

OXFORD

# Progress in

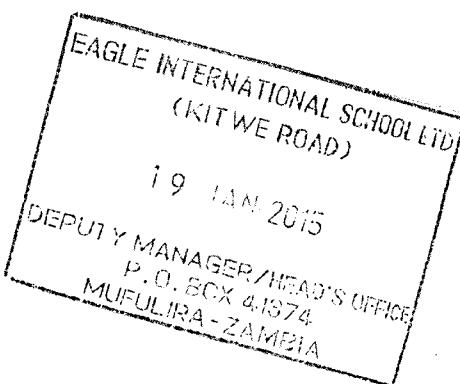
## Integrated Science

LEARNER'S BOOK

BALDWIN KANDINDA  
ARTHUR SIKAPIZYE  
with GARY MANN

Grade

8



OXFORD  
UNIVERSITY PRESS

# Contents

How to use this book .....	v
<b>Topic 1 The human body</b> <span style="float: right;">1</span>	
Sub-topic 1 The human reproductive system and puberty .....	2
Sub-topic 2 Fertilisation and embryo development .....	11
Summary, revision and assessment .....	19
<b>Topic 2 Health</b> <span style="float: right;">25</span>	
Sub-topic 1 Nutrition .....	26
Summary, revision and assessment .....	43
<b>Topic 3 The environment</b> <span style="float: right;">48</span>	
Sub-topic 1 Water, air and land pollution .....	49
Summary, revision and assessment .....	60
<b>Topic 4 Plants and animals</b> <span style="float: right;">65</span>	
Sub-topic 1 Plant cells .....	66
Sub-topic 2 Plant growth and nutrients .....	71
Sub-topic 3 Animal cells .....	83
Summary, revision and assessment .....	85
<b>Topic 5 Materials and energy</b> <span style="float: right;">91</span>	
Sub-topic 1 Composition of matter .....	92
Sub-topic 2 Physical change of state .....	99
Sub-topic 3 Mixtures .....	104
Sub-topic 4 Mass and weight .....	110
Sub-topic 5 Density .....	116
Sub-topic 6 Heat transfer .....	125
Sub-topic 7 Heat and expansion of substances .....	130
Sub-topic 8 Reflection and refraction of light .....	140
Sub-topic 9 Composition of air .....	148
Summary, revision and assessment .....	155
Study and examination skills .....	166
Glossed index .....	167

## How to use this book

Welcome to the *Progress in Integrated Science* series for Grades 8–9!

This series is based on the Junior Secondary Syllabus for Integrated Science issued by the Ministry of Education, Science, Vocational Training and Early Education. All the knowledge, skills and values expressed in the document are addressed in the *Progress in Integrated Science Grade 8 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		Materials and energy
5		
Sub-topics		
Composition of matter		<ul style="list-style-type: none"><li>Describe the composition of matter.</li><li>Describe the basic structure of atoms.</li><li>Identify common atoms using symbols.</li><li>Demonstrate the formation of molecules using models of atoms.</li></ul>
Physical change of state		<ul style="list-style-type: none"><li>Describe the arrangement of atoms in the three states of matter.</li><li>Identify the temperatures at which matter changes state.</li></ul>
Mixtures		<ul style="list-style-type: none"><li>Explain the structure and identify different types.</li><li>Identify methods of separating mixtures.</li><li>Explain some individual applications of separation techniques.</li></ul>
Mass and weight		<ul style="list-style-type: none"><li>Explain what mass and weight are.</li><li>Measure the mass of different objects.</li><li>Measure the weight of a given object correctly.</li><li>Relate the mass of a substance to its weight, given the mass.</li><li>Distinguish between mass and weight.</li></ul>
Density		<ul style="list-style-type: none"><li>Explain the concept of density.</li><li>Demonstrate how to determine the density of substances.</li><li>Demonstrate that an object will sink or float on a liquid.</li><li>Investigate the effects of overloading.</li></ul>
Heat transfer		<ul style="list-style-type: none"><li>Demonstrate the types of heat transfer.</li><li>Investigate the movement of heat in matter.</li><li>Investigate the effects of insulation.</li></ul>
Heat and expansion of substances		<ul style="list-style-type: none"><li>Describe the use of expansion of substances in everyday life.</li><li>Investigate the expansion and contraction of substances.</li></ul>
Refraction and reflection of light		<ul style="list-style-type: none"><li>Describe what refraction is.</li><li>Investigate the characteristics of reflection of light on a mirror.</li><li>Investigate the characteristics of refraction of light on a prism.</li><li>Identify the real and apparent depths of an object under water.</li><li>Identify the uses of refraction and reflection of light.</li></ul>
Composition of air		<ul style="list-style-type: none"><li>Identify the components of air.</li><li>Investigate the proportion of each substance in air.</li><li>Investigate the effects of air pressure in air.</li><li>Describe the uses of each substance in air.</li></ul>
Starter activity		
Collect items and sort them according to the state of matter in which they occur. Draw a table and record their examples.		
		Solid      Liquid      Gas
Topic 5 Materials and energy 91		

A box that shows you which **Sub-topics** and **Specific Outcomes** will be covered during the topic.

At the *end* of each topic, you will find:

TOPIC		Summary, revision and assessment
4		
Summary		
Plant and animal cells		

- We can look and study plant and animal cells using microscopes.
- Microscope lenses magnify the image of specimens so we can them more clearly.
- Parts of a microscope: eyepiece (for viewing object); magnifying lens; enlarges image of specimen; body tube (holds eyepiece); rotating nosepiece for lens.

Revision exercises	
1. Choose an item from Column B that matches a description in Column A. Write only the number next to the corresponding question number.	
Column A	Column B
a) The response of a plant part to water	i) Phototropism
b) A source of the nutrient potassium (K) for plants	ii) Carbon dioxide
c) A deficiency of this element causes yellowing in leaves	iii) Phosphorus
d) A deficiency of this element causes leaf fall in plants	iv) Hydroponism
e) A source of the nutrient carbon (C) for plants	v) Decomposition
f) The response of a plant part to light	vi) Nitrogen
g) A deficiency of this element causes reduced plant growth	vii) Iron
h) A source of the nutrient magnesium (Mg) for plants	viii) Manure
	ix) Hydrogen

Assessment exercises	
1. Study the diagram of a cell and answer the following questions.	
a) What is a cell?	(3)
b) Explain your answer.	
c) Name the parts labelled 1–6.	(6)
d) Name one function of each labelled part.	
	(6)
88 Topic 4 Summary, revision and assessment	

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

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

Assessment exercises that help you prepare for tests and exams.

The bold numbers in colour indicate higher order questions. We have highlighted the grading of questions in this way to cater for learners of different abilities.

# TOPIC 1

You will see the following throughout the book:

**TOPIC 3**  
**The environment**

Sub-topics	Specific Outcomes
Water, air and land pollution	<ul style="list-style-type: none"> <li>Explain what pollution is.</li> <li>Identify different types of pollution of the environment.</li> <li>Describe causes of pollution of the environment.</li> <li>Describe the effects of pollution on the environment.</li> <li>Describe ways of preventing pollution of the environment.</li> </ul>

**Starter activity**

Work in groups of four to six for this activity. Discuss what you see in the photographs on this page. Think of places in your area where there are similar places. Talk about these places too.

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

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

**Activity 4** Demonstrate geotropism in stems and roots

Work in groups of three or four when doing this activity. You will find out about geotropism in roots and stems using a cress germination tray.

**1 Experiment**

**Materials:**

- germinating bean seeds
- beaker or glass jar
- cotton wool
- water

**Method:**

- Soak the cotton wool in water.
- Place the germinating bean seeds on the cotton wool.
- Place the germinating bean seeds between the wall of the beaker/glass jar and the soaked cotton wool so that they can be seen through the glass jar or the beaker.
- When the roots are long enough, arrange at a 45° angle so that they can be seen spreading and their plumule (above) points downwards.
- Allow the cress to grow for five days. Observe that the cotton wool is kept moist at all times during this time.

**Observations/Results:**

This shows that:

- the stems are negatively geotropic as the stems are growing upwards (away from the earth).
- the roots are positively geotropic as they are growing downwards (towards the earth).

**Figure 8 Predicted results for Activity 4**

74 Topic 4 Plants and animals

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

**TOPIC 3**  
**Land pollution**

**New words**

biodegradable: able to be broken down by biological means, such as bacteria

organic food: food grown without chemicals or pesticides

- Reduce the use of pesticides and fertilisers in agricultural activities.
- Reduce the amount of items that you buy that have a lot of packaging. This will lead to less items ending up in landfill sites.
- Items that you do not litter.
- Educate and make people aware of the harmful effects of littering.
- Ensure that you dispose of all garbage correctly.
- Use a drip tray to collect engine oil.
- Do not dump motor oil on the ground.
- Buy biodegradable products.
- Do organic gardening and eat organic food that is grown without the use of chemicals.
- Create landfill sites away from residential areas.

**Activity 4 Consider land pollution in your area**

Work in groups of three to four for this activity.

- Describe the type of land pollution that occurs in the area in which you live.
- Describe how land pollution affects the environment in your area.
- Make a list of ideas how land pollution can be reduced where you live.
- Find out about recycling activities in your area and how you can help.

**Figure 13 Causes of land pollution: A: Mining; B: Nuclear waste and other poisons buried in the earth; C: Deforestation; D: Air pollution**

Sub-topic 1 Water, air and land pollution 59

**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 example 1**

A piece of metal has a mass of 240 g. When it is placed into a measuring cylinder containing 100 cm<sup>3</sup> of water, the water level rises to the 120 cm<sup>3</sup> mark. Calculate the density of the metal.

**Solution:**

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\text{Density} = \frac{240 \text{ g}}{20 \text{ cm}^3}$$

$$\text{Density} = 12 \text{ g/cm}^3$$

**Figure 27** The experimental set-up for determining the density of the metal

**Glossary:** can be treated by adding protein to the diet gradually over time.

**kwashiorkor:** a Ghanaian word meaning the older child gets when a younger sibling arrives.

**kwashiorkor:** In people who work, they need energy from carbohydrates. It is not uncommon to see people in the developing world in countries like India to do this. Most cheap food contains a lot of carbohydrates. Kwashiorkor is caused by protein shortage of nearly all

**Figure 10** Children suffering from kwashiorkor

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

**The microscope**

A microscope is an instrument that allows us to see individual cells, small groups of cells and even small organisms. For us to see microscopic structures, we use a compound light microscope.

**Parts of the microscope and their functions**

We must know how to use a microscope correctly and the names and functions of its different parts.

**Body tube:** The eyepiece is inserted into this.

**New words:**

microscopic: very small and can only be seen with a microscope

**Compound Microscope:** a microscope that uses a combination of lenses to magnify an object

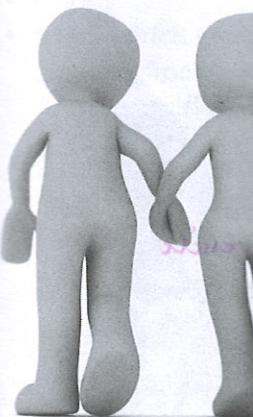
## Sub-topics

Human reproductive system and puberty

Fertilisation and embryo development

## Starter activity

Work in groups of four to six. Make a table in which each group lists the following: women. Use your predictions to give your group a discussion about the following:



None of us look the same when we are younger. We change as we grow. Let's look at the changes to our bodies and how they change over time.

# TOPIC 1

## The human body

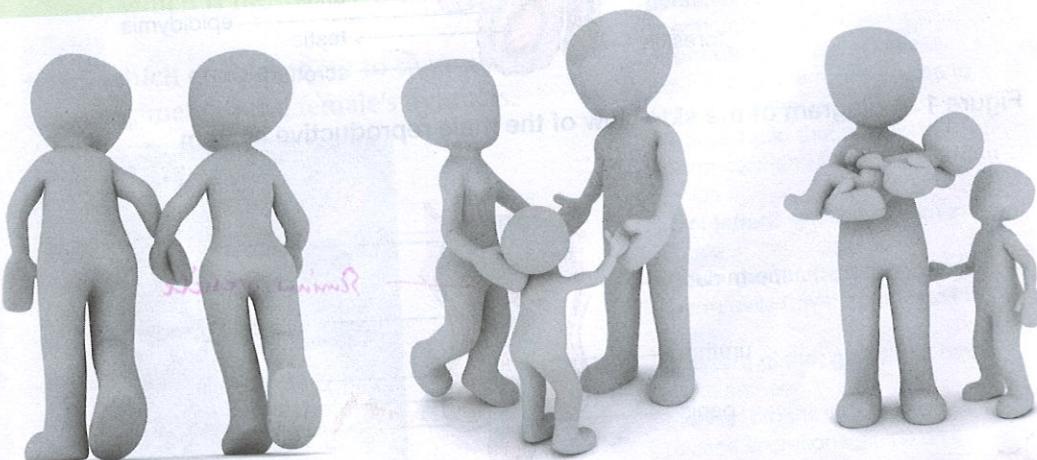


Sub-topics	Specific Outcomes
Human reproductive system and puberty	<ul style="list-style-type: none"><li>Identify organs of the human reproductive system.</li><li>Explain the functions of the parts of the reproductive system.</li><li>Identify changes associated with puberty for both male and female.</li><li>Explain the importance of observing personal hygiene of the reproductive organs.</li></ul>
Fertilisation and embryo development	<ul style="list-style-type: none"><li>Describe the process of fertilisation in humans.</li><li>Explain the functions of the parts important for development of the embryo.</li><li>Describe gestation period and birth.</li></ul>

### Starter activity

Work in groups of four to six when doing this activity.

Make a table in which you list the physical differences between men and women. Use your present knowledge and also study the pictures of people on this page to give you ideas to help you with your list. Then have a class discussion about the list.



None of us look the same as we did when we were born or were a few years younger. We change all the time. You can see people of different ages in these pictures and how they differ. Think of all the changes that you can discuss.

## The female reproductive system

The main parts of the female reproductive organ are shown in Figure 4. They are shown in their position in the body. This helps you understand where they are.

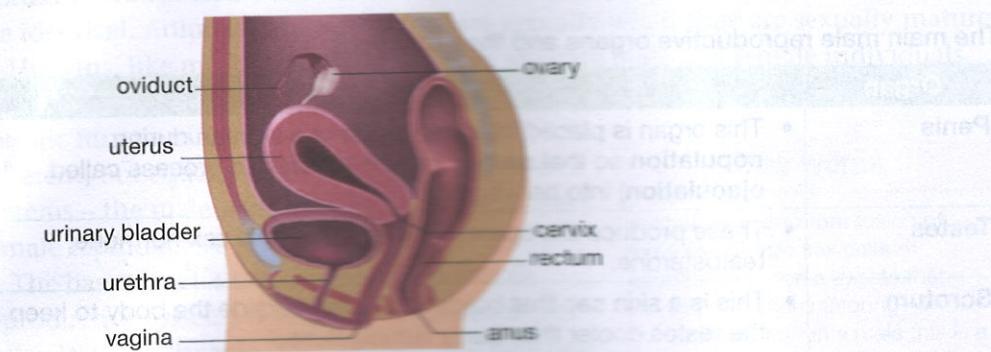


Figure 4 A diagram of the side view of the female reproductive system

### New words

**vagina:** tube that leads from the outside of a female to the uterus  
**cervix:** narrow end of the uterus where it joins the vagina  
**uterus:** organ in which the embryo/foetus develops  
**oviducts:** tubes along which ova travel from the ovaries to the uterus  
**ovaries:** female organs that produce ova (egg)

## The main organs of the female reproductive system

### The main female reproductive organs and their functions

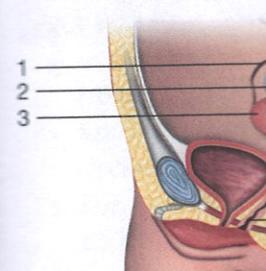
Organ	Function
<b>Vagina</b>	<ul style="list-style-type: none"><li>This tube leads from the outside to the uterus.</li><li>It accepts the penis during copulation and is the birth canal for the foetus during normal childbirth.</li></ul>
<b>Cervix</b>	<ul style="list-style-type: none"><li>This is the lower narrow end of the uterus where it joins the vagina.</li><li>The cervix is closed during pregnancy.</li></ul>
<b>Uterus (womb)</b>	<ul style="list-style-type: none"><li>This pear-shaped, muscular organ houses and protects the developing foetus during pregnancy.</li><li>Its muscular wall pushes the foetus down the vagina (birth canal) during normal childbirth.</li></ul>
<b>Oviducts</b>	<ul style="list-style-type: none"><li>The ova (eggs) travel along these tubes from the ovary to the uterus.</li><li>Fertilisation takes place in the oviducts.</li></ul>
<b>Ovaries</b>	<ul style="list-style-type: none"><li>These are a pair of oval-shaped organs that produce the ova (eggs).</li></ul>

Figure 5 A diagram of the female reproductive system

### Activity 1

Study the diagrams below.

1. Name the system.
2. Name the parts of the system.
3. Give the function of the system.
4. Name the parts of the system.
5. Give the function of the system.



A

Figure 6 Diagrams

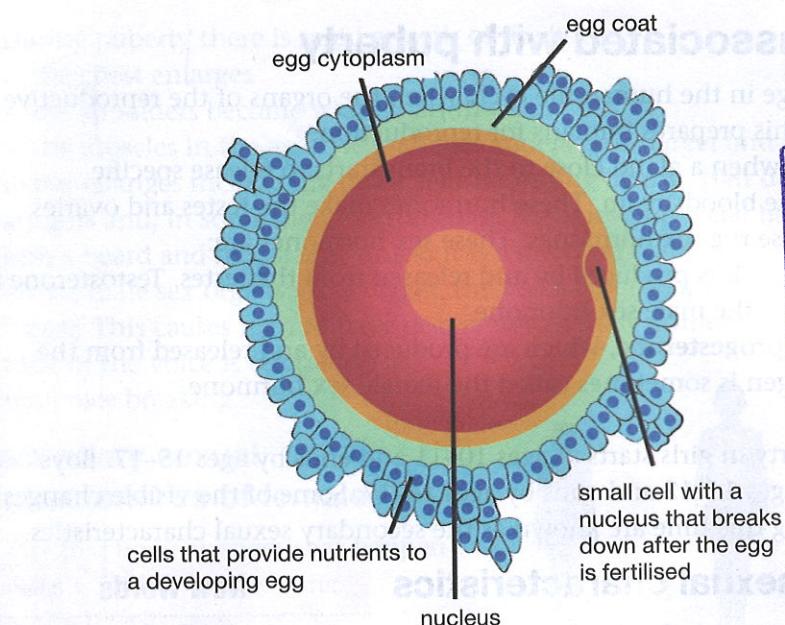


Figure 5 A diagram of a female gamete, an ovum

### Activity 1 Organs involved in reproduction

Study the diagrams below and then answer the questions that follow.

1. Name the systems represented by diagrams A and B.
2. Name the parts numbered 1 to 6 in diagram A.
3. Give the function of the parts labelled 1, 2, 3 and 6 in diagram A.
4. Name the parts numbered 1 to 6 in diagram B.
5. Give the function of the parts labelled 3, 4, 5 and 6 in diagram B.

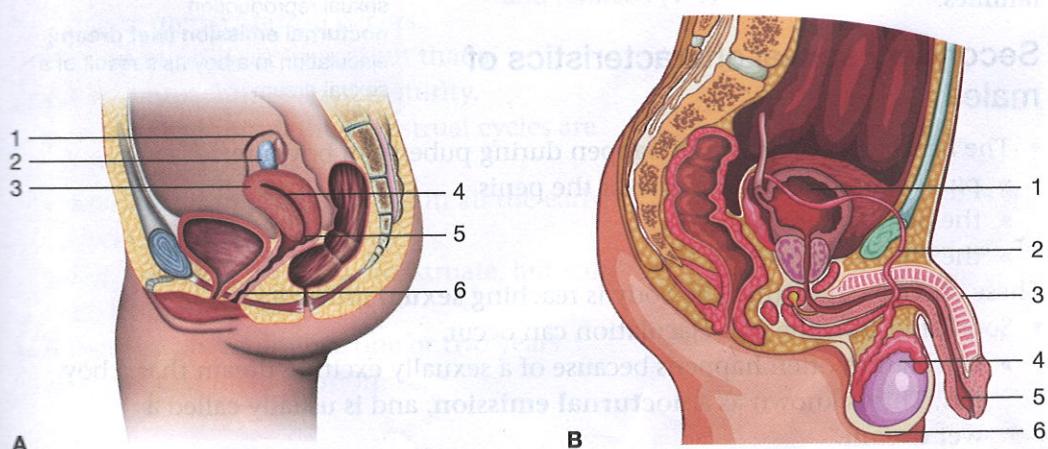


Figure 6 Diagrams of the human reproductive systems

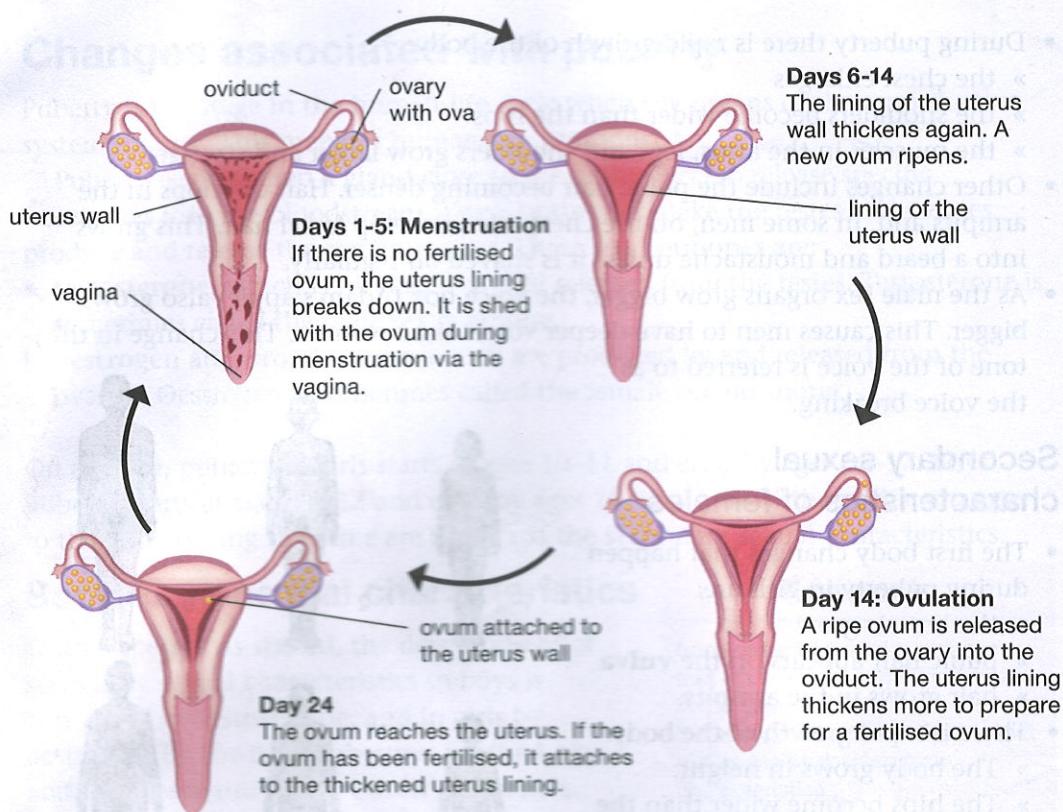


Figure 8 Diagrams showing the events in the menstrual cycle

- In women, the voice box does not increase in size to the same extent as in men.
- Women's voices do not change as much as men's do.
- By the end of puberty, women are mostly less muscular and slightly shorter than men.
- The breasts have developed a rounded shape. They do not produce milk until after pregnancy.

## Activity 2 Physical change during puberty

Work in groups of three or four when doing this activity.

1. Make a table in which you compare the differences between the physical changes that occur in males and females during puberty.
2. Make a list of the similarities in the physical changes that occur in males and females during puberty. Discuss this list with your group.

## The importance of good personal hygiene for reproductive health

Good personal hygiene is important for reproductive health. Wash your hands especially, and

Be careful not to come into contact with people. Clean the items you use. If you are unwell, put used tissues in a bin (they may have germs), instead of a bin.

Use protection, such as condoms, for sick or injured people, such as condoms, for example, prevents you from getting syphilis, gonorrhoea, etc.

## Good personal hygiene for reproductive health

### For women

- The vagina can clean itself. Women do not need to wash their external genitalia.
- Do not put anything into the vagina as the vaginal walls are easily damaged. The vaginal walls protect it against infections. The vaginal tissue can become damaged.
- During menstruation, use a tampon in the same way as you always have done.
- Change tampons frequently to prevent the spreading of bacteria. Do not leave a tampon in after handling a tampon.



Figure 9 An example of a tampon

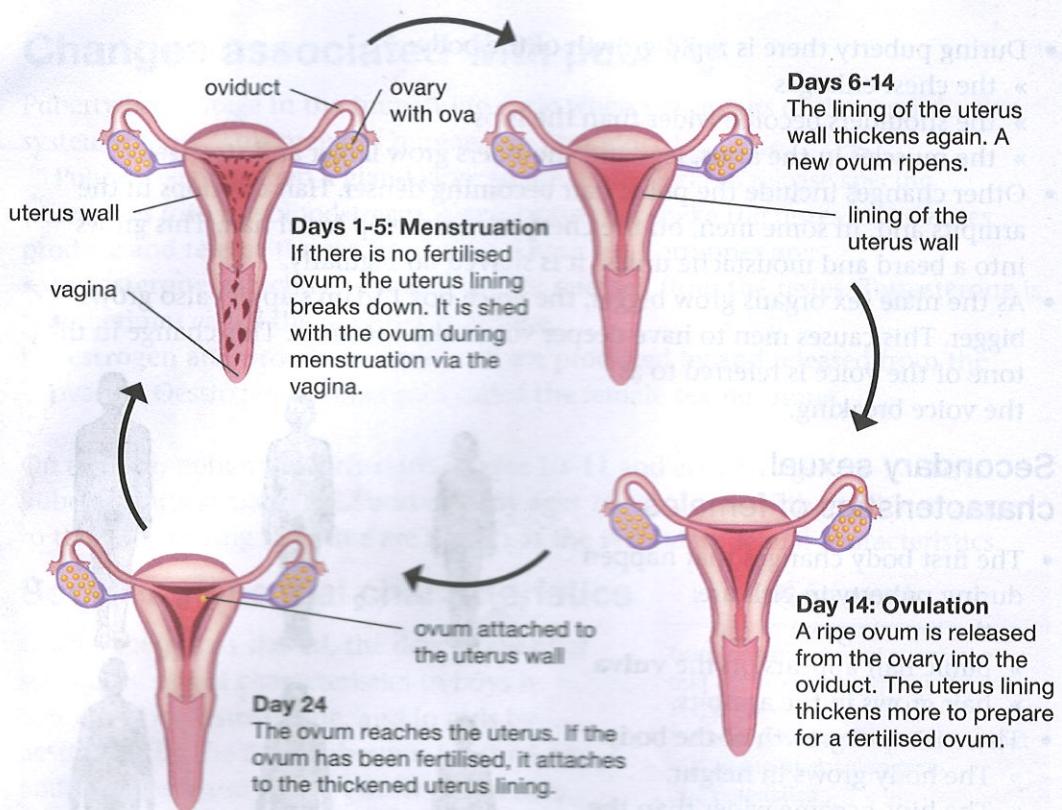


Figure 8 Diagrams showing the events in the menstrual cycle

- In women, the voice box does not increase in size to the same extent as in men. Women's voices do not change as much as men's do.
- By the end of puberty, women are mostly less muscular and slightly shorter than men.
- The breasts have developed a rounded shape. They do not produce milk until after pregnancy.

## Activity 2 Physical change during puberty

Work in groups of three or four when doing this activity.

1. Make a table in which you compare the differences between the physical changes that occur in males and females during puberty.
2. Make a list of the similarities in the physical changes that occur in males and females during puberty. Discuss this list with your group.

## The importance of reproductive

Good personal hygiene, hands especially, and

Be careful not to touch people. Clean the items if you are unwell. Put used tissues in a bin (they may have germs), instead of a pocket.

Use protection, such as condoms, for example, prevents you from getting syphilis, gonorrhoea, etc.

## Good personal reproductive choices

## For women

- The vagina can clean itself by washing their external genitalia.
- Do not put anything in the vagina as the vaginal walls are delicate and can be easily damaged. The vaginal walls have a natural protective layer that can be easily damaged.
- During menstruation, always wash the way as you always wash the external genitalia.
- Change tampons and pads frequently to prevent spreading bacteria.
- After handling a tampon or pad, always wash your hands.



Figure 9 An example

## The importance of personal hygiene of the reproductive system

Good personal hygiene protects us and other people from illness. Wash your hands especially, and also wash your body regularly.

Be careful not to cough or sneeze on other people. Clean the items that you touch if you are unwell. Put used items, such as tissues (that may have germs), into a rubbish bin.

Use protection, such as gloves, when touching sick or injured people. Always use protection, such as condoms, for sexual intercourse. This prevents you from getting infections such as **syphilis**, **gonorrhoea**, or **HIV**.

### Good personal hygiene of the reproductive organs

#### For women

- The vagina can clean itself, but women must wash their external genitals.
- Do not put anything such as **douches** into the vagina as the delicate skin can be damaged. The vagina contains millions of good bacteria, which are needed to protect it against infection. Using harsh soaps, douches and perfumes on the vaginal tissue can destroy these bacteria, so increasing the risk for infection.
- During menstruation, wash your body, including your genital area, in the same way as you always do.
- Change **tampons** or sanitary towels each time you use the toilet to avoid spreading bacteria and yeast infections. Always wash your hands before and after handling a tampon or pad.



Figure 9 An example of tampons



Figure 10 An example of sanitary towels (pads)

#### New words

**syphilis:** an infectious disease contracted through sexual intercourse that affects the reproductive system

**gonorrhoea:** an infectious disease contracted through sexual intercourse

**HIV:** a virus contracted through sexual intercourse; HIV causes AIDS

**AIDS:** an illness that makes people open to infections and diseases

**douche:** a means of washing out the vagina with a jet of water for contraception

**tampon:** a plug of soft material for inserting into the vagina to absorb menstrual blood

- Some feminine hygiene products contain harsh dyes and perfumes that can irritate the vagina and cause infection. To reduce these risks, choose unscented pads, pantie liners and tampons.
- Cystitis or urinary tract infection is an infection of the bladder or urethra. This is a common condition in sexually active young women. To prevent these infections:
  - Always wipe from front to back after a bowel movement, urinating or when washing.
  - Keep the skin around and between your rectum and vagina clean by washing with soap and water at least once daily.
  - Urinate after sexual intercourse to help to flush out bacteria that may be in the urethra and bladder.
  - Wash before and after sexual intercourse to lower the risk of developing urinary tract infections.

Vaginal thrush is a common infection caused by an overgrowth of the yeast, *Candida albicans*. This yeast lives naturally in the bowel and in small numbers in the vagina. It is mostly harmless, but symptoms can develop if yeast numbers increase.

Some people develop thrush when they use antibiotics. Some soaps and detergents can irritate the skin of the vagina; this makes thrush infections more likely. To reduce the chances of thrush, use mild soap and unperfumed toilet paper and avoid tight, synthetic underwear.

### For men

A build-up of secretions, called **smegma**, can form under the foreskin of uncircumcised men. Together with loose epithelial cells, it forms whitish deposits under the foreskin; if not washed off regularly, bacteria grow which can lead to inflammation.

If you are uncircumcised, gently pull back the foreskin when you have a shower or bath and wash with water. You can use soap, but rinse it off well. If you do not do this, the bacteria that occur under the foreskin and feed on dead tissue will cause an unpleasant smell.

### New words

**bowel:** the intestine  
**antibiotic:** medicine that destroys micro-organisms  
**smegma:** a secretion produced by glands in the foreskin of the penis



Figure 12 A single sperm fertilise an ovum

### The process

- During copulation (sex), the sperm travel through the vagina when the man ejaculates.
- The sperm cells pass through the cervix.
- The sperm cells swim in the uterus, which might occur.
- When the sperm cells reach the fallopian tube, they move through the tube to move through the lining of the uterus.
- The head of the first sperm cell to pass through the egg cell passes through it. The head of the sperm cell changes the membrane of the egg cell.
- Only one sperm cell can pass through the egg cell.
- The nucleus of the sperm cell joins with the nucleus of the egg cell.
- The sperm cell nucleus and the egg cell nucleus join together to form a zygote. The zygote contains information from both the father and the mother.



Figure 11 The bacterium that occurs in smegma

## SUB-TOPIC 2

## Fertilisation and embryo development

Fertilisation is the combining of the nucleus of a sperm cell with the nucleus of an ovum to form a zygote.

An embryo is an animal in its earliest stage of development, before the main body structures start to form. In humans, the embryonic stage lasts until the end of the eighth week of pregnancy.

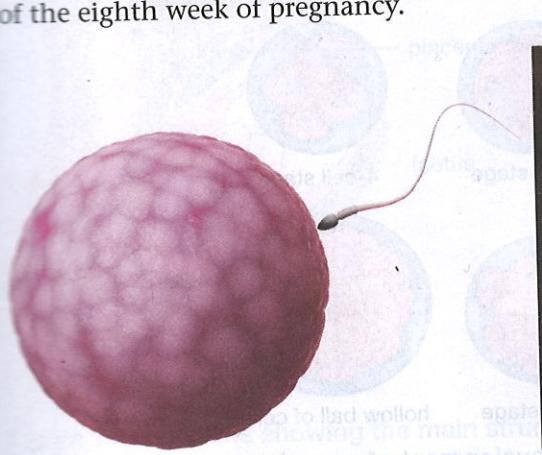


Figure 12 A single sperm cell about to fertilise an ovum



Figure 13 A 12–14 week old developing foetus with its placenta

### The process of fertilisation in humans

- During copulation (sexual intercourse), a man deposits sperm cells into a woman's vagina when the man ejaculates.
- The sperm cells pass through the cervix and enter the uterus.
- The sperm cells swim into the oviducts. If there is an ovum (egg cell), fertilisation might occur.
- When the sperm cells meet the ovum, many attach to the ovum. The sperm cells try to move through the layer of cells on the outside of the ovum.
- The head of the first sperm cell to reach the **cell membrane** around the ovum, passes through it. The tail remains outside the membrane.
- The membrane changes and no other sperm cells can pass through it to enter the ovum. Only one sperm cell enters the ovum.
- The nucleus of the sperm cell leaves the head of the sperm cell and moves towards the nucleus of the ovum.
- The sperm cell nucleus and the ovum nucleus join together to form a zygote. The zygote contains information from both the mother and the father.

#### New word

**cell membrane:** a thin layer on the outside of a cell

## The development of the embryo

The zygote divides to form 2, 4, 8, 16, ... cells as it moves along the oviduct towards the uterus. Eventually a solid ball of cells forms, which develops into a hollow ball of cells. The process takes between three and seven days to happen.

By now the hollow ball of cells has reached and entered the uterus. The hollow ball of cells spends the next 2–5 days in the uterus. If the ball of cells attaches to the lining of the uterus, the woman is pregnant.

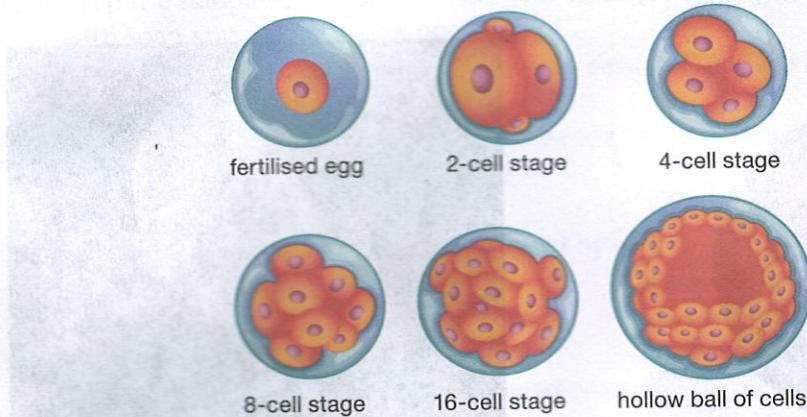


Figure 14 Diagrams showing the early development of an embryo

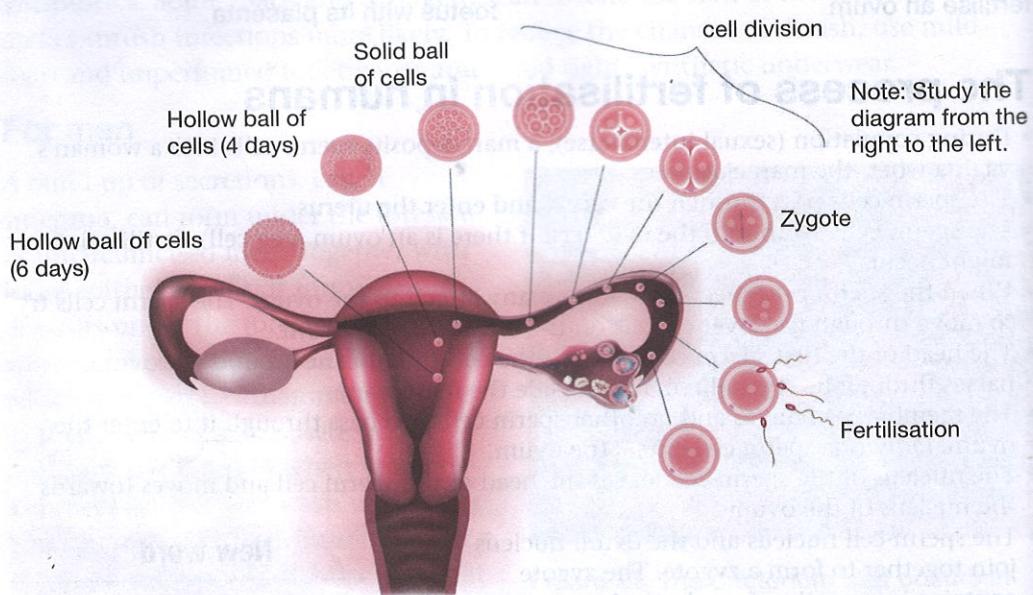


Figure 15 The female reproductive system showing where each stage of embryo development occurs

Over the next seven days...  
During this time, a new structure plays a vital role until it is ready to be born.



Figure 16 Diagrams showing an embryo and a fetus



Figure 17 A three-month-old baby showing the umbilical cord clamped, just before

Over the next seven months, the foetus develops inside the mother's uterus. During this time, a number of structures develop together with the foetus. Each structure plays a vital role in helping the foetus to develop safely and correctly until it is ready to be born.

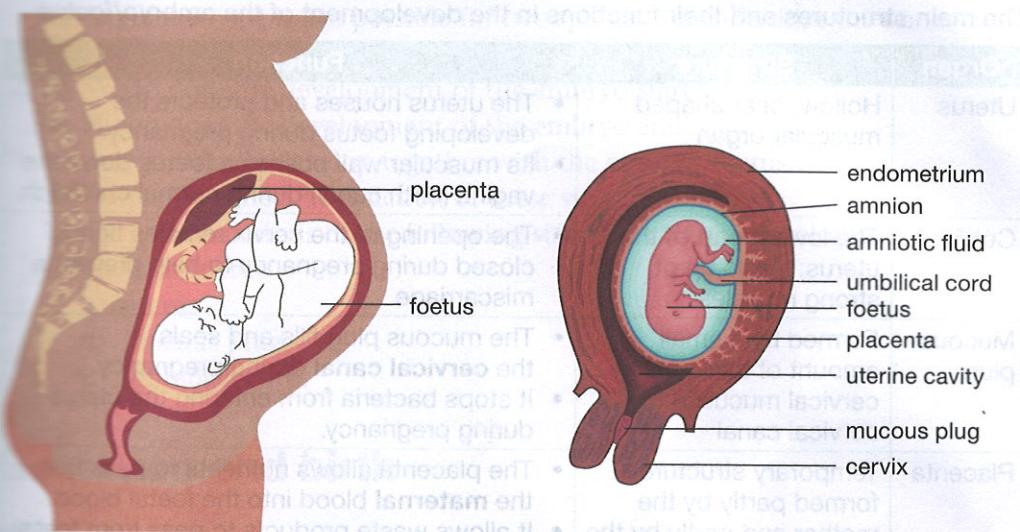


Figure 16 Diagrams showing the main structures in the development of an embryo/foetus

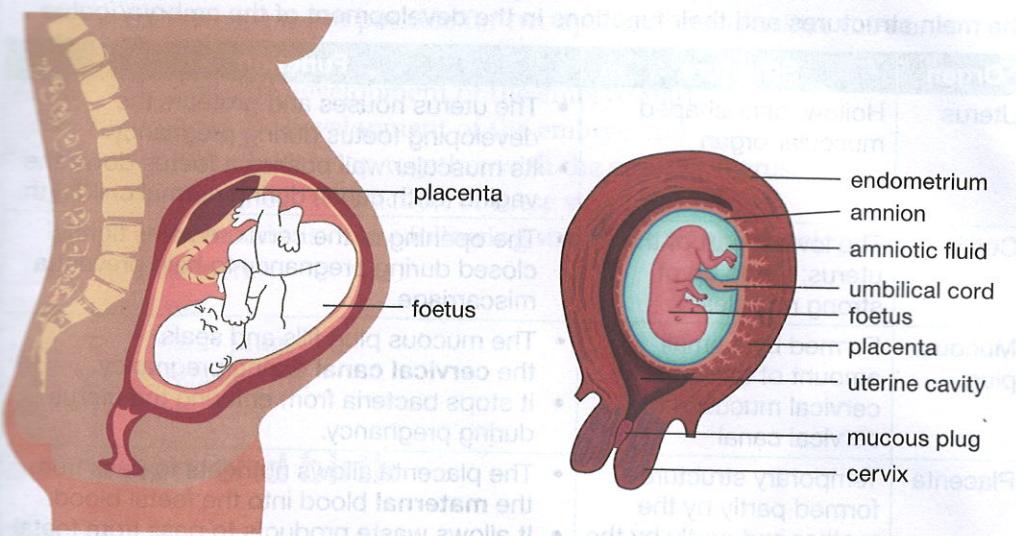


Figure 17 A three-minute-old newborn baby showing the umbilical cord still clamped, just before the cord is cut



Figure 18 A human placenta with the umbilical cord attached

Over the next seven months, the foetus develops inside the mother's uterus. During this time, a number of structures develop together with the foetus. Each structure plays a vital role in helping the foetus to develop safely and correctly until it is ready to be born.



**Figure 16** Diagrams showing the main structures in the development of an embryo/foetus



**Figure 17** A three-minute-old newborn baby showing the umbilical cord still clamped, just before the cord is cut



**Figure 18** A human placenta with the umbilical cord attached

## The functions of the parts important for the development of the embryo

The main structures and their functions in the development of the embryo/foetus

Organ	Structure	Function
Uterus	Hollow, pear-shaped muscular organ	<ul style="list-style-type: none"><li>The uterus houses and protects the developing foetus during pregnancy.</li><li>Its muscular wall pushes a foetus down the vagina (birth canal) during normal childbirth.</li></ul>
Cervix	The lowest part of the uterus; made up of strong muscles	<ul style="list-style-type: none"><li>The opening of the cervix remains tightly closed during pregnancy to help prevent a miscarriage.</li></ul>
Mucous plug	Formed by a small amount of thick, sticky cervical mucus in the cervical canal	<ul style="list-style-type: none"><li>The mucous plug fills and seals the <b>cervical canal</b> during pregnancy.</li><li>It stops bacteria from entering the uterus during pregnancy.</li></ul>
Placenta	Temporary structure formed partly by the mother and partly by the foetus during pregnancy	<ul style="list-style-type: none"><li>The placenta allows nutrients to pass from the <b>maternal</b> blood into the foetal blood.</li><li>It allows waste products to pass from foetal blood to the maternal blood.</li><li>It allows oxygen to pass from the maternal blood into the foetal blood.</li><li>It allows carbon dioxide to pass from foetal blood to the maternal blood.</li></ul>
Umbilical cord	The flexible cord connecting an embryo/foetus at its abdomen to the placenta	<ul style="list-style-type: none"><li>This cord transports blood from the embryo/foetus to and from the placenta.</li></ul>
Amnion	A thin, tough, membranous sac that encloses the embryo/foetus	<ul style="list-style-type: none"><li>This membrane ensures that the liquid that surrounds the developing embryo/foetus does not drain away.</li></ul>
Amniotic fluid	A watery fluid within the amnion that surrounds the embryo/foetus	<ul style="list-style-type: none"><li>This fluid allows the foetus to move freely inside the uterus while it is developing.</li><li>It ensures that development of the foetus will be normal and that the foetus will have <b>symmetrical</b> growth.</li><li>It protects the foetus from mechanical shocks (being bumped).</li><li>It stabilises the temperature around the foetus</li><li>It protects the foetus from dehydration.</li></ul>

### Activity 3

Answer the questions

- a) Where does fertilisation occur?  
b) Explain what happens to the egg after it has been fertilised.  
c) Explain why it is important for the egg to be fertilised in the uterus.
- a) When does the embryo implant?  
b) When does the embryo begin to grow?
- Certain structures are important for the development of the embryo/foetus.  
a) Name the following structures.  
b) Give the function of each of the following structures.  
i) uterus  
ii) mucous plug  
iii) umbilical cord

## Gestation and birth

### Gestation

Gestation is the period of time when an embryo/foetus in the womb grows. The length of time that gestation takes varies from species to species. In humans, this is the time between conception and birth. The embryo/foetus grows and develops in the uterus during gestation.

In humans, the exact date of conception is difficult to determine. The length of gestation is usually determined by the previous menstrual period. The average length of the gestation period is 266–270 days (38–39 weeks).

### Activity 4

Answer the questions

- If a woman conceives on 12 January, when will the birth date be?
- If a woman conceives on 12 January, when will the birth date be?

### Activity 3 Fertilisation and the development of the embryo

Answer the questions that follow.

1. a) Where does fertilisation occur?  
b) Explain what happens during the process of fertilisation.  
c) Explain why it is not possible for two sperm cells to fertilise the same ovum.
2. a) When does the development of the embryo start?  
b) When does the development of the embryo end?
3. Certain structures develop together with the embryo/foetus.
  - a) Name the collective function of these structures.
  - b) Give the functions of the following structures for the development of the embryo/foetus:
    - i) uterus
    - ii) mucous plug
    - iii) umbilical cord.

## Gestation and birth

### Gestation

Gestation is the period of development of the embryo/foetus in the uterus of a female. The length of time that gestation lasts is called the gestation period. In mammals, including humans, this is the time between conception and birth. The embryo (foetus) develops in the uterus during gestation.

In humans, the exact time of conception is difficult to determine. The beginning of gestation is usually dated from the beginning of the previous menstrual period. In humans, the average length of the gestation period is 266–270 days (38–38.5 weeks) or 9–9.5 months.

### New words

**cervical canal:** the narrow canal of the cervix  
**maternal:** from the mother  
**symmetrical:** having a similar shape on both sides  
**gestation:** the period of foetal development in the uterus from conception until birth  
**conception:** becoming pregnant as a result of an ovum being fertilised

### Activity 4 Predict the birth date

Answer the questions on birth dates.

1. If a woman conceives on 22 January, predict the birth date of her baby.
2. If a woman conceived on 3 March and the baby was born on 4 November, was the birth date earlier or later than predicted? Explain your answer.

## Stages of development of human offspring

The stages of development in humans from zygote to baby/infant

Stage of development	Description
Zygote	<ul style="list-style-type: none"> <li>This is formed as a result of fertilisation – the fusing of a male gamete (sperm cell) and a female gamete (an ovum) – before the zygote starts dividing. The zygote is the earliest stage in the development of the embryo.</li> </ul>
Embryo	<ul style="list-style-type: none"> <li>This is an animal in the early stages of development in the uterus after the zygote divides.</li> <li>In humans, this stage is from the time of attachment of the fertilised egg (zygote) to the uterine wall, until the eighth week of pregnancy.</li> <li>At eight weeks, the embryo does not look like a human yet because many body structures have not yet developed.</li> </ul>
Foetus	<ul style="list-style-type: none"> <li>This is the stage of human development that occurs in the uterus from the ninth week after fertilisation until birth.</li> </ul>
Newborn (neonate)	<ul style="list-style-type: none"> <li>This term describes a baby/infant for the first 28 days after it has been born.</li> </ul>
Baby (infant)	<ul style="list-style-type: none"> <li>This word describes a human from the 29th day after it has been born until it is 1–2 years old.</li> </ul>

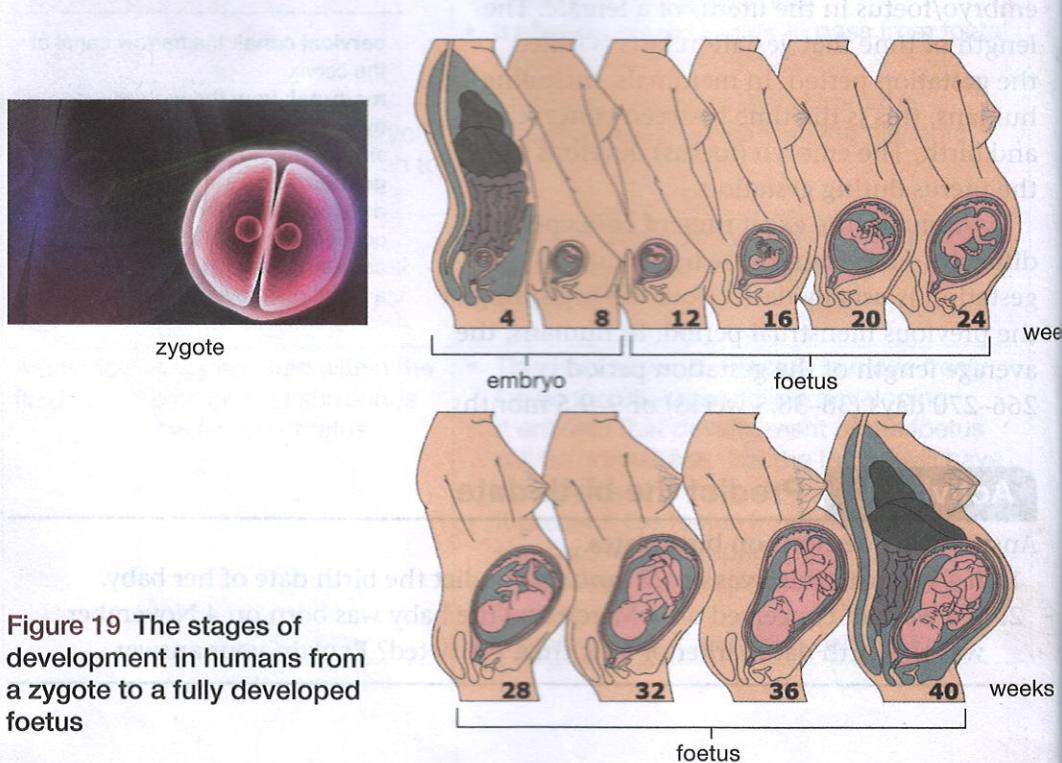


Figure 19 The stages of development in humans from a zygote to a fully developed foetus

## Birth

Birth happens at the same time or more newborns from a woman's uterus

If the birth cannot be natural, the foetus will be taken out by a doctor. This surgery is called a caesarean section, and the foetus is removed through a cut in the abdomen. This operation is called a C-section or a caesarean birth.

Normal birth occurs through the birth canal. The process is divided into three stages.

A woman knows she is in labour when she experiences contractions in her uterus. Pre-labour is the time when women go to their first children. There are things that can be done to reduce the time of labour, such as having a shorter for women who are in labour.

### The stages of birth

The stages of labour are:

- the dilation and stretching of the cervix
- the descent and birth of the baby
- the expulsion of the placenta

### First stage: Dilation

A woman has reached the first stage of labour when the cervix has dilated by 3–4 cm. The woman may feel contractions before the first stage begins.

The amniotic sac may burst about this time. This causes the amniotic fluid, which surrounds the baby, to leak out of the woman through her vagina. When this happens, the woman is said to be in labour.

Full dilation is reached when the baby's head has passed through the cervix and the cervix has reached the maximum of 10 cm.

## Birth

Birth happens at the end of a pregnancy when one or more newborn infants are pushed out from a woman's uterus.

If the birth cannot happen naturally, the foetus will be taken out of the mother's uterus by a doctor. This surgical procedure is called a caesarean section, and the foetus is removed through a surgical incision in the abdomen. This operation is also called a C-section or a caesar.

Normal birth occurs through the vagina/birth canal. The process of normal childbirth is divided into three stages of labour.

A woman knows she is going into labour when she experiences regular **contractions** of her uterus. Pre-labour can last for hours or days, especially for women giving birth to their first children. These days doctors help when labour takes too long. Much can be done to reduce the time and suffering of the mother. Pre-labour is often shorter for women who have already given birth.

### The stages of birth (labour)

The stages of labour are:

- the **dilation** and shortening of the cervix
- the descent and birth of the infant
- the expulsion of the placenta.

#### First stage: Dilation

A woman has reached this stage when the cervix is dilated by 3–4 cm. The woman might or might not have active contractions before **dilation**.

The amnion may break at about this time. This releases the amniotic fluid, which flows out of the woman through her vagina. When this happens, we say a woman's waters break.

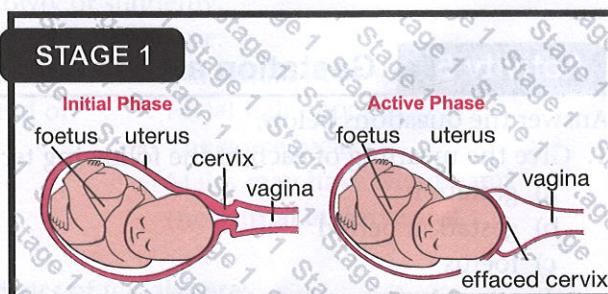
Full dilation is reached when the cervix has widened enough for the infant's head to pass through the opening. Full dilation occurs when the opening of the cervix has reached the size of about 10 cm.



Figure 20 A baby being born by caesarean section

#### New word

**contractions:** movements of the uterus muscles to enable a woman to push her baby down the birth canal and out through the vagina  
**dilation:** becoming wider or larger



The time for which labour lasts varies greatly. First stage/dilation lasts for an average of eight hours for women giving birth to their first child. It is shorter for women who have already given birth.

### Second stage: Birth of the infant

This stage starts when the cervix is fully dilated and ends when the baby is born. The second stage of labour is completed when the baby has been pushed out from the mother.

During the second stage of labour, the uterus contracts about every five minutes. Each contraction lasts 45–90 seconds. These contractions are usually accompanied by a need to push. Pushing speeds up the birth process.

The length of the birth stage depends on the position and size of the baby and the woman's ability to push with the contractions. For first-time mothers, the average length of pushing is one to two hours. In some cases, pushing can last longer than two hours.

### Third stage: Delivery of the placenta

This stage lasts from after the foetus is pushed out from the mother until after the placenta is pushed out from the mother.

During this stage the umbilical cord is closed with a clamp (an object that presses the cord closed). After clamping, the cord is cut. This is painless because there are no nerves in the umbilical cord.

The average time from the delivery of the baby until complete expulsion of the placenta is 5–15 minutes.

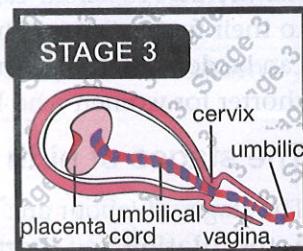
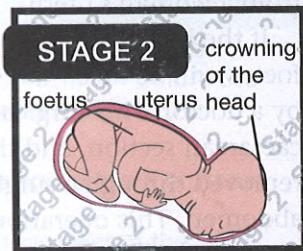


Figure 21 Diagrams showing the various stages of labour and birth

### Activity 5 Gestation and birth

Answer the questions below.

1. Give the meaning of each of the following terms:
  - gestation
  - gestation period
  - foetus
  - a new born
  - caesarean section.
2. When does birth occur?
3. Name the stages of labour.

**Summary****The human reproductive system**

- The basic function of the male and female reproductive systems is to produce gametes (sex cells).
- The male reproductive organs are: testes (produce sperm cells), sperm ducts (transport sperm cells to urethra), urethra (transport sperm cells in semen to outside through penis), penis (ejaculates sperm cells into female vagina) scrotum (holds testes and keeps sperm at optimum temperature), epididymus (stores sperm cells).
- Main female reproductive organs: ovaries (produce ova), oviducts (transport ova to uterus); uterus (protects embryo / foetus during development), cervix (closes in pregnancy), vagina (accepts penis, is the birth canal).

**Puberty**

- Puberty is the stage in the human life cycle when the organs of the reproductive system mature.
- Puberty prepares humans for reproduction.
- The testes and ovaries produce and release the sex hormones.
- These sex hormones are testosterone, oestrogen and progesterone.
- Some of the more obvious changes that happen to the body during puberty are known as the secondary sexual characteristics.
- The development of the secondary sexual characteristics in boys is controlled by testosterone, and in girls by oestrogen.
- These changes might happen slowly or suddenly.
- The secondary sexual characteristics of males are:
  - » Pubic hair appears.
  - » Hair appears in the armpits and on the chest.
  - » The penis enlarges.
  - » The testicles grow.
  - » The male can ejaculate.
  - » The whole body grows rapidly.
  - » Facial hair appears.
  - » The voice breaks.
  - » Males may have wet dreams (nocturnal emissions).
- The secondary sexual characteristics of females are:
  - » Pubic hair appears.
  - » The breasts develop.
  - » Hair appears in the armpits.
  - » The whole body grows rapidly.
  - » The first menstruation occurs.
  - » Fatty tissue collects in and around the breasts, shoulders, hips and buttocks.

## Summary, revision and assessment continued

### The importance of personal hygiene of the reproductive system

- Good personal hygiene protects us and other people from illness. Wash your hands, especially, and also wash your body regularly.
- Use protection, such as gloves, when touching very sick or injured people.
- Always use protection, such as condoms, for sexual intercourse.
- Men and woman can take specific actions to ensure good personal hygiene of the reproductive organs.

### Fertilisation

- In fertilisation, the nucleus of a sperm cell combines with the nucleus of an ovum to form a zygote.
- During copulation, sperm cells are deposited into a woman's vagina.
- The sperm cells pass through the opening in the cervix and enter the uterus.
- The sperm cells move through the uterus and into the oviducts.
- The head of the first sperm cell to reach to the cell membrane that surrounds the ovum passes through the membrane.
- This causes the membrane to change so that no other sperm cells can pass through the membrane and to the ovum.
- The sperm cell nucleus and the nucleus of the ovum join to form a zygote.

### Embryo development

- The zygote divides as it moves along the oviduct towards the uterus.
- This division of the zygote is the beginning of the development of the embryo.
- An embryo is an animal in its earliest stage of development.
- Eventually a solid ball of cells is formed.
- This ball of cells develops into a hollow ball of cells called the blastocyst.
- Once the blastocyst enters the uterus, it might become attached into the lining of the uterus. If this happens, the woman is pregnant.
- The blastocyst continues to grow until the development of the embryo is complete.
- In humans, the embryonic stage lasts until the end of the eighth week of pregnancy.

### Foetal development

- The development of the foetus continues inside the uterus of the mother over the next seven months.
- During this time, several structures develop together with the foetus. Each helps the foetus develop safely and correctly until it is ready to be born.
- The main organs for the safe development of the foetus are the placenta, umbilical cord, amnion and amniotic fluid.

### Gestation

- Gestation is the time of pregnancy.
- The length of time is about 40 weeks.
- This is the time between conception and birth.
- In humans, the average gestation time is 38–38.5 weeks.
- In humans, the beginning of gestation is the start of the previous menstrual period.

### Stages of development

- The stages are the following:

### Birth

- Childbirth happens when the baby is born.
- Newborn infants from birth to 1 month old.
- If a birth cannot happen naturally, it can be assisted by a doctor during a Caesarean section.
- During a caesarean section, a cut is made in the abdomen and womb.
- Normal birth occurs when the baby is born naturally.
- The process of normal birth is called birth.
- It involves dilation and shortening of the cervix.
- It involves descent and birth of the baby.
- It involves expulsion of the placenta.

### Revision exercises

Various options are provided for each question. Choose the correct answer for each question number.

1. Gestation is best described as

- A The length of the oviduct
- B A good eating habit
- C Carrying an embryo
- D The length of the menstrual cycle

2. The correct sequence of events in gestation is

- A Zygote → embryo → fetus → newborn
- B Zygote → embryo → fetus → placenta
- C Zygote → foetus → embryo → newborn
- D Zygote → embryo → foetus → newborn

## Gestation

- Gestation is the carrying of an embryo/foetus inside a female.
- The length of time for which gestation lasts is called the gestation period.
- This is the time between conception and birth.
- In humans, the average length of the gestation period is 266–270 days (38–38.5 weeks) or about 9–9.5 months.
- In humans, the beginning of gestation is usually dated from the beginning of the previous menstrual period.

## Stages of development of human offspring

- The stages are the zygote, embryo, foetus, newborn and infant.

## Birth

- Childbirth happens at the end of pregnancy with the expulsion of one or more newborn infants from a woman's uterus.
- If a birth cannot happen naturally, the foetus is taken out of the mother's uterus by a doctor during a caesarean section.
- During a caesarean section, the foetus is removed through a surgical incision/cut in the abdomen.
- Normal birth occurs through the vagina/birth canal.
- The process of normal childbirth is divided into three stages:
  - dilation and shortening of the cervix
  - descent and birth of the infant
  - expulsion of the placenta.

## 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. Gestation is best described as:
  - The length of time for which the woman is pregnant
  - A good eating experience
  - Carrying an embryo inside a female
  - The length of time for which labour lasts.
2. The correct sequence for the development of human offspring is:
  - Zygote → embryo → foetus → newborn → neonate
  - Zygote → embryo → foetus → infant → neonate
  - Zygote → foetus → embryo → newborn → neonate
  - Zygote → embryo → foetus → neonate → infant.

## Summary, revision and assessment continued

3. The event that happens at the end of a normal pregnancy is:  
A Miscarriage      C Ejaculation  
B Labour      D Ovulation.
4. The correct sequence of the stages of labour is:  
A Delivery of the placenta → descent and birth of the foetus → dilation  
B Delivery of the placenta → dilation → descent and birth of the foetus  
C Descent and birth of the foetus → delivery of the placenta → dilation  
D Dilation → descent and birth of the foetus → delivery of the placenta.
5. Full dilation of the cervix is:  
A 4 cm      C 12 cm  
B 10 cm      D 15 cm.
6. Which combination of events marks the start and end of the second stage of labour?  

Start	End
A Cervix dilated 3–4 cm; the birth of the baby	Cervix fully dilated; cutting the umbilical cord
B Cervix fully dilated; cutting the umbilical cord	Cervix dilated 3–4 cm; the water breaking
C Cervix dilated 3–4 cm; the water breaking	Cervix dilated 10 cm; the birth of the baby
D Cervix dilated 10 cm; the birth of the baby	Cervix fully dilated; the birth of the baby
7. The average length of time for the delivery of the placenta is:  
A 45–90 seconds      C 1–2 hours  
B 5–15 minutes      D 8 hours.
8. The correct term to describe sexual intercourse between a man and a woman is:  
A Ejaculation      C Ovulation  
B Orgasm      D Copulation.
9. The structure or organ in which fertilisation occurs is the:  
A Oviduct      C Vagina  
B Uterus      D Vulva.
10. The average age at which puberty starts and ends in boys is:  

Start	End
A 10–11 years old; 16–17 years old	B 11–12 years old; 15–17 years old
C 10–11 years old; 15–17 years old	D 11–12 years old; 16–17 years old.

11. Which activity should a woman avoid during the first 12 weeks of her reproductive cycle?  
A Douche with a strong disinfectant  
B Change tampons every 4 hours  
C Always wipe from front to back when washing the genital area  
D Use mild soap and warm water.

### Assessment exercise

1. Refer to the diagram of the female reproductive system and answer the following questions.
  - a) Name the structure numbered 1–4 in the diagram.
  - b) Give the function of the structure numbered 5 in the diagram.
  - c) Name the area of the vulva numbered 6 in the diagram.
  - d) Name the part of the vulva numbered 7 in the diagram.
2. List seven visible changes in a girl undergoing puberty.
3. List the hormones produced by the ovaries.
4. Refer to the diagram of the male reproductive system and answer the following questions.
  - a) Name the structure numbered 1–5 in the diagram.
  - b) Briefly explain the function of the structure numbered 6 in the diagram.
  - c) Name the structure numbered 7 in the diagram.
  - d) Give the number of the structure which represents the testes.
  - e) Give the number of the structure which represents the prostate.
5. Refer to the diagram of the female reproductive system and answer the following questions.
  - a) Name the structure numbered 1–5 in the diagram.
  - b) Briefly explain the function of the structure numbered 6 in the diagram.
  - c) Name the structure numbered 7 in the diagram.
  - d) Give the number of the structure which represents the ovaries.
  - e) Give the number of the structure which represents the uterus.

11. Which activity should a woman not do to ensure good personal hygiene of her reproductive organs?

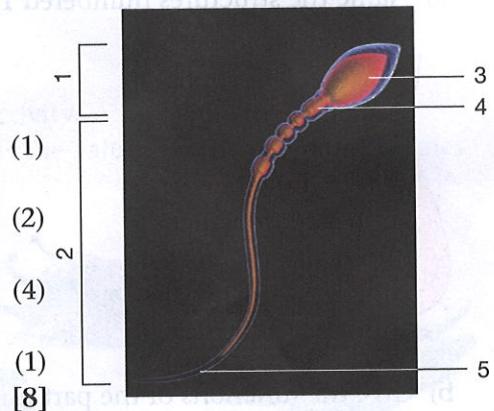
- Douche with a perfumed feminine hygiene product
- Change tampons each time she goes to the toilet when she is menstruating
- Always wipe from front to back after a bowel movement, urinating or when washing
- Use mild soap and avoid tight, synthetic underwear

Total for Revision exercises:  $11 \times 2 = [22]$

## Assessment exercises

1. Refer to the diagram and answer the questions.

- Name the structure represented by the diagram.
- Give the function of the structure named in question 1a.
- Name the areas of this structure labelled 1, 2, 4 and 5.
- Name the part of this structure labelled 3.

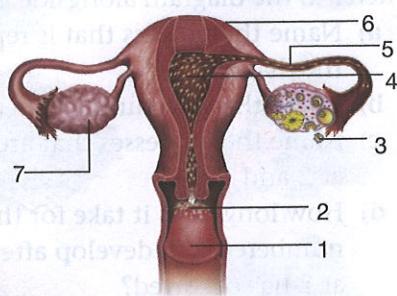


2. List seven visible developmental features shown by individuals undergoing puberty. Indicate where only for males and females. [7]

3. List the hormones responsible for changes during puberty. [2]

4. Refer to the diagram of the female reproductive system. Answer the questions.

- Name the structure labelled 6. (1)
- Briefly explain what is taking place at the parts numbered 2 and 3. (4)
- Name the structures labelled: 1, 3, 5, 7. (4)
- Give the number of the structure which represents the male gamete. (1)
- Give the number of the structure which represents the female gamete. (1)



5. Refer to the diagram of a structure that plays a large role in helping the

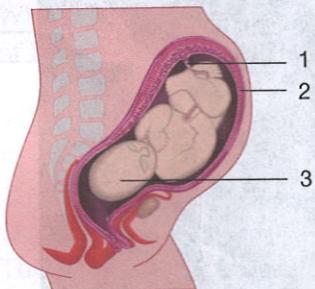
## Summary, revision and assessment continued

3. foetus develop properly.

- Name the structures numbered 1 and 2. (2)
- Describe the function of structure 1 during pregnancy. (5) [7]

6. Refer to the diagram that shows a developing foetus in a mother's body, and answer the questions.

- Name the structures numbered 1, 2 and 3. (3)



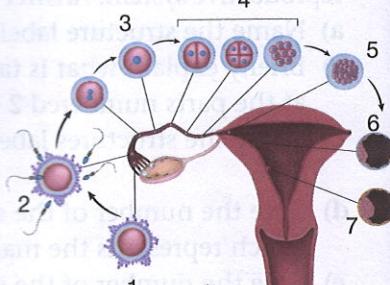
- Give the functions of the part numbered 1. (2)
- The correct term for the second stage of labour is (5)

**TOTAL MARKS FOR ASSESSMENT EXERCISES: 40**

### Challenge

Refer to the diagram alongside and answer the questions.

- Name the process that is represented by the diagram.
- Name the structures labelled 1, 3 and 5.
- Name the processes that are happening at 2 and 4.
- How long does it take for the structure numbered 5 to develop after the process at 2 has occurred?
- How long does it take for the change to occur between numbers 5 and 6?





Sub-topics	Specific Outcomes
<b>Nutrition</b>	<ul style="list-style-type: none"> <li>Describe the different types of food nutrients.</li> <li>Describe the dietary needs for different persons.</li> <li>Identify common nutritional deficiency diseases and their symptoms.</li> <li>Describe the importance of children's clinics.</li> </ul>

**Starter activity**

Work in groups of three or four for this activity.

List the foods you ate yesterday. Discuss the value they have for your bodies.



## Importance of nutrition

All animals, including humans, need different types of food. The energy supplied by these foods is used to carry out life processes, such as cell division, cellular respiration, excretion, movement, breathing and reproduction. The nutrients in the food are for growth, to repair old or damaged parts of the body and for development. The cells and tissues of animals are constantly wearing out. Food is needed to repair and replace them.

Correct nutrition is important for healthy biological functioning of the body. When the body does not have all the substances it needs in the correct, balanced quantities, life processes do not occur properly, and disease or death can result.

## The types of nutrients in food

The body needs a supply of nutrients from all three main food types – **carbohydrates, lipids** (fats and oils) and **proteins** – as well as **vitamins, minerals, fibre** and water. It is also important that these nutrients are supplied in the right proportions.

You can get all the nutrients your body needs for proper functioning by drinking enough water and eating the correct amounts of food from the basic food groups. These are dairy products, meat and protein, fruits and vegetables, and oils, and carbohydrates. For a **balanced diet** you should eat the basic food groups in these proportions:

- Carbohydrates: 6–8 servings per day
- Fruit: 2–4 servings per day
- Vegetables: 3–5 servings per day
- Protein: 2–3 servings per day
- Dairy products: 2–3 servings per day
- Fats, oils, and sweets: eat sparingly

### New words

**carbohydrates:** a food type that can be broken down to release energy; also known as starch

**lipids:** a food type that includes fats and oils

**proteins:** a food type that contains nitrogen; they make up the structural parts of body cells and tissues

**vitamin:** an organic substance that is essential in small amounts in a person's diet for normal growth and good health

**mineral:** an inorganic substance that is essential in small amounts in a person's diet for good health

**balanced diet:** a diet with the correct amounts of each food type



Figure 1 A: Carbohydrates

### Did you know ?

Your level of physical activity and stage of development – and not your age – determine how much energy and protein you need.

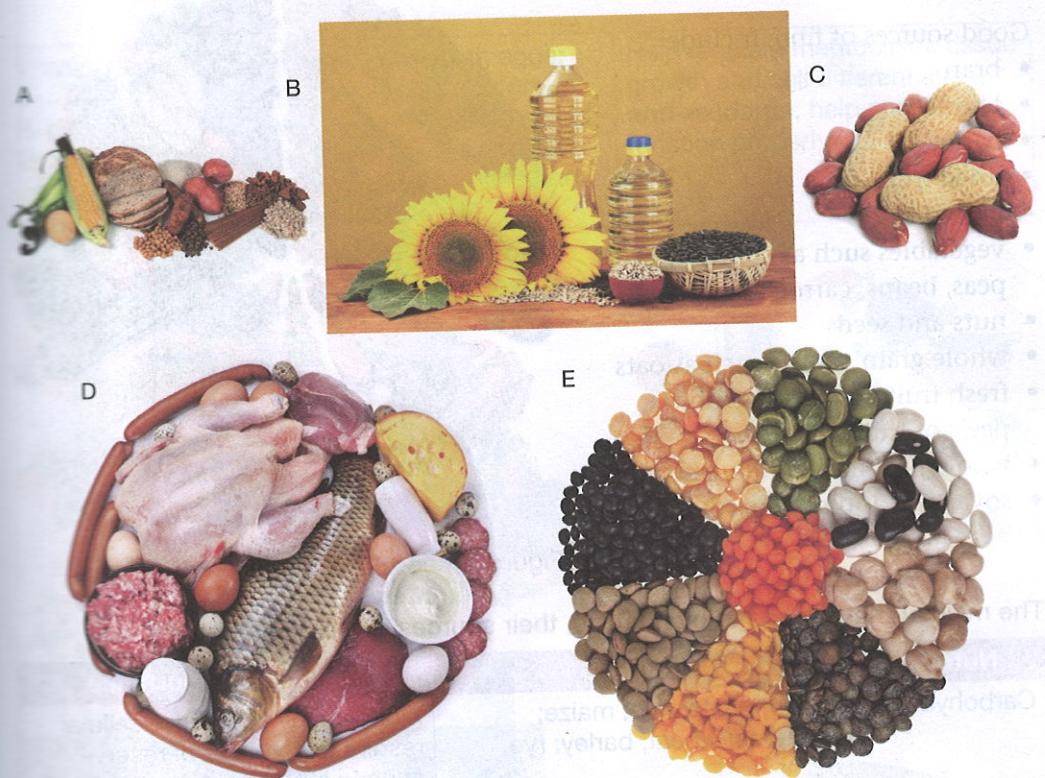


Figure 1 A: Carbohydrates; B and C: Lipids; D and E: Proteins

Water is a vital part of a balanced diet. Its importance is often overlooked and its intake is often too low. Water keeps our inside parts moist, cools our bodies and moves nutrients around our bodies. An adequate intake for a man is about 3 litres of liquid a day and for women 2.2 litres of liquid a day. Teenagers 13 years and older are thought of as adults.

An easy way to check if you are drinking enough water throughout the day is to look at the colour of your urine. When your water intake is adequate, your urine will be pale yellow to almost clear in colour; you will produce about 1.5 litres of urine per day.

Fibre is also called roughage. It is the cell walls of plant cells that do not break down in our bodies. The main function of fibre is to keep the digestive system healthy and functioning properly. Fibre helps with and speeds up the excretion of waste and toxins from the body. This prevents them from staying in the intestine or bowel for too long, which could cause a build-up and lead to several diseases.

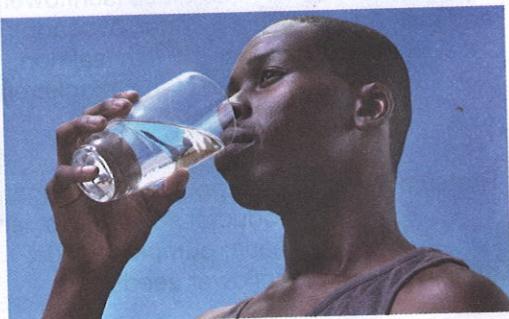


Figure 2 A healthy young man drinking water

Good sources of fibre include:

- bran
- lentils
- barley
- dried fruit
- brown rice
- vegetables such as spinach, peas, beans, carrots, potatoes
- nuts and seeds
- whole grain cereals such as oats
- fresh fruit, including edible peels of fruit
- wholemeal flour and breads
- soya milk and soya products.



Figure 3 Food for a balanced diet

The main nutrients needed by humans, their sources in the diet and their uses

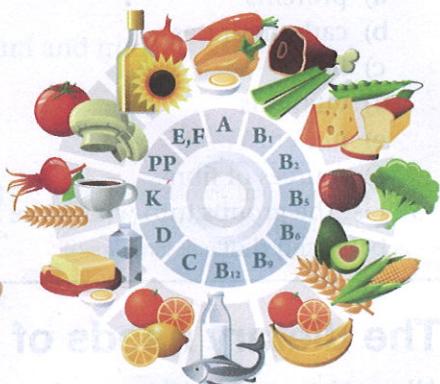
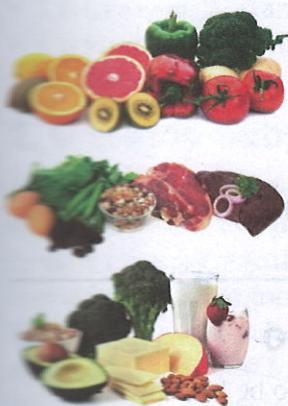
Nutrient	Source	Biological importance
Carbohydrates	Bread; pasta; rice; maize; potatoes; wheat; barley; rye, millet	Main energy source for cellular respiration; source of reserve energy; structural component of cells
Lipids (fats and oils)	Vegetable oils (sunflower oil, peanut butter, avocado); soya beans; oily fish (salmon, sardines, tuna, mackerel)	Source of energy; storage of excess energy; <b>insulation</b> ; structural component of cell membranes; source of water when broken down by metabolic activity
Proteins	Meat; poultry; fish; eggs; dairy products; soya beans; lentils; beans; pumpkin seeds; sunflower seeds	Reserve source of energy; structural part of protoplasm, cell membranes, <b>chromosomes</b> and other cell parts; regulatory and controlling function; helps immune system to work properly
Minerals calcium, magnesium, sodium, potassium, sulphur, phosphorus, iron	Fruit and vegetables	Have specific structural or functional roles in the chemical reactions that occur in our cells; Act as <b>electrolytes</b>

Vitamins A, B-complex, C, D, E, K	Cod liver oil, unrefined oils, leafy vegetables, grains, fruits and seeds
--------------------------------------	---



Figure 4 Food sources of vitamins and minerals needed by humans

Vitamins A, B-complex, C, D, E, K	Cod liver oil; rice; meat; eggs; unrefined vegetable oils; green leafy vegetables; dairy products; grains; yellow, orange and red fruits and vegetables; nuts and seeds; avocados	Help regulate metabolism, tissue growth and cell differentiation; <b>anti-oxidants</b> ; help enzymes to function properly
--	---	--



## Various vegetables



## Sweet potatoes



## Green leafy vegetables

## New words

**insulation:** protection from loss of heat

**chromosome:** a threadlike structure carrying genetic (hereditary) information

**electrolyte:** a constituent of the blood and body fluids that carries an electric charge

**anti-oxidant:** a chemical that increases the body's ability to fight infection and disease

**Figure 4** Food sources of vitamins and minerals needed by humans

## Activity 1

### The importance of nutrition

Answer the questions below.

1. Name the seven groups of nutrients or substances that are needed for proper nutrition in humans.
2. List four examples of:
  - a) proteins
  - b) carbohydrates
  - c) lipids
  - d) vitamins
  - e) minerals
  - f) sources of fibre.
3. List the groups into which the kinds of food are divided when working out a balanced diet.

### The dietary needs of different people

All people need food for growth and repair of their bodies, to be healthy and to provide energy. The ideal diet and how much food to eat varies from one individual to the next. Some factors that influence diet are age, gender, the activity level of the person and state of health. Let's look at the dietary needs of various groups of people.

#### 1. Babies

As we learnt in Topic 1, during pregnancy the foetus gets its nutrients from its mother through the placenta.

The baby's source of nutrients changes immediately after birth. At this stage, the baby takes its food into the stomach (where it is digested) before it is absorbed into the bloodstream. The baby's food nutrients are provided by the milk it gets from its mother. Human milk is produced in the mother's breasts.

Breastfeeding is important for babies; it provides milk that contains all the nutrients the baby needs, such as protein and minerals. Breastfeeding is important in creating a strong bond between a mother and her child.

When breastfeeding is not possible, it is substituted with bottle feeding using milk formula, cow's milk or goat's milk. But none of these are as good as human milk.

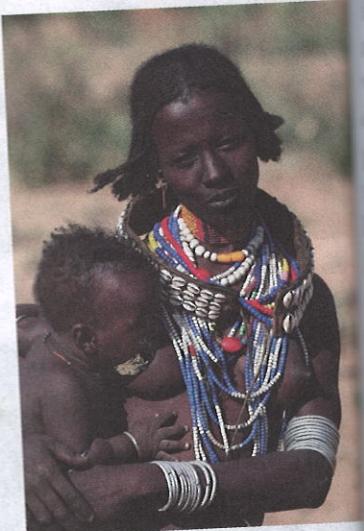


Figure 5 A mother breastfeeding her baby

During the first six weeks, the only dietary fibre is not enough. The proportions in which the different groups of food are eaten change over time. For example, in the first six months of a baby's life:

- 3 times more energy
- 3 times more protein
- 3 times more B vitamins
- 4 times more vitamins than an adult needs.

#### 2. Growing babies

As the child grows older, the diet changes. The child needs more energy than the mother can provide. From four to six months, the child is introduced to solid food. The baby is slowly taken off the breast and given solid food to eat. This process is called weaning.

The food we give to the child should be soft enough for the child to eat without chewing. The food should include porridge (nsima), mashed food, for example, vegetables and soft meat, such as chicken. Mothers sometimes add protein and nutrient-rich foods, such as groundnuts, to porridge and mashed food.

As the baby grows, it needs more energy and the soft food should be replaced by solid food that can be chewed easily during the day.

Young children grow quickly and need more energy, vitamins (such as A, C and D) and minerals. Vitamins are needed to meet the nutritional requirements of children and adults.

During the first six weeks, a baby needs all the nutrients that all humans need; only dietary fibre is not needed at this stage.

The proportions in which babies need nutrients are different to adults. In the first 12 months of a baby's life, and in proportion to its size, a baby needs:

- 3 times more energy
- 3 times more protein
- 3 times more B vitamins
- 4 times more vitamins A, C and D, and calcium and iron than an adult needs.

## 2. Growing baby

As the child grows older, it needs more nutrients than the mother can provide in her breast milk. From four to six months and older, the baby is introduced to solid foods in addition to its milk.

The baby is slowly taken off breast milk and given solid foods by mouth. This process is called weaning.

The food we give to babies must be soft enough for them to swallow without chewing. These foods include porridge (*nshima*) and mashed food, for example bananas, vegetables and soft meat, such as chicken. Mothers sometimes add protein and nutrient-rich foods to meals, such as groundnuts and soya beans to porridge and maize-based meals.

As the baby grows, the teeth develop and the soft, mashed food can gradually be replaced with other solid food that can be chewed easily by the baby. Small children need to be fed several times during the day.

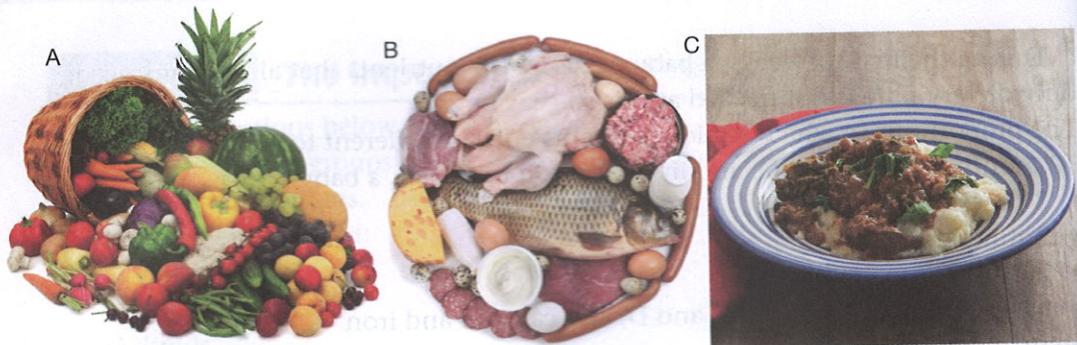
Young children grow quickly and are active. They need food that provides a lot of energy, vitamins (such as green vegetables and fresh fruit), minerals and dietary fibre. Vitamins are needed for growth and protection from infections. Their energy and nutritional requirements are proportionally (by body mass) greater than those of adults.

### New word

**weaning:** slowly taking a baby or child off breast milk and giving them other liquids and solid foods



Figure 6 Soft foods, such as cereal porridges, are suitable for weaning babies.



**Figure 7** The type of food needed by young, active, growing children:  
 A: Fruit and vegetables; B: Proteins; C: A healthy meal with rice, beans and other vegetables

### 3. Sick person

The correct diet is important for a sick person. A sick person requires more vitamins, proteins and carbohydrates than normal. The vitamins and proteins repair the parts of the body affected by the illness and are also needed for growth. The carbohydrates give energy.

If a sick person does not eat enough food, growth may slow down. This is because a lot of the food eaten repairs the body and provides energy. Most food is not used not for growth. This causes a person to lose weight when they are sick; this is known as **wasting**. For a sick person to recover properly from illness, it is important for them to eat extra proteins, carbohydrates, minerals and vitamins.

### 4. Pregnant woman

A pregnant woman needs to eat enough food that contains all the correct nutrients for her own health – and for the health of the foetus developing in her uterus. If a pregnant woman does not eat enough correct nutrients, her health is affected. This is because the developing foetus absorbs the essential nutrients it needs from the mother's blood.

Many people think that when a woman is pregnant she should be eating enough food for two people. This is not true. Pregnancy changes the proportions in which energy and some nutrients are required.

A pregnant woman's diet should differ from a normal balanced diet in these ways:

#### New word

**wasting:** losing weight as a result of illness



**Figure 8** A pregnant woman should have a healthy diet with plenty fresh fruit and vegetables.

- The total amount of food should increase. This increase must be healthy food, and the woman should gain a healthy weight.
- The quality of the food she eats should be the best she can afford. It is important that the food contains all the nutrients.
- The woman should eat a balanced diet. The carbohydrates provide the biological functions that the foetus has enough energy for.
- The woman should eat foods that are especially iron (Fe) and omega-3 fatty acids.
- The extra iron will help the woman's blood to transport oxygen to the foetus. It will also ensure that the woman's blood to transport oxygen to the foetus.
- The calcium will help the woman's skeleton and developing teeth to grow. It will also help the developing foetus to grow.
- The folic acid and vitamins will help the nervous system to develop properly.
- The woman should avoid smoking, as smoking can cause the woman's blood to become thicker and less able to carry oxygen to the foetus.
- She should increase her fluid intake. Most of this should be water, as it will help to prevent dehydration and help the foetus to develop properly.
- She should avoid alcohol, as it can have a negative effect on the health of the foetus.

- The total amount of energy in the woman's food should increase by about 20%. This increase must be because she is eating more healthy food, and not more **junk food**. A woman should gain no more than 10–13 kg during her pregnancy, assuming that she had a healthy weight before the pregnancy.
- The quality of the food a pregnant woman eats should be the best she can find and afford. It is important that her food contains the maximum amount of nutrients.
- The woman should increase the amount of protein and carbohydrates in her diet. The carbohydrates will give her and the foetus enough energy for all their biological functions for a healthy pregnancy. More protein will ensure that the foetus has enough of the nutrients needed for it to build its own proteins.
- The woman should increase the amount of minerals and vitamins in her diet – especially iron (Fe), calcium (Ca), folic acid (vitamin B9) and vitamin D and omega-3 fatty acids.
  - The extra iron will ensure that the mother does not become anaemic. It will also ensure that the foetus is able to make enough red blood cells. This is for its blood to transport the oxygen around its body.
  - The calcium will ensure that the mother does not lose calcium from her skeleton and develop **osteoporosis**. It will also ensure that the foetus has enough calcium for it to make healthy and strong bones and teeth.
  - The folic acid and the omega-3 fatty acids will ensure that the brain and nervous system of a foetus develop properly.
- The woman should increase the amount of fibre she eats. This will prevent her from becoming constipated.
- She should increase the amount of liquid she drinks to about 2.5 litres per day – most of this should be water. This will help to ensure that she does not become dehydrated and can produce enough amniotic fluid for the foetus to develop properly.
- She should avoid junk food, alcohol and **nicotine**. All of these have a negative effect on the health of a mother, and they also harm the foetus.

### New words

**junk food:** food that provides little or no nutritional value  
**osteoporosis:** a condition in which the bones become weak and fragile as a result of insufficient calcium  
**nicotine:** a chemical in tobacco that is poisonous and harmful to a developing foetus

## Suggestion for daily meal plan for a pregnant woman

### Breakfast

- Rooibos/herbal tea or decaffeinated coffee
- Porridge
- Skim milk
- 1 fruit, for example, sliced banana/chopped dried fruit in cereal/half a pawpaw

### Mid-morning snack

- Fruit
- Mabisi/Magehu

### Lunch

- Wholewheat bread
- Chicken, sardines, pilchards, cheese
- Salad
- Avocado, low oil mayonnaise
- 1 glass skim milk

### Afternoon snack

- Fruit
- Handful of peanuts

### Dinner

- Brown rice, sweet potatoes or maize
- Red meat/pork/chicken/fish/lentils or beans
- Green and yellow/orange vegetables

### Evening

- 1 glass skim milk

A comparison of a balanced diet for pregnant and non-pregnant woman

Food group	Non-pregnant woman (Number of servings)	Pregnant woman (Number of servings)
Breads and grains	6–8	8–11
Dairy	2–3	4
Protein	2	3
Fruit	3	4 or more
Vegetables	4	5 or more
Fats and sweets	Eat sparingly	Eat sparingly

## 5. Lactating m

When a woman's breast milk is lactating. She needs good nutrition to produce milk she produces during lactation (extra energy, protein and vegetables).

- Breastfeeding mothers:
  - 20% increase in protein
  - 25% increase in energy
  - 25% increase in B vitamins
  - 100% increase in calcium
  - 150% increase in zinc

## 6. Worker performance

A worker performing physical work, such as lifting, carrying and pushing, uses more energy than a person who sits at a desk. A person who sits at a desk uses less energy than a person who does most of their work sitting down.

Farm workers and miners perform physical work. A diet that contains more energy-dense foods, such as potatoes and cassava, is better for farm workers and miners.



### Activity 2

Answer the questions

1. Explain why the following are important for a lactating woman:
  - Lactating women need more energy.
  - Growing babies need more energy.
  - Sick children need more energy.
2. List and explain the differences between a diet for a pregnant woman and a diet for a non-pregnant woman.

## 5. Lactating mother

### New word

**lactating:** producing milk

When a woman's breasts are producing milk, she is **lactating**. She needs extra energy and good nutrition to produce more nutrient-rich milk for the baby. The quality of the milk she produces depends on the quality of the food she eats. So, a mother needs extra energy, proteins and vitamins (obtained from eating fresh fruit and vegetables).

A breastfeeding mother needs:

- 20% increase in protein and iron
- 25% increase in energy
- 25% increase in B vitamins
- 100% increase in vitamins A and C.
- 150% increase in calcium, so more vitamin D is also needed.

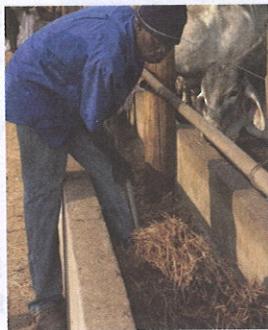
### Did you know ?

Vitamin D increases the absorption of calcium in our bodies. We get most of our vitamin D from being in the sunshine.

## 6. Worker performing manual labour

A worker performing manual labour uses a lot of muscle activity by pulling, lifting, carrying and digging. The workers shown in Figure 9 need more energy than a person who works in an office (a sedentary worker). A sedentary worker does most of their work while sitting down.

Farm workers and construction workers do manual labour and need a balanced diet that contains more energy-giving foods (carbohydrates) such as nsshima, rice, potatoes and cassava.



**Figure 9**  
Construction workers and farm workers do manual labour.

### Activity 2 The dietary needs of various people

Answer the questions below.

1. Explain why the following people need more proteins and carbohydrates.
  - a) Lactating woman
  - b) Growing baby
  - c) Sick child
2. List and explain five ways in which a pregnant woman's diet should be different from the diet of someone who is not pregnant.

## Nutritional deficiency diseases and their symptoms

Nutritional diseases are diseases in humans that are caused by a lack of the necessary nutrients in the diet. Nutritional diseases are usually linked with long-lasting **malnutrition**. Conditions such as obesity from overeating, can also cause or contribute to serious health problems.

### Malnutrition

Malnutrition is caused by eating a diet in which certain nutrients are missing, in excess (too high an intake) or in the wrong proportions. Many different nutritional disorders may occur. This depends on which nutrients are under-abundant or over-abundant in the diet. In most of the world, malnutrition is present in the form of **under-nutrition**. This is caused by a diet lacking enough energy-giving foods and protein from not eating enough food or eating poor quality food. Extreme under-nutrition is starvation; its symptoms and effects include exhaustion caused by lack of food. Malnutrition is more common in less-developed countries. In more-developed countries, it is more likely to be caused by unhealthy diets that have too much energy, fats and refined carbohydrates. People who are malnourished may:

- eat too many calories (**over-nutrition**)
- not eat enough calories/kilojoules and protein for growth and maintenance (**under-nutrition**).

### Over-nutrition

This type of malnutrition has too many nutrients compared to the amounts needed for normal growth, development and metabolism.

### Under-nutrition

This type of malnutrition is caused by not eating enough nutrients or by eating foods that do not contain enough energy and proteins for normal growth and body maintenance. The results of under-nutrition include stunting (growth is slowed down and reduced), wasting and deficiencies of essential vitamins and minerals.

Examples of the more common nutritional deficiency diseases, their causes and symptoms are discussed on the following three pages.

### New words

**malnutrition:** lack of proper nutrition as a result of not eating a balanced diet

**obesity:** grossly fat or overweight from eating too much

**under-nutrition:** having too few nutrients from not enough healthy food

**over-nutrition:** having too many nutrients for normal growth from eating too many fats and unrefined carbohydrates

### Kwashiorkor

Proteins are important proteins in the diet.

Symptoms of kwashiorkor:

- swollen ankles, feet
- a swollen stomach
- an enlarged fatty liver
- wasting muscles (thinner)
- diarrhoea
- hair loss
- anaemia

Kwashiorkor can be treated.

### Did you know ?

Kwashiorkor is a Ghanaian sickness the older child gets when a new baby arrives.

### Marasmus

For people to work, they need carbohydrates.

For people to suffer from diseases, they need carbohydrates.

Carbohydrates in the diet are found in cheap foods containing carbohydrates. Marasmus is a severe shortage of carbohydrates, especially carbohydrates.

Marasmus symptoms include:

- general tissue wasting
- swollen stomach
- dry skin
- loose skin folds hanging from buttocks and arms
- drastic loss of body weight from buttocks and thighs
- restlessness
- irritability
- extreme hunger.

## Kwashiorkor

Proteins are important in the diet, particularly if a person is still growing. A lack of proteins in the diet can lead to the disease known as kwashiorkor.

Symptoms of kwashiorkor include:

- swollen ankles, feet and hands
- a swollen stomach
- an enlarged fatty liver
- wasting muscles (thin arms and legs)
- diarrhoea
- hair loss
- anaemia

- loss of teeth
- loss of skin colour
- dermatitis
- irritability
- loss of appetite
- unable to produce antibodies after being vaccinated against diseases.

Kwashiorkor can be treated by adding protein to the diet gradually over time.

### Did you know ?

Kwashiorkor is a Ghanaian word meaning the sickness the older child gets when a new baby arrives.

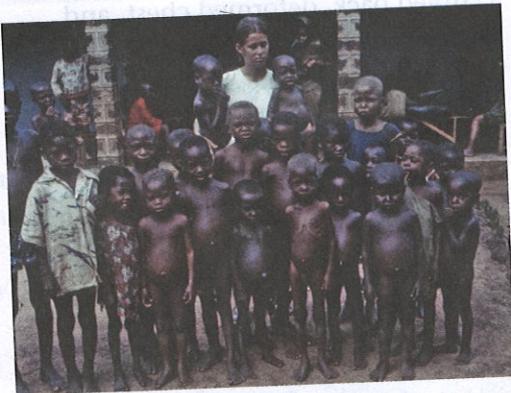


Figure 10 Children suffering from kwashiorkor

## Marasmus

For people to work, they need energy from carbohydrates. It is not common for people to suffer from a lack of carbohydrates in the diet, since most cheap foods contain a lot of carbohydrates. Marasmus is caused by a severe shortage of nearly all nutrients, especially protein and carbohydrates. Symptoms of marasmus include:

- general tissue and muscle wasting
- swollen stomach
- dry skin
- loose skin folds hanging over the buttocks and armpits
- drastic loss of body fat from the buttocks and thighs
- restlessness
- irritability
- extreme hunger.



Figure 11 An Indian man and his son, both suffering from marasmus

## Rickets

Rickets is a common childhood disease in many developing countries. It is caused by a lack of vitamin D, phosphorus or calcium. Most cases occur in children suffering from severe malnutrition in early childhood. This condition causes the bones of the skeleton to soften. The bones may break easily and the skeleton becomes deformed. Long-term consequences include: permanent bends or disfiguration of the long bones, a curved back, deformed chest, and changes in the skull causing a square-headed appearance.

Symptoms of rickets include:

- aching bones
- dental problems
- muscle weakness
- uncontrolled muscle spasms (tetany)
- skeletal deformity, such as bowed legs and knock-knees.

Osteomalacia is a similar condition that occurs in adults. It occurs mostly in women and is caused by lack of vitamin D and calcium. The bones soften and weaken, so they break easily.

## Scurvy

Scurvy is caused by the lack of vitamin C. In modern Western societies, adults seldom suffer from scurvy. However, infants and elderly people can be affected. It is fairly common in developing countries.

Symptoms of scurvy include:

- general symptoms of illness
- tiredness
- spots on the skin, especially on thighs and legs
- spongy gums
- bleeding from the mucous membranes
- depression
- pale skin
- partial immobility.

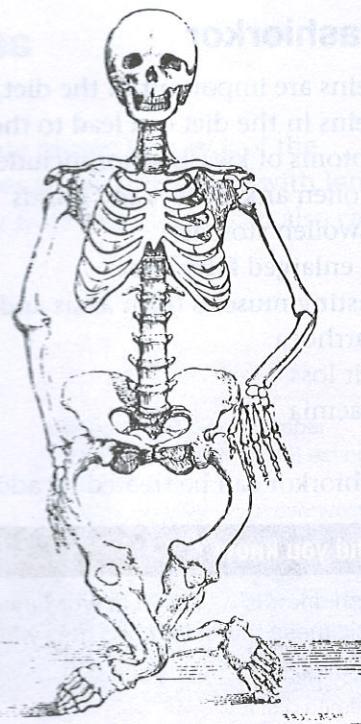


Figure 12 A skeleton showing the typical symptom of rickets, bowed legs

Advanced cases of scurvy show these symptoms:

- open, oozing wounds
- loss of teeth
- jaundice
- fever
- diseased nervous system
- death.

## Anaemia

Anaemia affects women more than men. It is caused by a deficiency. This can be:

- too little iron in the diet
- not being able to absorb iron properly from food
- iron loss due to heavy bleeding
- The most important cause in Third World children is worms. These worms cause blood loss. Hookworms and threadworms contribute to anaemia in most developing countries.

Symptoms of anaemia:

- pale yellow skin
- tiredness/sleepiness
- light-headedness
- weakness
- constipation
- ringing in the ears
- mouth ulcers
- hair loss
- fainting
- depression
- breathlessness
- missed menstrual periods

Advanced cases of scurvy also have these symptoms:

- open, oozing wounds
- loss of teeth
- jaundice
- fever
- diseased nervous system
- death.

## Anaemia

Anaemia affects women more often than men. It is caused by an iron deficiency. This can be caused by:

- too little iron in the diet
- not being able to absorb iron properly from food
- iron loss due to internal bleeding.
- The most important cause of anaemia in **Third World** children is parasitic worms. These worms cause intestinal bleeding, which is not always noticeable in the faeces. Malaria, hookworms and vitamin A deficiency contribute to anaemia during pregnancy in most developing countries.

Symptoms of anaemia include:

- pale yellow skin
- tiredness/sleepiness
- light-headedness
- weakness
- constipation
- ringing in the ears
- mouth ulcers
- hair loss
- fainting
- depression
- breathlessness
- missed menstrual cycle.

### ⚠ Did you know ?

Teenagers need extra calcium and iron during adolescence.



Figure 13 A photograph of the mouth of a person suffering from scurvy

### New word

**Third World:** the developing countries of Africa, Asia and South America



Figure 14 A photograph of the face of a man suffering from anaemia

### Activity 3 Nutritional deficiency diseases

Answer the questions below.

1. State the nutritional disease caused by a deficiency of:
  - a) vitamin A and D
  - b) calcium and iron.
2. List five symptoms of each of the following deficiency diseases:
  - a) kwashiorkor
  - b) rickets
  - c) marasmus.
3. List the most important causes of anaemia in the Third World.

### The importance of children's clinics

In Zambia, children's clinics provide a Children's Clinic Card (Figure 15) to every child born in Zambia. These clinics are important for monitoring the growth and development of all babies born in Zambia. Every month, and whenever the child falls ill, the parent(s) or carers must take the child and the Children's Clinic Card to the local under-five clinic. This is to check whether the child is growing healthily. The check is done by weighing the child regularly and recording the mass on a mass/age graph.

The vertical axis of the card shows the mass of the child and the horizontal axis shows the age of the child. The card is marked with safe upper and lower mass limits for each month. If the mass of the child increases and the line rises above the upper limit, it may mean that the child is overfeeding or being fed the wrong diet. If the child is underfed, he or she will lose weight and the line will fall below the lower safe limit. This may also indicate that the child is suffering from an illness. The clinics provide nutritional advice to parents and carers. Clinics also provide supplementary feeding for under-nourished children.

The other information given on the card is the information about the child's family and immunisation programme. It provides a medical and health record for the child during the first five years of development.

### Activity 4 The importance of children's clinics

Study the copy of a child's clinic card in Figure 15a and 15b and then answer the questions below.

1. Name three of the most common causes of poor health in children in the age group 0–5 years.
2. List the information that a children's clinic card should provide.
3. From the graph on the children's clinic card, determine:
  - a) the mass of the child at the age of two months
  - b) the age of the child when it has a mass of 5 kg.

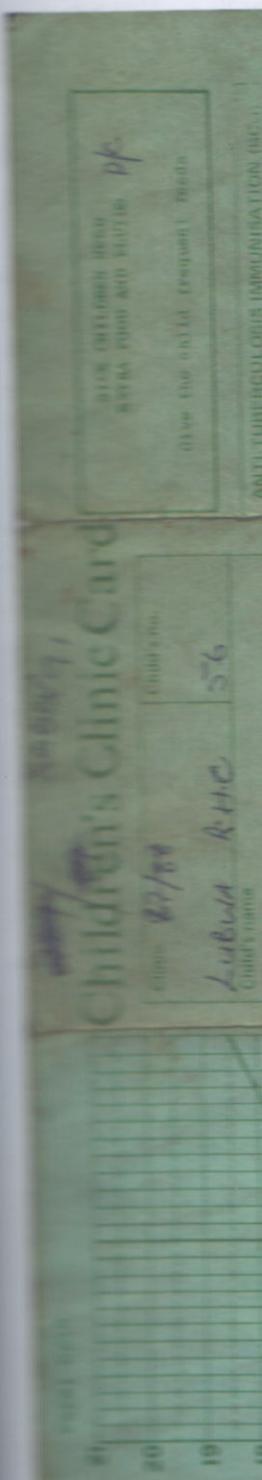


Figure 15a A Zambia Children's Clinic Card

Form: BPF18

5000/7/1  
Children's Clinic Card

20	Child's name <b>MUSONDA BANDA</b>	Child's no. <b>56</b>
19	Child's name <b>LUBWA K-H-C</b>	Child's no. <b>56</b>
18	Mother's name <b>CHISHIMBA</b>	Registration No. <b>56</b>
17	Father's name <b>ANDSON BANDA</b>	Registration No. <b>56</b>
16	Date first seen <b>12/3/84</b>	Birthday/birthweight <b>8/2/84</b>
15	Where the family live: address <b>K K SEC SCHOOL</b>	
14		
13		
12		
11		
10		
9		
8		
7		
6		
5		
4		
3		
2		

SICK CHILDREN NEED **PF**  
EXTRA FOOD AND FLUIDS

Give the child frequent feeds

ANTI-TUBERCULOSIS IMMUNISATION (BCG)

Date of BCG immunisation **12/3/84** **(+)**

(BCG can be given immediately after birth)

POLIOMYELITIS IMMUNISATION

Date of first immunisation **20/8/84**

Date of second immunisation **11/9/84**

Date of third immunisation **16/10/84**

~~Booster~~ **28/11/84**

WHOOPING COUGH, TETANUS & DIPHTHERIA IMMUNISATION

Date of first immunisation (at age of 2 months or 1st birthday) **20/8/84**

Date of second immunisation (1 month after the 1st injection) **11/9/84**

Date of third immunisation (1 month after the 2nd injection) **16/10/84**

MEASLES IMMUNISATION

Date of immunisation **13/11/84**

OTHER IMMUNISATIONS

**TT 21/6/88**

**ALL HEALTHY**

**3-4 years 4-5 years**

Figure 15a A Zambian Children's Clinic Card, side one.

## Summary

- The body needs protein to stay healthy.
- Fats and carbohydrates are used for energy.
- Proteins build and repair body tissues.
- Vitamins are used for growth.
- Minerals help form bones and teeth.
- Water cools the body and helps it to dissolve and transport substances in the blood.
- Children's clinics are run by nurses.
- A balanced diet has all the nutrients the body needs.
- Minerals, such as calcium, are used for the growth of bones and teeth, and the formation of blood cells.

### The importance of

- The energy supplier of processes.
- Nutrients in the food of the body and food.
- Proper nutrition is a

## The types of nutrients

- The body needs a source of energy
  - » Carbohydrates:
    - are the main energy source
    - store energy
    - are a structural component
  - » Lipids (fats and oils):
    - are a source of energy
    - store energy
    - are a structural component
    - provide water-soluble vitamins
  - » Proteins:
    - are a structural component
    - have controlling functions
    - play a role in metabolism
    - are a reserve source of energy

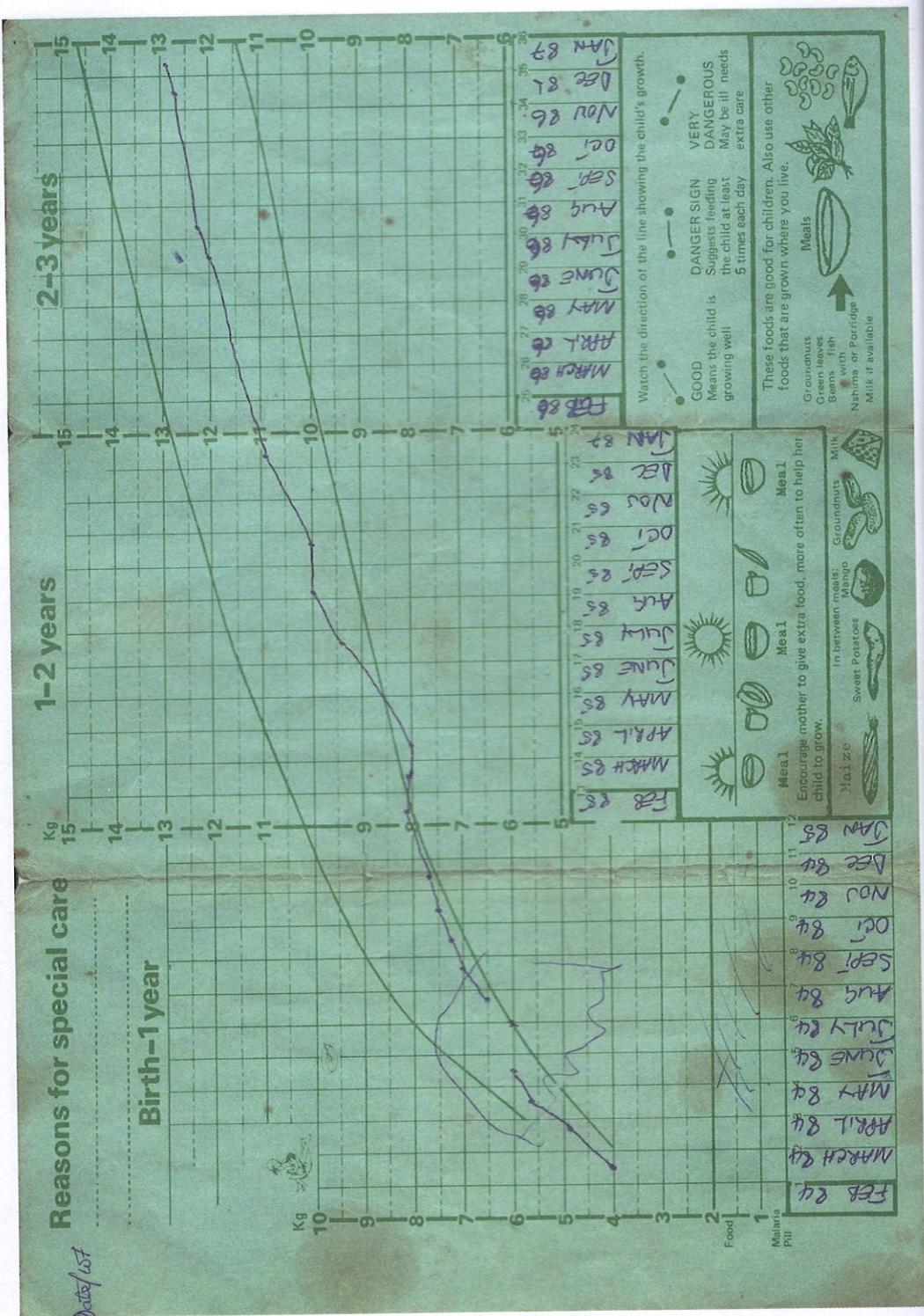


Figure 15b A Zambian Children's Clinic Card, side two.

**Summary**

- The body needs proteins, fats, carbohydrates, vitamins, minerals and water to stay healthy.
- Fats and carbohydrates are needed for energy.
- Proteins build and repair body tissue.
- Vitamins are used for chemical work in the cells.
- Minerals help form cell parts.
- Water cools the body and carries away body wastes. Chemical changes take place in water.
- Children's clinics are important for monitoring child development.
- A balanced diet has a variety of foods from the six food groups.
- Minerals, such as calcium and iron, are needed for bone and teeth formation and the formation of red blood cells.

**The importance of nutrition**

- The energy supplied by the foods is used to carry out various life sustaining processes.
- Nutrients in the food are needed for growth, the repair of old or damaged parts of the body and for development.
- Proper nutrition is important for the healthy biological functioning of the body.

**The types of nutrients that occur in food**

- The body needs a supply of nutrients from all three of the main food types:
  - Carbohydrates:
    - are the main energy source
    - store energy
    - are a structural part of cell walls.
  - Lipids (fats and oils):
    - are a source of energy
    - store energy
    - are a structural part of cell membranes
    - provide waterproofing.
  - Proteins:
    - are a structural part of cell membranes, chromosomes, and other cell parts
    - have controlling and regulatory functions as hormones and enzymes
    - play a role in the functioning of the immune system
    - are a reserve source of energy.

## Summary, revision and assessment continued

- It is also vital to have a supply of:
  - vitamins, which:
    - help to regulate cell activity
    - act as anti-oxidants
    - help enzymes to function properly.
  - minerals, which:
    - act as electrolytes
    - have structural or functional roles in cell metabolism.
  - fibre, which:
    - aids in and speeds up the excretion of waste and toxins
    - prevents constipation.
  - water, which:
    - acts as a lubricant
    - is a solvent
    - is a coolant in the body.

### The dietary needs of different people

- The ideal diet and how much food to eat varies from one person to the next.
- Factors that influence diet are:
  - age
  - gender
  - the activity level of the person
  - state of health.
- Sick people require more vitamins, proteins and carbohydrates than normal. Pregnant women and lactating mothers must eat a healthy diet to nourish a developing foetus and a breastfed baby. People who do manual labour should eat lots of high-energy foods.

### Nutritional deficiency diseases

- Nutritional deficiency diseases in humans are caused by a lack of necessary nutrients in the diet.
- Malnutrition is caused by eating a diet in which certain nutrients are missing, in excess (too high an intake), or in the wrong proportions.
- Malnutrition is more common in less-developed countries.
- In most of the world, malnutrition is present in the form of under-nutrition.
- Under-nutrition is malnutrition caused by not eating enough nutrients, or by eating foods that do not contain enough energy and proteins for normal growth and body maintenance.
- Over-nutrition is malnutrition in which there are too many nutrients compared to the amounts needed for normal growth, development and metabolism.
- Over-nutrition is not commonly found in the Third World.

- Some of the more common deficiency diseases are:
  - kwashiorkor (lack of protein)
  - marasmus (lack of energy)
  - rickets (lack of vitamin D)

### The importance of children's clinics

- Children's clinics are run by the Ministry of Health in Zambia.
- The clinics provide free medical services.
- These cards are used to record a child's growth:
  - age
  - mass
- The cards provide a record of a child's growth over years of development.

### Revision exercises

- Various options questions. Choose the correct answers.  
a) The recommended daily intake of a balanced diet is:  
A 2-3 litres  
B 2-4 litres  
b) The recommended daily intake of a balanced diet is:  
A 2-3 litres  
B 2-4 litres  
c) On average how much water should a person drink:  
A 3 litres  
B 1.5 litres  
d) Name a good source of protein:  
A Sardines  
B Rice  
e) Which combination of foods is a good part of a human diet?  
A A; C; E; G;  
B B; D; F; H;

- Some of the more common nutritional deficiency diseases are:
  - kwashiorkor (lack of protein) » scurvy (lack of vitamin C)
  - marasmus (lack of carbohydrates) » anaemia (lack of iron).
  - rickets (lack of vitamin D)

### The importance of children's clinics

- Children's clinics are important as they monitor the development of all babies born in Zambia.
- The clinics provide a Children's Clinic Card to every child born in Zambia.
- These cards are used to track each child's:
  - age » growth and development
  - mass » immunisation programme.
- The cards provide a medical and health record for each child during its first five years of development.

### 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.
  - The recommended number of servings per day of carbohydrates in a balanced diet (for an adult) is:
 

A 2-3	C 6-8
B 2-4	D 3-5.
  - The recommended number of servings per day of vegetables in a balanced diet (for an adult) is:
 

A 2-3	C 6-8
B 2-4	D 3-5.
  - On average how much liquid should a woman drink per day?
 

A 3 litres	C 8 litres
B 1.5 litres	D 2.2 litres
  - Name a good example of a food that should be eaten to obtain lipids.
 

A Sardines	C Cabbage
B Rice	D Tomato
  - Which combination of letters represents the vitamins needed in the human diet?
 

A A; C; E; G; I; K	C A; B; C; D; E; F
B B; D; F; H; J; L	D A; B; C; D; E; K

## Summary, revision and assessment continued

f) Which combination of minerals is needed in the human diet?  
A Ca; P; Na; Cl; Fe      C Ca; P; Na; S; Ag  
B Mg; K; S; I; Se      D Se; Hg; Cl; Au; K

g) Name a good example of a food that should be eaten to obtain minerals.  
A Eggs      C Tuna  
B Chicken      D Sweet potato

[14]

2. Give the correct biological term for each of the following descriptions. Write only the term next to the question number.

a) The process when a baby's diet is gradually changed from milk to solids  
b) The part of the diet that helps to prevent constipation  
c) The nutrient that helps to ensure that a developing foetus's brain develops properly  
d) A word that describes when a woman's breasts are producing milk  
e) The condition that is caused by a diet that does not contain the correct nutrients for a balanced diet  
f) The result of long-term over-nutrition  
g) The condition that occurs when the diet does not contain enough of some of the essential nutrients  
h) The disease that occurs in children because of a lack of protein and carbohydrate in the diet  
i) The condition that can be caused by a lack of iron in the diet  
j) The document used in Zambia to record the medical and health record for the first five years of a child's life

[10]

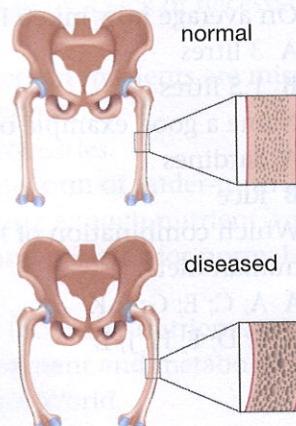
Total for Revision exercises [24]

### Assessment exercises

1. Study the diagrams and answer the questions.

a) The images show symptoms of a nutritional deficiency disease. Name this disease.  
b) Name four symptoms of this deficiency disease, besides the one shown in the diagrams.  
c) Name a similar condition that occurs in adults.  
d) Describe the condition you named in question 1c.

(1) (4) (1) (3) [9]



2. Study the diagram and answer the questions.

a) What is represented by the diagram?  
b) Name the food group represented by each part labelled 1-5.  
c) How much of each group labelled 1-5 is included in a balanced diet on a daily basis?  
d) Besides the nutrient component of the diet, what else does this food group provide?  
e) Identify the number:  
i) stores excess energy  
ii) is a reserve source of energy  
iii) provides electrical energy  
iv) is a source of amino acids  
v) is the main source of protein

3. Study the photograph and answer the questions.

a) Identify the nutrient component of the diet labelled A-D.  
b) List six symptoms.  
c) List five symptoms.  
d) List five symptoms.  
e) List four symptoms.



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

a) What is represented by this diagram? (1)

b) Name the food group represented by each of the parts labelled 1–5. (5)

c) How much of each of the food groups labelled 1–5 should be included in a balanced diet on a daily basis? (5)

d) Besides the nutrients they contain, name the other essential component of the diet that is obtained from number 1. (1)

e) Identify the number of the part of the diet that:

- i) stores excess energy
- ii) is a reserve source of energy
- iii) provides electrolytes
- iv) is a source of anti-oxidants
- v) is the main source of energy. (5)



[17]

3. Study the photographs and answer the questions.

a) Identify the nutritional deficiency disease represented by the images labelled A–D. (4)

b) List six symptoms of the disease represented by A. (6)

c) List five symptoms of the disease represented by B. (5)

d) List five symptoms of the disease represented by C. (5)

e) List four symptoms of the disease represented by D. (4)

[24]

**TOTAL MARKS FOR ASSESSMENT EXERCISES: 50**



# TOPIC 3

## The environment

### SUB-TOPIC 1

W

### What is pollution?

Pollution is the contamination of soil by the introduction of products into the environment. Living organisms are affected by substances that can be chemically harmful. These substances are called pollutants. There are three types of pollution:

- water pollution
- air pollution
- soil pollution.

### Water pollution

Water pollution is the contamination of bodies of water such as:

- lakes
- rivers
- oceans
- aquifers
- groundwater.

Water pollution happens when harmful substances, which are not useful, are allowed to enter water bodies.

Water pollution affects almost all living things. In almost all cases, water pollution affects natural biological systems.

Water is important for all living things. Some of the common sources of water pollution are:

- streams
- rivers

The water from many industries is polluted, which makes it unfit for use. Some of the common sources of water pollution in industries are:

Sub-topics	Specific Outcomes
Water, air and land pollution	<ul style="list-style-type: none"><li>Explain what pollution is.</li><li>Identify different types of pollution of the environment.</li><li>Identify causes of pollution of the environment.</li><li>Describe the effects of pollution on the environment.</li><li>Describe ways of preventing pollution of the environment.</li></ul>

### Starter activity

Work in groups of four to six for this activity.

Discuss what you see in the photographs on this page. Think of places in your area where there are similar places. Talk about these places too.



## SUB-TOPIC 1

## Water, air and land pollution

## What is pollution?

Pollution is the **contamination** of air, water or soil by the introduction of substances or products into the environment that are harmful to living organisms and the environment. These substances can be chemicals, **particulates** or biological matter. The substances that cause pollution are called pollutants. There are many different types of pollution. We will deal with three types:

- water pollution
- air pollution
- soil pollution.

## Water pollution

Water pollution is the contamination of water bodies such as:

- lakes
- rivers
- oceans
- **aquifers**
- groundwater.

Water pollution happens when substances that make the water poisonous, or less useful, are allowed to flow into our water sources.

Water pollution affects plants and organisms living in these water bodies. In almost all cases, water pollution damages individual species and populations, and also natural biological communities.

Water is important for all living organisms. It supports life.

Some of the common water sources are:

• streams	• lakes	• oceans
• rivers	• dams	• rain.

The water from many of these sources is polluted. It contains harmful substances that make it unfit for drinking and cooking. Even rainwater is contaminated by air pollution in industrial areas.

## New words

**contamination:** making impure or unclean by adding harmful substances

**particulate:** a very small piece or part; a tiny speck

**aquifer:** underground water between layers of rock



Figure 1 Untreated water that is pumped into rivers and dams destroy our water sources.

# TOPIC 3

## The environment

Sub-Topic 1

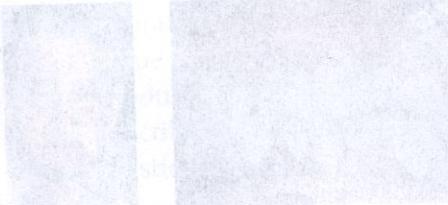
Wa

Sub-topics	Specific Outcomes
Water, air and land pollution	<ul style="list-style-type: none"><li>Explain what pollution is.</li><li>Identify different types of pollution of the environment.</li><li>Identify causes of pollution of the environment.</li><li>Describe the effects of pollution on the environment.</li><li>Describe ways of preventing pollution of the environment.</li></ul>

### Starter activity

Work in groups of four to six for this activity.

Discuss what you see in the photographs on this page. Think of places in your area where there are similar places. Talk about these places too.



## SUB-TOPIC 1

# Water, air and land pollution

## What is pollution?

Pollution is the contamination of air, water or soil by the introduction of substances or products into the environment that are harmful to living organisms and the environment. These substances can be chemicals, **particulates** or biological matter. The substances that cause pollution are called pollutants. There are many different types of pollution. We will deal with three types:

- water pollution
- air pollution
- soil pollution.

## Water pollution

Water pollution is the contamination of water bodies such as:

- lakes
- rivers
- oceans
- aquifers
- groundwater.

Water pollution happens when substances that make the water poisonous, or less useful, are allowed to flow into our water sources.

Water pollution affects plants and organisms living in these water bodies. In almost all cases, water pollution damages individual species and populations, and also natural biological communities.

Water is important for all living organisms. It supports life.

Some of the common water sources are:

• streams	• lakes	• oceans
• rivers	• dams	• rain.

The water from many of these sources is polluted. It contains harmful substances that make it unfit for drinking and cooking. Even rainwater is contaminated by air pollution in industrial areas.

### New words

**contamination:** making impure or unclean by adding harmful substances

**particulate:** a very small piece or part; a tiny speck

**aquifer:** underground water between layers of rock



**Figure 1** Untreated water that is pumped into rivers and dams destroy our water sources.

## Causes of water pollution

Water becomes polluted when it gets contaminated. This can be done by:

- untreated sewage flowing into it
- untreated industrial waste and chemicals flowing into it
- untreated storm water drainage flowing into it
- nutrient/fertiliser-rich agricultural run-off draining into it
- washing clothes and bathing in sources of water, such as streams, rivers and dams
- animals grazing on the banks of streams, river and dams.

## The effects of water pollution

Polluted water is harmful for these reasons:

- It may contain harmful bacteria or viruses. These may cause diseases in people.
- It may contain chemicals that are harmful to living organisms. Examples include phosphates from detergents.
- It may contain compounds that are a good source of food for bacteria that live in the water. This will result in an increase in the population of bacteria that feed on these compounds. These bacteria will use up so much oxygen from the water, that fish living in this water will die or migrate to less polluted places.
- The nitrogen in some pollutants is washed into water sources and soils. This disturbs the balance of the nutrients in the soil and water sources. Tiny aquatic plants called algae grow in water. Too much algal growth takes place in lakes and water sources. This is called **eutrophication**. It results in harmful living conditions for aquatic organisms, which then do not have enough oxygen to stay alive.



Figure 2 Water pollution can cause fish to die and water to become unusable.

## Ways of prevention

Ways of preventing water pollution include:

- Treat sewage waste before it reaches streams, rivers, dams and lakes.
- Use latrines (toilets) instead of open defecation.
- Avoid taking live stock to streams, rivers, dams and lakes to graze.
- Do not throw chemical medicines down sinks.
- Buy more environment-friendly products in public places.
- Do not overuse pesticides and fertilisers on farmland.
- Do not throw litter into water sources.

### Activity 1

Answer the questions

- Explain, in your own words, what is meant by water pollution.
- Name the water sources that are most likely to be polluted.
- Describe how water pollution can affect living things.
- Propose a plan of action to prevent water pollution in your area.



Figure 3 Eutrophication is caused by water pollution.

## Ways of preventing water pollution

Ways of preventing or reducing water pollution include:

- Treat sewage waste before it flows into streams, rivers, dams and all other water sources.
- Use latrines (toilets) correctly.
- Avoid taking **livestock** to the banks of streams, rivers, dams and other water points to graze.
- Do not throw chemicals, oils, paints and medicines down sinks, drains or toilets.
- Buy more environmentally safe cleaning liquids for using at home and in other public places.
- Do not overuse **pesticides** and fertilisers. This will reduce **run-off** of the material into nearby water sources.
- Do not throw litter into streams, lakes, rivers or seas.

### New words

**livestock:** domestic animals that are kept by people for their own use, such as milk, meat, skins, wool

**pesticide:** a chemical used to kill or chase away pests

**run-off:** water that runs or drains off land

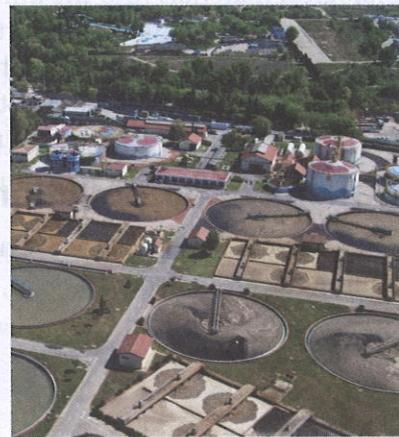
### Activity 1 Consider water pollution in your area

Answer the questions that follow.

1. Explain, in your own words, the meaning of the term water pollution.
2. Name the water sources in your area.
3. Name the most common sources of water.
4. Describe how water pollution affects life in your area.
5. Propose a plan on how water pollution could be prevented or reduced in your area.



**Figure 3** Eutrophication is one of the results of water pollution.



**Figure 4** A sewage plant treats water before releasing it.

## Air pollution

The atmosphere is a layer of mixed gases that surrounds the earth. The air, from which the atmosphere is made, contains these gases:

- nitrogen – makes up 78% of the atmosphere
- oxygen – makes up 20% of the atmosphere
- carbon dioxide – makes up 0.04% of the atmosphere
- rare gases – make up 1.0% of the atmosphere
- water vapour – varies from 0.5%–4.0% of the atmosphere
- other impurities – the amount in the atmosphere varies.



Figure 5 Sources of air pollution: A: Vehicle exhaust fumes; B: Industrial plant with smoke and particulates

Air may have a lot of impurities. Air pollution is the introduction of chemicals, particulates, or biological materials into the atmosphere. These pollutants may cause discomfort, disease or death to humans, damage to other living organisms, or damage to the natural environment and **built-up environment**.

### Causes of air pollution

Air pollution can be caused by humans and by natural events. Natural events that pollute the air include:

- forest fires
- volcanic eruptions
- wind erosion
- pollen dispersal
- natural radioactivity.

### New words

**built-up environment:** buildings that make up a town or city

**radioactivity:** gives off energy waves called radiation

Human activities that include:

- Emissions from industrial activities:
  - Waste incinerators and power plants give off dangerous gases such as monoxide and other chemicals that can damage tissues. It can result in heart disease.
  - Petroleum refineries (which produce oil and hydrogen) in the USA cause cancer.
- Burning fossil fuels
  - Cars, heavy trucks and aircraft



Figure 6 Natural events that pollute the air:  
C: Pollen dispersal.

- Fumes from the burning of coal and oil contain monoxide, nitrogen oxides and other chemicals that cause breathing difficulties.
- Particulates (solid particles) can cause respiratory problems.
- On their own, some natural events such as volcanic eruptions and forest fires are not very harmful. Long-term exposure to these events can cause premature death.
- Household and factory emissions make other toxic chemicals such as sulphur dioxide and nitrogen oxides.
- Crop dusting, fumigation, burning of solid wastes, over-exploitation of natural resources and the use of fossil fuels to generate power all contribute to air pollution.

Human activities that result in air pollution include:

- Emissions from industries and manufacturing activities:
  - » Waste incinerators, manufacturing and power plants give out high levels of dangerous gases such as carbon monoxide, and other chemicals into the air. Carbon monoxide reduces the amount of oxygen reaching the body's organs and tissues. It can result in death in high concentrations.
  - » Petroleum refineries release lots of hydrocarbons (chemicals made of carbon and hydrogen) into the air. Some of these are dangerous gases which can cause cancer.
- Burning fossil fuels:
  - » Cars, heavy trucks, trains, ships and airplanes all burn lots of fossil fuels.

### New words

**incinerator:** a furnace for burning garbage to ashes

**toxic:** poisonous and able to cause harm and possibly death

**fumigate:** to apply smoke, vapour or gas for disinfecting places or destroying pests



**Figure 6** Natural events that cause air pollution: A: Volcanic eruptions; B: Pollen dispersal.

- » Fumes from these exhausts contain dangerous gases such as carbon monoxide, nitrogen oxides, hydrocarbons and particulates. Nitrogen dioxide causes breathing problems and makes lung diseases worse.
- » Particulates (solid particles) can make heart or lung diseases worse and cause respiratory problems.
- » On their own, each gas can cause great harm to people who breathe them in. Long-term exposures can cause heart or lung disease and sometimes premature deaths. These gases can also react with environmental gases to make other **toxic** gases.
- Household and farming chemicals:
  - » Crop dusting, fumigating homes, household cleaning products, painting supplies, over-the-counter insect/pest killers and fertiliser dust all release harmful chemicals into the air that cause pollution.

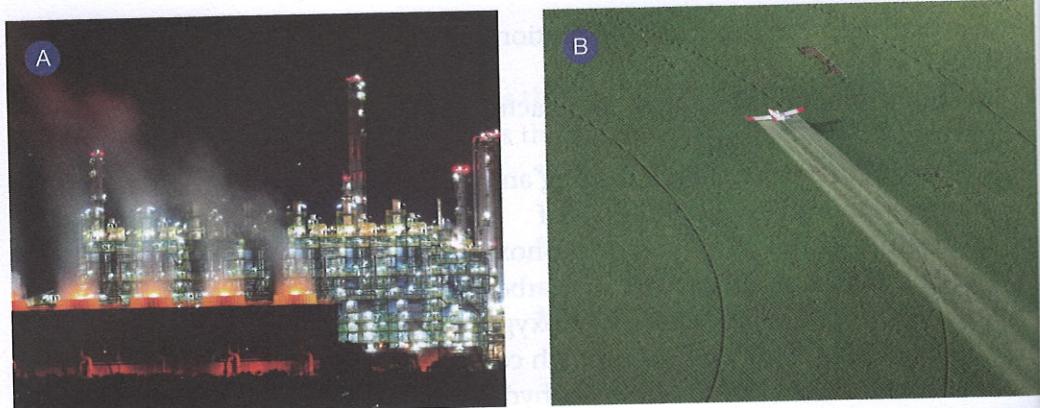


Figure 7 Human activities that produce air pollution: A: An oil refinery; B: Crop dusting

## The effects of air pollution

Air pollution has the following effects.

- Chemical reactions involving air pollutants and water can make acidic compounds known as **acid rain**. This can harm plants, animals, the soil, water sources and buildings. Examples of pollutants that can produce acid rain are hydrogen chloride and sulphur dioxide.
- Exposure to pollution in the form of small particles is harmful to human health and can cause breathing difficulties and other problems. The level of the effect depends on the length of time of exposure, and the type and concentration of the pollutant.
- Short-term effects include: headaches; irritation to the eyes, nose and throat; upper **respiratory tract** infections; **nausea**; allergic reactions.
- Long-term effects include: chronic respiratory disease, lung cancer, heart disease and damage to the brain, nerves, liver or kidneys.
- Air pollution may cause damage to crops, as the impurities in air may affect the crops' growth in the fields.
- Giving off too many CFCs may cause the **ozone layer** high up in the atmosphere to become thin. This allows more ultraviolet rays from the sun to pass through the ozone layer and reach the surface of the earth. This increase in the amount of ultraviolet radiation is harmful to life. It can cause skin cancer and plays a role in causing **global warming**.

### New words

**acid rain:** harmful rain that has become dirty and polluted

**respiratory tract:** the breathing passages

**nausea:** feeling of sickness that makes a person want to vomit

**CFCs:** gases or foams that may cause a breakdown of ozone in the earth's atmosphere

**ozone layer:** a region of the upper atmosphere, between about 15 and 30 kilometres in altitude, containing a high concentration of ozone

**global warming:** the increasing temperature of the earth's surface, including land, water and air

## Ways of reducing pollution

Air pollution in our environment is harmful to life. We will look at ways of preventing air pollution.

### At home

- Conserve energy by turning off appliances and lights when not in use.
- Add insulation to your home.
- Insulate your hot water tank.
- Recycle paper, plastic, cardboard and aluminium. (This conserves energy and reduces greenhouse gas emissions.)
- Plant deciduous trees to give you shade in summer and shelter in winter.
- If possible, buy green energy or even zero-energy homes.
- Connect your outdoor lights to solar panels.
- Wash clothes in warm water, not hot water.
- Lower the temperature of your water to 60 °C.



Figure 8 Recycling bins

## Ways of reducing air pollution

Air pollution in our communities is harmful to life. We will now consider ways of preventing air pollution.

### At home

- Conserve energy by turning off appliances and lights when you leave a room.
- Add insulation to your home.
- Insulate your hot water cylinder.
- Recycle paper, plastic, glass bottles, cardboard and aluminium cans. (This conserves energy and reduces production emissions.)
- Plant **deciduous** trees around your homes to give you shade in summer and sunlight in winter.
- If possible, buy **green electricity** produced by low- or even zero-pollution facilities.
- Connect your outdoor lights to a timer
- Wash clothes in warm or cold water instead of hot water.
- Lower the temperature setting on the **thermostat** on your hot water cylinder to 60 °C.



Figure 8 CFCs, used as an aerosol propellant, will damage the ozone layer.

### New words

**deciduous:** a tree or a shrub that sheds all its leaves each year

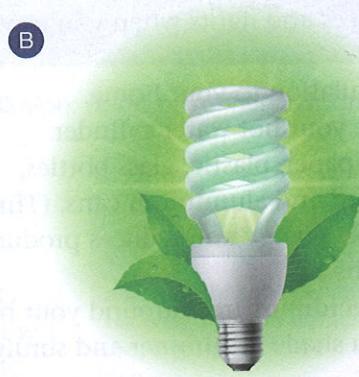
**green electricity:** electricity produced from resources that are renewed, such as sunlight, wind, waves and geothermal heat

**thermostat:** a device that regulates (controls) temperature in a heating or cooling unit



Figure 9 Recycling is one way of preventing air pollution.

- Use water-based paints, stains, finishes and paint strippers to avoid poisonous fumes.
- Choose not to smoke in your home, especially if you have children. If you or your visitors must smoke, then smoke outside.
- Write, print and photocopy on both sides of paper.
- Reduce packaging of goods that you buy.
- Reduce household waste.
- Do not burn garden refuse.



**Figure 10** Ways of reducing pollution: A: Producing green electricity by means of solar panels or wind turbines; B: Using energy efficient light bulbs where possible

### Buy smartly

- Buy energy efficient appliances.
- Choose efficient, low-polluting models of vehicles.
- Choose products that have less packaging and are reusable.
- Choose recycled products.
- Choose products with recyclable packaging.
- Use fabric bags for shopping instead of paper and plastic bags.
- Buy rechargeable batteries for devices that you use frequently.

### Drive wisely

- Plan your trips. Save petrol and reduce air pollution.
- Keep vehicle tyres correctly inflated, balanced and aligned.
- In the summer, fill the petrol tank during cooler evening hours to cut down on evaporation. Avoid spilling petrol. Make sure the petrol cap is replaced tightly.
- When possible, use public transport, walk or ride a bicycle.
- Have your vehicle's engine tuned and its maintenance checks done at regular intervals.
- Use energy-conserving (EC) grade motor oil in your vehicles.
- Join a carpool (share cars) or vanpool to get to work.
- Drive slowly on untarred or gravel roads.

### Activity 2

Work in groups of three.

1. Describe the types of pollution.
2. Describe how air pollution affects us.
3. Make a list of ideas to reduce pollution.
4. Discuss your list with the group.

### Land pollution

Plants that grow on land produce food for growing plants for their food.

Animals need land

- for shelter
- for nesting/reproducing
- Humans also need land
- for farming
- for housing
- for storing water (dam)
- as a source of water for drinking

This is very important that we protect land as much as possible. To do this, we must not pollute land.

Land pollution is the pollution of land, often directly or indirectly, by human resources.

### Activity 3

Work in groups of three.

1. Study the photograph.
2. Discuss what you see in the photograph.



## Activity 2 Consider air pollution in your area

Work in groups of three to four for this activity.

1. Describe the type of air pollution that occurs in the area in which you live.
2. Describe how air pollution affects/influences life in the area in which you live.
3. Make a list of ideas of how air pollution can be reduced where you live.
4. Discuss your list from question 3 with the rest of your class.

## Land pollution

Plants that grow on land absorb water and other nutrients from the soil and produce food for growth and repair. Animals depend directly or indirectly on plants for their food.

Animals need land for various other reasons, such as:

- for shelter
- for nesting/reproduction

Humans also need and use land for:

- farming
- housing
- storing water (dams) that become a source of water for animals
- industrial development
- mining
- construction of roads and other infrastructures.

It is very important that we try to reduce the amount of polluted land to as little as possible. To do this, we need to know what land pollution is.

Land pollution is the degradation or destruction of the earth's land surfaces and soil, often directly or indirectly as a result of man's activities and the misuse of land resources.

## Activity 3 Discuss land pollution

Work in groups of three or four for this activity.

1. Study the photographs (A–D) in Figure 11 on this page and on the next page.
2. Discuss what you see in the photographs.



Figure 11 Landfill sites pollute the environment by adding to the problem of pollution buried in the earth. © Distortion 2002. © Erosion



Figure 11 Sources of land pollution: A: A landfill site showing people recovering some of the re-usable or recyclable materials; B: A domestic waste landfill site; C: Land contaminated with toxic waste containing heavy metals from mining; D: Illegal dumping of waste

- Reduce the use of plastic bags
- Reduce the amount of waste
- lead to less garbage
- Ensure that you do not pollute the environment
- Educate and make people aware of the harmful effects of land pollution
- Ensure that you dispose of waste appropriately.
- Use a drip tray to collect oil
- Do not dump motor oil or oil-based paint
- Buy biodegradable products
- Do organic gardening instead of using chemical pesticides.
- Create landfill sites in appropriate locations

## Causes of land pollution

Causes of land pollution include the following:

- deforestation
- soil erosion
- agricultural (farming) activities
- mining activities
- overcrowded landfills
- industrialisation
- construction activities
- nuclear waste
- sewage treatment
- refining of crude oil.

## The effects of land pollution

The effects of land pollution include the following:

- loss of soil fertility
- air pollution due to increased amount of dust
- increased amount of soil accumulating in water bodies
- reduction of the amount of natural vegetation
- increased occurrence of poor health conditions, such as skin cancer and human respiratory system problems
- reduced attractiveness of an area or city
- a possible reduction in the attraction of an area as a tourist destination.

### New words

**deforestation:** to cut down and remove trees or forests

**industrialisation:** the development of modern industry for making goods; includes factories, machines and large-scale production processes

**crude oil:** naturally occurring, unrefined petroleum



Figure 12 A recycling logo

## Ways of preventing land pollution

Ways to reduce land pollution include:

- Make people aware of the concept of Reduce, Recycle and Reuse.
- Find out about recycling activities in your area so you can support them.

- Reduce the use of pesticides and fertilisers in agricultural activities.
- Reduce the amount of items that you buy that have a lot of packaging. This will lead to less garbage ending-up in landfill sites.
- Ensure that you do not litter.
- Educate and make people aware of the harmful effects of littering.
- Ensure that you dispose of all garbage appropriately.
- Use a drip tray to collect engine oil.
- Do not dump motor oil on the ground.
- Buy **biodegradable** products.
- Do organic gardening and eat **organic food** that is grown without the use of pesticides.
- Create landfill sites away from residential areas.

### New words

**biodegradable:** able to be broken down by biological means, such as bacteria

**organic food:** food grown without chemicals or pesticides

#### Activity 4 Consider land pollution in your area

Work in groups of three or four for this activity.

1. Describe the type of land pollution that occurs in the area in which you live.
2. Describe how land pollution affects life where you live.
3. Make a list of ideas of how land pollution can be reduced where you live.
4. Find out about recycling activities in your area, and how you can help.

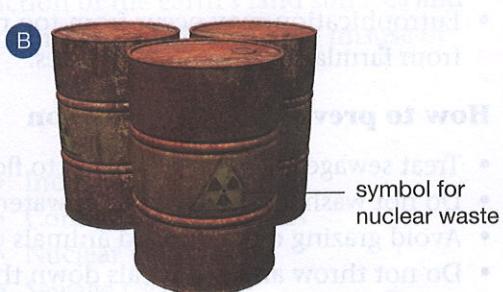


Figure 13 Causes of land pollution: A: Mining; B: Nuclear waste and other poisons buried in the earth; C: Deforestation; D: Erosion

## Summary

### Water pollution

Water pollution occurs when pollutants enter water bodies without suitable treatment to remove the harmful compounds.

#### Causes of water pollution

- Untreated sewage flowing into water sources
- Untreated industrial waste flowing into water sources
- Untreated storm water drainage flowing into water sources
- Nutrient/fertiliser-rich agricultural run-off draining into water sources
- Washing and bathing in sources of water such as in streams, rivers and dams
- Animals grazing on the banks or streams, rivers and dams

#### Effects of water pollution

- Pollutants may cause diseases in people.
- Detergents may be harmful to living organisms found in water.
- Pollutants may result in a sudden increase in the population of bacteria in the water. This may use all oxygen in the water causing other aquatic organisms to die.
- Eutrophication may occur from too much nitrogen from fertilisers running off from farmlands into water sources.

#### How to prevent water pollution

- Treat sewage before it is allowed to flow into water sources.
- Do not wash clothes or bathe in water sources.
- Avoid grazing domesticated animals on the banks of water sources.
- Do not throw any chemicals down the sink, drain or toilet.
- Use more environmentally safe cleaning liquids.
- Do not overuse pesticides and fertilisers.
- Do not throw litter into water sources.

### Air pollution

Air pollution occurs when chemicals, particulates or biological materials enter the atmosphere. They cause discomfort, disease or death to living organisms, or damage the natural or built-up environment.

#### Causes of air pollution

- Forest fires
- Volcanic eruptions
- Wind erosion
- Pollen dispersal
- Dissemination of organic material

#### Effects of air pollution

- Acid rain
- Harmful to human respiratory problems
- Damage to crops

#### How to prevent air pollution

- Reduce the usage of fossil fuels
- Drive as many electric vehicles as possible
- Make sure they are recycled
- Limit the use of motor vehicles

### Land pollution

Land pollution is the damage done directly or indirectly to the environment.

#### Causes of land pollution

- Deforestation
- Soil erosion
- Chemical pollution (from industrial activities)
- Landfill sites

#### Effects of land pollution

- Loss of soil fertility
- Deforestation due to increased amounts of soil
- Chemicals cause severe problems
- Landfill reduces

### **Causes of air pollution**

- Forest fires
- Volcanic eruptions
- Wind erosion
- Pollen dispersal
- Evaporation of organic compounds
- Natural radioactivity
- Emissions from industries and manufacturing activities
- Burning fossil fuels
- Household and farming chemicals

### **Effects of air pollution**

- Acid rain
- Harmful to human health, such as respiratory problems
- Damage to crops
- Giving off too many CFCs may cause the ozone layer high up in the atmosphere to become thin
- Global warming

### **How to prevent air pollution**

- Reduce the usage of electrical energy in homes and in the workplace.
- Recycle as many different types of substances as possible.
- Use/buy recycled or re-used material whenever possible.
- Limit the use of motor vehicles.

### **Land pollution**

Land pollution is the degradation or destruction of the earth's land surfaces and soil, often directly or indirectly as a result of man's activities and the misuse of land resources.

### **Causes of land pollution**

- Deforestation
- Soil erosion
- Agricultural (farming) activities
- Mining activities
- Overcrowded landfills
- Industrialisation
- Construction activities
- Nuclear waste
- Sewage treatment
- Refining of crude oil

### **Effects of land pollution**

- Loss of soil fertility
- Air pollution due to increased amount of dust
- Increased amount of soil accumulating in water bodies
- Increased occurrence of conditions, such as skin cancer and human respiratory system problems
- A possible reduction in the attraction of the area as a tourist destination

# Summary, revision and assessment continued

## How to prevent land pollution

- Make people aware of the concept of Reduce, Recycle and Reuse.
- Reduce the use of pesticides and fertilisers.
- Reduce the use of excessive amounts of packaging.
- Ensure that you do not litter.
- Ensure that you dispose of all garbage appropriately.
- Do not dump motor oil on the ground.
- Use biodegradable products.
- Create landfill sites away from residential areas.

## Revision exercises

1. 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.
  - a) Which combination represents possible causes of water pollution?
    - A Untreated sewage, untreated industrial waste, untreated storm water, fertiliser-rich agricultural run-off
    - B Untreated sewage, untreated industrial waste, untreated storm water, wind erosion
    - C Fertiliser-rich agricultural run-off, wind erosion, untreated industrial waste, untreated storm water
    - D Deforestation, refining crude oil, untreated sewage, untreated industrial waste
  - b) Which combination represents possible causes of land pollution?
    - A Nuclear waste, industrialisation, overcrowded landfills, fertiliser-rich agricultural run-off
    - B Volcanic eruptions, pollen dispersal, fertiliser-rich agricultural run-off, nuclear waste
    - C Construction activities, nuclear waste, industrialisation, overcrowded landfills
    - D Washing in water sources, industrialisation, pollen dispersal, fertiliser-rich agricultural run-off
  - c) Which combination represents possible causes of air pollution?
    - A Fertiliser dust, petroleum refineries, pollen dispersal, untreated sewage
    - B Evaporation of organic compounds, volcanic eruptions, burning fossil fuels, crop dusting
    - C Exhaust fumes, forest fires, waste incinerators, untreated storm water
    - D Fertiliser dust, exhaust fumes, volcanic eruptions, washing in water sources

d) Which combination represents possible effects of air pollution?  
 A Ozone depletion, upper respiratory infections, loss of soil fertility  
 B Excessive algal growth in water sources, acid rain, lung cancer  
 C Ozone depletion, reduction in amount of natural vegetation, eutrophication  
 D Global warming, acid rain, breathing difficulties  $4 \times 2 = (8)$

2. Give the correct term for each of the following descriptions. Write only the term next to the question number.  
 a) The degradation or destruction of the earth's land surfaces and soil  
 b) A gradual increase in the average temperature of the earth  
 c) The permanent removal of natural vegetation from the environment  
 d) Dumping pollutants, directly or indirectly, into water bodies without suitable treatment to remove the harmful compounds  
 e) The introduction of substances or products into the environment that are harmful to living organisms and the environment.  $(10)$

3. Choose an item from Column B that matches a description in Column A. Write only the number next to the corresponding question number.

Column A		Column B	
a)	A possible way of preventing water pollution	i)	Oxygen
b)	The most common gas in the atmosphere	ii)	Exhaust fumes
c)	A natural source of air pollutants	iii)	Biodiversity
d)	A word that describes substances that break down due to natural processes	iv)	Correct use of toilets
e)	All of the different organisms on the earth	v)	Soil erosion
f)	A man-made source of air pollutants	vi)	Volcanic eruptions
		vii)	Biodegradable
		viii)	Nitrogen

$6 \times 2 = (12)$

**Total for Revision exercises [30]**

## Summary, revision and assessment continued

### Assessment exercises

1. Study the photograph and answer the questions.
  - a) Name the type of place where you are likely to find the situation in the photograph. (1)
  - b) Name the type of pollution. (1)
  - c) List the activities that would ensure that most of the waste shown in the photograph would not end up at the place you gave in 1a. (2)
  - d) Suggest six possible effects of this type of pollution. (6)

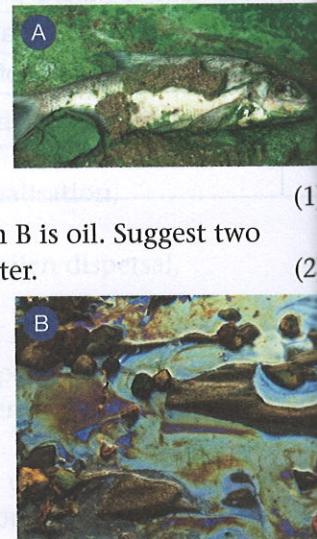
[10]


2. Study the photograph and answer the questions.
  - a) Name the type of pollution. (1)
  - b) Describe what is happening in the engines of the vehicles responsible for the pollutant. (1)
  - c) Name four pollutants that are being released into the atmosphere by these vehicles (4)
  - d) One of these pollutants can have both long-term and short-term effects on human health.
    - i) Name this pollutant. (1)
    - ii) Name four of the short-term effects of this pollutant. (4)
    - iii) Name two of the long-term effects of this pollutant. (6)

[12]


3. Study the photographs and answer the questions.
  - a) Name the process that causes the type of pollution shown in photograph A. (1)
  - b) Name the pollutant that is responsible for this excessive algal growth. (1)
  - c) Describe a consequence of the process you named in question 3a that caused the fish to die. (1)
  - d) The shiny, bluish substance visible in photograph B is oil. Suggest two ways in which the oil could have entered this water. (2)
  - e) Suggest a possible source of this pollutant. (1)
  - f) Name four other sources of water pollutants. (4)
  - g) List three reasons why polluted water is harmful. (3)
  - h) List five ways of preventing water pollution. (5)

[18]



**TOTAL MARKS FOR ASSESSMENT EXERCISES: 40**

# TOPIC 4

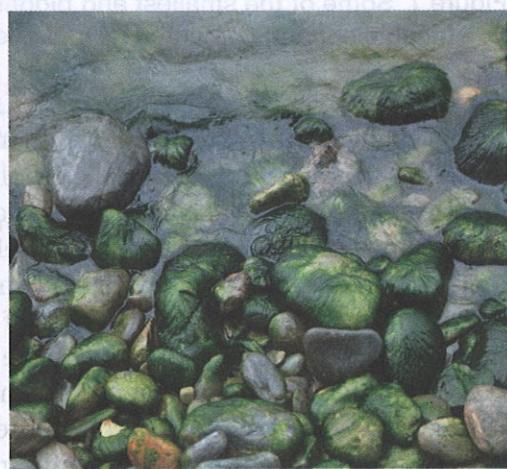
## Plants and animals



Sub-topics	Specific Outcomes
Plant cells	<ul style="list-style-type: none"><li>Identify the main parts of a microscope.</li><li>Examine the plant cell structure using a microscope.</li><li>Describe the functions of the parts of the cell.</li></ul>
Plant growth and nutrients	<ul style="list-style-type: none"><li>Identify the regions of growth of a plant.</li><li>Demonstrate responses to stimuli in shoots and roots.</li><li>Describe the nutrients important to plant growth.</li><li>Investigate how plants obtain dissolved mineral salts from the soil.</li><li>Identify sources of plant nutrients.</li><li>Explain the advantages and disadvantages of inorganic and organic fertilisers.</li><li>Explain the effect of excessive use of inorganic fertiliser to the soil.</li></ul>
Animal cells	<ul style="list-style-type: none"><li>Describe the basic structure of an animal cell.</li><li>Describe the functions of the parts of an animal cell.</li><li>Identify different features in the basic structure of an animal cell and plant cell.</li></ul>

### Starter activity

List the differences that you can observe between a stone and a small animal, such as a rat or a frog. Also compare a rat or a frog and a young plant.



## SUB-TOPIC 1 Plant cells

### Introduction

We can sort all things that occur on earth into two groups: living or non-living. Trees, grass, dogs and human beings are examples of living things. Rocks, buildings and mountains are examples of non-living objects. We divide living organisms into a number of groups. The best-known groups are plants and animals. Grasses, rose plants, mango trees and maize plants are examples of plants. Dogs, frogs, snakes, elephants, cows and monkeys are examples of animals.

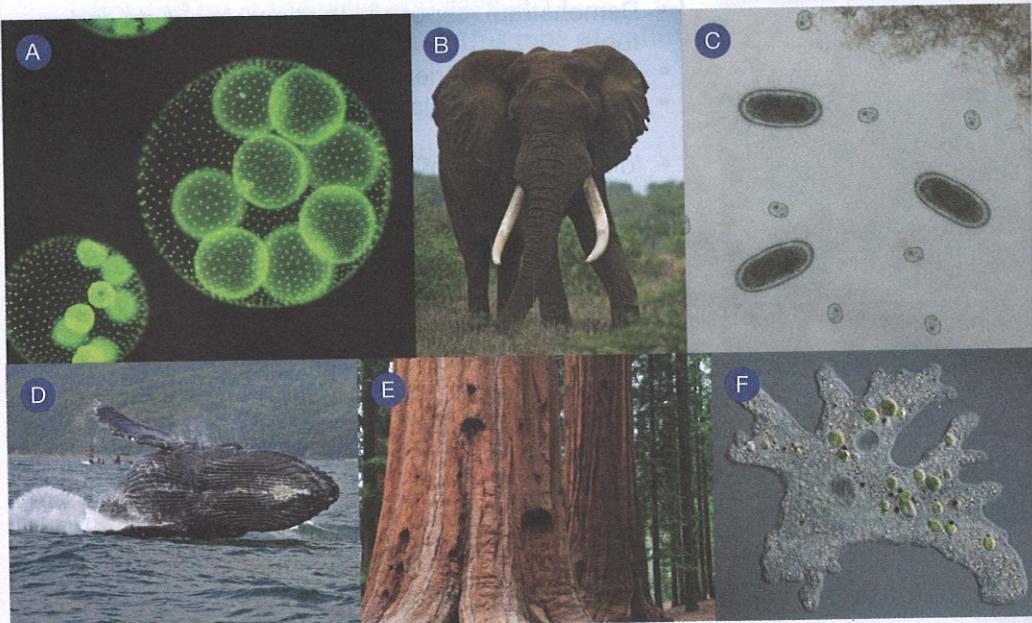


Figure 1 Some of the smallest and biggest living organisms on earth: A: Algae; B: African elephant; C: Bacteria; D: Whale; E: Giant redwood tree; F: Amoeba

Some living organisms are large enough for us to see with the naked eye (unassisted vision). We can see birds flying in the air, dogs around us, plants and our fellow learners in our classes. Other living organisms are too tiny for us to see without help. Some of these organisms are **unicellular** living organisms, such as bacteria and amoeba.

The bodies of large plants are made of tiny units of life called cells. We can compare cells to bricks or blocks that are used to make buildings. In the same way, cells make the bodies of all living organisms. Different types of cells are joined together to form specific parts of the plant. The different kinds of cells found in plants are called plant cells.

### New word

**unicellular:** made of one cell

### The microscope

A microscope is an instrument used to view cells and tiny unicellular organisms. It uses a compound light microscope.

### Parts of the microscope and their functions

We must know how to use a microscope correctly, and the names of its different parts.

**Body tube:** The eyepiece is inserted into this cylindrical tube.

**Rotating nosepiece:** The objective lenses are attached to this part.

**Objective lenses:** These lenses enlarge the size of the image of the specimen.

**Diaphragm and condenser:** These control the amount and brightness of the light falling onto the specimen.

**Mirror:** This reflects rays from a light source through the opening in the stage onto the slide. As light passes through the specimen, its details become clearly visible.

### Figure 2 The parts of a microscope

## The microscope

A microscope is an instrument that allows us to see individual cells, small groups of cells and tiny unicellular organisms. For us to see **microscopic** structures, we use a compound light microscope.

### Parts of the microscope and their functions

We must know how to use a microscope correctly, and the names and functions of its different parts.

#### New word

**microscopic:** only seen with the aid of a microscope

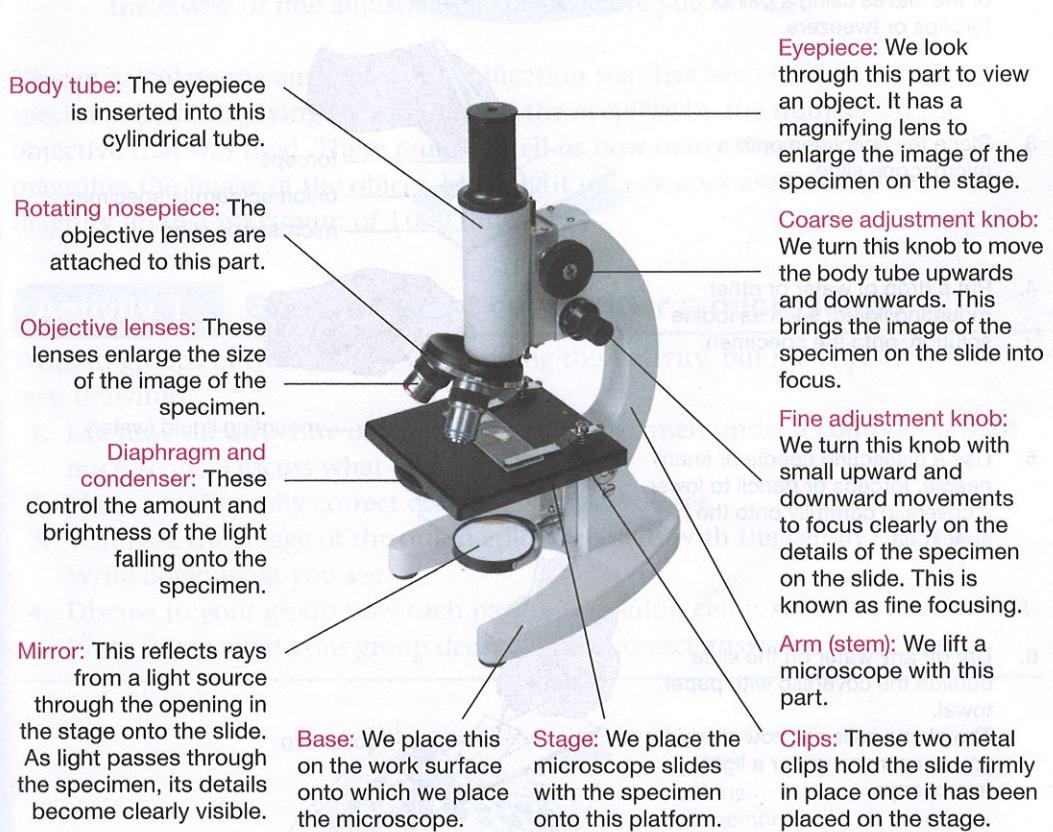
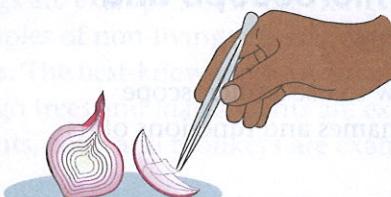


Figure 2 The parts of a compound light microscope

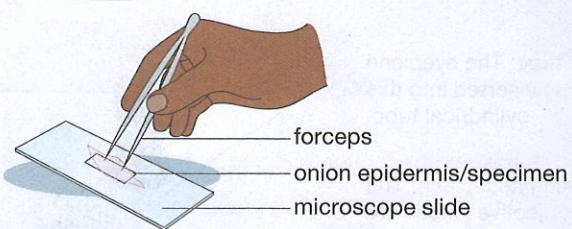
## Examining the plant cell structure using a compound light microscope

We can examine plant cells through a compound light microscope using cells from the epidermal layer of sisal or onion bulb leaves. Your teacher will mount these cells on a microscope slide as shown in Figure 3.

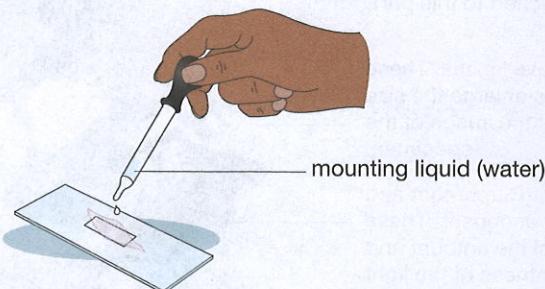
1. Cut open an onion with a knife.



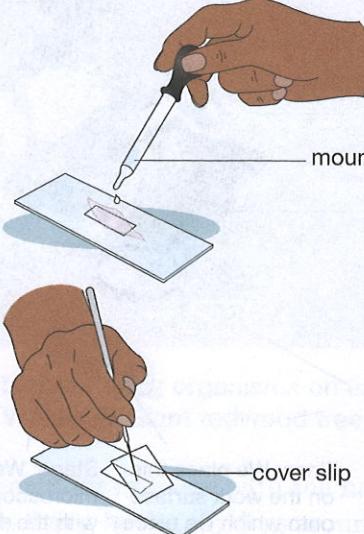
2. Carefully remove the transparent layer of the upper epidermal layer of the leaves using a pair of forceps or tweezers.



3. Place the specimen onto a microscope slide.



4. Put a drop of water or other mounting liquid, such as iodine solution, onto the specimen.



5. Use a dissecting needle or sharp needle, forceps or pencil to lower a coverslip carefully onto the specimen.

6. Dry off any water on the slide outside the coverslip with paper towel.

The plant cells are now ready for you to examine under a light microscope.

**Figure 3** Preparing a microscope slide to view the cells in the epidermal layer of an onion leaf

Follow these steps to view a specimen with a microscope.

**Step 1** Turn the coarse adjustment knob of the microscope to lower the stage to its lowest point.

**Step 2** Place the slide on the stage and hold it firmly in place with the clips.

**Step 3** Adjust the mirror to reflect rays of light from the light source through the opening on the stage onto the specimen on the slide.

**Step 4** Turn the rotatable magnification

**Step 5** Look through the eyepiece and raise the stage until the specimen is in focus.

**Step 6** Turn the fine adjustment knob to focus the specimen.

**Step 7** The specimen may need to be viewed many times. Turn the stage to examine the specimen from different angles.

**Step 8** If you need to change the magnification, turn the rotating nosepiece to change the magnification from the coarse or fine adjustment knobs.

We can calculate the overall magnification of a specimen by multiplying the magnification of the objective that was used with the magnification of the eyepiece. This magnifies the image of the specimen up to a maximum magnification.

### Activity 1

Work in groups of two and draw your own drawings.

1. Examine the structure of a plant cell under a light microscope. Discuss the structure of the cell.
2. Make a biological drawing of the cell.
3. Compare the images of the cell.
4. Write down what you have learned.
5. Discuss in your group.
6. Write down what you have learned.

**Figure 4** The structure of a plant cell

**Step 4** Turn the rotating nosepiece until the objective lens with the lowest magnification is in line with the body tube.

**Step 5** Look through the eyepiece. Slowly turn the coarse adjustment knob to raise the stage until you see a clear image of the specimen.

**Step 6** Turn the fine adjustment knob until you see a very clear, magnified image of the specimen.

**Step 7** The specimen is visible because the microscope has enlarged its image many times. This is known as magnification.

**Step 8** If you need to view the object under higher magnification, turn the rotating nosepiece until the objective lens with the next highest magnification is in line with the body tube. Do not move the stage or turn the coarse or fine adjustments knobs before you do this.

We can calculate the amount of magnification that has been used to view a specimen by multiplying the number on the eyepiece by the number on the objective that was used. These numbers tell us how many times each lens magnifies the image of the object. Most light microscopes used in high schools magnify up to a maximum of 1 000 times.

### Activity 1 Examine plant cells under a microscope

Work in groups of two or three when doing this activity, but make your own drawings.

1. Examine the structure of the cells in your specimen under a compound light microscope. Discuss what you see.
2. Make a biologically correct drawing of what you see.
3. Compare the image of the onion epidermis cells with the cell in Figure 4. Write down what you see.
4. Discuss in your group how each part of the onion cell is suited to its function. Write down what your group decides is the correct answer for each part.

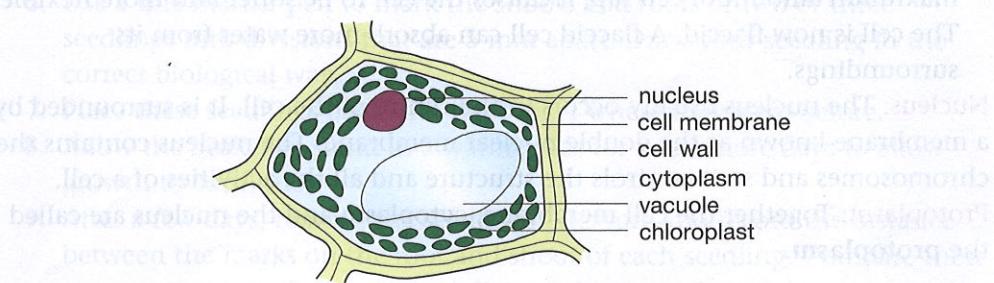


Figure 4 The structure of a typical plant cell as seen under a light microscope

## Structure and functions of the parts of a plant cell

- Cell wall: This outermost layer of plant cells is made of fibrous material called cellulose. It protects the cell from bacteria, gives the cell its shape and makes a plant cell firm (hard). It allows free movement of substances, such as gases and salts (ions), into and out of the cell. We say the cell walls are **permeable**.
- Cell membrane: This is the thin, outer most boundary of the cell. It occurs just inside the cell wall. It controls the movement of substances that enter and leave the cell and the speed at which this happens. We describe this ability as **selectively permeable** or **differentially permeable** to materials.
- Cytoplasm: This is the jelly-like material that fills a cell. Many different kinds of small structures, called organelles, are found in the cytoplasm. Each organelle performs a function that is vital for the survival of the cell.
- Chloroplast: These are small structures or organelles found in the green parts of plants, such as green leaves and stems. They contain the green pigment, chlorophyll. Chlorophyll is vital for photosynthesis. This process allows plants to trap light energy and change it into stored chemical energy in the form of glucose, a sugar.
- Vacuole: This is a large liquid-filled space found in a plant cell. It contains a solution of salts and sugars known as the cell sap. The vacuole is surrounded by a membrane, similar to the cell membrane.
  - » When the vacuole contains the maximum amount of cell sap, it causes the cell to be firm. The cell is now **turgid**. A turgid cell cannot absorb any more water from its surroundings. When the vacuole contains less than the maximum amount of cell sap, it causes the cell to be softer and more flexible. The cell is now **flaccid**. A flaccid cell can absorb more water from its surroundings.
- Nucleus: The nucleus usually occurs in the centre of the cell. It is surrounded by a membrane known as the double nuclear membrane. The nucleus contains the chromosomes and so it controls the structure and all the activities of a cell.
- Protoplasm: Together the cell membrane, cytoplasm and the nucleus are called the **protoplasm**.

## New words

**permeable:** allowing free movement of substances, such as gases and salts (ions), into and out of a cell

**selectively permeable** (**differentially permeable**): controlling the movement of substances that enter and leave a cell

**turgid:** containing enough cell sap to make a cell firm

**protoplasm:** the cell membrane, cytoplasm and nucleus together

## TOPIC 2

Pla

## Regions of growth

Cells grow as they take in materials to form new cells. Cells grow in diameter and length in shoots and roots. The region of growth is called the

## Activity 2

Ide

Work in groups of three. Observe the growth in the seedlings. You keep a careful

## Experiment

### Materials

- 250 ml beaker or glass
- Filter paper or paper towel
- Bean or maize seed
- Water
- Fine marker pen
- Ruler

- 1 Place the beaker on a flat surface and allow the seeds to germinate.
- 2 Once the seeds have germinated, use a fine marker pen to draw the seedlings into the beaker.
- 3 Use a ruler to measure the height of the seedlings.
- 4 Place these seedlings in a warm, bright place.
- 5 Allow the beaker to stand in a warm, bright place for a few days, until the plants have grown.
- 6 After a few days, measure the height of the seedlings again.
- 7 Draw your seedlings with your ruler.
- 8 Explain your results.

**SUB-TOPIC 2** **Plant growth and nutrients**
**Regions of growth in plants**

Plants grow as they take in nutrients. This takes place as existing cells continually divide to form new cells. This continuous process of cell division causes plants to grow in diameter and in height. Shoots grow taller and roots grow longer. The growth in shoots and in roots takes place in the region just behind their tips. This type of growth is called apical growth.

**Activity 2** **Identify the regions of apical growth in a plant**

Work in groups of three when doing this activity. **Aim:** identify the regions of apical growth in the shoots and roots of germinating bean or maize seeds. Make sure you keep a careful record of your measurements.

 **Experiment**
**Materials**

- 250 ml beaker or glass jar
- filter paper or paper towel
- bean or maize seeds
- water
- fine marker pen
- ruler

**Method**

1. Line the sides of the beaker or jar with the filter paper.
2. Place a few bean seeds between the wall of the beaker and the filter paper.
3. Pour a little water into the beaker so that the bean seeds are not immersed in the water. The filter paper must be moist.
4. Place the beaker in a warm, dark place (such as a cupboard) for a few days and allow the seeds to germinate.
5. Once the seeds have germinated, remove the seedlings from the beaker.
6. Use a fine marker pen to mark the shoots and roots of two or three seedlings into divisions that are 5 mm apart. Draw your seedling in the correct biological way.
7. Place these seedlings back into the beaker where they were before.
8. Allow the beaker to stand in a warm place for a few more days to allow growth to continue.
9. After a few days, remove the seedlings. Measure and record the distance between the marks on the root and shoot of each seedling. Compare these measurements with the original distance between the marks.
10. Again draw your seedling in the correct biological way. Compare this drawing with your first drawing.
11. Explain your results and observations.

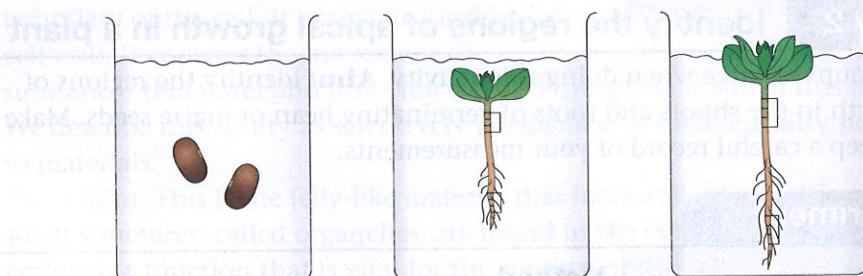
## Continued

### Observations/Results

The distance between the marks on the stem and the root increased in the part of the stem and root a short way behind the stem and root tips.

### Explanation of observations/results

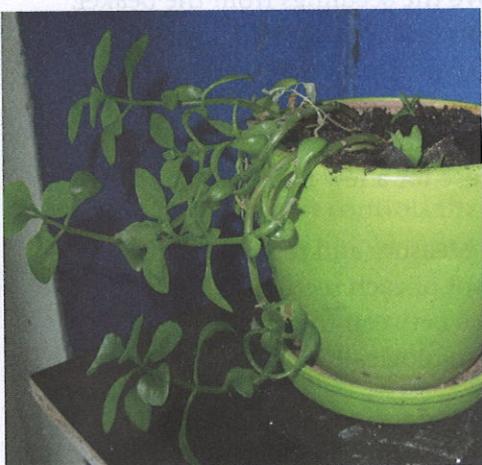
The increase in distance between the marks on both the roots and the stems of the seedlings shows that there is more root or stem in that area. The increase in the amount of root or stem is caused by new cells forming in this area. This increase in length is also caused by the newly formed cells increasing in length.



## Plant responses to stimuli

Living organisms react to the situations in which they find themselves. Humans may run from danger, feel happy when something good happens, or drink when they are thirsty. The situation to which an organism reacts is known as a **stimulus**. The reaction is known as a **response**.

Plants react to a variety of stimuli. They grow towards or away from the stimulus. This type of growth movement is known as a **tropic movement**. If the plant grows towards the stimulus, it is called a positive response. If the plant grows away from the stimulus, it is called a negative response.



### New words

**stimulus:** a situation to which an organism responds or reacts

**response:** the reaction to a stimulus

**tropic movement:** a growth movement of plants in response to a stimulus

Figure 6 This pot plant stood next to a window (on the left in the picture).

### A summary of stimuli

Plant Part	Source of stimulus
Root	Light
Root	Gravity/the earth
Root	Water
Stem	Light
Stem	Gravity/the earth
Stem	Water

### Activity 3

Work in groups of three. Investigate phototropism in a seedling.

### Experiment

#### Materials

- a cardboard box
- bean seedlings in a pot/tin
- cotton wool
- sharp knife/pair of scissors
- sticky tape/glue
- a few sheets of drawing paper

7. Again draw your drawing with your
8. Explain your re

#### Observations/Results

The stems are all growing towards the box.

#### Explanation of results

This shows that stems grow towards light as they are growing.

A summary of stimuli to which plant parts react

Plant Part	Source of stimulus	Name of response	Direction of growth	Name/Type of response
Root	Light	Phototropism	Away from	Negative phototropism
	Gravity/the earth	Geotropism	Towards	Positive geotropism
	Water	Hydrotropism	Towards	Positive hydrotropism
Stem	Light	Phototropism	Towards	Positive phototropism
	Gravity/the earth	Geotropism	Away from	Negative geotropism
	Water	Hydrotropism	Away from	Negative hydrotropism

### Activity 3 Demonstrate phototropism in a stem

Work in groups of three or four when doing this activity. **Aim:** find out about phototropism in a stem using a growing bean seedling.



#### Experiment

##### Materials

- a cardboard box
- bean seedlings in a pot/tin
- cotton wool
- sharp knife/pair of scissors
- sticky tape/glue
- a few sheets of dark paper

##### Method

1. Cut a small opening into one side of the cardboard box, close to the sealed end.
2. Use the dark paper and sticky tape/glue to seal all other openings and prevent light from entering.
3. Place the pot/tin containing the bean seedlings near a window or on the window sill. Draw your seedling in the correct biological way.
4. Cover with the cardboard box. Ensure that the opening you have made faces the window.
5. Leave to stand for two to three days.
6. After this, carefully remove the box and observe the stems.
7. Again draw your seedling in the correct biological way. Compare this drawing with your first drawing.
8. Explain your results and observations.

##### Observations/Results

The stems are all growing towards the opening in the box.

##### Explanation of observations/results

This shows that stems are positively phototropic as they are growing towards the light.

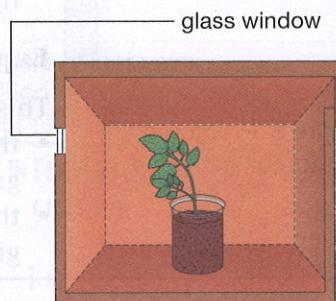


Figure 7 Predicted results for Activity 3

## Activity 4

## Demonstrate geotropism in stems and roots

Work in groups of three or four when doing this activity. **Aim:** find out about geotropism in roots and stems using a newly germinated bean.



### Experiment

#### Materials

- germinating bean seeds
- beaker or glass jar
- cotton wool

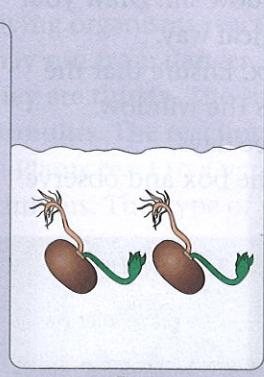
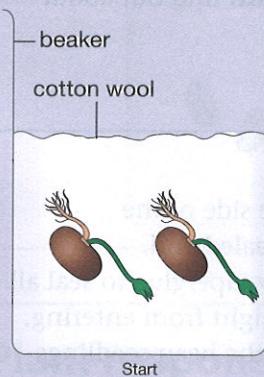


Figure 8 Predicted results for Activity 4

#### Method

- Soak the cotton wool in water.
- Place the cotton wool into the beaker/glass bottle.
- Place the germinating bean seeds between the wall of the beaker/glass jar and the soaked cotton wool so that they can be seen through the glass wall of the beaker/jar.
- When positioning the seeds, arrange at a  $45^\circ$  angle so that their radicles (roots) point upwards and their plumules (shoots) point downwards. Draw your seedling in the correct biological way.
- Place in a warm sunny place.
- Allow to stand for three to five days. Ensure that the cotton wool is kept moist at all times.
- Again draw your seedling in the correct biological way. Compare this drawing with your first drawing.
- Explain your results and observations.

#### Observations/Results

- The roots of the germinating seeds have curved away from the top of the beaker. The roots are now growing downwards.
- The shoots of the germinating seeds have curved away from the bottom of the beaker. The shoots are now growing upwards.

#### Explanation of observations/results

This shows that:

- the stems are negatively geotropic as the shoots are growing upwards (away from the earth)
- the roots are positively geotropic as they are growing downwards (towards the earth).

## Nutrients in

Animals need food of the right type and amount to stay alive, healthy and strong. Plants need the correct nutrients in the right amounts to be healthy, grow and reproduce. Plants absorb these nutrients from the soil in which they grow. In general, plants need all the nutrients listed below, but some are more important than others. It is important to know which nutrients are the most important for a particular plant. If the soil does not contain enough of a particular nutrient, the plants will not grow well, and this is caused by a nutrient deficiency. A deficiency can be caused by a disease or condition.

### Essential plant nutrients

Nutrient
Nitrogen (N)
Calcium (Ca)
Phosphorus (P)
Potassium (K) (most important nutrient in cells)
Sodium (Na)
Iron (Fe)

## Nutrients important to plant growth

Animals need food that contains the correct type and amount of nutrients to keep them alive, healthy and growing. Plants also need the correct nutrients in the correct amounts to live, be healthy, grow and produce a large **crop yield**. Plants absorb these nutrients from the soil in which they grow. It is important to know which are the most important nutrients, and how to tell that plants have enough of each nutrient. Plants that grow on nutrient-poor soils grow badly, are unhealthy and do not produce a good crop yield. A condition that is caused by a lack of any of the essential nutrients is known as a **deficiency disease** or condition.

### Essential plant nutrients, their sources and deficiency conditions

Nutrient	Source	Effects of deficiency
Nitrogen (N)	Root nodules of legumes (peas and bean plants) From the soil as nitrate and ammonium particles	Chlorosis (yellowing) in older leaves Poor growth of all plant organs
Calcium (Ca)	From the soil as calcium ions	Poor growth of plant
Phosphorus (P)	From the soil as phosphate particles	Stunted growth Leaf fall
Potassium (K) (most important ion in cells)	Manure Compost Wood ash	Reduced plant growth Reduced root, fruit and seed development Chlorosis (yellowing) of leaves Brown scorching of leaves Curling of leaf tips
Sodium (Na)	From the soil as sodium particles – added to soil from wood ash	Reduced plant growth
Iron (Fe)	From the soil as iron and iron sulphate	Chlorosis of leaf veins Inhibition of photosynthesis and cellular respiration

### New words

**crop yield:** the amount of harvest that a plant crop produces per unit of land area

**deficiency disease:** a condition caused by a lack of any essential nutrients

EAGLE INTERNATIONAL SCHOOL LTD  
(KITWE ROAD)

19 JAN 2015

DEPUTY MANAGER/HEAD'S OFFICE  
P.O. BOX 41374  
MUFULIRA - ZAMBIA

## The absorption of mineral salts by plants

Plants absorb all the minerals – in the form of mineral salts – that they need through their roots. For a plant to absorb enough water and mineral salts, the roots have tiny hairlike structures, called root hairs, near their tips. Each root hair is made of a single cell and is part of a cell that forms the epidermis (outer layer) of the root. Root hairs allow water and dissolved mineral salts (ions) from the soil to enter them easily.

Water moves into the root hairs by a process known as **osmosis**.

The process by which the mineral salts move into the root hairs is known as **diffusion**. The water with the dissolved mineral salts is carried from the roots up through the stem into the branches, leaves and flowers of the plant.

This upward movement of water in the plant is due to a number of factors. The most important factor is a suction force that is created by a process known as **transpiration**. Transpiration is the loss of water vapour from the parts of the plant that occur above the ground, mainly the leaves.

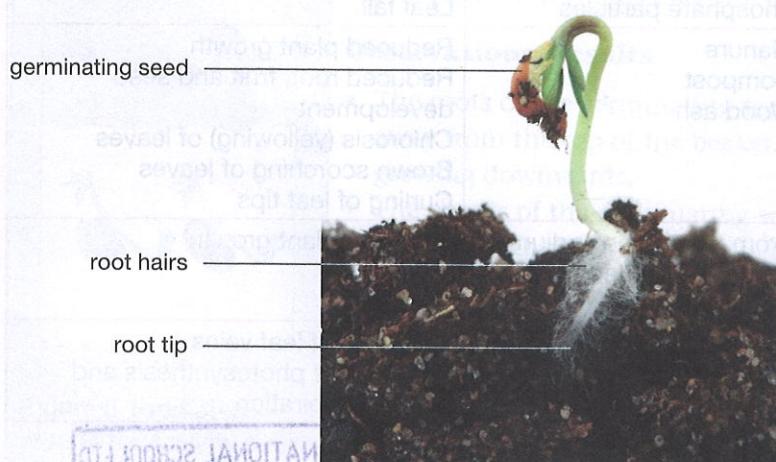


Figure 9 A newly germinated seed showing its shoot and the root hairs just behind the root tip

### New words

**osmosis:** the movement of a liquid, usually water, through a semi-permeable membrane from a less concentrated to a more concentrated solution until both solutions have the same concentration

**diffusion:** the movement of atoms or molecules from an area of higher concentration to an area of lower concentration until the concentration is the same everywhere. Atoms and small molecules can move across a cell membrane by diffusion.

**transpiration:** the loss of water as water vapour from the above-ground parts of a plant

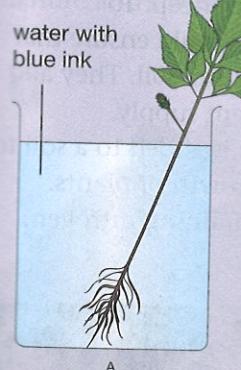
### Activity 5

Work in groups of three. You will need to absorb water and dissolved mineral salts into a plant.

#### Experiment

##### Materials

- two beakers/glass jars
- red or blue ink (to represent dissolved minerals)
- coloured chalk (to represent insoluble particles)
- scalpel or razor blade
- a few young plants such as blackjack (*Bidens pilosa*)



## Activity 5 Show how plants absorb dissolved mineral salts

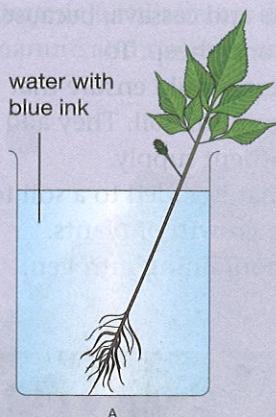
Work in groups of three or four when doing this activity. **Aim:** show how plants absorb water and dissolved mineral salts.



### Experiment

#### Materials

- two beakers/glass jars
- red or blue ink (to represent dissolved minerals)
- coloured chalk dust (to represent insoluble particles)
- scalpel or razor blade
- a few young plants, such as blackjack (*Bidens pilosa*)



#### Method

1. Pour an equal amount of water into both the beakers/glass jars.
2. Add an equal volume of red or blue ink, or chalk dust into each beaker.
3. Carefully remove two young plants from the soil. Place one plant into each beaker.
4. Place the beakers on the window sill in the classroom or in a sheltered, well-lit position.
5. Allow them to stand for one hour.
6. After an hour, observe the colour of the stems of both plants.
7. Remove the plants from the beakers.
8. Use the blade to cut a cross section through the stem and main (tap) root.
9. Carefully observe each cross section. Record your observations in a table like the one below.
10. If possible, observe the cross sections using a magnifying glass or microscope.

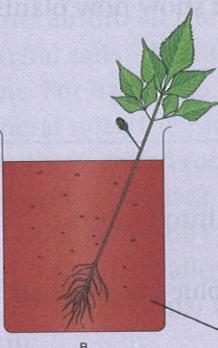
#### Observations/Results

Plant part	Observation	
	Water and ink solution	Water and chalk dust suspension
Root		
Stem		

#### Explanation of observations/results

The cross sections of the root and stem from the plant that was placed into the ink solution showed the colour of the ink in the areas of the root and stem that correspond to the position of the vascular bundles (more specifically, the xylem cells). This shows that the ink, together with the water, has been absorbed by

### Continued



the root and passed into the vascular bundles (xylem cells) for transport up the plant to the leaves. This means that minerals dissolved in water will be transported within plants.

The cross sections of the root and stem from the plant that was placed in the chalk suspension did not show the colour of the chalk anywhere. This shows that unless a substance, such as a mineral, is dissolved in the water, a plant will not absorb that substance.

water and chalk dust suspension

**Figure 10** Diagrams of the plants in A: ink and B: chalk dust solutions.

### Some important plant nutrients

#### Nutrient

Carbon (C)
Hydrogen (H)
Oxygen (O)
Nitrogen (N)
Phosphorus (P)
Potassium (K)
Sulphur (S)
Calcium (Ca)
Magnesium (Mg)
Sodium (Na)
Iron (Fe)

## Sources of plant nutrients

Plants make food in a process called photosynthesis. Plants are known as producers and all animals depend on them for their food. Animals are known as consumers.

Farmers grow crops, such as maize, rice, wheat, groundnuts and cassava, because they can feed humans or livestock, such as cattle, goats, pigs and sheep. To maximize the amount of food produced by their crops, farmers should ensure that the plants have the correct types and amounts of nutrients from the soil. They add fertilisers to the soil to ensure that plants have the correct nutrient supply.

Fertilisers are natural or synthetic (man-made) material that is added to a soil to supply one or more plant nutrients that are essential for the growth of plants. These materials include manure and chemical compounds containing nitrogen, phosphorus and potassium.



**Figure 11** Maize plants showing the type of growth that is produced when a crop is well fertilised

### Organic and inorganic fertilisers

Soil fertility can be increased by adding organic and inorganic fertilisers.

#### Organic fertilisers

Organic fertilisers are made from natural materials such as manure and stalks.

A



C



**Figure 12** Organic fertilisers: A: Natural organic material; B: Humus; C: Industrial prepared fertilisers

## Some important plant nutrients and their sources

Nutrient	Source
Carbon (C)	Carbon dioxide in the atmosphere
Hydrogen (H)	Water absorbed by the plant
Oxygen (O)	Water absorbed by the plant
Nitrogen (N)	Nitrogen in the atmosphere; nitrate and ammonium ions in the soil
Phosphorus (P)	Phosphate ions from the soil, bone meal
Potassium (K)	Manure, compost, wood ash
Sulphur (S)	Sulphate ions in the soil
Calcium (Ca)	Calcium ions in the soil, bone meal
Magnesium (Mg)	Magnesium ions in the soil, compost, humus, dung
Sodium (Na)	Sodium particles in the soil, wood ash
Iron (Fe)	Iron sulphate in the soil

## Organic and inorganic fertilisers

Soil fertility can be improved by adding organic fertilisers or inorganic fertilisers.

### Organic fertilisers

Organic fertilisers are dead, decaying substances such as leaves, cow dung, poultry manure and stalks of cereals, for example, maize, sun flowers and bean stems.



**Figure 12** Organic fertilisers: A: Humus, rich in leaves and other decomposing plant matter; B: Humus compost containing many earthworms; C: Manure piles in a field; D: Industrial preparation of organic compost

### Advantages of using organic fertilisers

- They make the soil rich by adding humus.
- Humus improves soil texture by creating air spaces in between the soil particles.
- Humus improves water retention (ability to hold water) in the soil.
- Humus makes the soil soft for cultivation.
- Humus enables bacterial action in soil.

### Disadvantages of using organic fertilisers

- Manure may not be easily available to farmers.
- They take a long time to decompose and so the nutrients take a long time to be available to plants.
- They may promote the growth of weeds in the field.
- They may encourage worms, termites and ants which feed on crops, causing them harm.

### Chemical or inorganic fertilisers

Chemical fertilisers are also known as inorganic or artificial fertilisers. These are made in factories by industrial companies, such as Nitrogen Chemicals of Zambia situated in Kafue in Lusaka Province. Nitrogen Chemicals of Zambia manufactures fertilisers, such as D Compound and ammonium nitrate.

Farmers who grow maize apply D Compound fertiliser when their crop is young. It promotes the development of roots and leaves. Ammonium nitrate is applied to a crop when it is about to flower. It promotes cob formation.



Figure 13 Inorganic fertilisers: A: A truck collecting inorganic fertiliser from the factory; B: The main active ingredients of inorganic fertilisers; C: A bag of inorganic fertiliser for use on the onion plants; D: A stockpile of bagged inorganic fertiliser

### Advantages of using inorganic fertilisers

- Inorganic fertilisers are easy to store.
- They are quick acting.
- They are effective.

### Disadvantages of using inorganic fertilisers

- They are costly.
- Chemical fertilisers can pollute the environment, for example, soils may leach into rivers.

Farmers can improve their soil by:

- Mixed farming: growing different crops in the same season, for example, groundnuts and maize.
- Crop rotation: growing different crops in the same field in different seasons, for example, growing a leguminous crop like groundnuts after a cereal crop like maize.

### The effect of inorganic fertilisers on the soil

Inorganic fertilisers are good for crops and vegetables in the short term, but they can affect the soil in the long term. If the correct amount of fertiliser is applied to the soil, the soil will be healthy and crops will grow well. If too much fertiliser is applied, it can damage the soil and crops. If farmers apply too much fertiliser, their crops will not grow any better. Using too much fertiliser is expensive and it costs money and causes pollution.

The disadvantages of inorganic fertilisers are:

#### Burning

The high levels of salt in inorganic fertilisers can damage the root systems. The salt can draw water out of the soil, dehydrate them. This can cause the plants to wilt and die.

#### Making the soil acidic

Many inorganic fertilisers are acidic. If too much of these fertilisers are applied to the soil, the soil becomes too acidic. This can damage the plants' root systems and they will not grow well.

### Advantages of using inorganic fertilisers

- Inorganic fertilisers are easy to use on large areas of land.
- They are easy to transport over long distances.
- They are quick acting.
- They are effective if correctly used and greatly increase crop yield.

### Disadvantages of using chemical fertilisers

- They are costly because farmers must buy them.
- Chemical fertilisers change the amount of acidic substances in the soils, for example, soils may become acidic.

Farmers can improve their soil by practising these farming methods:

- Mixed farming: This is growing different types of crops in the same field during the same season, for example, growing maize with legumes, such as beans or groundnuts
- Crop rotation: Grow a different crop in a field each season, for example, growing a leguminous crop in a field where a cereal crop, such as maize, was grown and growing a cereal crop in a field where a legume crop was grown.

## The effect of excessive use of inorganic fertilisers on the soil

Inorganic fertilisers improve the growth of plants and increase the yields of fruits and vegetables in a short time. If inorganic fertilisers are not applied carefully, they can affect the soil in ways that harm plants. Fertiliser companies recommend the correct amount of fertiliser for crops; this amount is beneficial to (good for) crops. If farmers apply more than the recommended amounts, the crops do not grow any better. Using too much inorganic fertiliser results in more fertiliser being added to the soil than the plants can take up. Using too much fertiliser wastes money and causes plant and environmental damage.

The disadvantages of inorganic fertilisers are:

### Burning

The high levels of chemical salts in inorganic fertilisers may burn plants' leaves or root systems. The salts draw out all the moisture from the leaves or roots, and dehydrate them. This kills the leaves or roots and so kills the plants.

### Making the soil acidic

Many inorganic fertilisers contain sulphuric acid and hydrochloric acid. When these fertilisers are over used, they increase the acidity of the soil. The soils become too acidic, which causes the plants to stop growing properly or to die.

### Destruction of soil micro-organisms

Micro-organisms help to increase plants' natural defences against pests and diseases, and improve the fertility of the soil. When soils become too acidic, they harm the micro-organisms that occur in the soil.

### Soil compaction

When soils become too acidic, they cause the soil particles to break down and become too small. The result is a highly compacted soil with reduced drainage and reduced air circulation.

### Groundwater pollution

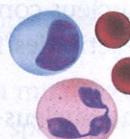
Plants can only absorb a certain amount of nutrients. If inorganic fertilisers are over-applied, not all their chemically produced nutrients will be absorbed by the plants for their use. Unused fertilisers seep into the ground where they may be carried by rainwater and irrigation water into streams, rivers, lakes, reservoirs and oceans. The chemical compounds in the fertilisers can contaminate these waters. This affects drinking water supplies and harms ecosystems.

## Reducing the adverse effects of inorganic fertilisers

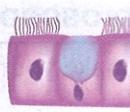
We can reduce these adverse effects if we use the chemicals correctly:

- Carefully follow the directions for correct use on fertiliser packaging.
- Always use the minimum required amount.
- Do not apply inorganic fertilisers just before rain.
- Water the fertiliser into the soil, but prevent water run-off from the surface.
- Keep the soil aerated to avoid run-off.
- Promptly clean any areas of spilled fertiliser.
- Never apply inorganic fertilisers near waterways, lakes, rivers or dams.
- Test the soil for nutrients and check the plants for disease symptoms before adding fertiliser.
- Use slow-release inorganic fertilisers. They release nutrients more slowly and leach into water supplies less than other inorganic fertilisers.
- Use organic fertilisers, such as compost or manure. They release nutrients more slowly and leach into water supplies less than other fertilisers. Organic fertilisers improve soil texture and nutrient levels.
- Use organic fertilisers to save costs, as they may be produced free of cost.
- Neutralise the soil by adding agricultural lime, or woodstove or fireplace ash.

We know that plants are made from cells. Their structure and function form specific parts of



blood cells



columnar epithelia



neuro

Figure 14 Diagrams s

## The basic str

Figure 15 The structu microscope

## SUB-TOPIC 3 Animal cells

We know that plants are made from tiny units of life called cells. Animals are also made from cells. There are many different types of animal cells, each with its own structure and function. As in plants, different types of cells are joined together to form specific parts of the body of animals.

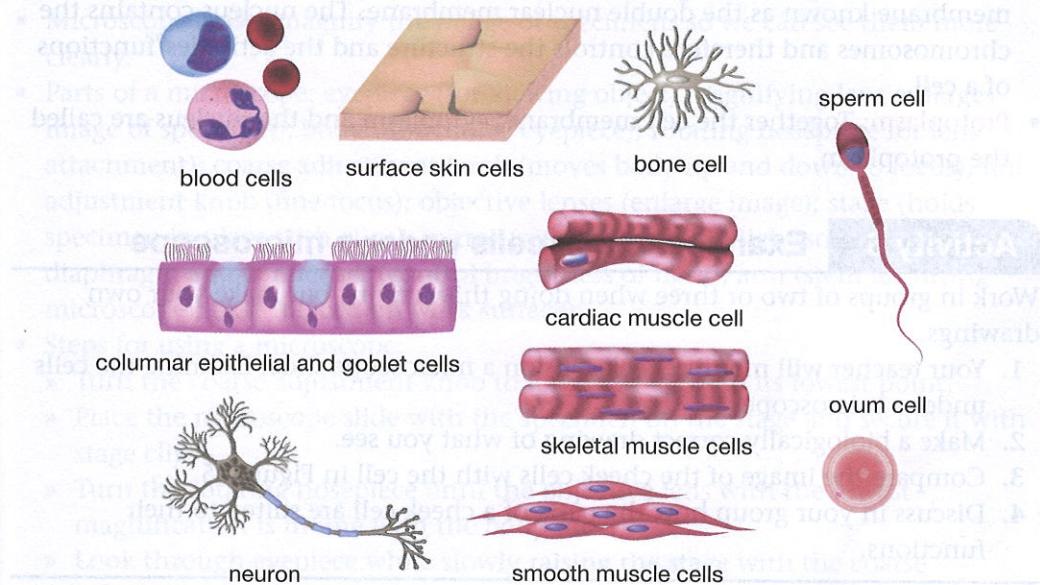


Figure 14 Diagrams showing the different types of animal cells

### The basic structure of an animal cell

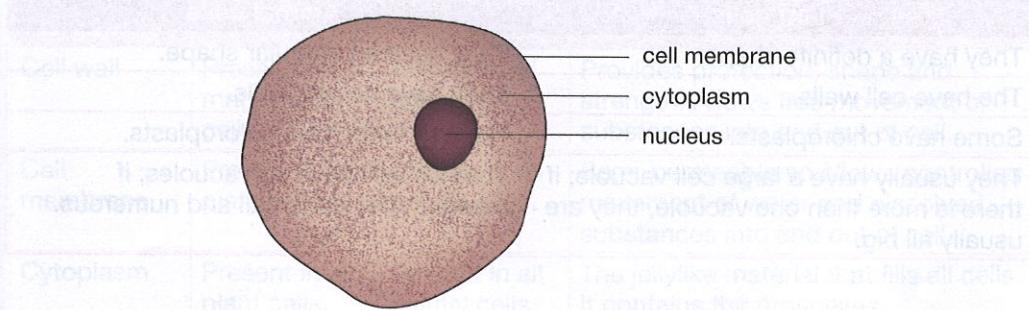


Figure 15 The structure of a typical animal cell as seen under a compound light microscope

- **Cell membrane:** This is the thin outermost boundary of the cell. It allows solutions and gases to enter and leave the cell. It controls which substances enter and leave the cell and the speed at which this happens. We describe this ability as selectively permeable or differentially permeable.
- **Cytoplasm:** This is the jelly-like material that fills a cell. Many different kinds of small structures, called organelles, are found in the cytoplasm. Each organelle performs a function that is vital for the survival of the cell.
- **Nucleus:** It usually occurs in the centre of the cell. It is surrounded by a membrane known as the double nuclear membrane. The nucleus contains the chromosomes and therefore controls the structure and the activities/functions of a cell.
- **Protoplasm:** Together the cell membrane, cytoplasm and the nucleus are called the protoplasm.

### Activity 6 Examine cheek cells under a microscope

Work in groups of two or three when doing this activity, but make your own drawings.

1. Your teacher will mount cheek cells on a microscope slide. Examine the cells under a microscope.
2. Make a biologically correct drawing of what you see.
3. Compare the image of the cheek cells with the cell in Figure 15.
4. Discuss in your group how the parts of a cheek cell are suited to their functions.

### The structural differences between plant and animal cells

Plant cells	Animal cells
They have a definite shape.	They have an irregular shape.
They have cell walls.	They have no cell walls.
Some have chloroplasts.	None of them have chloroplasts.
They usually have a large cell vacuole; if there is more than one vacuole, they are usually all big.	They usually have no vacuoles; if present, they are small and numerous.

### Summary

#### Plant and animal cells

- We can view and study plant and animal cells.
- Microscope lenses magnify the image of a specimen.
- Parts of a microscope (specimen stage, eyepiece lens, objective lens, eyepiece adjustment knob (fine adjustment), objective adjustment knob (coarse adjustment), diaphragm and eyepiece adjustment knob (fine adjustment), base (specimen in place with eyepiece adjustment), diaphragm and eyepiece adjustment knobs).
- Steps for using a microscope:
  - Turn the coarse adjustment knob.
  - Place the microscope on a flat surface.
  - Turn the rotating nosepiece until the eyepiece is in place.
  - Look through eyepiece adjustment knob.
  - Use the fine adjustment knob to make the image visible.
- Structure and components of plant and animal cells.

Structure/ Organelle	Plant cells	Animal cells
Cell wall	Present in mature plant cells.	Present in all plant cells.
Cell membrane	Present in all plant cells.	Present in all animal cells.
Cytoplasm	Present in all plant cells.	Present in all animal cells.
Chloroplasts	Present in plant cells for photosynthesis.	Present in plant cells for photosynthesis.

## Summary

### Plant and animal cells

- We can view and study plant and animal cells using microscopes.
- Microscope lenses magnify the image of specimens so we can see them more clearly.
- Parts of a microscope: eyepiece (for viewing object; magnifying lens enlarges image of specimen); body tube (holds eyepiece); rotating nosepiece for lens attachment); coarse adjustment knob (moves body up and down to focus); fine adjustment knob (fine focus); objective lenses (enlarge image); stage (holds specimen in place with clips); mirror (reflects rays from light source onto slide); diaphragm and condenser (control brightness of light); arm (stem for lifting microscope); base (placed on work surface).
- Steps for using a microscope:
  - » Turn the coarse adjustment knob to lower the stage to its lowest point.
  - » Place the microscope slide with the specimen on the stage and secure it with stage clips.
  - » Turn the rotating nosepiece until the objective lens with the lowest magnification is in line with the body tube.
  - » Look through eyepiece while slowly raising the stage with the coarse adjustment knob, until a clear image is formed.
  - » Use the fine adjustment knob to re-adjust the focus until a clear image is visible.
- Structure and comparison of plant and animal cells:

Structure/ Organelle	Plant cells	Animal cells	Function
Cell wall	Present in all mature plant cells.	Absent in all animal cells.	Provides protection, shape and strength. Allows free movement of substances into and out of cell.
Cell membrane	Present in all plant cells.	Present in all animal cells.	Semi-permeable so allows controlled movement of water and dissolved substances into and out of cell.
Cytoplasm	Present in all plant cells.	Present in all animal cells.	The jellylike material that fills all cells. It contains the organelles.
Chloroplasts	Present in cells found in green parts of plants.	Absent in animal cells.	Contain chlorophyll. This is where photosynthesis takes place.

- **Cell membrane:** This is the thin outermost boundary of the cell. It allows solutions and gases to enter and leave the cell. It controls which substances enter and leave the cell and the speed at which this happens. We describe this ability as selectively permeable or differentially permeable.
- **Cytoplasm:** This is the jelly-like material that fills a cell. Many different kinds of small structures, called organelles, are found in the cytoplasm. Each organelle performs a function that is vital for the survival of the cell.
- **Nucleus:** It usually occurs in the centre of the cell. It is surrounded by a membrane known as the double nuclear membrane. The nucleus contains the chromosomes and therefore controls the structure and the activities/functions of a cell.
- **Protoplasm:** Together the cell membrane, cytoplasm and the nucleus are called the protoplasm.

### Activity 6 Examine cheek cells under a microscope

Work in groups of two or three when doing this activity, but make your own drawings.

1. Your teacher will mount cheek cells on a microscope slide. Examine the cells under a microscope.
2. Make a biologically correct drawing of what you see.
3. Compare the image of the cheek cells with the cell in Figure 15.
4. Discuss in your group how the parts of a cheek cell are suited to their functions.

### The structural differences between plant and animal cells

Plant cells	Animal cells
They have a definite shape.	They have an irregular shape.
The have cell walls.	They have no cell walls.
Some have chloroplasts.	None of them have chloroplasts.
They usually have a large cell vacuole; if there is more than one vacuole, they are usually all big.	They usually have no vacuoles; if present, they are small and numerous.

Structure/ Organelle	Plant cells
Cell wall	Present in mature plant cells.
Cell membrane	Present in plant cells.
Cytoplasm	Present in plant cells.
Chloroplasts	Present in cells found in green parts of plants.

## Summary, revision and assessment continued

Structure/ Organelle	Plant cells	Animal cells	Function
Vacuole	Single, large vacuoles are present in plant cells.	Usually absent in animal cells. If present they are small and numerous.	Storage of water and mineral salts. Assists in water movement in and through plant cells. Provides support.
Nucleus	Present in all plant cells.	Present in all animal cells.	Controls the activities in cells, including cell division. Contains hereditary information.

### Plant growth and nutrients

- The region of plant growth is just behind the stem and root tips.
- This increase in length is caused by new cells forming and elongating.
- Organisms respond to stimuli in their environments.
- The reaction that each stimulus produces is known as a response.
- Plants respond to a stimulus by growing towards or away from the direction of a stimulus.
- This type of growth movement is known as a tropic movement.
- If plants grow towards the stimulus, it is a positive tropic response or movement.
- If plants grow away from the stimulus, it is a negative tropic response or movement.
- Light, gravity and water are three stimuli that produce a tropic response in plants.
- Plants need the correct kinds of nutrients in the correct amounts for good growth.
- All plant nutrients are absorbed from the soil in which the plants grow.
- Plants that grow on nutrient-poor soils grow poorly and are unhealthy.
- Plants absorb nutrients through their root hairs near their root tips.
- The process by which the water moves into the root hairs is known as osmosis.
- The process by which the mineral salts moves into the root hairs is known as diffusion.
- Absorbed water and dissolved mineral salts are carried from the roots, up through the stem and into the branches, leaves and flowers of the plant.
- The upward movement of the water occurs in the vascular bundles (in xylem cells).
- This movement of water is mainly due to transpiration.

- To maximise the amount of growth, plants need the correct types and amounts of nutrients. This is done by adding fertilisers to the soil.
- Fertilisers are natural or synthetic substances that contain nutrients that are essential for plant growth.
- Examples of fertilisers include nitrogen, phosphorus and potassium.
- Organic and inorganic fertilisers are used to fertilise soil with plant matter and manure.
- Inorganic fertilisers are usually more expensive than organic fertilisers.
- Soil can also be improved by adding organic matter.
- Inorganic fertilisers can be washed away by rain, which can pollute waterways.
- Too much fertiliser can be harmful to plants and the environment.
- Some disadvantages of fertilisers include leaching, which makes the soil acidic; destruction of soil micro-organisms and groundwater pollution.

### Revision exercises

1. Choose an item from the following list. Write only the number.

a The response of a plant to a stimulus  
b A source of the nutrients in soil  
c A deficiency of this nutrient  
d A deficiency of that nutrient  
e A source of the nutrient  
f The response of a plant to a stimulus  
g A deficiency of this nutrient  
h A source of the nutrient

2. Various options are given below. Turn to the next page. Choose the correct option and write the number next to the question.

- To maximise the amount of food produced by crops, farmers ensure that the correct types and amounts of nutrients are in the soil. This is achieved by adding fertilisers to the soil.
- Fertilisers are natural or artificial materials that are added to soil to supply plant nutrients that are essential for the growth of plants.
- Examples of fertilisers are manure and chemical compounds containing nitrogen, phosphorus and potassium.
- Organic and inorganic fertilisers improve the nutrient content of soil.
- Organic fertilisers are dead, decaying substances, such as plant and animal matter and manure.
- Inorganic fertilisers are also known as chemical fertilisers or artificial fertilisers.
- Soil can also be improved by practising mixed farming and/or crop rotation.
- Inorganic fertilisers can affect the soil in ways that can harm the plants.
- Too much fertiliser wastes money, causes plant damage and environmental harm.
- Some disadvantages of using too much inorganic fertiliser are: burning; making the soil acidic; destruction of soil micro-organisms; soil compaction; groundwater pollution.

## Revision exercises

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

	Column A		Column B
a)	The response of a plant part to water	i)	Phototropism
b)	A source of the nutrient potassium (K) for plants	ii)	Carbon dioxide
c)	A deficiency of this element causes yellowing in leaves	iii)	Phosphorus
d)	A deficiency of this element causes leaf fall in plants	iv)	Hydrotropism
e)	A source of the nutrient carbon (C) for plants	v)	Compost
f)	The response of a plant part to light	vi)	Nitrogen
g)	A deficiency of this element causes reduced plant growth	vii)	Iron
h)	A source of the nutrient magnesium (Mg) for plants	viii)	Manure
i)		ix)	Hydrogen
j)		x)	Sodium

[16]

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

## Summary, revision and assessment continued

a) Give the term used to describe an organism that consists of one cell only.

- i) Multicellular
- ii) Monocellular
- iii) Unicellular
- iv) Microcellular

b) Name the instrument that is used to look at individual cells.

- i) Telescope
- ii) Microscope
- iii) Megascope
- iv) Oscilloscope

c) Name the thin sheet of glass that is placed on top of the specimen when mounting a microscope slide.

- i) Lid
- ii) Leg slip
- iii) Coverslip
- iv) Covering

d) Name a substance used as a mounting liquid in preparing a microscope slide of onion epidermal cells.

- i) Salt solution
- ii) Sugar solution
- iii) Glucose solution
- iv) Iodine solution

e) Give the term for describing the fact that a plant cell contains the maximum amount of water possible.

- i) Turbid
- ii) Turgid
- iii) Turgor
- iv) Turbor

f) Give the collective term for describing all the small structures that occur inside a cell.

- i) Organs
- ii) Micro-organs
- iii) Mega-organs
- iv) Organelles

g) Give the collective term for describing the cell membrane, nucleus and cytoplasm of a cell.

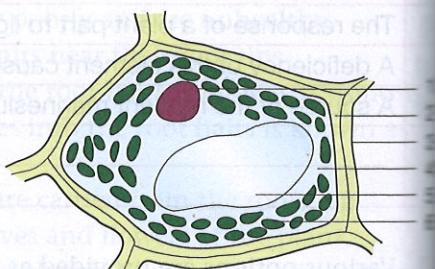
- i) Hyaloplasm
- ii) Nucleoplasm
- iii) Microplasm
- iv) Protoplasm

7 × 2 = (14)  
**Total for Revision exercises [30]**

## Assessment exercises

1. Study the diagram of a cell and answer the questions.
  - a) State whether this is a plant or an animal cell. Explain your answer. (3)
  - b) Name the parts labelled 1–6. (6)
  - c) Name one function of each labelled part. (6)

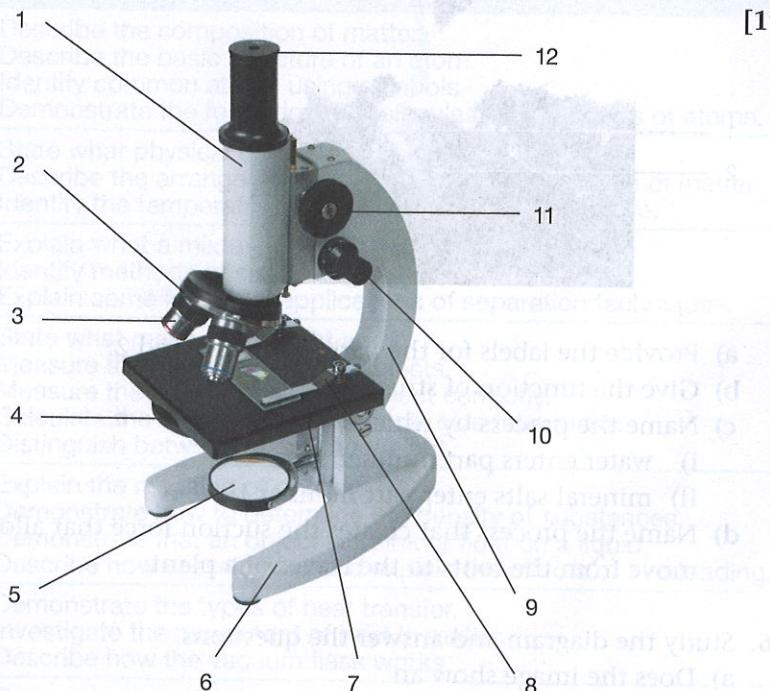
[15]



2. Study the picture below and answer the questions.

- Name the apparatus shown in the picture. (2)
- Name the parts labelled 1–12. (12)
- State the functions of parts labelled 3, 4, 5, 11 and 12. (5)

[19]



3. Compare the differences between plant and animal cells. Write your answer in a table.

4. Study the photograph and answer the questions.

- Name the generalised type of plant growth movement shown in the photograph. (1)
- Name the specific plant growth movement shown. (1)
- Name the stimulus to which the stem is responding. (1)
- Is the reaction shown in the photograph a positive or negative response? (1)
- Explain why you gave your answer to question 4d. (1)

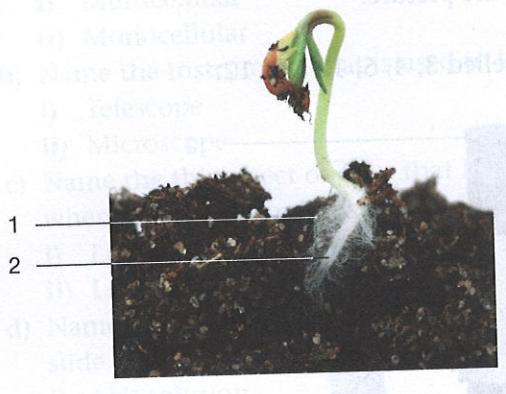
[5]



## Summary, revision and assessment continued

5. Study the diagram below and then answer the questions that follow.

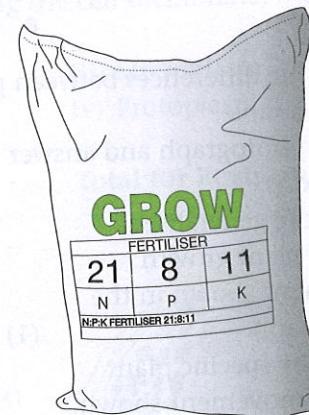
(S) a) Multicellular  
(S) b) Monocellular  
(S) c) Name the first cell seen in the picture  
(S) d) Name the microscope used to view the cell  
(S) e) Name the specimen viewed in the microscope  
(S) f) Name the part of the specimen viewed in the microscope  
(S) g) Name the part of the specimen viewed in the microscope  
(S) h) Name the part of the specimen viewed in the microscope  
(S) i) Name the part of the specimen viewed in the microscope  
(S) j) Name the part of the specimen viewed in the microscope  
(S) k) Name the part of the specimen viewed in the microscope  
(S) l) Name the part of the specimen viewed in the microscope  
(S) m) Name the part of the specimen viewed in the microscope  
(S) n) Name the part of the specimen viewed in the microscope  
(S) o) Name the part of the specimen viewed in the microscope  
(S) p) Name the part of the specimen viewed in the microscope  
(S) q) Name the part of the specimen viewed in the microscope  
(S) r) Name the part of the specimen viewed in the microscope  
(S) s) Name the part of the specimen viewed in the microscope  
(S) t) Name the part of the specimen viewed in the microscope  
(S) u) Name the part of the specimen viewed in the microscope  
(S) v) Name the part of the specimen viewed in the microscope  
(S) w) Name the part of the specimen viewed in the microscope  
(S) x) Name the part of the specimen viewed in the microscope  
(S) y) Name the part of the specimen viewed in the microscope  
(S) z) Name the part of the specimen viewed in the microscope



a) Provide the labels for the parts labelled 1 and 2. (2)  
 b) Give the function of structure 1. (1)  
 c) Name the process by which:  
 i) water enters part number 1 (2)  
 ii) mineral salts enter part number 1. (2)  
 d) Name the process that creates the suction force that allows water to move from the roots to the leaves of a plant. (1)

6. Study the diagram and answer the questions.

a) Does the image show an organic or inorganic fertiliser? (1)  
 b) Give a reason for your answer to question 6a. (1)  
 c) Name the nutrients that are present in the fertiliser. Explain how you know they are present. (4)  
 d) Give one advantage of using this type of fertiliser. (1)



**TOTAL MARKS FOR ASSESSMENT EXERCISES: 60**

Sub-topics	•
Composition of matter	•
Physical change of state	•
Mixtures	•
Mass and weight	•
Density	•
Heat transfer	•
Heat and expansion of substances	•
Reflection and refraction of light	•
Composition of air	•

### Starter activity

Collect items and occur. Draw a table

**Solid**

# TOPIC 5

## Materials and energy



Sub-topics	Specific Outcomes
Composition of matter	<ul style="list-style-type: none"> <li>Describe the composition of matter.</li> <li>Describe the basic structure of an atom.</li> <li>Identify common atoms using symbols.</li> <li>Demonstrate the formation of molecules using models of atoms.</li> </ul>
Physical change of state	<ul style="list-style-type: none"> <li>State what physical change is.</li> <li>Describe the arrangement of atoms in the three states of matter.</li> <li>Identify the temperatures at which water changes state.</li> </ul>
Mixtures	<ul style="list-style-type: none"> <li>Explain what a mixture is and identify different types.</li> <li>Identify methods of separating mixtures.</li> <li>Explain some industrial applications of separation techniques.</li> </ul>
Mass and weight	<ul style="list-style-type: none"> <li>State what mass and weight are.</li> <li>Measure the mass of different objects.</li> <li>Measure the weight of a given object correctly.</li> <li>Calculate the weight of a substance, given the mass.</li> <li>Distinguish between mass and weight.</li> </ul>
Density	<ul style="list-style-type: none"> <li>Explain the meaning of density.</li> <li>Demonstrate how to determine the density of substances.</li> <li>Demonstrate that an object will sink or float on a liquid.</li> <li>Describe how vessels float and explain the effects of overloading.</li> </ul>
Heat transfer	<ul style="list-style-type: none"> <li>Demonstrate the types of heat transfer.</li> <li>Investigate the movement of heat in matter.</li> <li>Describe how the vacuum flask works.</li> </ul>
Heat and expansion of substances	<ul style="list-style-type: none"> <li>Demonstrate expansion of substances.</li> <li>Describe the use of expansion of substances in everyday life.</li> <li>Explain the effect of expansion and contraction of substances.</li> </ul>
Reflection and refraction of light	<ul style="list-style-type: none"> <li>Describe what reflection is.</li> <li>Investigate the characteristics of reflection of light on a mirror.</li> <li>Describe what refraction is.</li> <li>Identify the real and apparent depths of an object under water.</li> <li>Explain the application of reflection and refraction.</li> </ul>
Composition of air	<ul style="list-style-type: none"> <li>Identify the components of air.</li> <li>Investigate the proportion of each substance in air.</li> <li>Describe the nature of each substance in air.</li> <li>Describe the uses of each substance in air.</li> </ul>

### Starter activity

Collect items and sort them according to the state of matter in which they occur. Draw a table and record their examples.

Solid	Liquid	Gas

## The composition of matter

All materials are made of matter.

Matter occupies space and has mass.

Matter is made of tiny particles called **atoms**. Atoms are the basic building blocks of matter.

Some substances consist of one type of atom. These substances are known as **elements**. In nature, most atoms do not occur separately, but are joined chemically to one or more other atoms. The joined atoms are called a **molecule**.

If the two atoms that form a molecule are of the same element, they form a diatomic molecule. Oxygen ( $O_2$ ); hydrogen ( $H_2$ ); chlorine ( $Cl_2$ ) and nitrogen ( $N_2$ ) are diatomic molecules.

If a molecule consists of two or more atoms of different elements, it forms a **chemical compound**. Water ( $H_2O$ ) and carbon dioxide ( $CO_2$ ) are compounds.

Most elements do not occur as pure elements in nature, but as part of the millions of different compounds that exist on earth.

Atoms are too small to be seen with the naked eye or a light microscope. At first, scientists investigated the composition of matter using experiments and observation. Now electron microscopes enable us to create images of atoms.

Experiments have shown that most of an atom is empty space. In this space there are smaller particles known as subatomic particles. The three basic subatomic particles are protons, neutrons and electrons.

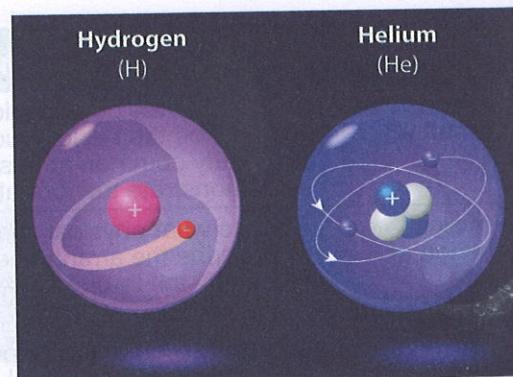


Figure 1 The two simplest atoms, hydrogen and helium

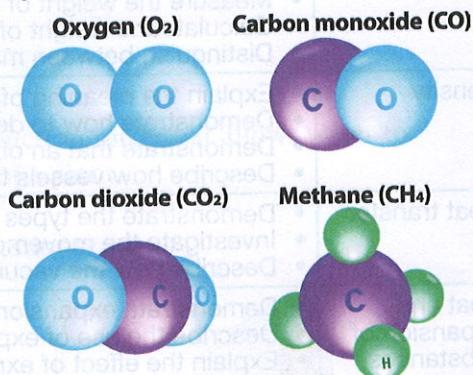


Figure 2 Models that represent some of the molecules that occur in nature

### New words

**atom**: the smallest unit of matter or a substance

**element**: a substance made of one type of atom

**molecule**: a chemical combination of two or more atoms; the smallest unit of a compound

**compound**: a substance made of more than one type of atoms

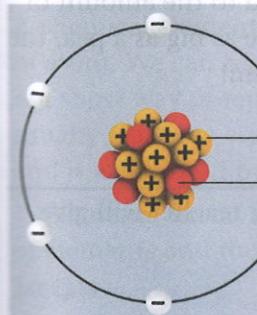


Figure 3 A diagram of electrons, protons and an atom

The centre of an atom is the nucleus. A nucleus is tiny but makes up 99.9%

A nucleus contains subatomic particles. Protons are positively charged. An element has a special number of the element's particles with no electrons. A neutron has a slight

Atoms contain other called electrons. They are negatively charged. They move in orbits (levels) around the nucleus. A certain number of electrons

- The first shell or orbital can hold two electrons.
- The second shell or orbital can hold eight electrons.
- The third shell or orbital can hold eighteen electrons.
- The fourth shell or orbital can hold thirty two electrons.

Figure 4 shows this

electrons in a simple

## The basic structure of an atom

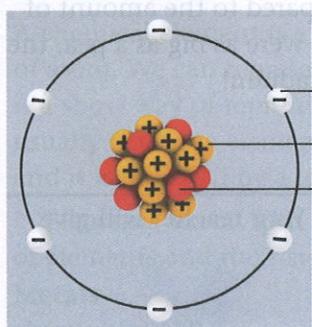


Figure 3 A diagram showing the electrons, protons and neutrons in an atom

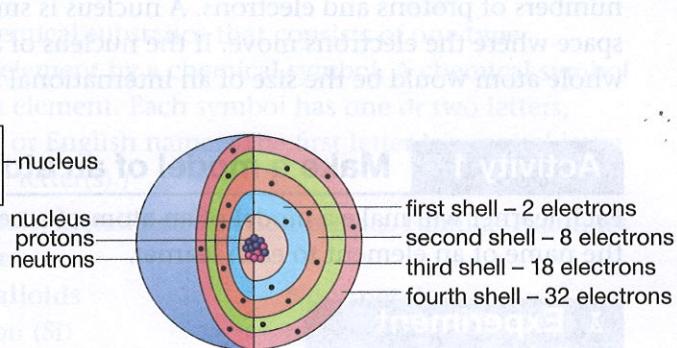


Figure 4 A diagram showing the electron shells with electrons around the nucleus; the protons and neutrons form the nucleus in the centre

The centre of an atom is called its **nucleus**. A nucleus is more than a hundred thousand times smaller than its atom, but makes up 99.9% of the mass of the atom.

A nucleus contains two different kinds of subatomic particles held together by atomic forces. Protons are positively charged particles. Each element has a special number of protons in its nucleus. This number is known as the atomic number of the element. Neutrons are neutral particles with no electric charge. The protons and neutrons of an atom are almost equal in mass, but a neutron has a slightly greater mass than a proton.

Atoms contain other subatomic particles called **electrons**. They are negatively charged. They move fast in **shells (energy levels)** around the nucleus. Each level holds a certain number of electrons.

- The first shell or energy level can hold two electrons.
- The second shell or energy level can hold eight electrons.
- The third shell or energy level three can hold eighteen electrons.
- The fourth shell or energy level four can hold thirty two electrons.

Figure 4 shows this arrangement of electrons in a simple way.

### New words

**nucleus:** the small central part of an atom composed of protons and neutrons; makes up most of an atom's mass

**force:** something that changes the way an object moves, such as a push or a pull

**electron:** one of the small particles that make up an atom; a negatively charged particle

**shell (energy level):** areas around the nucleus of an atom where electrons with energy may be found

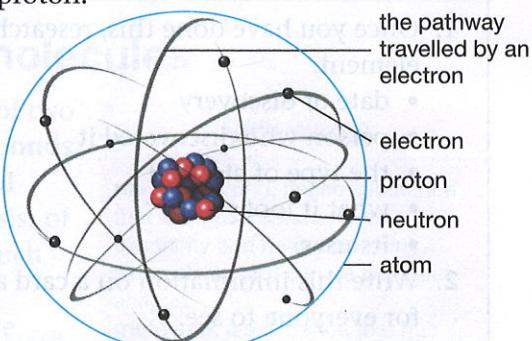


Figure 5 A model of an atom showing the protons and neutrons within the nucleus and electron shell or energy levels. The blue circle shows the size of the atom; this helps us to see how big the empty space is.

Although an atom consists of charged particles, it is neutral because it has equal numbers of protons and electrons. A nucleus is small compared to the amount of space where the electrons move. If the nucleus of an atom were as big as a pea, the whole atom would be the size of an international soccer stadium!

### Activity 1 Make a model of an atom

Each learner will make a model of an atom of an element. Your teacher will give the name of an element to each learner.



#### Experiment

##### Materials

- paper plate
- glue
- compass
- dried lentils
- dried peas
- marker pen

##### Method

1. Using the compass, draw five **concentric** circles on the paper plate. The first circle represents the nucleus. The other four circles represent the first, second, third and fourth electron shells.
2. Draw a large plus sign on half of the dried beans. These represent the protons.
3. The unmarked beans represent the neutrons. The dried lentils, which are smaller, are the electrons.
4. For the element your teacher gave you, glue the correct number of protons and neutrons onto the plate. Your teacher will give you this number.
5. Now glue the correct number of electrons onto the plate in the correct electron shells.
6. Display your models in the classroom for everyone to see.

##### Enrichment

1. Once you have done this, research the following information about your element:
  - date of discovery
  - person who discovered it
  - the type of element
  - what it looks like
  - its uses.
2. Write this information on a card and attach it to your model of the element for everyone to see.

#### New word

**concentric:** circles with the same centre

### Elements and

A chemical element is a substance made of one type of atom. We can represent an element by its symbol. This is a short way of representing an element. It is usually taken from the element's name and it is followed by a superscript.

Elements are divided into two main groups: **metals** and **non-metals**.

metals: aluminium (Al), iron (Fe), copper (Cu), gold (Au), mercury (Hg), lead (Pb), sodium (Na)

### Activity 2

1. Explain why atoms are neutral.
2. Name the subatomic particles.
3. Name the subatomic particles.
4. What role does each subatomic particle play in an atom?
5. How many electrons are in each shell?
  - a) the first shell
  - b) the second shell
6. Name the three main parts of an atom.

### The formation of molecules

A molecule is an element or more atoms held together. It can consist of atoms of the same element, such as oxygen, or atoms of more than one type of element, such as carbon dioxide (CO<sub>2</sub>).

Figures 6–10 show how molecules are formed from atoms. Figure 6 shows you a simple molecule. Figure 7 shows you a simple molecule. Figure 8 shows you a simple molecule. Figure 9 shows you a simple molecule. Figure 10 shows you a simple molecule.

## Elements and their symbols

A chemical element is a pure chemical substance that consists of one type of atom. We can represent each element by a chemical symbol. A chemical symbol is a short way of representing an element. Each symbol has one or two letters, usually from the element's Latin or English name. (The first letter is a capital letter and it is followed by a lower case letter(s).)

Elements are divided into metals, metalloids and non-metals. Familiar examples of elements and their symbols are:

### Metals

aluminium (Al)  
iron (Fe)  
copper (Cu)  
gold (Au)  
mercury (Hg)  
lead (Pb)  
sodium (Na)

### Metalloids

silicon (Si)  
arsenic (As)

### Non-metals

carbon (C)  
oxygen (O)  
hydrogen (H)  
nitrogen (N)  
chlorine (Cl)

### Activity 2 Test yourself on atoms

1. Explain why atoms have no charge.
2. Name the subatomic particle that gives an element its identity.
3. Name the subatomic particle that has no electric charge.
4. What role does the neutron play in the atom?
5. How many electrons occur in each of the following:
  - a) the first shell
  - b) the second shell
  - c) the third shell
  - d) the fourth shell?
6. Name the three main groups into which we can divide the elements.

## The formation of simple molecules

A molecule is an electrically neutral group of two or more atoms held together by **chemical bonds**. It can consist of atoms of the same chemical element, such as oxygen ( $O_2$ ), or it can consist of more than one type of chemical element, such as carbon dioxide ( $CO_2$ ).

Figures 6–10 show you how molecules are formed from atoms. In each figure, the A diagram shows you a simple model. The numbers in a molecular formula tell you number of atoms of the elements in a compound.

### New words

**metal:** a strong, dense substance that is a good conductor of electricity and heat; also shiny when clean, and can be bent and shaped

**metalloid:** a substance that has some properties of metals

**non-metal:** a chemical element that has no metallic properties

**chemical bond:** the pull that joins two atoms

For example,  $\text{H}_2\text{O}$  is the molecular formula for water. The symbols H and O indicate that water is made from hydrogen and oxygen. The  $_2$  tells you that there are two atoms of hydrogen. There is no number to the right of the O, so there is only one atom of oxygen. Therefore, the smallest unit of the compound water is the molecule  $\text{H}_2\text{O}$ .

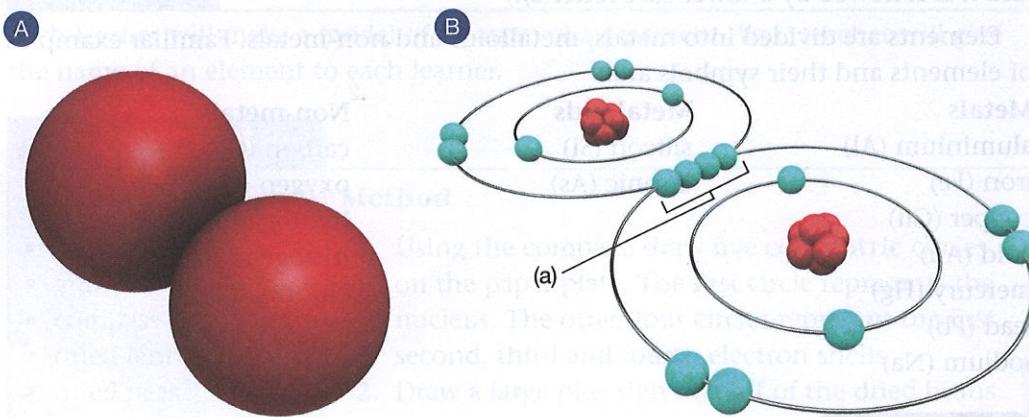


Figure 6 A: An oxygen molecule is represented by two identical spheres joined together. B: An oxygen molecule is represented by the nucleus and energy levels with electrons for both atoms. The four blue balls at (a) represent the four shared electrons that join the two oxygen atoms.

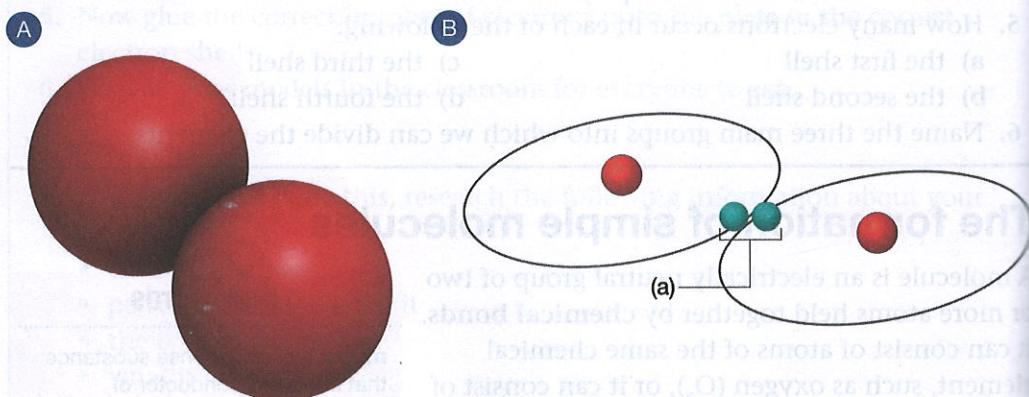


Figure 7 A: A hydrogen molecule is represented by two identical spheres joined together. B: A hydrogen molecule is represented by the nucleus and energy levels with electrons for both atoms. The two blue balls at (a) represent the two shared electrons that join the two hydrogen atoms.



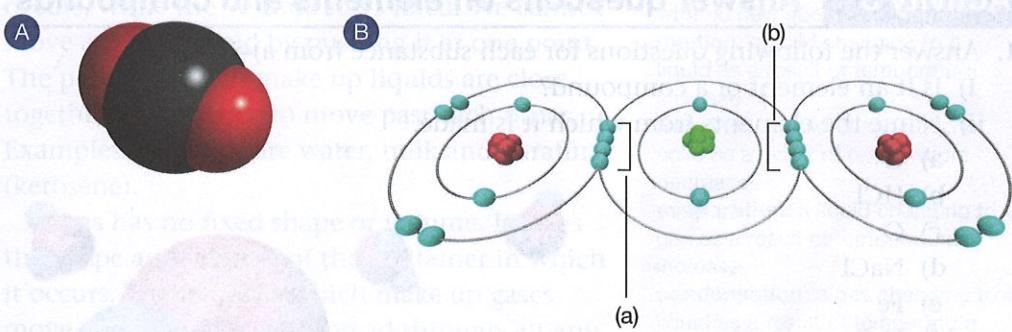
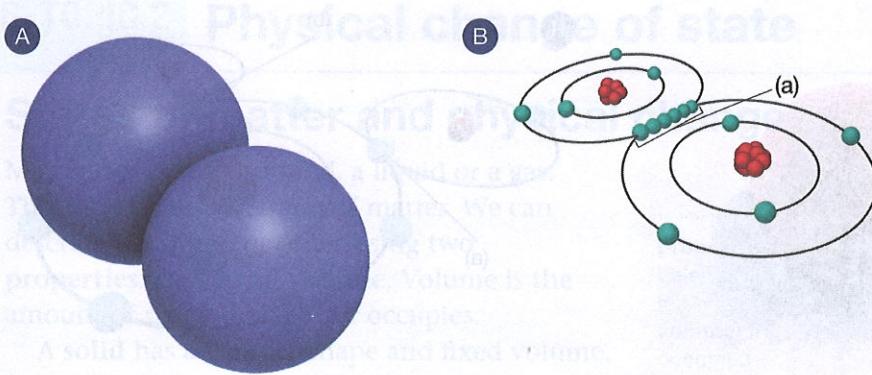
Figure 8 A: A nitrogen molecule is represented by two identical spheres joined together. B: A nitrogen molecule is represented by the nucleus and energy levels with electrons for both atoms. The four blue balls at (a) represent the four shared electrons that join the two nitrogen atoms.



Figure 9 A: A carbon dioxide molecule is represented by one black sphere representing a carbon atom and two red spheres representing oxygen atoms. B: A carbon dioxide molecule is represented by the nucleus and energy levels with electrons for both atoms. The four blue balls at (a) represent the four shared electrons that join the carbon atom to each oxygen atom.

$\text{H}_2\text{O}$  is called the molecular formula for water. This molecule shows the number of atoms in one molecule. There are two molecules of water to the left of the molecular formula.

- $\text{H}_2\text{O}$  shows one molecule consisting of one hydrogen atom and one oxygen atom.
- $2\text{H}_2\text{O}$  shows two molecules of water, each consisting of two hydrogen atoms and one oxygen atom.
- In this example, there are two molecules of water, each consisting of two hydrogen atoms and one oxygen atom.



$\text{H}_2\text{O}$  is called the molecular formula for water. The **molecular formula** of a molecule shows the number, ratio and type of atoms that make up a molecule. If more than one molecule of water is needed for a reaction, we write a number to the left of the molecular formula for a molecule. For example:

- $\text{H}_2\text{O}$  shows one molecule of water consisting of two hydrogen atoms and one oxygen atom.
- $2\text{H}_2\text{O}$  shows two molecules of water, each consisting of two hydrogen atoms and one oxygen atom.
- In this example, there are a total of four hydrogen atoms and two oxygen atoms.

### New words

**molecular formula:** short way of writing the name of a molecule showing the number, ratio and type of atoms

## States of matter

Matter can occur as a solid, liquid or a gas. These are called the states of matter. They describe the different states of matter in terms of the properties: shape and volume, and the amount of space that matter occupies.

A **solid** has a definite shape and volume. Its particles are closely packed together. When we push a solid at one end, the whole solid moves. Examples of solids are metal and rock.

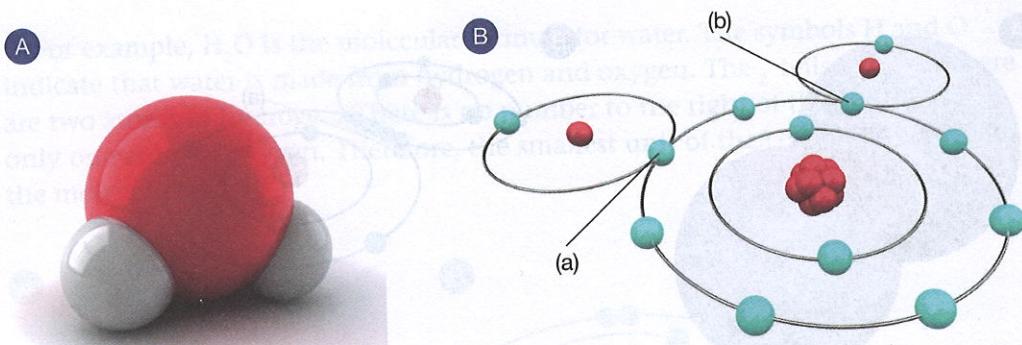
A **liquid** does not have a definite shape, but it takes on the shape of the container in which it occurs, while the volume remains constant. We move a whole liquid by pouring it. The particles which make up a liquid are close together, but are free to move about. Examples of liquids are water, oil and kerosene.

A **gas** has no fixed shape or volume. It takes on the shape and volume of the container in which it occurs. The particles which make up a gas are free to move about quickly and fill the space they enter. Examples of gases are oxygen, carbon dioxide and nitrogen.

When heated, some substances undergo permanent change. A change of state is a change of place to form a new substance. Examples of chemical changes are: burning, rusting, and decaying substances.

In a **physical change**, a new substance is not formed. An example of a physical change is matter changing its state from solid to liquid or liquid to gas. These changes occur as a result of changes in temperature and/or pressure. Temperature remains constant during a physical change. There is a change of state, but no new substance is formed.

- The change from solid to liquid
- The change from liquid to gas



**Figure 10** A: A water molecule is represented by two identical white spheres representing hydrogen that are joined by a red sphere representing oxygen. B: A water molecule is represented by the nucleus and energy levels with electrons for both atoms. The blue ball at (a) and (b) represent the two shared electrons that join the two hydrogen atoms to the oxygen atom.

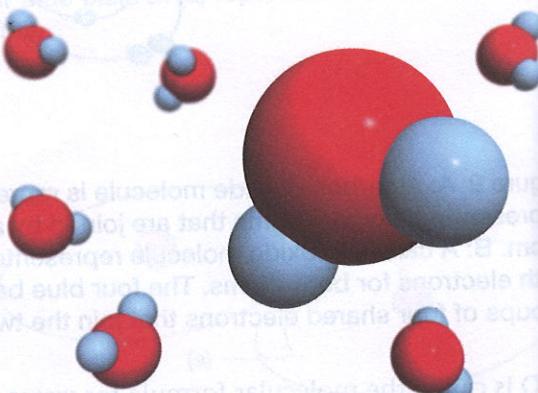
### Activity 3 Answer questions on elements and compounds

1. Answer the following questions for each substance from a)-i).

- Is it an element or a compound?
- Name the elements from which it is made.
- C
- HCl
- O<sub>2</sub>
- NaCl
- Fe
- H<sub>2</sub>O
- CH<sub>4</sub>
- CO<sub>2</sub>
- N<sub>2</sub>

2. Give the symbol or chemical formula for each substance:

- sodium
- carbon monoxide
- hydrogen
- aluminium
- carbon dioxide
- water.



**Figure 11** A diagram showing seven water molecules: We write the number of water molecules as  $7\text{H}_2\text{O}$  in a molecular formula.

## SUB-TOPIC 2 Physical change of state

## States of matter and physical change

Matter can occur as a solid, a liquid or a gas. These are called the states of matter. We can describe the different states using two **properties**: shape and **volume**. Volume is the amount of space that matter occupies.

A **solid** has a definite shape and fixed volume. Its particles are closely packed in a clear pattern. When we push a solid at one point, the whole solid moves. Examples of solids are wood, clay and rock.

A **liquid** does not have a specific shape. It takes on the shape of the container in which it occurs, while the volume stays fixed. We cannot move a whole liquid by pushing it at one point. The particles which make up liquids are close together, but are free to move past each other. Examples of liquids are water, milk and paraffin (kerosene).

A **gas** has no fixed shape or volume. It takes the shape and volume of the container in which it occurs. The particles which make up gases move about quickly and spread throughout any space they enter. Examples of gases are oxygen, carbon dioxide and nitrogen.

When heated, some substances undergo a permanent change. A chemical change takes place to form a new substance. Examples of chemical changes are: burning wood, rusting and decaying substances.

In a **physical change**, no new substance is formed. An example of physical change is matter changing from one state to another. These changes occur as a result of changes in temperature and/or pressure.

Temperature remains constant when there is a change of state of a substance.

- The change from solid to liquid is called **melting**.
- The change from liquid to solid is called **freezing**.

## New words

**property**: characteristics that belong to something that identifies it

**volume**: the amount of space occupied

**solid**: a substance with a definite shape, but a fixed volume

**liquid**: a substance with no definite shape or volume

**gas**: a substance with no definite shape or volume

**physical change**: the change of matter from one phase to another with no new substance forming

**melting**: a solid changing to a liquid as a result of temperature increase

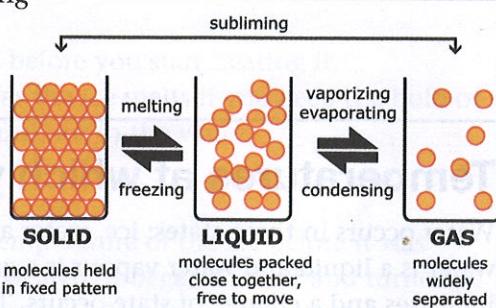
**freezing**: a liquid changing to a solid as a result of temperature decrease

**evaporation**: a liquid changing to a gas as a result of temperature increase

**condensation**: a gas changing to a liquid as a result of temperature decrease

**sublimation**: a solid changing to a gas as a result of temperature increase

**deposition**: a gas changing to a solid as a result of temperature decrease



- The change from liquid to gas is called **evaporation**. The change from gas to liquid is called **condensation**.
- The change from solid to gas is called **sublimation**.
- The change from gas to solid is called **deposition**.

## Behaviour of atoms in the three states of matter

The arrangement of atoms in the three states of matter

	Solid	Liquid	Gas
Arrangement of atoms	Very close together	Close together	Far apart
	Regular pattern	Random	Random
Movement of atoms	Vibrate on the spot	Move around each other	Move quickly in all directions
	Cannot move from place to place	Can move from place to place within limits	Can move freely in all directions

### Activity 4 Revise the states of matter

- Name three states of matter. For each, give an example and list their properties.
- Define these terms:
  - condensation
  - sublimation.
- Study Figure 13.
  - Name the process marked:
    - A
    - E
    - D

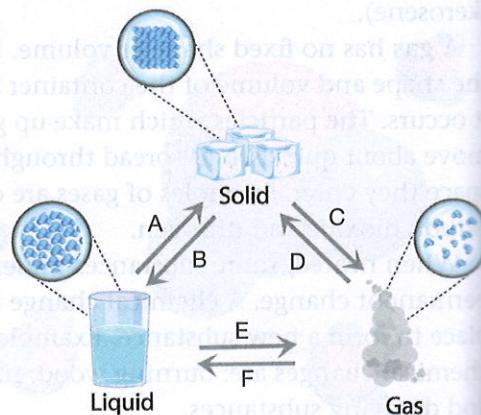


Figure 13 The three states of matter

## Temperatures at which water changes state

Water occurs in three states: ice, water and water vapour (steam). Ice is a solid, water is a liquid and water vapour is a gas. When ice is heated, its temperature increases and a change of state occurs. The ice changes into water. During this change, a solid changes into a liquid; this is called melting. As the heating

continues, the temperature of the water rises. The water is heated from the top of the liquid. (Water vapour is heated from the bottom of the liquid.) Water vapour condenses into water droplets. This is called condensation. Condensation is the opposite of evaporation.

### Activity 5 Observe the melting point of ice

Work in groups of four or five when doing this activity. You will heat ice and make observations.

**Aim:** determine the melting point of ice

### Experiment

#### Materials

- source of heat, for example, Bunsen burner
- beaker
- tripod
- ice
- thermometer
- gauze

#### Observations/Results

The temperature of the ice is measured. The temperature should remain constant until the thermometer reaches the melting point of ice. The temperature of the ice is measured again. The temperature should remain constant until the thermometer reaches the melting point of ice.

#### Explanation of observations

Water freezes at  $0^{\circ}\text{C}$  to become ice. When ice is heated, its temperature increases. The temperature of the ice is measured. The temperature should remain constant until the thermometer reaches the melting point of ice. The temperature of the ice is measured again. The temperature should remain constant until the thermometer reaches the melting point of ice.

continues, the temperature of the water rises and water vapour escapes from the top of the liquid. (Water vapour is invisible – steam is when the water vapour condenses into water droplets and become visible.) A liquid changing into a gas is called evaporation.

### Activity 5 Observe what happens when ice is heated

Work in groups of four or five when doing this activity. You will heat ice and make observations.

**Aim:** determine the melting point of ice

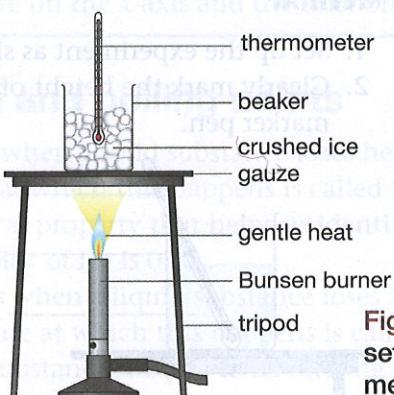


Figure 14 The experimental set-up for determining the melting point of ice

#### Experiment

##### Materials

- source of heat, for example, Bunsen burner
- beaker
- tripod
- ice
- thermometer
- gauze

##### Method

1. Set up the experiment as shown in Figure 14.
2. Before heating the ice, allow the thermometer to remain in the ice for 2–3 minutes until the temperature reading stays constant.
3. Record this reading as the start/initial reading.
4. Now gently heat the ice in the beaker.
5. Record the temperature and the condition of the contents of the beaker every 30 seconds, until all the ice has disappeared.

##### Observations/Results

The temperature of the ice should be  $0\text{ }^{\circ}\text{C}$  before you start heating it. The temperature should remain constant as the ice melts if you keep the bulb of the thermometer between the ice blocks and not in the water.

##### Explanation of observations/results

Water freezes at  $0\text{ }^{\circ}\text{C}$  to become ice. The temperature of the ice before it was heated is therefore  $0\text{ }^{\circ}\text{C}$ . Once the ice was heated, it began to melt and turned into water, but the temperature remained at  $0\text{ }^{\circ}\text{C}$ . The heat did not cause the temperature to rise, but broke the bonds forming the ice crystals. So, we can say that ice melts at  $0\text{ }^{\circ}\text{C}$ .

## Activity 6 Observe what happens when water is heated

Work in groups of four or five when doing this activity. You will heat water and make observations. **Aim:** to determine the boiling point of water. (Note: the boiling point of water will differ depending on the height above sea level.)

### Experiment

#### Materials

- source of heat, for example, Bunsen burner
- tripod
- tap water
- thermometer
- gauze

#### Method

1. Set up the experiment as shown in Figure 15.
2. Clearly mark the height of the water level with a marker pen.

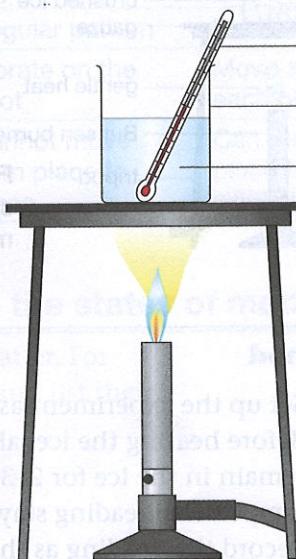


Figure 15 The experimental set-up for observing the boiling point of water

3. Before heating the water, keep the thermometer in the water for 2–3 minutes until the temperature reading stays constant.
4. Record this reading as the start/initial reading.
5. Now gently heat the beaker of water.
6. Record the temperature of the water every 30 seconds until it starts to boil.
7. Continue heating and taking temperature readings for the next five minutes.
8. After five minutes, mark the height of the water level using a marker pen.

#### Observations/Results

As the water is heated, the temperature increases until the water starts to boil. Once the water is boiling fast, the temperature remains at 100 °C (at sea level – it may differ where you are).

The water level in the beaker rises when the water is heated.

## Activity 7

1. Make one table to show the temperature of the water vapour.
2. Draw a line graph to show how the temperature has changed during the experiment.

## Melting, freezing and condensation

**Melting:** Melting occurs when a solid becomes a liquid. The temperature at which a solid melts is called its melting point. For example, the melting point of ice is 0 °C.

**Freezing:** Freezing occurs when a liquid becomes a solid. The temperature at which a liquid freezes is called its freezing point. For example, the freezing point of water is 0 °C and water freezes at 0 °C.

**Boiling:** When a liquid boils, it changes from a liquid to a gas by evaporation. Once the temperature of a liquid reaches its boiling point, it continues to boil. The boiling point of water is 100 °C.

**Condensation:** When a gas cools down, it changes back into a liquid. This process is called condensation. The temperature at which a gas condenses is called its condensation point. The condensation point of water is equal to its freezing point, 0 °C. Therefore, water boils at 100 °C and condenses at 0 °C.

## Activity 8

1. State the difference between:
  - freezing and melting
  - boiling and condensation
2. Define the following:
  - freezing point
  - melting point
  - boiling point
  - condensation point

## Activity 7 Draw a graph

1. Make one table to record your results for Activities 5 and 6. The table will show the temperature change from ice to water and from water to water vapour.
2. Draw a line graph of the temperature change to show how the temperature changed during the change from ice to water to water vapour. Remember to place the temperature on the  $x$ -axis and the time on the  $y$ -axis of the graph.

## Melting, freezing and boiling points

**Melting:** Melting occurs when a solid substance loses heat energy and changes to a liquid. The temperature at which this happens is called the **melting point**. Melting point is a physical property that helps us identify a substance. For example, the melting point of ice is  $0\text{ }^{\circ}\text{C}$ .

**Freezing:** Freezing occurs when a liquid substance loses heat energy and changes to a solid. The temperature at which this happens is called the **freezing point**. The freezing point of a substance is equal to its melting point. Therefore, ice melts at  $0\text{ }^{\circ}\text{C}$  and water freezes at  $0\text{ }^{\circ}\text{C}$ .

**Boiling:** When a liquid is heated, it changes into a gas. This process is called evaporation. Once the liquid reaches a certain temperature it starts to boil. The temperature at which this happens is called **boiling point**. The boiling point of water under normal conditions at sea level is  $100\text{ }^{\circ}\text{C}$ .

**Condensation:** When heat is removed from a gaseous substance, it changes into a liquid substance. This process is called condensation. The temperature at which this happens is called **condensation point**. The boiling point of a substance is equal to its condensation point. Therefore, water boils at  $100\text{ }^{\circ}\text{C}$  and water vapour condenses at  $100\text{ }^{\circ}\text{C}$ .

## New words

**melting point:** the temperature at which melting occurs  
**freezing point:** the temperature at which freezing occurs  
**boiling point:** the temperature at which boiling occurs  
**condensation point:** the temperature at which condensation occurs

## Activity 8 Revise the temperatures of phase changes

1. State the difference between:
  - freezing and melting
  - boiling and condensing.
2. Define the following:
  - freezing point
  - melting point
  - boiling point
  - condensation point.

## What are mixtures?

A mixture is a substance which consists of two or more different substances that are not chemically joined. The different substances are not in fixed amounts.

When a mixture is formed, a new substance is not produced. Each substance that forms part of the mixture keeps its own chemical composition and chemical properties. However, certain physical properties of a mixture might differ from those of the substances that form the mixture. The substances in a mixture can usually be separated from each other by physical methods.

## Different types of mixtures

Before you can separate a mixture, you need to know whether it is **homogeneous** or **heterogeneous**.

### Homogeneous mixture

In a homogeneous mixture, the substances mix together uniformly. All parts of the mixture have the same properties. Homogeneous mixtures can form a solution if one substance is a liquid and the other is a solid that can dissolve. Examples are sugar water or sea water, which contains many different salts that are dissolved in water. Air is a homogeneous mixture. It consists of the gases nitrogen, oxygen, carbon dioxide, water vapour and various other gases in small amounts. We can separate its parts by physical methods. Blood is also a homogeneous mixture.

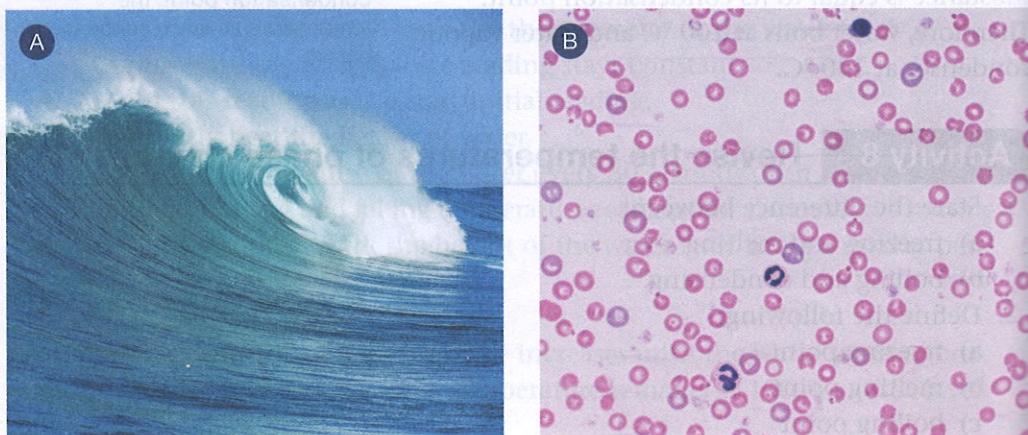


Figure 16 Homogeneous mixtures: A: Sea water; B: Blood

### New words

**mixture:** a substance made of two or more different substances that are not chemically combined

**homogeneous:** uniform; made of parts that are all the same

**heterogeneous:** not uniform; made of different parts

### Heterogeneous

In a **heterogeneous** mixture, the substances do not mix uniformly. The substances are not chemically joined. Some examples of heterogeneous mixtures are salad, sand in water, rocks in soil, and some soups and stews.

### Methods of separation

Some methods of separation are:

- filtration
- distillation
- mechanical/hand sorting
- evaporation

### Filtration

**Filtration** is the process of separating solid particles from liquids using a filter. For example, separating the sand and water.

We can also separate chalk particles from water using filter paper. The water passes through tiny holes in the paper and the chalk particles collect on the paper.

The water purification plants and breweries use filtration to remove solid or **suspended** particles. In water purification, materials are removed by sand and gravel.

### Simple distillation

In **distillation**, a liquid is heated to form a vapour. This vapour is then cooled to form a pure liquid from other parts. The pure liquid is recovered and collected.

Cold water enters a Liebig condenser before coming out. The condenser cools the vapour and the liquid is collected. Industrial water plants use this method.

## Heterogeneous mixture

In a **heterogeneous** mixture, the substances do not mix uniformly. The substances remain separate and different parts of the mixture do not have the same properties. Some examples of heterogeneous mixtures are soil, fruit salad, sand in water, rocks, marble, cork, oil and water, some soups and stews.



Figure 17 Rock is an example of a heterogeneous mixture.

## Methods of separating mixtures

Some methods of separating mixtures are:

- filtration
- distillation
- mechanical/hand sorting
- evaporation
- crystallisation
- fractional distillation
- magnetisation
- decanting.

### Filtration

**Filtration** is the process of separating **insoluble** particles from liquids using filter paper, for example, separating the sand from a mixture of sand and water.

We can also separate chalk particles from water using filter paper. The liquid particles flow through tiny holes in the filter paper and the chalk particles collect on the filter paper.

The water purification systems at water works and breweries use filtration methods to remove solid or **suspended** particles from their liquid parts. In water purification, the suspended materials are removed by passing the liquid through large filter beds made from sand and gravel.

### Simple distillation

In **distillation**, a liquid is boiled to form a vapour, and then condensed back to a liquid. This liquid is collected; it is called the **distillate**. Distillation removes the pure liquid from other particles that may be dissolved in it; the pure liquid is recovered and collected. Distillation is carried out using a Liebig condenser.

Cold water enters a Liebig condenser from its lower part. It moves through the condenser before coming out of its upper part of the outer casing. All suspended matter and dissolved materials remain in the flask when the mixture boils.

Industrial water plants use distillation to produce fresh water (distilled).

### New words

**filtration:** the process of filtering a liquid or gas through a filter to remove solid particles

**insoluble:** cannot dissolve

**suspended:** hanging and not sinking

**distillation:** the evaporation and subsequent condensation of a liquid to obtain a pure liquid from a solution

**distillate:** the liquid from distillation

## Activity 9 Pure water from a copper sulphate solution

Work as a class with your teacher for this activity. You will use distillation to separate pure water from copper sulphate in a copper sulphate solution.

### Caution

- Take care with the source of heat, the glassware and the solutions.
- Tighten the retort stand clamps securely.
- Seal the rubber tubing correctly where it joins onto glassware or taps.

### Experiment

#### Materials

- source of heat, for example, Bunsen burner
- delivery tube flask
- rubber tubing
- tripod
- retort stand
- retort stand clamp
- gauze
- beaker
- Liebig condenser

#### Method

- Set up an experiment as shown in Figure 19.
- Pour the copper sulphate solution into the flask (about 100 cm<sup>3</sup>).
- Heat the flask until the copper sulphate solution boils.
- Ensure that the rubber tubing at A is connected to an open tap. The tap opening must allow a constant flow of water through the Liebig condenser.
- Make sure that the rubber tubing at B allows the water flowing through the Liebig condenser to flow into a sink.

#### Observations/Results

Observe and record what happens as you heat the flask.

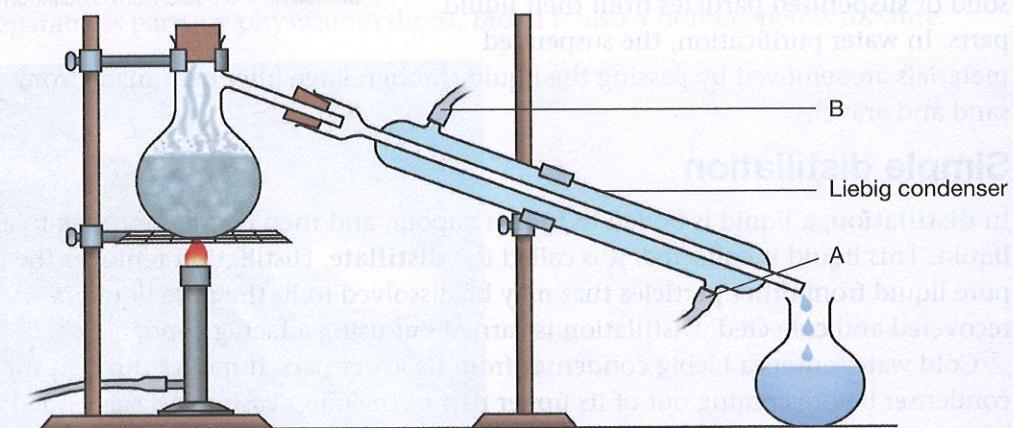


Figure 19 Water is removed from a copper sulphate solution by simple distillation.

## Evaporation

Evaporation is the escape of vapour. A substance is heated. The solution is heated. Se continues, the liquid (w

Collect your own salt solution in a sunny place

Evaporation is used in

## Crystallisation

Crystallisation separates a substance from an impurity. The impurities remain in the solution. Compounds are heated. They separate from the crystals. These crystals are used in crystallisation. Crystallisation separate. When the separate crystals, we can use evap

You can make crystals by winding string around a stick. Hang into the solution for days. Crystals should start to form.

Both evaporation and crystallisation remove liquid. Cool the hot solution to obtain the crystals. Place on filter paper. Crystals that are larger and have a better form quickly.

## Magnetisation

Magnetisation is a separation process that uses the property of magnetism to separate magnetic substances from non-magnetic substances. Magnetisation is used in recycling metals and to separate metals from non-magnetic materials. An electromagnet can separate ferromagnetic metals.

## Evaporation

Evaporation is the escape of molecules from the top of a liquid to form a gas or vapour. A substance is often recovered from the solution. For evaporation to occur, the solution is heated. Sometimes the source of heat is the sun. As the heating continues, the liquid (water) vaporises, leaving the substance behind.

Collect your own salt from a salt water solution. Place a saucer with salt solution in a sunny place for a few days to see what happens.

Evaporation is used in the commercial production of salt.

## Crystallisation

**Crystallisation** separates a pure solid form of a substance from an impure solution in a liquid. The **impurities** remain dissolved in the solution. Compounds or salts break up when heated. They separate from their solution as crystals. These crystals usually contain a little water, called the water of crystallisation. Crystallisation involves heating a solution until the substances separate. When the separated solution cools, it forms crystals. If we do not want crystals, we can use evaporation to separate the substances.

You can make crystals from a strong sugar water solution in a bottle. Tie a piece of string around a stick. Place the stick over the top of the bottle and let the string hang into the solution to the bottom of the bottle. Let the solution stand for a few days. Crystals should start to form on the string.

Both evaporation and crystallisation involve heating a solution to evaporate the liquid. Cool the hot solution slowly by allowing it to stand. Pour off the cooled solution to obtain the crystals. Dry the crystals by pressing them between sheets of filter paper. Crystals that form slowly are larger and have a better shape than those that form quickly.

## Magnetisation

**Magnetisation** is a separation method that uses the property of magnetism. Magnets separate magnetic substances from non-magnetic substances. Magnetisation is used for recycling metals and to separate magnetic metals from non-magnetic metals from a mixture of scrap metals. For example, an electromagnet can separate iron from other metals.

### New words

**crystallisation:** the process of forming solid crystals

**impurities:** particles that do not belong in the pure substance



Figure 19 Separation using magnetism. The huge magnet on a crane at a refuse dump or demolition site lifts metal waste.

Figure 25 A: Extracting silver from copper. B: Skimmers with oil separated from them

## Activity 10 Plan an investigation to separate a mixture

Work in groups of three or four when doing this activity.

1. Choose any method of separation and plan your own investigation.
2. Write down your plan using the headings Materials and Method.
3. Predict and write down your Observations/ Results.

### New word

**technique:** a method

## Industrial applications of separation techniques

Industry uses separation techniques for many purposes.

Sugar cane is the raw material used in making sugar. It is grown at Nakambala Estate in Mazabuka (Southern Province).

- Figure 20 (on the next page) shows a flow chart of the main stages in refining sugar. The main stages involved in producing sugar are:
- **Cutting and crushing:** Harvested sugar cane is transported to a sugar mill, weighed and placed onto a conveyor belt. The sugar cane passes through cutting machines. Small pieces of cane are crushed to produce a sugary juice. The juice is collected and filtered to remove large suspended particles of fibre.
- **The clarifying unit:** After filtration the juice is dark brown. It is heated to allow the starch to convert to sugar.
- **Filtration of the juice:** The impurities are removed by filtration.
- **Evaporating water from the juice:** The water is evaporated from the juice. This produces thick, brown syrup, which contains about 60% sugar.
- **Crystallisation of the juice:** The syrup is poured into pans and heated with steam at a reduced pressure to lose water by evaporation. Small crystals of sugar (seed crystals) are formed. The seed crystals are added to the syrup for crystallisation to start.
- After the crystals have grown, the mixture is moved into a tank where it **cools** and the **crystals continue growing**. The mixture is centrifuged to obtain brownish crystals, which are later dried and stored as raw sugar.
- What's left after crystallisation is known as **molasses**. It is used as cattle feed and to produce alcohol.
- **Sugar refining:** In the final process of production of sugar, more molasses and coloured impurities are removed from a raw sugar solution.
- **Decolourisation:** The solution is filtered through a charcoal bed where the coloured materials are removed. This leaves a clear solution, which is crystallised to give white sugar crystals. The crystals are dried and packaged to be sold.

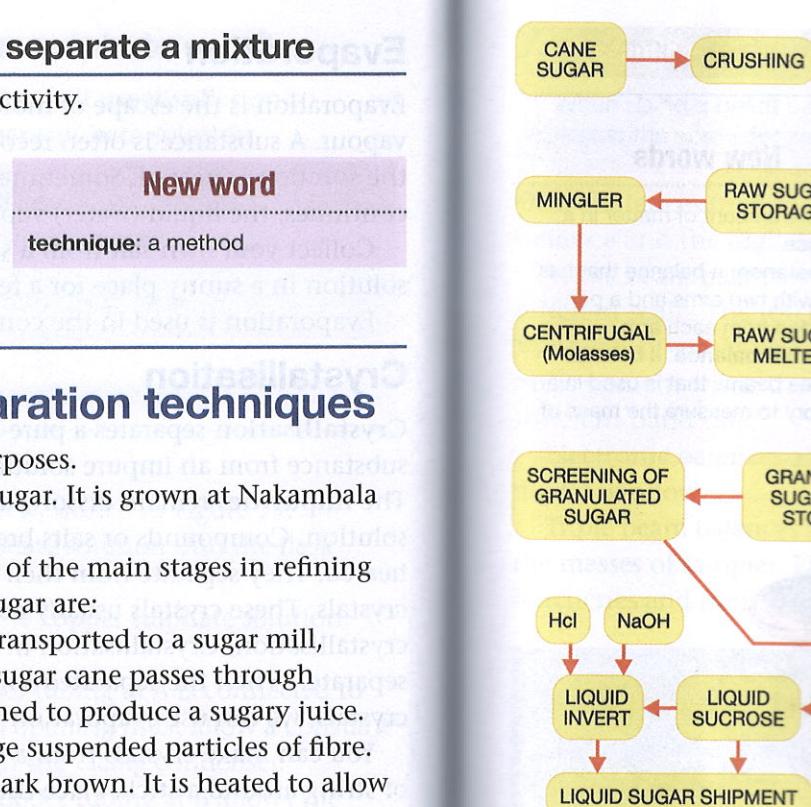


Figure 20 Stages in the

## Extracting salt from sea water

Salt can be extracted from sea water by the heat of the sun evaporation. Salt collected in this way is an impurity and must be washed with salt to stay dry and not a

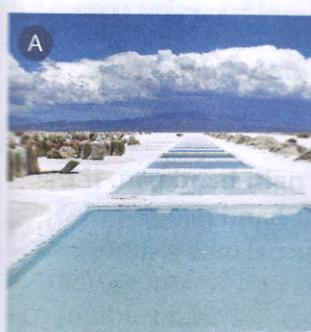


Figure 25 A: Extracting salt from sea water

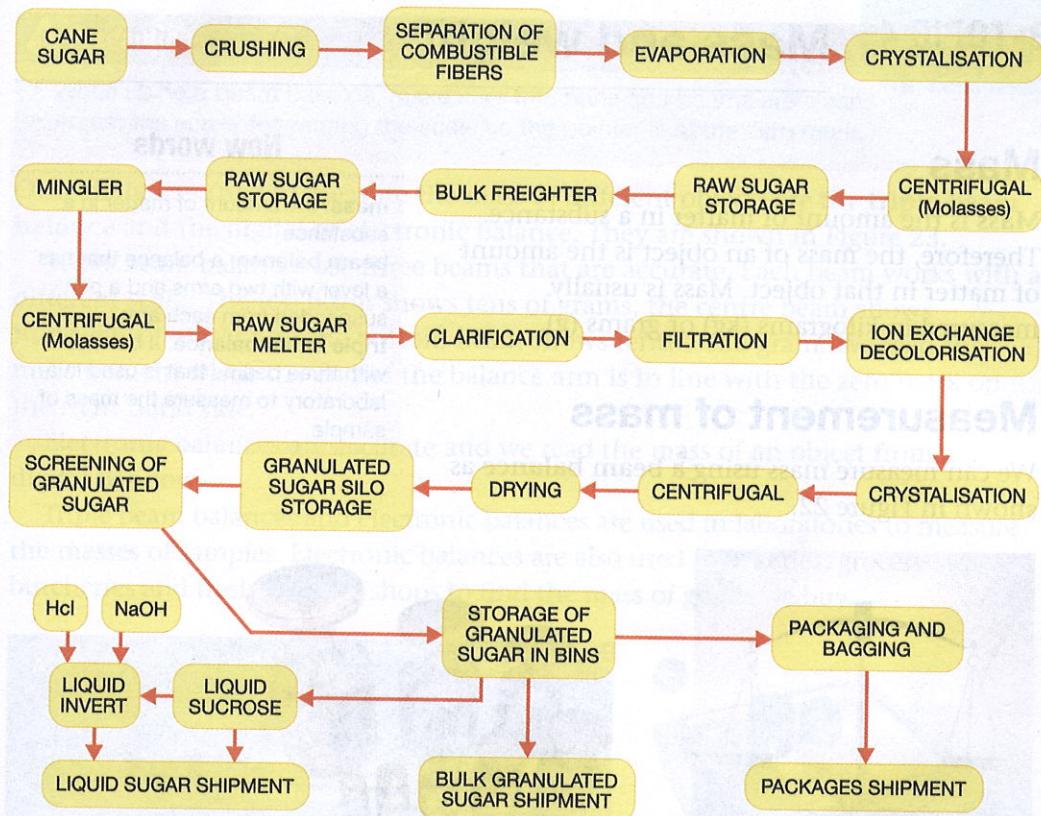


Figure 20 Stages in the production and refining of sugar

### Extracting salt from sea water

Salt can be extracted from sea water. Sea water is pumped into open pans. The heat of the sun evaporates the water, leaving the salt in the pans for collection. Salt collected in this way contains small quantities of magnesium chloride. This is an impurity and must be removed. Sodium sulphate is added, which causes the salt to stay dry and not absorb any moisture.

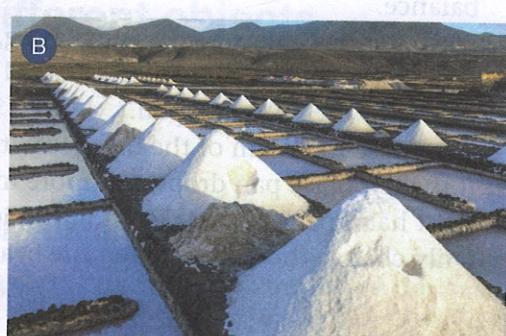


Figure 25 A: Extracting salt from seawater B: Salt pans with salt collected from them

## SUB-TOPIC 4

# Mass and weight

## Mass

Mass is the amount of matter in a substance. Therefore, the mass of an object is the amount of matter in that object. Mass is usually measured in kilograms (kg) or grams (g).

## Measurement of mass

We can measure mass using a **beam balance** as shown in Figure 22.

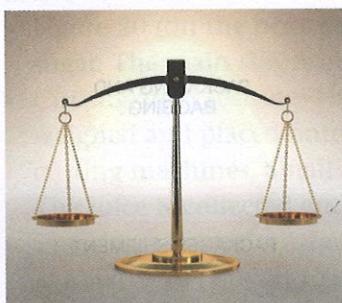


Figure 22 We can use a beam balance to measure the mass of anything that is within the range of weights to balance it. A balance compares mass with mass. So, a balance would give a correct measurement of mass on the moon, where the weights of the masses would be less than those on the earth.

When we measure mass with a beam balance, we start with the pans in the rest position.

- Place the object that you will measure on the left hand pan of the beam balance.
- Place standard mass pieces (such as 1 g, 10 g, 100 g,) on the right hand pan. The total mass of these mass pieces should equal your guess of the mass of the object on the left hand pan.
- Now raise the beam of the balance with the level.
- If the left hand pan drops, put more mass pieces on the right hand pan. If the right hand pan drops, take off mass pieces from the right hand pan.
- Only change the masses when the beam is raised and the balance is at rest.

## New words

**mass:** the amount of matter in a substance

**beam balance:** a balance that has a lever with two arms and a pan suspended from each arm

**triple beam balance:** a balance with three beams that is used in a laboratory to measure the mass of sample

## Precaution

- When using a beam balance, adjust the screw for zero.

Other balances used to measure mass are the triple beam balance and the digital balance.

Triple beam balances have a different scale. The top beam is for hundreds of grams and the bottom beam is for measurement when the beam is raised.

Electronic balances are digital balances with a digital window.

Triple beam balances are used to measure the masses of samples. Electronic balances are used in butcheries and fresh produce.



Figure 23 A: A triple beam balance is used in a laboratory. This sample has to measure the mass of a sample.

## Measuring the mass of a sample

Think of salt in a beaker. The more salt in the beaker, the more mass. Therefore, the more mass there is in a beaker of salt.

## Activity 11 Using a triple beam balance

Work in groups of four or five. You will need a triple beam balance and a triple beam balance scale. You can replace the triple beam balance with a triple beam balance scale.

If you do not have a triple beam balance, you can use a triple beam balance scale. You can replace the triple beam balance with a triple beam balance scale.

**Precaution**

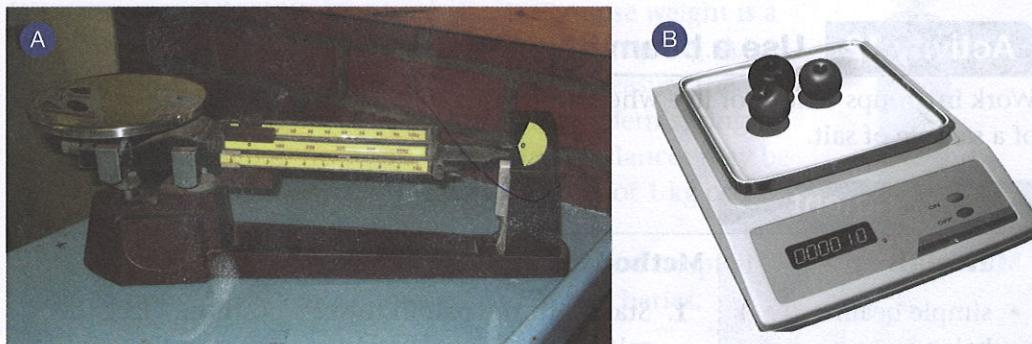
- When using a beam balance, make sure that pans and beams are clean.
- Adjust the screw for zeroing the scale so the pointer is at the zero mark.

Other balances used to measure the mass of different objects are the **triple beam balance** and the digital or electronic balance. They are shown in Figure 23.

Triple beam balances use three beams that are accurate. Each beam works with a different scale. The top beam shows tens of grams, the centre beam shows hundreds of grams and the bottom beam shows tenths of a gram. We read the measurement when the end of the balance arm is in line with the zero mark on the right hand side.

Electronic balances are accurate and we read the mass of an object from a digital window.

Triple beam balances and electronic balances are used in laboratories to measure the masses of samples. Electronic balances are also used in bakeries, grocery stores, butcheries and fresh produce shops to find the mass of goods we buy.



**Figure 23** A: A triple beam balance is used to measure the mass of a sample in a laboratory. This sample has a mass of 215 g. B: An electronic digital balance is used to measure the mass of a sample. This sample has a mass of 10 g.

## Measuring the mass of different objects

Think of salt in a beaker as an example of matter. Each salt crystal has a certain mass. Therefore, the more salt crystals in the beaker, the greater the mass of the salt.

### Activity 11 Using a triple beam balance

Work in groups of four or five when doing this activity. You will measure the mass of a sample of salt.

If you do not have a triple beam balance or an electronic balance, use a kitchen scale. You can replace the beaker with a drinking glass or jar.



## Experiment

### Materials

- triple beam balance
- beaker
- salt
- flour
- rice

### Method

1. Place an empty beaker on the triple beam balance and record its mass ( $M_1$ ).
2. Pour the salt into the beaker and record the new mass,  $M_2$  (mass of beaker and salt).
3. Calculate the difference between the mass of the beaker,  $M_1$ , and the mass of the salt and beaker,  $M_2$ .
4. This gives the mass of the salt.  
Thus, mass of empty beaker =  $M_1$   
Mass of container + salt =  $M_2$   
Mass of salt =  $M_2 - M_1$
5. Repeat the experiment using other substances, such as flour or rice.

## Weight

Weight is the pull of gravity on an object. Weight is the mass of the object and the force of gravity pulling it from one place to another. This is because the distance from the centre of the Earth to the centre of the object is taken into space, its mass is still the same as it is on earth. But the object is lighter because the force of attraction due to the Earth's gravity is not felt in space.

Weight = mass  $\times$  force of gravity. On Earth this force is about 10 N/kg in calculations.

## Measuring the weight of an object

We measure weight with a spring balance. When we pull on a spring balance, it stretches. The amount of stretch depends on the force. The unit of weight is the newton (N). Spring balances are marked in newtons. Most spring balances are marked in grams or kilograms. The scale of a spring balance scale weighs up to 10 N.

We use spring balances to measure the weight of an object.

## Measurement of weight

We hold a spring balance by the handle at the top. We attach the hook at the bottom of the balance to the object. The marker on the scale shows down the scale of the spring balance.

Figure 24 A: An example of an object is weighed on a spring balance. The weight of 10 newtons (N) is marked on the scale.



## Experiment

### Materials

- simple beam balance
- standard mass pieces
- salt
- beaker

### Method

1. Start with the pan in the rest position. Place the salt, whose mass you will measure, on the left hand pan of the beam balance.
2. Place a known mass (for example, a 1 g or 100 g mass piece) on the right hand pan.
3. Raise the beam of the balance with the level.
4. If the left hand side drops, put on more known mass pieces. If the right hand side drops, take off known mass pieces.
5. Adjust the known mass pieces until the beam balances.



### Precaution

Change the known mass pieces only when the beam balance is at rest, and not when the beam is raised.

## Weight

**Weight** is the pull of gravity on the mass of an object. We calculate weight by the mass of the object and the distance from the centre of earth. If we move an object from one place to another, its weight changes.

This is because the distance between the object and the centre of earth changes. If an object is taken into space, its mass stays the same as it is on earth. But the object is weightless, because the force of attraction due to the **gravity** of earth is not felt in space.

**Weight = mass × force** (due to gravity). On earth this force is about 9.8 N/kg. We will use 10 N/kg in calculations to work out the weight of an object.

### New words

**weight:** the pull of gravity on the mass of an object  
**gravity:** the force that pulls objects towards each other  
**newton:** the unit of measure for weight

## Measuring the weight of an object

We measure weight with a spring balance. Because weight is a force, we can measure it by finding its effect on a spring. A spring balance uses the stretch of its spring to measure the force. The unit of weight is the **newton** (N). Modern spring balances are marked in newtons. Older spring balances may be marked in grams or kilograms. On earth, a mass of 1 kg on a spring balance scale weighs 10 N.

We use spring balances most often in clinics and hospitals (for measuring the weights of babies) and in butcheries.

### Measurement of weight

We hold a spring balance or attach it to a fixed surface by its ring at the top. We attach the object we will weigh to the hook at the bottom of the balance. This causes the spring in the spring balance to stretch. We then measure the weight of the object. The marker on the outside of the spring balance moves down the scale of the spring balance.



Figure 24 A: An example of a spring balance; B: A mass piece is weighed on a spring balance. A 1 kg mass piece has a weight of 10 newtons (N).

## Activity 13 Find the weight of an object

Work in groups of four or five when doing this activity. You will measure the mass pieces using a spring balance.



### Experiment

#### Materials

- spring balance
- string
- standard mass pieces

#### Method

1. Attach a standard mass piece to the hook of the spring balance with string.
2. Read the weight in newton.
3. Record the weight in a table.
4. Repeat the experiment with mass pieces of different mass.
5. Compare the mass and weights of each mass piece. Are they the same?

## Calculating the weight of a substance with a given mass

Weight is the force of gravity that is **exerted** on the mass of an object. Weight gives an object its downward acceleration when it is falling freely near earth's surface. The average rate of acceleration is  $9.8 \text{ m/s}^2$ .

At school level we use the value of  $10 \text{ m/s}^2$  when doing calculations that involve the force of gravity.

We take the acceleration of **free fall** as  $10 \text{ m/s}^2$  on earth. Then we calculate the weight of an object when we know the mass of the object. Use the following **formula**:

$$\text{Weight (of the object)} = \text{mass (of the object)} \times \text{acceleration (due to gravity)}$$



#### Remember

The relationship between the force exerted on objects on earth and acceleration due to gravity is called weight:  $\text{weight} = \text{mass} \times \text{acceleration}$ . Weight is a force that we measure in newton (N). The unit of mass is the kilogram (kg) and the unit of acceleration is metres per second squared ( $\text{m/s}^2$ ). So we can say:  $1 \text{ N} = 1 \text{ kg} \times \text{m/s}^2$ .

## Worked example

Calculate the weight of an object that has a mass of  $10 \text{ kg}$ . The acceleration due to gravity is  $10 \text{ m/s}^2$ .

$$\text{Weight} = \text{mass} \times \text{acceleration}$$

$$= 10 \times 10$$

$$= 200 \text{ N}$$

**Hint:** When an object is in free fall, the weight on earth, while it is falling, is  $10 \text{ N}$ .

## Activity 14 Calculate the weight of an object

1. Give the units in which the following are measured.
  - mass
  - weight
2. A stone has a mass of  $10 \text{ kg}$  on earth. Calculate its weight on the moon. (Acceleration due to gravity on the moon is  $1.6 \text{ m/s}^2$ ).
3. Calculate the weight of a person with a mass of  $60 \text{ kg}$  on the moon. (Acceleration due to gravity on the moon is  $1.6 \text{ m/s}^2$ ).
4. Calculate the weight of a person with a mass of  $60 \text{ kg}$  on the moon. (Acceleration due to gravity on the moon is  $1.6 \text{ m/s}^2$ ).

## Distinguishing between mass and weight

Mass and weight are different. Mass is the amount of matter in an object. Weight is the force of attraction between two objects that are on each other. The strength of the gravitational force depends on the mass of the objects and the distance between them. The stronger the gravitational force, the greater the weight of an object. The weight of an object is greater at the bottom of the Earth than at sea-level, even though the mass of the object is the same.

The mass of any object does not change, but the weight of an object does decrease in size. Weight depends on the size of the object and the distance between it and the center of the Earth. Weight changes as the distance between the object and the center of the Earth changes. For example, a person who has a certain weight on Earth will weigh less on the Moon because the gravity of the Moon is less than that of Earth.

## Differences between mass and weight

Feature
Nature
Measuring instrument
Unit of measure
Value

## New words

**exerted:** pushed or pulled by a force

**free fall:** the motion of an object is only affected by gravity and nothing else - not by the air or anything else that can slow the speed of the fall

**formula:** words, numbers or symbols showing how to work out an answer

**Worked example**

Calculate the weight of a 20 kg stone on earth (acceleration due to gravity is  $10 \text{ m/s}^2$ ).

$$\begin{aligned}\text{Weight} &= \text{mass} \times \text{acceleration due to gravity} \\ &= 20 \times 10 \\ &= 200 \text{ N}\end{aligned}$$

**Hint:** When an object is taken to another planet, the weight differs from the weight on earth, while the mass remains unchanged.

**Activity 14 Calculate mass and weight**

1. Give the units in which we measure:
  - a) mass
  - b) weight.
2. A stone has a mass of 10 kg on earth. Calculate the weight of a stone on the moon. (Acceleration due to gravity is  $1.6 \text{ m/s}^2$  on the moon.)
3. Calculate the weight of a 1000 kg satellite in space where there is no acceleration due to gravity.
4. Calculate the weight of a mass of 1 kg on earth.

**Distinguishing between mass and weight**

Mass and weight are different as you saw in Activity 13. Weight is a measure of the attraction between two objects due to gravity. All objects exert a force of gravity on each other. The strength of the force depends on the mass of the objects and the distance between them. Weight depends on gravity, and may vary from place to place on earth. As the distance between objects increases, the force of gravity between them decreases. You would weigh less on the top of a high mountain than at sea-level, even though you have the same mass.

The mass of any object has a constant value if the object does not increase or decrease in size. Weight does not have a constant value. The weight of an object depends on the size of the force of gravity acting on the object. Weight can change as the distance between the two objects changes. For example, a person who has a certain weight on earth would weigh much less on the moon. This is because the gravity of the moon is about one-sixth of the gravity of earth.

**Differences between mass and weight**

Feature	Mass	Weight
<b>Nature</b>	Constant	Variable
<b>Measuring instrument</b>	Beam balance	Scale or spring balance
<b>Unit of measure</b>	Gram (g) or kilogram (kg)	Newton (N)
<b>Value</b>	Constant	Varies from place to place

## What is density?

Density is defined as the mass per unit volume of a substance. Density is the measurement of the amount of matter (mass) in a given volume of an object. The formula that shows this relationship between density, mass and volume is:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

The unit for density is grams per cubic centimetre ( $\text{g}/\text{cm}^3$ ). Density is an important quantity because it enables scientists to identify and compare objects.

## Determining the density of different substances

In the next four activities, you will determine the density of different materials. Work in groups and change tasks for each activity, so that you practise the different skills required for the experiments.

### Activity 15 Determine the density of an object

Work in groups of three when doing this activity. You will discover a method that you can use to determine the density of any solid material that sinks in water.

#### Experiment

##### Materials

- beam balance or kitchen scale
- thin string
- measuring cylinder
- water
- stone, small enough to fit into the measuring cylinder

##### Method

- Weigh a small stone by placing it on a beam balance. Read and record its mass (M).
- Pour water into a measuring cylinder and record its volume ( $V_1$ ) as the first reading.
- Tie a thin string to the small stone.
- Gently lower the small stone into the water until it is fully under water.
- Record the total volume of the water and stone ( $V_2$ ) as the second reading.
- Now calculate the density of the stone:

$$\text{density} = \frac{M}{V_2 - V_1}$$

#### New words

**density:** the mass per unit volume of a substance

**determine:** to work out

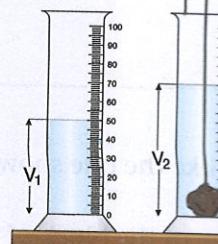


Figure 25 The experiment determining the density

### Activity 16 Determine the density

Work in groups of three to determine the density

#### Experiment

##### Materials

- beam balance or kitchen scale
- thin string
- displacement can
- measuring cylinder
- water
- stone, small enough to fit into the measuring cylinder

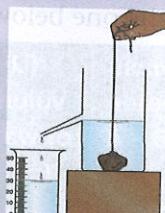


Figure 26 The experimental set-up for determining the density of a stone



## Continued

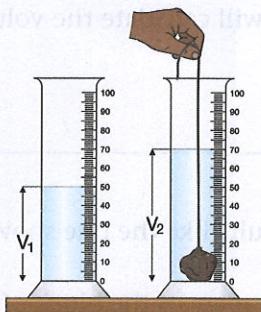


Figure 25 The experimental set-up for determining the density of an object

**Observation**

The water level in the measuring cylinder rose when the stone was placed into the measuring cylinder.

**Explanation of observations**

The amount by which the water level rose is equal to the volume of the stone. We can calculate this volume by subtracting  $V_1$  from  $V_2$ .

### Activity 16 Determine the density of a stone

Work in groups of three when doing this activity. You will use a displacement can to determine the density of a stone.



## Experiment

**Materials**

- beam balance or kitchen scale
- thin string
- displacement can
- measuring cylinder
- water
- stone, small enough to fit into the measuring cylinder

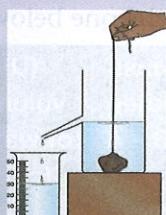


Figure 26 The experimental set-up for determining the density of a stone

**Method**

1. Weigh a small stone by placing it on a beam balance. Read and record its mass ( $M$ ).
2. Pour water into a displacement can until it overflows through the spout. The water will stop flowing out when its surface is level with the bottom of the spout.
3. Place a clean, dry measuring cylinder under the spout.
4. Tie a thin string to the small stone.
5. Gently lower the stone into the displacement can until it is fully under water.
6. Collect the displaced water in the dry cylinder. The volume of the water displaced by the stone is the same as the volume of the stone.
7. Calculate the density of the stone:

$$\text{density} = \frac{\text{mass of stone}}{\text{volume of water displaced by the stone}}$$



## Activity 17 Determine the density of a block of wood

Work in groups of three when doing this activity. You will calculate the volume of an object, and then determine its density.

### Experiment

#### Materials

- block of wood
- ruler
- beam balance or kitchen scale

#### Method

1. Draw a table for the results like the one shown below.
2. Measure and record the mass of the block of wood on the beam balance.
3. Measure and record the length, width and height of the block of wood.
4. Calculate the volume of the block using the formula:  $L \times W \times H$
5. Calculate the density of the wooden block using the formula density =  $\frac{\text{mass}}{\text{volume}}$ .

Mass (g)	Length (L) (cm)	Width (W) (cm)	Height (H) (cm)	Volume = L × W × H (cm <sup>3</sup> )

## Activity 18 Calculate the density of a liquid

Work in groups of three when doing this activity. You will calculate the density of different liquids from a record of measurements that you take.

### Experiment

#### Materials

- water
- measuring cylinder
- beam balance or kitchen scale

#### Method

1. Draw a table for your results like the one below.

Liquid	(A) Mass of cylinder (g)	(B) Mass of cylinder + water (g)	(C) Mass of water C = B - A (g)	(D) Volume of water (cm <sup>3</sup> )
Water				

### Worked example 1

A piece of metal has a mass of 240 g. When it was placed in a cylinder containing water, the water level rose as shown in the diagram. Calculate the density of the metal.

#### Answer

$$\text{Mass} = 240 \text{ g}$$

$$\begin{aligned}\text{Volume} &= 80 \text{ cm}^3 - 50 \text{ cm}^3 \\ &= 30 \text{ cm}^3\end{aligned}$$

$$\begin{aligned}\text{density} &= \frac{\text{mass}}{\text{volume}} \\ &= \frac{240}{30} \\ &= 8 \text{ g/cm}^3\end{aligned}$$

### Worked example 2

A metal block has a mass of 45 g. Calculate the density of the metal block.

#### Answer

$$\text{Mass} = 45 \text{ g}$$

$$\text{Density} = \frac{9 \text{ g}}{\text{cm}^3}$$

**Continued**

2. Carefully determine the mass of the empty measuring cylinder using the beam balance.
3. Record this in column A in your table.
4. Pour water into the measuring cylinder.
5. Record the volume of this water in column D.
6. Now place the measuring cylinder with the water on the beam balance. Record the mass in column B.
7. Calculate the mass of the water in column C.
8. Use the data recorded in your table to calculate the density of the water.
9. Repeat the experiment using other liquids, such as milk or oil.

**Worked example 1**

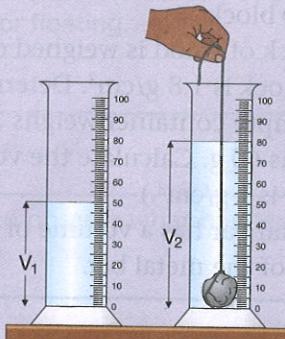
A piece of metal has a mass of 240 g. When it was placed into a measuring cylinder containing water, the water level rose as shown in the diagram. Calculate the density of the metal.

**Answer**

$$\text{Mass} = 240 \text{ g}$$

$$\begin{aligned}\text{Volume} &= 80 \text{ cm}^3 - 50 \text{ cm}^3 \\ &= 30 \text{ cm}^3\end{aligned}$$

$$\begin{aligned}\text{density} &= \frac{\text{mass}}{\text{volume}} \\ &= \frac{240}{30} \\ &= 8 \text{ g/cm}^3\end{aligned}$$



**Figure 27** The experimental set-up for determining the density of the metal

**Worked example 2**

A metal block has a mass of 45 g and a density of 9 g/cm<sup>3</sup>. Calculate the volume of the metal block.

**Answer**

$$\begin{aligned}\text{Mass} &= 45 \text{ g} \\ \text{Density} &= \frac{9 \text{ g}}{\text{cm}^3}\end{aligned}$$

$$\begin{aligned}\text{volume} &= \frac{\text{mass}}{\text{density}} \\ &= \frac{45 \text{ g}}{9 \text{ g/cm}^3} \\ &= 5 \text{ cm}^3\end{aligned}$$

### Worked example 3

A learner has a box with a length of 7 cm, a width of 3 cm and a height of 2 cm. He fills the box with sand, which has a density of  $3 \text{ g/cm}^3$ . Calculate the mass of the sand.

#### Answer

$$\text{Density} = 3 \text{ g/cm}^3$$

$$\text{Volume} = 7 \text{ cm} \times 3 \text{ cm} \times 3 \text{ cm} = 63 \text{ cm}^3$$

$$\text{mass} = \text{density} \times \text{volume}$$

$$\text{Mass} = 3 \text{ g/cm}^3 \times 63 \text{ cm}^3 = 189 \text{ g}$$

### Experiment

#### Materials

- small stone
- small block of wood
- candle
- feather
- coin
- leaf
- cooking oil
- beaker
- water



Figure 28 Examples of with the density of the

### Activity 19 Calculate with volume, mass and density

1. A measuring cylinder contains  $50 \text{ cm}^3$  of water. A stone has a mass of 1.75 g. The stone is lowered into the cylinder. The level of the water in the cylinder rises to  $52.5 \text{ cm}^3$ . Calculate the density of the stone.
2. A metal block has a mass of 45 g and a volume of  $6 \text{ cm}^3$ . Calculate the density of the block.
3. A block of wood is weighed on a beam balance. Its mass is 54 g. The density of the block is  $1.8 \text{ g/cm}^3$ . Determine the volume of the block.
4. An empty container weighs 20 g. After it is filled with water, the container weighs 60 g. Calculate the volume of the water in the container. (Density of water is  $1 \text{ g/cm}^3$ .)
5. A metal bar has a volume of  $20 \text{ cm}^3$  and a density of  $2 \text{ g/cm}^3$ . Calculate the mass of the metal bar.

## Floating and sinking

Different substances have different densities.

- When a solid object is placed into a liquid with a lower density than that of the solid, it sinks.
- When a solid object is placed into a liquid with a higher density than that of the solid, it floats.
- When two liquids of different densities are poured into one container, the liquid with the lower density floats on top of the other liquid (if they cannot mix).

### Activity 20 Observe solids in water

Work in groups of three when doing this activity. You will place different solids in water and observe what happens. **Aim:** observe solids in water.

### Activity 21 Observe oil in water

In this activity, you will observe oil in water.

#### Aim: Observe oil in water

#### Materials

- water
- oil
- beaker




**Experiment**
**Materials**

- small stone
- small block of wood
- candle
- feather
- coin
- leaf
- cooking oil
- beaker
- water

**Method**

1. Place the stone gently into a beaker of water.
2. Observe what happens to the stone in the beaker.
3. Repeat the experiment using the other solids. Observe what happens to them.
4. From your observations, make a list of the materials that float and a list of those that sink.

**Observation/Result**

Draw diagrams to show the final position of the stone and the other solids in the beaker.

**Conclusion**

Write down your conclusions based on your observations/results.

**Figure 28** Examples of things that sink or float. Compare the density of each item with the density of the liquid in which it is sinking or floating.


**Activity 21 Observe oil in water**

In this activity, you will place a liquid in water and observe what happens.

**Aim:** Observe oil in water.


**Experiment**
**Materials**

- water
- oil
- beaker

**Method**

1. Pour about 100 ml of oil into a beaker.
2. Now add about 100 ml of water to the beaker.
3. Allow the beaker stand for about 3–4 minutes.

**Observation/Result**

Draw a labelled diagram to show the position of the liquids in the beaker.

**Conclusion**

In groups of four to six, discuss and compare the density of the two liquids. Once the group is in agreement, each learner must write down the group's conclusion.

## How vessels float

If you drop a steel nail into a cup of water, it sinks. The nail sinks because the density of the steel is higher than the density of the water. But ships are made of steel, so why do they float?

When an object, such as a ship, first goes into water, it pushes down with a force due to gravity; this force moves the water aside to make room for the ship. This is called **displacement of water**. At the same time that the ship is pushing down against the water, the water is pushing up against the object. This is called **buoyancy**. If the buoyancy force and the gravity force are equal, then the object floats. Any object that floats feels these two forces.



**Figure 29** A: A steel nail sinks in water. B: A steel cargo ship floats as it is guided by a tugboat into port. C: An iceberg shows how water is displaced.

The ability of a boat to float depends on its average density. Average density depends on the weight of the steel hull and the air trapped inside it. A ship with a large volume of trapped air has a lower density than that of the water in which it sits. The shape of a ship enables it to dip into the water. This dip displaces enough water to create a buoyancy force as strong as the gravity force. These forces cancel each other and the ship floats.

When a ship's hold is full of cargo, it floats lower in the water because there is less trapped air, so making the ship denser. Likewise, a ship with no cargo has more trapped air, so the ship is less dense and floats higher in the water.

### Activity 22 Find out what makes a vessel float

In this activity you will use different shapes of modelling clay as your solid, and observe how they float.

### Experiment

#### Materials

- modelling clay
- water
- large bowl

#### New words

**displacement of water:** the measure of how much water is pushed aside when an object floats  
**buoyancy:** a force on an object making the object move upwards so that it floats

## Experiment

## Materials

modelling clay  
water  
large bowl

## Method

1. Take small, equal amounts of modelling clay and roll them into different shapes, such as a ball, a cylinder, a hollow bowl and a flat disk.
2. Fill the bowl with water.
3. Place the rolled modelling clay ball on the surface of the water.
4. Observe what happens.
5. Repeat steps 3 and 4 of this experiment with the rest of your modelling clay shapes.

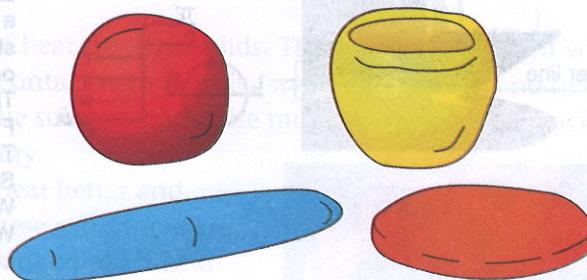


Figure 30 Different shapes made from modelling clay

## Observations

Record your observations in a table, such as the one shown below.

Shape	Sink	Float
Ball		
Cylinder		
Hollow bowl		
Flat disk		

## Explanation of observations

This shows that modelling clay, which has a higher density than water, can float on top of water. If we change the shape of the modelling clay, such as making a hollow cup, the modelling clay floats. This is because the cup-shape displaced an amount of water equal to its mass. The ball-shaped modelling clay sank because it displaced an amount less than its mass.

## The effects of overloading vessels

When a ship is loaded, its mass increases and it floats lower down in the water. To ensure that ships are not overloaded, they have plimsoll lines. These lines are marked on the side of a ship to show the levels at which a loaded ship can float safely in certain types of water. Using these lines correctly prevents ships from being overloaded and therefore from sinking and having accidents. If ships are overloaded, the lines will be below water level; this is the warning sign to remove some cargo or passengers.

Figure 31 shows the plimsoll lines and how they are marked on a ship.

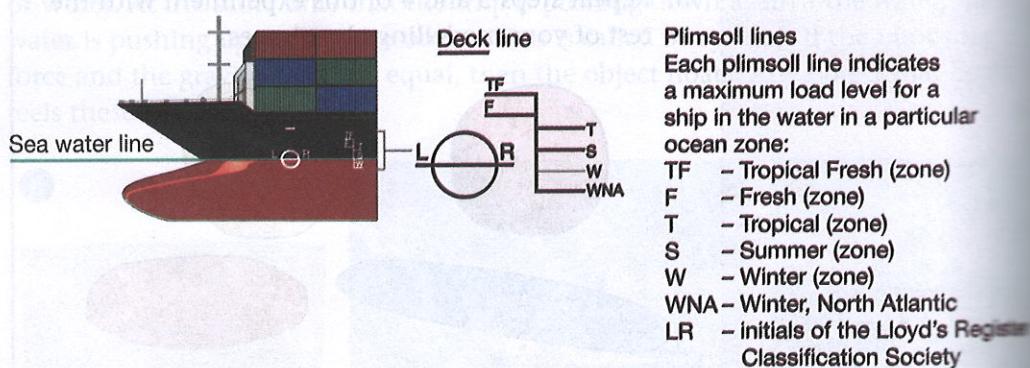


Figure 31 Plimsoll lines on a ship are different for different areas of the ocean.

### Activity 23 Answer questions on density and buoyancy

1. During an experiment on density, a learner places a piece of wood into a measuring cylinder containing methylated spirits. The density of the wood is  $0.9 \text{ g/cm}^3$  and the density of the methylated spirits is  $0.83 \text{ g/cm}^3$ .
  - a) Describe what will happen to this piece of wood if you place it in methylated spirits.
  - b) Give a reason for your answer to question 1a).
  - c) Draw a diagram to show the position of a piece of wood when placed in water.
2. a) Describe how a ship floats in water.
  - b) Give the function of a plimsoll line on a ship.

Heat energy moves from hot places. The movement of heat from one place to another is called heat transfer. Heat transfer is transferred by three different ways: conduction, convection and radiation.

### Types of heat transfer

#### Conduction

Conduction is the transfer of heat when a hotter substance is in direct contact with a cooler substance. In this case, the movement of molecules in the hotter substance is faster than in the cooler substance, so they transfer heat energy to the cooler substance.

Some substances transfer heat more quickly than others. For example, metals are good conductors of heat. Metal is a good conductor of heat because it has many free electrons that move quickly when heated. Metals are used on pans because copper is a good conductor of heat. Copper is a good conductor of heat because it has many free electrons that move quickly when heated.

Plastic, foam, wood and glass are poor conductors of heat. These materials are poor conductors of heat because they have fewer free electrons than metals. They are used as insulators to prevent heat loss. The handles of cooking utensils are often made of wood or plastic because they are poor conductors of heat. Copper is a good conductor of heat but it is a poor conductor of heat because it has fewer free electrons than metals.

#### Convection

Gases and liquids are poor conductors of heat. Heat travels through gases and liquids by convection. Convection is the transfer of heat by the movement of molecules in a gas or liquid. When a liquid or gas is heated, the molecules move faster and the density of the heated part of the liquid or gas decreases.

## Heat transfer

energy moves from hotter places to colder places. The movement of heat from one place to another is called **heat transfer**. Heat can be transferred by three different processes: conduction, convection and radiation.

### Types of heat transfer

#### Conduction

**Conduction** is the transfer of heat through solids. The heat is transferred when a substance is in direct contact with a cooler substance. There is no free movement of molecules in the substances. As the molecules bump into each other, they transfer heat energy.

Some substances transfer heat better and more quickly than others. These substances are good conductors of heat. Metals conduct heat better than non-metals. Silver and copper are good conductors of heat. Copper coatings are on pans because copper is a better conductor of heat than many other metals. Plastic, foam, wood and rubber do not conduct heat well; these materials are poor conductors of heat. Poor conductors of heat are used as insulators to prevent the movement of heat. The handles of cooking pots and pans are made of wood or plastic instead of iron or metal. This slows down or prevent heat from reaching our hands.

#### Convection

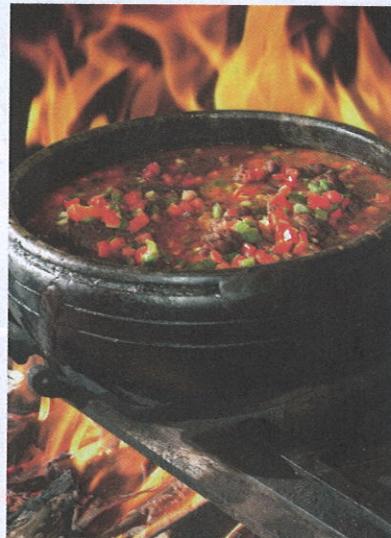
Convection and liquids are poor conductors of heat. Heat travels through gases and liquids by convection. Convection is the transfer of heat by the movement of molecules in a liquid or gas. When a liquid or gas is heated, some molecules move faster and further apart. So, the density of the heated part of the liquid or gas increases.

#### New words

**heat transfer:** the transfer of heat energy from a hotter place to a colder place

**conduction:** the transfer of heat energy through solids

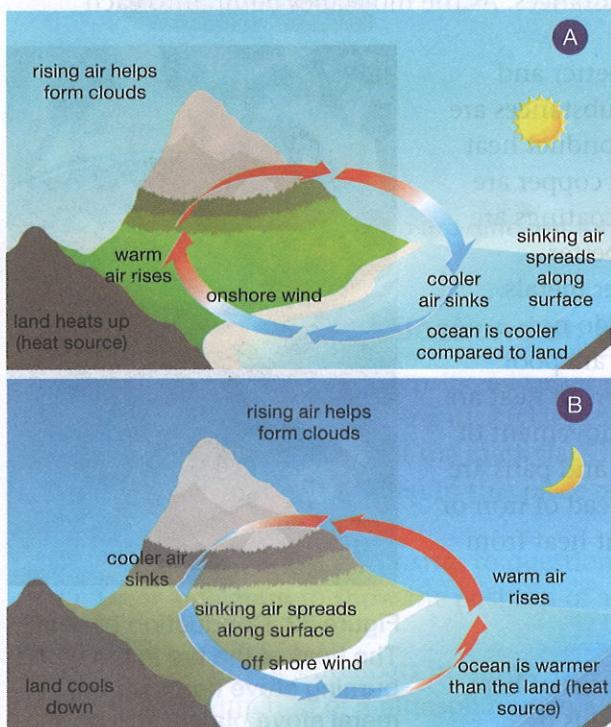
**convection:** the transfer of heat energy through liquids and gases by movements of the particles



**Figure 32 Conduction of heat:** The heat of the fire in the wood burning stove heats up the metal stove plates. The hot stove conducts heat to the cast iron pot which heats up. The hot pot conducts the heat to the food for cooking.

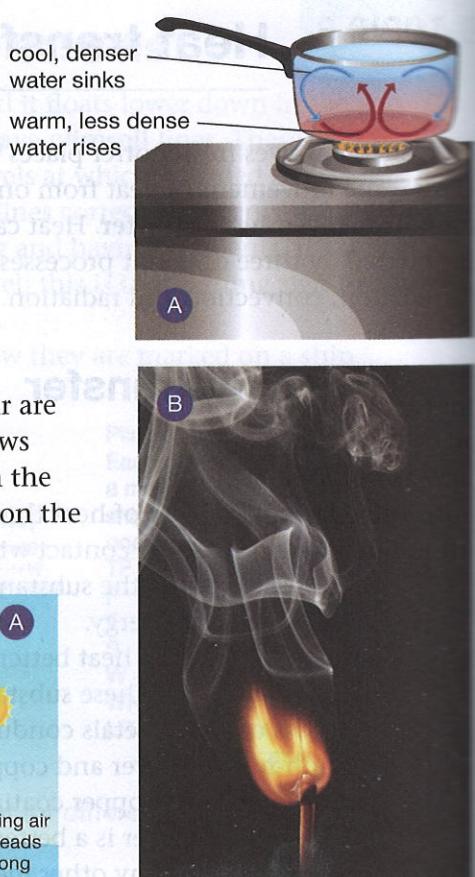
Because the heated part is less dense than the surrounding liquid or gas, it rises and creates currents that carry heat. As the newly heated air/liquid rises, the cooler air/liquid sinks. The constant rising of warm air/liquid and sinking of cool air/liquid sets up the convection current. This current helps to spread heat evenly throughout the gas/liquid.

Examples of convection currents in the air are off-shore and on-shore winds. The wind blows either from the land onto the water, or from the water onto the land. The direction depends on the temperature of the land and of the water.



**Figure 34** Convection is responsible for causing A: onshore and B: offshore winds.

Another example of convection is using a fire in a fireplace to heat your home. If you stand in front of the fire, you will feel that the fire heats up the air in front of it. This hot air rises because it is less dense. The cool air is pushed down, and is in turn heated, and so rises. In this way, convection currents warm the air in the room in which the fire is.



**Figure 33** Convection of heat: A: The constant rising of warm liquid and sinking of cool liquid sets up a convection currents in a liquid. These currents spread heat evenly throughout the liquid. B: We can see how heat is distributed in a gas when we watch how the smoke rises from a burning match.

## Radiation

Light travels from the sun. Most of the space between the sun and the Earth is a vacuum. Heat cannot be transferred by conduction and convection in a vacuum. Heat transfer by radiation. So heat from the sun reaches Earth by radiation. A clear day is an example of this.

You can observe radiation. Turn on an electric heater, and place a hand to the side of the heat source. Convection and conduction are not involved. Radiation is heating your hand without it passing through matter.

## Investigating thermal energy

### Activity 24 Show me the heat

Work in groups of three or four. Place a hand over a heat source and observe what happens.

### Experiment

#### Materials

- metal spoon
- source of heat, for example, a candle

2. Keep your hand on the spoon.
3. Remove your hand when the spoon is hot.

#### Result

Record what you feel about the temperature of the spoon.

#### Explanation of result

Explain why you were able to touch the spoon after the spoon had been heated.

## Radiation

Light travels from the sun to earth, and heats the earth. Most of the space between earth and the sun is almost a **vacuum**. Heat cannot be transferred through space by conduction and convection because there is almost no matter in space. Heat transfer through space takes place by **radiation**. So heat from the sun reaches earth by radiation. The heating effect of sunshine on our bodies on a clear day is an example of radiation.

You can observe radiation in your homes. Sit near a fire or electric heater, and place your hands a few centimetres to the side of the heat source. Your hands will feel warm. Convection and conduction cannot carry the heat sideways to your hands. Radiation is heating your hands. Heat energy is transferred by radiation without passing through matter.

### New words

**vacuum:** a space where there is no matter

**radiation:** the transfer of heat energy from a hotter place to a colder place without passing through matter

## Investigating the movement of heat in matter

### Activity 24 Show the movement of heat through solids

Work in groups of three or four when doing this activity. You will place an object in a heat source and observe what happens.

#### Experiment

##### Materials

- metal spoon
- source of heat, for example, a candle

##### Method

1. Place the concave end of a metal spoon over or in the source of heat for some time.
2. Keep your hand on the handle of the spoon.
3. Remove your hand when the handle is warm.



Figure 35 Heating a metal spoon in a candle flame

#### Caution

Do not allow the metal spoon to get too hot as it may burn your hands.

##### Result

Record what you feel about the temperature of the spoon's handle.

##### Explanation of result

Explain why you were able to feel the sensation after the spoon had been heated.

## Activity 25 Show the movement of heat through liquids

Work in groups of three or four. You will use the movement of potassium permanganate in water to show how heat moves through liquids.

### Experiment

#### Materials

- beaker
- source of heat, for example, Bunsen burner
- tripod stand and gauze
- water
- potassium permanganate
- plastic straw

#### Method

1. Fill a beaker with water.
2. Drop a few crystals of potassium permanganate into the bottom of the beaker through a straw.
3. Gently heat the bottom of the beaker directly under the crystals.

#### Caution

Potassium permanganate is poisonous, can be dangerous and stains. Wear latex gloves when you work with it.

#### Result

Record what you see happening in the water. Draw the colour pattern that you observe.

#### Explanation of result

Explain why you saw the result that you described.

## Activity 26 Show the movement of heat through liquids

Work in groups of three or four. You will use the movement of heat to show how heat moves through liquids.

### Experiment

#### Materials

- cardboard box
- candle
- paper and matches or a lighter

## How a vacuum flask works

A vacuum flask (see Figure 36) is a bottle that keeps liquids hot or cold by preventing heat transfer. The heat cannot escape from the flask nor enter it.

The inner glass container has double walls with a vacuum between them. To create the vacuum, air is sucked out from between the walls and the outer wall is sealed at the tip. This vacuum prevents heat loss or gain by conduction and convection.

The silver coated walls of the outer housing reflect radiant heat. This prevents heat from entering or leaving the flask. A cork or plastic stopper reduces more heat loss or gain. If the flask is left open, heat would escape by convection, conduction and evaporation.

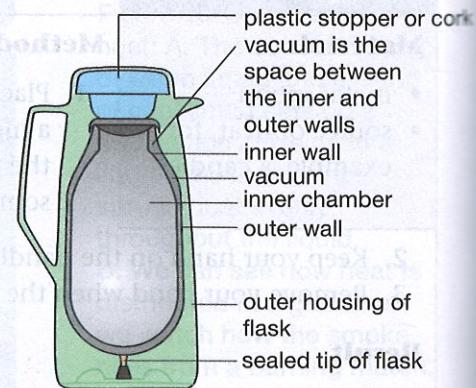


Figure 36 The internal structure of a vacuum (thermos) flask shows the features that help prevent heat loss or gain.

Figure 37 A simple convection box showing the movement of smoke due to convection

## Activity 27 Answer

1. Name three methods of heat transfer.
2. a) In which state of matter is heat transferred?  
b) Give an example of each.  
c) Explain how heat is transferred.
3. a) Name the device used to transfer heat by convection.  
b) Name the part of the device that transfers heat by convection.  
c) Which types of heat transfer are used in this device?

## Activity 26 Show the movement of heat in gases

Work in groups of three or four when doing this activity. **Aim:** observe the movement of heat in gases by observing the movement of smoke.

### Experiment

#### Materials

- cardboard box
- candle
- paper and matches or a lighter

#### Method

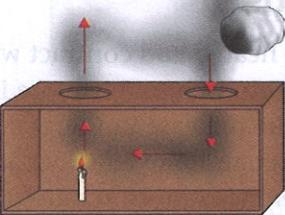
1. Cut two small holes in the top of the box, one near each end.
2. Light the candle and place it inside the box directly below one hole.
3. Hold the smouldering paper over the other hole of the box as shown in Figure 37.

#### Observations/Results

Observe what happens to the smoke from the paper. In which direction does the smoke move?

#### Explanation for observations/results

Explain why your results happened.



**Figure 37** A simple convection box showing the movement of smoke due to convection

## Activity 27 Answer questions about heat transfer

1. Name three methods of heat transfer.
2. a) In which state of matter does convection take place?  
b) Give an example of convection currents in everyday life.  
c) Explain how heat transfers from the sun to earth.
3. a) Name the device which can keep liquids at a constant temperature.  
b) Name the part of the device that helps reduce heat loss by radiation.  
c) Which types of heat transfer can the vacuum in this device prevent?

# Heat and expansion of substances

## Expansion of substances

All substances take up more space when they are heated. As a substance is heated, the particles move faster and further apart. This causes the substance to **expand**. We call this **expansion**.

As a substance cools, the movement of the particles decreases and they move closer together. This causes the material to **contract**. We call this **contraction**.

Materials differ in how much they expand when heated or contract when cooled.

When substances expand or contract, their particles stay the same size and do not increase in number. The space between the particles changes:

- The particles in a solid vibrate more when it is heated, and take up more space.
- The particles in a liquid move around more when it is heated, and take up more space.
- The particles in a gas move more quickly in all directions when it is heated, and take up a lot of space.

## Expansion of solids

Most solids expand when heated and contract when cooled. Temperature affects the size of the objects. When their temperature is raised their **dimensions** (length, width, height) increase. The increase in thermal (heat) energy causes the particles of the solid to **vibrate** faster and move further apart.

Different solids have different expansion rates. From fastest to slowest, the rates of expansion for some solids are aluminium, brass, bronze, copper and steel.

Therefore, for example, aluminium expands more than copper does when they are heated by the same amount.

### Activity 28 Show that solids expand when heated

Work in groups of three or four when doing this activity. You will use a metal ball and ring for this experiment. The ball must just be able to fit through the ring at room temperature. **Aim:** show that solids expand when heated.

### New words

**expand:** to increase in size

**expansion:** increase in amount of space used by matter due to heating

**contract:** to decrease in size

**contraction:** decrease in amount of space used by matter due to cooling

**dimension:** a measure of length, width or height

**vibrate:** move back and forth very quickly

### Experiment

#### Materials

- source of heat, for example, Bunsen burner
- metal ball
- metal ring
- beaker of cold water or tap water

#### Caution

Be careful when working with a flame from the source of heat.



## Experiment

### Materials

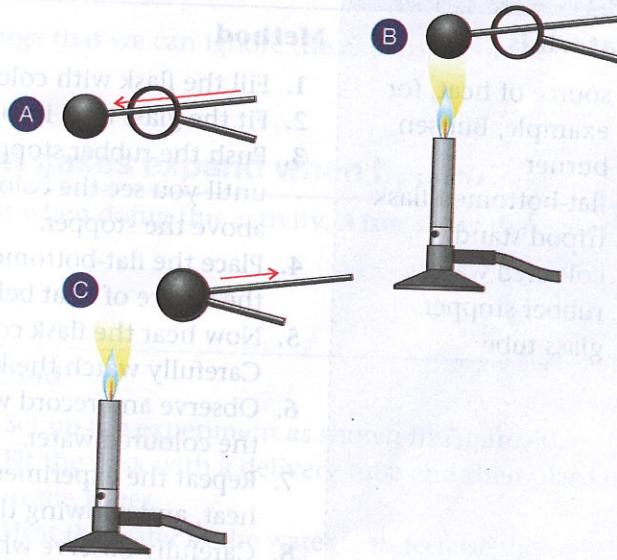
- source of heat, for example, Bunsen burner
- metal ball
- metal ring
- beaker of cold water or tap water



Be careful when working with a flame from the source of heat.

### Method

- Pass the metal ball through the ring.
- Light the heat source.
- Hold the metal ball above the flame and heat it for a minute or two.
- Try to pass the heated metal ball back through the ring.
- Put the heated metal ball into the beaker of cold water.
- Try to pass the cooled metal ball through the ring.



**Figure 38** The effect of heating on a solid metal ball.  
 A: The unheated ball fits through the ring. B: The metal ball is heated in the flame. C: After heating, the ball cannot pass through the ring.

### Observations/Results

Record your observations of each step.

### Explanation of observations/results

What can you conclude about the behaviour of solids when they are heated?

## Expansion of liquids

Liquids have no fixed shape and must be kept in containers. To see the increase in volume of a liquid due to heating, we also heat the container in which the liquid is. The container will also expand. If we see that the liquid level in the container has risen as we heat it, the liquid has expanded more than the container.

### Activity 29 Show that liquids expand when heated

Work in groups of three or four when doing this activity. You will show that liquids expand when they are heated. **Aim:** show that liquids expand when heated.

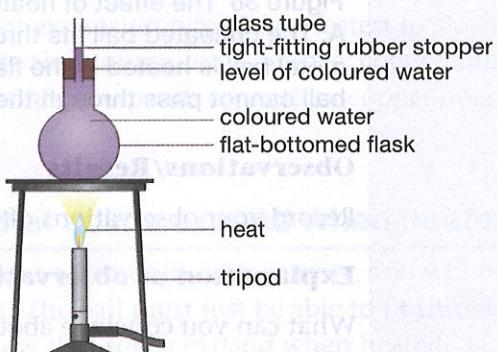
#### Experiment

##### Materials

- source of heat, for example, Bunsen burner
- flat-bottomed flask
- tripod stand
- coloured water
- rubber stopper
- glass tube

##### Method

- Fill the flask with coloured water.
- Fit the glass tube into the rubber stopper.
- Push the rubber stopper into the neck of the flask until you see the coloured water in the glass tube above the stopper.
- Place the flat-bottomed flask on the tripod with the source of heat below it.
- Now heat the flask containing the coloured water. Carefully watch the level of the coloured water.
- Observe and record what happens to the level of the coloured water.
- Repeat the experiment by removing the source of heat, and allowing the flask to cool down.
- Carefully observe what happens to the level of the coloured water in the flask.



**Figure 39** The experimental set-up to show that liquids expand when they are heated

#### Continued

##### Observations/Results

The water level falls at first.

##### Explanation of observations

The initial drop in the water level is because the heat reaches the water in the glass tube faster than the rest of the water increasing as the flask warms up.

## Expansion of gases

The expansion of gases is seen when they are heated.

### Activity 30 Show that gases expand when heated

Work in groups of three or four when doing this activity. You will show that gases expand when they are heated.

#### Experiment

##### Materials

- source of heat, for example, Bunsen burner
- water bath filled with water
- 500 ml round-bottomed flask
- rubber stopper
- delivery tube
- 500 ml beaker filled with water
- tripod

 **Continued**
**Observations/Results**

The water level falls at first, and then rises steadily.

**Explanation of observations/results**

The initial drop in the water level occurs because the flask expands first, before the heat reaches the water. The next rise in the water level is due to the volume of the water increasing as it is heated.

**Expansion of gases**

The expansion of gases is so large that we can ignore the expansion of the containers they are stored in.

**Activity 30 Show that gases expand when heated**

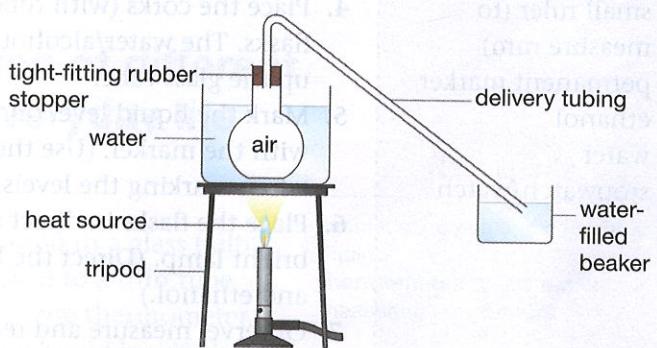
Work in groups of three or four when doing this activity. **Aim:** show that gases expand when they are heated.

 **Experiment**
**Materials**

- source of heat, for example, Bunsen burner
- water bath filled with water
- 50 ml round-bottomed flask
- rubber stopper
- delivery tube
- 500 ml beaker filled with water
- tripod

**Method**

1. Set up the experiment as shown in Figure 40.
2. Fit the flask with a delivery tube and then place it in the water.
3. Heat the water in the water bath to raise the temperature of the air in the round-bottomed flask.



**Figure 40** The experimental set-up to show that gases expand when they are heated

## Continued

### Observations/Results

Carefully observe and record what happens.

Bubbles start to come out of the open end of the submerged delivery tube in the beaker.

### Explanation of observations/results

As the air in the round-bottomed flask heats up, the air molecules start to gain energy. This allows them to move faster and further and further apart. This results in the volume of the air in the flask increasing. The air escapes from the flask by moving along the delivery tube. We can see this because the air forms bubbles in the beaker of water as it escapes from the delivery tube.

## Continued

### Observations/Results

Accurately measure and record the volume of the air bubbles after each time interval.

### Explanation of observations/results

- As the water and ethanol heat up, the amount of space occupied by the molecules in the tubes nose. This is because the molecules have more energy due to heating and thermal expansion.
- For each of the given time intervals, measure the volume of the air bubbles. This shows that when a substance is heated, they expand by different amounts.

## Activity 31 Compare the expansion of different substances

Work in groups of three or four when doing this activity.

**Aim:** show that substances expand at by different amounts.

### Experiment

#### Materials

- two conical flasks (125 or 250 ml)
- two corks/rubber stoppers
- two thin, glass tubes
- food colouring
- small ruler (to measure mm)
- permanent marker
- ethanol
- water
- stopwatch/watch

#### Method

- Fit each glass tube into a cork or rubber stopper. Make sure there is an airtight seal.
- Fill one flask with cold water (add food colouring to improve visibility).
- Fill the other flask with cold ethanol (add food colouring to improve visibility).
- Place the corks (with tubes) into the mouth of the flasks. The water/alcohol should rise a short way up the glass tube.
- Mark the liquid level on each of the glass tubes with the marker. (Use the bottom of the meniscus when marking the levels.)
- Place the flasks in direct sunlight or under a bright lamp. (Direct the lamp towards the water and ethanol.)
- Observe, measure and record the level of the liquid in both of the glass tubes after 5, 10 and 15 minutes.

## Expansion and contraction

When solids, liquids and gases are heated, they expand. The addition of heat to solids, liquids and gases causes them to expand. The movement is greatest in liquids and smallest in solids. The increase in the space occupied by a substance due to heating is known as thermal expansion. The decrease in the space occupied by a substance due to cooling is known as thermal contraction.

When a substance is cooled, the particles move more slowly and the space between them decreases. When a substance is heated, the particles move more rapidly and the space between them increases. Substances are cooled to the lowest temperature, more in solids and liquids.

## Uses of expansion and contraction in everyday life

### Thermometers

Thermometers contain a liquid in a glass tube. The liquid in the bulb is liquid that expands when heated and contracts when cooled. When the bulb is heated, the liquid expands and rises up the tube. The tube is marked with a scale for the Celsius and Fahrenheit scale. We can measure the temperature of an object by immersing the bulb in it.

**Continued****Observations/Results**

Accurately measure and record the observation (height of the water column) after each time interval.

**Explanation of observations/results**

- As the water and ethanol became warmer (the longer it was in the sun), the amount of space occupied by each liquid increased. The liquid level in the tubes rose. This is because the volume of the liquid had increased due to heating and thermal expansion.
- For each of the given lengths of time, the alcohol rose more than the water. This shows that when different substances are heated by the same heat source, they expand by different amounts.

**Expansion and contraction**

When solids, liquids and gases are heated or cooled, their volumes change. Addition of heat to solids, liquids and gas increases the movements of particles. The movement is greatest in gases. This increase in movement results in an increase in the space occupied by the solid, liquid or gas. The increase in volume due to heating is known as expansion. The amount of expansion which takes place is small in the case of solids, larger for liquids and very large for gases.

When a substance is cooled, its particles lose energy. This loss of energy causes the particles to move around less. The particles are closer together, so the volume of the substance decreases. This reduction in volume is known as contraction. If substances are cooled to the same temperature, there is usually less contraction in solids, more in liquids and most in gases.

**Uses of expansion of different substances in everyday life****Thermometers**

Thermometers contain a liquid in a glass bulb. The liquid in the bulb is linked to a thin tube that runs along the length of the thermometer. When the bulb is heated, the liquid inside the bulb expands and rises up the tube. The tube is marked with a scale for the measurement of temperature, either the Celsius scale or the Fahrenheit scale. We use the Celsius scale most often.

**New words**

**meniscus:** curve at the top of a liquid  
**thermometer:** an instrument for measuring temperature

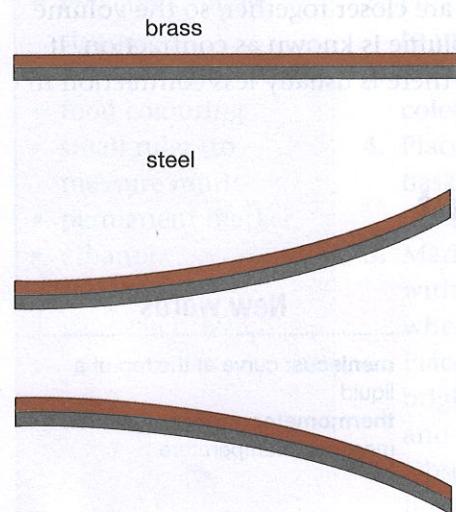
Doctors and scientists use thermometers that contain either mercury or alcohol. These substances expand quickly.

## Thermostats

Thermostats are devices that help control the temperature of indoor areas and of electrical appliances. They maintain a steady temperature between limits in electrical appliances by switching the appliances on and off. They are used in appliances such as air conditioners in buildings, refrigerators, ovens, irons and fire alarms.

Thermostats use bimetallic strips as switches. A bimetallic strip is a device that makes use of different rates of expansion of solids. Such a strip consists of two different metals joined together. When heated or cooled, one metal expands or contracts faster than the other, causing the strip to bend.

For example, for any rise in temperature, brass expands more than steel, so heating a bimetallic strip made of these two metals results in its bending towards the steel as shown in Figure 42.



The bimetallic strip is straight at a certain reference temperature.

Colder than the reference temperature: the brass contracts more than the steel. Its shorter length causes the strip to bend with the brass on the inside of the curve.

Hotter than the reference temperature: the brass expands more than the steel. Its longer length causes the strip to bend with the brass on the outside of the curve.

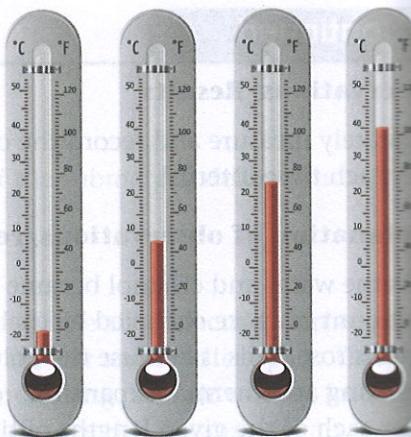


Figure 41 Thermometers marked with both Celsius and Fahrenheit scales and showing different temperatures

## New words

**thermostat:** a heat control device

**bimetallic strip:** two strips of different metals joined closely together

An electric current passes through the bimetallic strip and the heating element. The heating element provides heat which causes the bimetallic strip to bend and unbend, so separating the contacts and switching off current. When the temperature reduces to a certain level, the bimetallic strip bends back and reconnects the circuit, switching the electrical appliance on once again.

## Internal combustion

An internal combustion engine that uses contraction and expansion

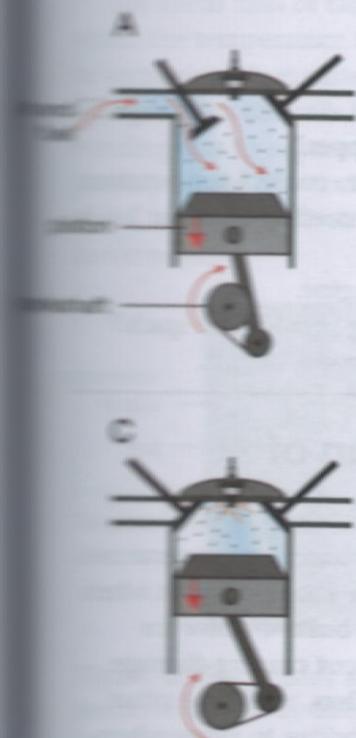


Figure 44 Internal combustion

Figure 42 A brass and steel bimetallic strip bends when heated uniformly.

An electric current passes through the bimetallic strip and the heating element. The heating element provides the heat which causes the bimetallic strip to bend and unbend, so separating the contacts and switching off the current. When the temperature reduces to a certain level, the bimetallic strip bends back and reconnects the circuit, switching the electrical appliance on once again.

The brass strip on top expands more than the steel strip when heated, causing the bimetallic strip to bend and break contact.

The screw adjusts the temperature at which the contacts open and the appliance switches off.

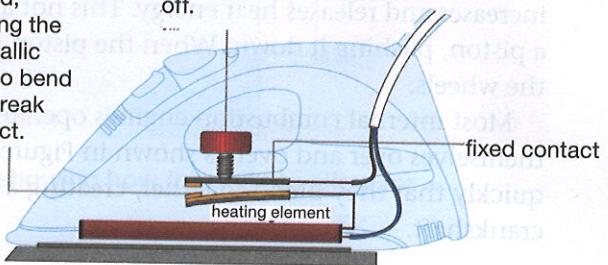


Figure 43 A bimetallic strip in a steam iron functions as a thermostat in an electric iron.

## Internal combustion engines

An internal combustion engine is another device that uses contraction and expansion.

### New words

combustion: burning  
ignite: set on fire

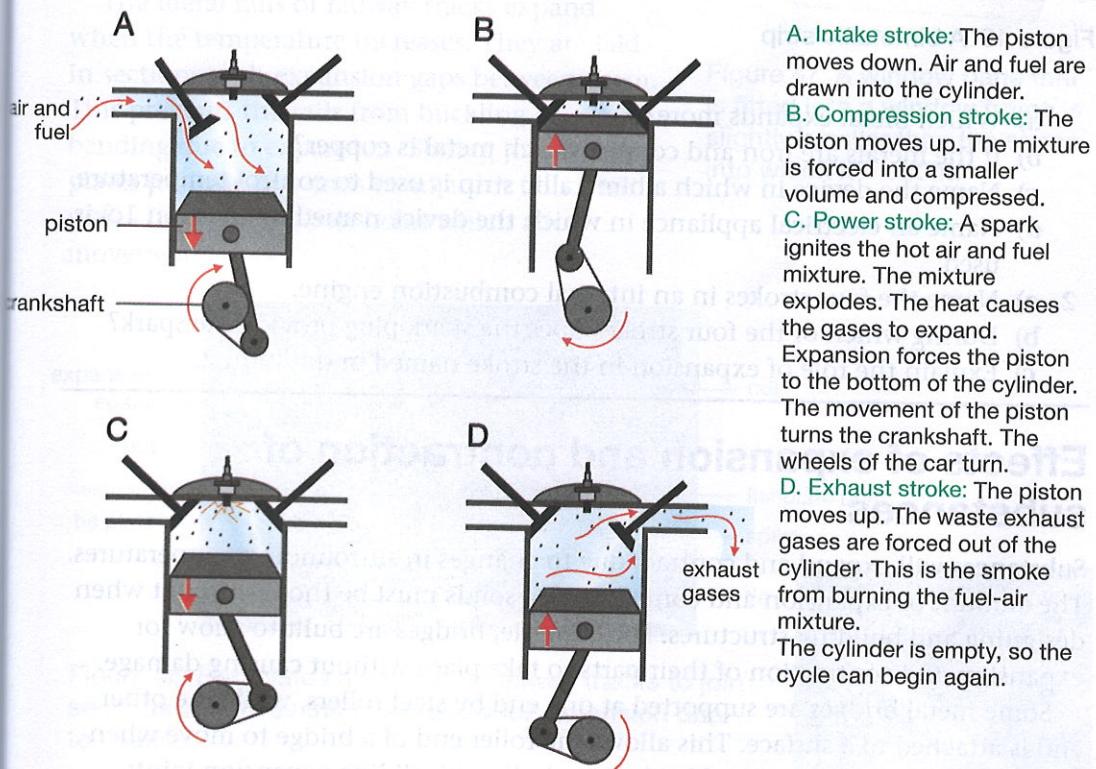


Figure 44 Internal combustion engine: Cycles of a four-stroke petrol engine

The main parts of the engine are the cylinders, spark plugs, pistons and crankshaft. The fuel evaporates and mixes with air. This mixture of fuel and air is drawn into the cylinder. In the cylinder, the mixture is **ignited** by a spark from the spark plug. The mixture burns at a high temperature. As the mixture burns, its temperature increases and releases heat energy. This hot air now expands rapidly and pushes **on** a piston, pushing it down. When the piston moves, it pushes a crankshaft that **tur**ns the wheels.

Most internal combustion engines operate using four strokes. The strokes repeat themselves over and over as shown in Figure 44. The four strokes happen so quickly that they blend together, creating a smooth, strong motion in the crankshaft.

## Activity 32 Expansion in everyday life

1. The bimetallic strip shown in Figure 45 is heated evenly.

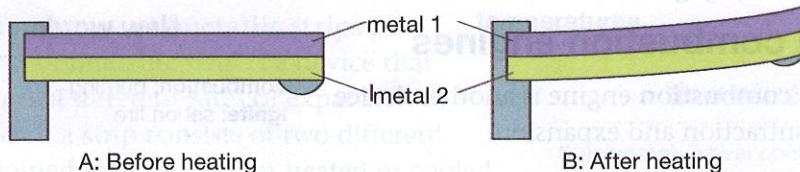


Figure 45 A bimetallic strip

a) Which metal expands more?

b) If the metals are iron and copper, which metal is copper?

c) Name the device in which a bimetallic strip is used to control temperature.

d) Name an electrical appliance in which the device named in question 1c) is used.

2. a) Name the four strokes in an internal combustion engine.

b) During which of the four strokes does the spark plug provide the spark?

c) Explain the role of expansion in the stroke named in question 2.

# Effects of expansion and contraction of substances

Substances will expand and contract due to changes in surrounding temperatures. The amount of expansion and contraction of solids must be thought about when designing and building structures. For example, bridges are built to allow for expansion and contraction of their parts to take place without causing damage.

Some metal bridges are supported at one end by steel rollers, while the other end is attached to a surface. This allows the roller end of a bridge to move when expansion occurs. Other metal bridges are built with sliding expansion joints which allow for movements for expansion and contraction.

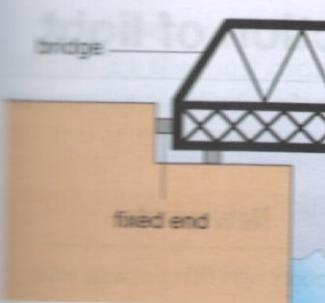


Figure 46 A diagram of a molecule expanding due to heat.

When putting panes of glass smaller than the opening of the window, it is necessary to heat the glass, and not press against the window frame. If the pane is heated before being put into the frame, the glass would crack. The pane is secured with putty in the correct position, and to allow it to expand.

The metal rails of railway when the temperature increases with expansion. This prevents the rails from bending due to expansion. plates join the two ends of rails have slotted bolt holes for movement.



**Figure 48** Fish plates are used to join sections of railway track and to bearing.

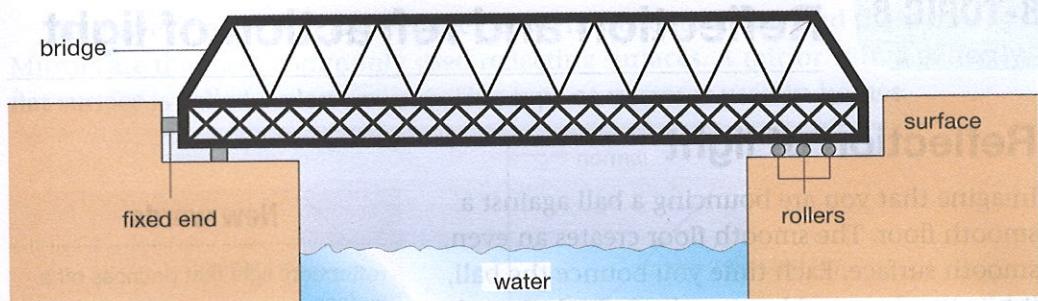


Figure 46 A diagram of a metal bridge showing how it is built to allow for expansion due to heat

When putting panes of glass into window frames, the glass must be about 2 mm smaller than the opening of the frame. This allows the glass to expand when it gets hot, and not press against the sides of the window frame. If the pane is too big for the frame, the glass would crack with expansion. The pane is secured with putty to keep it in the correct position, and to allow the glass to expand.

The metal rails of railway tracks expand when the temperature increases. They are laid in sections with expansion gaps between them. This prevents the rails from buckling or bending due to expansion. Sliding joints or fish plates join the two ends of adjacent rails. Fish plates have slotted bolt holes which allow movement.

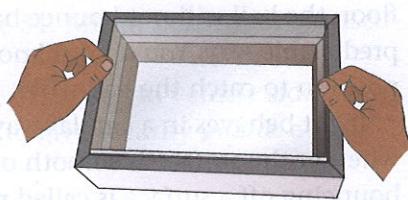


Figure 47 A window pane that is fitted into a window frame is slightly smaller than the space into which it must fit.



Figure 48 Fish plates are used on railway tracks to join sections of railway track and allow for expansion due to heating.

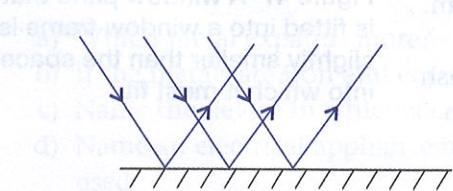


## Reflection of light

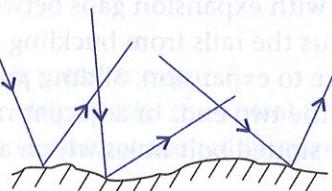
Imagine that you are bouncing a ball against a smooth floor. The smooth floor creates an even, smooth surface. Each time you bounce the ball, it hits the floor and bounces back. Each time the ball bounces back, your hand is in the correct position to catch it. You know more or less where the ball will be, because it bounces back in a regular, predictable way.

If the floor is not smooth, it creates an uneven surface. If you bounce the ball on this floor, the ball will not bounce back in a regular, predictable way. You do not know where to place your hands for the correct position to catch the ball when it bounces back.

Light behaves in a similar way to a bouncing ball. When light strikes a surface, whether the surface is smooth or rough, it bounces off of the surface. Light bouncing off a surface is called **reflection**.



Regular reflection from smooth surfaces



Diffuse reflection from rough surfaces

Figure 49 Reflection of light from smooth and rough surfaces

No matter what the source of light is, whenever light strikes an object three things can happen to the light: 1) The light might bounce off the object, 2) pass through the object, or 3) be absorbed by the object.

All objects/surfaces reflect a certain amount of light. Smooth, highly polished surfaces reflect light in a regular way. For example, if a **light ray** strikes a mirror at an angle as shown in Figure 50, the light is reflected off the mirror in a regular way. The light ray that strikes the surface is called the **incident ray**. The light ray that leaves the surface is called the **reflected ray**.

The **normal** is an imaginary line drawn at right angles to the reflecting surface. The angle of incidence is the angle between the incident ray and the normal.

### New words

**reflection:** light that bounces off a surface

**light ray:** a thin beam of light that travels in a straight line

**incident ray:** light ray that strikes a surface

**reflected ray:** light ray that bounces off a surface

**normal:** an imaginary line drawn at right angles to the reflecting surface

The angle of reflection  
Mirrors are the most common  
flat surface is called a plane

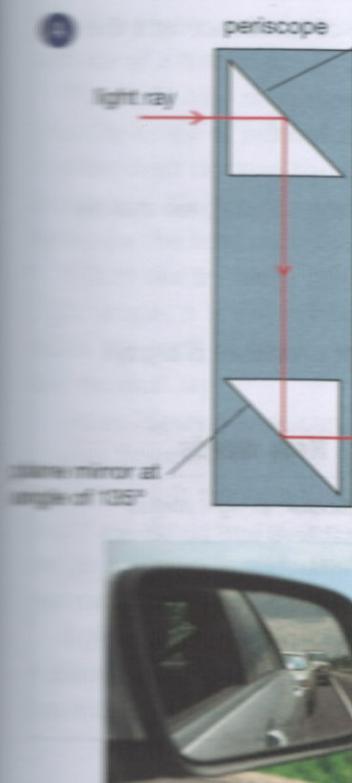
incident ray

angle of

Figure 50 The behaviour of light

Another use of mirrors is for an observer to see over an obstacle. In submarines.

Convex mirrors have large fields of view and rear-view mirrors. They are used in shopping areas.



The angle of reflection is the angle between the reflected ray and the normal. Mirrors are the most commonly used reflecting surfaces. A mirror with a perfectly flat surface is called a plane mirror. This type of mirror is used in homes.

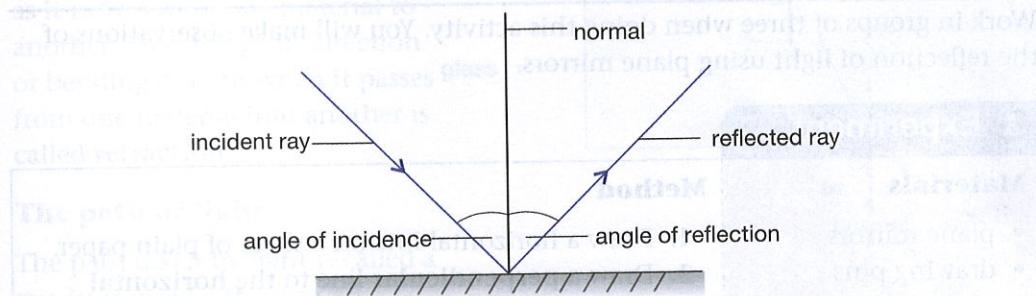


Figure 50 The behaviour of a light ray that falls onto a smooth reflective surface.

Another use of mirrors is in the mirror periscope. This instrument enables an observer to see over an **obstacle** as shown in Figure 51. Mirror periscopes are used in submarines.

**Convex mirrors** have large areas of reflection. They are used in vehicle side-view and rear-view mirrors. They are also used in shops to give security guards a wide view of shopping areas.

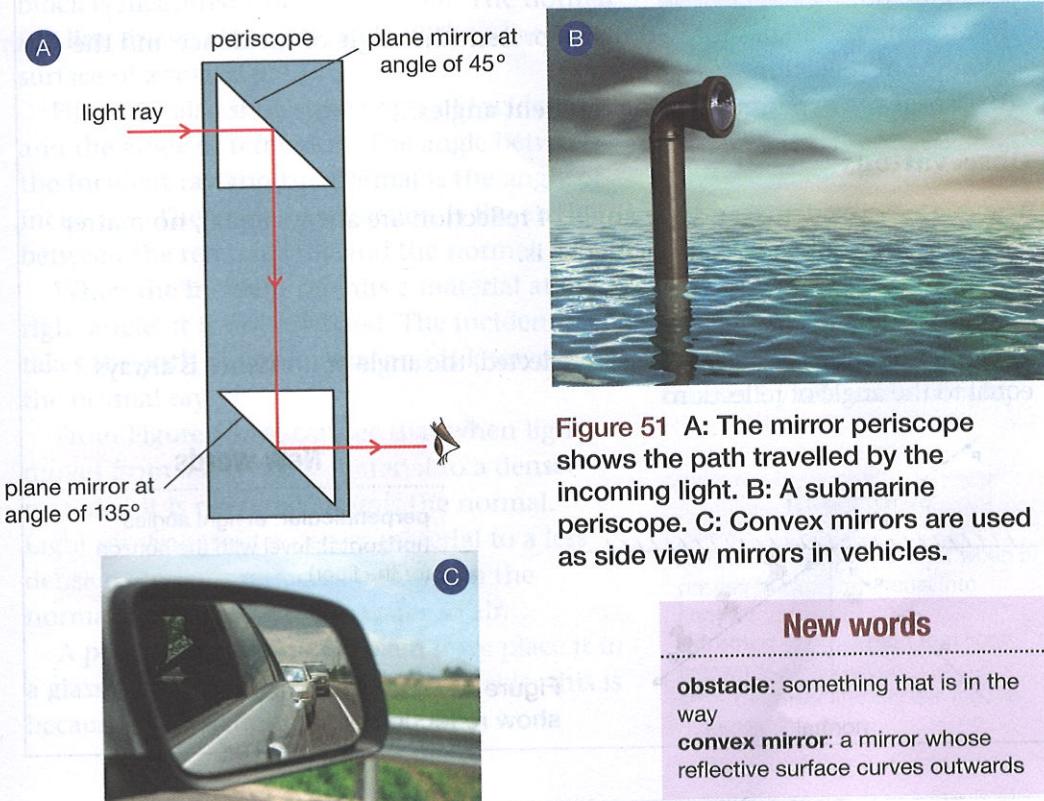


Figure 51 A: The mirror periscope shows the path travelled by the incoming light. B: A submarine periscope. C: Convex mirrors are used as side view mirrors in vehicles.

### New words

**obstacle:** something that is in the way

**convex mirror:** a mirror whose reflective surface curves outwards

# The reflection of light on mirrors

## Activity 33 Observe reflection of light

Work in groups of three when doing this activity. You will make observations of the reflection of light using plane mirrors.



### Experiment

#### Materials

- plane mirrors
- drawing pins
- plain paper
- protractor
- ruler
- pencil

#### Method

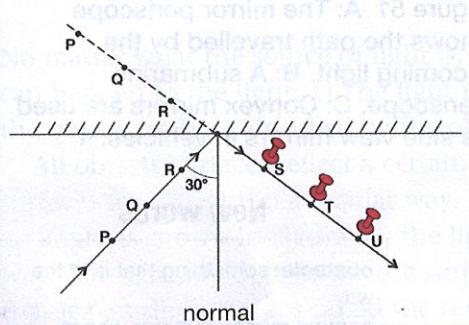
1. Draw a horizontal line on a sheet of plain paper.
2. Draw a **perpendicular** line to the horizontal line. This is the **normal**.
3. Measure a  $30^\circ$  angle to the perpendicular line and draw the line AB.
4. Place a plane mirror upright on the horizontal line with the reflecting surface facing the normal.
5. Fix three drawing pins P, Q and R on the line AB to represent the incident ray. Look into the mirror and find the images P, Q and R.
6. Fix pins S, T and U to the paper in line with the images P<sub>1</sub>, Q<sub>1</sub> and R<sub>1</sub>. See Figure 58.
7. Measure the angles formed that represent the angle of incidence and the angle of reflection.
8. Repeat the experiment using different angles.

#### Observations

The angle of incidence and the angle of reflection are always equal, no matter what the size of the angle of incidence is.

#### Explanation of observations

The results confirm that when light is reflected, the angle of incidence is always equal to the angle of reflection.



#### New words

**perpendicular:** at right angles  
**horizontal:** level with the horizon (or the floor)

Figure 52 The experimental set-up to show reflection of light

# Refraction of light

Light changes direction, as it moves from one material to another. The change in direction of light when it moves from one material into another is called **refraction**.

#### The path of light

The path taken by light is called a ray. In Figure 53 the line AB represents the incident ray. The incident ray falls on the surface of the next medium. The line BC represents the refracted ray. The refracted ray is the path followed by the ray. The ray leaving the block is the emergent ray. The angle at which a ray is refracted is measured from the normal drawn at a right angle to the surface of a material.

Figure 53 also shows the angle of incidence and the angle of refraction between the incident ray and the normal. The angle of refraction is between the refracted ray and the normal.

When the incident ray is at a right angle, it is not refracted. It follows the path of the normal ray.

From Figure 53 we can see that when light moves from a less dense material to a denser material, it is refracted towards the normal. Light moving from a denser material to a less dense material is refracted away from the normal, such as in glass.

A pencil looks bent or broken when viewed in a glass of water and viewed because of refraction. See Figure 54.

## Refraction of light

Light changes direction, or bends, as it moves from one material to another. The change in direction or bending of light when it passes from one material into another is called **refraction**.

### The path of light

The path taken by light is called a **ray**. In Figure 53 the line AB represents the **incident ray**. The incident ray falls on the surface of the next medium. Line BC represents the **refracted ray**. The refracted ray is the path followed by a ray after refraction. The ray leaving the block is called the **emergent ray**. The angle at which an incident ray hits the block is measured from the normal. The normal is a line drawn at a right angle ( $90^\circ$ ) to the surface of a material.

Figure 53 also shows the angle of incidence and the angle of refraction. The angle between the incident ray and the normal is the angle of incidence. The angle of refraction is the angle between the refracted ray and the normal.

When the incident ray hits a material at a right angle, it is not refracted. The incident ray takes the path of the normal and is known as the **normal ray**.

From Figure 53 we can see that when light moves from a less dense material to a denser material, it is refracted *towards* the normal. Light moving from a denser material to a less dense material is refracted *away* from the normal, such as in glass or water to air.

A pencil looks bent or broken if we place it in a glass of water and view it from the side; this is because of refraction. See Figure 54.

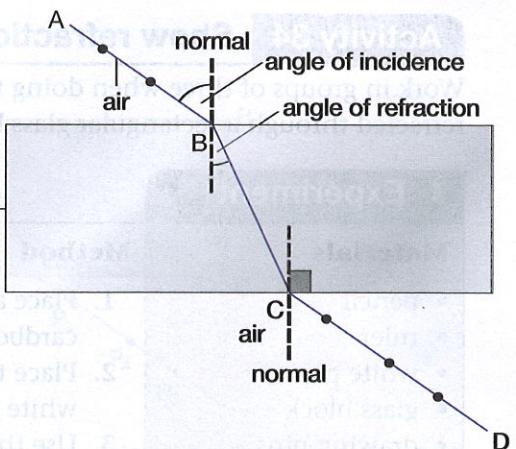


Figure 53 Refraction of light as it travels from air through a rectangular glass block and back into air

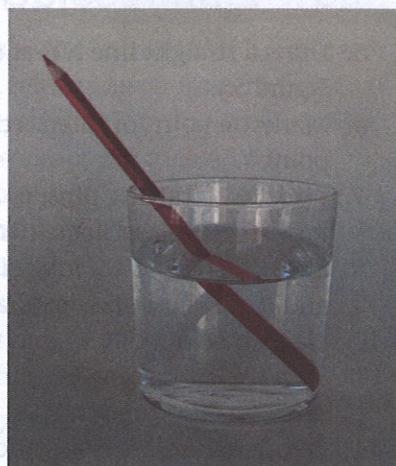


Figure 54 The pencil in this glass of water appears to be broken. This optical illusion is caused by refraction of light.

### New words

**refraction:** bending of light when it passes from one material into another

**refracted ray:** the path that light follows after refraction

**emergent ray:** the ray leaving the material

## Activity 34 Show refraction of light through a glass block

Work in groups of three when doing this activity. You will show how light is refracted through a rectangular glass block.

### Experiment

#### Materials

- pencil
- ruler
- white paper
- glass block
- drawing pins
- cardboard
- protractor

#### Method

1. Place a sheet of plain white paper on the cardboard.
2. Place the glass block in the centre of the sheet of white paper.
3. Use the pencil to draw the outline of the block onto the sheet of white paper. Remove the block.
4. Use a ruler to find the middle of the longer sides you have drawn, and mark all these middle points.
5. Draw a straight line XY, at an angle of  $45^\circ$  to the horizontal line, as shown in Figure 55.
6. Mark the point of intersection between this line (XY) and line AB. Call this point Y.
7. Place two drawing pins,  $P_1$  and  $P_2$ , along the line you have drawn.
8. Replace the glass block into the outline that you drew.
9. Look into the lower long side of the glass block so that the drawing pins  $P_1$  and  $P_2$  appear to be one drawing.
10. Place  $P_3$  below CD, so that the pin is lined up with the images of  $P_1$  and  $P_2$ . Take two more drawing pins,  $P_4$  and  $P_5$  and line them up with the images of  $P_1$  and  $P_2$  and the pin  $P_3$ .
11. Remove the glass block and all the pins. Draw a line through the position of pins  $P_3$ ,  $P_4$  and  $P_5$  until it intersects/touches the line CD that represents the lower/bottom surface of the glass block.
12. Mark the point of intersection between this line and line CD. Call this point Q.
13. Join the points Y and Q with a straight line (see Figure 55).

#### Observations

Comment on the position of the lines you have drawn that represent the incident, refracted and emergent rays.

#### Explanation of observations

Explain why the incident, refracted and emergent rays occur in the positions that you have marked them, and not in a position that you would have expected.

glass block

Figure 55 The refraction of

## Real and apparent

When light emerges from a water-air boundary at an

Refraction of light at the boundary between two media is greater than they are. A dam that is viewed from directly above is measured with a ruler, is the apparent depth. Light used for forming an image in water.

Figure 56 shows that an object appears closer to the surface of water than it is. This is because light refracts away from the object as it passes from a denser to a less dense medium. Light rays from point B, directly above the object, reach the observer's eye from point A. However, the distance from the surface of water, the apparent depth, is less than the distance from the surface, the real depth.

real depth of the object  
apparent depth of the object  
water when

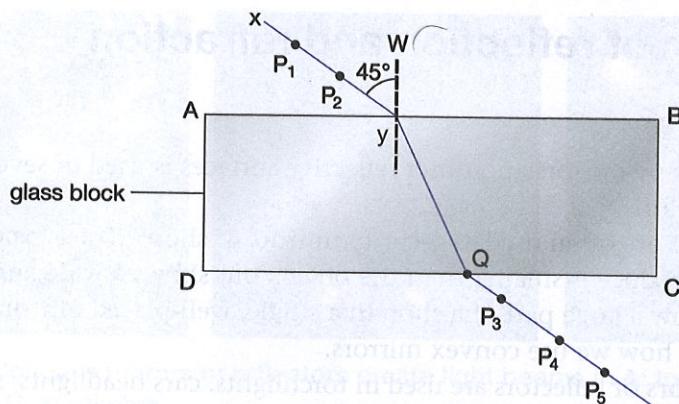


Figure 55 The refraction of light as it passes through a rectangular glass block

## Real and apparent depth of an object under water

When light emerges from glass or water into air, its speed increases. If light meets a water-air boundary at any angle other than  $0^\circ$ , it refracts away from the normal.

Refraction of light at the surface of water makes water bodies appear shallower than they are. A dam that is 2 m deep appears to be about 1.5 m deep when viewed from directly above. The true distance of an object beneath the surface, as measured with a ruler, is the **real depth**. The depth at which the object appears to be is the **apparent depth**. Apparent depth is due to the refraction of the path of light used for forming an image under water.

Figure 56 shows that an object in water appears closer to the surface than it really is. This is because light reflected from the object is refracted away from the normal at the water surface. The light travels from a denser to a less dense material. Light reaching the observer's eye appears to come from point B, directly above point A. However, the distance from B to the surface of water, the apparent depth, is less than the distance from A to the surface, the real depth.

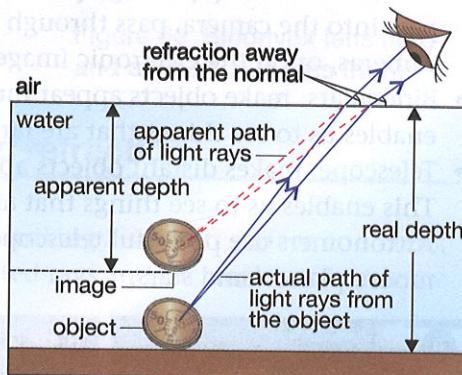


Figure 56 The real and apparent depth of an object

### New words

**real depth:** the actual distance below the surface of the water to the position of the object under water

**apparent depth:** the distance an object appears to be below the surface of the water when the object is viewed from above the water surface

# Application of reflection and refraction

## Reflection

Reflection of light by mirrors and other reflective surfaces is used in several everyday applications.

Convex mirrors are often used as security mirrors in shops. The type of image convex mirrors produce is smaller than the object, but shows a wide angle view. These mirrors show a large part of a shop in a single, well-placed mirror. Look back at page 141 to see how we use convex mirrors.

Concave mirrors or reflectors are used in torchlights, cars headlights, spotlights, searchlights and lighthouse lights. The light from the light bulb travels in many directions towards the mirror behind it. The light rays are reflected by the mirror and form a **beam of light**. The beam can be directed in a particular direction.

## Refraction

Refraction is used in some optical instruments. These instruments use lenses which are usually curved. Examples are hand lenses and microscope lenses. The application of refraction is also used in making spectacles, which have lenses held in a frame. People wear spectacles to improve their eye-sight. All these lenses work on refraction of light.

Other optical instruments that we use in everyday lives also make use of the refraction of light.

- **Camera:** for taking photographs for a record of the things we see. Light rays pass into the camera, pass through the lens and focus on the film in film cameras, or on the electronic image sensor in digital cameras.
- **Binoculars:** make objects appear much closer than they are really are. This enables us to see things that are far away more clearly and in more detail.
- **Telescope:** makes distant objects appear much closer than they are really are. This enables us to see things that are far away more clearly and in more detail. Astronomers use powerful telescopes to study objects outside earth, such as the moon, planets and stars.

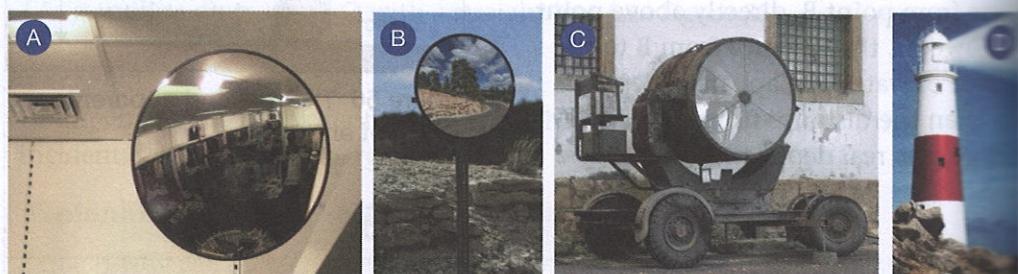


Figure 57 A: A convex security mirror in a shop; B: A convex safety mirror on a dangerous hairpin bend in a road; C: Searchlights used in air defense; D: Lighthouse for coastal navigation.

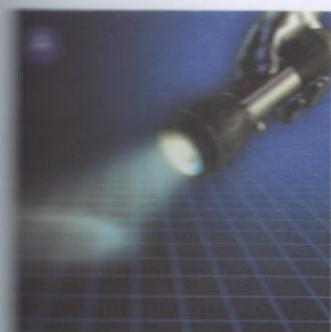


Figure 58 Concave mirrors  
A: headlights; C: spotlights.



Figure 59  
optical in  
use bicon

## Activity 35 Revise

- Define reflection.
- Draw a diagram to show reflection. Label the incident ray, normal, reflected ray and reflection.
- State the two laws of reflection.
- Give one use of a periscope.
- Give one application of reflection.

- Define refraction.
- Draw a diagram to show refraction between air and water. Label the angles of incidence and refraction.
- Define apparent depth.
- Give one application of refraction.

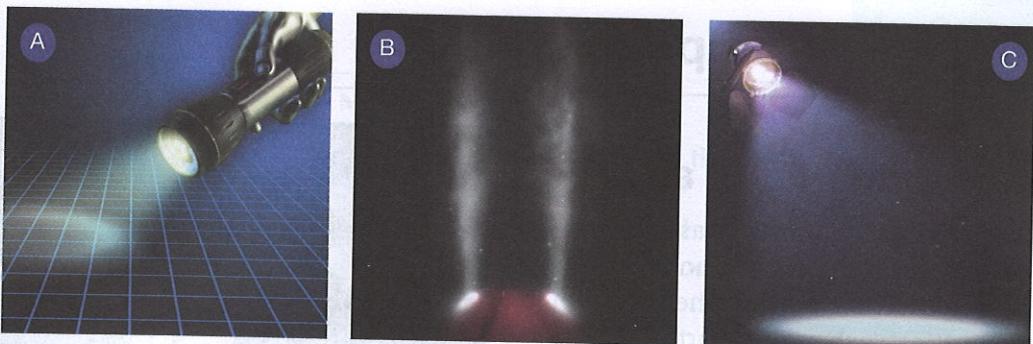


Figure 58 Concave mirrors or reflectors create light beams in A: torches; B: car headlights; C: spotlights.



Figure 59 A selection of optical instruments that use biconvex lenses.

### New words

**concave mirror:** a mirror whose reflective surface curves inwards  
**beam of light:** a bundle of parallel light rays



Figure 60 Biconvex lens (left) and a biconcave lens (right).

### Activity 35 Revise reflection and refraction

1. a) Define reflection.
- b) Draw a diagram to show a ray of light striking a smooth surface and being reflected. Label the incident and reflected rays and the angles of incidence and reflection.
- c) State the two laws of reflection.
- d) Give one use of a periscope.
- e) Give one application of reflection.
2. a) Define refraction.
- b) Draw a diagram to show a light ray being refracted at the boundary between air and water. Label the incident ray, normal, refracted ray, and the angles of incidence and refraction.
- c) Define apparent depth.
- d) Give one application of refraction.

## Components of air

Air is a mixture of many gases. These gases occur in different amounts in the atmosphere. Mixed with the gases are impurities, such as dust particles, sand and waste gases from industries that pollute the air. The atmosphere is made of several gases:

- nitrogen ( $N_2$ ), about 78%
- oxygen ( $O_2$ ), about 21%
- carbon dioxide ( $CO_2$ ), about 0.04%
- water vapour, varying amounts.

The amounts of water vapour and impurities in the atmosphere differ with the condition of the day and the environment.

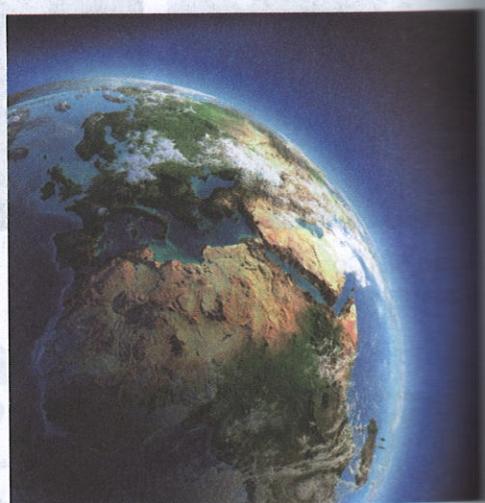
On a hot, wet day when the humidity is high, the amount of water vapour in the air is higher than on a hot, dry day.

There are more impurities in air in areas where there are a lot of emissions of waste gases, such as in areas where there are mines and factories.

## Proportions of gases in the air

## Activity 36 Investigate the proportion of oxygen in air

Work in groups of three when doing this activity. Be careful with matches and the burning candle.



**Figure 61** A section of the planet earth showing Africa with various layers of the atmosphere visible around earth.

### New word

**humidity:** the amount of water vapour in the air



Figure 6.2 The effect of candle has just been covered.

**Explanation of observation**



## Experiment

### Materials

- glass trough or plastic bowl
- candle
- matches
- gas jar or clear glass bottle
- four metal blocks or metal nuts

### Method

1. Fix the candle firmly to the bottom of the dry trough/bowl.
2. Place enough water in the trough/bowl to cover the lower half of the candle.
3. Light the candle.
4. While the candle is burning, cover it with a dry gas jar/glass bottle.
5. Observe what happens to the candle and the water level in the trough/bowl and the gas jar/glass bottle.

### Observations/Results

The expected results are shown in Figure 62.

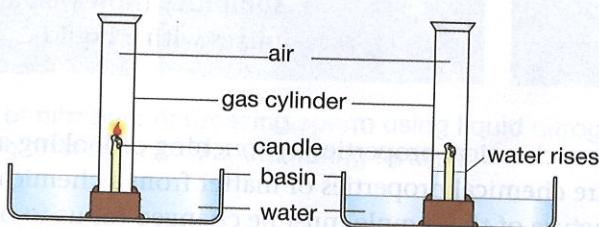


Figure 62 The effect of covering a burning candle with a gas cylinder: A: The candle has just been covered. B: The observation after the candle has gone out.

### Explanation of observations

As the candle burnt, the level of the water in the gas cylinder rose until the candle went out. The water level rose to replace the air that was used during burning (combustion). The water rose to a level of about one fifth (20%) of the height of the gas cylinder. This amount corresponds with the proportion of oxygen in air. This shows that oxygen is the gas that supports combustion, and that oxygen makes up about 20% of the air in the atmosphere.

## Activity 37 Revise oxygen in air

1. Explain why the candle stopped burning.
2. How much (what volume) of the gas cylinder filled with water?
3. Explain why the water was able to move into the gas cylinder.
4. Name the gas that supports combustion.

- Plants with nodules convert nitrogen into nitrates. This enriches the soil.
- Nitrogen is used in the Haber-Bosch process.
- Nitrogen is an important component of fertilisers.
- Nitrogen is used to freeze food.

## The nature and uses of the gases in the air

All matter has physical and chemical properties that we sometimes describe as the nature of the matter.

We can see or measure physical properties without changing the composition of the matter. We use these properties to observe and describe matter. These properties include:

- appearance
- texture
- colour
- odour (smell)
- melting point
- boiling point
- density
- solubility (how well a substance mixes with a liquid).

### New word

**solubility:** how well a substance mixes with a liquid



Figure 6.3 Uses of nitrogen  
B: Manufacturing ammonia

We cannot determine chemical properties by touching or looking at a sample. We observe and measure chemical properties of matter from a chemical change to a substance. The structure of the sample must be changed for us to observe the chemical properties.

## Nitrogen

### The physical properties/nature of nitrogen

- It is a gas.
- It is colourless.
- It has no smell (it is odourless).
- It is tasteless.
- It is slightly soluble in water.
- It has almost the same density as that of air.
- It occupies the largest part of air in the atmosphere.

### The uses of nitrogen

Nitrogen is an important element with the following uses.

- It provides a non-reactive (inert) environment:
  - » inside an incandescent (ordinary) light bulb to prevent the filament from reacting with oxygen in air
  - » to protect historical documents by preventing paper and ink from reacting with the oxygen in air. This stops the document decomposing (rotting).

## Oxygen

### Physical properties/

- Its density is approximately 1.43 times that of air.
- It is a gas.
- It is colourless.
- It is tasteless.

### Uses of oxygen

Oxygen has many practical uses.

#### Medical

- Oxygen supplementation
- Oxygen therapy is used to treat people with breathing difficulties.
- Oxygen is used in ventilators to help people breathe.
- Oxygen is used in incubators to help premature babies breathe.

- Plants with nodules containing bacteria, such as legumes, can convert nitrogen into nitrates. This enriches the soil with nitrates for good plant growth.
- Nitrogen is used in the preparation of ammonia when it is made to react with hydrogen.
- Nitrogen is an important element that is found in fertilisers, such as ammonia nitrate.
- Nitrogen is used to freeze materials and keep things cold during transportation.

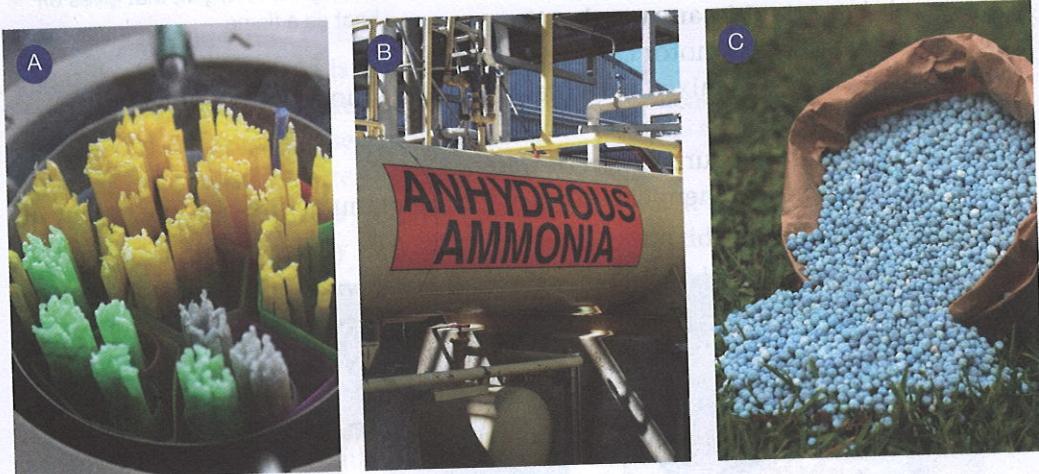


Figure 63 Uses of nitrogen: A: Freezing sperm using liquid nitrogen; B: Manufacturing ammonia; C: Manufacturing fertiliser

## Oxygen

### Physical properties/nature of oxygen

- Its density is approximately the same as that of air.
- It is a gas.
- It is colourless.
- It is tasteless.
- It is odourless.
- It is slightly soluble in water (100 cm<sup>3</sup> of water contain about 4 cm<sup>3</sup> of oxygen).

### Uses of oxygen

Oxygen has many practical uses.

#### Medical

- Oxygen supplementation increases the oxygen levels in patients' blood.
- Oxygen therapy is used to treat some infections, diseases and disorders. Examples are pneumonia, emphysema and heart failure.
- Oxygen is used in ventilators for patients on life support systems.
- Oxygen is used in incubators for premature babies.

## Industrial

- Oxygen is used in oxy-acetylene flames for welding and cutting metals.
- Oxygen is used for manufacturing steel from iron. It oxidises impurities, such as carbon, sulphur, silicon and phosphorus which are found in iron. The steel is then pure.
- Oxygen is important in any **combustion** process, including the motor car engine and rocket fuel. Oxygen is mixed with fuel both in the motor car engine and in rockets.
- Oxygen is used in the purification of water.
- Oxygen is used in the chemical industry for the manufacture of some chemical compounds.

## New words

**oxidise:** to combine with or to add oxygen  
**combustion:** burning; a chemical reaction between substances, usually with oxygen, that gives off heat as a flame

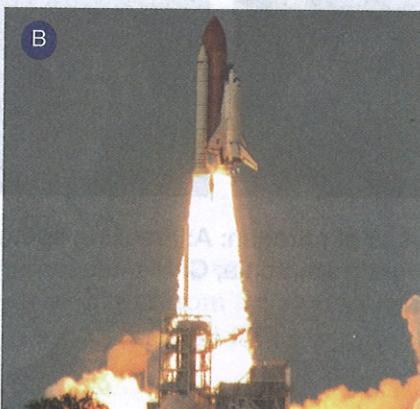
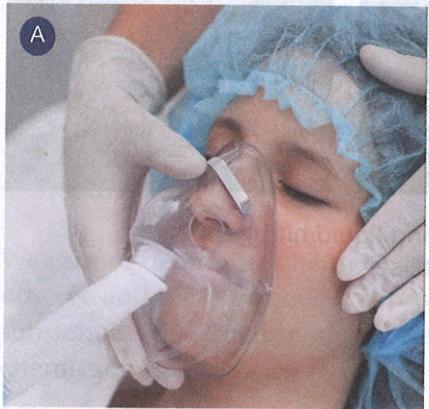


Figure 64 Uses of oxygen: A: Ventilators to keep people alive; B: In any kind of combustion process oxygen is mixed with fuel to cause a controlled explosion as in rocket launches and motor car engines; C: Oxy-acetylene torch; D: Manufacturing steel

## Carbon dioxide

### Physical properties/

- It is a colourless gas.
- It is odourless.

### Uses of carbon dioxide

- Carbon dioxide does not burn and it is non-flammable and it makes it useful in fire extinguishers.
- Carbon dioxide gas is used to make drinks, such as soda water.
- Carbon dioxide is used as a refrigerant (dry ice). This is done by cooling carbon dioxide begins to turn into a solid. Carbon dioxide is used as a refrigerant.
- Carbon dioxide gas is used to make yeast rise. When yeast produces carbon dioxide it causes the yeast to escape.
- Carbon dioxide is used in the production of glucose and oxygen gas.



Figure 65 Uses of carbon dioxide: A: A refrigerant, dry ice; B: A fire extinguisher

## Carbon dioxide

### Physical properties/nature of carbon dioxide

- It is a colourless gas.
- It is denser than air.
- It is odourless.
- It is soluble in water.

### Uses of carbon dioxide

- Carbon dioxide does not support combustion, is **non-flammable** and is denser than air. This makes it useful in fire extinguishers.
- Carbon dioxide gas is used in carbonated drinks, such as soda water.
- Carbon dioxide is used as a refrigerant because it can be made into a white solid (dry ice). This is done by making liquid carbon dioxide evaporate. As the solid carbon dioxide begins to form, the temperature falls to  $-78^{\circ}\text{C}$ . When heated, carbon dioxide sublimates, leaves no residue and cools the surroundings.
- Carbon dioxide is used as a coolant in refrigerators to keep temperatures low.
- Carbon dioxide gas is used in bakeries. During baking, baking powder or yeast is added to dough. When the dough begins to ferment, the baking powder or yeast produces carbon dioxide. This causes the dough to rise as the gas begins to escape.
- Carbon dioxide is used by green plants during photosynthesis to produce food (glucose) and oxygen gas.

#### New word

**non-flammable:** not easily set on fire and does not burn easily

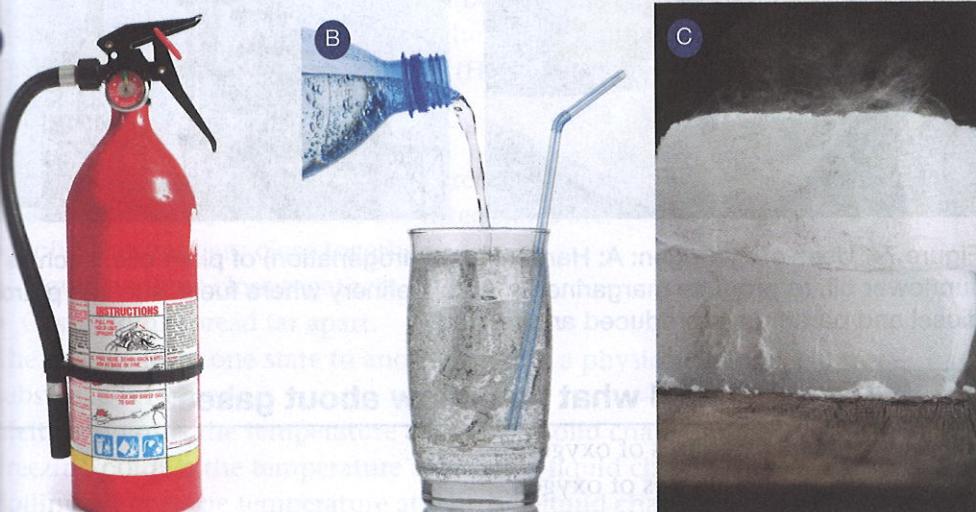


Figure 65 Uses of carbon dioxide: A: Fire extinguishers; B: Carbonated water and drinks; C: A refrigerant, dry ice

## Hydrogen

Hydrogen is the lightest, simplest and most abundant element in the universe. But, it does not normally exist as a free gas: It is present in compounds, such as water, ammonia and ammonium compounds, for example, fertilisers. These fertilisers include ammonium nitrates and ammonium chlorides.

## Physical properties/nature of hydrogen

- It is a gas.
- It is colourless.
- It is odourless
- It is less dense than air.

## Uses of hydrogen

Hydrogen is used:

- in the production of ammonia
- for removing impurities in refining petrol
- extracting metals such as iron, from oxide ores
- in the production of fertilisers, such as ammonia compounds
- for hardening vegetable oils – this changes them into solid saturated fats, such as margarine.



Figure 74 Uses of hydrogen: A: Hardening (hydrogenation) of plant oils, such as sunflower oil, to produce margarine, B: An oil refinery where fuels, such as petrol, diesel and paraffin are produced and refined

## Activity 38 Recall what you know about gases

1. List three medical uses of oxygen.
2. List four industrial uses of oxygen.
3. List five uses of carbon dioxide.
4. List five uses of hydrogen.

## Summary, revision and assessment

### Summary

#### Composition of matter

- All matter is made of particles called atoms (basic building blocks of matter).
- Atoms combine chemically to form molecules.
- A molecule that consists of two or more atoms of different elements is a compound.
- Substances that consist of atoms of only one type are called elements.
- An atom contains three sub-atomic particles: protons, neutrons and electrons.
- Protons and neutrons occur in the nucleus; electrons occur in a cloud around the nucleus.
- Electrons are arranged in many different shells or energy levels around the nucleus.
- The number of protons in an atom is the same as the number of electrons.
- Each element is represented by a chemical symbol.
- A chemical symbol is a shorthand way of representing an element and is usually taken from the element's name.
- Elements are divided into metals, metalloids, and non-metals.
- Some common elements with their symbols are carbon (C), hydrogen (H), oxygen (O), nitrogen (N), Copper (Cu), iron (Fe) and aluminium (Al).
- A molecule is a group of two or more atoms held together by chemical bonds. The atoms that form a molecule can either be the same or different.
- Some common molecules with their chemical formulae are: water ( $H_2O$ ); carbon dioxide ( $CO_2$ ); oxygen ( $O_2$ ); hydrogen ( $H_2$ ) and nitrogen ( $N_2$ ).

#### Physical change of state

On earth, matter usually occurs in three states: solid, liquid or gas.

The arrangements of atoms in the three states are:

- Solid – atoms very close together
- Liquid – atoms close together
- Gas – atoms spread far apart.

The change from one state to another state is a physical change. No new substance is formed.

Melting point is the temperature at which a solid changes into a liquid.

Freezing point is the temperature at which a liquid changes into a solid.

Boiling point is the temperature at which a liquid changes into a gas.

Condensation point is the temperature at which a gas changes into a liquid.

Sublimation point is the temperature at which a solid changes into a gas.

Deposition point is the temperature at which a gas changes into a solid.

## Summary, revision and assessment continued

### Mixtures

- A mixture is made of two or more substances that are not chemically combined.
- Mixtures can be homogeneous or heterogeneous.
- Homogeneous mixtures are substances that mix together uniformly.
- Heterogeneous mixtures are substances that do not mix uniformly.
- The components of a mixture can be separated from each other by physical methods.
- Some physical methods of separating mixtures are:

Separation method	Action	Example
Filtration	Separates insoluble particles from liquids using filter paper	Separating a sand and water mixture
Simple distillation	Purifies a liquid mixture using the boiling points of the two liquids	Removing the alcohol from a water and alcohol mixture
Evaporation	Recover a substance from a solution	Removing salt from seawater
Crystallisation	Removes a pure substance from an impure solution	Separating copper sulphate from a copper sulphate solution
Magnetisation	Separates certain metals from non-magnetic metals	Separating iron from other materials in a scrap yard

Practical applications of physical separation techniques in industry include:

- » producing sugar from sugar cane
- » extracting salt from seawater.

### Mass and weight

- Mass is the measurement of the amount of matter in a substance.
- Mass is measured in grams (g) and kilograms (kg).
- Mass is measured using a beam balance, triple beam balance or electronic balance.
- Weight is the force exerted on an object due to gravity.
- Weight is determined by the mass of the object and the distance from the centre of earth.
- Weight is measured in newtons (N).
- Weight (N) = mass (kg)  $\times$  10.
- The weight of an object on earth differs slightly from place to place.
- Weight is measured using a spring balance or a scale.

### Density

- Density is the measure of mass per unit volume.  
$$\text{density} = \frac{\text{mass}}{\text{volume}}$$
- The unit for density is g/cm<sup>3</sup>.
- Different substances have different densities.
- When an object is placed in a liquid, it sinks.
- When an object is placed in a liquid, it floats.
- When two liquids of different densities are mixed, the liquid with a lower density floats on top.
- Displacement happens when an object pushes a liquid out of the way. The liquid displaced will be equal in mass to the object.
- When an object pushes a liquid out of the way, it displaces the liquid.
- Dense materials can float in a large volume of air. The density of air is less than the density of most materials.

### Heat transfer

- Heat can be transferred in three ways.
- Conduction is the transfer of heat through a solid object.
- Substances that transfer heat easily are called good conductors.
- Convection is the transfer of heat by currents.
- Radiation is the transfer of heat by waves.
- A vacuum flask is designed to prevent heat transfer.
- The inner part of a vacuum flask is a vacuum.
- This vacuum prevents heat transfer by conduction, convection and radiation.

### Heat and expansion

- Substances expand when heated.
- When substances expand, the number of particles increase in number.
- The amount of expansion depends on the type of substance. Solids expand the least, liquids expand more and gases expand the most.
- The amount of expansion is proportional to the temperature change.

## Density

- Density is the measurement of the amount of matter/mass in a given volume:  
» density =  $\frac{\text{mass}}{\text{volume}}$
- The unit for density is grams per cubic centimetres (g/cm<sup>3</sup>).
- Different substances have different densities.
- When an object is placed into a liquid with a lower density than that of the object, it sinks.
- When an object is placed into a liquid with a higher density than that of the object, it floats.
- When two liquids of different densities are poured into one container, the one with a lower density floats on top of the other liquid.
- Displacement happens when an object is placed into a liquid. The object pushes the liquid out of the way and takes the place of the water. The volume of the liquid displaced will be equal to the volume of the object under water.
- When an object pushes down against the water it is in, the water pushes up against the object. This force is called buoyancy.
- When displacement and buoyancy are equal, an object will float.
- Dense materials can float by changing their shape so that the shape holds a large volume of air. This decreases an object's average density. If the average density is less than the density of water, the object will float.

## Heat transfer

- Heat can be transferred by conduction, convection and radiation.
- Conduction is the transfer of heat through solids.
- Substances that transfer heat better and more rapidly than other substances are called good conductors of heat.
- Convection is the transfer of heat by the movement of particles in a liquid or gas.
- Radiation is the transfer of heat through space.
- A vacuum flask is designed to keep hot things hot and cold things cold for long.
- The inner part of a vacuum flask has double walls with a vacuum between them.
- This vacuum prevents heat loss or gain by conduction and convection.

## Heat and expansion of substances

- Substances expand when they are heated and contract when they are cooled.
- When substances expand or contract, their particles stay the same size and do not increase in number. The spaces between the particles change.
- The amount of expansion which takes place is small in the case of solids, larger for liquids and very large for gases.

## Summary, revision and assessment continued

- If substances are cooled to the same temperature, there is less contraction in solids, more in liquids and most in gases.
- Materials differ in how much they expand or contract.
- Thermometers measure temperature and work on the expansion of liquids.
- Thermostats maintain temperature between limits in electrical appliances.
- Bimetallic strips are used as switches in thermostats.
- A bimetallic strip makes use of different rates of expansion of solids.
- Internal combustion engines use the rapid expansion of compressed gases when ignited to move the pistons, which cause the crankshaft to turn, which causes the wheels of a vehicle to turn.
- The effect of expansion and contraction of substances can cause problems in the cracking of bridges, railway lines buckling and glass/window panes breaking.

### Reflection and refraction of light

- Reflection is light bouncing off a surface.
- Light rays that strike a mirror are reflected and appear to come from behind the mirror.
- The light ray that strikes the surface is called the incident ray.
- The light ray that leaves the surface is called the reflected ray.
- The normal is an imaginary line drawn perpendicular to the reflecting surface.
- The angle of incidence is the angle between the incident ray and the normal.
- The angle of reflection is the angle between the reflected ray and the normal.
- Refraction is bending of light rays when they pass from one material to another.
- The incident ray is the path followed by a light ray before refraction.
- The refracted ray is the path followed by a light ray after refraction.
- When the incidence ray hits a medium at right angles, it is not refracted.
- When light moves from a less dense medium to a denser material, it is refracted towards the normal.
- When light moves from a denser medium to a less dense material, it is refracted away from the normal.
- The actual position of an object under water is called the real depth, and the apparent (false) position of an object under water is called the apparent depth.
- Reflection of light is used in search lights, headlamps, spotlights and magnifying mirrors by using concave reflecting surfaces.
- Refraction of light is used in optical instruments that contain lenses, such as spectacles, microscopes, hand lenses, camera lenses, binoculars and telescopes.

### Composition of air

- The air is composed of gases in very small amounts.
- The proportion of gases is constant (0.04% carbon dioxide).

### The physical properties of air

Gas	Physical properties
Nitrogen	<ul style="list-style-type: none"><li>• A colourless, tasteless gas</li><li>• Slightly soluble in water</li><li>• Density is about the same as the air</li><li>• Occupies three-quarters of the atmosphere</li></ul>
Oxygen	<ul style="list-style-type: none"><li>• A colourless, tasteless gas</li><li>• Density is about the same as the air</li><li>• Slightly soluble in water</li></ul>
Carbon dioxide	<ul style="list-style-type: none"><li>• A colourless, tasteless gas</li><li>• Denser than air</li><li>• Soluble in water</li></ul>
Hydrogen	<ul style="list-style-type: none"><li>• A colourless gas</li><li>• Less dense than air</li></ul>

## Composition of air

### Composition of air

The air is composed of nitrogen, oxygen, carbon dioxide, water vapour, other gases in very small amounts and impurities.

The proportion of gases in air is: nitrogen (78%), oxygen (21%), carbon dioxide (0.04%), other gases (>1%) and water vapour (varying).

### Physical properties and practical uses of various gases

Gas	Physical properties	Practical uses
Nitrogen	<ul style="list-style-type: none"> <li>A colourless, odourless, tasteless gas</li> <li>Slightly soluble in water</li> <li>Density is almost the same as that of air</li> <li>Occupies the largest proportion of air in the atmosphere</li> </ul>	<ul style="list-style-type: none"> <li>Provides a non-reactive environment</li> <li>Preparation of ammonia and artificial fertilisers</li> <li>Freezing materials and keeping things cold when transported</li> </ul>
Oxygen	<ul style="list-style-type: none"> <li>A colourless, odourless, tasteless gas</li> <li>Density is almost the same as that of air</li> <li>Slightly soluble in water</li> </ul>	<p><b>Medical</b></p> <ul style="list-style-type: none"> <li>Increases the oxygen levels in patients' blood</li> <li>Treat infections and diseases</li> <li>Used in ventilators and incubators</li> </ul> <p><b>Industrial</b></p> <ul style="list-style-type: none"> <li>Used in oxy-acetylene flames and manufacturing steel</li> <li>Mixed with fuel to cause controlled explosions to move motor cars and rockets</li> <li>Used for purifying water</li> <li>Use for manufacturing certain chemical compounds</li> </ul>
Carbon dioxide	<ul style="list-style-type: none"> <li>A colourless, odourless, tasteless gas</li> <li>Denser than air</li> <li>Soluble in water</li> </ul>	<ul style="list-style-type: none"> <li>Used in fire extinguishers, carbonated drinks, refrigerant in the form of dry ice</li> <li>Causes dough to rise in baking</li> <li>Used by green plants during photosynthesis to produce food</li> </ul>
Hydrogen	<ul style="list-style-type: none"> <li>A colourless, odourless gas</li> <li>Less dense than air</li> </ul>	<ul style="list-style-type: none"> <li>Used in ammonia production, petrol refining, reduction of oxide ores, fertiliser production</li> <li>Used for hardening vegetable oils</li> </ul>

## Summary, revision and assessment continued

### Revision

- Give the correct term for each of the following descriptions. Write only the term next to the question number.
  - The units from which all matter is made
  - The positively charged sub-atomic particle
  - The sub-atomic particle that contributes almost nothing to the mass of an atom
  - The uncharged sub-atomic particle
  - The state of matter in which the particles have the most energy
  - The state of matter in which the particles are closest together
  - The change between one state of matter and another
  - The temperature at which a solid changes into a liquid
  - The temperature at which a gas becomes a liquid
  - A substance which consists of two or more different substances that are not chemically joined
  - The physical method of separation that uses the different boiling points of different liquids
  - The process in sugar refining when juice is passed through a charcoal bed to remove coloured material
- Choose an item from Column B that matches a description in Column A. Write only the letter next to the corresponding question number.

[12]

[5]

	Column A		Column B
a)	Separation of a mixture using filter paper	i)	Magnetisation
b)	Removal of salt from seawater	ii)	Solid
c)	Change in state from solid to gaseous phase	iii)	Evaporation
d)	The vibration of atoms around a fixed point	iv)	Filtration
e)	The separation of steel from aluminium	v)	Sublimation
		vi)	Deposition
		vii)	Liquid

- Give the correct term for each of the following descriptions. Write only the term next to the question number.
  - The unit in which mass is measured
  - The instrument used to measure mass
  - The unit in which force is measured
  - The instrument used to measure force
  - The mass per unit volume
  - The upward force of a liquid
  - The lines found on a balance scale that can be safely loaded
  - The amount by which a substance will sink into the water
  - The amount of space an object occupies
  - The fact that an object falls towards the earth's gravity.
- Choose an item from Column B that matches a description in Column A. Write only the letter next to the corresponding question number.

	Column A
a)	Increased movement of particles
b)	Decreased distance between particles
c)	An instrument used to measure temperature
d)	A metal plate used to heat each other
e)	An instrument used to measure force
f)	Increased volume of a liquid
g)	The most common scale used in the world
h)	An electrical switch that connects different types of metal

Give the correct term for each of the following descriptions. Write only the term next to the question number.

- a) The unit in which mass is measured
- b) The instrument used to determine the mass of an object
- c) The unit in which weight is measured
- d) The instrument used to determine the weight of an object
- e) The mass per unit volume of a substance
- f) The upward force on a ship exerted by the water in which it is floating
- g) The lines found on the side of a ship that show the level to which it can be safely loaded
- i) The amount by which the water level rises when an object is placed into the water
- j) The amount of space occupied by an object
- k) The fact that an object in space is no longer under the influence of earth's gravity.

[10]

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

	Column A		Column B
a)	Increased movement of particles in matter	i)	Cooling
b)	Decreased distance between particles in matter	ii)	Thermostat
c)	An instrument used to measure temperature	iii)	Connecting plate
d)	A metal plate used to join railways tracks to each other	iv)	Heating
e)	An instrument used to regulate temperature	v)	Fahrenheit
f)	Increased volume of matter	vi)	Fish plate
g)	The most commonly used temperature scale	vii)	Thermometer
h)	An electrical switch made from two different types of metal	viii)	Power stroke
		ix)	Celsius
		x)	Bimetallic strip
		xi)	Expansion
		xii)	Compression stroke

[8]

## Summary, revision and assessment continued

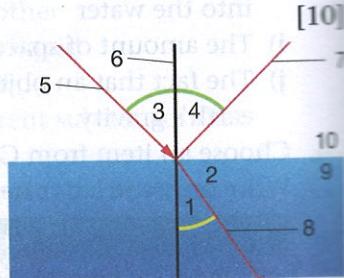
5. Give the correct term for each of the following descriptions. Write only the term next to the question number.

- The transfer of heat through solids
- A space or area that does not contain matter
- The apparatus used to show the movement of heat in a gas
- The transfer of heat by the movement of particles in a liquid or gas
- Substances through which heat is able to pass easily
- The piece of equipment used to keep liquids at a constant temperature
- The method of heat transfer that lets us to feel heat from a heater
- The transfer of heat through space
- A wind blowing from the ocean towards the land
- The constant rising of warm liquid and sinking of cool liquid in a pot of water being heated.

6. Various options are provided as possible answers to the following questions. Refer to the diagram, and choose the correct answer. Write only the letter next to the corresponding question number.

- Which number represents the reflected ray?  
A 5      C 7  
B 6      D 8
- Which angle represents the angle of refraction?  
A 1      B 2      C 3      D 4
- Which number represents the refracted ray?  
A 5      B 6      C 7      D 8
- Which angle represents the angle of incidence?  
A 1      B 2      C 3      D 4
- Which material (medium) is less dense?  
A 2      B 3      C 9      D 10
- Which number represents the incident ray?  
A 5      B 6      C 7      D 8
- Which angle represents the angle of reflection?  
A 1      B 2      C 3      D 4
- Which number represents the normal?  
A 4      B 6      C 9      D 10

7. Choose an item from Column B that matches a description in Column A. Write only the letter next to the corresponding question number. You can use the same answer more than once.



[10]

[8]

a)	Amount of water
b)	Most abundant g
c)	Gas that makes u
d)	Gas used for a no
e)	The gas that has
f)	Gas used to solid
g)	Gas used during

## Assessment exercise

- Name the basic units
- Describe an atom and
- Name the three basic
- Name the three states
- most commonly.
- The diagram represents
- three states of matter

  - Identify the proce
  - Name a substance
  - Which arrow repr

- Define the following

  - melting point

- Draw diagrams to

  - a liquid

- Compare the mov

  - of the particles in

- Study the graph and
- questions.

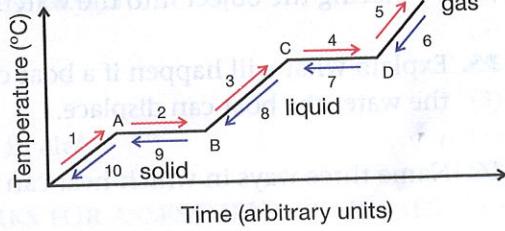
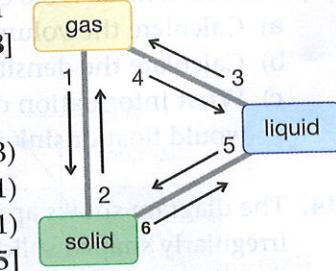
  - At which point(s)
  - addition of heat e
  - an increase in tem
  - At which point(s)
  - temperature chan
  - the addition of en
  - Name the physica

Column A	Column B
a) Amount of water vapour in the atmosphere	i) Oxygen
b) Most abundant gas in earth's atmosphere	ii) Helium
c) Gas that makes up 21% of earth's atmosphere	iii) Carbon dioxide
d) Gas used for a non-reactive environment in museums	iv) Hydrogen
e) The gas that has a higher density than air	v) Humidity
f) Gas used to solidify vegetable oils into margarine	vi) Water vapour
g) Gas used during the refining process of petrol	vii) Nitrogen

Total marks for Revision exercises [60]

## Assessment exercises

1. Name the basic units of matter. [1]
2. Describe an atom and a molecule, and give two examples of each. [8]
3. Name the three basic sub-atomic particles found in an atom. [3]
4. Name the three states of matter that occur on earth most commonly. [3]
5. The diagram represents the changes between the three states of matter.
  - a) Identify the processes numbered 6, 3 and 1. (3)
  - b) Name a substance which undergoes process 2. (1)
  - c) Which arrow represents freezing? (1)
6. Define the following:
  - a) melting point b) boiling point. (4)
7. a) Draw diagrams to represent the arrangement of particles in:
  - i) a liquid
  - ii) a solid
  - iii) a gas.
- b) Compare the movement of the particles in a solid with the movement of the particles in a liquid. (3)
8. Study the graph and answer the questions.
  - a) At which point(s) does the addition of heat energy cause an increase in temperature? (2)
  - b) At which point(s) is there no temperature change, despite the addition of energy? (2)
  - c) Name the physical changes that are happening at points 2 and 7. (2)



## Summary, revision and assessment continued

9. a) Define a mixture.  
b) Compare a homogeneous mixture with a heterogeneous mixture.  
c) Name seven physical methods of separating mixtures.

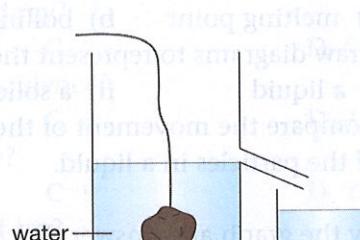
10. Explain what is meant by the terms mass and weight.

11. An object has a mass of 20 kg. Calculate its weight.

12. a) Define density.  
b) A metal block has a mass of 45 g and a volume of  $6 \text{ cm}^3$ . Calculate the density of the block.  
c) Will this block float or sink if placed in mercury?  
(Density of mercury =  $13.6 \text{ g/cm}^3$ )  
d) Give a reason for your answer to question 3c.

13. A block of metal is 3.0 cm long, 55.0 cm wide and 6.0 cm high. Its mass is 90 g.  
a) Calculate the volume of the metal block.  
b) Calculate the density of the metal block  
c) What information do you need to decide whether or not this block would float or sink in a liquid?

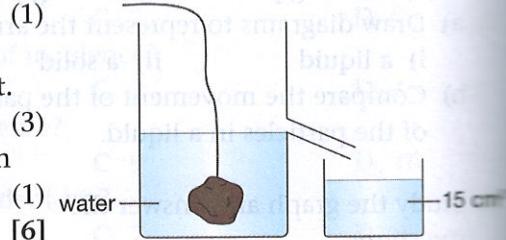
14. The diagram shows apparatus used to determine the density of an irregularly shaped solid object.  
a) What is the volume of the irregular solid object?  
b) Name the apparatus used to find the mass of the object. (1)  
c) If the mass of the object is 45 g, calculate the density of the object.  
Show your working. (3)  
d) State one precaution to take when placing the object into the water. (1) [6]



15. Explain what will happen if a boat carries a load greater than the mass of the water the boat can displace.

16. Name three ways in which heat can be transferred from its source.

17. Explain how the following parts of the vacuum flask minimise heat loss.  
a) Vacuum  
b) Silvered walls  
c) Cork



18. Name and explain briefly an example of the practical use of expansion in everyday life due to:

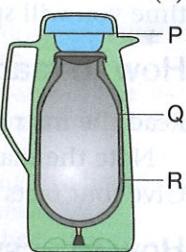
a) liquid expansion      b) solid expansion      c) gas expansion.

19. a) Name the parts labelled Q and P. [6]

b) Give a reason why P is made of (cork) wood or plastic. (2)

c) Explain how heat loss is reduced by the parts labelled P, Q and R. (3)

d) Name the process by which heat can pass through space R. (1)



19. [8]

20. Define the following:

a) reflection      b) refraction.

[4]

21. Study the diagram and answer the questions.

a) What process happens to ray A as it moves from substance 1 to substance 2? (2)



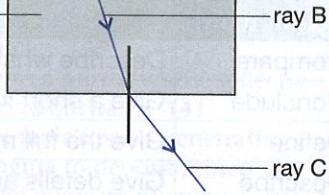
b) Name the ray marked B. (1)

c) Which of the two substances is denser? (1)

d) Give a reason for your answer to question 2c. (2)

e) Give two effects we observe in everyday life of the process named in 2a. (2)

[8]



22. a) Give the gaseous composition of clean air.

(4)

b) What percentage of the atmosphere is oxygen? (1)

c) Give three uses of oxygen. (3)

d) State three properties of oxygen. (3)

e) Give three uses of carbon dioxide. (3)

f) What is the percentage of nitrogen in air? (1)

[15]

**TOTAL MARKS FOR ASSESSMENT EXERCISES: 140**

### 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
Investigate	Follow a systematic way of analysing a problem
Match	Pair an item with another to which it is related, or which it resembles
State	Give, say or write down the information asked for
Suggest	Give ideas, solutions or reasons for something
Summarise	Give the main points, briefly

**A**  
acid rain: harmful rain that has been made acidic by gases from burning fossil fuels 54  
AIDS: an illness that makes people more likely to get infections and diseases 9  
antibiotic: medicine that destroys bacteria and other organisms 10  
anti-oxidant: a chemical that protects the body's ability to fight infections 10  
apparent depth: distance an object appears to be below the surface of the water 11  
aquifer: underground water-bearing layer of rock 49  
atom: the smallest unit of a substance 10

**B**  
balanced diet: a diet with the right amounts of each food type 10  
beam balance: a balance that has a beam with two arms and a pan suspended from each arm 110  
beam of light: a bundle of light rays 11  
binocular strip: two strips of material joined closely together 11  
biodegradable: able to be broken down by living organisms, such as bacteria 11  
boiling point: the temperature at which a liquid boils 113  
bowel: the intestine 10  
built-up environment: buildings in a town or city 52  
buoyancy: a force on an object that makes it float so that it moves upwards 11  
buttocks: the round fleshy part of the human bottom 7

**C**  
carbohydrates: a food type that are broken down to release energy. Also known as starch 26  
cell membrane: a thin layer of fat that surrounds a cell 11  
cervical canal: narrow canal of the uterus 4  
cervix: narrow end of a uterus 4  
CH<sub>4</sub>: gases or fumes that may contribute to the breakdown of ozone in the atmosphere 54  
chemical bond: the pull that holds atoms 95

## Glossed index

### A

acid rain: harmful rain that has become dirty and polluted 54  
AIDS: an illness that makes people open to infections and diseases 9  
antibiotic: medicine that destroys micro-organisms 10  
anti-oxidant: a chemical that increases the body's ability to fight infection 29  
apparent depth: distance an object appears to be below the surface of the water 145  
aquifer: underground water between layers of rock 49  
atom: the smallest unit of a substance 92

### B

balanced diet: a diet with the correct amounts of each food type 26  
beam balance: a balance that has a lever with two arms and a pan suspended from each arm 110  
beam of light: a bundle of light rays 147  
bimetallic strip: two strips of different metals joined closely together 136  
biodegradable: able to be broken down by biological means, such as bacteria 59  
boiling point: the temperature at which boiling occurs 103  
bowel: the intestine 10  
built-up environment: buildings that make up a town or city 52  
buoyancy: a force on an object making the object move upwards so that it floats 122  
buttocks: the round fleshy parts of the human bottom 7

### C

carbohydrates: a food type that can be broken down to release energy; also known as starch 26  
cell membrane: a thin layer on the outside of a cell 11  
cervical canal: narrow canal of the cervix 15  
cervix: narrow end of a uterus where it joins the vagina 4  
CFCs: gases or foams that may cause a breakdown of ozone in the earth's atmosphere 54  
chemical bond: the pull that joins two atoms 95

chromosome: threadlike structure carrying genetic (hereditary) information 29

combustion: burning 137

combustion: a chemical reaction between substances, usually with oxygen, that gives off heat as a flame 152

compound: a substance made of more than one type of atom 92

concave mirror: a mirror whose reflective surface curves inwards 147

concentric: circles with the same centre 94

conception: becoming pregnant as a result of an ovum being fertilised 15

condensation: a gas changing to a liquid as a result of temperature decrease 99

conduction: the transfer of heat energy through solids 125

contamination: making impure or unclean by adding harmful substances 49

contract: to decrease in size 130

contraction: decrease in amount of space used by matter due to cooling 130

contractions: movements of the uterus muscles to enable a woman to push her baby down the birth canal and out through the vagina 17

convection: the transfer of heat energy through liquids and gases by movements of the particles 125

convex mirror: a mirror whose reflective surface curves outwards 141

copulation: a male's penis penetrating a female's vagina to deposit semen 3

crop yield: the quantity of crop produced per unit of land area 75

crude oil: naturally occurring, unrefined petroleum 58

crystallisation: the process of forming solid crystals 107

### D

deciduous: a tree or a shrub that sheds all its leaves each year 55

deficiency disease: a condition caused by a lack of any essential nutrients 75

deforestation: to cut down and remove trees or forests 58

density: the mass per unit volume of a substance 116

**deposition:** a gas changing to a solid as a result of temperature decrease 99

**detergent:** a cleansing substance that removes dirt and grease 50

**determine:** to work out 116

**diffusion:** the movement of atoms or molecules from an area of higher concentration to an area of lower concentration until the concentration is the same everywhere. Atoms and small molecules can move across a cell membrane by diffusion. 76

**dilation:** becoming wider or larger 17

**dimension:** a measure of length, width or height 130

**displacement of water:** the measure of how much water is pushed aside when an object floats 122

**distillate:** the liquid from distillation 105

**distillation:** the evaporation and subsequent condensation of a liquid to obtain a pure liquid from a solution 105

**douche:** a means of washing out the vagina with a jet of water for contraception 9

## E

**ejaculation:** ejection of semen from a male 3

**electrolyte:** a constituent of the blood and body fluids that carries an electric charge 29

**electron:** one of the particles that make up an atom; a negatively charged particle 93

**element:** has only atoms that have the same number of protons 92

**emergent ray:** the ray leaving the material 143

**eutrophication:** a process in which water sources receive too many nutrients that result in too much plant growth 50

**evaporation:** a liquid changing to a gas as a result of temperature increase 99

**exerted:** pushed or pulled by a force 114

**expand:** to increase in size 130

**expansion:** increase in amount of space used by matter due to heating 130

## F

**filtration:** the process of filtering a liquid or gas through a filter to remove solid particles 105

**force:** something that changes the way an object moves, such as a push or a pull 93

**formula:** words, numbers or symbols showing how to work out an answer 114

**free fall:** the motion of an object is only affected by gravity and nothing else – not

by the air or anything else that can slow the speed of the fall 114

**freezing:** a liquid changing to a solid as a result of temperature decrease 99

**freezing point:** the temperature at which freezing occurs 103

**fumigate:** to apply smoke, vapour or gas for disinfecting places or destroying pests 53

## G

**gamete:** sex cell; sperm (in a male), and ovum (in a female) 2

**gas:** a substance with no definite shape or volume 99

**gestation:** period from conception to birth 15

**glands:** organs which produce and release secretions (fluids and hormones) 3

**global warming:** the increasing temperature of the earth's surface, including land, water and air 54

**gonorrhoea:** an infectious disease contracted through sexual intercourse 9

**gravity:** the force that pulls objects towards each other 113

**green electricity:** produced from resources that are renewed, such as sunlight, wind, waves and geothermal heat 55

## H

**heat transfer:** the transfer of heat energy from a hotter place to a colder place 125

**heterogeneous:** not uniform; made of different parts 104

**HIV:** a virus contracted through sexual intercourse; HIV causes AIDS 9

**homogeneous:** uniform; made of parts that are all the same 104

**horizontal:** level with the horizon (or the floor) 142

**hormones:** chemical substances that act like messenger molecules in the body 6

## I

**ignite:** produce a spark 137

**impurities:** particles that do not belong in the pure substance 107

**incident ray:** ray that strikes a surface 140

**incinerator:** furnace for burning garbage 53

**industrialisation:** the development of modern industry for making goods; includes factories, machines and large-scale production processes 58

**infertile:** not able to reproduce sexually 7

**insoluble:** cannot dissolve 105

**insulation:** protection from loss of heat 29

**J**  
**junk food:** food that provides little or no nutritional value 33

**L**  
**lactating:** producing milk 35  
**light ray:** narrow beam of light 140  
**lipids:** food type that includes fats and oils 26  
**liquid:** substance with no shape 99  
**livestock:** domestic animals that are kept by people for their own use, such as milk, meat, skins, wool 51

**M**  
**malnutrition:** lack of proper nutrition as a result of not eating a balanced diet 36  
**mass:** amount of matter in a substance 110  
**maternal:** from the mother 15  
**melting:** a solid changing to a liquid as a result of temperature increase 99  
**melting point:** the temperature at which melting occurs 103  
**menstruation:** flow of blood from the uterus at monthly intervals 7  
**metal:** dense substance that is a good conductor of electricity and heat; also shiny when clean 95  
**metalloid:** a substance that has some properties of metals 95

**microscopic:** only seen with the aid of a microscope 67  
**mineral:** inorganic substance essential in a person's diet for good health 26  
**mixture:** made of two or more substances that are not chemically combined 104  
**molecular formula:** short way of writing the name of a molecule showing the number, ratio and type of atoms 97  
**molecule:** a chemical combination of two or more atoms; the smallest unit of a compound 92

**N**  
**nausea:** feeling of sickness that makes a person want to vomit 54  
**newton:** unit of measure for weight 113  
**nicotine:** a chemical in tobacco that is poisonous and harmful to a foetus 33  
**nocturnal emission (wet dream):** ejaculation as a result of a sexual dream 6  
**non-flammable:** not easily set on fire 153

**non-metal:** a chemical element that has no metallic properties 95

**normal:** an imaginary line drawn at right angles to the reflecting surface 140

**nucleus:** the small central part of an atom composed of protons and neutrons; makes up most of an atom's mass 93

**O**  
**obesity:** grossly fat or overweight from eating too much 36

**obstacle:** something that is in the way 141  
**oestrogen:** hormone that initiates females' characteristics 6

**organic food:** food grown without chemicals or pesticides 59

**osmosis:** movement of molecules through a semi-permeable membrane from a less concentrated to a more concentrated solution until both solutions have the same concentration 76

**osteoporosis:** a condition in which the bones become weak and fragile as a result of insufficient calcium 33

**ovaries:** female organs that produce ova 4  
**over-nutrition:** having too many nutrients for normal growth from eating too many fats and unrefined carbohydrates 36

**oviducts:** tubes along which ova travel from the ovaries to the uterus 4

**ovulation:** discharge of eggs from ovaries 7

**oxidise:** to combine with or add oxygen 152

**ozone layer:** a region of the upper atmosphere, between about 15 and 30 kilometres in altitude, containing ozone 54

**P**  
**particulate:** very small part; a tiny speck 49  
**penis:** male organ which ejects sperm cells into female vagina 3

**permeable:** allowing movement of substances, such as gases and salts (ions), into and out of a cell 70

**perpendicular:** at right angles 142

**pesticide:** a chemical used to kill or chase away pests 51

**physical change:** the change of matter from one phase to another with no new substance forming 99

**progesterone:** hormone that prepares and maintains the uterus for pregnancy 6

**property:** characteristics that belong to something that identifies it 99

**prostate gland:** gland that helps make semen 3

**proteins:** containing nitrogen; make up the structural parts of body cells and tissues 26

**protoplasm:** the cell membrane, cytoplasm and nucleus together 70

**R**

**radiation:** the transfer of heat energy from a hotter place to a colder place without passing through matter 127

**radioactivity:** gives off energy waves called radiation 52

**real depth:** the actual distance of an object below the surface of the water 145

**reflected ray:** ray that bounces off a surface 140

**reflection:** light bouncing off a surface 140

**refracted ray:** the path that light follows after refraction 143

**refraction:** bending of light when it passes from one material into another 143

**respiratory tract:** breathing passages 54

**response:** the reaction to a stimulus 72

**run-off:** water that runs off land 51

**S**

**selectively permeable (differentially permeable):** controls the movement of substances that enter and leave a cell 70

**semen:** liquid that consists of sperm cells and seminal fluid from glands 3

**sexual maturity:** stage at which a male or female is ready for sexual reproduction 6

**sexual reproduction:** fusion of male and female sex cells (gametes) to form a zygote that develops into the offspring 2

**shell (energy level):** areas around the nucleus of an atom where electrons with energy may be found 93

**smegma:** a secretion produced by glands in the foreskin of the penis 10

**solid:** a substance with a definite shape, but a fixed volume 99

**solubility:** how well a substance mixes with a liquid 150

**sperm duct:** tube through which sperm cells travel from testes to urethra 3

**stimulus:** a situation to which an organism responds or reacts 72

**sublimation:** a solid changing to a gas as a result of temperature increase 99

**suspended:** hanging and not sinking 105

**symmetrical:** of similar shape on both sides 15

**syphilis:** an infectious disease contracted through sexual intercourse that affects the reproductive system 9

**T**

**tampon:** a plug of soft material to absorb menstrual blood 9

**technique:** a method 108

**testosterone:** a male hormone that makes males develop male characteristics 6

**thermometer:** an instrument for measuring temperature 135

**thermostat:** device that controls temperature in a heating or cooling unit 55

**thermostat:** a heat control device 136

**Third World:** the developing countries of Africa, Asia and South America 39

**toxic:** poisonous and able to cause harm and possibly death 53

**transpiration:** the loss of water as vapour from a plant 76

**triple beam balance:** a balance with three beams that is used in a laboratory to measure the mass of sample 110

**tropic movement:** a growth movement of plants in response to a stimulus 72

**turgid:** with enough sap to make a cell firm 70

**U**

**under-nutrition:** having too few nutrients from not enough healthy food 36

**unicellular:** made of one cell 66

**urethra:** tube that transports semen through a penis 3

**uterus:** organ in which the embryo/foetus develops 4

**V**

**vacuum:** space without matter 127

**vagina:** tube that leads from the outside of a female to the uterus 4

**vibrate:** move back and forth quickly 130

**vitamin:** organic substance, essential for normal growth and good health 26

**volume:** the amount of space occupied 99

**vulva:** the external parts of the female reproductive system 7

**W**

**wasting:** weight loss due to illness 32

**weaning:** slowly taking a baby off breast milk and substituting other foods 31

**weight:** the pull of gravity on the mass of an object 113