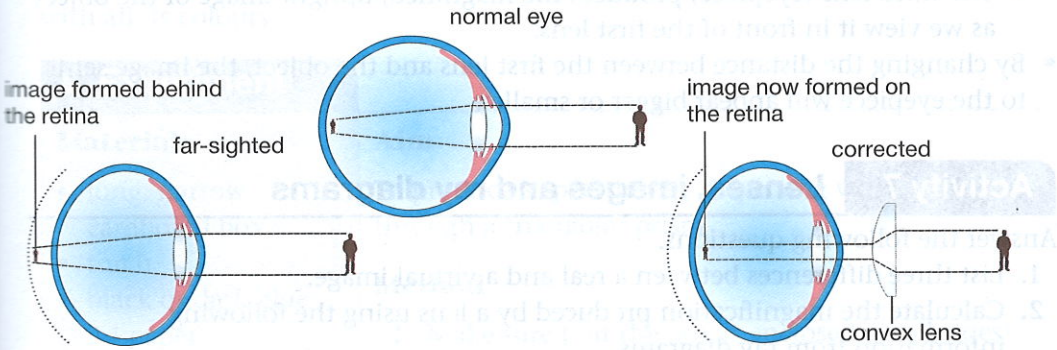


Figure 14 Correcting far-sightedness using a convex lens

Magnifying glasses

- A magnifying glass is a simple, direct application of a convex lens.
- As light passes through the lens, it is focused on a specific focal point in front of the centre of the lens.
- Once you move the magnifying glass to the perfect distance, the focal point reaches the object. The object appears at maximum magnification and in best focus.
- If you move the lens further from the object, the object becomes distorted.
- If you move the lens closer to the object, the object decreases in magnification.

Cameras

- Convex lenses are used in cameras to focus and magnify images.
- Most camera lenses consist of converging lenses and diverging lenses.
- The typical arrangement is a converging lens, followed by a diverging lens, followed by a second converging lens.
- The first convex lens controls the magnification of the image and inverts the image.
- Light passes through the first convex lens, and then through the concave lens.
- When light passes through the second convex lens, it inverts the image once again.
- The image then forms at the back of the camera. The image can be printed onto film or a digital media surface.

Microscopes

- Microscopes use convex lenses to create greatly magnified images of very small objects.
- Most compound microscopes have three lenses.
  - » The first lens at the end of the microscope produces an inverted, magnified image.
  - » The second lens inverts and further magnifies this image.
  - » The third lens (eyepiece) produces the magnified, upright image of the object as we view it in front of the first lens.
- By changing the distance between the first lens and the object, the image sent to the eyepiece will appear bigger or smaller.

Activity 7 Lenses, images and ray diagrams

Answer the following questions.

1. List three differences between a real and a virtual image.
2. Calculate the magnification produced by a lens using the following information from ray diagrams.
   a) Height of the image: 20 cm; height of the object: 8 cm
   b) Distance from the object to the lens: 6 cm; distance from the image to the lens: 3 cm
3. Draw a ray diagram to shown how a real image is formed using a converging lens.
4. If a person is far-sighted, name the type of lens that must be fitted into their spectacles for them to see clearly.
5. Explain how the lenses in the spectacles mentioned in question 4 make clear vision possible for a far-sighted person.

Produce a sp

When we see light fr
light, but it is made u
light wave with a diff

In 1666, Isaac New
triangular prism, the
colours is called the s

- The colours always
  Indigo, Violet.
- You can use ROY G
  colours and the seq
  in the spectrum.

A spectrum is produce
rays of different wave
substance to another.
that white light is dis

Activity 8 Di

Work in groups of fou
with all its colours.

Experiment

Materials

- long, narrow cardboard box
- torch
- black or dark blue A4 paper
- white A4 paper
- small, sharp knife
- triangular prism
- colour pencils

4. Cover the base of
   dark-blue paper. C
   with white paper.

Produce a spectrum from white light

When we see light from the sun, it appears colourless. Sunlight is known as white light, but it is made up of many different colours. We can think of each colour as a light wave with a different wavelength (or size).

In 1666, Isaac Newton discovered that when he passed sunlight through a triangular prism, the prism split the light into a band of colours. This band of colours is called the spectrum or the visible spectrum.

- The colours always occur in this order: Red, Orange, Yellow, Green, Blue, Indigo, Violet.
- You can use ROY G BIV to remember the colours and the sequence in which they occur in the spectrum.

New word

dispersed: separated, split or divided

A spectrum is produced when light passes from one substance to another. Light rays of different wavelengths are bent by different amounts as they pass from one substance to another. This forms the different colours of the spectrum. We say that white light is **dispersed** (separated) to form the different colours.

Activity 8 Disperse white light to produce a spectrum

Work in groups of four to five for this activity. You will produce a light spectrum with all its colours.

Experiment

Materials

- long, narrow cardboard box
- torch
- black or dark blue A4 paper
- white A4 paper
- small, sharp knife
- triangular prism
- colour pencils

Aim

To produce a spectrum by dispersing white light through a triangular prism

Method

1. Make sure that the box is enclosed on all sides except for the top.
2. Cover the inside walls of the box with white paper.
3. On one side of the box, cut a small rectangular hole. Cut this hole close to the bottom of the box and about 5 mm wide.
4. Cover the base of the box with black or dark-blue paper. Cover the sides of the box with white paper.

Note

It is difficult to see the light spectrum if the room is not dark enough.

Continued

5. Darken the room as much as possible. Cover up or switch off all light sources except for the one you will use for the investigation.
6. Place the prism on top of the dark paper on the base of the box. The prism must be in line with the hole that you cut in the end of the box.
7. Shine the torch through the hole in the box.
8. Rotate (turn) the prism slightly until you see a spectrum on the white paper.
9. Use pencils that match the colours of the spectrum to trace the light patterns.

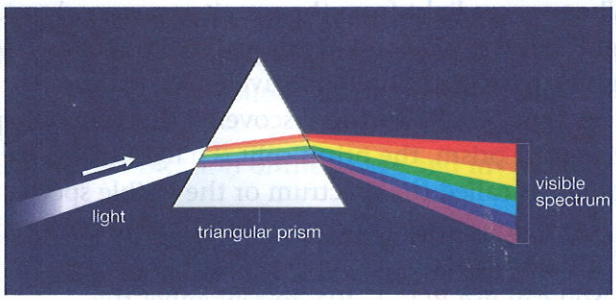


Figure 15 Producing a visible spectrum using a triangular prism

Observations/results

As soon as the prism is placed at the correct angle, a visible spectrum pattern appears on the white paper. You can see this spectrum in Figure 15.

Activity 9 Combine the spectrum colours to produce white light

Work in groups of four to five for this activity.

Experiment

Materials

- long, narrow cardboard box
- torch
- black or dark-blue A4 paper
- small, sharp knife
- two triangular prisms

Aim

To produce white light by combining the colours of the spectrum using two triangular prisms

Method

1. Repeat Activity 8, but use two triangular prisms.
2. Place the second prism a few millimetres to the right of the first prism. Arrange the prisms as they are shown in Figure 16.

Continued

Observations/resu

- The beam of light spectrum.
- This beam of light prism; it is parallel

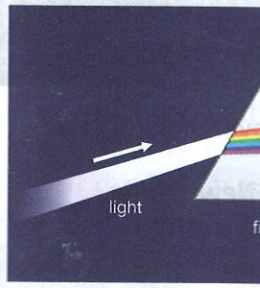


Figure 16 Combining white light

Rainbows

The sun forms rainbow drops act as tiny prism the bottom.

If you saw a rainbow circle. People in an aer rainbow.

We usually see a rai semi-circle in the sky. the top half of the rain from the ground. The the bottom half of the rainbow from view.

- The best time to loo is after rain.
- There must be brigh Have your back to th between the sun and
- The lower the sun is

Splashing water forms formation of a rainbow rainbow using a hosepi

Continued

Observations/results

- The beam of light that leaves the second prism is white light and not a spectrum.
- This beam of light is not in line with the beam of light going into the first prism; it is parallel to it.

Figure 16 Combining the visible spectrum using triangular prisms to create white light

Rainbows

The sun forms rainbows when sunlight passes through water drops. The water drops act as tiny prisms. The colour red is at the top of the rainbow and violet is at the bottom.

If you saw a rainbow from an aeroplane in the sky, it would be a complete circle. People in an aeroplane can look upwards and downwards to see the whole rainbow.

We usually see a rainbow as a semi-circle in the sky. We see only the top half of the rainbow circle from the ground. The ground blocks the bottom half of the circular rainbow from view.

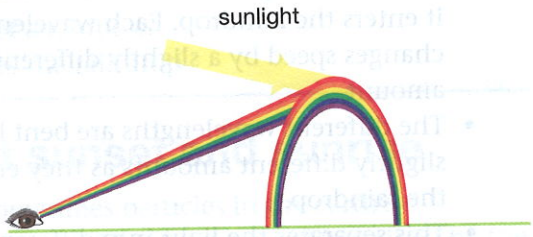


Figure 17 How a person on the ground sees a rainbow

- The best time to look for a rainbow is after rain.
- There must be bright sunlight. Have your back to the sun and be between the sun and the rain.
- The lower the sun is in the sky, the higher the arc of the rainbow will be.

Splashing water forms a mist of water droplets in the air that often results in the formation of a rainbow. Rainbows form over waterfalls. You can make your own rainbow using a hosepipe or garden sprinkler.

Formation of a rainbow

Figure 18 A rainbow over Victoria Falls

1. **Light from the sun strikes the raindrops**
   - Light must strike (hit) the raindrops at the correct angle to form a rainbow.
   - The best time to see this is when the sun is fairly low in the sky (before 08:30 and after 16:30).
2. **Some light is reflected**
   - When light strikes a raindrop, some light bounces off the surface of the raindrop. This is called **reflection**.
3. **Most light is refracted**
   - The light that is not refracted goes into the raindrop.
   - This slows down the speed at which the light is travelling.
   - The decrease in speed changes the direction in which the light is travelling.
   - The path along which the light is travelling is bent. This is called **refraction**.
4. **The light splits into the colours of the spectrum**
   - White sunlight is made up of a spectrum of colours, each with its own wavelength.
   - Each wavelength travels at its own speed. The speed of light slows down as it enters the raindrop. Each wavelength changes speed by a slightly different amount.
   - The different wavelengths are bent by slightly different amounts as they enter the raindrop.
   - This separates the light into different colours. This splitting of white light is called dispersion.
5. **The light is reflected at the back of the raindrop**
   - The light passing through the raindrop strikes the back of the raindrop. If the angle at which it strikes is correct, the light will reflect off this surface.

New words

reflection: refers to light bouncing off a surface
refraction: bending of light

Note

Refer to Figure 19 as you work through this section.

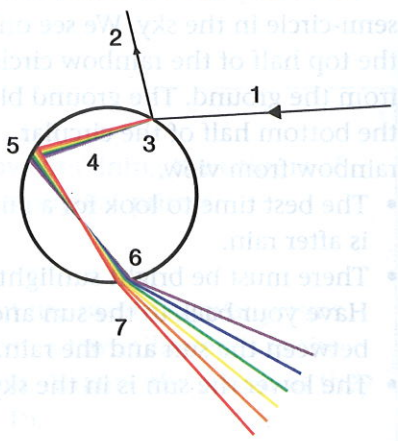


Figure 19 How water drops create a rainbow

- This changes th
  is moving.
- The light now
  can see the rai
- If the angle at
  correct, the ligh
  raindrop. A rai

6. **Light is refracted**
   - As light leaves
7. **Colours are furth**
   - When the light
     in dispersion o
   - If this light is s

Activity 10 Th

Answer the following
1. Name the band o
2. Name the colours
   with the colour se
3. Name the conditi
4. Arrange these stat
   formed.
   A Most of the lig
   B Colours are fu
   C Sunlight strike
   D Light is reflect
   E Some of the lig
   F The light split
   G Light is refract

Why the sky

Light usually travels in
atmosphere scatter lig
wavelength of the ligh

Scattering is stronge
wavelengths. This scat
This is why we see the

When the sun is clo
through a longer path
is scattered from the o
wavelengths of red, ora
eyes. These colours ma

- This changes the direction in which the light is moving.
- The light now moves towards the person who can see the rainbow.
- If the angle at which the light strikes is not correct, the light will pass through the raindrop. A rainbow will not form.

Did you know?

Each raindrop makes its own rainbow, but it takes millions of raindrops for us to see a rainbow.

6. **Light is refracted as it leaves the raindrop**
   - As light leaves the raindrop, its path bends. The light is refracted again.
7. **Colours are further dispersed**
   - When the light leaving the raindrop is refracted again, there is an increase in dispersion of light. The colours of white light split further.
   - If this light is seen by a person, they see a rainbow in the sky.

Activity 10 The light spectrum and rainbows

Answer the following questions.

1. Name the band of colours that we can produce from white light.
2. Name the colours that occur in this band of light in the correct order, starting with the colour seen at the top of a rainbow.
3. Name the conditions that are the best suited for the formation of a rainbow.
4. Arrange these statements in the correct order to describe how a rainbow is formed.
   - A Most of the light is refracted.
   - B Colours are further dispersed.
   - C Sunlight strikes the raindrops.
   - D Light is reflected at the back of a raindrop.
   - E Some of the light is reflected.
   - F The light splits into the colours of a rainbow.
   - G Light is refracted again as it leaves the raindrop.

Why the sky looks red at sunset and sunrise

Light usually travels in a straight line. Sometimes particles in the earth's atmosphere scatter light in different directions. The direction is determined by the wavelength of the light and the size of the particles doing the scattering.

Scattering is strongest for the shortest wavelengths and weakest for the longest wavelengths. This scattering occurs most for the wavelength that we see as blue. This is why we see the sky as blue.

When the sun is close to the horizon as at sunrise and sunset, light passes through a longer path in the atmosphere than during the rest of the day. Blue light is scattered from the original direction in which the light was travelling. The longer wavelengths of red, orange and yellow travel in the original direction and reach our eyes. These colours make the sky look red and orange at sunrise and sunset.

The colour of objects

- The colour of any object depends on:
  - » the type of light that shines on it
  - » the type of light that bounces off or passes through it.

  We know that each colour is a light wave with a different wavelength, so we can say that the colour of any object depends on:
  - » the wavelengths of light that reach the object
  - » the wavelengths that reach the eye after the light is reflected or transmitted by the object.
- We can only see the light that reaches our eyes.
- When light shines on an **opaque** object (one that light will not pass through), some wavelengths are absorbed by the object and others are reflected.
- A surface that reflects sunlight (that has all colours) without absorbing any colours appears white.
- A surface that absorbs all colours and reflects none appears black.
- A surface that reflects weak waves of white light appears grey.
- An opaque object that appears blue absorbs all colours except blue. The blue light is reflected to our eyes, giving the object its colour. A red object reflects only red light; a green object reflects only green light and so on.
- **Transparent** objects do not reflect light, but transmit it.
  - » The colour of transparent objects depends on the colour of the light that passes through them.
  - » Plain window glass transmits all colours and has no colour of its own.
  - » Blue glass transmits only blue light and absorbs all other colours, and so on.

New words

opaque: does not allow light to pass through it
transparent: does allow light to pass through it

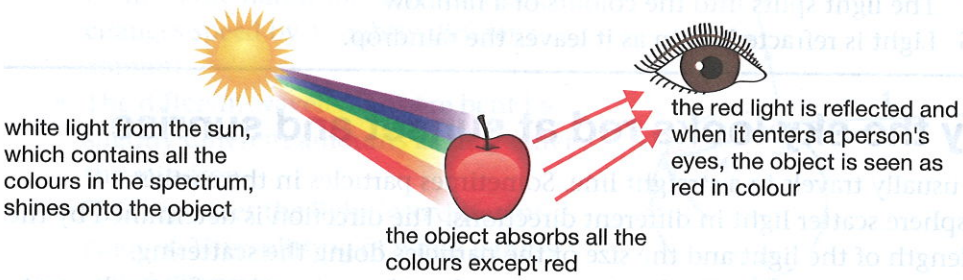


Figure 20 Absorption and reflection of light by a coloured object

The effect of

- A filter is a substanc
  but not others.
- Colour filters allow
  by absorbing all the
- When white light sh
  yellow, blue, indigo
  light pass through t
- When blue light pas
  reflect blue light and
- But when blue light
  absorbed and no lig
- This makes the obje

Figure 21 The effect of

Activity 11 Ligh

Answer the following q

1. Name the wavelen
   a) the most
   b) the least.
2. Explain why the sk
3. Name the factors th
4. Give the correct ter
5. Explain why object
6. Explain how a colo

The effect of colour filters on light

- A filter is a substance or device that allows some substances to pass through it, but not others.
- Colour filters allow certain colours (wavelengths of light) to pass through them by absorbing all the other colours (wavelengths of light).
- When white light shines on a green colour filter, the filter absorbs red, orange, yellow, blue, indigo and violet wavelengths of light. The green wavelengths of light pass through to the other side of the filter.
- When blue light passes through a blue filter onto a blue object, the object will reflect blue light and appear blue.
- But when blue light from a blue filter falls on a red object, the blue light will be absorbed and no light will be reflected.
- This makes the object appear black.

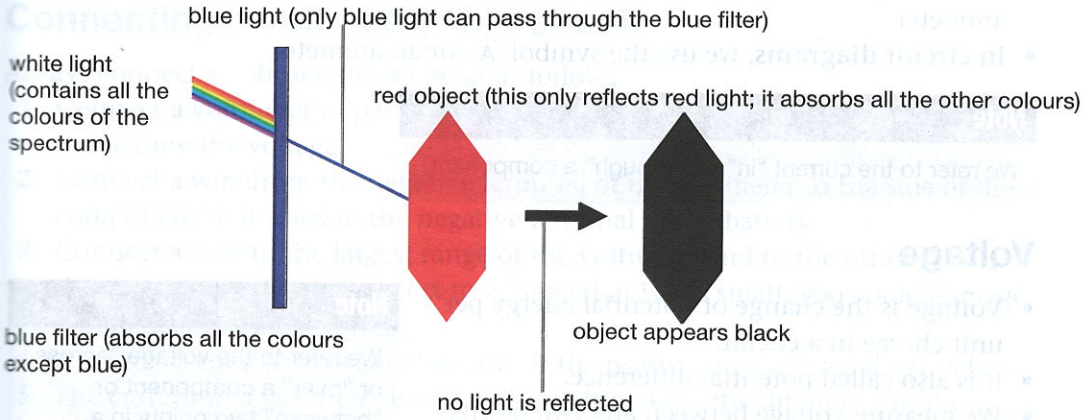


Figure 21 The effect of a light filter on white light and the viewed colour of an object

Activity 11 Light and colours

Answer the following questions.

1. Name the wavelengths of light that are scattered by the atmosphere:
   a) the most
   b) the least.
2. Explain why the sky appears to be red or orange at sunset.
3. Name the factors that determine the colour of an object.
4. Give the correct term for an object through which light can shine.
5. Explain why objects appear yellow.
6. Explain how a colour filter affects white light.

SUB-TOPIC 3

Electric current and voltage in a circuit

Batteries have stored chemical energy, which they convert to electrical energy. We will study electricity flowing through electrical circuits using batteries as our source of electrical energy.

Difference between electric current and voltage

Electric current

New words

current: the rate of flow of charge in a circuit
circuit diagram: a diagram that represents a circuit
voltage: the change of potential energy per unit charge in a circuit

- **Current** is the rate of flow of charge in a circuit.
- This means that current is the amount of charge that goes past a particular point in a circuit each second.
- We measure current in amperes (A) using an ammeter.
- In **circuit diagrams**, we use the symbol Ⓐ for an ammeter.

Note

We refer to the current "in" or "through" a component.

Voltage

- **Voltage** is the change of potential energy per unit charge in a circuit.
- It is also called potential difference.
- We measure voltage between any two points in a circuit.
- We measure voltage in volts (V) using a voltmeter.
- In circuit diagrams, we use the symbol Ⓥ for a voltmeter.

Note

We refer to the voltage "across" or "over" a component or "between" two points in a circuit.

Connecting meters in a circuit

It is important to connect meters correctly to circuits to prevent damaging the elements and for safety reasons.

Connecting an a

Always connect an amm

1. Position the ammet the point where you current.
2. Connect the negativ ammeter to the side to the negative term
3. Connect the positiv the largest range of of the circuit that le terminal of the batte
4. It is safe to connect reading on the large
5. Never connect an ar A connection in par

Connecting a vo

Always connect a voltme

1. Connect a voltmeter to measure the volta
2. Connect a wire from component that lead
3. Connect a wire to th the component. If yo the meter.
4. It is safe to connect t
5. The current in a volt current in the main

Activity 12 Curr

Answer the following que

1. Give the definition o means.
2. With regard to poten
   a) the unit in which
   b) the symbol we use
   c) the instrument wi
   d) the symbol we use question 2c).
3. Describe how to con

Connecting an ammeter to a circuit

Always connect an ammeter to a circuit as follows:

1. Position the ammeter **in series** in a circuit at the point where you want to measure the current.
2. Connect the negative terminal of the ammeter to the side of the circuit that leads to the negative terminal of the battery.
3. Connect the positive connecting wire from the largest range of the ammeter to the side of the circuit that leads to the positive terminal of the battery.
4. It is safe to connect to a smaller range if the reading on the large range is low.
5. Never connect an ammeter **in parallel**. An ammeter has very low resistance. A connection in parallel will cause a **short circuit**.

New words

in series: refers to an electric circuit in which the current passes through each circuit element without branching
in parallel: refers to an electric circuit in which the current divides into two or more paths before rejoining to complete the circuit
short circuit: a fault in a circuit or wiring that damages the circuit

Connecting a voltmeter to a circuit

Always connect a voltmeter to a circuit as follows:

1. Connect a voltmeter in parallel with the component(s) across which you want to measure the voltage.
2. Connect a wire from the negative terminal of the voltmeter to the side of the component that leads to the negative terminal of the battery.
3. Connect a wire to the largest range of the voltmeter and to the other side of the component. If you connect to a range that is too small, you could damage the meter.
4. It is safe to connect to a smaller range if the reading on the large range is low.
5. The current in a voltmeter is so small that it makes little difference to the current in the main circuit.

Activity 12 Current and voltage

Answer the following questions.

1. Give the definition of current. Explain clearly and simply what the term means.
2. With regard to potential difference (voltage), name the following:
   a) the unit in which we measure it
   b) the symbol we use for the unit in question 2a)
   c) the instrument with which we measure it
   d) the symbol we use in a circuit diagram for the instrument mentioned in question 2c).
3. Describe how to connect an ammeter to a circuit.

Activity 13 Use an ammeter in series to measure current strength

Work in groups of four to five for this activity.

Experiment

Materials

- two 1.5-V cells
- two bulbs
- two bulb holders
- switch
- ammeter
- connecting wires

Caution

Always follow the correct connecting procedures given on page 115 when you construct electrical circuits.

Aim

To use an ammeter in a series circuit to measure the current strength

Method

1. Use the materials to construct the circuit represented in the circuit diagram in Figure 22.

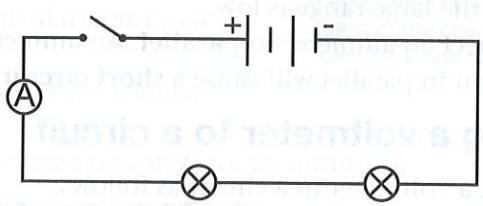


Figure 22 A circuit diagram representing a circuit of two cells in series, a switch, two bulbs in series and an ammeter

2. Open and close the switches, and note what happens to the ammeter readings.

Observations/Results

- When the switch is open, the ammeter shows no reading.
- When the switch is closed, the ammeter shows a reading.

Explanation of Observations/Results

- Since there is no reading on the ammeter when the switch is open, we know that there is no current flowing through the circuit.
- Since there is a reading on the ammeter when the switch is closed, we know that there is a current flowing through the circuit.
- The reading on the ammeter shows the strength of the current flowing in the circuit.

Activity 14 Use

Work in groups of four

Experiment

Materials

- as for Activity 12

Caution

Follow the correct connecting procedures given on page 115 when you construct this circuit.

2. Open and close th readings.

Observations/Resul

- When the switch is
- When the switch is

Explanation of Obse

- Since there is no rea that there is no curre
- Since there is a readi that there is a curren
- The reading on the a the circuit.

Conclusion

1. Compare the curre
2. Draw a conclusion series and parallel.

Activity 14 Use an ammeter in a parallel circuit to measure current strength

Work in groups of four to five for this activity.

Experiment

Materials

- as for Activity 12

Caution

Follow the correct connecting procedures given on page 115 when you construct this circuit.

Aim

To use an ammeter in a parallel circuit to measure the current strength

Method

1. Use all the materials to construct the circuit represented in the circuit diagram in Figure 23.

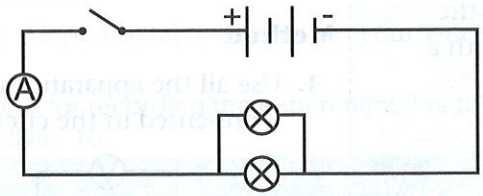


Figure 23 A circuit diagram representing a circuit of two cells in series, a switch, two bulbs in parallel and an ammeter

2. Open and close the switch, and note what happens to the ammeter readings.

Observations/Results

- When the switch is open, the ammeter shows no reading.
- When the switch is closed, the ammeter shows a reading.

Explanation of Observations/Results

- Since there is no reading on the ammeter when the switch is open, we know that there is no current flowing through the circuit.
- Since there is a reading on the ammeter when the switch is closed, we know that there is a current flowing through the circuit.
- The reading on the ammeter shows the strength of the current flowing in the circuit.

Conclusion

1. Compare the current strengths you recorded in Activities 13 and 14.
2. Draw a conclusion about current strength and bulbs (resistors) connected in series and parallel.

Activity 15 Use a voltmeter in a circuit to measure voltage

Work in groups of four to five for this activity.

Caution

Follow the correct connecting procedures given on page 115 when you construct this circuit.

Experiment

Materials

- as for Activity 12, but replace the ammeter with a voltmeter

Aim

To use a voltmeter in a circuit to measure the voltage

Method

1. Use all the apparatus to construct the circuit represented in the circuit diagram in Figure 24.

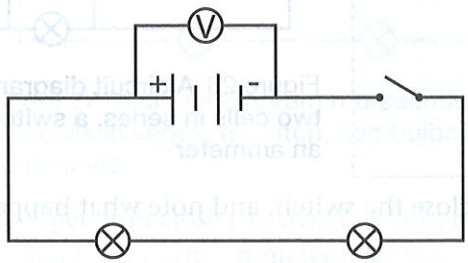


Figure 24 A circuit diagram representing a circuit of two cells in series, a switch, two bulbs in series and a voltmeter

2. Open and close the switches, and note what happens to the voltmeter readings.

Observations/Results

Whether the switch is open or closed, there is a reading on the voltmeter.

Explanation of Observations/Results

Since there is a reading on the voltmeter, we know that there is a potential difference between the negative and positive poles of the battery.

Relationship betw and current

Activity 16 Investiga differenc

Work in groups of four or five

Experiment

Materials

- six 1.5-V cells
- ammeter
- voltmeter
- circuit board
- two bulbs
- connecting wires
- switch
- bulb holders
- graph paper
- pen and pencil

Ai

To i diff

Me

1.

Tab Act

N
2
3
4
5
6

2. Set up the circuit as show
3. Ask your teacher to chec have connected the circu correctly *before* you close switch.
4. Once your teacher is sati that your circuit is correc connected, close the swit
5. Record any readings on t voltmeter and/or the am accurately in your table.
6. Open the switch and ad cell in series.
7. Record the readings from voltmeter and ammeter i table.
8. Repeat steps 6 and 7 thre

Relationship between potential difference and current

Activity 16 Investigate the relationship between potential difference and current

Work in groups of four or five for this investigation.

Experiment

Materials

- six 1.5-V cells
- ammeter
- voltmeter
- circuit board
- two bulbs
- connecting wires
- switch
- bulb holders
- graph paper
- pen and pencil

Aim

To investigate the relationship between potential different and current

Method

1. Copy the table below into your workbook.

Table for recording the experimental results of Activity 16

Number of cells	Current (A)	Voltage (V)	$\frac{\text{voltage}}{\text{current}}$
2			
3			
4			
5			
6			

2. Set up the circuit as shown in Figure 25.
3. Ask your teacher to check if you have connected the circuit correctly *before* you close the switch.
4. Once your teacher is satisfied that your circuit is correctly connected, close the switch.
5. Record any readings on the voltmeter and/or the ammeter accurately in your table.
6. Open the switch and add another cell in series.
7. Record the readings from the voltmeter and ammeter in your table.
8. Repeat steps 6 and 7 three times.

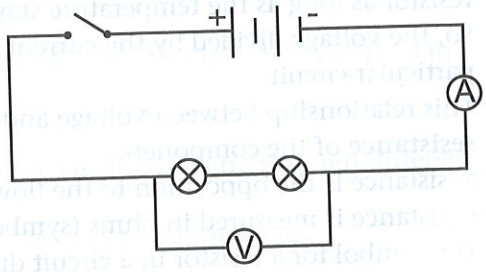


Figure 25 Activity 16 circuit: two cells connected in series, a switch, two bulbs connected in series, an ammeter and a voltmeter connected across both bulbs

Continued

9. Use your results to draw a line graph of voltage versus current. Use the *y*-axis (vertical line) for voltage and the *x*-axis (horizontal line) for current.

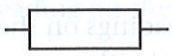
Observations/Results

- When the switch is closed, the bulbs turn on.
- The pointers on the voltmeter and ammeter move.
- Each time you add another cell to the battery, the bulbs burn more brightly than before.
- The readings on the voltmeter and the ammeter change.

Conclusion

What can you conclude from your results for this activity? Refer to the data you recorded for two and four cells as well as for three and six cells.

If you have done Activity 16 correctly, you will know that when the voltage in a circuit is increased, the current also increases.

- You might not have noticed that the voltage and current strength are **directly proportional**. This is because you used bulbs and not resistors. If you double the voltage, the current strength also doubles.
- This relationship between voltage and current strength is known as Ohm's Law.
- Ohm's Law states: The current (I) flowing through a conductor is directly proportional to the voltage (V) between the two ends of the conductor or the resistor as long as the temperature stays the same.
- So, the voltage divided by the current always gives a constant value for a particular circuit.
- This relationship between voltage and current strength is known as the **resistance** of the component.
- Resistance is the opposition to the flow of electric current.
- Resistance is measured in ohms (symbol Ω).
- The symbol for a resistor in a circuit diagram is: 
- We can represent Ohm's Law by the following formula:

$$\text{resistance} = \frac{\text{voltage}}{\text{current}} \text{ or } R = \frac{V}{I}$$

New words

directly proportional: a relationship in which a number increases or decreases with another number in the same ratio
resistance: the opposition to the flow of electric current

Note

We refer to the current as "in" or "through" a component or resistor.

Activity 17 Vo

Answer the following

1. A series circuit co
   When the switch
   Calculate the resi
2. Two 1.5-V cells a
   to a 4.0-Ω resisto
3. Read Ohm's Law
   experimental resu
   Ohm's Law.
4. Suggest how you

Use of electr

Many rural people ha
electrification project
the use of electricity a

Electrical appliance
When this happens, t
energy. This enables t

Different electrical

1. Heat energy: stov
2. Light energy: inc
   cells, television se
3. Sound energy: ra
4. Some appliances
   cellphones, CD p
5. Microwave energ
6. Mechanical energ
   electric hair clipp

From the examples w
electrical appliances e

- see when it is da
- cook food
- communicate
- process informat
- regulate the temp
  our houses and p

Activity 17 Voltage and current strength

Answer the following questions.

1. A series circuit consists of a 12-V battery, a resistor, a switch and an ammeter. When the switch is closed, a reading of 0.5 A shows on the ammeter. Calculate the resistance of the resistor that produces this result.
2. Two 1.5-V cells are connected in series to produce a battery. This is connected to a 4.0-Ω resistor. Calculate the strength of the current flowing in the circuit.
3. Read Ohm's Law carefully. Use this information to explain why your experimental results in Activity 16 did not produce perfect results for Ohm's Law.
4. Suggest how you could improve Activity 16 to give more accurate results.

Use of electrical current in the local environment

Many rural people have little or no access to electricity in Zambia. The electrification project plans to supply them with electricity. This would give them the use of electricity as well as creating employment opportunities.

Electrical appliances work only if an electrical current flows through them. When this happens, the appliance converts electrical energy into another form of energy. This enables the appliance to function correctly.

Different electrical appliances produce different types of energy.

1. Heat energy: stove, oven, iron, kettle, electric heater, toaster
2. Light energy: incandescent bulbs, fluorescent bulbs, energy-saving bulbs, LED cells, television sets, computer, cellphone, DVD player
3. Sound energy: radio, television, computer, cellphone, DVD player, CD player
4. Some appliances produce light and sound energy, for example, televisions, cellphones, CD players, DVD players, and computers with speakers.
5. Microwave energy: microwave oven
6. Mechanical energy: electric lawnmower, electric edge trimmer, electric fan, electric hair clippers and audio speakers

From the examples we can see that an electric current flowing through different electrical appliances enables us to:

- see when it is dark
- cook food
- communicate
- process information
- regulate the temperature of our houses and places of work
- access information
- mow lawns
- cut or shave hair
- have entertainment.

SUB-TOPIC 4

Pressure

What is pressure?

Pressure is produced when something presses or pushes against something else. We define pressure as a force per unit area that is applied at right angles to the surface of an object.

We can write pressure as:

$$\text{pressure} = \frac{\text{force}}{\text{area}}$$

We use the equation $p = \frac{F}{A}$ to calculate pressure.

Note

Pressure = p; Force = F; Area = A

The unit of force is the newton (N) and the unit of area is the square metre (m^2).

Therefore the unit for pressure is newton per square metre (N/m^2). This unit is also known as the pascal (Pa).

Pressure depends on a force being applied and the area on which the force is applied. When a force is applied to a surface, the smaller the area to which that force is applied, the greater the pressure is. Similarly, when a force is applied to a surface, the larger the area, the less the pressure.

Think about a sharp, pointed heel and a flat heel. A sharp, pointed heel pushes into the ground because the pressure acting on the heel is big. The weight (force) of the person wearing the shoe is being applied to a very small area. If the area of the heel is increased, the pressure will be much smaller. The heel will not push into the ground.

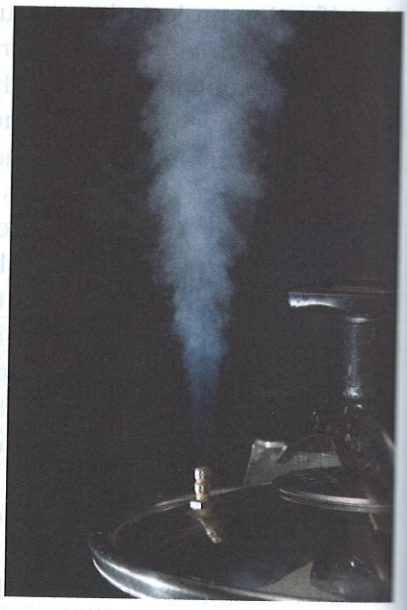


Figure 26 Steam is released from a pressure cooker due to the increased pressure inside the pot.

Figure 27 The effect of heel size on the pressure exerted by a person on the ground varies from heel to heel. a) The small high heel applies a greater force to the ground because it has a small surface area. b) The flatter low heel applies a smaller force to the ground because it has a greater surface area.

Pressure in gases and factors that affect it

Gas particles move about very quickly. When a gas is placed inside a container, the gas particles collide with each other and with the walls of the container. These collisions apply a force to the walls of the container. This force is known as gas pressure. The amount of pressure produced by the gas in a closed container depends on three factors.

The three factors that affect pressure in gases are the temperature of the gas, the volume of the gas and the number of gas particles in the container.

Temperature

- If the temperature of a gas (or a solid or a liquid) increases, the particles move faster. As the temperature falls, the particles move more slowly.
- Because the gas particles are moving faster, there are more collisions between the gas particles and the walls of the container in a fixed period of time.
- The total force (pressure) that is applied to the walls of the container increases. Therefore the pressure inside the container also increases.
- If the container is made from a material that can stretch, this increase in pressure will cause the size of the container to increase as the walls expand.
- So, when a gas is in a closed container, an increase in temperature will cause an increase in pressure.
- Similarly, when a gas is in a closed container, a decrease in temperature will cause a decrease in pressure.

Volume

- Volume is the amount of space that an object or substance occupies. We measure volume in cubic units such as cubic centimetres (cm^3) or cubic metres (m^3).
- If the volume that a gas occupies decreases, the same number of gas particles occupies a smaller space than before. There will be more collisions between the walls of the container and the gas particles. This will result in an increase in the pressure inside the container.
- If the volume that a gas occupies increases, the same number of gas particles occupies a larger space than before. There will be fewer collisions between the walls of the container and the gas particles. This will result in a decrease in the pressure inside the container.
- So, when a fixed amount of gas occupies a container with a smaller volume than before, there will be an increase in pressure.
- Similarly, when the volume of the container increases, there will be a decrease in pressure.

The number of gas particles in a container

- The number of gas particles inside a container affects the pressure applied by the gas if the volume and the temperature are kept constant.
- If the number of gas particles (the amount of gas) inside a container is increased, there is an increase in the number of collisions between the gas particles and the walls of the container. The pressure applied by the gas increases.
- If the container is made from a material that can stretch, the increase in pressure causes the size of the container to increase and the walls expand.
- So, when there is an increase in the amount of a gas that occurs in a closed container (constant volume) at a constant temperature, there will be an increase in pressure.
- Similarly, when there is a decrease in the amount of a gas that occurs in a closed container at a constant temperature, there will be a decrease in pressure.

Activity 18 How volume affects pressure in gases

Work in groups of four to five for this investigation.

Experiment

Materials

- 30 to 50 ml syringe
- two wooden blocks with holes drilled halfway through the centre of each block
- small piece of thin wire
- four to five bricks about the same size and with a mass of about 1 kg
- scale for measuring the mass of the bricks, for example, a bathroom scale is acceptable
- notebook, ruler and pen

Aim

To investigate how volume affects pressure in gases

Method

1. Remove the plunger from the syringe. Seal the tip of the syringe with a tight-fitting cap. Remember to seal the tip with epoxy or silicone sealant if you do not have a suitable cap. Allow the epoxy or silicone time to dry before continuing with the investigation.
2. Insert the plunger and a thin piece of wire to the 30 or 50 ml mark of the syringe, as shown in Figure 28.

Note

- If the syringe does not have a tight-fitting cap, seal it with epoxy or silicone sealant.
- The block that holds the syringe upright needs a hole that is slightly larger than the diameter of the syringe. It also needs a smaller hole for the syringe tip.
- The other block is placed on top of the syringe plunger. The diameter of the hole should fit the top of the syringe plunger tightly.

Continued

3. Hold the plunger i
4. Make sure that the plunger downward you have sealed th side of the plunger
5. When your sealed the hole in the bas
6. Record the initial v
7. Place the second w This wooden block on the plunger. Ma plunger.
8. Place the first brick on the shelf.
9. Record the resultin volume of air in the syringe.
10. Repeat steps 8 and 9 until you have four to five bricks stacked on top of the syringe.
11. Remove the bricks one at a time, recording the volume of air in the syringe each time.
12. Take the average of your two sets of values for the volume of air in the syringe. (The two sets of values are for
13. Remove the plunger sets of results.

Observations/Results

- Record your results an table a suitable headin
- Draw a line graph from

Continued

3. Hold the plunger in place and carefully remove the wire.
4. Make sure that the plunger can move easily in the syringe. Gently push the plunger downwards to check that it springs back. If it does not, check that you have sealed the tip of your syringe properly. If you have, lubricate the side of the plunger with a small amount of silicone lubricant.
5. When your sealed syringe is ready for use, insert it tip-down and firmly into the hole in the base (see Figure 28). The syringe should fit tightly.
6. Record the initial volume of the air in the syringe.
7. Place the second wood block over the top of the plunger (see Figure 28). This wooden block acts as a shelf for the bricks to exert a downward force on the plunger. Make sure that the shelf is level and fits tightly onto the plunger.
8. Place the first brick on the shelf.
9. Record the resulting volume of air in the syringe.
10. Repeat steps 8 and 9 until you have four to five bricks stacked on top of the syringe.
11. Remove the bricks one at a time, recording the volume of air in the syringe each time.
12. Take the average of your two sets of values for the volume of air in the syringe. (The two sets of values are for loading and unloading the bricks.)
13. Remove the plunger and repeat steps 2–12 so that you have at least four sets of results.

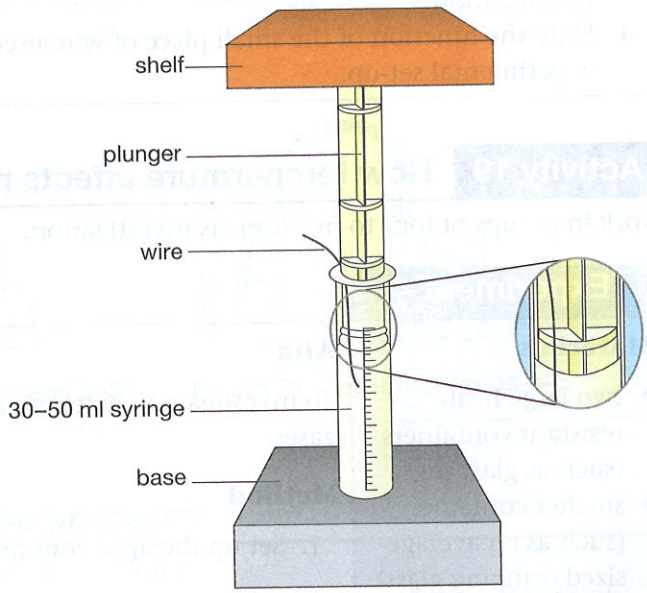


Figure 28 The experimental set-up for Activity 18

Observations/Results

- Record your results and average values in a table. Remember to give your table a suitable heading.
- Draw a line graph from the results you obtained in this investigation.

Continued

Discussion

Discuss your results. Indicate if your results agree with your expected results, based on what you learnt about the factors affecting pressure in gases.

Questions

1. Name each of the following for this investigation:
   a) the independent variable
   b) the dependent variable
   c) four fixed variables.
2. Explain why you must remove the plunger from the syringe before you seal the tip of the syringe.
3. Explain why it is necessary to repeat steps 2–12 four times in this investigation.
4. State the function of the small piece of wire used during the experimental set-up.

Activity 19 How temperature affects pressure in gases

Work in groups of four to five for this investigation.

Experiment

Materials

- two large heat-resistant containers (such as glass jugs)
- smaller container (such as an average-sized drinking glass)

Aim

To investigate how temperature affects pressure in gases

Method

1. Set up the apparatus as show in Figure 29.

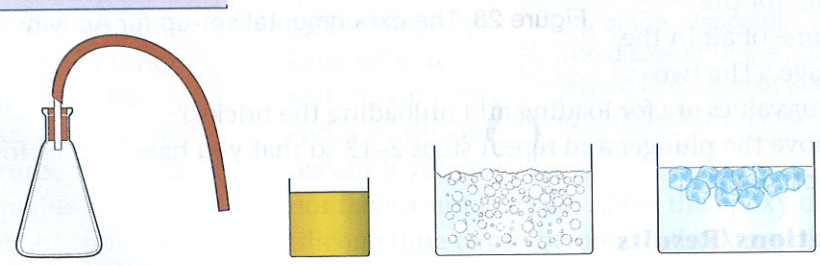


Figure 29 The materials for Activity 19

Continued

Materials

- 250 ml conical flask (Erlenmeyer flask) o smaller
- rubber stopper, with a tube running through it, to fit the conical flask
- 50 cm length of rubber tubing to fit tightly over tube in stopper
- 1 litre boiling water
- 1 litre iced water
- 150 ml salad oil

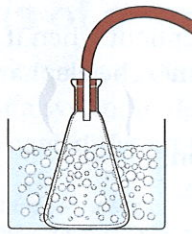


Figure 30 Set-u

Activity 20 Solv

Solve these problems or

1. A duster that weigh duster is 15 cm by 1 the table. Give your
   a) N/cm²
   b) N/m²
2. Calculate the force on a surface if its co and the pressure it
3. Calculate the pressu computer standing 0.3 m² and the weig

Continued

Materials

- 250 ml conical flask (Erlenmeyer flask) or smaller
- rubber stopper, with a tube running through it, to fit the conical flask
- 50 cm length of rubber tubing to fit tightly over tube in stopper
- 1 litre boiling water
- 1 litre iced water
- 150 ml salad oil

2. Set up the apparatus as shown in Figure 30.
3. Observe this set-up for the next 5–10 minutes.
4. Now set up the apparatus as shown in Figure 31.
5. Observe this set-up for the next 5–10 minutes.

Observations/Results

Record your observations for both experimental set-ups.

Discussion

Discuss your results. Indicate if your results agree with your expected results based on what you have learnt about the factors affecting pressure in gases.

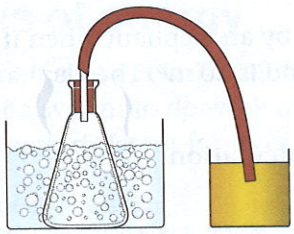


Figure 30 Set-up for steps 2–3

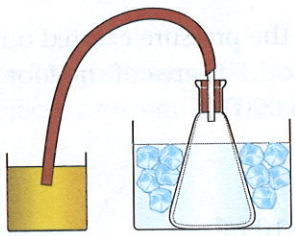


Figure 31 Set-up for steps 4–5

Activity 20 Solve the problems

Solve these problems on pressure and force.

1. A duster that weighs 20 N is placed on a table. The size of the base of the duster is 15 cm by 10 cm. Calculate the pressure that the duster exerts on the table. Give your answer in:
   a) N/cm^2
   b) N/m^2
2. Calculate the force that an object exerts on a surface if its contact area is 2.0 m^2 and the pressure it exerts is 400 N/m^2.
3. Calculate the pressure exerted by computer standing on a table if the base of the computer covers an area of 0.3 m^2 and the weight of the computer is 90 N.

Note

- Make sure you work through the Worked examples on the next page before you do Activity 20.

a

Worked examples

1. Calculate the pressure exerted by a block on the surface on which the block is standing. The block weighs 0.009 N. The dimensions of the part of the block that is in contact with the surface are 6 cm by 5 cm.

Data:

$p = \frac{F}{A}$

area $= L \times B$

Convert 6 cm and 5 cm to metres.

$\frac{6}{100} = 0.06$ m

$\frac{5}{100} = 0.05$ m

$\therefore$ area $= 0.06 \times 0.05$

$= 0.003$ m^2

force = weight

$\therefore$ force $= 0.009$ N

Calculation:

$p = \frac{F}{A}$

$= \frac{0.009}{0.003}$

$= 3$ N/m^2

2. Calculate the pressure exerted on the ground by an elephant when it stands on one foot. The area of the foot on the ground is 10 m^2. The elephant weighs 40 000 N.

Data:

$p = \frac{F}{A}$

area $= 10$ m^2

force = Weight

$\therefore$ force $= 40\,000$ N

Calculation:

$p = \frac{F}{A}$

$= \frac{40\,000}{10}$

$= 4\,000$ N/m^2

3. Find the pressure exerted by a bucket standing on a table. The base of the bucket covers an area of 0.5 m^2 on the surface of the table and the bucket weighs 20 N.

Data:

$p = \frac{F}{A}$

area $= 0.5$ m^2

force = Weight

$\therefore$ force $= 20$ N

Calculation:

$p = \frac{F}{A}$

$= \frac{20}{0.5}$

$= 40$ N/m^2

What is energy

Energy makes work poss
matter to move or to ch

Work is the process o
moves the body in the
from the floor, the work
height.

We measure energy in
is a very small amount
think about this: We ne
margarine) a height of 2
kilojoules (kJ) as the uni

Forms of ener

Energy occurs in a numb
object or a system to do
systems have different f

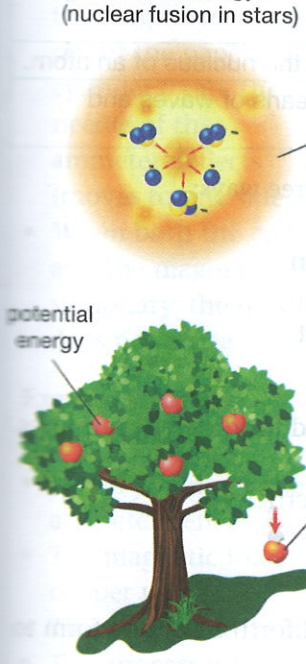


Figure 32 Different forms

SUB-TOPIC 5

Energy and its conservation

What is energy?

Energy makes work possible. It is the ability to do work. Energy also enables matter to move or to change.

Work is the process of transferring energy to a body by applying a force that moves the body in the direction of the force. For example, when you lift a box from the floor, the work you do to the box is the force it takes to lift it to a certain height.

We measure energy in units called joules. The symbol for a joule is J. One joule is a very small amount of energy. To give you an idea of how little energy it is, think about this: We need 1 J of energy to lift 500 g (for example, a block of margarine) a height of 21 cm. Because a joule is so small, we normally use kilojoules (kJ) as the unit of energy.

Forms of energy

Energy occurs in a number of different forms. They all measure the ability of an object or a system to do work on another object or system. Different objects or systems have different forms of energy.

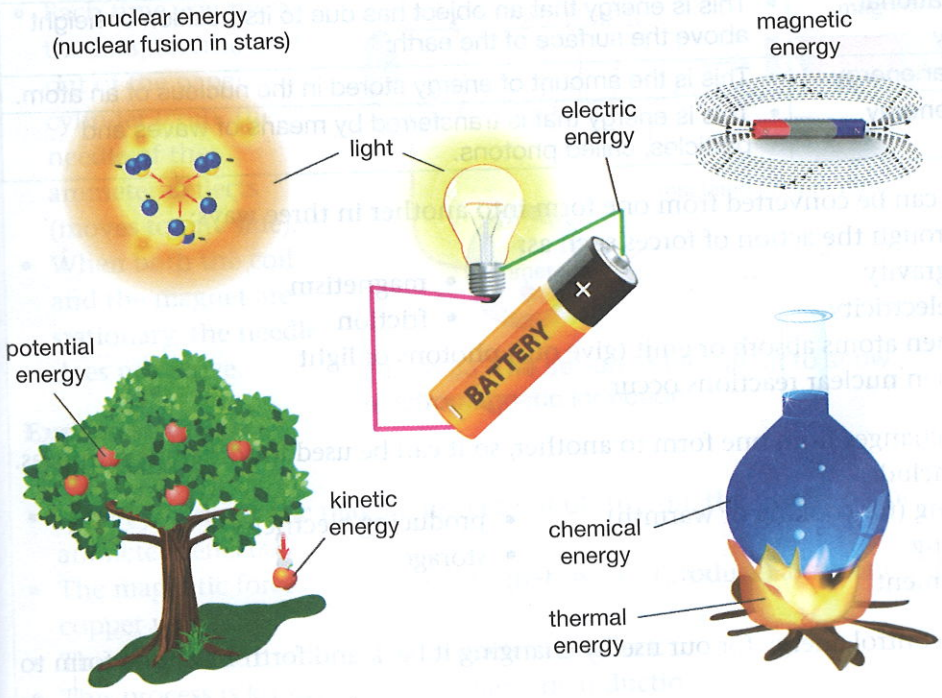


Figure 32 Different forms of energy

How different forms of energy can be changed

Table showing different forms of energy

Form of energy	Explanation
Kinetic energy	• This is energy that a body has because it is in motion (moving).
Potential energy	• This is energy that is stored in a body that is not doing work.
Chemical energy	• This is energy that is stored in fuel or food and is released when a chemical reaction takes place.
Electric energy	• This is the energy carried by moving electrons in an electric conductor.
Heat (thermal) energy	• This is energy that an object has due to the activity of its atoms or molecules. In a hot object, the atoms or molecules are excited and move quickly. In a cool object, the atoms or molecules are less excited and move slowly.
Mechanical energy	• This is the amount of potential and kinetic energy that an object has to do work. It is the amount of energy in an object because of its position or movement, or both.
Sound energy	• This is the movement of energy through an object in longitudinal waves. Sound is produced when a force causes an object to vibrate.
Radiant energy	• This is energy that occurs in electromagnetic waves. It is a form of energy that can travel through space.
Gravitational energy	• This is energy that an object has due to its position or height above the surface of the earth.
Nuclear energy	• This is the amount of energy stored in the nucleus of an atom.
Light energy	• This is energy that is transferred by means of waves and particles, called photons.

Energy can be converted from one form into another in three ways:

1. Through the action of forces such as:
   - gravity
   - electricity
   - magnetism
   - friction
2. When atoms absorb or emit (give out) photons of light
3. When nuclear reactions occur

Energy changes from one form to another, so it can be used for different purposes. These include:

- heating (for cooking or warmth)
- lighting
- movement
- producing electricity
- storage.

We can control energy for our use by changing it back and forth from one form to another.

Activity 21 Co

Work in groups of thre

Experiment

Materials

- ammeter
- permanent magnet
- A4 sheet of paper
- insulated copper wire
- sticky tape or glue

Caution

Make sure you connect your circuit correctly as you learnt to do in Sub-topic 4.

Observations

- Each time you mov the magnet into an out of the paper cylinder (coil), the needle of the ammeter deflects (moves to one side)
- When both the coil and the magnet are stationary, the need does not move.

Explanation of observations

- When you move th ammeter deflects.
- The magnetic force copper wire.
- This causes the nee
- This process is know

Activity 21 Convert magnetic energy into electrical energy

Work in groups of three or four for this activity.

Experiment

Materials

- ammeter
- permanent magnet
- A4 sheet of paper
- insulated copper wire
- sticky tape or glue

Caution

Make sure you connect your circuit correctly as you learnt to do in Sub-topic 4.

Aim

To convert magnetic energy into electrical energy

Method

1. Make a cylinder using the sheet of paper and sticky tape.
2. Make a coil by winding the insulated copper wire around the paper cylinder.
3. Connect the copper wire coil to the terminals of the ammeter.
4. Hold the magnet and move it into and out of the coil.
5. Observe what happens to the needle of the ammeter as you move the magnet into and out of the coil.

Observations

- Each time you move the magnet into and out of the paper cylinder (coil), the needle of the ammeter deflects (moves to one side).
- When both the coil and the magnet are stationary, the needle does not move.

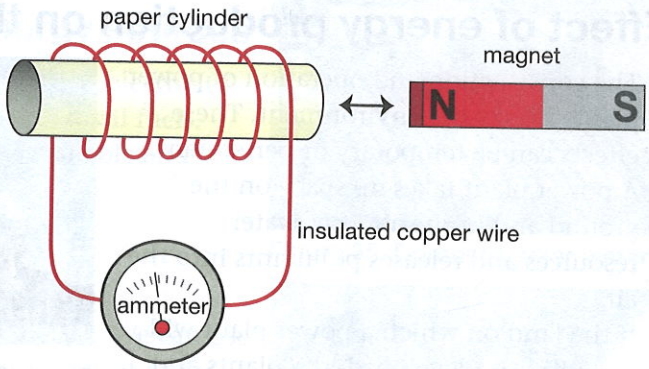


Figure 33 The set-up of the circuit to show electromagnetic induction

Explanation of observations

- When you move the magnet into or out of the coil, the needle of the ammeter deflects.
- The magnetic forces around the magnet induce (produce) a current in the copper wire.
- This causes the needle of the ammeter to deflect.
- This process is known as electromagnetic induction.

Activity 22 Energy and its different forms

Answer the following questions.

1. Explain what is meant by each of the following terms:
   a) energy
   b) work
   c) kinetic energy
   d) electric energy
   e) radiant energy
   f) light energy.
2. Name four forces that can change energy from one form into another.
3. In the experiment in Activity 21, what does the deflection of the ammeter needle indicate?
4. Name the process that is being demonstrated in Activity 21.

The law of energy conservation

- As we know, energy can be changed from one form into another. During any energy conversion, the amount of energy that we start with is always the same as the amount of energy that we have at the end.
- This idea is known as the law of conservation of energy. It states: Energy cannot be created nor destroyed, but can be changed from one form to another.
- Energy can change form, but the total amount of energy in the universe stays the same.

Effect of energy production on the environment

- The construction and operation of power plants affects the environment. These effects can be temporary or permanent.
- A power plant takes up space on the ground and in the air, uses water resources and releases pollutants into the air.
- If the land on which a power plant will be built is undeveloped, the plants and wildlife will be affected.

Figure 34 A coal-fired power plant

- Fossil-fuel-fired plants burn coal or natural gas to turn power turbines to generate electricity.
- Burning the fuel produces exhaust gases and other waste products, including air pollutants.
- Using water to create steam requires large amounts of water. Power plants obtain their water from nearby rivers, lakes or underground water sources.
- Sometimes water is released from a power plant after it has been used. The amount of water released, its temperature and its concentration of pollutants all affect the environment.

- Solid wastes are prod
  minimise their effect
- Power plants that use
  water before releasing
- Power plants must di
  their effect on the en
- Water used for coolin
- Air that is warmed by
  vapour. This is lost to
  shows that a power p

Activity 23 Ene

Answer the following qu

1. Explain in detail ho
   environment.
2. State the law of con
3. Using the idea of th
   about the total amo

Ways of conse

Using alternative

- Alternative energy inc
  that is produced witho
- Alternative energy is w
  environmentally frien
- It causes little or no po

1. Solar energy

Sunlight is the source of
solar power instead of ele
and for solar cookers and
bulbs. Solar energy is also

- Solid wastes are produced by power plants and must be disposed of correctly to minimise their effect on the environment.
- Power plants that use water for steam or cooling should filter and/or purify the water before releasing it to the environment.
- Power plants must dispose of filtered solid waste products correctly to minimise their effect on the environment.
- Water used for cooling often passes through cooling towers to reduce its heat.
- Air that is warmed by the water in the cooling tower has large amounts of water vapour. This is lost to the atmosphere every day. So much lost water vapour shows that a power plant uses a large amount of water.

Activity 23 Energy in the universe

Answer the following questions.

1. Explain in detail how a fossil-fuel powered power station affects the environment.
2. State the law of conservation of energy.
3. Using the idea of the law of conservation of energy, explain what we know about the total amount of energy in the universe.

Ways of conserving energy

Using alternative energy sources

- Alternative energy includes all the electricity that is produced without using fossil fuels.
- Alternative energy is widely available and environmentally friendly.
- It causes little or no pollution.

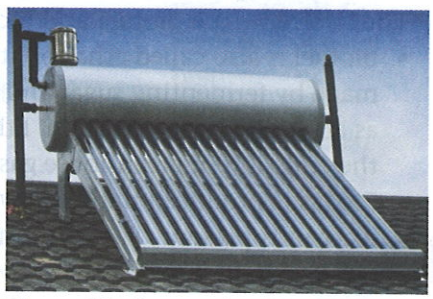


Figure 35 Domestic solar water heating

1. Solar energy

Sunlight is the source of solar energy. We can use solar power instead of electricity to heat water, and for solar cookers and solar-powered light bulbs. Solar energy is also used to generate electricity directly.

Figure 36 Solar panels

2. Wind energy

Windmills that contain wind turbines generate electricity on wind farms. We can produce this energy only in areas that have constant and relatively high wind speeds.

Figure 37 Wind turbines

3. Hydroelectric energy

Hydroelectric energy is the largest source of alternative energy. The kinetic energy in flowing water drives turbines that generate electricity. We can produce it only where there is sufficient water that can fall far enough to turn the turbines. This form of electricity production on a large scale is usually limited to large dams. As we discussed in Topic 3, Zambia produces hydroelectricity.

4. Geothermal energy

Geothermal energy is drawn from beneath the earth. It is clean and renewable. No fuel is needed to harness the energy from beneath the earth.

This form of energy occurs in those areas that have earthquakes and volcanic eruptions. As we discussed in Topic 3, geothermal power in Zambia could be possible in the Great Rift Valley area.

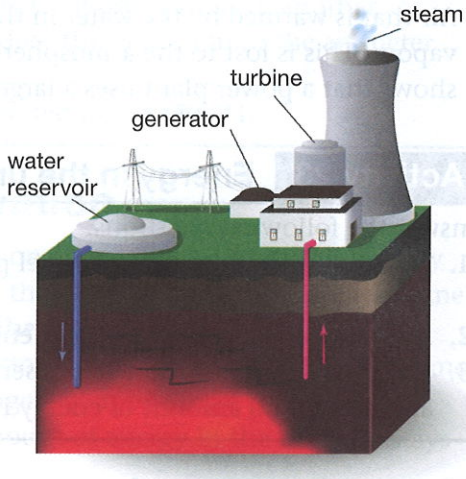


Figure 38 A geothermal power station

5. Biofuel energy

Biofuel energy is derived from plants. The two types are biofuel and biogas.

- Biofuel is also called ethanol. It is made by fermenting sugar and is used as an additive to petroleum. Ethanol burns in a cleaner way than petroleum, so the emission of greenhouse gases is less.
- Biogas is produced naturally when organic waste material decomposes where no oxygen is present. The resulting mix of gases is flammable and provides clean energy when burnt.

6. Ocean energy

About 70% of the earth's surface is covered by oceans. This means that energy produced from oceans could be used more widely than any other energy. Ocean energy is available as tidal energy and wave energy. Both forms are used to generate electricity directly using turbines.

Ocean energy is renewable, widely available and environmentally friendly. Tidal energy can produce a constant supply of electricity on a large scale.

Figure 39 Tidal energy power generators

Activity 24 Co

Compare the advantag
table. Remember to gi

Avoiding energ

- Now more than eve
- Using less electricity
environment.
- Here are ways in wh

1. Minimise leakir

This is the energy that
uses when it is not tur
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2. Change your lig

Replace your light bulb
bulbs. They use about
times longer than inca

3. Use fans for co

Use fans for cooling ai
conditioning units, wh

4. Improve insulat

Traditional rural Zamb
materials. They are coo
In brick houses, muc
temperature. Insulatio
between the inside and
temperature. The easie

Figure 41 Insulation in
b) Synthetic environme

Activity 24 Compare different energy sources

Compare the advantages and disadvantages of alternative energy sources in a table. Remember to give your table a heading!

Avoiding energy wastage

- Now more than ever before, we must save on energy consumption.
- Using less electricity means that fewer harmful emissions are released into the environment.
- Here are ways in which you can make your lives more energy-efficient.

1. Minimise leaking electricity

This is the energy that an appliance or electronic device uses when it is not turned on. Unplug appliances and electronic devices when you are not using them.

2. Change your light bulbs

Replace your light bulbs with compact fluorescent light bulbs. They use about 75% less energy and last about ten times longer than incandescent bulbs.

Figure 40 a): An incandescent light bulb;
b): A compact fluorescent bulb

3. Use fans for cooling

Use fans for cooling air inside buildings instead of air conditioning units, which are expensive to run.

4. Improve insulation in homes

Traditional rural Zambian homes are well insulated as they are made of natural materials. They are cool in summer and warm in winter.

In brick houses, much of a home's energy costs are spent on controlling its temperature. Insulation in the walls, floors and ceilings slows the flow of air between the inside and the outside. This makes it easier to control your home's temperature. The easiest place to insulate your home is the ceiling.

Figure 41 Insulation in houses: a) Rural houses in Zambia have natural insulation; b) Synthetic environmentally friendly insulation in the ceiling of a brick house

5. Conserve hot water

Use less hot water to save electricity. Use as little hot water as possible for washing dishes and clothes, preparing food and bathing. Have quick showers rather than a bath.

6. Plant trees and shrubs

Plant shade trees and shrubs near your house. This reduces the house's exposure to the sun, so it stays cooler in summer. If you plant shrubs and bushes about 30 cm from the house walls, they create airspace that helps to insulate against hot or cold outdoor temperatures.

7. Turn down the refrigerator setting

Set the refrigerator temperature to 3 °C and the freezer to –16 °C. Make sure that your refrigerator/freezer doors are clean and seal tightly.

8. Turn down the geyser setting

Set the geyser temperature to 60 °C or less. Water at this temperature is hot enough for all domestic uses.

9. Avoid personal transport

Walk, cycle and use lift clubs or public transport to reduce the amount of petrol or diesel used. This will also reduce air pollution.

Reduce, reuse and recycle

- The three Rs of conservation are Reuse, Reduce and Recycle. These enable all of us to make a difference to preserving and conserving our earth.
- When we use the three Rs of conservation, we:
  - » reduce the amount of waste that we throw away
  - » conserve natural resources, landfill space and energy.

Figure 42 The three Rs of conservation

Reduce

- Reduce means using fewer resources. This is the easiest of the three Rs to apply.
- Change what you are doing now to help the environment.
- These actions can help towards reducing:
  - » Buy products made from recycled materials.
  - » Buy products made locally, so less energy is used for transport.
  - » Buy products that do not have a lot of packaging.
  - » Buy products in bulk, reducing the amount of packaging.
  - » Do not buy disposable goods. They are more expensive as you throw them away and replace them.
  - » Use a dish cloth instead of paper towels.
  - » Make double-sided photocopies whenever possible.
  - » Save energy by turning off lights that you are not using.
  - » Reduce the amount of travelling in fuel-driven vehicles. Cycle or walk instead of driving.
  - » Save water by turning off the tap while you brush your teeth.

Reuse

- Before you recycle or thr
- Reusing items saves you
- Ideas for reusing items ir
  - » Return returnable bott
  - » Use empty bottles, jars containers.
  - » Turn kitchen waste int
  - » Use envelopes and pap
  - » Reuse shopping bags o
  - » Repair broken applian
  - » Sell used clothes, appli

Recycle

- Recycling is a series of ste sold as a new product.
- You can recycle items at
- You can contribute to recycling by:
  - » buying products made from recycled material
  - » recycling products that have been bought.
- Products that you can recycle include:
  - » all types of paper
  - » cardboard
  - » glass
  - » metal cans
  - » all types of plastic
  - » oil.

Activity 25 Consid

Answer the following questi

1. Name and explain five
2. Briefly explain how the
3. Explain what "Reduce"
4. List five ways in which
5. List the ways in which a

Reuse

- Before you recycle or throw away items, think of new ways to use them.
- Reusing items saves you buying new items and adding old items to rubbish dumps.
- Ideas for reusing items include:
  - » Return returnable bottles.
  - » Use empty bottles, jars, shoe boxes and margarine containers for storage containers.
  - » Turn kitchen waste into compost.
  - » Use envelopes and paper printed on one side for making lists.
  - » Reuse shopping bags or take your own cloth bags to the shops.
  - » Repair broken appliances, household goods, furniture and toys.
  - » Sell used clothes, appliances and furniture or donate them to needy people.

Recycle

- Recycling is a series of steps in which a used product is reprocessed, remade and sold as a new product.
- You can recycle items at home, at school, at work and in your community.
- You can contribute to recycling by:
  - » buying products made from recycled materials
  - » recycling products that have been bought.
- Products that you can recycle include:
  - » all types of paper
  - » cardboard
  - » glass
  - » metal cans
  - » all types of plastic
  - » oil.

Figure 43 Some items that you can reuse:
a) Paper and cardboard; b) Glass; c) Plastics; d) Tins

Activity 25 Consider the three Rs of recycling

Answer the following questions.

1. Name and explain five ways in which you can reduce energy wastage.
2. Briefly explain how the three Rs of conservation help to reduce energy wastage.
3. Explain what "Reduce" means and why it is so easy to apply.
4. List five ways in which we can "Reuse" in everyday life.
5. List the ways in which a person or organisation can help towards recycling.

SUB-TOPIC 6

Communication

What is communication?

Communication is the process of passing on or exchanging information, ideas or feelings using behaviour, signals, speech or writing. We use language most often to communicate with each other.

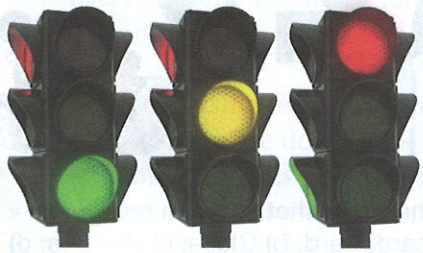
Communication is complete once the receiver understands the sender's message. Feedback is a necessary part of good communication.

Long-distance communication

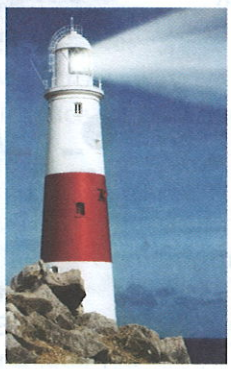
Long-distance communication takes place when the people who are communicating with each other are not in each other's presence. There are several ways of communicating over long distances.

1. **Visual signals**, for example:
   - smoke signals
   - beacons
   - signal flags
   - heliographs
   - letters.

a



b



c

Figure 44 Visual signals for communication: a) Traffic lights are a form of heliograph. b) A lighthouse flashes its beam of light to give ships at sea an identification signal. c) A man holds a handheld distress signal to show he needs help.

2. **Auditory signals**, for example:
   - drumbeats
   - whistles
   - lung-blown objects (such as horns and shells).

a

Figure 45 Auditory signa
specific messages for di
gives a visual signal with

3. **Electrical signals**, f
   - telegraph
4. **Electromagnetic sig**
   - radio
   - television
   - fax
   - cellphone

a

b

Figure 46 Communicatin
b) A television; c) A cellp
computer

In the modern world, we
electrical signals or electr
of communication is kno
telecommunication.

Telecommunication sy
three elements:

1. **A transmitter**: This t
   changes it into a sign

Figure 45 Auditory signals for communication: a) In Zambia, drums are used to give specific messages for different occasions. b) A football referee blows a whistle (and gives a visual signal with a red card).

3. **Electrical signals**, for example:
   - telegraph
   - telephone.
4. **Electromagnetic signals** or wireless communication, for example:
   - radio
   - television
   - fax
   - cellphone
   - instant messenger
   - video telephone (Skype)
   - email.

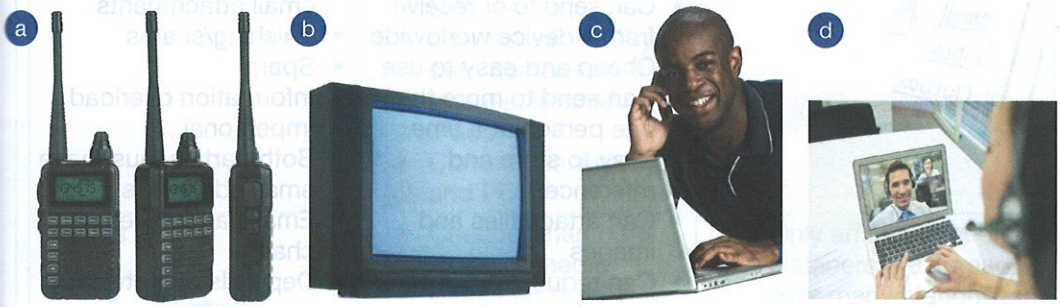


Figure 46 Communicating with electromagnetic signals: a) A handheld radio set; b) A television; c) A cellphone and computer/laptop; d) Skyping with a laptop computer

In the modern world, we usually communicate over long distances through electrical signals or electromagnetic waves using technological devices. This type of communication is known as **telecommunication**.

Telecommunication systems always use these three elements:

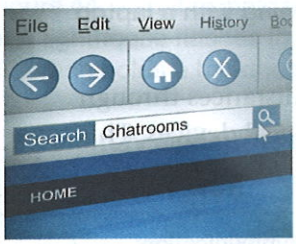
1. **A transmitter**: This takes information and changes it into a signal.

New word

telecommunication: communication over long distances through electrical signals or electromagnetic waves using technological devices

2. **A transmission** medium: This carries the signal.
3. **A receiver**: This takes the signal from the transmission medium and changes it back into usable information for the receiver.

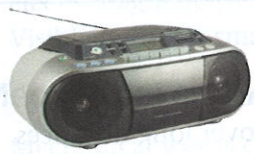
Advantages and disadvantages of telecommunication

Method of sending information	Advantages	Disadvantages
Text messaging 	• Cheaper than a phone call • Good for recording messages and their contents • Messages can be read at any time • Can respond at your convenience	• Limited storage capacity • Length of message must be short • Message can only have text • Not suitable in emergencies • Lack of privacy/security • Depends on network availability
Email 	• Extremely fast • Can send or receive at any time • Can send to or receive from a device worldwide • Cheap and easy to use • Can send to more than one person at a time • Easy to store and reference • Can attach files and images • Can request proof of receipt or reading	• Requires access to Internet • Viruses can spread via email attachments • Phishing/scams • Spam • Information overload • Impersonal • Both parties must have email addresses • Emails addresses can change • Depends on network availability
Instant messenger 	• Can use it worldwide • Can communicate in real time • Allows virtual conferencing • Can conduct business with it	• Impersonal • Cannot confirm identity of other party/parties • Exposes device to virus infection • Can be abused during business hours for personal use • Depends on network availability

Cellphones

Skype

Radios

Cellphones 	• Helpful in emergencies • Can communicate in different ways: speech, text, email, instant messaging • Convenient • Provide mobile access to Internet • A medium for advertising • Can get most use from available time • Can use as electronic diary	• Possible negative effects on health • High cost • High exposure to telesales • Can be distracting in public places • Increase traffic accidents • Depend on network availability
Skype 	• Worldwide communication • Cost-effective • Free computer-to-computer connection • Can have live video conversations • Can leave chat message if recipient is not logged on • Can communicate with more than one user at a time • Can download Skype onto computers, smart phones, iPhones and iPads • Compatible with Mac and PC	• No communication outside Skype network • Communication depends on being logged on • Services depend on software and hardware capabilities of user and recipient • Requires Wi-Fi or 3G service to run • No language translator
Radios 	• Cheaper than other forms of media • Useful for semi-literate and illiterate people • Can use in many places • Businesses can target advertising • Businesses can create identity using sounds and voices	• Only an audio medium • Listeners are spread over many stations, so advertisements are heard simultaneously on many stations • Listeners cannot refer back to important points • Advertisements are repeated within a programme

Television sets 	• Keep us informed of worldwide current affairs • Excellent medium for education • Source of entertainment • Effective device in fight against anti-social elements such as corruption, alcoholism, drug addiction, smoking • Good advertising medium	• Expose children to inappropriate content such as violence, racism, sexism, swearing, criminal activities • Promote anti-social behaviour • Negative impact on physical and emotional development of children • Negative impact on eyesight

Activity 26 Use different types of communication

Work in groups of four to five for this activity.

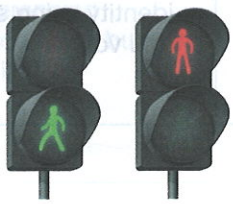
1. Give each learner in your group a number.
2. Create a message to share with the other learners in your group.
3. The number of sentences in your message must correspond with your given number.
4. Once everyone in your group has created a message, send your message to all the learners in your group. Use as many methods of communication as possible.
5. Keep a record of all of the messages you receive.
6. Allow 24 hours for steps 4 and 5.
7. Discuss and decide in your groups which method of communication is the most reliable.
8. Make a conclusion about whether the length of the message affects the choice of the most suitable type of communication.

Activity 27 Communication and signals

Answer the following questions.

1. Explain what is meant by the term communication.
2. Give the correct term for communicating over long distances.
3. Name four types of signals that we use to communicate over long distances.
4. Study the pictures below and then answer the questions.

a 

b 

a) State which of the two pedestrian traffic lights can be used worldwide.
b) Give a reason for your answer to question 4a).

SUB-TOPIC 7 Digi tran

Transmission o

Radio

Radio transmitters send r
German scientist, Heinric
of radio waves in nature.
send and receive radio wa
we measure radio frequer

Radios work by changi
that can be transmitted o
outer space. At the receiv
changed back into sound
and then amplified by a s

Waves

- Waves in water and so
mechanical waves. The
medium such as water,
- Waves in the electroma
light and radio waves,
to travel in. They can r
- Radio waves have the l
the electromagnetic sp
can be longer than a so
electromagnetic waves,
television waves, are at
electromagnetic spectr
Visible light is a small p

Mechanical and lon

- Mechanical waves can
  - In **longitudinal wav**
move in the same di
or move apart from l
  - Examples of longitud
through a slinky spri
  - In **transverse waves**
wave moves forward
banjo) and guitar str

SUB-TOPIC 7 Digital and analogue transmission

Transmission of radio and television signals

Radio

Radio transmitters send messages by radio waves. A German scientist, Heinrich Hertz, proved the existence of radio waves in nature. He was the first person to send and receive radio waves. To honour his discovery, we measure radio frequencies in units of Hertz (Hz).

Radios work by changing sounds into radio waves that can be transmitted over vast distances, even into outer space. At the receiving end, the radio waves are changed back into sound waves by a radio receiver, and then amplified by a speaker.

Did you know?

Many years ago, messages were transmitted from sender to receiver via telegraphic wires. When the radio was invented, it was also known as a "wireless" since it did not use wires.

Waves

- Waves in water and sound waves are mechanical waves. They move through a medium such as water, air or a coil.
- Waves in the electromagnetic spectrum, such as light and radio waves, do not need a medium to travel in. They can move through a vacuum.
- Radio waves have the longest **wavelengths** in the electromagnetic spectrum. A radio wave can be longer than a soccer field. Long electromagnetic waves, such as radio and television waves, are at one end of the electromagnetic spectrum; short X-rays and gamma rays are at the other end. Visible light is a small part of the spectrum between these two ends.

New words

wavelength: the distance between one peak of a wave and the next
longitudinal wave: a wave that vibrates in the same direction in which it travels
transverse wave: a wave in which the particles of the medium move up and down as the wave moves forwards

Mechanical and longitudinal waves

- Mechanical waves can be either longitudinal or transversal.
  - In **longitudinal waves** the particles of the medium vibrate. The vibrations move in the same direction as the sound wave. The particles bunch together or move apart from left to right when they vibrate.
  - Examples of longitudinal waves are sound waves and waves that move through a slinky spring.
  - In **transverse waves** the particles of the medium move up and down as the wave moves forwards. Examples are waves in water, and in *karindula* (large banjo) and guitar strings.

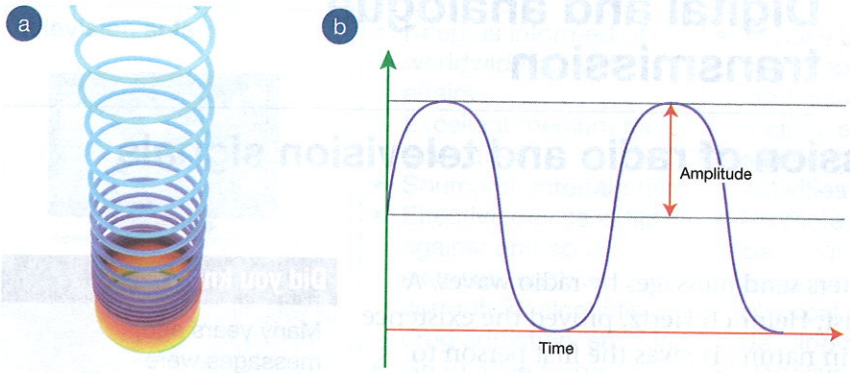


Figure 47 a) A longitudinal wave in a spring coil; b) A transverse wave represented on a graph

Activity 28 Illustrate longitudinal waves with a spring coil

Work in pairs for this activity. You will need a spring coil, also known as a slinky toy or spring.

1. Take turns holding each end of the spring coil and pushing a wave towards each other. These are mechanical waves that move through a medium (air). They are also longitudinal waves.
2. Observe carefully how the waves move through the spring coil. Describe to your partner in your own words how the waves move.

Antennas

Antennas are devices used to transmit and receive radio signals. The length of an antenna depends on the wavelength. When you turn a knob to tune your radio or television set, you lengthen or shorten a wire to match the wavelength being broadcast by your favourite radio station.

A radio wave carries information. Think of the wave as a blank paper on which you "write" information by modulating (changing) either the **amplitude** or the **frequency** of the wave.

New words

amplitude: distance from the centre line of a wave to its highest (or lowest) point
frequency: the number of complete waves that passes a particular point

Television

In 1927, Philo Farnsworth demonstrated a simple television camera that could change a picture into a series of lines of electricity. A cathode ray tube changed these lines back into a picture for viewing on a screen.

Analogue and digital transmission

Analogue transmission

- Analogue means something that is similar to something else. An analogue clock face has two similar hands that represent the passage of time in minutes and hours.
- In analogue transmission, the information about an image and its audio signal are represented by rapid variations of some aspect of the signal, for example, its amplitude or frequency.
  - » These variations can be extremely small. Even the smallest change in the original colour or sound is reproduced by the radio or television receiver.
  - » But this also means that the smallest unwanted change in the signal, caused by electronics or interference, is amplified by the receiver. For that reason, a weak analogue signal becomes snowy.

Figure 48 A selection of analogue and digital watches

Digital transmission

- When information is digital, it has been broken down into a bundle of on-off, yes-no or one-zero signals.
- In contrast to analogue transmission, a weak digital signal in digital transmission can be amplified to sound of the same quality as a strong signal.

Activity 29 Transmission of radio and television signals

Answer the following questions.

1. Give the name of the unit used for measuring radio frequencies. Why was it given this name?
2. List all the electromagnetic waves that you know about. Then research the electromagnetic spectrum in a library or on the Internet. Locate the waves that you know on the spectrum.
3. Compare analogue and digital transmission.

Amplification of sound

Amplification means to make something bigger or stronger. Loudness has to do with the amount of air pressure that reaches your ear. Extremely loud noises are the result of so much air pressure that they can damage your hearing. The air pressure is caused by the amplitude of the sound wave. The bigger the amplitude, the more air pressure there is and the louder the sound. We measure loudness in decibels (dB). Normal conversation is about 60 dB.

New word

amplification: make bigger or stronger; increase the volume or loudness of sound

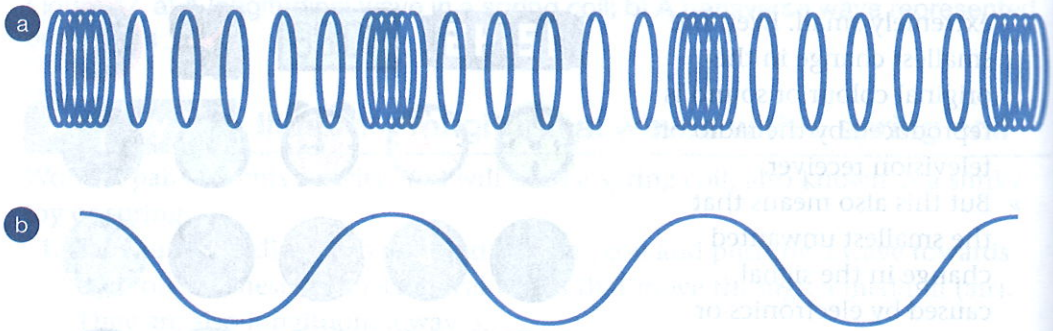


Figure 49 Mechanical waves can be either longitudinal or transverse waves. a) We hear sounds because of changes in air pressure, like in the longitudinal waves above. Speakers have a membrane that moves in and out, pushing the air towards our ears. b) Transverse waves are like waves moving through water.

Mechanical amplification of sound

Sound can be amplified mechanically or electronically. When you cup your hands around your mouth to shout to someone far away, you are amplifying the sound by concentrating it in a narrow beam.

Look at Figure 50. The dominoes have been stood up next to each other and the first one has been pushed over onto the next one. This demonstrates a wave. This is a good illustration of how sound travels through a medium.

Figure 50 Falling dominoes illustrate a mechanical wave.

Activity 30 Sho

Work in pairs for this a

Experiment

Materials

- one balloon betwee two learners

Method

1. Blow up the ballo fingers.
2. Hold the balloon other side. Note th
3. Blow more air into
4. Continue blowing loudness of the ta
5. Explain what is ha

Explanation

When you blow up the closer together. Think does not need to fall fa

Electrical amplifi

The first microphones co There was a thin metal o the side into which you s current was run through waves hit the diaphragm, carbon dust, which chan resistance. The changing the amount of current.

In modern microphon moves a magnet past a s magnet induces current

This process is reverse electrical signal is turned speaker. The bigger the v produce a quiet sound. S will sound high-pitched the high, medium and lo

Activity 30 Show how compressed air amplifies sound

Work in pairs for this activity.

Experiment

Materials

- one balloon between two learners

Aim

To show how compressed air amplifies sound

Method

1. Blow up the balloon, but not too hard. Squeeze the opening shut with your fingers.
2. Hold the balloon close to your ear while your partner taps lightly on the other side. Note the loudness of the sound.
3. Blow more air into the balloon. Repeat step 2.
4. Continue blowing more air into the balloon in stages and noting the loudness of the tapping sounds.
5. Explain what is happening.

Explanation

When you blow up the balloon, you force the air molecules inside the balloon closer together. Think of the dominoes that are close together. Each domino does not need to fall far before pushing over the next domino.

Electrical amplification of sound

The first microphones contained carbon dust. There was a thin metal or plastic diaphragm on the side into which you spoke. A small electric current was run through the carbon. As sound waves hit the diaphragm, they compressed the carbon dust, which changed their electrical resistance. The changing resistance changed the amount of current.

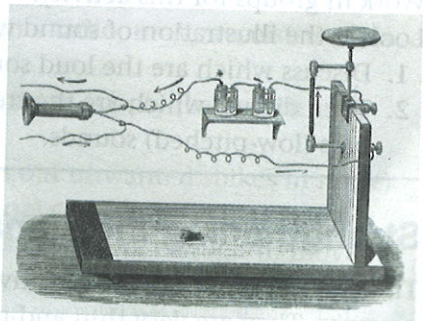


Figure 51 The first microphone

In modern microphones, the diaphragm moves a magnet past a small coil of wire. The magnet induces current to flow in the wire.

This process is reversed when you lead the sound through a speaker. The electrical signal is turned back into mechanical vibrations that move the cone of a speaker. The bigger the vibrations, the louder the sound is. Small vibrations will produce a quiet sound. Slow vibrations will sound deep (bass) and fast vibrations will sound high-pitched (treble). Expensive speakers use cones of different sizes for the high, medium and low frequencies.

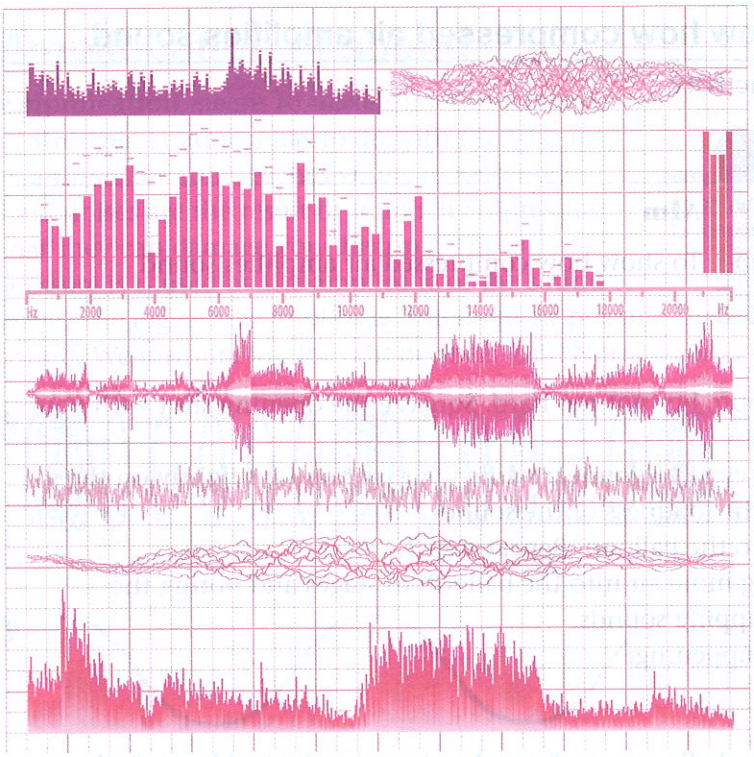


Figure 52 Diagram of sound waves from a music track

Activity 31 Identify loud and soft, low and high sounds

Work in groups for this activity.

Look at the illustration of sound waves from a music track in Figure 52.

1. Discuss which are the loud sounds and which are the soft sounds.
2. Then discuss which are the treble (high-pitched) sounds and which are the bass (low-pitched) sounds.

Strengthening the signal

The best microphones are sensitive and pick up the smallest changes in air pressure. They are very thin and move only a short distance. These microphones produce only a small electrical current.

This small current is strong enough for use in the recorder and is easily transmitted through wires. However, more power is needed to push the speaker cone back and forth. For this reason, the current must be increased, but in the same pattern as the original signal.

An amplifier produces a more powerful version of the original signal. Amplifiers can be complex devices with hundreds of tiny pieces, but they all work in the same way.

How an amplifier w

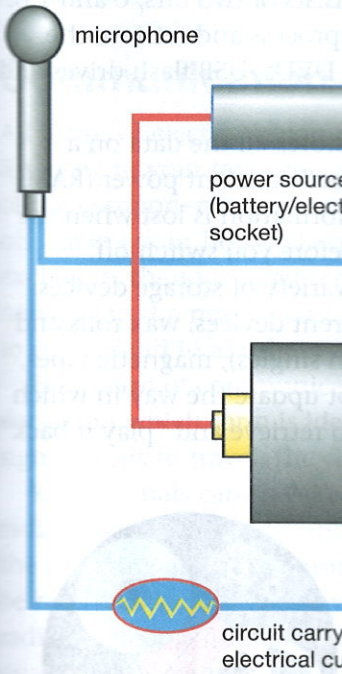


Figure 53 Diagram showing

- An amplifier turns a small
- An amplifier sends a new
original (weak) signal.
- The input signal (weak) is
or a microphone.
- A strong signal is generate
household plug).
- A good amplifier smooths
Think of clean paper on w
called the output signal. T
speaker cone.
- The input signal modifies
resistance to the output si
of the original audio signa

Storing data

We can store data (informati
oldest and simplest way is u
electromagnetic and sound e
energy to write, or engrave,

How an amplifier works

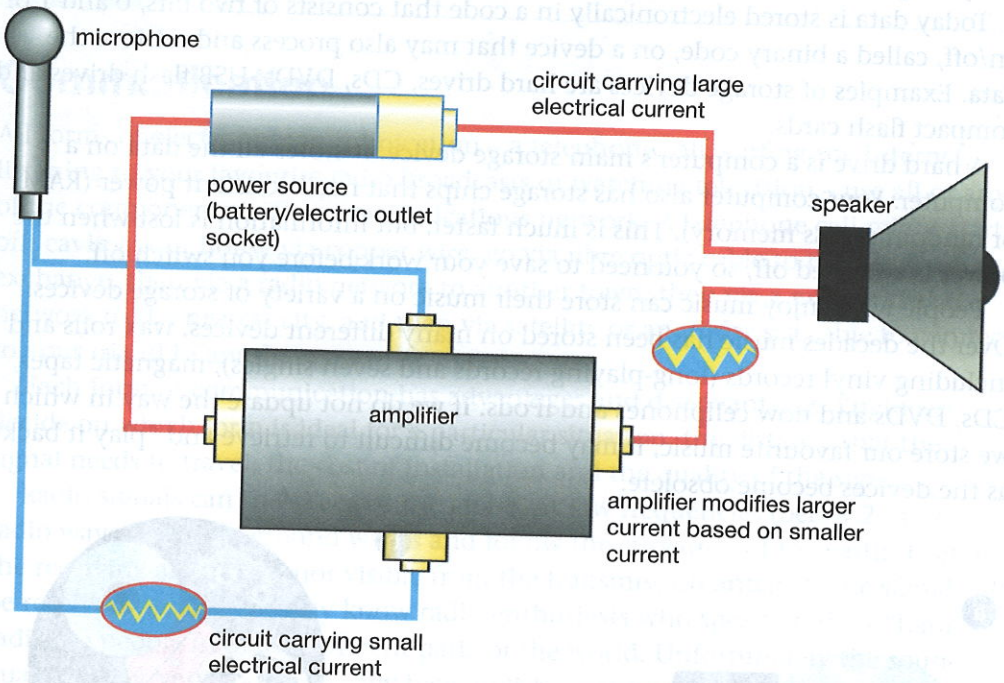


Figure 53 Diagram showing how an amplifier works

- An amplifier turns a small electric current into a larger one.
- An amplifier sends a new (stronger) signal to the speaker, modified by the original (weak) signal.
- The input signal (weak) is the audio signal from a radio, music recorded on tape or a microphone.
- A strong signal is generated by the amplifier's power supply (battery or household plug).
- A good amplifier smooths out this signal (takes out unwanted spikes in noise). Think of clean paper on which the original signal can "write" a new signal called the output signal. The output signal must be strong enough to move the speaker cone.
- The input signal modifies the output signal. The input signal applies varying resistance to the output signal. This re-creates the voltage fluctuations (changes) of the original audio signal.

Storing data

We can store data (information) in everyday life using any form of energy. The oldest and simplest way is using physical energy for handwriting. We can also use electromagnetic and sound energy for storing data. The oldest devices used sound energy to write, or engrave, data onto wax cylinders, and then onto vinyl plates.

Ask your parents and grandparents about LP records.

Today data is stored electronically in a code that consists of two bits, 0 and 1 or on/off, called a binary code, on a device that may also process and retrieve the data. Examples of storage devices are hard drives, CDs, DVDs, USB flash drives and compact flash cards.

A hard drive is a computer's main storage device. It stores all the data on a computer. Your computer also has storage chips that need constant power (RAM or random access memory). This is much faster, but information is lost when the power is switched off, so you need to save your work before you switch off.

People who enjoy music can store their music on a variety of storage devices. Over the decades music has been stored on many different devices, wax rolls and including vinyl records (long-playing records and seven singles), magnetic tapes, CDs, DVDs and now cellphones and iPods. If we do not update the way in which we store our favourite music, it may become difficult to retrieve and "play it back" as the devices become obsolete.

Figure 54 Data storage devices: a) Digital data can be stored on CDs and DVDs, USB flash drives and external hard drives. b) Music has been stored on vinyl records, magnetic tapes, CDs and USB flash drives.

Activity 32 Sound amplification

Answer the following questions.

1. Ask your parents and grandparents (or other adults) how they listened to music when they were your age. Then list the advantages or disadvantages of the devices that you have today.
2. Write down the function of an amplifier.
3. Make a simple flow diagram to show how an amplifier works.
4. You would like to make a small family recipe book. Your elderly aunt has many traditional recipes, but she has not written them down. Decide how you will store her information in the most useful possible way.

SUB-TOPIC 8 Satel

Communication

All forms of electronic com
listening to your favourite
of the components in the
off leaving your house via
exchange, then via a radio
network to the nearest city,
to your friend in another c
Each form of communic
decide on which form is id
signal needs to travel, the
Radio signals can travel
radio waves travel as groun
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be received clearly. You ma
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quality is not very good an

Use of satellites

Microwave radio signals do
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into space instead of going
Wherever you see a microw
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directly at dishes within sig
tower where you are standi

Did you know?

Microwaves have wavelengths that can be measured in centimetres and fractions of a centimetre.

SUB-TOPIC 8

Satellite communications

Communication

All forms of electronic communication – a telephone call, surfing the Internet, listening to your favourite radio broadcasts or watching television – use all or any of the components in the communications network. A telephone call might start off leaving your house via copper wire, go via fibre optic cable to the nearest exchange, then via a radio network to another town, then via a microwave network to the nearest city, and then via satellite or an under-sea cable to connect to your friend in another country.

Each form of communication has advantages and disadvantages. Engineers decide on which form is ideal for a particular situation, the distance that the signal needs to travel, the cost of installation and the quality of the signal.

Radio signals can travel across the globe. At low frequencies (below 2 MHz) radio waves travel as ground waves and follow the curvature of the earth. Even if the receiving antenna is not visible from the transmission antenna, the signal will be received clearly. You may know radio enthusiasts who speak on their "ham" radios to people in many different parts of the world. Unfortunately the sound quality is not very good and they have to listen extremely carefully.

Use of satellites in long-distance communication

Microwave radio signals do not suffer much from interference (noise) and are easier to listen to. However, the disadvantage is that microwave radio antennas must be in line of sight of each other. Large radio waves (low-frequency radio waves) can fold over and around obstacles, but small microwaves are easily blocked by obstacles. Also, they travel at such speed and in such a straight line that they will shoot off into space instead of going around the world. Wherever you see a microwave tower with dish antennas, you can be sure the dishes are pointed directly at dishes within sight of the microwave tower where you are standing.

Figure 55 A microwave tower with dish antennas

Did you know?

Microwaves have wavelengths that can be measured in centimetres and fractions of a centimetre.

The disadvantage of microwave communication is that it depends on many microwave towers to form a microwave communication link

between Zambia and Egypt, for example. Each microwave tower must be within line of sight of the next. But if you could have an antenna very high up in the sky, you would make this connection in one bound.

Communications satellites are antennas in the sky. Geostationary satellites move in such a way that they always remain in the same area above the earth.

Figure 56 A geostationary satellite

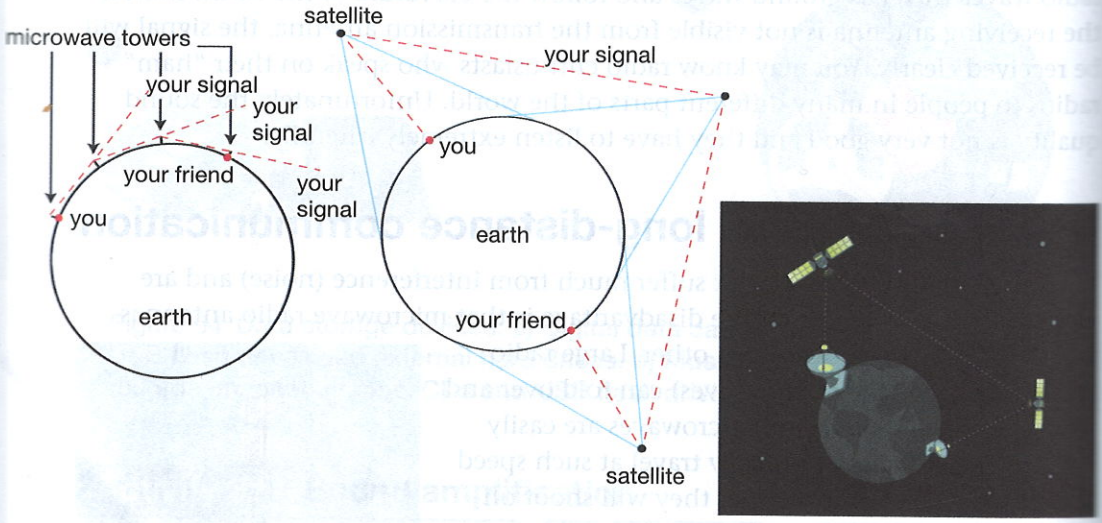

Figure 57 Fewer links are necessary in a worldwide satellite link-up than in an earth-based link-up via microwave towers.

Did you know?

The moon is a natural satellite of the earth. Communications satellites are artificial satellites. There are many different kinds of satellites, depending on their function. examples include navigation, search and rescue, weather and space exploration satellites. Satellites stay in their orbits according to the same principle that you can swing a ball at the end of a line around your head. The line stops the ball from flying off and breaking a neighbour's window. The force that holds a satellite in its orbit around the earth is the earth's gravity.

Figure 58 Diagrams showing

At present, some television s
in Sub-topic 7, analogue tele
and sound than the original.
the worse the reproduction is

Digital television transmis
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can broadcast many channel

Analogue television sets ca
box. This box converts digita
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Activity 33 Spot sat

Work alone for this activity, a

1. Ask an adult to go outsid
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2. Remember to use a flashl
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3. Write down the time you
the sky.
4. Do not confuse a shootin
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5. Find out how many of yo
times and position in the

A website called Heavens-abov
that you can download is avail

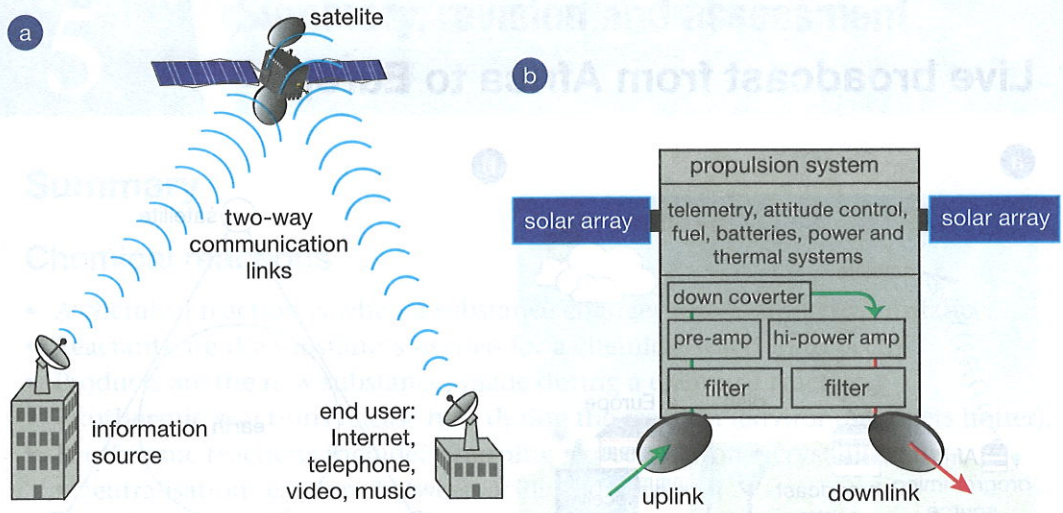

Figure 58 Diagrams showing a) how a satellite link works and b) how a satellite works

At present, some television sets are analogue and others are digital. As you learnt in Sub-topic 7, analogue television transmission produces lower-quality pictures and sound than the original. The further away you are from a television station, the worse the reproduction is.

Digital television transmission gives very clear pictures and sound over long distances, with no fading or interference. With this technology, television stations can broadcast many channels with different programming.

Analogue television sets cannot receive digital transmissions without a set-top box. This box converts digital signals to analogue signals that your television set can understand. However, if you have a satellite connection, your signal provider should convert the signal for you.

Activity 33 Spot satellites in the sky at night

Work alone for this activity, and then report back to your group.

1. Ask an adult to go outside with you after dark to help you spot satellites in the sky.
2. Remember to use a flashlight that has a red light or cover your flashlight with red plastic. That will prevent you from losing your night vision.
3. Write down the time you saw the satellite and roughly where you saw it in the sky.
4. Do not confuse a shooting star for a satellite. A shooting star appears and disappears quickly. A satellite moves more slowly and will not suddenly disappear. If you are lucky, you will see a flash of light as the sun's rays reflect off the satellite's solar array. These solar panels charge the satellite's batteries.
5. Find out how many of your classmates saw the same satellite by comparing times and position in the sky.

A website called Heavens-above predicts when satellites will be visible. A mobile app that you can download is available at http://www.heavens-above.com/mobile.

Live broadcast from Africa to Europe

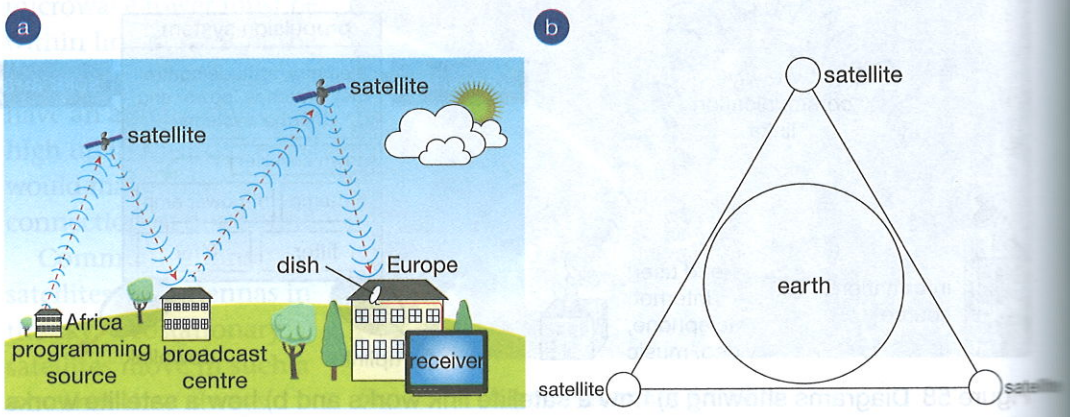

Figure 59 a) Block diagrams illustrating live broadcast from Africa to Europe; b) Only three satellites are needed for worldwide coverage of an event.

A sporting event in Africa can be broadcast live in Europe as it happens using two satellites. Worldwide coverage uses three satellites.

Broadcasts can be recorded, edited and transmitted or they can be "live." Recorded broadcasts are made more interesting by taking out the boring parts and repetitions. They can show a goal being scored in slow motion and use other techniques to make the event more interesting. Some sports television broadcasts can include slow-motion clips of important goals and replays while the live broadcast is continuing.

Live television can pose problems for television networks because of the possibility of mishaps. Television networks often broadcast live programmes with a slight delay to give them time to censor words and images, while keeping the broadcast as live as possible.

A disadvantage of recorded broadcasts is that the public will already know the result of a game. In countries with authoritarian control, live broadcasts are not allowed so that the authorities have time to censor what is being said or shown.

Activity 34 Long-distance communication

Answer the following questions.

1. State the advantage that low-frequency radio waves have over microwaves.
2. Use your knowledge of microwaves to plan the best position in your area for a tower with dish antennas. Give reasons for your decisions.
3. Suggest why geostationary satellites are given their name.
4. Explain how geostationary satellites are used in live broadcasting over great distances.

TOPIC 5 Sum exer

Summary

Chemical reaction

- A chemical reaction i
- Reactants are the sub
- Products are the new
- Exothermic reaction
- Exothermic reactions
  - neutralisation react
- Endothermic reactio
- Endothermic reaction
  - evaporation.

Types of chemical re

- We represent chemica separated by an arrow
- Four basic types of ch
  - **Synthesis:** Two or substance. The gen
  - **Decomposition:** A parts. The general
  - **Single replacemer** compound. The ge
  - **Double replaceme** places to form two is: VW + XY → XW

The chemical reactio

- Two or more simple s
- The reactants may be compound.

Chemical reaction o

- When an electric cur
- This is known as elec

The law of conserva

- The law states: Matte
- So, all the atoms pres form of the product(s
- This law is represente of atoms in the reacta

TOPIC 5

Summary, revision and assessment exercises

Summary

Chemical reactions

- A chemical reaction is when a substance changes into a different substance.
- Reactants are the substances needed for a chemical reaction to occur.
- Products are the new substances made during a chemical reaction.
- **Exothermic reactions** release heat during the reaction (environment gets hotter).
- Exothermic reactions include: • burning • precipitation • crystallisation • neutralisation reactions between acids and alkalis.
- **Endothermic reactions** absorb heat during the reaction (environment gets colder).
- Endothermic reactions include: • electrolysis • photosynthesis • melting ice • evaporation.

Types of chemical reactions

- We represent chemical reactions by a chemical equation with two sides separated by an arrow. Reactants are on the left and products are on the right.
- Four basic types of chemical reaction are:
  - » **Synthesis**: Two or more simple substances combine to form a more complex substance. The general equation for these reactions is: $X + Y \rightarrow XY$
  - » **Decomposition**: A more complex substance breaks down into its simpler parts. The general equation for these reactions is: $XY \rightarrow X + Y$
  - » **Single replacement**: A single uncombined element replaces another in a compound. The general equation for these reactions is: $W + XY \rightarrow XW + Y$
  - » **Double replacement**: The anions and cations of two compounds change places to form two different compounds. The general form for these reactions is: $VW + XY \rightarrow XW + YV$

The chemical reaction of synthesis

- Two or more simple substances combine to form a more complex substance.
- The reactants may be elements or compounds and the product is always a compound.

Chemical reaction of water using an electric current

- When an electric current is passed through water, the water breaks down.
- This is known as electrolysis. It is a decomposition reaction.

The law of conservation of matter

- The law states: Matter cannot be created or destroyed during a chemical reaction.
- So, all the atoms present in the reactants are present after the reaction in the form of the product(s).
- This law is represented by a balanced chemical equation in which the number of atoms in the reactants is equal to the number of atoms in the products.

Summary, revision and assessment exercises continued

Light and its nature

- There are two types of lenses: convex and concave.
- **Convex lenses** are also known as converging lenses. • They are thick in the middle and thin at the edges. They cause light rays to converge.
- **Concave lenses** are diverging lenses. • They are thick at the edges and thin in the middle. • They cause light rays to diverge (bend away from a central point).
- **Real images** are upside down (inverted) and can be formed on a screen. • They can be bigger than, smaller than or the same size as the object. • They can be on the same or opposite side of the lens as the object. • The distance between the lens and the screen must be adjusted to focus the image.
- **Virtual images** are always upright and cannot be formed on a screen. • To see this type of image, you look through a lens towards the object. • The image is always bigger than the object (magnified). • The image is always on the same side of the lens as the object.
- **Ray diagrams** show the object, the lens, light rays and the image.
- A real image is produced when the object is further away from the converging or convex lens than the focal length of the lens.
- A virtual image is produced when the object is closer to the converging or convex lens than the focal length of the lens.
- The two types of lenses refract (bend) light differently, so we use them in different ways.
- **Converging (convex) lenses** are used to converge light rays.
- Applications of convex lenses include: » spectacles » magnifying glasses » cameras » microscopes. (Cameras and microscopes have both types of lenses.)

Produce a spectrum from white light

- Sunlight is white light. It is made up of of many different colours of light, known as the visible spectrum.
- The colours always occur in this order: Red, Orange, Yellow, Green, Blue, Indigo and Violet.
- The spectrum is created when light passes from one substance into another and the light rays are bent.
- Each colour has a different wavelength that bends at a slightly different angle, which causes the colours to separate and spread out.

Rainbows

- We see a rainbow as a semi-circle in the sky with red at the top.
- The best time to look for a rainbow is after 16:30 or before 08:30.
- Have bright sunlight behind you and rain clouds in the distance in the direction of your shadow.

Why the sky looks

- Light that passes thr atmosphere.
- Scattering is greatest wavelengths.
- When the sun is clos through the atmosp
- This causes blue ligh orange and yellow a looks red.

The colour of object

- The colour of an obj » shines on the obje
- A surface that reflect
- A surface that absorb
- An opaque object th reflected towards the
- Transparent objects t that passes through i

The effect of colour

- A filter prevents certa
- Colour filters allow s other wavelengths o

Electric current an

- **Current** is the rate o
  - » We measure curre
  - » In circuit diagrams
  - » The reading on an
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  - » In circuit diagrams
  - » The reading on a v the battery or othe

Connecting meters i

- Always connect an a wish to measure the
- Never connect an am
- Refer to page 115 for

Why the sky looks red at sunset and sunrise

- Light that passes through the atmosphere is scattered by particles in the atmosphere.
- Scattering is greatest for the shortest wavelengths and least for the longer wavelengths.
- When the sun is close to the horizon, light passes through a longer path through the atmosphere than during the rest of the day.
- This causes blue light to be scattered more. The longer wavelengths of red, orange and yellow are not scattered as much and reach our eyes, so the sky looks red.

The colour of objects

- The colour of an object depends on the type of light that:
  - » shines on the object
  - » bounces off the object.
- A surface that reflects sunlight without absorbing any colours appears white.
- A surface that absorbs all colours and reflects none appears black.
- An opaque object that appears blue absorbs all colours but blue. Blue light is reflected towards the eye, giving the object its colour.
- Transparent objects transmit light. The colour depends on the colour of light that passes through it.

The effect of colour filters on light

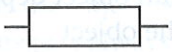
- A filter prevents certain things from passing through it, but not others.
- Colour filters allow some wavelengths of light to pass through them, but absorb other wavelengths of light.

Electric current and voltage in a circuit

- **Current** is the rate of flow of charge in a circuit.
  - » We measure current in amperes (A) using an ammeter.
  - » In circuit diagrams we use the symbol Ⓐ for an ammeter.
  - » The reading on an ammeter shows the strength of the current flowing in a circuit.
- **Voltage** is the change of potential energy per unit charge in a circuit.
  - » We measure voltage in volts (V) using a voltmeter.
  - » In circuit diagrams, we use the symbol Ⓥ for a voltmeter.
  - » The reading on a voltmeter shows the potential difference (voltage) across the battery or other component of the circuit.

Connecting meters in a circuit

- Always **connect an ammeter** in series in a circuit at the point at which you wish to measure the current.
- Never connect an ammeter in parallel.
- Refer to page 115 for details.

- Always **connect a voltmeter** to a circuit in parallel with the component(s) across which you want to measure the voltage.
- Never connect a voltmeter in parallel.
- Refer to page 115 for details.
- The relationship between potential difference and current strength is directly proportional.
- This relationship is known as **Ohm's Law**, which states: The current (I) flowing through a conductor is directly proportional to the voltage (V) between the two ends of the conductor/resistor if the temperature stays the same.
- This relationship is known as the resistance of the component.
  - » **Resistance** is the opposition to the flow of electric current.
  - » We measure resistance in ohms, symbol Ω.
  - » The symbol for a resistor in a circuit diagram is: 
- We can represent Ohm's Law as follows: resistance = $\frac{\text{voltage}}{\text{current}}$ or $R = \frac{V}{I}$

Uses of electrical current in local environment

- An **electrical appliance** works if an electrical current is flowing through it.
- It converts electrical energy into another form of energy to do its function.
- Electrical appliances produce: » heat energy » light energy » microwave energy » mechanical energy.
- Electrical appliances enable us to: » see when it is dark » cook food » be entertained » communicate » process information » access information
- cut/shave hair » regulate the temperature of our homes and workplaces.

Pressure

- **Pressure** is force per unit area that is applied at right angles to the surface.
- OR pressure is the size of a force divided by the size of the area to which it is applied.
- The equation we use for calculating pressure is: $P = \frac{F}{A}$
- The unit of force is the newton (N) and the unit of area is the square metre (m^2).
- The unit for pressure is the newton per square metre (N/m^2) or the pascal (Pa).

Pressure in gases

- Gas particles in a container collide with each other and with the container walls. These collisions apply a force called gas pressure to the container walls.

Factors affecting pressure in gases

- **Temperature:** When a gas is in a closed container, an increase in temperature causes an increase in pressure. A decrease in temperature causes a decrease in pressure.
- **Volume:** When a fixed amount of gas is in a container with a smaller volume

than before, the pressure increases. When the volume of the container increases, the pressure decreases.

- **Number of gas particles:** An increase in the amount of a gas in a closed container at constant temperature increases the pressure. A decrease in the amount of a gas in a closed container at a constant temperature decreases the pressure.

Energy and its conservation

- **Energy** is: » the ability to do work » that which allows matter to move » that which allows matter to change.
- **Work** is the transfer of energy to a body by applying a force that moves the body in the direction of the force.
- We measure energy in units called joules. The symbol for a joule is J. One joule is a very small amount of energy.
- **Forms of energy** are: » kinetic energy » potential energy » chemical energy » electric energy » heat energy » mechanical energy » sound energy » radiant energy » gravitational energy » nuclear energy » light energy.
- Energy is converted from one form to another, to be used for different purposes.
- **The law of energy conservation** states: Energy cannot be created or destroyed, but can be changed from one form to another.

Effect of energy production on the environment

- The construction and operation of power plants affect the environment.
- Power plants: » take up space on the ground and in the air » use water resources » release pollutants into the air.

Ways of conserving energy

- **Alternative energy sources** are different ways of producing electricity that do not rely on fossil fuels. They cause little or almost no pollution.
- Common forms of alternative energy sources are:
  » wind energy » solar energy » hydroelectric energy » geothermal energy » biofuel energy » ocean energy.
- To **avoid energy wastage**, we can:
  » minimise phantom loads » change your light bulb type » use fans for cooling » improve insulation » conserve water » plant trees and shrubs » turn down the refrigerator setting » turn down the setting on the geyser » use personal transport as little as possible.
- **Reduce, Reuse and Recycle** are the keys to preserving and conserving the earth.
- The three Rs contribute towards:
  » reducing the amount of waste we throw away
  » conserving natural resources, landfill space and energy.

Summary, revision and assessment exercises continued

Communication

- **Communication** refers to the exchange of information, ideas or feelings using behaviour, signals, speech or writing.
- **Long-distance communication** occurs when those who are communicating are not in each other's presence.
- Methods of communicating over long distances include: » visual signals » auditory signals » electrical signals » electromagnetic signals.
- Today long-distance communication relies on technological devices that use electrical signals or electromagnetic waves.
- This type of communication is known as **telecommunication**. All telecommunication systems use:
  - » a transmitter, which takes information and changes it into a signal
  - » a transmission medium, which carries the signal
  - » a receiver, which takes the signal from the transmission medium and changes it back into usable information.

Advantages and disadvantages of various types of telecommunication: Refer to the table on pages 140–142.

Digital and analogue transmission

Transmission of radio and television signals

- **Radio** transmitters send messages by radio waves.
- We measure frequencies in units called Hertz (Hz).
- Radios waves can be transmitted over vast distances to the outer reaches of space. At the receiving end, the radio waves are changed back into mechanical waves by a radio receiver. They are amplified by a speaker.

Waves

- **Mechanical waves** need a medium, such as air, to travel.
- **Electromagnetic waves** do not need a medium; they can travel in a vacuum.
- Radio waves have the longest wavelengths, and X-rays and gamma rays have the shortest wavelengths.
- Mechanical waves can be longitudinal or transverse.
- Electromagnetic waves are transverse.
- In **longitudinal waves**, the particles of the medium vibrate. The vibrations move in the same direction as the wave.
- In **transverse waves**, the particles of the medium move up and down as the wave moves forwards.

Antennas

- These are devices used to transmit and receive radio signals.
- The length of an antenna is related to the wavelength of the signal.

Analogue transmission

- The information about an image signal and its audio signal are represented by rapid variations of some aspect of the signal.
- The variation can be in either the amplitude or the frequency of the wave/signal.

Digital transmission

- The information about an image signal and its audio signal is broken down into bundles of on-off, yes-no or one-zero signals.

Amplification of sound

- The loudness of a sound is determined by the amplitude of the sound wave.
- The bigger the amplitude, the louder the sound. The smaller the amplitude, the softer the sound.
- We measure loudness in decibels (dB). Normal conversation is about 60 dB.
- **Mechanical amplification of sound** happens if an existing sound wave increases the number of particles that are vibrating.
- If a vibrating object is placed on a larger, flat surface, it causes the whole surface to vibrate. More air particles vibrate, which makes the sound louder.
- **Electrical amplification of sound** is done with an amplifier.
- An **amplifier** uses the small electrical current from the audio input (such as a microphone or a received radio signal) to modify a large electrical current.
- This modified large current (output) then vibrates the speaker cones to produce sound that is louder than the original signal.

Storing data

- We can store data using any form of energy: physical energy (writing on paper), sound and mechanical energy (engraving a wax cylinder or vinyl record) or electromagnetic energy (on/off code stored on a microchip).
- Examples of storage devices are: » hard drives » CDs » DVDs » USB flash drives compact flash cards » cellphones » iPods.

Satellite communications

- You can use all or any of the components in the communications network.
- Components in a communications network include: » copper wire » fibre optic cable » radio network » microwave network » satellite » under-sea cable.

Use of satellites in long-distance communication

- **Microwave radio signals** travel in straight lines so their antennas must be in line of sight of each other.
- Microwave communication needs many towers, each within line of sight of the next tower, to form a microwave communication link between distant places.
- **Geostationary (communications) satellites** are microwave antennas in space that transmit microwave radio signals over vast distances.

Summary, revision and assessment exercises continued

Live broadcast from Africa to Europe

- An event in Africa can be broadcast live in Europe via satellite.
- Television networks often broadcast live programmes with a slight delay to give them time to censor words and images.
- Recorded broadcasts can have boring parts cut and additional material inserted, such as: slow-motion clips » repetitions or replays » insertion of subtitles.

Revision exercises

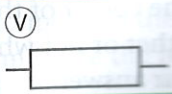
Various options are provided as possible answers to the following questions. Choose the correct answer and write only the letter (A to D) next to the corresponding question number.

1. Which process is an example of an exothermic reaction?
   A Ice melting
   B Electrolysis
   C Crystallisation
   D Evaporation
2. Which process is NOT an example of a type of chemical reaction?
   A Synthesis
   B Insertion
   C Decomposition
   D Replacement
3. The type of lens that causes light rays to converge is:
   A Concave B Convex C Plane D Oval.
4. Which description is not true of a virtual image?
   A It is always upright.
   B It is always on the same side of a lens as the object.
   C It is always bigger than the object.
   D It can be formed on a screen.
5. In which unit do we measure resistance?
   A Amperes
   B Volts
   C Ohms
   D Potential difference
6. Which symbol do we use for potential difference?
   A V B Ω C A D Pa
7. Which two factors are responsible for producing pressure?
   A Area and mass
   B Area and force
   C Force and mass
   D Force and weight
8. Which factor does not influences gas pressure?
   A Temperature
   B Volume
   C Number of gas particles
   D Size of gas particles
9. In which process is an electric current produced in a coil by rapidly moving a magnet into and out of the coil?
   A Electric energy
   B Magnetism
   C Gravity
   D Electromagnetic induction

10. Which type of turb
    A Coal-fired turbi
    C Tidal energy-po
11. What is the most ef
    conserving our natu
    A Recycle
12. Which of these proc
    A Lighthouse
13. Which description i
    communication?
    A Inexpensive
    C Message needs t
14. Name the unit used
    A Pascal
15. Name the compone
    A Resistor
16. Name the earth's on
    A Sun
17. Indicate whether ea
    both A and B or to n
    both A and B neithe

	Column
a	The type of reac on energy transf
b	The type(s) of ch represented by t equation: AB + CD → CB +
c	The distance fro a concave lens t which it forms ar
d	Characteristic(s) lens
e	Connect in paral electrical circuit
f	The symbol for th that measures po difference in an e

10. Which type of turbine does not produce an alternative source of energy?
    A Coal-fired turbine B Wind-powered turbine
    C Tidal energy-powered turbine D Geothermal-powered turbine
11. What is the most effective way in which we can contribute to preserving and conserving our natural resources?
    A Recycle B Reduce C Reuse D Reward
12. Which of these produces a visual signal used for communication?
    A Lighthouse B Drums C Telephone D Radio
13. Which description is a disadvantage of text messaging as a form of communication?
    A Inexpensive B Easy to store and reference
    C Message needs to be fairly short D More discreet than a phone call
14. Name the unit used to measure the frequency of radio waves.
    A Pascal B Newton C Hertz D Ohm
15. Name the component that amplifies sound in an electrical circuit.
    A Resistor B Amplifier C Transistor D Capacitor
16. Name the earth's only natural satellite.
    A Sun B Moon C Stars D Mars
17. Indicate whether each statement in Column I applies to A only, to B only, to both A and B or to neither of the items in Column II. Write A only, B only, both A and B neither next to the question number.

	Column I		Column II
a	The type of reaction that relies on energy transfer	A B	Endothermic Exothermic
b	The type(s) of chemical reaction represented by the general equation: $AB + CD \rightarrow CB + AD$	A B	Single replacement Double replacement
c	The distance from the centre of a concave lens to the point at which it forms an image	A B	Focal point Focal length
d	Characteristic(s) of a concave lens	A B	Causes light rays to diverge Thickest in the middle
e	Connect in parallel in an electrical circuit	A B	Ammeter Voltmeter
f	The symbol for the instrument that measures potential difference in an electrical circuit	A B	

Summary, revision and assessment exercises continued

Column I		Column II	
g	An equation that we can use to calculate pressure	A B	$p = \frac{F}{A}$ $A = \frac{P}{F}$
h	Longitudinal waves	A B	Sound energy Radiant energy
i	Energy that is transferred in photons	A B	Radiant energy Light energy
j	Component(s) of a communications network	A B	Microwave radiation Carbon fibre

Assessment exercises

1. During an investigation on chemical reactions, learners added 6 g of iron filings and 9 g of flowers of sulphur to a test tube. They heated it over a Bunsen burner until it glowed. They observed and recorded the changes that took place.
   a) Explain why the learners had to weigh the test tube with the iron filings and sulphur before and after heating. (1) C
   b) How would the two masses compare with each other? (1) K
   c) Name the law that this comparison supports. (1) K
   d) Explain your answer to question 1b). (2) C
   e) Did a chemical reaction occur in the test tube? (1) K
   f) Explain your answer to question 1e). (2) C
   g) If a chemical reaction did occur, give the word formula to represent the reaction. (3) C
   h) Write the balanced chemical equation of this reaction. Write down the workings to show how you determined your equation. (4)Ap
   [15]

2. A ray of white light is shone through a triangular prism to produce a spectrum of light.
   a) Describe what happens to the light ray when it strikes the surfaces of the prism. (4) C
   b) List the colours of the spectrum in order, starting with the colour that refracts the most. (2)Ap
   c) Identify the colour of the spectrum that has the highest frequency. (1) C
   d) State whether or not white light is a colour with a single frequency. Justify your answer. (3) E
   [10]

3. Read the information and answer the questions that follow.

Sulphur dioxide and human health

Breathing high levels of sulphur dioxide can tighten airways. This causes wheezing, coughing and other breathing problems. Long-term exposure may cause bronchitis. Exposure to sulphur dioxide can also weaken the respiratory system's defences against foreign particles and bacteria.

Elderly people and people with asthma, cardiovascular or lung diseases are the most sensitive to sulphur dioxide exposure. Children are exposed to more sulphur dioxide because they breathe more air for their body weight than adults. Long-term exposure can affect a child's ability to breathe deeply.

Low concentrations of sulphur dioxide in outdoor air irritate the eyes, nose, throat and respiratory tract, which causes coughing and shortness of breath.

Long-term exposure to low concentrations of sulphur dioxide causes headaches, nausea, dizziness and temporary loss of smell. Exposure to very high levels of sulphur dioxide may be life-threatening.

a) Write down the word equation of the reaction that results in the formation of sulphur dioxide. (2)Ap

b) Explain why it would be bad to exercise outdoors if the sulphur dioxide levels are too high. (2) C

c) Explain why children are exposed to more sulphur dioxide than adults living in the same area. (2) C

d) Explain why people are more likely to catch other respiratory infections if the sulphur dioxide levels in the area are high. (2)An

e) What is formed when sulphur dioxide in the air reacts with water vapour? (1)Ap

[9]

4. Answer the following questions about lenses.

a) Draw a ray diagram to show how a convex lens forms an image of an object. The object is twice as far from the lens as the focal length of the lens. The object is on the right-hand side of the lens and its height is 3 cm. (10) S

b) Calculate the magnification of the image. (4) Ap

c) Identify the type of image formed in this ray diagram. (1) C

[15]

5. Answer the following questions about current and voltage in a circuit.

a) Draw a circuit diagram to illustrate the following circuit: two cells connected in series to form a battery, an open switch, three light bulbs connected in parallel, an ammeter to measure the total current strength of the circuit and a voltmeter to measure the potential difference across all three bulbs. (10)Ap

b) If the total voltage of the circuit in 5a) is 3 V and the total current strength is 1.5 A, calculate the total resistance of the circuit. (4) Ap

[14]

6. Two women attend a garden party that is held on a lawn. Both women wear high-heeled shoes. One woman has a mass of 48 kg and the total area of her heels is 5 cm^2. The other woman has a mass of 53 kg and the total area of her heels is 7 cm^2.
   a) Determine which of the two women's heels will sink furthest into the lawn. (1) An
   b) Support your answer to question 6a) with the calculations. Show all your workings. (9) S

   [10]

7. Answer the following questions about pressure in gases.
   a) Name the three factors that affect the pressure produced by gases. (3) K
   b) Outline how each factor affects pressure in gases. (17) An

   [20]

8. Zambia needs more electricity, so a power station is planned for the north. Use your knowledge about the effects of producing electricity. Write a short paragraph to convince the government *not* to build a coal-powered power plant. [10] E

9. Muleya has spent two years living in South Africa and is now returning to Zambia. He plans to keep in contact with his friends in South Africa. He is wondering whether to use text messaging or email. Help Muleya decide which method to use by comparing the advantages and disadvantages of both forms of communication. [20] E

10. Answer the following questions about the amplification of sound.
    a) Name the ways in which sound can be amplified. (2) K
    b) Illustrate one method of sound amplification that you named in question 10a). Use the idea of tapping on a balloon that contains increasing amounts of air to do this. (4) Ap
    c) Name four examples of devices on which you can store data electronically. (4) K

    [10]

11. Answer the following questions about satellite communications.
    a) By means of a labelled diagram, show how a communications satellite can be used to transmit microwaves across extremely long distances. (4) An
    b) Explain why a slightly delayed television broadcast of a sporting event is often used rather than a live broadcast. (4) Ap

    [8]

Study and

How to approach

Planning your time

Read through your test

time you will spend on e

How to read questi

Read the instructions tw

Note the mark allocati

Give four facts if the que

How to answer the

Multiple-choice quest

Do not guess.

Questions with short

Do not write full sentenc

Questions that requir

sure you understand the

"explain"? Plan your ans

Exam word	
Compare	Describe
Conclude	Give a sh
Define	Give the f
Describe	Give detai
Determine	Find out
Discuss	Give differ
Display	Show
Draw	Show in a
Explain	Give the f
Identify	Find, nam
Illustrate	Give an ex
Indicate	Show
Investigate	Follow a s
Match	Pair an ite
State	Give, say
Suggest	Give ideas
Summarise	Briefly give
Support	Use examp

Study and exam skills

How to approach tests and exams

Planning your time

Read through your test or exam paper before you start writing. Plan how much time you will spend on each question.

How to read questions

Read the instructions twice to make sure you understand what you have to do.

Note the mark allocation so that you do not write a paragraph for one mark. Give four facts if the question is for four marks.

How to answer the different kinds of questions

Multiple-choice questions: Read all the optional answers before you decide. Do not guess.

Questions with short answers: Give one word only if you are asked to do so. Do not write full sentences unless you are asked to do so.

Questions that require longer answers: Look at the mark allocation. Make sure you understand the instructions. For example, do you have to "compare" or "explain"? Plan your answers.

Exam word	Meaning
Compare	Describe what is similar and different between two or more things
Conclude	Give a short interpretation of results or give a summary
Define	Give the full meaning of something accurately as in a dictionary
Describe	Give details and facts in full sentences without giving reasons
Determine	Find out
Discuss	Give different ideas and arguments about the topic
Display	Show
Draw	Show in a visual way
Explain	Give the full details in full sentences and give reasons
Identify	Find, name and mention
Illustrate	Give an example of what you mean or explain it visually
Indicate	Show
Investigate	Follow a systematic way of analysing a problem
Match	Pair an item with another to which it is related or that it resembles
State	Give, say or write down the information asked for
Suggest	Give ideas, solutions or reasons for something
Summarise	Briefly give the main points
Support	Use examples to prove what you have said

Glossed index

NOTE: Most key concepts are explained in the text and not all are repeated here.

F

fibrinogen: a protein in the blood plasma that is essential for blood clotting 2, 4
fixation: process of changing nitrogen into a usable form 43, 44
focal length: the distance from a lens to its focal point 88, 100, 101, 102, 105, 156, 165
focal point: the point at which light rays converge (for a convex lens) or diverge (for a concave lens) after passing through a lens 88, 100, 101, 102, 103, 104, 105
frequency: the number of complete waves that pass a particular point 144, 145, 151, 154, 161, 163, 164

G

genitals: the external sexual organs of animals 30, 31, 32, 36
graft: to join a bud or stem from one plant to the stock (stem) of another plant 61

H

haemoglobin: the iron-containing protein that carries oxygen 3, 23, 26
heparin: a substance found in the liver, which slows the clotting of blood 3, 23
HIV: Human Immunodeficiency Virus 29, 30, 32, 33, 34, 35, 36, 37
humidity: how much water vapour there is in the air 80, 81, 85, 87

I

immune system: the system that protects the body and fights infection 21, 33, 35
infertility: unable to have a child 31
inflammation: red, swollen, painful and hot area of the body 31
inhalation: breathing in 12, 14, 15, 16, 17, 25, 27
in parallel: when the current in an electric circuit divides into two or more paths before rejoining 115, 117, 157, 158, 163, 165
in series: refers to an electric circuit in which the current passes through each circuit element without branching 115, 116, 117, 118, 119, 121, 157, 165
invasive: alien organisms that spread out of control 66, 67, 84

L

light intensity: how much light there is 80, 85
longitudinal wave: a wave that vibrates in the same direction in which it travels 143, 144

M

macrophage: a type of white blood cell that is part of the body's defence mechanism 33
mitochondria (mitochondrion, singular): organelles present in living cells of all plants and animals in which tissue respiration takes place 78
mucous membrane: moist skin lining the nose, mouth, throat and other hollow organs of the body that are open to the outside 30, 31

N

neutralisation: a chemical reaction in which an acid and a base form a salt 91
newborn: a baby from birth to four weeks old 31
nicotine: a colourless, oily and poisonous substance found in tobacco 20, 25
nitrate: naturally occurring form of nitrogen that can be absorbed by plants 43, 54, 92, 93
nitrite: naturally occurring form of nitrogen that bacteria change to nitrates 43

O

opaque: does not allow light to pass through it 112, 157

P

pandemic: spread throughout a country, continent or the whole world 32–34
pathogen: something that can cause disease 30, 50, 51
photosynthesis: a process in which green plants use the sun's energy to turn carbon dioxide and water into glucose 40, 41, 42, 43, 54, 57, 65, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 82, 84, 86, 87, 90, 155
precipitate: fine particles that form and settle at the bottom of a container, especially when a reaction takes place in a liquid 90

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