Natural Science

Grade 7

Teacher's Guide

The content of this textbook was formatted to combine the two original workbook volumes into a single textbook

Natural Science Grade 7 Teacher's Guide

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Contents

1 The biosphere

Chapter overview

1 week

In this introduction to the biosphere learners are exposed to the components of the biosphere, namely the lithosphere, hydrosphere and atmosphere, as well as the organisms that live in each of these spheres. Learners are required to identify organisms that are specifically adapted to live in each of these spheres, in different temperatures and at different altitudes, and will learn how and why some organisms have developed specific adaptations to survive. They are then guided to distinguish between living and non-living elements of the biosphere, by identifying the seven life processes (a revision of Gr. 4 work).

Having revised the seven life processes, they will then learn what is necessary to continue these seven life processes, by studying the requirements to sustain life and learning about adaptations that enable organisms to live in extreme environments. This links back to work done in Gr. 5 and 6 on the interdependence between living and non-living things in ecosystems and food webs. Learners will look at the biosphere again in Gr. 8 in the context of ecology, as well as in Earth and Beyond in Gr. 9, where there is a greater focus on the lithosphere and atmosphere.

In the section on 'Requirements to sustain life' there is an investigation to germinate seeds and grow seedlings under different conditions. This is the first investigation for Natural Sciences in this phase. Learners will repeat a familiar study of observing the requirements to sustain the life of a bean plant; however, for the first time they are confronted with topics such as dependent and independent variables, and more on graphing. As learners progress into high school, they will be required to conduct more and more of the investigation design and planning on their own, whereas now they are still led through the steps. **NB**: We suggest doing this investigation concurrently to the rest of the content so that you are growing seedlings through the week that you do the biosphere, and you might even only finish it and do the results and conclusion a bit later.

These tables and how to use them are explained in the Teacher's Guide Overview at the front of the book. We have also explained how to use the bit.ly links to websites and videos in the front of the book.

1.1 What is the Biosphere? (1.5 hours)

Tasks	Skills	Recommendation
Activity: Where do you think life exists on Earth?	Identifying, describing, writing	CAPS suggested
Activity: Describe the components of the biosphere	Describing, writing	CAPS suggested
Activity: Study the atmosphere	Identifying, writing	Optional (Extension)
Activity: The water cycle	Remembering, identifying, describing, writing	Optional (Revision)
Activity: How do organisms depend on the lithosphere?	Identifying, describing, writing	Optional (Extension)

1.2 Requirements for sustaining life (1.5 hours)

Tasks	Skills	Recommendation
Activity: Identify the requirements for sustaining life	Identifying, discussing, group work, writing	CAPS suggested
Investigation: What are the requirements to sustain life in plants	Investigating, observing, recording, measuring, plotting graphs, group work	CAPS suggested
Activity: Adaptations in organisms	Identifying, describing, writing	Optional (Extension)

Key questions

- What is the biosphere?
- What are the coldest or hottest places where life can exist?
- How deep can you go in the sea before you do not find anything living anymore?
- Are there living organisms on top of the world's highest mountains?
- How can you tell if something is alive or if it was never alive?
- What do organisms need to stay alive?
- How come some organisms can live in certain places while others cannot?

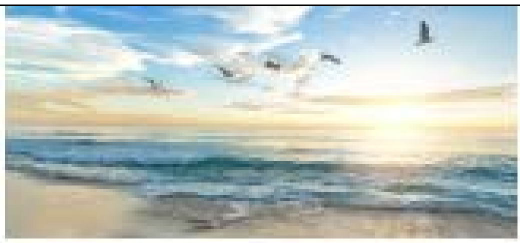
1.1 What is the biosphere?

This website has many interesting articles about science and science-related jobs. They have been classified according to topics and also provide tips on how to incorporate the articles into your classroom. If you are interested in incorporating real world science into your classroom, visit: [1] bit.ly/16zEuUf

ACTIVITY: Where do you think life exists on Earth? LB page 3

This is meant as an introductory activity to show that life exists everywhere on Earth and also bring to mind some of the work done on habitats in Gr. 4-6. You can also use it to assess what learners understand by the term 'life'. For example, do they only identify animals as life, and forget that plants are also living organisms? Learners have not yet been exposed much to microorganisms and so might not identify these as life forms.

A place on Earth	What is this image showing?	Do you think there is life there? If so, what?
	A desert with rocks, some mountains and grass.	Yes, life exists here. Organisms include: • Snakes • Birds • Grasses • Cacti • Insects • Possibly buck, jackal, hares, etc Possibly humans (this is actually a photo from

		Namibia)
	A mountain range covered in snow.	Yes, life exists here. Organisms include: l Trees (seen at bottom of photo) l Possibly bears, snow leopards, rabbits, etc. l Possibly humans
	The sky with clouds and some birds.	Yes, life exists here. Organisms include: l Birds l Insects

Components of the biosphere

ACTIVITY: Describe the components of the biosphere

LB page 4

1. There are rocks. They are hard, sharp, porous in places, eroded by water. There is sand. It is grainy, rough, contains many small pieces of shell and rocks.
2. This is the seawater and sea spray. Some learners might mention the water vapour that evaporates from the sea. The water is clear and fast flowing, the sea water tastes salty, the sea foam forms on top.
3. This is the gases. The air includes gases such as oxygen, carbon dioxide and nitrogen. Atmospheric gases are not visible, but the sky looks blue.
4. Learner-dependent answer. Learners should be able to imagine for example dolphins swimming in the water, or snails or mussels on the rocks, seaweed in the water and perhaps microbes in the sand. Other organisms could be: crabs, sea gulls and other birds, many types of fish, sharks and whales out at sea, corals, anemones, etc.

This question was specifically included in this way to assist teachers in gauging learner's ability to differentiate between living (biotic)and non-living (abiotic) components of the biosphere.

Atmosphere

ACTIVITY: The atmosphere

LB page 5

Learners do not need to know the layers of the atmosphere – this will be done in more detail in Gr. 9 Earth and Beyond. The focus of this activity is to show that the atmosphere is actually a very wide layer around the Earth, but life only exists at the bottom near to the Earth's surface where their requirements for life are met.

1. This question is deliberately included to encourage debate. Without the atmosphere, life as we know it would not be possible. The oxygen and carbon dioxide in the lower layers of the troposphere (that touches Earth) allow life to exist as organisms can respire and plants can photosynthesise. The atmosphere also helps to keep the Earth warm by trapping solar energy. The atmosphere protects life from too much UV radiation from the Sun. Earth is the only planet in our solar system that can support life, due in part to our atmosphere.

Hydrosphere

ACTIVITY: The water cycle   LB page 5

This acts as a revision of some of the previous work done on the water cycle and states of matter and links this to different aquatic habitats for organisms.

1. Water is a liquid in the sea, dams, river, rain and dew. Water is a solid as snow on the mountains (or in hail). Water is a gas as water vapour in the air.
2. Aquatic habitats include: rivers, dams, lakes, ponds, marshes, estuaries, groundwater and aquifers. There are many different aquatic habitats in the sea, such as rocky shorelines and rock pools, deep water and polar ice caps.

Lithosphere

Learners will look at the lithosphere in much more detail in Gr. 9 Earth and Beyond, where they will look at the rock cycle as well as mining in South Africa. This is meant as an introduction and the focus should be on how organisms interact with the lithosphere.

ACTIVITY: How do organisms depend on the lithosphere?   LB page 6

Learners will look at the lithosphere in much more detail in Gr. 9 Earth and Beyond, where they will look at the rock cycle as well as mining in South Africa. This is meant as an introduction and the focus should be on how organisms interact with the lithosphere.

A frequent misconception is that plants get larger and grow because of nutrients they absorb from the soil. However most of the organic mass from any plant is from carbon dioxide that is captured during photosynthesis and used to make organic molecules. It is important to stress that the main nutrient obtained from the soil is water, and relatively small amounts of minerals. If plants 'took up' the actual soil, then one would expect it to be depleted and there would be large craters around every large tree!

Some of the things which learners could note are:

- Animals live in parts of the lithosphere, such as earthworms which live in the soil, ants which make their nests out of sand. Many microorganisms live in soil.
- Some birds make their nests on rocks and also use sand to make the nests.
- Most plants and trees need soil to grow in. They absorb water and minerals and use the soil to anchor their roots.
- Rocks form rock pools on the shoreline. Rock pools are homes to many different organisms.
- Humans use mud and stones to build houses and other buildings.

Characteristics of living plants and animals

This was first introduced in Gr. 4 Life and Living and revised in Gr. 5 and 6.

The seven life processes:

1. All living things need to be able to **move**. Moving does not have to consist of big movements. Even plants move, for example, flowers and leaves turn to face the sun during the course of the day.
   Learners may wonder about certain animals that don't move (are sessile) such as anemones, barnacles and corals. Usually these animals do move during some part of their life cycle and are sessile or stationary for the adult phase. In addition, even animals that stay in one spot can

still moves parts of their body, such as barnacles which have feathery appendages which beat the water and bring food into the shell.

2. All living things need energy to perform the life processes. Organisms release energy from their food by a process called **cellular respiration**.
3. All living things need to be **sensitive** to their environment. Think of an example of why animals need to sense their environment and write it down below.
   For example, animals need to sense food and be able to find it. They also need to sense danger in their environment or sense temperature changes and respond to them.
4. All living things need to be able to **grow.**
5. All living things need to be able to **reproduce** so that they do not die out.
6. All living things need to be able to **excrete** waste.
7. All living things need **nutrition,** as they need to break down nutrients during cellular respiration to release energy.

1.2 Requirements for sustaining life

ACTIVITY: Identify the requirements for sustaining life LB page 7

The answers to this activity are summarised in the subsequent text. In order to get learners to first think about the answers and discuss them without just reading them up in the text, perhaps get them to first take notes in a separate notebook or on scrap paper and have the class discussion before opening the workbooks and allowing them to then take down some notes.

When groups are finished discussing their most important requirements, let groups share their lists with the other groups and have a class discussion. List their answers on the board and make a tick for each one that is repeated – for example Food/ Oxygen/ Water might be repeated so each time it repeats make a tick next to it. This way they will quickly be able to see which requirements are most commonly repeated in the class. Learners might identify 'Food' rather than energy. Remind them that they also have to think about the plants which do not need to eat food. So, ask the learners what term they could use as a more general term for food? This links back to nutrition in the seven life processes.

The answer is that living things need a source of energy. If learners do not come up with the fact that living things need 'favourable/good/optimal temperatures', ask them some leading questions such as: 'Do you think the space station needs to be heated or cooled? Why? Will the humans and plants be able to survive at the temperature it is on the Moon?' etc.

Ask your learners what they think makes Earth's atmosphere unique. Answers: Our atmosphere contains the right gases to sustain life (i.e. oxygen and carbon dioxide), our atmosphere also protects us from the harmful rays of the Sun (such as UV rays) by absorbing some of them.

In previous grades learners were required to complete a similar investigation to determine the optimal requirements for seeds to grow. CAPS suggests that they do this activity again in order to reinforce the concept of the requirements to sustain life. Teachers should gauge how many learners did this particular activity in previous grades and should explain that this repetition is not so much to find out what requirements are necessary to sustain life, but to give them an opportunity to learn how to conduct a science investigation. This has therefore been included again as a very good opportunity (with learners already aware of the outcome) to review the scientific method and allow learners to practise this.

INVESTIGATION: What are the requirements to sustain life in plants? LB page 9

Start growing seedlings at the beginning of the term in the first lesson. A suggestion is to break the class up into groups and assign each group a different requirement to investigate. For example, one group should test whether water is needed, one group should test whether light is needed, one group should test the favourable temperature. Each group should also conduct a control so that they can all attempt to get seed to germinate.

Aim
'To find out what plants need to grow'. (An aim MUST start with 'To find out / To determine / To see if .. etc. This is different from a scientific question like 'What do plants need to grow?')

Learner-dependent answer. The hypothesis should include a prediction about the need for soil, light, water and the favourable temperature. For example: 'The plant will grow best in full sunlight, less in the shade, and not at all in full darkness.'

Variables
Stress to the learners that dependent variables should be measured using NUMBERS as far as possible, as this leads to tables and graphs. They should avoid subjective evaluations, for example, saying that it 'looks good' or 'feels nice'. This is not science.

Ask learners if they can think of any other variables that need to be kept the same in this example. They might think of things like the starting weight of the people should be the same, they should be the same sex, same age, they should both be healthy and not sick etc.

You, the teacher, can decide how you want to conduct this investigation. Perhaps learners can just assess whether it germinates or not, or they can look at how tall the plant grows, how many leaves it grows, and so on. In most cases, the seeds probably will not germinate and grow if put in a cupboard or fridge or not given any water. So the best test is just to see whether it germinates or not.

1. Learners need to explain that they will only change one factor, i.e. remove light from the plant (by putting it in a dark cupboard) or remove water (by not watering it), while keeping all the other factors constant.
2. Learner-dependent answer
3. Learners need to explain how they will keep the other factors the same in each case but only change one at a time. It is important that learners understand and reflect on having a control group that has all the necessary factors/requirements to allow it to grow. We suggest that more than one control group be included.

The above questions give learners the opportunity to reflect on their variables and control groups. As Gr. 7s might not have had a chance to work with these concepts it is imperative that you spend time explaining why a control group is required and why only one variable be changed in each of the plants. Use the above example of testing whether eating too much sugar makes you put on weight, so that learners can then apply what you discuss about the example to this investigation.

Method
As groups are discussing their design, go around and check that they are on the right path and discuss it with them and provide help. Help learners to find ways that they can test the requirement, especially if they are looking at a favourable temperature. Perhaps you have a fridge that learners could put the seeds in? (However, remember to take into account whether the plants will receive light in the fridge). Find a suitable spot in the classroom for the control group plants, perhaps on a windowsill with light. How many seeds will the learners use for each experimental condition? Is one seed enough? What can go wrong if only one seed is used?

A suggestion is to give learners some options for materials for germinating the seeds. For example, they could either use cotton wool, or newspaper, or soil. But, whatever they use, it must be the same in the control and test plants within one group. It does not matter if different groups do different things. This should actually be encouraged.

Learners also need to think about how they are going to record their results before starting the investigation. If they are just seeing whether plants germinate or not, then perhaps they can draw a table. If they are going to be measuring how much the plants grow, then they will need a table for this, and they will then need to draw a graph. If they are measuring the growth of seedlings, a suggestion is to use string to measure out the height, and then to measure the length of the string on a ruler.

Results and observations
Learner-dependent answer. (Some examples of the types of tables learners can draw are shown below. They might need help with this and you could draw these on the board. Learners could also record the results of each other's investigations.)

Table to show whether plants have germinated or not		
Requirement being tested	**Did test plants germinate?**	**Did control plants germinate?**
Light	Some did.	Yes
Water	No	Yes
Favourable temperature	No	Yes

If the learners have included a number of seeds in each test group/ condition, they may want to express the result as numbers rather, or as a percentage of seeds that germinated.

Table to show growth of seedlings over time in light and in dark		
Day	**Average height of seedlings in dark (mm)**	**Average height of seedlings in light (mm)**
0	0	0
1	0	2
2	0	5
3	1	10
4	2	15
5	3	22
6	3	30

Analysis
Learner-dependent answer. An example of the type of line graph which could be drawn, using the information in the second table is given below. Time will be along the independent x-axis. The height of the plants is the dependent variable, and this goes along the y-axis. Both the test plants and the control plants can then be plotted on the same graph to compare the growth between the two groups. Ensure that the intervals are equal along each of the axes. On each axis the interval between points must represent an increase of the same amount! (E.g. 0, 5, 10, 15, 20, 25). However, the intervals on the x-axis and the y-axis can be different in order to suit the data. For example, you may use an interval of 1 mm on the x-axis to represent number of days, but an interval of 5 mm on the y-axis to represent change in height.

Conclusion

1. Learner-dependent answer.
2. Learner-dependent answer.
3. Learner-dependent answer.
4. Learner-dependent answer.
5. Learner-dependent answer.
6. Learner-dependent answer.

Learning about adaptations is a precursor to an understanding of the concepts of natural selection and evolution which will be introduced later in the term. Make sure that learners understand that organisms cannot will their bodies to change or learn to survive in a particular environment in a single generation (lifetime). These adaptations take place over many generations as a result of natural selection, in which organisms who are better adapted to their environment are more likely to thrive and have lots of off-spring.

These offspring will have the genes of the parents and will inherit the characteristics (adaptations) that made the parents better able to survive. Teachers do not need to go into any detail about natural selection yet but should make sure that the learners are not under the impression that any organism can 'decide' to acquire an adaptation.

Adapted for life

Discuss this with your learners. If you put a polar bear in the Kalahari Desert, it would overheat, and similarly, if you put a gemsbok in Antarctica, it would freeze to death.

1. How do you think the penguin is adapted to swim in water? Hint: What are its wings used for? Does it have small or large feathers? How do you think this helps?

The penguin is adapted to swim in water as it uses its wings as flippers to swim. The feathers are very small/fine which help make it waterproof.

ACTIVITY: Adaptations in organisms LB page 11

1. The penguin is adapted to swim in water as it uses its wings as flippers to swim. The feathers are very small/fine which help make it waterproof.
   Some additional adaptations to discuss: Penguins are able to hold their breath and dive deep underwater to catch food. Penguins are black and white which helps them to be camouflaged in the water and hide from predators (They look dark like the water from above, and light like the sky from below). Penguins have even adapted to drink salty sea water.
2. Fish eagles have very long wings and long feathers to enable flight and to be able to soar in the air and then swoop down and catch prey.
   Some additional adaptations to discuss: They have long talons/claws so that they can catch their food as they swoop down and grab it. They also have large tail feathers that they can fan out to help them control their speed when flying.
3. The great white shark is adapted to move very fast through the water as its body is streamlined and it has fins and a tail to swim. It has sharp teeth to bite into prey.
4. The lion is a light brown colour so that it is camouflaged in the savanna/bush to sneak up on its prey. It has 4 strong legs with claws to chase and catch prey.

Summary

Concept map

Throughout this year, we are going to develop the skill of designing and making **concept maps** in Natural Sciences. The 'Key concepts' listed above is a summary written out in full sentences. A concept map provides another way of representing information (ideas and concepts) in a more visual way. The benefits of a concept map are that it allows one to show the linkages between different concepts. Often a concept map has a 'focus question' around which the other concepts radiate from – in these books the focus question will be the main topic for the chapter. The relationships between different concepts are shown using arrows with linking phrases, such as 'results in', 'includes', 'can be', 'used to', 'depends on', etc.

As this year progresses, learners will have to start filling in more parts of the concept maps themselves, and then hopefully draw their own ones by the end of the year. This teacher's guide contains the full version of each concept map. Encourage your learners to study the concept maps and make sense of them at the end of each chapter before doing the revision questions. Help your learners to understand and 'read' the concept maps by constructing sentences from them. For example, in this case you could read: 'The biosphere is made up of dead organic matter and living things. Living things can be plants, animals or microorganisms. Living things are adapted to their environment and carry out the 7 life processes. These are ….' **Learners need to learn how to learn!** This is one skill which might help them later in their school career where they have a lot more information to ingest and learn and make sense of. Concept mapping is one tool to use to summarise information and also understand how different concepts link together. Real understanding and knowledge comes from grappling with the subject matter, and not just memorising facts.

"Knowledge is real knowledge only when it is acquired by the efforts of your intellect, not by memory." – Henry David Thoreau.

Revision

1. The biosphere is where life exists on earth. It includes the atmosphere, lithosphere and hydrosphere.
2. a) Lithosphere: Rocks or sand
   b) Hydrosphere: Water, for example, oceans and seas, lakes, rivers
   c) Atmosphere: Gases, for example, carbon dioxide, nitrogen, oxygen
3. The atmosphere is the layer of gases around Earth. The atmosphere contains important gases that are key to life on Earth, namely oxygen for respiration in organisms and carbon dioxide for photosynthesis in plants. The layers of the atmosphere filter out harmful rays of the sun and hold the heat energy from the sun's rays in the atmosphere to help it maintain the necessary heat levels required for life. The weather changes occur in the lower part of the atmosphere allowing it to rain / snow / hail in order for the water cycle to get water to the plants on land.
4. Learners need to be able to use their knowledge of the 7 (seven) life processes to ask these key questions lto establish if this organism is living or not. Questions should include something as follows:
   - Can it move?
   - Can it make more of its own kind? How does this reproduction occur?
   - Can it sense changes in its environment and respond to this?
   - Does this organism grow?
   - How does it get energy for movement, reproduction or growth?
   - Does it excrete waste products?
   - Does it get nourishment somehow?
5. Organisms require energy, gases, water, soil and favourable temperatures.
6. a) Giraffes have very long necks so that they can reach the leaves at the tops of trees.
   An additional adaptation which is not visible here, but you can mention, is that giraffe have very tough tongues so that they do not get hurt when pulling the leaves off branches covered in thorns.
   b) The cactus has thick succulent stems which can store water for when there is none around.
   The cactus leaves have long, sharp thorns to prevent animals from eating the leaves.
   Additional adaptation to discuss: The stems have a thick waxy layer that prevents the loss of water.
   c) This insect is very camouflaged as it looks just like the sticks around it. This helps to protect it from being eaten by predators.
7. Learner-dependent answer. Make sure that learners justify their answer.

2 Biodiversity

Chapter overview

3.5 weeks

After looking at the biosphere and where life exists on Earth, we will now look at the biodiversity of life on Earth. This chapter starts off with looking at the classification system and how scientists have classified all living organisms. This hierarchical classification system provides an overview and will be dealt with again in Gr. 10 if learners take Life Sciences. After looking at the five kingdoms, we will then look at the biodiversity of plants and animals. In CAPS, learners would have looked at the variety in plants and animals before in Gr. 5 and heard the term biodiversity. This is built upon and extended as we look at the different classifications of plants and animals. The other three kingdoms, namely Protista, Fungi and Bacteria are not dealt with in detail, but in Gr. 9, learners will again look at some examples when they do microorganisms in more detail.

2.1 Classification of living things (3 hours)

Tasks	Skills	Recommendation
Activity: Group some everyday objects	Observing, classifying, group work, describing, discussing, recording, writing	CAPS suggested
Activity: Aristotle's classification system	Observing, classifying, drawing, explaining	Optional (Extension)
Activity: Comparing plants and animals	Observing, identifying, comparing, discussing	CAPS suggested

2.2 Diversity of animals (4.5 hours)

Tasks	Skills	Recommendation
Activity: Classifying vertebrates and invertebrates	Identifying, classifying	CAPS suggested
Activity: Identify the five classes of vertebrates (Chordata)	Identifying, classifying, remembering	CAPS suggested
Activity: Identify defining features of fish	Observing, identifying, listing	Optional (Suggested)
Activity: Describing amphibians	Observing, identifying, explaining, hypothesising	Optional (Extension)
Activity: Reflect on reptiles	Drawing, labelling, identifying, classifying	Optional (Extension)
Activity: Identify characteristics of birds	Group work, explaining, identifying, characterising, comparing	Optional (Extension)
Activity: Identify characteristics of mammals	Group work, brainstorming, remembering, listing	Optional (Extension)
Activity: Comparing vertebrates	Comparing	Optional (Suggested)
Activity: Classifying arthropods	Observing, describing, classifying	Optional (Extension)
Activity: Observing molluscs	Observing, identifying, describing, drawing, labelling	CAPS suggested

2.3 Diversity of plants (3 hours)

Tasks	Skills	Recommendation
Activity: Invasive plants in South Africa	Observing, researching, describing	Optional (Extension)
Activity: Discovering the differences between monocotyledons and dicotyledons	Observing, describing, summarising	CAPS suggested

Key questions

- How do we group or classify all the living organisms in the world?
- Why do we need to group or classify living things?
- How can we classify all the animals on Earth?
- What is the difference between reptiles and amphibians?
- Are insects and arachnids (spiders) different?
- Is there a way to classify plants?
- What is the diversity of plants and animals in South Africa?

If possible, display a selection of nature magazines, books and reading materials in the class during the time that you go through this chapter. You can collect photos or pictures from magazines of many different plants and animals, fungi and bacteria. A suggestion is to cover them in plastic, in order to reuse them in subsequent years.

2.1 Classification of living things

ACTIVITY: Group some everyday objects LB page 17

In this activity learners will get an opportunity to group a selection of everyday objects according to observable features. This lays the foundation for the classification and grouping work that is covered in this section. Teachers should collect enough shoeboxes or recycled ice-cream tubs (or if this is not possible shopping bags should also work) for each of the groups in the class. As homework the previous day each learner needs to bring five items from home. These items should be small enough to go into the shoebox. They should choose items that they use in their everyday lives. Please ensure that no valuables are brought!

During this activity, encourage learners to look at the observable features of the items in order to classify them, for example shape, colour, size, texture, use, and so on.

Questions

1. Learner-dependent answer.
2. Learner-dependent answer.
3. Learner-dependent answer.

ACTIVITY: Aristotle's classification system LB page 18

This is an **optional activity** to introduce different types of classification.

Learner-dependent answer. The table should look as follows. There may be some variations depending if learners decide to put an animal in more than one group or classify it according to its main method of movement.

Classification of a group of animals according to Aristotle's method		
Walkers	**Flyers**	**Swimmers**
Penguin, elephant, cat, crocodile, human	Eagle, butterfly, bats	Penguin, dolphins, crocodile, human

Questions
1. Difficult animals to classify are those which can fall into more than one group, such as the penguin, crocodile, human.
2. Possible answers might include: Some animals fit into more than one group (penguin, crocodile, etc.) because it looks more at what the animals do rather than what they are or similarities and differences between their forms.

Discuss this as a class. Refer to this process as being a constant refining of the way that classification is done and that it is not a 'given' or a static method. It needs to evolve as our knowledge and understanding of the world and the organisms in it develops and must take these new discoveries into account.

Since we know that we are not a fungi or plant, or a protista or bacteria (quite a bit bigger!), we belong to the animal kingdom.

ACTIVITY: Comparing plants and animals LB page 21

1. Learner-dependent answers. Might include: all these animals can move using a variety of methods or that all might have a special body covering. These animals all have to eat, either plants or other animals. They generally reproduce by mating with other animals of the same species. Animals drink water. Animals respire as they take in oxygen and give off carbon dioxide, often through breathing. Animals need to excrete their waste from their bodies.
2. Learner-dependent answers. Might include: plants cannot move, they are rooted to one spot. Plants do not need to eat as they produce their own food by photosynthesis. They take in water. Plants also respire, like animals, but they take in carbon dioxide for photosynthesis and give off oxygen as a by-product. Plants' reproduction differs to animal reproduction in that many plants produce seeds while others produce other structures (such as ferns), among other differences.

3. Learners should compare the observable differences on the diagram / illustration between plants and animals. Some of these may include:

Plants	**Animals**
Plants are generally rooted in one place and move by growing in shape and turning their leaves or petals towards the sun or a water source.	Animals can self-propel (move themselves around) through locomotion in order to find food, a mate or shelter, or to evade danger.
Plants that contain chlorophyll can photosynthesise to produce glucose (food) from sunlight and carbon dioxide.	Animals cannot produce their own food and have to eat plants or other animals to get nourishment.
Plants produce oxygen and take in carbon dioxide.	Animals take in oxygen and produce carbon dioxide.
Plants have a limited ability to sense.	Animals have a well-developed ability to sense.

Fungi

Protists and bacteria

Learners will be able to fully understand the differences between Protists and Bacteria only once they have learnt about cells in Gr. 9. Essentially, Protists are eukaryotic (usually unicellular, but not always) as they have cells with a membrane-bound nucleus, whereas Protists are prokaryotic as their DNA material is not membrane bound. Bacteria are always unicellular. Protists require a liquid medium, whereas Bacteria occur almost everywhere.

These images are included to give learners some idea about these two kingdoms, otherwise they will have no reference point until they get to Gr. 8 and do microorganisms again. These images are also interesting and show what is possible with the microscopy techniques available today. They include a range of techniques from scanning electron microscopy, confocal, fluorescent and light microscopy. The differentiation of having a membrane-bound nucleus in Protists and not in Bacteria is too advanced for learners at this stage if they have not yet learnt about cells. For now, encourage learners to look at the photos, perhaps ask them to explain what they see, and let them get excited about the unseen world! Learners do not need to know how to recognise or name any of these microorganisms.

2.2 Diversity of animals

Provide learners with old magazines and ask them to cut out any and all animals that they see. (If you teach this lesson a few years running it is worth the effort and money to cut their animals out carefully and have these laminated then they can be used over and over again!) When they have collected a large quantity of animals ask them to group the animals into only two groups. Encourage them to manipulate the animals and transfer them from one group to another, and encourage positive debate about their groupings and why they chose those specific groupings. Then end result should be that there are two main groups of animals, and scientifically speaking these would hopefully be vertebrates and invertebrates, or alternatively those with feathers and those without; those with mammary glands and those without, those with wings and those without, etc.

As learners work with the pictures, make sure to model words like observe, compare, contrast, evaluate, etc.

Some learners might ask "WHY" we classify and they should be praised for doing this. If this occurs, point out to them that classification helps us to sort out ancestor / descendent relationships and we are therefore able to track the evolutionary history of all living organisms.

Thus the presence or absence of one specific characteristic might show that an organism is related to others in in a specific genus, family or order and can also guide an investigation into the evolutionary history of these organisms. Many learners might for instance be unaware that lions, rhino and elephants are indigenous to Africa but are also found naturally in other parts of the world, like India, and through classification we are able to see how the Black Buck and the Kudu, or the One-horned Rhinoceros of Asia and the South African black rhino, are related.

Classifying animals

The presence or absence of a backbone is used to classify animals as vertebrates or invertebrates. The dolphin, dog and goose are vertebrates and the grasshopper and crab are invertebrates.

Invertebrates do not have a backbone, but this does not necessarily mean that they have an exoskeleton. Many invertebrates have a **hydrostatic skeleton**, like the jellyfish and earthworm. Some invertebrates such as the snail and have an exoskeleton (shell) and a hydrostatic skeleton. Sponges actually have a type of endoskeleton as their 'skeletons' are made of calcareous spicules.

ACTIVITY: Classifying vertebrates and invertebrates LB page 23

1.– 2.

Animal	 A grasshopper	 A bluebottle
Type of skeleton	Exoskeleton	Hydroskeleton
Vertebrate or invertebrate	Invertebrate	Invertebrate
Animal	 Cape sparrow	 Butterfly
Type of skeleton	Endoskeleton	Exoskeleton
Vertebrate or invertebrate	Vertebrate	Invertebrate

Animal	 Tortoise	 Frog
Type of skeleton	Endoskeleton	Endoskeleton
Vertebrate or invertebrate	Vertebrate	Vertebrate
Animal	 Crab	 Earthworm
Type of skeleton	Exoskeleton	Endoskeleton
Vertebrate or invertebrate	Invertebrate	Invertebrate

The five phyla making up the invertebrates have scientific names, but it Is not necessary to know these at this stage. We will focus on only two of the phyla: Arthropoda and Mollusca.

ACTIVITY: Identify the five classes of vertebrates LB page 25

Questions

a) Fish – scales / gills / fins / etc
b) Amphibians – soft moist skin / lungs and skin used for breathing / four limbs with webbed feet
c) Reptiles – scaly skin / lungs used for breathing / four limbs with toes
d) Birds – beak, feathers cover body / air sacs used for breathing / two scaly legs and two wings
e) Mammals – fur or hairy skin / lungs / four limbs / mammary glands, live birth

Since many animals in Africa are under threat due to habitat loss and poaching the animals featured in this section were specifically included to raise awareness and to expose learners to the wonderful animals living in South Africa. Teachers are encouraged to work with teachers from other subjects, such as the languages or art, to let learners make anti-poaching or awareness campaign posters to address the environmental issues and raise awareness with other learners in the school.

Vertebrates

Visit [1] bit.ly/195EX30 for a teachers' support website on fish.

ACTIVITY: Identify defining features of fish LB page 26

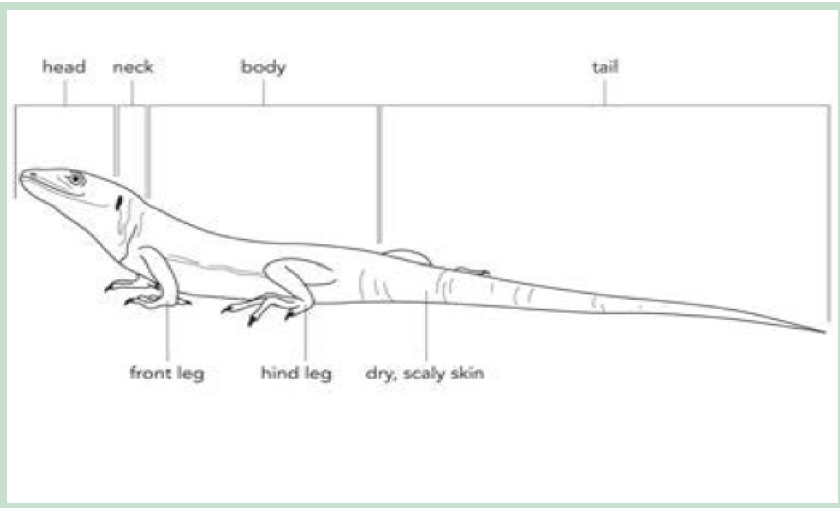
1. Features learners may list include: ectothermic, backbone, fins, gills, scales, living in water, breathing oxygen from water, streamlined body, lay eggs.
2. The combination of gills, fins and the fact that fish live only in the water are the main defining characteristics of fish and make fish different from all other animals.

A sea horse is in fact a fish. It breathes with gills, has a swim bladder to control buoyancy and a spine, and even though it doesn't have a tail fin, it has four other fins that helps It to move. Unlike most fish, sea horses do not have scales, but skin.

Amphibians

ACTIVITY: Describing amphibians LB page 27

1. The young larvae are all in water whereas the adults are on land or near water.
2. The larvae need gills to breathe in water; the adults have lungs to breathe on land.
3. Amphibians have two stages in their life cycle. First, they have the larval stage where they are in water, and then they have the adult stage where they live on land (and also in or near water).
4. They get heat from their environment and therefore need to live in areas where it is warm enough for them to have enough body heat to survive. If it gets very cold an amphibian will need either to find a space under a log or leaves, or sit in the sun.
5. Learners need to compile a plausible explanation or hypothesis. The correct explanation is: Glands in the skin secrete liquid to keep the skin slimy and moist as frogs may need to use the skin alongside the lungs and mouth for gaseous exchange.



6. In order not to be classified as an invertebrate, such a worm, the animal needs to have a backbone. The caecilian does have a backbone and a skull. The caecilian is not a snake (it is not a reptile) as it has a larval stage which is born in water and it undergoes metamorphosis to become the adult caecilian. The larvae also have gills to breathe underwater. Caecilians also

do not have scales like reptiles.
7. Some possible reasons are: The eggs are in water so that when the larvae hatch they are already in the water to swim around, the eggs would dry out if they were not in water, the fertilisation process in amphibians often requires water as the female will lay the eggs and as she does so, the male deposits his sperm in the water around them so that they are fertilised.

Reptiles

ACTIVITY: Reflect on reptiles   LB page 29

1. a) chordata or vertebrates
   b) They cannot regulate their body temperature but depend on their environment for heat.
2. Learner-dependent answer
3.

	
crocodiles and alligators	**lizards and geckos**
	
snakes	**turtles, terrapins and tortoises**

Birds

If possible, take your learners outside before you start discussing birds to see if you can spot any in the school grounds. Ask learners to identify what is common among all the birds – they should note that all birds have feathers. This is the most distinguishing feature of birds.

ACTIVITY: Identify characteristics of birds   LB page 30

Learner-dependent answers. You should once again ask groups to share their characteristics with the class in order to avoid the inclusion of incorrect characteristics from being included. A typical incorrect characteristic may be that all birds can fly. Point out that many birds, such as penguins and ostriches, cannot fly and remind them that Aristotle used this same classifying technique which proved to be of little use. There are also other animals that can fly which are not birds, such as bats and flies. Learners should note that all birds have beaks, wings and feathers and they lay eggs.

1. All vertebrates have a backbone with a hollow tube running inside it which carries the nerves.
2. This means that birds can control or regulate their body temperature and can therefore keep warm in very cold climates and keep cool in very hot temperatures.
3. Learner-dependent answer. **Note:** Although almost all learners will say that all birds have feathers, not many will be able to identify that birds' feet are covered in scales like those on reptiles. If you are able to go outside to look at some birds, try to see if you can take note of their legs and feet.
4. Learners are required to evaluate a statement and give an explanation for their evaluation. It is in fact incorrect to say that birds have wings to fly since not all birds' wings are used for flying and many flightless birds exist. Think of the emu, ostrich, penguin, cassowary, kiwi and rhea. A better statement would be: Birds that can fly have wings to do so.
5. The ostrich is very big and has a heavy body with long legs. Its long legs help it to run fast on land. It has wings, but its wings are small in comparison to its big heavy body. The albatross is also a big bird but it has a very large wing span relative to its body. The feathers in the albatross are also small and lie close together to help the bird to fly. Whereas the ostrich has many feathers, but they are big and loose and will not catch the updraft of the wind. The penguin also has a body shape which is not designed to help it fly, but rather to swim. It has short, stubby wings, which are not strong enough to lift it off the ground but are useful for swimming. It is quite fat and heavy, but this helps to keep it warm in the water. The hummingbird is very light and has small wings which beat extremely fast, allowing it to fly and hover. The hummingbird has wings designed to flap quickly in the wind as they are narrow and light, while the penguin has fatter wings shaped like a paddle which are rather used for swimming.

Mammals

ACTIVITY: Comparing vertebrates LB page 33

Tortoise	**Chimpanzee**	**Frog**	**Guinea fowl**	**Goldfish**	
Class	**Reptile**	**Mammals**	**Amphibian**	**Birds**	**Fish**
Skin covering	dry, scales	Hair or fur	smooth, slippery	feathers	slimy, scales
How babies are born	lays eggs	live birth	lays eggs	lays eggs	lays eggs
Habitat	on land	on land	in water when young, on land when older	on land	in water
Ectothermic or Endothermic	ectothermic	endothermic	ectothermic	endothermic	ectothermic
Distinguishing features	Scales and lay eggs	Young drink milk from the mammary glands of the mother and have fur	Live first stage in water, then on land	Have feathers	Live only in water, have fins, scales and gills.

Invertebrates

ACTIVITY: Classifying arthropods LB page 34

If possible, collect different arthropods in a terrarium and have learners study them with magnifying glasses as they work through the activity. However, photos have been provided if this is not possible. Learners can still be encouraged to study different arthropods in the school premises as they work through the activities. If the school permits this, ask learners to walk around school taking photos with cell phones or cameras of arthropods to share with the class. If the school has access to an interactive whiteboard, put these photos up and use these to complete this activity.

Questions

1. a) They have hard shell-like bodies that look sturdy and inflexible; it would possibly feel hard and would crunch if broken.
   b) Their bodies would feel similar to the temperature of their environment.
2. a) The legs are made of different parts that are joined together and are mostly covered in the same hard exoskeleton as the body.
   b) Where the pieces of the leg come together they form a flexible joint that allows the leg to bend and move.
   c) The learners' tables must look like this:

Insects = 6 legs	**Arachnids = 8 legs**	**Crustaceans = 10 legs**	**Diplopoda and Chilopoda = many legs**
Dung beetle Grasshopper Butterfly	Spider Scorpion	Crab Prawn Crayfish	Centipede Millipede

3. It sheds the hard exoskeleton (outer skeleton) in a process called **moulting**.
4. Most crustaceans are aquatic, either marine or freshwater. The other classes mostly live on land, although many live near water.
5. Insects have wings. No, not all insects have wings.

Molluscs

ACTIVITY: Observing molluscs LB page 37

1. Molluscs have soft bodies, which are often slimy to touch. Most molluscs have one or two hard shells to protect their bodies, sometimes the shell is inside, like that of the cuttlefish, squid and octopus. Molluscs live in moist environments, mostly in the sea.
2. They would dry out and die.
3. Learner-dependent answers – they might say that they found more snails in low-traffic areas and in shady, less-exposed places, often where it is damp or under foliage.
4. **Note:** In the last section of this term's work learners are going to study variation and survival of the strongest / fittest. They will need snails for that activity too, so if possible keep the snails from this activity for then. Just make sure the lid is securely shut on the terrarium as snails will escape and arriving to a slime-covered desk / class before school is no fun at all!
5. a) As the snail moves it leaves behind a trail of slime to make it easier for the rest of the body to slide or glide over. This allows it to move easily over any type of surface.

b) Muscles in the foot of the snail contract and relax causing it to move along.
c) Snails can have one or two pairs of tentacles (antennae) depending on the species (however they may be retracted). One pair of light-sensitive eyes are usually on the longest pair of antennae and the other pair of antennae are used for smell and touch.
d) The snails' shells are marked to blend into their environment and to break the outline of their shape to help to camouflage them.
e) Learners should say that they cannot see any difference and should be able to conclude that either they only collected one sex or that snails do not have a male and a female snail (which is in fact the truth). Most land snails have both male and female parts. They are hermaphrodites. When they meet with other snails during mating they will both conceive and lay eggs, so double the number of offspring are formed.

6. Learner-dependent answer.

2.3 Diversity of plants

This section guides learners as they investigate the plant kingdom by grouping plants with seeds and those without seeds into two main groups.

As an introduction to the diversity of plants, you can do a short walk around your school, aimed at developing a greater awareness of the plants in and around the school, and specifically those that produce seeds and those that do not. Also encourage learners to take note of leaf shape, size, flowers, etc.

If possible, pick some fern fronds to bring to school. You can also look for moss growing in moist environments, such as under a dripping tap and pick some to bring to class. You can then show learners the spore forming structures on the underside of the fern leaves.

A small hand lens is useful to examine the underside of the fern leaves (if available).

Discuss this with your learners. Encourage them to take notes in the margins of their workbooks. A fungus is not a plant. Fungi are one of the five kingdoms of organisms. Fungi do not contain chlorophyll and cannot photosynthesize. They therefore need to obtain their nutrients from elsewhere. Ask your learners what they think a symbiotic relationship is. A symbiotic relationship is one in which one or both organisms benefit. A parasite is something which lives off another organism in some way and harms that organism. The relationship benefits the parasite, but not the host. It is not mutually beneficial. On the other hand, the honey bird and the badger, which learners may have learned about in Gr 6, both benefit from their relationship. It is a mutually beneficial symbiotic relationship. Start by asking learners if the relationship between the fungus and the alga is beneficial to one or both of them? Both the algae and fungi benefit from the relationship. Therefore, it is a mutually beneficial symbiotic relationship.

The words to fill in on the diagram are **monocotyledon** for one cotyledon and **dicotyledon** for two cotyledons.

Seed-bearing plants

Gymnosperms

ACTIVITY: Invasive plants in South Africa LB page 40

1. An indigenous plant is one which occurs naturally in a particular geographical such as South Africa.
2. An alien species is one which is not indigenous to South Africa, or a particular geographical area. It has been brought in by humans from another part of the world. They are said to be invasive as they invade (take over) the areas in which indigenous plants grow.
3. They reproduce by making seeds in cones.
4. Learner-dependent answer. Learners may either disagree or agree. There are many viewpoints on this at the moment. Perhaps they feel that this is one area which mountain bikers should be allowed to enjoy as a forest as the rest of Table Mountain is covered in fynbos. Alternatively, they may agree that we need to re-establish the local flora and fauna, and although it may take time for a forest and shade to regrow, it will be better in the long run from an ecological point of view.

Angiosperms

An idea to introduce this topic is to get sheets of paper and get learners to brainstorm the names of as many flowering plants as possible that they know. As many learners are not that familiar with the names of plants and animals in their area, we encourage teachers to use this to add names of plants as learners get to know them in this section. Encourage learners to review the chart they make and to add to it as they go along. Try and identify as many local examples as possible with your class. This is aimed at showing the diversity of flowering plants in South Africa. You can even cut some flowers to bring in to class.

If possible, bring some examples of monocotyledons and dicotyledons into class for this activity so that learners can study actual examples of the plants. Be sure to include some wind pollinated plants that do not have obvious flowers, as many learners don't realise that grasses form flowers.

ACTIVITY: Discovering the differences between monocotyledons and dicotyledons

LB page 42

Monocotyledons

1. Learner-dependent answer. The leaves are generally long and narrow. The veins run parallel down the length of the leaves.
2. The stems are all green, with no wood. They are herbaceous.
3. Agapanthus flowers also have six petals, while the disa has three petals. We can say that in general, monocotyledonous flowers have parts in multiples of three.
4. Some examples include: wheat, rice, oats, barley, sorghum.

Dicotyledons

1. The leaves are varied in shape and size. They are generally broad, and the veins form a branching network across the leaves.
2. The stems are varied; some are green, and some are woody, for example in the tree species.
3. The geranium flowers have ten petals, the plumbago flowers have five petals, the hibiscus flower has five petals, the hydrangea flowers have four petals. We can say the dicotyledons have flowers with parts in multiples of four or five.

4. Learners may be under the impression that the entire mealie pip is the cotyledon. You may want to explain that the little "yellow bit" that can be squeezed out of a maize pip is the cotyledon of the embryonic plant. The rest is just stored food.

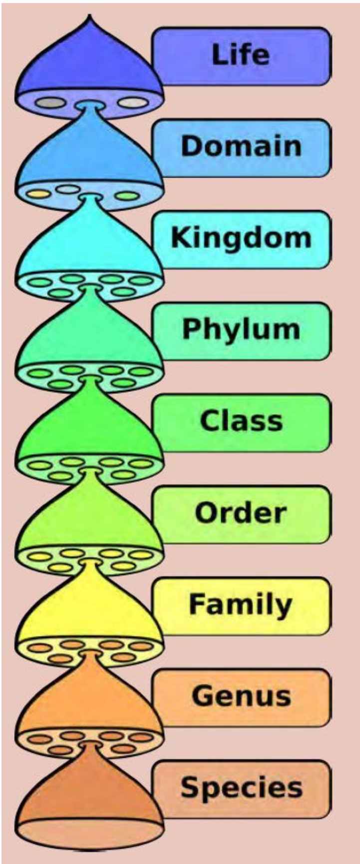
	Monocotyledons	**Dicotyledons**
Cotyledons	One	Two
Stems	The stems are herbaceous, meaning they do not have much wood, are often green and soft.	The stems can be herbaceous or woody.
Flowers	Generally, the flower parts are in multiples of three.	Generally, the flower parts are in multiples of four or five.

Summary

Concept map

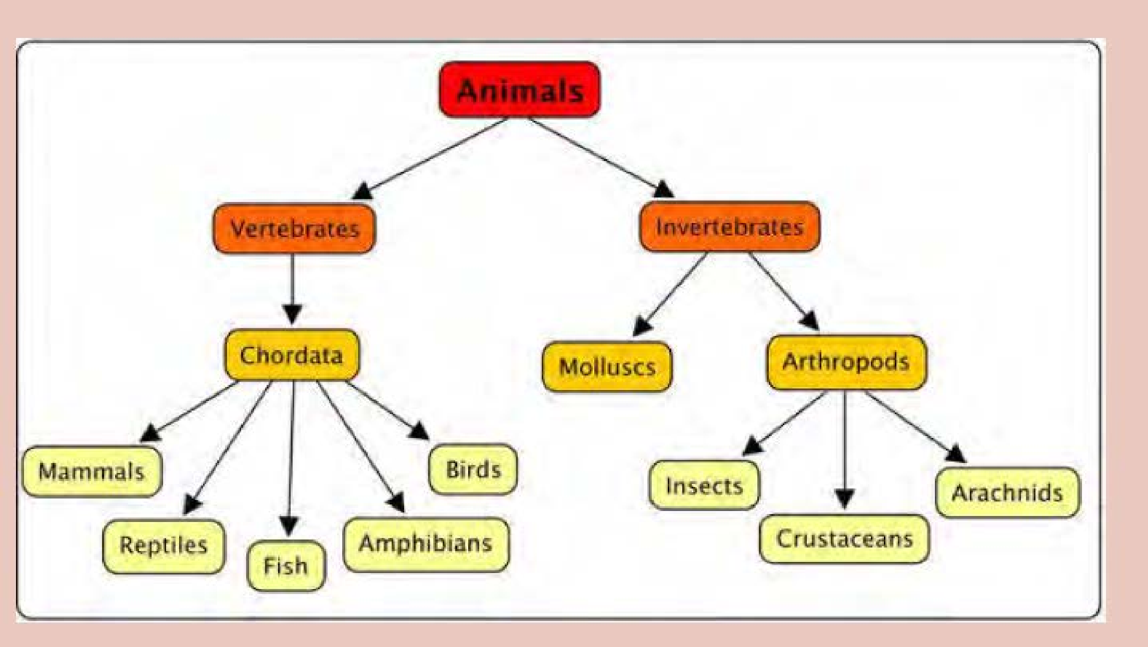
Remember that concept maps are different from mind maps in that concept maps have a hierarchical structure and show how concepts link together using arrows and linking words. Mind maps generally contain a central topic and individual branches coming out which do not necessarily link together. Mind maps can also be a useful way of summarising information and studying. However, we are using concept maps as they help to show linkages, which is very important in science. Help your learners to "read" the concept map by showing them that the arrows show the direction in which concepts progress and are linked to each other.

Revision

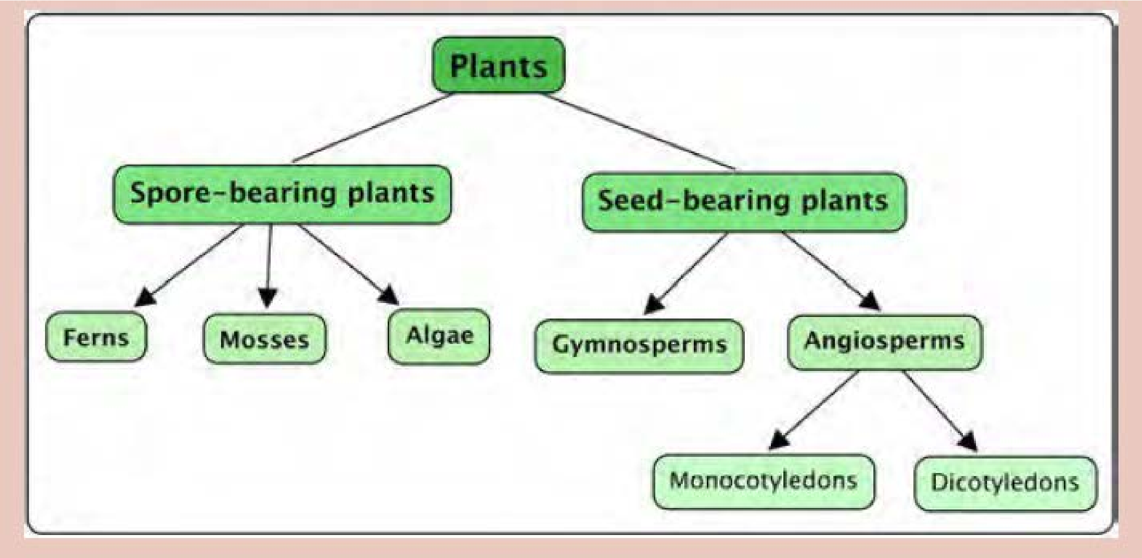
1. 

2. As more animals were being discovered it became obvious that many animals can fall into all of these classes and thus it was not a very accurate method of classification.
3. Learner-dependent answer. The following gives an example of the animal classification

learners could have drawn.



4. a) biodiversity
   b) vertebrates and invertebrates
   c) fish, amphibia, reptiles, mammals, birds
   d) arthropods
   e) molluscs
5. a) False – A large percentage of living organisms are invertebrates; OR A small percentage of the living organisms are vertebrates.
   b) True
   c) True
   d) False – Molluscs typically have a hydroskeleton and only some have shells.
   e) False – Birds have feathers but also have leathery scales covering their legs. (A body covering encompasses the entire body of the animal.)
   f) False – An advantage of being endothermic is that the animal is able to move when it is very cold unlike cold-ectothermic animals.
6. a) Too broad – all animals should be able to fulfil these if they are alive.
   b) Too vague – birds and mammals can regulate their body temperatures.
   c) Too vague – this can easily describe birds as well.
   d) Learners should underline d.
   e) Could describe a boa constrictor as well.
7. Seeds in angiosperms are enclosed in fruit; seeds of gymnosperms are 'naked' or on the cone itself.
8. Learner-dependent answer. Learners could produce something like the following:


Plants
Spore-bearing plants
Seed-bearing plants
Ferns
Mosses
Algae
Gymnosperms
Angiosperms
Monocotyledons
Dicotyledons

3 Sexual reproduction

Chapter overview

3.5 weeks

In Unit 2 we looked at how to classify organisms, and at the diversity in plants and animals. In this chapter, we will now focus on how angiosperms (plants) and humans (animals) reproduce. A brief introduction and description of asexual and sexual reproduction has been included. This is necessary so that learners are aware that we are learning about one type of reproduction (sexual) in different organisms, but that there are other groups of organisms that reproduce asexually. The differences (and also similarities) in reproduction between these two different systems will further highlight the diversity of organisms on Earth. Sexual reproduction is studied again in Gr. 9 Life and Living and so many of the concepts dealt with here will be reinforced later. One of the aims of this chapter is to also educate learners about human reproduction so that they can make informed and responsible choices regarding sexual activity.

3.1 Reproduction in angiosperms (5 hours)

Tasks	Skills	Recommendation
Activity: Growing a bean plant	Growing, observing, measuring, recording, plotting graphs	CAPS suggested
Activity: Identify the outer structures of flowers	Identifying, describing, drawing, labelling	CAPS suggested
Activity: Flower dissection	Dissecting, observing, labelling	CAPS Suggested
Activity: Identifying pollinators	Identifying, comparing, describing	CAPS suggested
Activity: Studying the flowers of wind and water pollinated plants	Observing, writing, comparing	CAPS suggested
Activity: Article from 'The Earth Times'	Reading, identifying, interpreting, explaining	Optional (Extension)
Activity: Studying different kinds of seeds	Identifying, classifying, explaining	CAPS suggested

3.2 Human reproduction (5.5 hours)

Tasks	Skills	Recommendation
Activity: What happens during puberty?	Identifying, listing	CAPS suggested
Activity: Draw a timeline of your life	Thinking, remembering, drawing, presenting	CAPS suggested
Activity: Conduct a survey	Reading, communicating, recording, discussing	CAPS suggested

Key questions

In angiosperms

- How do plants make seeds?
- What is the role of flowers in reproduction?
- Flowers come in many different colours, shapes and sizes. So, are there some structures that are common to all flowers?

- What is a 'pollinator'? Why are pollinators also important to humans? Is the flower on a rose the same as the flower on a sweet pea or on a daisy bush?
- Why are seeds in different shapes and sizes, or contained in fruits? Does it have something to do with the way seeds are spread to new areas?
- Does fertilisation mean the same things in plants as it does in animals?

In humans

- Why is your body starting to change?
- What is puberty and what does it mean when we "reach puberty"?
- How is it possible that we all go through puberty at different times and rates?
- What changes take place inside our bodies during puberty?
- What do our reproductive organs look like when they are mature?
- How does reproduction occur?
- What is menstruation and why does it occur once a month?
- How does a baby grow inside a woman's uterus?
- There is a lot of awareness now of HIV/AIDS and STDs, but what exactly can we learn in Natural Sciences to help us lead a safe and healthy lifestyle for the rest of our lives?

3.1 Reproduction in angiosperms

As an introduction to this section, remind learners of the diversity and classification of plants which was discussed in Chapter 2 and how angiosperms fit into the classification. CAPS suggests that learners grow a bean plant during this topic in order to observe the stages in the life cycle of angiosperm plants. It is recommended that learners plant their seeds during the first lesson.

ACTIVITY: Growing a bean plant LB page 51

1. Germination
2. Moisture (water), warmth and light
3. Learner-dependent answer

Flower structures

ACTIVITY: Identify the outer structures of flowers LB page 53

1. Receptacle
2. The brightly coloured petals attract pollinators. Plants pollinated by wind do not need to attract insects or animals to pollinate them and thus do not need brightly coloured petals. By not producing petals they can invest in producing more pollen instead.
3.

Rose	Long straight peduncles (stalks) to hold the flowers high up to the sun; green sepals to protect the buds; flower petals are bright to attract pollinators
Lily	Long straight peduncle, which is underwater and less rigid than the sunflower, so it can sway in the water; there is an inner layer of white petals, and the outer layer are actually white sepals, and not petals.
Petunias	Short peduncles that branch from a shrub; small green sepals, large pink petals to attract pollinators.

Male and female reproductive structures

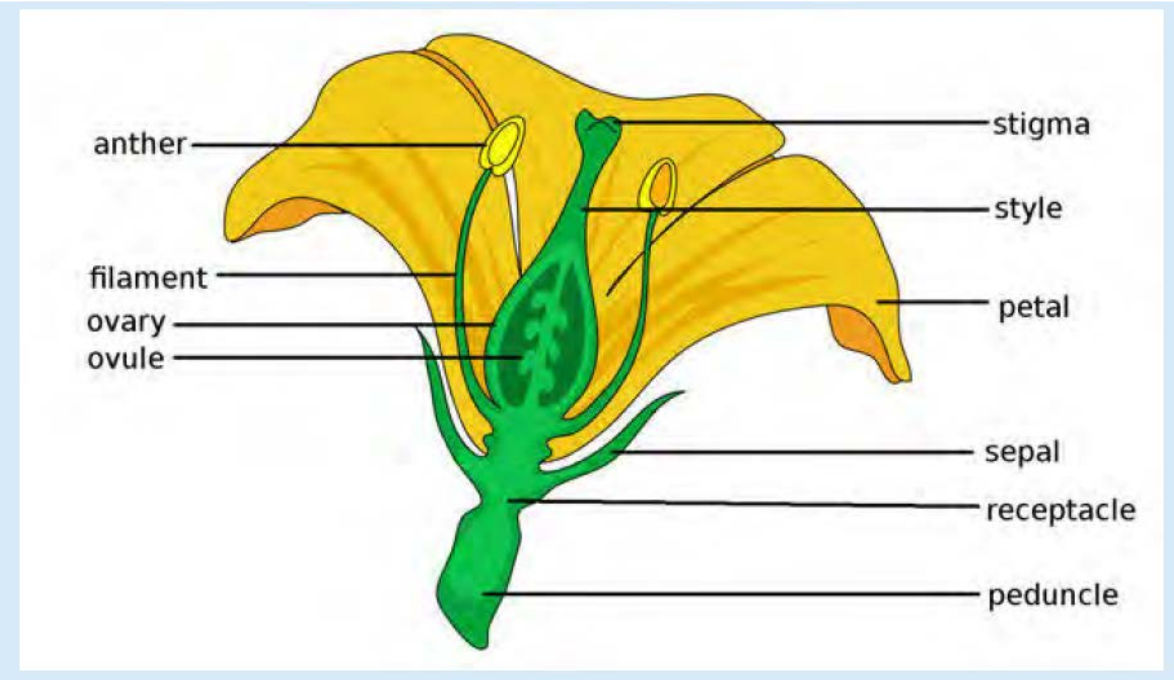
Cells have not yet been taught in Natural Sciences, but a general understanding is useful for this section to know what is meant when males and female sex cells are referred to. A note has been included in the margin about cells, and it will be beneficial to your class to introduce what cells are, even though they only formally study cells in Gr. 9 Life and Living.

ACTIVITY: Flower dissection LB page 55

Petunia or hibiscus flowers work best for a dissection. However, you can use any flowers from the gardens or surrounding area that you are able to find. You can watch the video of the flower dissection using a hibiscus flower in the visit link provided prior to your lesson so that you know how to do the dissection and guide learners.

Learners must make sure to label in the correct way, using a ruler to draw straight, parallel label lines pointing and touching the structure to be named. Take note that the receptacle label should point to the green bulge in between the sepals and the peduncle label must point to the short stalk at the bottom.

A labelled diagram should look as follows:



Pollination

Take note that learners may confuse the processes of pollination and seed dispersal. Pollination is the process whereby the male pollen is transferred to the female stigma in order for fertilisation to take place. Seed dispersal occurs after fertilisation and involves dispersal of the new seed (offspring) to a location where it will not compete with the parent plant.

The image of pollen on page xx of the Learner's book is taken using a scanning electron microscope. You can mention this to learners, but they will only formally learn about different microscopes in Gr. 9 Life and Living.

Learners need to be able to identify the stamens and stigma of a flower. In the photo on page xx of the Learner's Book, there are numerous stamens covered in yellow pollen and the four 'stalks' with rounded heads sticking out the top are the stigma.

Pollination by animals

ACTIVITY: Identifying pollinators LB page 57

1. They are mostly insects.
2. These pollinators are mostly feeding on the nectar, and also on the pollen in some cases.
3. Flowers have large colourful petals to attract pollinators. Flowers have sweet nectar for pollinators to feed on as a reward. Flowers have a sweet scent to attract pollinators.
   Note: A common misconception among learners is that they think flowers make pollen for the insects. Insects, such as bees, do collect the pollen and use it for the manufacture of the wax in their hives, but this is not why flowers make pollen. Also, flowers do not make nectar for the bees, rather you must stress that the nectar is made as a reward system for the pollinator.
4. The flower is long and thin so that the bird has to stick its beak down the flower and then it will rub its head against the stamens containing the pollen. The stamens and stigma are long and sticking out the top of the flower so that they brush against the head of the bird when it is drinking nectar and the pollen then either sticks onto the bird's head or some from another flower is rubbed off onto this flower. The flower stem needs to be strong to support the bird.
5. Flies are attracted to rotting meat, so the most likely pollinators of this flower are flies.
6. Learner-dependent answer.
7. Learner-dependent answer. **Note:** If possible, invite the school's maintenance personnel to help learners identify the names of these plants. Let them do an Internet search to find the scientific names or have gardening books available in class for them to search in.
8. Learner-dependent answer. Learners might refer to the brightly coloured petals, strong scent, the specific length of the stigma, stamen, nectar pouch, etc.
9. Learner-dependent answer. Answers should include an explanation that these plants have brightly coloured flowers to attract certain insects for example, a strong odour or perhaps a long nectar producing pouch.

Pollination by wind and water

Before going through the next section with your learners, get them to first think about what the flowers of wind and water pollinated plants will look like and if they need the same or different adaptations to flowers that attract pollinators. For example, wind and water pollinated flowers do not need to attract animals so they do not need large, colourful flowers that emit scents. Wind pollinated plants will need large amounts of very light pollen that is easily wind-borne.

ACTIVITY: Studying the flowers of wind- and water-pollinated plants LB page 59

Some images are supplied in the Learner’s Book, but if possible, collect some grass flowers beforehand and bring these to class. Alternatively, you could take a quick walk around the school to see if there are any grasses or reeds growing nearby with flowers that learners can observe. Learners can also do this in pairs and discuss their answers with each other before writing them down.

Afterwards, go through the questions with the class. This activity relies on teachers and learners making observations with real plants and flowers. Learners must use what they have already learnt about the adaptations in plants whose flowers are pollinated by animals. This will enable them to make conclusions/deductions about the adaptations in wind-pollinated plants.

Shown in the Learner's Book are the male and female flowers of the maize plant. If you wish to do so, you can discuss cross pollination with your learners, meaning that the pollen from one plant has to travel to the female flowers of another plant.

1. The flowers are not colourful like the flowers that are pollinated by animals. They are dull in colour (whites, browns and greens). The flowers are quite small, but there are many flowers per plant. The flowers are mostly long and slender and quite flimsy (loose). There are large number of anthers which hang out of the flower so that the pollen can easily be swept away by the wind.
2. These flowers do not need to attract animals with their colourful petals as they rely on the wind for pollination.
3. Generally, these flowers do not produce nectar as they do not need to attract animals to feed on them in order to pollinate them. They rely on the wind.
4. Mostly grasses and reeds, and also many trees
5. Learners may battle with this question, so you could discuss it as a class. These flowers produce large amount of pollen as they cannot predict which way the wind will blow, so the more pollen the greater the chances that pollen will land on other flowers when carried in the wind. In flowers that are pollinated by animals, the animals transfer the pollen directly from one flower to the next, so they can produce smaller amounts. In flowers that are wind pollinated, they have to rely on the chance that the wind will blow and that it will blow in the right direction. The more pollen there is the greater the chances of pollination.
   Note: At this point you can also point out to learners that plants that are wind pollinated often grow in large populations where the huge numbers of plants increase the chances of these plants being pollinated (think of fields of grasses or reeds or forests of trees).
6. In wind-pollinated flowers, the pollen needs to be carried by the wind as it blows. Therefore, the pollen cannot be sticky, otherwise it will not be blown off the flowers when the wind blows. it also must not clump or stick together otherwise it will not be carried in the wind. The smaller and lighter the pollen grains are, the further the wind can carry it.
7. The long filaments of the stamens enable the anthers to be exposed to the wind so that the can blow and move in the wind and easily release the pollen. The stamens are large and feather-like so that they can 'catch' the pollen in the air as it blows through. They are still light so that they can blow and wave around in the wind.
8.

Structure	**Wind-pollinated plants**	**Pollinato- pollinated plants**
Petals	Very small or absent petals that may be brown or dull green – do not need to attract insects.	Large, brightly coloured petals to attract insects
Scent	No scent – do not need to attract insects.	Often specific scent to attract specific pollinator.
Nectar	No nectar – do not need to attract insects.	Many produce nectar to attract insects.
Amount of pollen	Very large quantities of pollen produced as there is a lot of wastage.	Smaller amounts of pollen produced because there is less wastage than in wind pollinated plants.
Structure of pollen	Pollen light and smooth to travel	Pollen often sticky or spiky to

	on the wind and not clump together.	attach to pollinators.
Anthers	Anthers loosely attached and dangle down (mostly) to release pollen easily into the wind.	Anthers firmly placed inside flowers to brush against pollinators.
Stigma	Stigma is large and feather-like to filter the air and catch the drifting pollen.	Stigma is inside the flower where the pollinator will brush up against it and has a sticky coating that the pollen sticks to.

Pollinators and us

ACTIVITY: Article from "The Earth Times" LB page 60

1. a) (noun) extreme hunger, starvation or lack (scarcity) of food.
   b) (noun) when something does not work, and in this case, it specifically refers to crops which have produced a small amount or not produced at all
   c) (adverb) very badly, or harshly
   d) (adjective) the species has ended or died out, there are no more left
   e) (verb) to keep something alive or make it last
   f) (adjective) far away, out-of-the-way, away from human habitation
   g) (noun) something that has variety and differences
   h) (verb) to change
2. Loss of pollinators lead to crop destruction – third year of famine
3. The loss of the wild bees, butterflies and moths has caused major food shortages because they usually help pollinate the food crops; the message might also be a warning to us to value our bee and butterfly populations more, and to reduce air pollution.
4. The pollinators are not around to pollinate the flowers of the crop plants. Therefore, the flowers are not fertilised and can then not produce seeds. There are then no seeds to plant the next crops for the next year, and therefore there is less food for humans.
5. Wild bees, butterflies and moths.
6. The air pollution and resulting acid rain damaged the wings of the pollinators, who could not fly to reach nectar and therefore died of starvation.
7. Learners could mention:
   - Anthers are carried on long filaments that hang down. This allows the wind to move and carry away the pollen easily.
   - Pollen grains are light and dry to prevent them clumping together and are easily carried on the wind.
   - Female stigma is feathery and branched and acts as a filter trapping the pollen that is blown through it.
8. Learner-dependent answer. Learners should make reference to the above adaptations in plants which are already adapted to be pollinated with the help of the wind.
9. Learners can either agree or disagree that this could happen in the future. Their reasoning is important in this question. For example, they could reason that it might happen as there is already lots of air pollution and it is not decreasing so it could get to a level where it affects pollinators. Or else, they could say that they do not think air pollution will get to the level where it affects the flight of pollinators, or there could be other pollinators that might not be affected, etc.

Fertilisation

Seed dispersal

Hold a class discussion on why do seeds need to be dispersed. Learners must be encouraged to take notes as they will have a question on this at the end of the chapter. They will need to refer to this discussion to formulate their answers, so it is important that they start learning how to take notes. You can even write down some of the main points on the board.

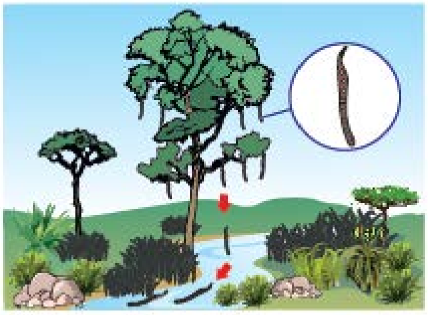
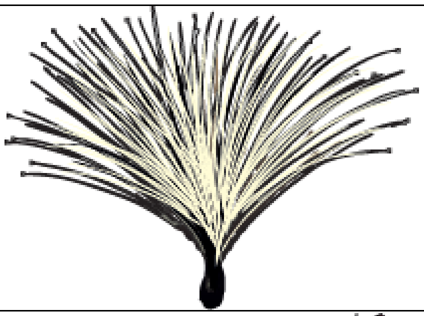
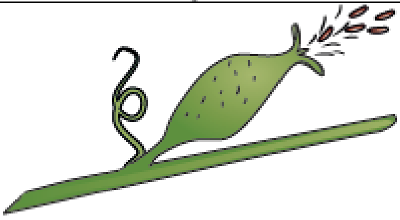
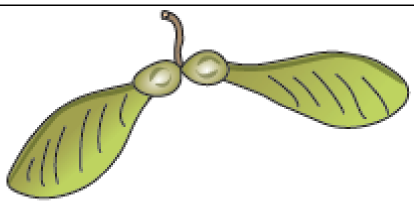
Some points for the discussion:

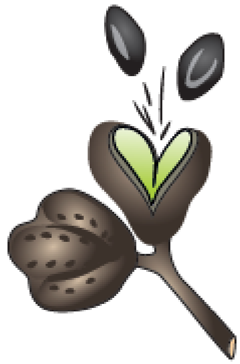
- It is important that seeds are moved to different habitats from those directly around the parent plant.
- If the seeds that are produced by the parent plant germinate and start to grow directly under it, in some cases it may replace aging plants, but in most cases, it would be in direct competition with the parent plant for light, minerals and water.
- When seeds grow too close to others, they grow long and spindly to reach enough light, making them weak and poor fruit producers.
- Therefore, in order to avoid being in competition with the parent plant and to produce stronger plants, the seeds are dispersed away from the parent plant with the hope that they will land in a 'better' habitat where they will receive enough minerals, light and water.
- The cells along the opening are specially designed so they rip open with force. (They have three thickened walls and one very thin wall.)

ACTIVITY: Studying different kinds of seeds LB page 66

If possible, try to collect some of these different seeds, pods and fruit before you do this activity and bring them to class for learners to look at. They can also try throwing upwards some of the seeds that are wind dispersed to see how they move through the air. This will help them understand the adaptations. Explain to your learners how they should explain how something is adapted and how this structure suits the function. The most common way to do this is to state the structure and then state why this structure helps the function. This normally takes the format of: The seed has 'x structure' **so that** it can do 'y function'.

Seed	**How is it dispersed?**	**What adaptations does the seed or plant have for dispersal?**
	**By an animal (bird)**	The seeds are within fruit (berries) which the bird likes to eat. Therefore, when they bird eats the fruit, the seeds pass through the bird and are dispersed far away in the bird's droppings. The seeds are also adapted by having a hard outer coat which is not digested by the bird so they can pass through its system.

	**By water**	These trees normally grow near water so that when the seeds fall off, they fall into the water to be transported away. The seeds are adapted by being able to float (they are buoyant) so that they can travel down the river to a new place.
	**By wind**	The seed is very light so that it can blow in the wind. It is 'feathery' so that it catches the wind and can travel.
	**By explosive force**	This seed pod might respond to touch to cause the explosion. This is beneficial so that not all pods explode at the same time, but they do so in stages. The seeds are small and light so that they can travel when they are shot out of the pod.
	**By an animal (dog)**	These seeds have burrs (little hooks) so that they can catch onto the fur of the dog and attach to the dog. As the seed dries or it is brushed against something else, they fall off. The seeds are often in position on a plant so that they are at a height to brush against an animal.
	**By wind**	These seeds are sometimes quite large, but still light so that they can travel through the air. The 'wings' are light and have a large surface area to catch the air and the seed spins as it moves through the air enabling it to travel

		further.
	**By explosive force**	These seed pods explode when they become dry and crack open. This makes sure the seeds are ready to be dispersed. The seeds are quite small to be able to travel.
	**By an animal (squirrel)**	Acorns are dispersed by squirrels who gather the nuts. The nuts are tasty to the squirrel, so the animal collects them and carries them to another place to store them. Some acorns will be eaten, but others will be buried and forgotten by the squirrel and will germinate and start growing later on. Acorns are also hard so that they can last a long time in storage before getting the chance to germinate.

3.2 Human reproduction

Be aware that learners may not feel comfortable discussing reproduction in the classroom, and may laugh or make inappropriate jokes to conceal their own discomfort.

Some tips for teaching human reproduction

1. Respect your learners' questions and concerns. Some of them may not have had an opportunity before to ask questions about reproduction, especially if their parents have not felt comfortable discussing this with them. This is a sensitive topic, and learners may be embarrassed to ask questions. Encourage your learners to ask questions and not be inhibited or embarrassed.
2. Discuss processes openly so that learners are comfortable within the classroom environment to talk and learn about reproduction and how it influences their lives. Discourage and discipline any laughing or disrespectful behaviour from other students. Insist that learners use the appropriate scientific terms when asking questions and having discussions, as this should prevent some learners from being intentionally vulgar.
3. Possibly bring in a guest speaker. Learners may feel more comfortable asking a stranger questions. Also, if you bring in an expert, such as a gynaecologist or midwife, learners might take the subject more seriously. It may be helpful to have someone from FAMSA come in and talk to the learners. Trained FAMSA facilitators will divide the class into smaller groups so that it is easier to ask questions.

4. If necessary, you can separate boys and girls. For example, if you are showing a graphic video about the female reproductive organs, it might be useful to have the boy watch a similar video in another room that explains the male reproductive organs. It may be very helpful to divide the classes into boys and girls at least once during the section so that learners can feel comfortable asking questions that they do not feel comfortable asking in front of their opposite-sex classmates.
5. Avoid portraying the reproductive system in a negative light or "forbidden" as this will only add to some of the discomfort that learners might already feel. At this stage in their lives, learners are already very interested in reproduction and the changes that their bodies are going through. This is natural and should be embraced so that they are educated and can make informed choices about their sexual health going forward.
6. Here is a website to do some further reading: bit.ly/1cfWcTS
   Some extra resources and pdfs can be accessed at bit.ly/19PWW09

It may be useful before starting this section to have a box where learners can put questions in advance of the lesson. Stress to learners that this is an anonymous exercise and that they do not need to identify themselves. You can then filter the questions in advance, and eliminate inappropriate questions, and also pick up on problem areas, misconceptions and concerns of some of the learners in the class who may be too shy to ask questions. You can then attempt to address these anonymous concerns while covering the material in this section. You can then ask the class in general what they may already know about human reproduction. Bear in mind that some learners might already know a significant amount, either from talking to their parents or from their own explorations, and some learners might not know much at all. You should point this out and let learners know that this is alright, and by the end of this section they will all know the basics of human reproduction. By asking them what they already might know, you are also encouraging them to start talking about it in class and not to be embarrassed or make jokes or tease each other. You can even ask some more basic questions, such as:

- Why do humans need to reproduce? (To produce children to continue the existence of our species. This is different from asking why humans have sexual intercourse, which is also for enjoyment with your partner.)
- Do you know how long pregnancy in humans is before the baby is born? (9 months)
- What is the stage in your life called when you go through physical and emotional changes as you become sexually mature? (puberty)

Learners have a right to their privacy during this section. Teachers should also be aware of and sensitive about possible victims of sexual abuse. It is also appropriate in this section to emphasise to girls in the class that it is perfectly all right to say "NO!" to persistent boys. Teachers should also encourage students to wait until they are older before becoming sexually active.

Why do humans need to reproduce?

ACTIVITY: What happens during puberty? LB page 68

1.

Changes in the girl	**Changes in the boy**
Changing body shape and figure Body fat increases Breasts start to develop Facial features more mature	Changing body shape and figure More muscular Penis grows bigger Facial features more mature

Hair growth under arms and on legs Pubic hair starts to grow (Acne / pimples in some individuals)	Hair growth under arms, legs, face, chest Pubic hair starts to grow (Acne / pimples in some individuals)

2. A line graph (or a growth curve graph)

   Note: Make sure that learners are aware that this graph displays an AVERAGE height. It does not just show a comparison between one girl and one boy, but rather takes the average height of a large group of girls and a large group of boys. Ask the learners why they think this is important. (There will always be a few exceptions of older people who are shorter than younger people, and girls who are taller than boys, but using the average helps us to see the general trend that occurs in most people.)

3. The average increase in height of boys and girls between birth and 18 years of age.
4. Independent variable: the age of the boys and girls Dependent variable: average height increase

   Note: You can explain to learners that the height depends on the age of the boys and girls and so the height is the dependent variable. As children grow older, they also grow taller, so height is dependent on age.

5. Height is measured in centimetres (cm) and age is measured in years. **Note:** Point out to learners that the axes of graphs must always have labels and if there is a unit of measurement, this must always be included in brackets after the heading.
6. **Note:** Interpreting graphs is a crucial skill in Natural Sciences. Learners might find it hard to explain what they are seeing in this graph, so go through the following steps in interpreting a graph.
   a) The blue line represents the average change in height of boys as they grow older. The red line indicates the average change in height of girls as they grow older.
   b) This means that boys and girls are on average the same height up until 6 years old.
   c) The graph line for boys is on top. This tells us that between age 6 and 10 years old, boys are generally taller than girls.
   d) Around age 10, boys and girls are roughly the same height again. This can be read from the graph where the two lines cross (we say they intersect). At around age 14 and a half, boys and girls are the same height again.
   e) Boys are generally taller than girls at age 18. The average height of boys at 18 years is about 187 cm and the average height of girls is about 171 cm.

   Note: You may need to help learners and show them how to read the values off the graph. They should use their rulers and draw a line across from 18 years old to the y-axis to see where it intersects and make an estimate of the height of boys and girls.
7. a) A sharp incline in the line of the graph indicates a growth spurt.
   b) No.
   c) Boys show a growth spurt between the ages of about 14 and 16.Girls show a growth spurt between the ages of about 11 and 13.
   d) These growth spurts correspond to the ages when girls and boys go through puberty. Girls go through puberty slightly earlier than boys and so the growth spurts take place at different phases.
8. Individual learners to mark this on the graph.
9. Learner-dependent answer.
10. Learner-dependent answer.

If you wish to challenge the students, ask them if they think this trend will continue between the ages of 25 and 35. (No, height should remain stable), What do they think they trend will look like between 65 and 85 (Older individuals often lose a bit of height in old age as their vertebra compress (or curve)).

You should check with the Life Orientation teacher at your school about what learners are doing at this stage, particularly with reference to sexual maturity, emotional changes and becoming self-aware. Some of the things which learners will be experiencing are listed below. If time allows, you may wish to grant learners 10 minutes for self-reflection. Perhaps send them outside to sit by themselves in silence. After this self-reflection exercise, return to class and have a discussion. You may wish to discuss some of these topics:

- **Strong feelings**: Puberty is for many a time when they move between very strong emotions; when these emotions last for more than a few minutes we call these 'moods'. Perhaps they feel excited and happy the one minute while they chat to friends but then walk home and arrive sombre, down and sad for no particular reason. This may lead to feelings of anxiety and frustration, which in turn leads to angry, emotional scenes with loved ones like parents or siblings. Since young people going through puberty are still learning how to deal with the many new feelings and emotions they are experiencing, they find this time particularly difficult. This might be alleviated as they learn to deal with conflict in a constructive way or they might choose to remove themselves from situations where they feel that there might be an emotional outburst that they cannot control.
- **More sensitive**: Linked closely to the many new and perhaps uncomfortable feelings, young people going through puberty might be more sensitive to the actions and intentions of those around them and might often misread facial expressions. This often comes across as being 'over sensitive'. However, as they mature and learn to 'read' or interpret facial expressions and the body language of others more accurately young people soon become better at interpreting messages and understanding the hidden or figurative messages and learn how to respond to these in a more controlled manner.
- **More self-conscious**: Some young people going through puberty and experiencing the different physical and emotional changes that this brings, are more self-conscious than others. They become more concerned with their physical appearance and tend to compare their bodies with those of famous celebrities, their friends and role models. If they do not look or sound the way they want to, this can affect the way they look at themselves and feel about themselves, what we call their self-esteem.
- **Looking for new experiences**: With the many physical changes being driven by the hormones in their bodies, young people going through puberty are more likely to look for new experiences and unknown 'paths' to explore. This may lead to dangerous, risk-taking behaviour that may put the young person's life in danger or derail their future plans. As they grow older, they start to learn to control these impulses and to make wiser decisions.
- **Exploring their sexual identity**: During this time young people start to form romantic relationships or go on 'dates'. Many young people prefer to wait until they are older to engage in sexual relationships. However, many others yearn for the thrill of a new experience and want to find out what sex is all about. It is therefore very important that they first make sure they know about the risks and take proper precautions to protect themselves (and their futures) if they do decide to have sex. (Which is one of the aims of this chapter!)

ACTIVITY: Draw a timeline of your life LB page 69

This can be a very **sensitive task** for learners to do, especially if they have suffered trauma in their lives. You must approach it sensitively and cautiously, making sure that learners feel comfortable with doing it. Some learners might also not want their timelines displayed, so this should be a personal activity for learners to do, without the pressure of having to display their timelines to the class.

Human reproductive organs

Different stages in human reproduction

ACTIVITY: Conduct a survey LB page 72

This should be done as a homework assignment in the lead up to the lesson about menstruation. The questions can then be answered in class and discussed.

Questions

1. Learner-dependent answer.
2. Learner-dependent answer.
3. Learner-dependent answer.
4. Learner-dependent answer.
5. Learner-dependent answer.

You should go through each of the myths to show that they are in fact all myths – they are NOT true. Read through these explanations and refer to them during your discussion with your class.

"Women who are menstruating are dirty and unclean."

- Women are not dirty and unclean during menstruation as menstruation is a perfectly natural process. Some people do believe this for religious reasons and you should be sensitive to their religious beliefs, while still stating that women are not "dirty".

"During your period you should never have cold food or walk with bare feet. If you get cold your period will be worse."

- This is not true. The uterus is the organ that controls menstruation and cold feet or food have nothing to do with the uterus.

"Exercise is bad for you when you menstruate."

- Menstruation is a normal, natural function of the body and not in any way a disability. Therefore you should continue with life as if nothing out of the ordinary is going on.

"Don't ever swim when you're having a period!"

- If using the right protection (tampons) there is no reason why girls should not be able to swim while they are having their periods.

"Virgins cannot use tampons – they will lose their virginity."

- Virginity is about whether a woman has had sexual intercourse or not. Long ago, a woman's virginity used to be assessed by whether her hymen was intact, as this ruptures during sex. However, nowadays, there are many times in a girl's life when her hymen can break without having sex, such as by using a tampon or horse-riding, or by doing gymnastics or ballet. This does not mean she has lost her virginity.

"It is unhealthy to have sex at the time of the month when you are menstruating."

- Although some people might find it off-putting, there is no medical reason why sex should be avoided. It is not unhealthy or unclean. It is the personal preference of the couple.

"You cannot fall pregnant during your period."

- There is a chance that you can get pregnant if you have sex during your period. Once in the vagina, sperm can stay alive for several days. That means that, even if the last time you had sex was three days ago during your period, you could now be ovulating and therefore you could get pregnant.

"You cannot fall pregnant or make someone pregnant if you have sex in water."

- This is not true. The water does not in any way prevent pregnancy, or the spread of STDs.

"Women are always moody and irrational during menstruation."

- Many women (not all) experience different pre-menstrual syndrome symptoms, which can include emotional changes, but this is not always so, and a woman's mood or emotional state should not automatically be attributed to PMS. After all, teenage boys can be similarly moody and emotional.

"Drinking and drugs make sex more fun."

- If you are drunk or on drugs, it is hard to make good decisions about sex. 20% of 15- to 17 year-olds say they have done something sexual while using alcohol or drugs that they might not have done if they were sober. At the time, it may seem like fun and a good idea, but it also means you are much less likely to practise safe sex and could then fall pregnant or contract an STD. Being under the influence of drugs or alcohol also makes girls more vulnerable to unwanted approaches.

"If you have a shower after sex, you will not fall pregnant."

- This is not true. The water will not 'wash off' the sperm. The sperm have already entered the vagina. As with STDs, showering after sex will not prevent pregnancy nor the transmission of STDs.

"You cannot fall pregnant if it is your first time."

- If you are ovulating, it does not matter if it is the first time you have sex, you can still fall pregnant. if your body has produced an egg during ovulation there is no reason why sperm will not fertilise the egg and result in pregnancy, even if it is the first time you are having sex.

"Everyone is having sex."

- To learners, it may seem as though everyone is having sex, but in reality, less than half (48%) of all high school students have ever had sex. Point out to learners that people often lie and exaggerate when it comes to sex. But, also point out that in the end it does not matter what others are doing and who is telling the truth or not, it matters what is best for you. Partners may apply pressure by saying things like "If you love me, you will". However, a truly loving and committed partner will wait until you are ready.

At the end of this lesson, you should make a point of discussing derogatory words that are used with reference to women and men. It might be useful to brainstorm bad name choices and to discuss the use of the correct terminology to avoid this.

If there are different cultural and religious groups in the class, it might be an opportune time to discuss religious laws and views on menstruation and what girls in the class experience as part of this group. However, teachers should be very careful to not degrade or embarrass girls that act in accordance to the religious beliefs of their families but should instead create an open and caring space where learners can discuss this.

Ways to prevent pregnancy and STDs

Teenagers may be more frightened by a possible pregnancy than by contracting a STD. This is a sad fact, as some STDs are incurable and life-threatening. It is useful to point out to learners in this section that hormonal contraceptive pills DO NOT protect against STDs and that a mistake made when they are young may affect the rest of their lives

You may want to point out to learners that due to the way that STDs are transmitted from person to person, when having sexual intercourse with a partner you are putting yourself at risk of catching disease from them, or ANY of their previous sexual partners, who in turn could have contracted an STD from any of their sexual partners etc.

Emphasise to learners that if someone is forcing you to have sex with them or threatening you in any way to have sex with someone else, you have the right to say no. Our country's constitution protects your right to say no. If this is happening to you, go and speak to someone you trust and ask them to help you solve the problem.

Emphasise to learners that when you decide that you want to have sex with someone, go and speak to a medical professional like the sister at your local clinic or the health care professional that works at the pharmacy. They will help you get the correct contraceptives and protection that you need. Emphasise that it is not only boys who can carry condoms. Girls can carry condoms too. If girls have condoms available, then they can INSIST on using protection.

ACTIVITY: Write a letter LB page 76

This activity is designed to empower the learners to take charge of their own sexual health. This is therefore a very personal activity and should not be for assessment purposes. Learners may choose to keep their letters entirely private.

Revision

1. 1: petal
   2: stigma
   3: style
   4: filament
   5: receptacle
   6: peduncle
   7: sepal
   8: ovules
   9: ovary
   10: anther
   11: pollen grain
   4 + 10: stamen
2.

Structure	Function
Petal	brightly coloured structure that attracts pollinators
Ovules	the part of the ovary of the flower that contains the female sex cell and that becomes the seed after fertilisation

pollen grains	fine powdery substance that contains the male sex cells that are transported to the stigma, and burrow down the style to the ovules where fertilisation takes place
Filament	stalk-like structure of the stamen that holds and supports the anther
Receptacle	tope part of the flower stalk to which all the other flower parts attach

3. Some of the points that learners could note are: The flower is brightly coloured and probably gives off a sweet-smelling smell to attract the bat. The flower has nectar for the bat to drink so that the bat comes to the flower. The flower is also probably open at night as the bat is nocturnal. The flower has a similar shape to the bat's head so that the bat can fit easily into the flower to reach the nectar. But the flower is still big enough with the nectar at the bottom so that the bat has to stick its whole head in and therefore brush against the pollen. The stamens are long and have feathery ends which brush against the bat as it sticks its head into the flower.
4. This seed is dispersed by wind. Learners may point out some of the following adaptations: This seed is large, but it is very light as the 'wings' are very thin, so that it can travel on the wind to be dispersed. The seed has 'wings' which help it move through the air like a helicopter. This helps it to move to a spot away from the parent tree so that it can grow somewhere else and not compete with the parent tree for space, water, etc. This also helps it to be lifted up by a draft of air, otherwise if it was just the small central brown seed without the wings, it would just fall directly down from the tree/plant.
5. 4: The sperm arrive in the oviduct.
   2 or 1: During sexual intercourse, the sperm is propelled from the penis.
   5: One sperm enters the outer cover of the egg to fertilise it.
   6: The fertilised egg is implanted in the uterine lining.
   3: The sperm travel from the vagina, through the uterus to the oviduct.
   1 or 2: The egg is released from the ovaries and travels along the oviduct.
6. Ovulation: when the ovary releases a ripe egg cell into the fallopian tube.
   Menstruation: when the blood-rich lining of the uterus and unfertilised egg cell is discarded through the vagina.
7. In the blood-rich lining of the uterus.
8.

Reproductive organs	Their function
Ovaries	Produces female sex hormones and stores, matures and releases ripe egg cells.
Oviducts	Transports the ripened egg cell from the ovary to the uterus; fertilisation takes place in the fallopian tubes (oviducts) so sperm swims from the uterus into the fallopian tube (oviduct).
Uterus	Once a month the lining of the uterus grows blood-rich and thick to allow the fertilised egg to implant in it and to grow an umbilical cord and placenta; uterus also undergoes strong contractions during childbirth.

Vagina	Muscular, elastic tube that can expand to hold the erect penis; sperm swim from the penis in the vagina to the uterus; it also allows the blood-thick lining of the uterus to be expelled once a month during menstruation; during childbirth it is the birth canal through which the baby travels and leaves the mother's body.
Penis	Can become erect (stiff and hard) to be placed into the vagina; ejaculates sperm in a liquid called semen; urine is also passed via the urethra.
Testes	Produce the male hormone; produces sperm that travel through different tubes to the penis from where it is ejaculated.

9. The penis grows longer and slightly wider; it begins to ejaculate preparing for reproduction. The testes mature and start to produce sperm which can fertilise an egg.
10. During puberty, the ovaries are stimulated to start maturing and releasing the eggs on a monthly basis. The fertilisation of a mature egg by a sperm cell is needed for pregnancy to occur.
11.

Term and definition	**Evaluation**	**Improvement**
Puberty: When you grow up.	Vague and not accurate; you grow up from birth to adulthood.	Puberty is the time during childhood when the sex organs mature and the body undergoes various changes, preparing it for reproduction.
Menstruation: When a girl bleeds.	Vague, inaccurate – if a girl cuts or hurts herself she may also bleed but not as is meant here.	If there is no fertilisation, the female's blood-rich uterus lining and unfertilised egg are discarded through the vagina once a month.
Fertilisation: When you put stuff into the garden to make it grow better.	Wrong context – that is called fertilising the garden.	When a male sperm cell fuses with a female egg cell.
Pregnancy: When the mom's stomach grows, and a baby pops out.	Inaccurate – it is not the stomach that grows, but the baby in the uterus. And a baby does not 'pop out'	The period (approximately 40 weeks) from conception to birth, where the foetus develops in the womb or uterus.
Conception: When the baby starts to come alive.	Inaccurate – life starts for some at different points	The moment that fertilisation takes place when the male sperm fuses with the female egg cell and forms a new individual.

4 Variation

Chapter overview

1 week

In the last chapter for this term, we will be looking at variation within a species and what this means. Learners have already learnt how to classify organisms using shared characteristics down to the species level. But, it is important for learners to understand that even within a species, the individuals are different.

These differences are called variation. As we have not yet learnt about cells and DNA, this chapter will not look at the genetic basis for variation, but rather focus on the fact that there are differences between individuals in the same species, and that some of those characteristics are inherited (passed down from one generation to the next). We will also introduce the concept of natural selection in which a particular variation can make an organism better suited (adapted) to a particular environment. This is crucial to the survival of the species, especially as environments can change. Learners will be introduced to DNA in Gr. 9, and only if they carry on with Life Sciences in Gr. 10-12 will they look at DNA, meiosis, variation, natural selection and human evolution in detail in Gr. 12.

4.1 Variation within a species (1.5 hours)

Tasks	Skills	Recommendation
Activity: Small, big, long-haired, short-haired, black, white, brown or spotty?!	Remembering, identifying, describing, explaining,	Optional (Suggested)
Activity: The height of learners in your class	Measuring, recording, plotting graphs, comparing, calculating, discussing	CAPS suggested

4.2 Inheritance in humans (1.5 hours)

Tasks	Skills	Recommendation
Activity: What is your inheritance?	Thinking, observing, recording, calculating, comparing, drawing, labelling	CAPS suggested
Activity: Natural selection in the peppered moth	Reading, explaining	Optional (Extension)

Key questions

- Are all dogs part of the same species if there are so many different sizes, shapes and colours?
- What about humans? What does it mean that we have different skin colours, heights and other differences if we are all part of Homo sapiens?
- What does variation mean?
- What causes variation?
- Why is it important that we study variation?

4.1 Variation within a species

The classification system is: Kingdoms, then phyla, then classes, then orders, then families, then genera, and the smallest group is species.

ACTIVITY: Small, big, long-haired, short-haired, black, white, brown or spotty?! LB page 82

1. The animal kingdom.
2. Dogs are from the phylum Chordata as they are vertebrates, having a backbone and internal bony skeleton.
3. Dogs are mammals as they are endothermic (warm-blooded), they have fur, they have mammary glands, they give birth to live young.
4. Some common characteristics include: four legs, fur, tail, sharp teeth, snout (elongated nose), pointy ears, paws with claws, a snout.
5. Yes, they are. All the different types of domestic dogs can reproduce with each other to create offspring. The ability to reproduce and have fertile offspring is the definition of a species.
6. Some differences include fur colour, fur length, body shape, body size, length of legs, length of tails, length of snout, shape of ears, etc.
7. Horses and donkeys are not the same species as they are not able to produce fertile offspring which can reproduce. Both belong to the family Equidae and the genus Equus, but they are different species. The domestic horse is from the species Equus caballus and the domestic donkey is from the species Equus asinus. This question was included to reinforce the concept of a species being organisms which can reproduce to produce fertile offspring.

Humans are all one species. Homo sapiens is the species name is for humans.

ACTIVITY: The height of learners in your class LB page 84

As a homework task, outlined in question 4 below, learners need to measure the heights of some of the adults in their family. First ask learners if this is possible. You can either get learners to do this the day before you do this activity and bring this information to class with them so that you can finish the activity and discussion off in one lesson, or you can do the activity, then complete the homework task afterwards.

If measuring adults in their family might be awkward for some learners (culturally, no adults at home, or other difficulties) then you could arrange to measure the height of the Grade 6 and Grade 9 learners as an investigation.

This activity could be used to introduce the concept of reliability in scientific investigations. Explain to your learners that sometimes mistakes creep into our scientific measurements and we record the wrong results. We overcome this by repeating the same experiment a few times and if we get the same (or very similar) results we can trust our results as being reliable. To illustrate this you can set up a couple of measuring stations where learners can take turns being measured and taking the measurements. Each learner can be measured 3 times and then you can calculate an average.

If you have a big class, you can divide learners up into groups of 10 and they can just record the heights of their group and use this to draw a graph.

Guide learners through this activity to draw a graph. The learners' names are the independent variables in this activity and so their names must go along the x-axis. The heights are dependent on the learner so the height goes along the y-axis.

As an extension, you can draw a histogram graph to illustrate the difference between these two types of graphs. To do a histogram graph, you will need to create ranges of heights and then count how many learners fall into each range. The height ranges go along the x-axis and the number of learners that fall into each category goes along the y-axis. Using this graph, you can easily see what the most common height range in the class is.

Questions

1. Class-dependent answer.
2. Learner-dependent answer
3. Learner-dependent answer.
4. Learner-dependent answer.
5. This discussion is meant as an entry point into the next section on inheritance. We will do one more short activity on similar characteristics between family members, before looking at inheritance in more detail. Use this discussion as an opportunity to introduce the concept of correlation. See if you can find some examples of correlation between the tallest learner in the class and the heights of his or her family members and the shortest learner in the class and the heights of his or her family members to illustrate that height is a trait that is often passed down in families.

4.2 Inheritance in humans

ACTIVITY: What is your inheritance? LB page 85

1. Learner-dependent answer.
2. Learner-dependent answer.

3.– 6. You may need to help learners to work out the percentage. To calculate the percentage, you need to:

- Add up the number of learners with a particular characteristic
- Divide that number by the total number of learners tested
- Multiply that number by 100.
- Draw a bar graph to show the percentages of learners who have each of the characteristics.

A possible homework activity: Use the above characteristics and see what family members at home can do and if they share the same characteristics or not. Calculate the percentage of family members that can roll their tongues or not.

Natural selection

This section is extra information and not crucial for you to go through with your learners if time does not permit. But it links well with what learners will do in later grades if they carry on with Life Sciences.

Visit the PhET website for ideas on how to construct a lesson around the simulation on Natural Selection identified here in the visit box. [1] bit.ly/15zeohI

Teacher's Note:

This is an extension activity that you can do with your learners if they have time, or get them to do it as a homework activity.

Revision

1. All these dogs belong to the same species because if they breed, the offspring are fertile and can breed again.
2. People observed some cats that were born with shorter than average front legs and then mated these cats with other cats with shorter front legs until over time they had cats with increasingly shorter legs.
3. They would probably not be able to jump, catch and claw their prey or be as fast as other cats, so they would probably not be as good at hunting as other cats.
4. Learners are required to give a value judgement. Some might agree that it is the right of humans, but others might feel that humans are being cruel and that it is wrong.
5. This means that the characteristics (traits) are passed down from the parents to the offspring from one generation to the next.
6. A species takes a long time to adapt as the individuals which have the trait which gives them an advantage are usually in the minority when the trait first starts to emerge. These individuals need to reproduce to pass on their trait. This takes over many generations. Only after many generations will the trait start to be dominant in the species as more and more individuals are born with the advantageous trait. Species which reproduce quickly and have short generation times (short life spans), such as moths, will evolve over a quicker time period than species which have long life spans and reproduce less, such as humans.

This is an extension question.

5 Properties of materials

Chapter overview

2 weeks

This chapter builds on the chapters about the properties of materials in Gr. 5 and 6 Matter and Materials. Some of the properties learners encountered in the earlier grades are revisited, but now we start placing greater emphasis on how properties that may be desirable in a consumer product, may become undesirable properties when that product turns to waste. New properties introduced are boiling point and melting point, and these are introduced using water as example.

5.1 Physical properties of materials (5 hours)

Tasks	Skills	Recommendation
Activity: Thinking about materials and their properties	Accessing and recalling information, classifying and sorting	CAPS Suggested
Activity: Advantages versus disadvantages	Accessing and recalling information, comparing, identifying problems and issues, writing	Optional
Investigation: Which type of paper is the strongest?	Hypothesising, planning investigation, doing investigation, recording information, comparing, communicating	CAPS suggested
Activity: Boiling and melting	Identifying problems and issues, writing	Optional
Investigation: What is the boiling point of water?	Hypothesising, accessing and recalling information, doing investigation, observing, recording information, interpreting information, writing	CAPS suggested
Activity: Boiling and melting points of other substances	Reading, plotting data on graph, comparing, writing	Optional/extension

5.2 Impact on the environment (1 hour)

Tasks	Skills	Recommendation
Activity: Environmental impact of material production	Accessing and recalling information, reading and writing	CAPS suggested

Key questions

- Which properties are important when choosing a material for a particular use?
- How can we measure the strength of a material?
- What does it mean when a liquid boils?
- How can we explain the term 'boiling point'?
- How can we explain the term 'melting point'?

- Why should we always think about the impact on the environment when we manufacture or use a particular material?

5.1 Physical properties of materials

Here you could also remind learners of a property they learnt about in Term 2 of Gr. 5.

New word

- **ductile**: the property of a material that allows it to be drawn out into a wire.

Metals conduct electricity and heat. Learners may also remember that metals are ductile. (Ductile describes a material which can be drawn out into a wire.)

ACTIVITY: Thinking about materials and their properties LB page 95

Instructions

Property	**Materials**
Strong	Learner-dependent answer: metals, plastics, leather, concrete and wood are all examples of materials that learners could mention.
Flexible	Learner-dependent answer: some plastics, rubber, some metals (especially in thin sheets) are all examples that learners could mention.
Conducts electricity	Metals
Conducts heat	Metals

Questions

1. Flexible means supple and bendy; able to flex and bend.
2. Flexible materials can be used to make clothing that needs to bend and fold; tubing or a pipe that needs to bend; coverings for electrical wiring that need to bend around corners; soles of shoes that need to flex when walking, etc.
3. Transmission cables for electricity, electrical wiring, electronic components for computers and other electronic equipment, electrical fencing (to protect property), etc.
4. Good conductors of heat can be used for making pots and pans, heating elements, etc.
5. Materials for cookware would need to be strong, rigid, and able to conduct heat.
6. These electrical wires need to be strong, flexible and able to conduct electricity.
7. The material used to make barbed wire fences needs to be strong, but also ductile so that it can be made into long thin wires, and also flexible so that the wires can be bent.

Learners should be encouraged at this stage to start thinking about scientific processes and products in terms of their advantages and disadvantages. This will create awareness that whatever payoff is created by scientific endeavour, one always has to consider the cost. Sometimes the cost is purely financial; at other times the cost may be damage to the individual (as in the case of the irresponsible use of medicines and drugs), or to the environment (some examples follow).

Advantages versus disadvantages

Learners could be encouraged to imagine carrying a shopping bag filled with heavy items, that would simply fall through a shopping bag that is too weak or thin.

Learners could be encouraged to think in terms of reusing shopping bags. Encourage them also to think of not-so-obvious uses for old shopping bags, like making artworks or weaving mats for instance.

When we throw a shopping bag away, its durability may mean that it takes years and years to break down, so it pollutes the environment for a long period of time. Its strength may mean that, when an animal becomes entangled in a piece of plastic that has been thrown away, the plastic would be too strong for the animal to escape from. The animal may eventually die as a result.

ACTIVITY: Advantages versus disadvantages LB page 96

This is an optional activity.

1. Learner-dependent answer. Encourage learners to write what they think of the golden car, what their thoughts and feelings are. Do they think it looks great? Would they like to own one?
2. A practical advantage is that gold doesn't rust. To some people, it may be important to display their wealth to everyone else.
3. Allow learners to debate this for a short while. You may want to point out that gold is actually quite a soft metal, and that driving a golden car would not offer more protection to the passengers than a car which has an exterior made mostly of steel would. Avoid the misconception that cars are made entirely out of steel. Cars have crumple zones to increase safety.
4. Gold is very expensive, and so the car would be unaffordable to most people. Gold is also very heavy (learners may need to be reminded of this), so the car would be heavy to move around. It would require lots of fuel to make it move and fuel is expensive. It would probably also scratch easily. Some learners may also say that because it is so valuable, it might get stolen. You could add that it could be insured against theft, but that insurance on a car this valuable would be very expensive. The conclusion is that although a gold car may seem like a nice idea, it is not practical or safe or fuel efficient.

Encourage learners to make their own notes as you are talking in class as this is a valuable skill. They can do it either here in the workbook or in a separate notebook if you make use of these. Some points to guide the class discussion:

- Something that is durable lasts a long time.
- Learners may say that something is strong when it is difficult to break.
- Allow learners to discuss how to test how strong a material is for a few minutes and come up with a few ideas.
- Learners may say the paper that is most difficult to tear would be the strongest.

INVESTIGATION: Which type of paper is the strongest? LB page 97

Learners can help you prepare for the activity by bringing different types of paper to school: newspaper, tissue paper, paper towel, or old magazines and gift wrap. Tell them to bring the biggest pieces they can find.

Aim

You could let the learners cut the paper into strips of 20 x 5 cm each, or you could do this beforehand to save time. Learners will compare the force required to tear the different types of paper. They have not yet encountered force as a concept (force is covered in Gr 9 Energy and Change) but you could encourage them to think about what they are doing when they hang the heavy marbles on the strip of paper. For example, ask learners: "What do more marbles in the yoghurt tub mean?" It means the yoghurt tub is heavier, and `pulls' harder on the strip of paper. (If you cannot get hold of marbles you could try finding small stones or pebbles that are more or less the same size. You would just have to explain to the learners that the stones do not all have a mass of 5 grams, but you will imagine that they do to simplify the calculations.)

Hypothesis
Possible hypotheses are: 'The thicker and stronger the paper, the more marbles it can hold before breaking.', 'Paper X is the strongest', where X is one of the papers supplied.

Material and apparatus
Make sure to use strong paper clips so that they do not bend under the strain of the marbles during the investigation. Make sure to use a range of papers, such as filter paper, tissue paper, crepe paper, wax paper, newspaper, normal white paper, harder card, etc. A suggestion is to also number the pieces of paper so that learners can easily reference them and then use the number to place them in order of strength later on in the questions. If you have time you can also test some other materials such as plastic shopping bags or aluminium foil.

Method
You can introduce the idea of a fair test here. Ask learners why they think they should punch the holes the same distance from the edge in each type of paper. This is because you want it to be a fair test – each piece of paper must be tested fairly and equally. If the holes were punched at different distances from the edge, this might make some papers appear stronger or weaker than they actually are. You need to control all other variables so that the only thing you are changing is the type of paper.

Results and observations
1. Learners should notice that the paper appears to be made of a layer of fibres. The fibres cling to each other because they have tiny branches on them, that become entangled to give the paper extra strength.
2. Learner-dependent answer based on the evidence from the investigation.
3. Learner-dependent answer based on the evidence from the investigation.
4. Learner-dependent answer

Analysis and evaluation
1. More than one factor play a role here, but generally paper that is thicker tends to be stronger. This is because the layer of fibres is thicker, so more fibres to cling to each other. Papers in which the fibres are longer and more tightly packed are also stronger, and coating the paper with a super thin layer of plastic also adds additional strength. Learners could be encouraged to look for signs of these treatments.
2. Plastics are generally stronger than paper, so for a start, the testing method should allow for greater weights to be hung from the plastic strips. This is a good opportunity to introduce the notion of fair testing: As many variables as possible should be kept the same: length of the plastic strips, method of fastening the weight to the plastic strips, etc.
3. We used paper strips of the same length and width.
    - We punched identical holes in all the different paper strips.
    - We punched the hole in exactly the same place on all the strips.
    - We used the same method to hang the marbles from the paper strip for all the different types of paper.
    - We repeated each measurement (by testing both sides of the paper strip).
4. Learner-dependent answer. One suggestion might be to cut strips of the same size of the materials to be tested, and lay them across the edge of a table, hang a weight on the

overhanging edge and find a way to measure the amount of flexing that occurs. Learners could discuss ways of ensuring the test is fair.
5. It is important to repeat experiments to be sure you get the same/similar answers every time. Repeating an experiment and calculating an average value helps to eliminate errors, or results that arise by chance (or luck). We say it makes the answer more reliable.

Possible conclusions include: 'The stronger the paper, the more marbles it can hold before tearing', or 'Paper X is the strongest as it can hold the most marbles before tearing and paper Y is the weakest', etc.

Most plastics melt easily because they melt at relatively low temperatures. We say they have low melting points. Note that this is not true for all plastics.

Boiling and melting points

1. The wax is melting
2. Discuss this with your class. The heat energy from the flame on the burning wick is transferred to the wax causing the temperature of the wax to rise. When the temperature gets to a certain point (called its **melting point**), the wax starts to melt as it changes state from a solid to a liquid.

There are some important differences between evaporation and boiling. Evaporation can take place below the boiling point of a liquid, but boiling takes place only once the liquid is heated and reaches its boiling point. Also, evaporation occurs at the surface of a liquid as individual particles gain enough energy to overcome the forces holding them in the liquid and become individual particles in the gas state. Boiling occurs within the liquid when enough particles escape en masse and form bubbles of gas in the liquid. The gas bubbles then rise to the surface of the liquid and the liquid is said to boil.

Ask your learners this question and get some answers. Encourage them to take notes:

- Water can be boiled in the kettle.
- Water can be boiled in a pot on the stove.
- Water can be boiled in a microwave oven.

ACTIVITY: Boiling and melting LB page 100

This is an optional activity.

1. Just a few sentences are required here. The learners should note that someone placed the plastic kettle on the stove. When the person tried to heat the water, the kettle melted as a result of contact with the flame/heat. The kettle is meant to be plugged in to heat the water.
2. Learners can come up with their own reasons here. Perhaps the person was used to heating water on the stove in a metal kettle. Perhaps the person did not know that the plastic would melt. Perhaps the person was just absent-minded and made a mistake.
3. No. Plastic is not a good choice because it melts when it is heated above a certain temperature.
4. The water boils at a temperature that is lower than the temperature needed to melt the plastic of the kettle.
5. This is because wood and plastic are not good conductors of heat, unlike metal, and so you can pick up the pot easily.

This is also an extension question as we have not specifically dealt with heat conductivity yet in this grade, but it has been covered in previous grades.

Some learners may know that water boils at a temperature around 100°C (100 degrees Celsius), depending on factors such as altitude above sea level and atmospheric pressure. Do not answer this question directly, but rather use it to introduce the next activity.

Here is an optional extension activity on how a thermometer works. It links to what learners will do in Gr 8 Matter and Materials. Next year, learners will look at the Particle Model of Matter, and within this, cover density and the contraction and expansion of materials. However, this is a good extension exercise to get learners thinking about how a thermometer works and introduce the idea that materials **expand** (when heated) and **contract** (when cooled) due to the increase in kinetic energy of the particles (the size and number of the particles do not change, it is only the spaces between the particles that get bigger or smaller).

Note: An exception is water, which actually expands when it becomes a solid (ice). This will be covered in detail in later grades.

Questions
1. The liquid level will rise when the liquid expands.
2. The inside of the refrigerator is cold. This will make the liquid inside the thermometer contract. The liquid level will drop.

INVESTIGATION: What is the boiling point of water? LB page 101

The investigation in the Learner's Book includes only that of investigating boiling point of water, as suggested in CAPS. However, if you would also like to look at melting point of ice, this second part has been included later in the Teacher's Guide.

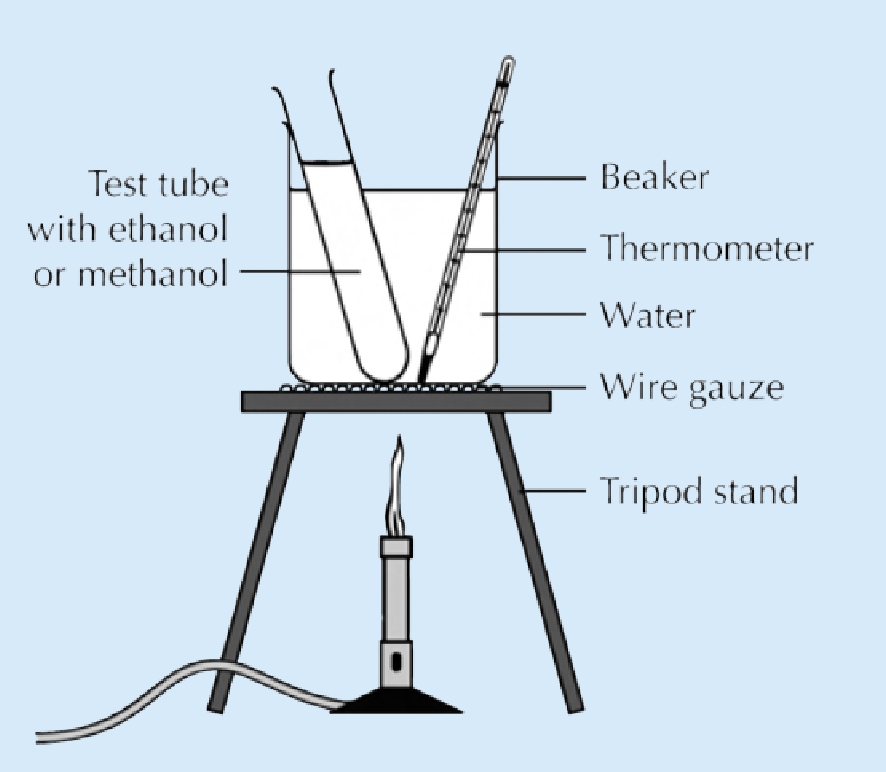
Aim
CAPS suggests that this investigation could be performed on `other liquids' such as orange juice, apple juice and cola. One issue to be aware of is that the suggested beverages are all solutions of substances in water. Their boiling points will be slightly higher than that of pure water, but this is because adding some substances to water elevates the boiling point of the solution. It is still water that is boiling in all these instances (the phenomenon is called boiling point elevation). Sometimes, adding substances (such as ethanol) to water can bring the boiling point down (refer to Raoult's Law). This is a lot of detail and not necessary for the learners to know about at this stage.

Here are some suggestions for extensions for this investigation:
1. Determining the boiling point of methanol (methylated spirits) or ethanol (available as 'surgical spirits' from the pharmacy). The point of this extension would be to show that different substances have different boiling points.

Note: Methylated spirits can be used instead of methanol, but it contains only about 9.5 % methanol in more than 80 % ethanol. This means there may not be a big difference between the experiments carried out with ethanol and methylated spirits.

Warning: Take care when working with these substances, especially methanol, since it is dangerous. Wear gloves if possible and avoid inhaling the fumes.

Furthermore, ethanol and methanol are both extremely flammable and care should be taken when heating them. A safe way of heating ethanol or methanol to its boiling point is shown in the following diagram. The test tube containing the ethanol or methanol should be suspended in a beaker of tap water, and slowly heated. The principle of thermal equilibrium means that the water and ethanol/methanol will be at the same temperature, so the temperature of the water can be substituted for the temperature of the ethanol/methanol.



2. Determining the boiling point of water by another method, for instance in a pot on the stove, or in a kettle. The point of this would be to show that the boiling point of water is constant (at constant pressure, of course, so it would make sense to do the extensions concurrently with the prescribed procedure below).

Hypothesis
Possible hypotheses that learners could give include stating the boiling point of water that they might know from previous knowledge.

Materials and apparatus
Before starting the investigation, divide the class up into groups in which they will perform the investigation and get learners to discuss the following questions first in their group to revise concepts from Gr 6.

1.
   - The particles in solids are tightly packed into fixed positions, so solids retain their shape. They cannot be compressed.
   - The particles in liquids are also close to each other, but they are not in fixed positions and can move around, that means liquids can fill the container they are in. They are not really compressible either.
   - The particles of gases are really far apart, they are not ordered in any way, they can move anywhere they want. Gases are compressible as a result.
   - Learners should be encouraged to think about the different states of matter in terms of the particle model which was first introduced in Gr 6 and is built upon more next year in Gr 8.
2. In order for water to freeze, it needs to be cooled down.
3. In order for water to boil it needs to be heated.
4. We measure temperature with a thermometer.
5. It is not important that learners remember these temperatures, as they will be determining them experimentally shortly. This question has been added to allow you to gauge how many

learners know them.

6. Learner-dependent answers.

The concept of making predictions in science investigations is introduced here.

When lighting the burner, always light the match (or lighter) before opening the gas.

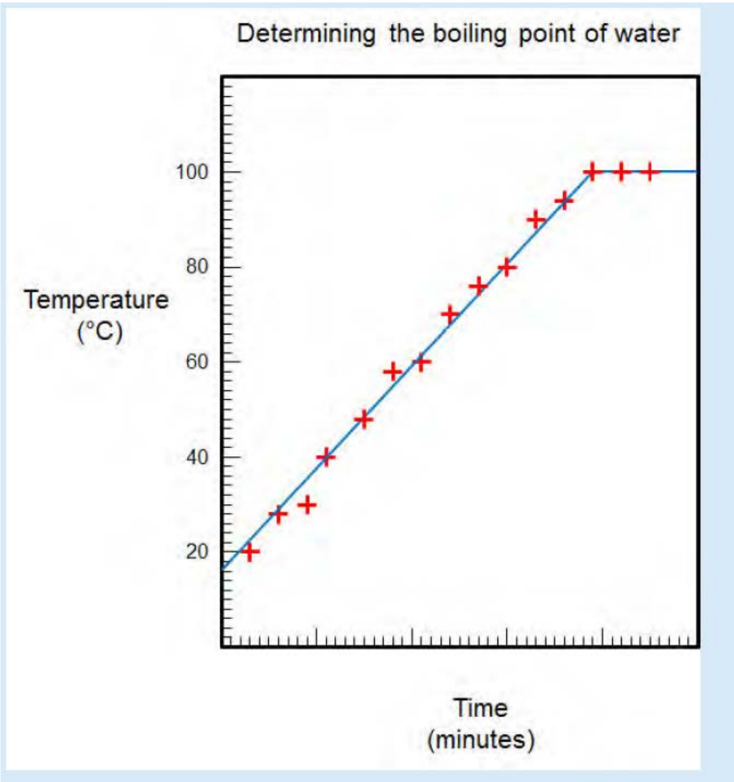
It might be best to try this experiment in advance to determine how frequently water temperature should be measured. Time intervals would depend on the volume of water. CAPS suggests intervals of 3 minutes, but shorter intervals will provide more data points to plot on the graph.

Learners should observe that the water is starting to boil. When boiling starts the temperature of the water remains constant. The best graph is obtained when the water is stirred gently throughout; this ensures that the water is heated uniformly.

Learners should be reminded that the independent variable is the one that was `manipulated'; in this case the total amount of energy added to the water increased with time. Since we have no real measure of the energy added to the water, but since we do know that the energy was added at a constant rate, we can use the **time** that the water was heated as our independent variable.

Learners could be reminded that the dependent variable is the one that was 'measured' or observed; in this case the temperature of the water as it increased with time.

Learners' graphs should have the following general shape and features:



Analysis

1. Bubbles could be seen in the water.
2. Some of the liquid water turned into gas, that is why there were bubbles.
3. The first part of the graph has a positive slope, then the graph becomes a horizontal line.
4. The temperature of the water increased gradually, then it became constant.
5. The left part of the graph where the slope is positive, shows that the temperature of the water increased. The right part of the graph where the graph is horizontal, shows that the

temperature of the water did not change over time, but stayed constant.

6. The temperature did not go up anymore, it stayed constant.
7. Learner-dependent answer.
8. Learner-dependent answer.

   The boiling temperature depends on the elevation above sea level and the air pressure at the time of measurement. Water boils at 100°C at sea level and at temperatures slightly below that at elevated altitudes.

9. The temperature at which water boils is called the boiling point of water.

   The next question refers to a bigger flame. A bigger flame simply means that energy is added to the water at a higher rate. This question helps learners to realise that for a fixed amount of water, a fixed amount of energy will be needed to bring it to the boiling point. This may help them to understand the concept of specific heat later on.

10. a) The water will boil at the same temperature. The bigger flame gives more energy to the water but does not affect the boiling point.
    b) The water will boil in a shorter time. The bigger flame gives more energy to the water per time unit. That means less time will be needed to heat the water.

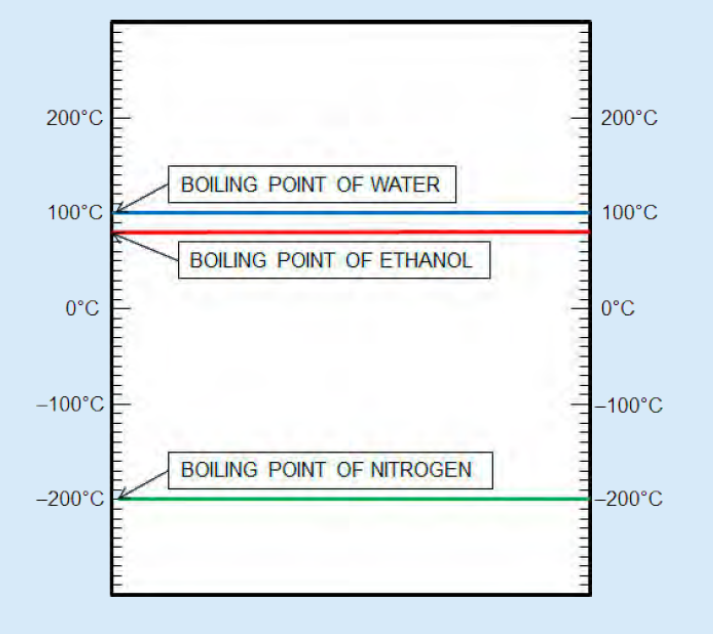
Learners should write a conclusion stating the boiling point of water that they determined from this investigation, for example, "From this investigation, it can be concluded that the boiling point of water is 100°C.

This is the second part of the investigation if you would like to look at melting point of ice.

ACTIVITY: Boiling and melting points of other substances LB page 105

This is an **optional** activity.

Teacher's Note:
The learners' diagrams should look like this:



Room temperature is normally 21°C. However, it varies in different laboratories in different countries, and the range between 21°C and 25°C is accepted.

Questions

1. Nitrogen would be a gas at room temperature, because room temperature is higher than the boiling point of nitrogen.
2. 78°C
3. Learners may be unsure, but you could say that the ethanol is still ethanol, it has not been changed in the process of mixing, so it will most certainly start to boil at 78°C.
4. No. Water only starts to boil at 100°C.

This question was included to prepare learners for the concept of distillation that will be introduced in the next chapter. Boiling point is a property of a substance. Boiling point can be used to identify a substance. You can explain this to your learners after you have done this question.

Possible answers are the metal of cooking pots conducts heat well to cook food and boil water, the metals that make up some heaters also need to conduct heat well.

The wool or fabric that the jersey is made of does not conduct heat well. It therefore acts as a heat insulator, keeping the body warm.

5.2 Impact on the environment

ACTIVITY: Environmental impact of material productionLB page 106

Mining

1. The local habitats are affected by the digging of the hole, the roads that are built and the other infrastructure put in place. Diamond mines require huge amounts of diesel which produce greenhouse gases which build up in the atmosphere.
2. **Note:** Learners may battle with this question, so you can ask them if they think anything can grow or live on these dumps again? As can be seen, these slag piles do not have anything growing on them as they are not green, and they have been there for decades, so they are reducing the possibilities for habitats and natural vegetation to grow back. The rock can contain toxic chemicals (such as cyanide) which seep into the ground and contaminate soil and water.
3. Huge amounts of land are destroyed when mining coal. Coal mining also requires large amounts of water, which reduces the water for surrounding areas. Water runoff can also contaminate water supplies. There is air pollution in coal mining and in the use of coal in power stations. when coal is burning, greenhouse gases are released which contribute to acid rain formation and the greenhouse effect. It also contaminates the air for other organisms.

Paper making

1. Plantations take up a lot of space and therefore natural, indigenous vegetation has to be cleared (deforestation). This destroys habitats for other organisms. These trees also use a lot of water and prevent anything from growing underneath them. They reduce the biodiversity in the area.
2. There is a huge amount of air pollution from paper-making factories, which contributes to a build-up in greenhouse gases. Paper mills use huge amounts of water, and the waste water contains many chemicals and substances which damage the environment.

Revision

1. a) The set of characteristics that describe a material are called the properties of that material.
   b) Materials that can be hammered into thin sheets are called malleable.
   c) Materials that can be bent are called flexible.
   d) The boiling point of a material is the temperature at which the liquid state of that material turns into a gas.
   e) When we want to measure temperature, we use a thermometer.
   f) The boiling point of water is 100 °C.
   g) A material that conducts heat well is said to have a high heat conductivity.
   h) If you want to create a circuit for a bulb, the material that you use in the circuit to connect the battery to the bulb must have a high electrical conductivity.
2. a) FALSE: There are a few alternative true statements possible:
   - Not all liquids boil at 100°C.
   - Water boils at 100°C.
   - Each liquid has its own unique boiling point.

   b) FALSE: At sea level, water boils at 100°C. (At higher altitudes water boils at temperatures slightly below 100°C.)
   c) TRUE
   d) FALSE: Two alternative TRUE statements are possible:
   - When water is boiled over a bigger flame, it will boil at the same temperature, namely 100°C (at lower altitude/at sea level).
   - When water is boiled over a bigger flame, it will boil more quickly (sooner).
3. a) The unknown liquid boils at 65°C. (Learner must indicate this temperature on the graph.)
   b) The unknown liquid starts to boil after approximately 40 minutes.
   c) The unknown liquid is methanol. The boiling point of methanol is the same as that of the unknown liquid, namely 65°C.
   d) 21°C

6 Separating mixtures

Chapter overview

1 week

The concept of 'Mixtures' was first introduced in Gr. 6, so learners should already be familiar with the concept. Learners would have also looked at some of the physical methods of separating different types of mixtures (including hand sorting, sieving, filtration), and this year we will explore some additional methods in more detail (including distillation and chromatography).

6.1 **Mixtures** (1 hour)

Tasks	Skills	Recommendation
Activity: Types of mixtures	Sorting and classifying, communicating, group discussions	CAPS Suggested

6.2 **Methods of physical separation** (4 hours)

Tasks	Skills	Recommendation
Activity: Thinking about hand sorting	Sorting and classifying, comparing	CAPS Suggested
Activity: Thinking about sieving and filtering	Sorting and classifying, comparing	CAPS Suggested
Activity: Thinking about magnetic separation	Sorting and classifying, comparing	CAPS Suggested
Activity: What if we want to keep both the water and the salt?	Demonstrating distillation	CAPS suggested
Activity: How can we separate two liquids with different boiling points?	Demonstrating distillation using Liebig condenser	Optional, extension
Investigation: Is black ink really black?	Separating ink by chromatography, hypothesising, doing investigation, observing, recording information, comparing, interpreting information,	CAPS suggested
Activity: Separating a complex mixture	Designing and explaining, planning investigation, sorting and classifying, comparing, writing	CAPS suggested

6.3 **Sorting and recycling materials** (1 hour)

Tasks	Skills	Recommendation
Activity: What happens when we throw things away?	Communicating, group discussions, writing, identifying problems and issues, raising questions	CAPS Suggested
Activity: Careers research task	Discussing, communicating	Optional

Key questions

- How can we explain the term 'mixture'?
- What types of materials can be mixed?
- What methods can be used to separate a mixture into its original components?
- Which factors are important when choosing a method for separating a mixture into its components?
- Which materials can be recycled?
- Who is responsible for the disposal of waste materials?
- What are the negative consequences of poor waste management?

6.1 Mixtures

In the first section of this chapter, learners will learn how to identify mixtures. One of the central ideas in this section is that the components in a mixture are not chemically joined. They still exist as separate compounds that have not reacted with each other in any way. For that reason, mixtures can be separated using physical methods. Physical methods cannot be used to separate elements that are chemically joined.

In order to make this section more interesting you could provide small samples of each of the mixtures discussed and ask learners to draw them, paying close attention to any features that a particular mixture may have. When they are faced with a solution (water and sugar, for instance) they might notice that there are no visible features to draw. This will help establish in their minds that solutions are mixtures where the substances are so intimately mixed (literally on the level of individual particles) that we cannot make out separate substances anymore.

Get your learners to act out the word 'mix'. Learners might make stirring motions with their arms. This exercise may seem trivial, but their attention will immediately be focussed (and their learning enhanced) if they are engaged in this way. Using gestures that require learners to move their bodies has been shown to enhance learning even at university level!

Some learners may say no you cannot mix water, you need two or more things mixed together to have a mixture. Other learners may answer that it is possible to mix hot water with cold water. Point out that the end result would just be water, and not really a mixture of hot and cold water; once mixed, the water would have the same temperature throughout.

Different kinds of mixtures

This is a revision of the types of mixtures that one can get, which has been done in Gr. 6 Matter and Materials. If you feel your learners have already grasped this, you can go through it briefly by just looking at the different pictures provided and ask learners what types of mixtures they are.

A mixture of a solid and a solid

Soil can contain clay, sand and small pebbles. Soil can also contain bits of plant matter. Clay and dust particles are very small, and sand particles are larger.

Pebbles are even larger.

A mixture of a solid and a liquid

Keep in mind that some mixtures that we expect to be solutions end up being suspensions. A good example is table salt and water that could end up looking cloudy because of the starch (free-flowing agent). In this case it would be better to use pure sea salt. (You could also use this apparent paradox as the basis of an extension activity about what appearances allow us to infer in certain situations.)

A mixture of a solid and a gas

Smoke is actually made of tiny solid lumps of soot and ash and dust that mix with the air (which is a gas) and water vapour (also a gas). That makes smoke a mixture of one or more solids and gases.

A mixture of a liquid and a liquid

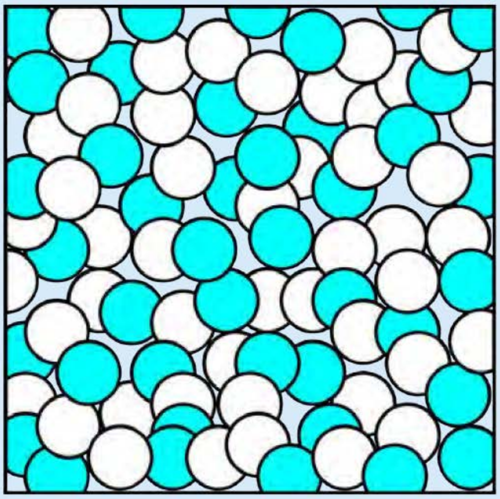
We use milk as an example of a suspension, however, milk is actually more complex since it also contains solutes. It is a great example of a mixture that has both solution and suspension (emulsion) components. Flour or Maizena (cornflour) mixed with water also makes a good suspension which settles after some time. This is also a good opportunity to revise the terms solute, solvent and solution, namely the solute (for example sugar) is the substance that is dissolved in the solvent (for example water) to form a solution (for example sugar water).

Look at the questions on page 115 of the Learner's Book. Explain to learners that firstly, no, not all liquid-liquid mixtures are opaque. Secondly, most solutions that learners will be able to think of are essentially solid-liquid mixtures at the fundamental level. It is good enough for learners at this level to offer examples of liquid-liquid mixtures such as 'a mixture of apple juice and water'.

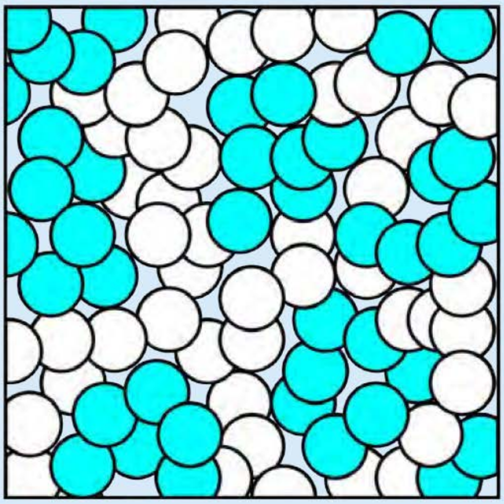
A better example of a liquid-liquid solution is vinegar, which is a mixture of ethanoic acid (acetic acid) – a liquid at room temperature – and water. This example might be a sensible inclusion since it would serve as early introduction to household acids that will feature prominently in the next chapter (Acids and Bases). If learners are given a vinegar sample to draw, it would be better to provide a sample of white vinegar, since it contains less solid matter. Once again, they will be confronted with the realisation that the solution does not have visible features. Another opportunity to establish that solutions are mixtures is where the substances are so intimately mixed that we cannot detect separate substances any more.

The particle model of matter will be dealt with in detail only in Gr. 8, but the following kinds of visual representations may aid understanding of abstract concepts. You can draw these on the board with different colours. Learners were exposed to similar images in Gr. 6.

However, it is not critical at this stage and you do not need to go into detail. Solutions look glassy/translucent, and the solid particles cannot be seen. The substances cannot be separated by filtration (dealt with later in this chapter).



Particles in a solution. Notice that the blue particles are more or less evenly spaced amongst the white ones.



Particles in a suspension or emulsion. Notice that the blue particles are present in little clumps or clusters amongst the white ones.

In a suspension, the particles of one of the substances are always clumped together. Sometimes one can even see little globules of oil (in the case of an emulsion) or little lumps of solid (in the case of a suspension) suspended in the liquid.

A mixture of a gas and a gas

Nitrogen gas and oxygen gas. Learners may say oxygen and carbon dioxide; nitrogen is actually the main component of air (roughly 80%) followed by oxygen (roughly 18%). Carbon dioxide is present in much smaller quantity.

A mixture of a liquid and a gas

The liquid turns to a gas.

A suggestion is to do a demonstration of this in class if you can get a kettle and plug it in to show learners the colourless steam at the spout of the kettle.

Learners may point to the cloud in front of the kettle. This is not actually water vapour, which would be invisible to the human eye. The cloud forms when the water vapour cools down sufficiently to condense into micro-droplets that are visible to the human eye.

We will only see the water when it starts to condense. When the water particles condense, they become liquid water again. That means the particles start clinging together in tiny micro-droplets, which grow into larger droplets when they come together. The small cloud of in front of the kettle is actually a cloud of micro-droplets of liquid water suspended in air. This is an example of a liquid suspended in a gas.

The image below indicates where the arrow should be drawn:

Most gases are colourless and cannot be seen. We cannot see individual particles as they are too small. However, some gases (such as Chlorine and Fluorine) can be seen because they are coloured.

ACTIVITY: Types of mixtures LB page 115

Gas-gas mixtures: Air

Gas-liquid mixtures: spray deodorant and air freshener Gas-solid mixtures: smoke, dust cloud and foam plastic Liquid-liquid mixtures: Clear fruit juice, hair oil

Solid-liquid mixtures: Salty water, paint (an emulsion/suspension of solid pigments particles in water or oil), cloudy apple juice (tiny bits of pulp are solid, and suspended in the juice)

Solid-solid mixtures: Alloys, soil

You can ask your learners what we use paint for. Paint is used to cover walls and other surfaces. Sometimes we want to protect these surfaces against water or wind (for instance when we are painting an outside wall or roof) and sometimes we just want to make them look attractive (for instance when we paint an inside wall, or when we create a beautiful artwork). The water or oil in the paint helps us to spread the pigments more evenly over the surface that we want to cover and binds the pigments tightly so that the paint forms a protective layer.

6.2 Methods of physical separation

As an introduction to this you can ask learners about why they think we would want to separate mixtures. For example, imagine that our drinking water comes from a well in the ground and it is muddy. Muddy water is not good to drink.

We would want to separate the water from the solid material (sand or clay) before using it! Once separated, we would keep the water to drink and throw the sand away. Ask learners if they can think of a way to separate the water from the sand? Learners may suggest filtration (filtering) as a method for separating the sand and water.

How do we separate mixtures?

Sugar and sand grains are too small to be sorted by hand, and they look very much the same. It would not be practical to sort them in this way.

Hand sorting

The most practical method would probably be to hand sort them into different colours.

The video about the Skittles sorting machine is merely for entertainment, but it could be used to introduce discussions on fun 'explorations' and hobbies that challenge us as a starting block for innovation and useful applications of technology.

ACTIVITY: Thinking about hand sorting LB page 116

1. Yes, as long as there are not too many of them to sort.
2. Probably not. It would take far too long!
3. Learner-dependent answer. Suggestions may include:
   - Sorting thorns from wool
   - Sorting Lego blocks into different sizes or colours
   - Sorting stones from a packet of dried lentils or beans
   - Sorting mail
   - Sorting fruit or eggs according to size or grade
4. When the 'particles' in the mixture are relatively large and when there are not too many of them to sort.

Sieving

It probably is not a good idea to hand sort as it would take too long.

Filtration

Learners did an exercise in Chapter 6 of Matter and Materials in Gr. 6 on cleaning muddy water. The chapter entitled 'Processes to purify water' required learners to design, make and evaluate their own filter. You can demonstrate the process again to refresh their memories. To set up a filter (as shown below), place a folded piece of filter paper in a funnel and place the funnel into a flask. Then, pour a mixture of muddy water into the filter and let the learners observe that clean water passes through the filter, while the mud/sand/clay remains behind.

It is a mixture of solid and liquid, and is a suspension. You can get learners to label the suspension, the filtrate and the residue on the diagram.

Inhaling dust or smoke is harmful to our lungs. The masks help to clean the air before it enters the respiratory tract.

ACTIVITY: Thinking about sieving and filtering LB page 118

1. Learner-dependent answer. Suggestions may include:
   - Sieving flour to remove lumps, husks and other large bits
   - Pouring tea through a sieve to catch the tea leaves (this is a crude way of filtering)
   - Rinsing sand or soil from spinach leaves before we cook them
   - Filtering leaves out of a swimming pool (we call it filtering, but what we are actually doing is sieving the leaves out of the water)
2. When the components of the mixture have different sizes and there are many of them to sort.
3. To remove the tea leaves from the tea before drinking it.
4. Learners may realise that they need to make the openings in the sieve smaller if they want to catch smaller particles.
5. Learner-dependent answer. Suggestions may include: Filtering coffee grounds through a coffee filter or in a plunger.
   - The vacuum cleaner has a filter for trapping dust particles inside the machine and letting clean air through. That is how it removes dust particles from the carpet and furniture.
   - Air conditioners contain filters to filter out dust before the air from outside enters a building.

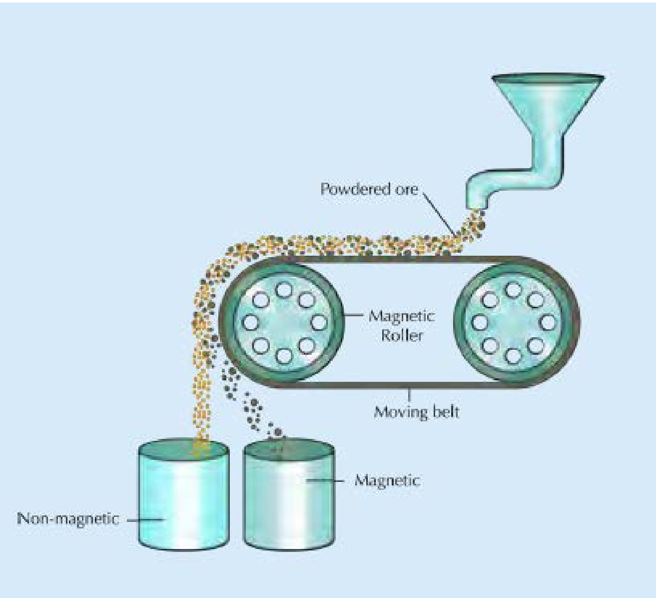
6. When the 'particles' in the mixture are very small, and in different states.

Magnetic separation

You could demonstrate how, or let the learners try, to separate a mixture of sand and iron filings by using a magnet. It may help to place the magnet in a small plastic bag so that the iron filings are attracted to the magnet, but do not stick to it.

Refer learners to the diagram on page xx of the Learner's Book. The non-magnetic grains are yellow-orange and fall into the container on the left. The magnetic grains are grey-brown and fall into the container on the right.

The diagram should be labelled as follows:



ACTIVITY: Thinking about magnetic separation   LB page 119

1. Learner-dependent answer. Suggestions may include:
   Removing iron filings (magnetic) from sand or sugar (non-magnetic). Separating aluminium cans (non-magnetic) from steel cans (magnetic).
2. When the components in the mixture have different magnetic properties, in other words when one or more components in the mixture is magnetic and the others are non-magnetic.

Separating solutions

Separation by evaporation

Demonstrate this in a lesson by dissolving some salt in water in front of the class at the beginning of the lesson. Make sure they take note of the clear solution.

Then pour a little into a shallow aluminium pan, like those used for baking. Place this out in a sunny spot for the duration of the lesson and allow the water to evaporate. The rate of evaporation will depend on how hot and humid it is on the day you do this. At the end of the lesson, collect the pan and show the dried salt that is left behind, just as in a salt pan. You might have to leave it out until the end of the day, depending in how hot it is.

Yes, it would.

ACTIVITY: What if we want to keep both the water and the salt? LB page 120

If you have time to do this in class, you can demonstrate this practically. Get learners to taste the salt water before boiling and then getting them to taste the condensed water afterwards. This way they will realise that only the water has evaporated, and that the salt has remained behind in the kettle. You could put the ice in a small plastic bag to ensure that the ice does not slip off the plate, but the plate is still cold enough for water vapour to condense. Keeping the ice in a plastic bag will also ensure that the melting ice does not drip into the beaker collecting condensed water. You can also use a beaker or glass of salt solution over a Bunsen burner and use a cold piece of glass or mirror to condense the water and collect it in another beaker.

Questions

1. Evaporation by itself is not a good method of separation if you want to keep both the salt and the water. Once the water evaporates, it is lost.
2. In the picture, the salt-water solution is heated in a kettle, and a metal plate (with some ice inside to keep its outer surface cold) is held in the water vapour that is escaping from the spout of the kettle. The water vapour cools when it touches the cold metal plate and condenses. It then runs off the plate and into the collection beaker. The salt is left behind in the kettle once all the water has evaporated. But, you still have the water in the beaker.
3. Salt water is boiling.
4. Liquid water is changing to water vapour. The process is evaporation.
5. Water vapour is changing to liquid water. The process is called condensation.
6. No. You can taste that the water is salty before evaporation, and not salty after condensation. If you boil the water until all of it has evaporated, you can see salt crystals form.
7. It does not taste salty after evaporation/condensation, so we assume that it is pure, but it may have other things in it which we can't taste.

   Some things we can't detect or taste, for example, if we were using sea water.

Distillation

If you have the equipment to set up this distillation process, then you can demonstrate it in class. Otherwise there are alternative materials and equipment that you can use. For example, if you do not have a Liebig condenser, you can use a piece of copper pipe. Here are two links which explain how to build your own distillation equipment:
http://www.instructables.com/id/Build-a-Lab-Quality-Distillation-Apparatus and
http://nukegingrich.files.wordpress.com/2009/06/diy-still.pdf.

Another suggestion is to get learners to also do the research to see how to make their own distillation apparatus, specifically looking at materials which are easy and cheaper to come by. You do not have to have laboratory equipment to demonstrate many science experiments – many can just be done by thinking of the materials which you use in everyday life and making a plan! This also makes science more accessible to everyone.

The solar still video refered to in the Visit box on page xx of the Learner’s Book, is short but provides an interesting topic for discussions: applications of separating methods; inventions; advantages and disadvantages; you could even discuss open-source projects and sharing information. The Italian inventor of the Eliodomestico solar still designed it with developing countries in mind. It is relatively cheap, easy to assemble, and requires no electricity. It is described as an eco-distiller that runs on solar power. All you need to do is pour in 5 litres of salty or impure water, tighten the cap, and leave it out in the sun. By the end of a day it can provide bacteria-free, salt-free water that is suitable for drinking. It is also an open-source project which means that anybody can use the design and replicate, modify or upgrade it, but not sell it for profit.

ACTIVITY: How can we separate two liquids with different boiling points? LB page 122

This is an optional activity, or else it could be done as a homework task. It is an extension of what learners would have learnt about using distillation.

1. 100°C
2. The boiling point of water
3. 78°C
4. Learners could be reminded that the ethanol is still ethanol, it has not been changed in the process of mixing, so it will most certainly start to boil at 78°C.
5. No. Water only starts to boil at 100°C. As long as the temperature is below 100°C, the water will not boil.

These questions are identical to the ones posed in the original activity. They were included in the original activity to serve as introduction for the concept of distillation.

We replace the receiving flask with a clean one and heat the distillation flask again, but this time to the boiling point of the second liquid. The second liquid will evaporate, condense in the cooler and flow into the clean receiving flask, leaving the final component in the mixture in the distillation flask.

The video about distillation of crude oil may be a bit too advanced, but it summarises the process of fractional distillation quite well and mentions relevant, real-world examples of products that are produced. Take note that the video repeatedly mentions 'hydrocarbons'. You can put the learners at ease and tell them it is not important for them to know what this means yet. The periodic table is only dealt with in Chapter 4, but you could help the learners 'decipher' that the crude oil contains a lot of **hydrogen** particles and **carbon** particles put together in different combinations (ratios). Each of the fractions that are eventually collected contain one kind of hydrocarbon combination.

INVESTIGATION: Is black ink really black? LB page 123

This is a fun activity that can be done quickly. If the class is divided into small groups and each group gets a different black marker to experiment with, the chromatograms can be stuck up on the wall afterwards for everyone to see and compare. By looking for matching chromatograms, learners can say which group had the same brand of marker, or which markers are filled with the same ink. If the ink from a certain marker will not separate in one liquid, try using another liquid in the beaker.

You could even build a story around the investigation: Stage a murder mystery in which the murderer can be identified by his (or her) black pen. Use three or four black or blue pens of different brands, and produce the unique chromatograms associated with each brand. The inks may look the same when used for writing, but they will behave differently when they are analysed by chromatography.

Hypothesis
Learner-dependent answer. A hypothesis could be 'Black ink is made up of different coloured pigments.'

Materials and apparatus
Laboratory Whatman filter paper no. 1 is ideal for chromatography. Alternatively, you can use coffee filters, watercolour paper or strips of paper towel. Even ordinary copy paper works, but more slowly and often this makes the colours separate better. For softer papers you may need longer strips of paper and taller containers, since the liquid is carried up the paper much faster.

Possible hazards
- Ammonia is a dissolved gas and a weak base. It is not likely to cause burns, but ammonia fumes can irritate the mucous membranes of your nose.
- Surgical spirits and methanol contain alcohol. Nail polish remover contains acetone. Alcohol and acetone are flammable and should be kept away from heat and flames. You should not inhale the vapours of these solvents.

Safe laboratory practice is extremely important. Take a moment to discuss risks, precautions and safety with learners. Discuss the fact that scientists often need to handle dangerous substances and/or equipment to be able to make observations.

When working with ammonia, take care to work in a fume hood or in a well-ventilated space. Leave the door and windows open, so that the fumes do not linger. Similarly, substances containing alcohol should be used in a well-ventilated space, but these are also flammable, so avoid using them in the presence of open flames.

It is always advisable to wear latex/nitrile gloves (available from pharmacies) to prevent the absorption of hazardous substances through your skin. Wear safety goggles to protect your eyes from harmful chemicals. Always have clean water nearby to rinse your eyes or wash your hands if chemicals do splash or spill.

Careful laboratory practice will not only ensure your own safety, it will also set a good example to learners.

Method
You can also use a clothes peg to hold the strip in place while drying.

Observations
1. Learner-dependent answer
2. Learner-dependent answer
3. Learner-dependent answer

Conclusions
1. Learners should note that black ink is actually made up of a number of different coloured pigments.
2. The yellow pigment is moving the fastest because it has travelled the longest distance.
3. The green pigment is moving the slowest because it has travelled the shortest distance.

ACTIVITY: Separating a complex mixture LB page 126

Some schools also use combo plates for the various practical tasks in Matter and Materials. This is encouraged and the activities in these workbooks can be adjusted slightly to work with whichever equipment and apparatus you have available to you in your school.

Also, if learners find the flow chart too complex at this stage, you can alternatively get them to write out the steps they would follow to separate all the materials in the mixture and why they have chosen each method of separation.

This may be a difficult task for the learners to accomplish, but it is very important for the learners to be able to visualise the mixture before they start to plan the experiment. If they do not, the ideas will remain abstract and the learners may have difficulty sequencing the different separation steps correctly. You could guide them by asking the following questions. Alternately, you could prepare the mixture for them to look at it before drawing it:

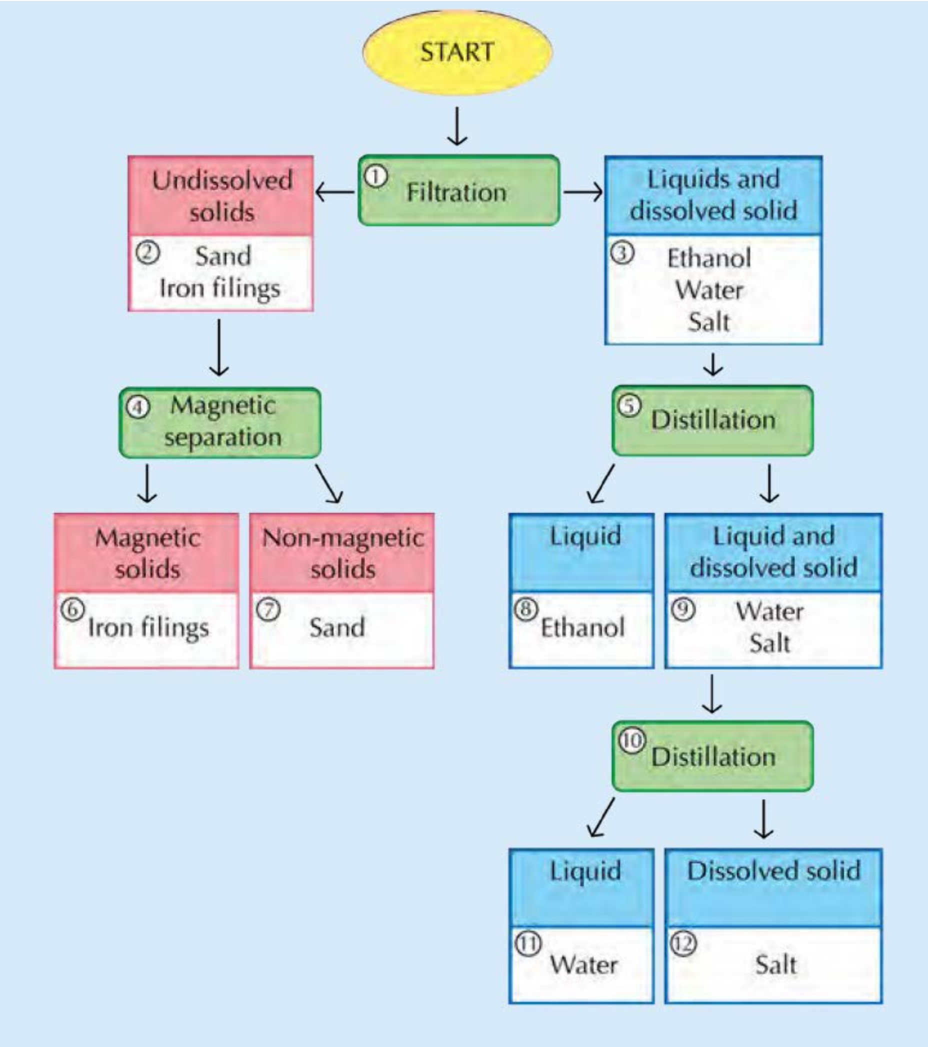
- What does the container look like? Draw it on your page.
- Which liquids are in the container? (Ethanol and water.) Now draw the container with a mixture of ethanol and water in it. Would you be able to see the ethanol AND the water when they are mixed? (No, they would just look like liquid in the container.)
- Now add the sand. Would it mix with the water or sink to the bottom? (Most of it would sink to the bottom.)
- Now add the iron filings. Would it mix with the water or sink to the bottom? (It would sink to the bottom.)
- Now add the salt. Would the salt sink to the bottom or dissolve in the water? (It would dissolve in the water.) Would we be able to see it if it was dissolved in the water? (No.)

1.

Component (substance)	**State (solid liquid or gas)**	**Dissolved or undissolved?**
Iron	solid	undissolved
Sand	solid	undissolved
Salt	solid	dissolved
Ethanol	liquid	dissolved (in solution with the water and salt)
Water	liquid	dissolved (in solution with the ethanol and salt)

2. The sand and iron filings are undissolved.
3. Salt is the only dissolved solid.
4. Learners should write FILTRATION in block 1.
5. Learners should write SAND and IRON FILINGS in block 2.
6. Learners should write SALT, ETHANOL and WATER in block 3.
7. Learners should write MAGNETIC SEPARATION in block 4.
8. Learners should write IRON FILINGS in block 6 and SAND in block 7.
9. Learners should write DISTILLATION in block 5.
10. Learners should write ETHANOL in block 8.
11. Learners should write WATER and SALT in block 9.
12. Learners should write DISTILLATION in block 10.
13. Learners should write WATER in block 11 and SALT in block 12.

The completed flowchart should look as follows:



6.3 Sorting and recycling materials

Allow learners to discuss this for a while. Some may know that rubbish eventually ends up on a rubbish dump somewhere, and this is a good starting point for the next activity that will require learners to think about the implications of dumping.

ACTIVITY: What happens when we throw things away? LB page128

'There is no away' and 'There is no Planet B' refers to the same issue, namely that everything that we throw away remains part of our environment. We should be thinking of ways to reintegrate our waste by making it part of the environment in ways that will not harm the environment; reusing, recycling and repurposing waste items and materials in creative and innovative ways. 'There is no Planet B' is also a play on words that refers to the well-known notion of a 'Plan B' that can be reverted to if the original plan (plan A) fails.

Questions

1. Learner-dependent answer
2. Many things can be reused or recycled. Many of the waste that is not recyclable can be turned into compost for the garden. Learners may have interesting opinions about this question, and hopefully it will get them thinking about creative ways of reusing and repurposing waste.
3. Learner-dependent answer. Learners should generate suggestions centred on reusing, recycling and repurposing.

An optional additional activity for this section is to get learners to assess how poor waste management techniques impact the environment.

For this activity, learners must use materials that would ordinarily go into the rubbish bin in your home (cereal boxes, cardboard, plastic wrappers etc) to make a poster that will create awareness for the environmental problem that concerns them the most. The poster should also contain suggestions for solving the problem. Here are a few ideas, but they only need to choose one:

- Cigarette butts can start veld fires.
- Broken glass bottles can start fires.
- Discarded plastics ensnare animals.
- Discarded plastic pollutes rivers and other natural habitats.
- Waste causes health hazards and spreads disease.
- Land is wasted when it is used to dump or bury garbage (landfills).
- Materials and other resources are wasted when it could have been recycled.

Once learners have created their posters, you can stick them up around the classroom and they can also do a short report back to the class. There is also potential to do this activity as a group.

How is household waste managed by local authorities?

Ask your learners this question before moving on to the next section where this will be discussed. The answers are:

- paper and cardboard
- glass
- metal (tins and cans)
- plastics

Items that have to be disposed of with care and not dumped in regular trash, include batteries, and fluorescent light bulbs.

Here is an additional, optional activity, which you could get learners to do as a homework task.

ACTIVITY: Conducting a survey on waste management LB page 128

In this short activity, we are going to think about creative ways of dealing with household waste items that are not in the 4 categories discussed above. For each item in the table, some recycling ideas have been given.

Can you think of other ideas to add to the table? Discuss this in a group and write them into the table.

Item	Recycling ideas
Garden waste and other organic waste such as vegetable peelings and foods that have spoiled.	These items can be turned into compost. Cooked food, spoiled meat or fish and bones should preferably be buried because they can attract flies and other pests. In this way they can decompose underground and provide nutrients to growing plants in the garden.
Old clothes and other textile items; old shoes.	• Clothes, shoes, curtains, and blankets that are still good enough to be used can be donated to shelters for the homeless. Clothes that are too worn can be turned into cloths for washing the car or the windows. Old jerseys can be sewn into blankets or other items.
Old and expired medicine	Medicine that is old or expired should never be repurposed. It should be dropped off at your nearest clinic or pharmacy, where they have methods for destroying it.

Careers in chemistry

Invite a chemist/scientist: Do you know someone who is a chemist or a chemical engineer? Perhaps you live near a university? If you do, you could invite a chemist to come to your school and talk to your class about the work that chemists do. Alternatively, you could visit the chemist at their workplace and ask them to show you around. You can get learners to prepare a few questions beforehand; for instance, you could ask them about their work, their training and what they think are the qualities needed if one wanted to become a chemist. Just remember to make an appointment first!

This activity could be turned into a small group project and learners could be required to write a short report on the information they have gathered.

ACTIVITY: Careers research task LB page 129

This is not for assessment purposes and is aimed at getting learners to start thinking about the possibilities for their futures. The emphasis should be on discovering the possibilities that science, technology maths and engineering give us, not just work opportunities, but using them to solve problems in the world.

Revision

1. The components in a mixture have not undergone any chemical changes. They still have the same properties they had before they were mixed. That is why mixtures can be separated using physical methods.
2. Learner's answer should contain the following elements:
   - Iron filings are attracted to the magnet, but sulphur is not.
   - If the magnet is held in the mixture the iron filings will cling to the magnet, but the sulphur will stay behind in the bowl.
3. The vacuum cleaner has a fine filter in it which traps the dust particles. The clean air is able to get through the filter, but the dust is left behind. Some more modern vacuum cleaners also filter the air through water which cleans the air even further. Some very fine dust particles may be able to get through the fine filter, but if the air is passed through water, then even very fine particles are trapped.
4. Learner's answer should contain the following elements:
   - Seawater is allowed to stand in shallow pans.
   - Sunlight heats the water and it evaporates.
   - Solid salt is left behind, that can be dried and put into packages to be sold.
5. boiling point
6. a) Three different colour bands mean there are (at least) three different pigments in the ink.
   b) The blue pigment moves the fastest. Arranged in order of increasing speed (from slowest to fastest moving pigment): yellow, then pink, then blue.
7.

Mixture	**Separation method**
Salt and water	Distillation or evaporation
Sand and iron filings	Magnetic separation
Sand and water	Filtration
Colour pigments in ink	Chromatography
Stones and sand	Sieving
Ethanol and water	Distillation
Oranges and apples	Hand sorting
Sugar and iron filings	Magnetic separation

8. Glass, metal, plastic, paper.
9. Vegetable peels can be buried in the garden or turned into compost.
   Old running shoes can be donated to someone who needs them, or to a shelter.
   Expired medicine should be taken to the pharmacy.

7 Acids, bases and neutral

Chapter overview

2 weeks

This is the first time learners are introduced to acids and bases. The approach is to start from the known and introduce the topic through learner's experiences with everyday acids and bases. We will also first look at how we experience acids and bases in foods. This links to Life and Living and the senses. We will then look at acids and bases in the laboratory and the basic properties of acids, bases and neutrals. They will look at acids and bases again in Gr. 9 in more detail, also covering the pH scale, and the reactions of acids and bases.

7.1 Tastes of substances (1 hour)

Tasks	Skills	Recommendation
Activity: Have a look at your own tongue	Observing, comparing	CAPS Suggested

7.2 Properties of acids, base and neutrals (2 hours)

Tasks	Skills	Recommendation
Activity: True or false?	Accessing and recalling information	CAPS Suggested
Activity: Acids and bases in our homes	Accessing and recalling information, observing, comparing, sorting and classifying	CAPS suggested

7.3 Acid-base indicators (3 hours)

Tasks	Skills	Recommendation
Activity: Preparing and testing red cabbage juice with acid and base	Following instructions, practical skills, observing, comparing	CAPS Suggested
Activity: Making red cabbage indicator paper	Following instructions, practical skills	Optional
Investigation: How does litmus respond to acids and bases?	Hypothesising, doing investigation, recording information, comparing, interpreting information	CAPS suggested
Investigation: Is red cabbage paper suitable as acid-base indicator?	Doing investigation, recording information, interpreting information	Optional

Key questions

- Which tastes can we sense with our tongues?
- How does our sense of taste ensure our survival?
- What are the unique properties of:
  - acids;
  - bases;
  - neutral substances?

- Which household substances are (or contain):
  - acids;
  - bases;
  - neutral substances?
- How can we tell if something is an acid, a base or a neutral substance?

7.1 Tastes of substances

Learners will study the nervous system in more detail in Gr. 9 Life and Living, as well as in Life Sciences if they carry on with the subject in Gr. 10. For now, this is just interesting information about how we taste foods and distinguish between different tastes.

ACTIVITY: Have a look at your own tongue LB page 134

As a homework exercise, learners can do the following activity. Otherwise, if you have some mirrors available in the classroom, learners can have a look at their tongues. If you do this in class, try bringing some lemons to class for learners to taste and then describe their experiences.

Learners should taste that lemons taste sour.

Your tongue can sense only four flavours: Sweet, sour, bitter and salt.

7.2 Properties of acids, bases and neutral substances

Acids

You can do this on the board and ask learners for their answers to write down. Some examples might be vinegar (which contains acetic acid), citric acid (found in citrus fruits such as lemons, oranges and grapefruit), ascorbic acid (also known as Vitamin C, which comes in tablets, capsules or chewable sweets, and it occurs naturally in citrus fruit, tomatoes, strawberries), tartaric acid, etc).

Ask your learners these questions. The answers are: The lemon juice contains an acid. The lemon juice was sour. **Encourage learners to write in their workbooks and make notes in the margins and empty spaces!** They should not be afraid of scribbling and taking notes during class while you are talking or explaining a concept. Taking notes is a very important skill to learn.

Learners will only study chemical formulae in detail in Gr. 9 Matter and Materials, however, this is a good opportunity to introduce them to the concept especially so that learners are able to recognise dangerous chemical substances.

ACTIVITY: True or false? LB page 139

This is a good place to briefly revise some of the concepts learnt in Gr. 6 about solutions and mixtures, and to refer back to Chapter 2 about separating mixtures.

1. False, we can sense four tastes, namely salty, sweet, sour and bitter.
2. True
3. False, not all acids are safe to taste, such as laboratory acids.
4. False, there are many household acids which are not dangerous, such as acetic acid and acids in foods.

5. True
6. True
7. False. This symbol means that the substance is corrosive, it is a warning.
8. False, ascorbic acid is commonly referred to as Vitamin C.
9. False, there are many other foods with higher ascorbic acid (Vitamin C), such as strawberries and chillies.

Bases

At this level, learners can think of neutralisation as a process in which something potent (and potentially harmful) is changed into something harmless (or at least less harmful). Later on (in Gr. 9) they will learn the proper scientific definition of neutralisation: "the process in which an acid reacts with a base to form a salt and water". It is important to note that a neutralisation reaction **does not** necessarily result in a neutral solution.

ACTIVITY: Acids and bases in our homes LB page 140

For this activity, learners must first identify the products in the photograph provided. All of these household products contain bases. The next part of the activity is a demonstration which you can set up beforehand in the front of your classroom. Instructions and materials for the demonstration are supplied here:

MATERIALS:

- five bowls
- water
- washing powder
- Handy Andy
- bicarbonate of soda or baking powder
- lemon juice
- vinegar
- labels for each bowl showing the product that is in them
- a towel for drying hands

INSTRUCTIONS:

1. Place the bowls in a row on a desk in the front.
2. Mix each of the bases (washing powder, Handy Andy, baking powder) in separate bowls with some water.
3. Pour some lemon juice into another bowl and some vinegar into the last bowl.
4. Arrange the bowls in a row, alternating between a base and an acid.
5. Once the learners have filled in the table to identify the products, get them to come up to the front in groups to put their fingers in the bowls to feel the different substances.
6. They must take note of what they are feeling and should dry their hands between each substance.
7. After feeling the difference between the acids and bases, the learners can go back to their desk to complete the activity.

As an extension, you can also let learners take note of the difference between the dry powder for washing powder and then how it feels when it is mixed with water. Bases which dissolve in water are called alkalis.

Many household products (such as certain apple-scented shampoos and dishwashing liquids) contain apple or lemon scents or essences as additives. It has been noted that some of these products may be more acidic than basic. Make sure to test all the products you will be using in the class beforehand, to make sure the bases all react as expected.

Product	**What is it used for?**
Stain remover (Vanish)	Removing stains from clothes
Windolene	Cleaning windows
Handy Andy	Cleaning surfaces (stove, bathroom, kitchen tops, etc.)
Baking powder	Ingredient in baked goods
Bicarbonate of soda	Ingredient in baked goods, also a mild disinfectant
Bleach	Disinfecting and removing stains
Sunlight liquid	Cleaning dishes, cutlery and crockery

The bases will be easy to describe as they mostly feel quite slippery between the fingers. Acids generally leave a "rough" feeling on the skin and are not slippery like bases.

Substance	**How did it feel between the fingers?**	**Is it an acid or a base?**
Washing powder	Slippery	Base
Lemon juice	Feels slightly rough between the fingers	Acid
Handy Andy/soap	Slippery	Base
Vinegar	Leaves a rough feeling on the skin	Acid
Baking powder	Slippery	Base

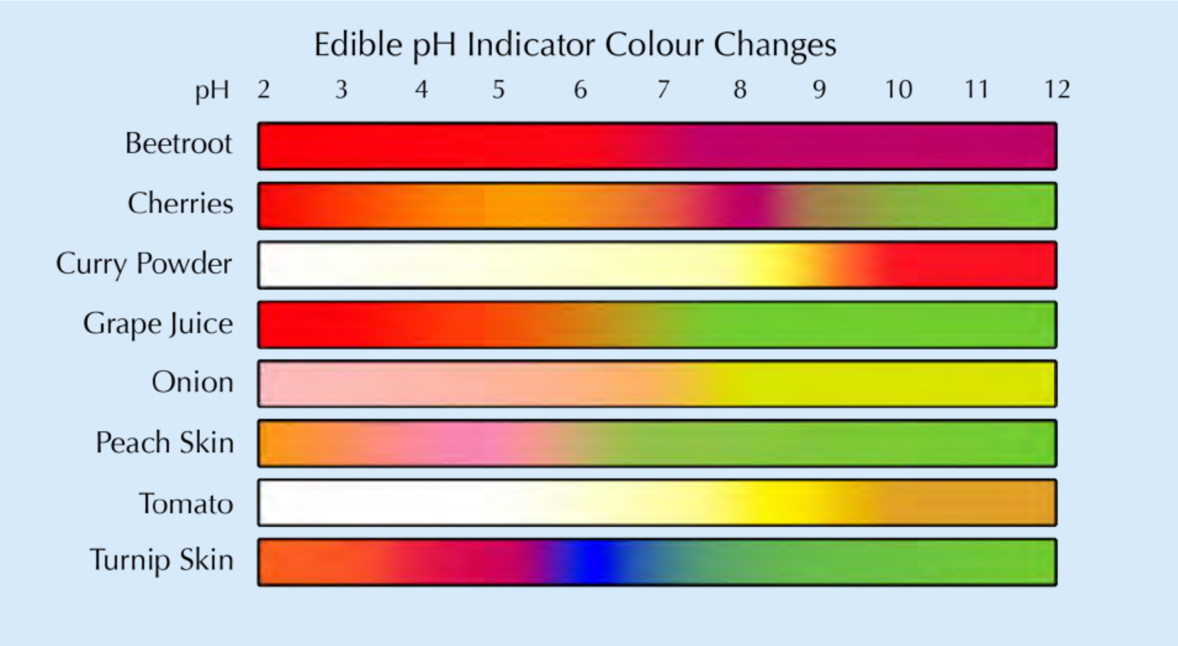
Questions

1. Bases feel slippery.
2. Generally, acids feel rough on the skin.
3. She/he had to add water to make it slippery. A solution of a base and water is called an alkaline solution.
4. Many acids and bases are dangerous to touch or taste – they are corrosive.

7.3 Acid-base indicators

Ask your learners this question to highlight the meaning of the word "indicate", which means to show. When the indicators on a car light up, they show other motorists that the driver of the car intends to turn left or right.

It has been noted that some household indicators that appear on the list above are not very effective, such as tea and beetroot. Some are more sensitive, including curry powder and turmeric. If you explore other indicators with the class, make sure to test a few to determine which ones produce the best results. Here is a table of other naturally occurring indicators which you could use in class:


Edible pH Indicator Colour Changes
pH 2 3 4 5 6 7 8 9 10 11 12
Beetroot
Cherries
Curry Powder
Grape Juice
Onion
Peach Skin
Tomato
Turnip Skin

Revision

1.

Acids	Bases
Sour taste	
Tartaric acid	Bitter taste
Feels rough	Bicarbonate of soda
Vinegar	Soaps
Lemon juice	Feels slippery
Citric acid	Bleach
Formic acid	Turns red litmus blue
Turns blue litmus red	
Corrosive	Corrosive

When marking this question, the first 9 items in the acids column should be marked, and the first 7 in the bases column. This is to discourage learners simply putting the whole list into both columns.

2. a) The most well-known of all acid-base indicators is called litmus.
   b) A substance that can eat away at other substances is called corrosive.
   c) Foods that are poisonous often taste bitter.
   d) Some scientists believe the human tongue can taste four basic flavours. These flavours are: salty, sweet, bitter and sour (in any order).
   e) An acid-base indicator is a substance that changes colour when it reacts with an acid or a base.
   f) Neutral substances are neither acids nor bases.
   g) An acid will neutralise a base (and vice versa).
   h) The juice of the red cabbage makes a very good acid-base indicator.
3. Strong acids include hydrochloric acid, sulphuric acid, and a strong base is sodium hydroxide.
4. Learner's answer should contain at least 2 of the following ideas:
   - When an acid reacts with a base, the acid and the base will neutralise each other.
   - That means they will both lose their strength/potency.
   - The acid will not be an acid anymore, and the base will not be a base anymore.
   - They will combine to form a neutral substance.
5. Learner's answer should contain at least the following ideas:
   - Laboratory acids should be handled very carefully because they are corrosive.
   - Laboratory acids should never be tasted.
   - You should protect yourself by wearing protective clothes, safety goggles and gloves when handling these acids.
6. Some household acids can be tasted. Some household acids are in our food. Laboratory acids should never be tasted. (optional)
7. Examples of acids that are safe to taste are: vinegar, lemon juice, ascorbic acid (vitamin C), citric acid (any other acceptable examples; learner should name 2).
8. We recognise them as acids by their taste; acids have a sour taste.
9. Learner's answer should contain at least 2 of the following ideas:
   - Most people don't like bitter food; that is because poisonous substances often have a bitter taste.

- When food tastes sour, it may be a sign that the food has spoiled.
- When food tastes strange (different from the way we remember it to taste) it may be a warning that the food has spoiled.

10. a) They are sulphur dioxide and carbon dioxide.
    b) They come from factories, power stations and car exhausts.
    c) The impacts include:
       - damage of plant life, both wilderness areas and also crops, depending on where the rain falls
       - the rain goes into soil, polluting it and making it more acidic
       - the rain can fall into various water sources and pollutes it.
11. Acids are corrosive and so they can corrode surfaces over time.

8 The Periodic Table of Elements

Chapter overview

2 weeks

2 weeks are allowed for this chapter. In this chapter learners are introduced to the Periodic Table of elements for the first time. They will learn about the main features of the Periodic Table and where the three categories of elements – metals, non-metals and semi-metals (also called the metalloids) – can be found. They will also learn that elements are arranged on the table according to their atomic numbers, starting with hydrogen (atomic number 1) at the top left-hand corner and continuing from left to right across the table. We will deal with atomic number from the point of view that it shows the position of a given element on the Periodic Table. In reality, the atomic number determines (rather than shows) the position of a given element on the table.

There are some important issues to note at this stage, namely:

1. The **atom** is introduced only in Gr. 8 in CAPS, although it was felt that some information on the atom was crucial at this stage to understand atomic numbers. Therefore, some information on the atom has been included as an introduction. However, the approach here has been to look at the Periodic Table as a means of **classifying** the elements. We are approaching it in the same way scientists did historically, namely, that they **observed** similarities and differences in elements and then used this information to arrange the elements in the table. Only later, when the model of the atom was further developed, were scientists able to explain why elements are arranged as they are on the table. This same **empirical approach** has been used here to introduce the Periodic Table.
2. The meaning of the term **atomic number** (the number of protons in an atom of a given element). This is because the subatomic particles protons, neutrons and electrons will only be introduced later (in Gr. 8 Matter and Materials). This is when they will formally learn that the atomic number indicates the number of protons in an atom. However, as indicated in point 1 above, we have included some information on the atom and subatomic particles here in Gr. 7.
3. The detailed arrangement of the heavier atoms at the bottom of the table is not dealt with at this stage. This is considered too complex for learners in Gr. 7.

8.1 Arrangement of elements on the Periodic Table (2 hours)

Tasks	Skills	Recommendation
Activity: Comparing Mendeleev's table with the modern version of the Periodic Table	Accessing and recalling information, comparing	CAPS Suggested
Activity: Periodic Table treasure hunt	Accessing and recalling information, observing	CAPS Suggested

8.2 Properties of metals, semi-metals and non-metals (4 hours)

Tasks	Skills	Recommendation
Activity: What do some of the elements look like?	Sorting and classifying, observing, identifying elements and properties, comparing	CAPS Suggested
Activity: Blitz revision of the properties of metals and	Sorting and classifying, identifying properties,	Optional revision (suggested)

non-metals	comparing	
Activity: Classifying element X	Accessing and recalling information, reading, observing, identifying properties	CAPS Suggested
Activity: The regions of the Periodic Table	Accessing and recalling information, sorting and classifying, comparing	CAPS suggested
Activity: Uses of the elements	Accessing and recalling information, communicating, group work, making a poster	CAPS suggested

Key questions

- What is an element?
- How can we classify the elements in our world?
- Which table helps us to make sense of the patterns we observe in the chemical properties of the elements?
- How are elements arranged on the Periodic Table?
- What does the position of an element on the Periodic Table tell us about its expected properties?
- What information can we use to represent the identity of an element?
- What are the typical properties of the:
  - metals;
  - non-metals; and
  - semi-metals?

The video in the link is an entertaining and simple way to introduce learners to the subject matter of this chapter about elements and the Periodic Table. It briefly explains what an element is, introduces Dmitri Mendeleev and his arrangement of the Periodic Table and also explains some of the concepts discussed later on in the chapter.

Mendeleev's original table is not part of what learners are required know, but it has been included to give learners a sense of the pace of scientific discovery. In order to make learners aware that scientific discovery can sometimes be a slow process, you could point out the gaps that are evident on Mendeleev's Periodic Table (for example, elements 44, 68 and 72). These gaps represented elements that were not known at the time but have been discovered since.

8.1 Arrangement of elements on the Periodic Table

The website found at http://rsc.li/195tO2e contains an interactive version of the Periodic Table. It is a wonderful tool to show some of the trends and information that the Periodic Table contains. This website can also be used in the later grades when the Periodic Table is covered again, in more detail. For now, it is a useful teaching tool to give an overview.

Another interesting website which contains mostly photos of the elements is http://bit.ly/1euHmVi. This is a very useful site to illustrate to learners what elements actually are.

Element names

The video above includes a bit more history about Dmitri Mendeleev, reviews Mendeleev's organisation of the Periodic Table and then moves on to relationships of elements on the Periodic

Table. Just before the end of the video, the host mentions the importance of electrons (to be discussed in another video).

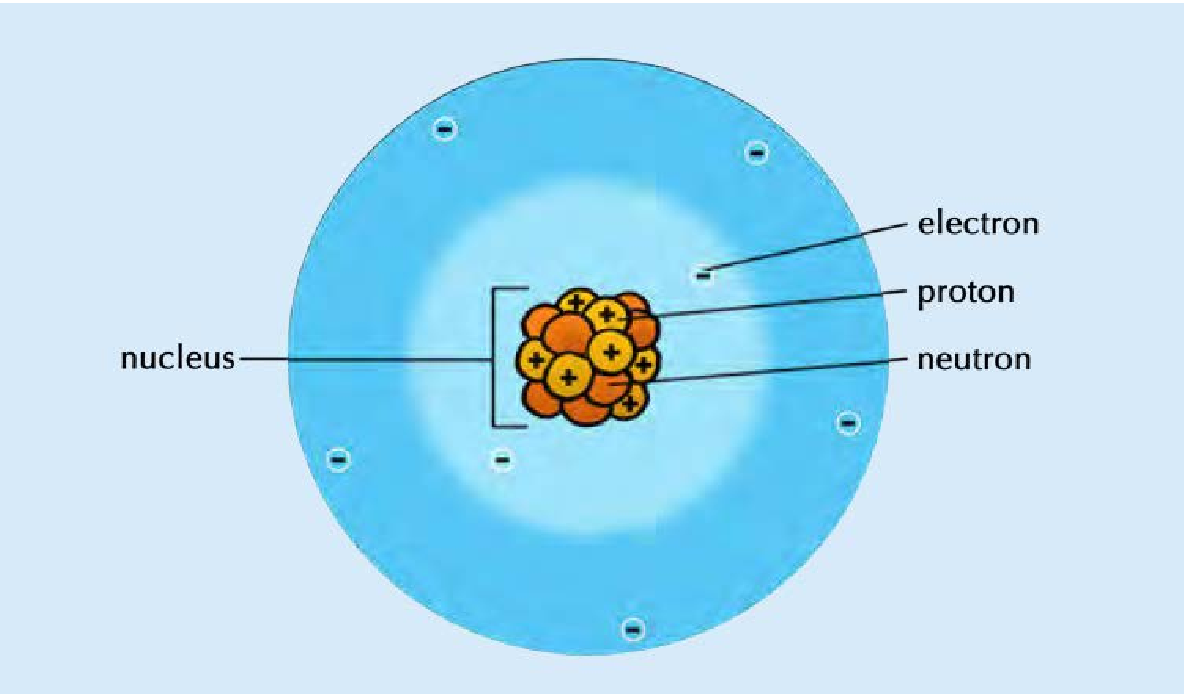
Atoms, electrons and protons are concepts that are discussed only in Gr. 8.

Atomic numbers

This site contains an interactive explanation of the history of the Periodic Table and the atom and explains how the concepts are related. It contains more information than learners need at this level, but you can read through it as an extension: http://bit.ly/132Nzbh.

Important note: We have briefly introduced the atom here, (although it was not specified in CAPS), so that the idea of the atomic number makes sense and is not just an abstract number. However, these concepts will be explored further in Gr. 8. For now, it is important the learners understand that each element has a unique atomic number and that the Periodic Table of elements is a way of classifying the elements so that they are grouped together in terms of similar properties.

When introducing the **subatomic particles**, you can draw a model of the atom on the board if you would like to show this to your learners. However, it is not crucial that learners understand the arrangement of the subatomic particles at this stage. Here is a simple model of the atom which you can illustrate on the board:



(The model here illustrates nitrogen atoms because there are 7 protons. Take note that there are equal numbers of protons and neutrons. Together they make up the nucleus of the atom. Protons have a positive charge, electrons have a negative charge, and neutrons are neutral. If the number of electrons equals the number of protons, then the atom is neutral and does not have a charge. The atom can gain or lose electrons resulting in a charge, and it is then called an ion.)

- Hydrogen has atomic number 1 and therefore has 1 proton.
- Carbon's atomic number is 6. It therefore has 6 protons in its atoms.

ACTIVITY: Periodic Table treasure hunt LB page 152

This is a fun activity aimed at getting learners to interact with the Periodic Table and learn the names and symbols of the first 20 elements.

C	H	O	Co	La	Te

It is important to point out to learners that this is not a 'formula' for chocolate, but simply a fun activity aimed at finding elements on the Periodic Table. Later we will learn how to put element symbols together into formulae that represent actual compounds.

1. C
2. Very first element on the Periodic Table (top left). The symbol for hydrogen is H.
3. O (oxygen)
4. Co (cobalt)
5. La (lanthanum)
6. Te (tellurium)
7. Chocolate
8. Science... F As C I N At Es (fascinates)... me!

Element	**Symbol**	**Element**	**Symbol**
Aluminium	Al	Magnesium	Mg
Bromine	Br	Nitrogen	N
Calcium	Ca	Oxygen	O
Carbon	C	Phosphorus	P
Chlorine	Cl	Potassium	K
Copper	Cu	Silicon	Si
Gold	Au	Silver	Ag
Hydrogen	H	Sodium	Na
Iodine	I	Sulphur	S
Iron	Fe	Tin	Sn
Lead	Pb	Zinc	Zn

8.2 Properties of metals, semi-metals and non-metals

ACTIVITY: What do some of the elements look like? LB page 153

We suggest doing this activity when you start to look at the arrangement of elements into metals, non-metals and semi-metals on the Periodic Table. This kind of activity is important to learners at this stage so that they understand that elements are actual substances that they can see. Often, learners battle to grasp the concept that elements are substances in the world around us.

Instructions for you to do this activity:

1. If possible, collect actual samples of the elements in this activity. You do not need all of the elements, but at least some of them listed here in the activity. You can use materials that you find around you such as a piece of coal or graphite stick (for carbon), a piece of copper piping, a tube with sulphur powder, a bottle of iodine solution from the chemist, a piece of aluminium

foil, an iron/steel nail, etc.

2. Once you have collected your samples, preferably in little containers, arrange them on the table up front.
3. Next, stick up a blank cardboard cut-out of the Periodic Table. You will need to create this yourself. You can draw out the table large on a sheet of cardboard, or else you can print one on a large piece of paper. There are many different websites where you can download blank Periodic Tables, such as this one: bit.ly/132NDb7. A blank Periodic Table has also been provided in the workbook for learners to write the symbols of the elements you discuss if you are not able to obtain samples and produce a large cardboard print out. They can still do this even if you do have the print out at the front of the class.
4. Then, go through the different elements that you have. Pass the sample around the class, or get learners to come up to your desk to look at them.
5. Ask for a volunteer from the class to come select an element and find its place on the Periodic Table by looking at the one in their workbooks. They must then stick the sample into the correct square on the blank cardboard table. Use adhesive tape or Prestik.
6. Do this for as many samples as you have. You can also print out some colour photos of different elements to do some more. Here is a website where you can download public domain images of the elements and print them: bit.ly/19PEEw3.
7. If you do not have actual samples, or colour print outs, some images have been provided in the workbooks which you can refer to, and then just write the symbols on the cardboard cut out.
8. Once you have done this for as many samples as you have, ask learners to describe what the elements on the left-hand side of the table look like, and what those on the right-hand side look like. This is the introduction to metals and non-metals. They should be able to see that those on the left are generally shiny and metallic (as they are metals), and those on the right are generally in powder form, brittle, dull, colourful, etc (as they are non-metals).
9. Learners must then answer the questions that follow at the end of the activity.

These questions should also be discussed in class. The aim is for learners to see that there is a difference in the elements on the left (and middle) and those on the right of the Periodic Table. In later grades, the concepts of periodicity and the patterns evident in the Periodic Table in the chemical and physical properties of the elements will be explored in much more detail. For now, the emphasis is on the main distinctions between metals and non-metals, and then also semi-metals.

1. Learners should note here that these elements look mostly like metals. They have looked at metals in previous grades, and so should be familiar with the properties of metals. They are mostly shiny and hard. Learners could also note the state of these elements, namely that at room temperature they are solids.
2. Learners should note that these elements look distinctly different to the metals on the left and middle of the Periodic Table. They are not shiny and metallic, but rather dull or have a colour. If you are able to use actual samples, learners may also note that these elements are not as hard and durable as the metals. For example, you can show learners how the graphite is brittle, or show them the various powder forms of these elements.

Learners should also be able to see that these elements are not all solids, but that some are liquids and there are also gases.

ACTIVITY: Blitz revision of the properties of metals and non-metals LB page 155

Properties of metals	**Properties of non-metals**
shiny	dull
lustrous	brittle
malleable	can be solid/liquid/gas
ductile	electrical insulator
conduct electricity	thermal insulator
conduct heat	
usually a solid	

1. Chromium is lustrous, malleable and conducts heat and electricity.
2. Chromium is a metal.
3. 24

1. Sulphur is dull, brittle and does not conduct electricity or heat well.
2. Sulphur is a non-metal.
3. 14

ACTIVITY: Classifying element X LB page 157

The material (element X) has a shiny, lustrous appearance. It also looks as if there are parallel ridges on the disk.

Metallic properties	**YES**	**NO**
Is the material shiny (lustrous)?	X	
Is the material malleable and ductile?		X
Does the material conduct electricity at room temperature?		X
Does the material conduct heat?		X

Non-metallic properties	**YES**	**NO**
Is the material brittle?	X	
Does the material have a dull appearance?		X
Is the material an insulator?		X

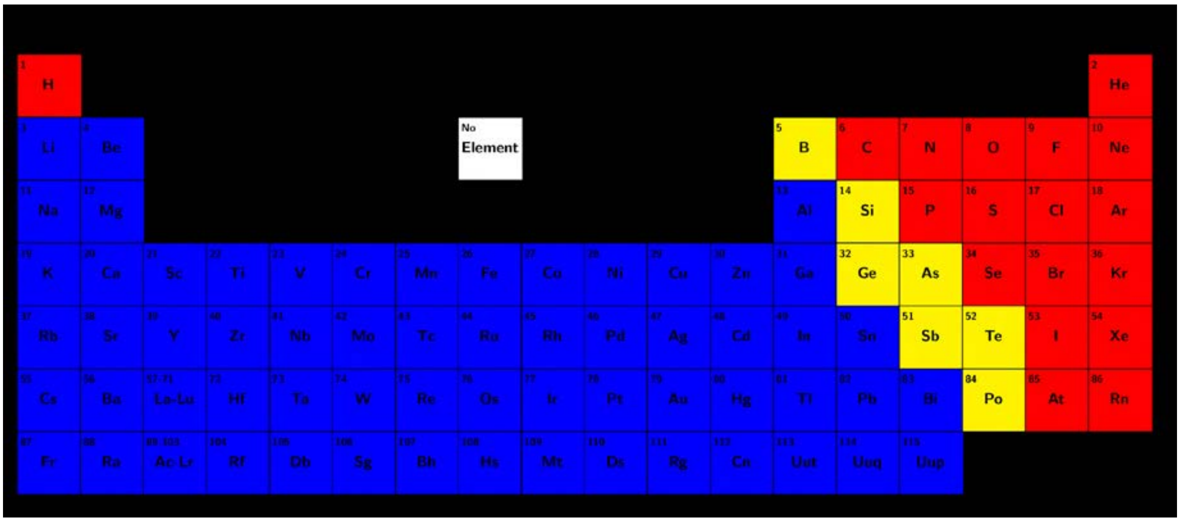
Additional comments (what else did you observe?):		
The material does not conduct electricity at room temperature. It does conduct electricity at very low temperatures.		

1. Element X is shiny and lustrous. It has the appearance of a metal.
2. Element X is brittle. It does not conduct heat and it does not conduct electricity at room temperature.
3. Learners may say that they don't know how to categorise element X, because it looks as if it might fit into both categories.

ACTIVITY: The regions of the Periodic Table LB page 159

Any colour other than yellow should be fine, as long as all the semi-metals have the same colour. The purpose of this activity is that learners must identify regions on the period table for each category, but the different regions do not have specific colours associated with them.

Once again, any colour other than blue should be fine, as long as all the metals have the same colour.



1. Metals
2. Semi-metals
3.

Element	**Chemical symbol**	**Category: (Metal, non-metal or semi-metal?)**
Iron	Fe	Metal
Silicon	Si	Semi-metal
Fluorine	F	Non-metal
Titanium	Ti	Metal
Nitrogen	N	Non-metal

Revision

1. a) It tells us that the element is a metal (hydrogen is an exception here). The metals occur on the left-hand side of the Periodic Table.
   b) It tells us that the element is most likely a non-metal. The non-metals occur on the right-hand side of the Periodic Table.
2. The chemical symbol of the element and the atomic number of the element.
3. The elements are arranged in order of increasing atomic number.
4. Hydrogen, H.
5. It means it has 1 proton in its atoms.
6. F, Cl, Br, I, At
7.

Names of elements	**Chemical symbols**
Sulphur	S
Carbon	C
Nitrogen	N
Sodium	Na
Oxygen	O
Silicon	Si
Chlorine	Cl
Helium	He

8. Learner's answer should contain at least the following information:
   - Semi-metals are elements that have some properties of both metals and non-metals.
   - They are found in a diagonal strip that separates the metals form the non-metals, towards the right-hand side of the Periodic Table.
   - Learner should give one example from the following list: boron (B), silicon (Si), germanium (Ge), arsenic (As), antimony (Sb), tellurium (Te) or polonium (Po).
9. Metals: Any two of the following properties:
   - Usually solid, shiny (lustrous), ductile, malleable, have high melting and boiling points, good conductors of heat and electricity.
   - Non-metals: Any two of the following properties:

   Most often gases and liquids (but can be solid), dull, brittle, poor conductors/good insulators.

9 Sources of energy

Chapter overview

1 week

This chapter builds on the energy concepts developed in Grades 4 and 5. We extend the idea of renewable and non-renewable energy sources by detailing the different types and classifying them. This chapter also introduces the idea of fossil fuels, which links to what learners will do next term in Earth and Beyond. An interesting article on how to encourage learners to pursue STEM careers: bit.ly/19Bpoip

9.1 Renewable and non-renewable sources (3 hours)

Tasks	Skills	Recommendation
Activity: Classify sources of energy	Identifying, classifying, explaining	CAPS suggested
Activity: Nuclear fuels – debate	Researching, reading, evaluating, writing, discussing	CAPS Suggested
Case Study: Biofuels	Reading, answering, reasoning	CAPS Suggested
Activity: What are the advantages and disadvantages?	Thinking, discussing, reasoning, writing	CAPS suggested

Key questions

- Why do we need energy?
- What do we mean by renewable and non-renewable energy sources?
- Why should we use non-renewable energy sources?
- What are fossil fuels?

9.1 Renewable and non-renewable energy

The concept of renewable versus non-renewable energy sources was introduced in Grade 6. Remind the learners of the meanings of the terms and then use the activity to see how much they remember from Grade 6. This will give you an indication of how well they remember the work. If they cannot answer the questions you will need to spend some extra time revising.

ACTIVITY: Classify sources of energy LB page 168

1. Different renewable and non-renewable energy sources

Renewable energy sources	Non-renewable energy sources
Wind	coal
Sunlight	oil
wood natural	gas
hydropower	uranium
Biofuel	

Note: Learners may find it confusing that wood is a renewable energy source. Explain to them that it is renewable in terms of the time it takes to grow more trees and produce wood to generate the fuel. The time to renew this source is short, compared to non-renewable sources, for example, fossil fuels take millions of years to form. Some learners may also confuse 'deforestation' with the sustainable use of wood as a fuel for cooking or heating.

2. Renewable energy sources can be used again or recycled or replaced. There is an unlimited supply of the energy source. Non-renewable energy sources cannot be used again or recycled. There is a limited supply of the energy source.
3. Non-renewable energy sources usually have a large amount of energy stored in them and the energy is easier to harness than that of renewable sources.

South Africa uses a variety of different energy sources for generating electricity. Most of the South African power stations are coal-fired power stations. We only have one nuclear power station, Koeberg near Cape Town. The South African government is encouraging the development of alternative energy sources but does not currently have any that are connected to the main grid.

In the 4th term, we will look at how the fossil fuels are formed under the section 'Stored solar energy'. This is an introduction to the different sources to link back to later.

Coal, oil and gas are called **fossil** fuels because they have been formed from the remains of prehistoric plants and animals (fossils) over millions of years.

Other sources that contribute to an increase in greenhouse gases are:

- **Deforestation** which is the clearing of large areas of natural forest such as in the Amazon, Central Africa and Southeast Asia. These forests are cut down to provide farmland and the large trees, which have taken hundreds of years to grow, are used for making wood products. Forests usually act as a sink, absorbing CO_2 from the atmosphere, therefore deforestation contributes to an increase in greenhouse gases.
- **Agriculture** as greenhouse gases are given off from livestock such as cows, the soil and rice production.
- **Certain products** also give off greenhouse gases.
- Uranium has the symbol U and atomic number 92. It is located at the bottom in the Actinides.

This question is a revision of what learners covered last term in Matter and Materials and serves to reinforce learning.

ACTIVITY: Nuclear fuels – a debate LB page 172

Get your learners to first do some of their own research about nuclear power and write down their own points. Then hold a class discussion where you compile the list of advantages and disadvantages and then discuss and debate the use of nuclear fuels. Encourage learners to give their own opinion.

This website provides a list of many of the arguments both for and against the use of nuclear power. Have a look at this website to help guide the discussion at the end of this activity. bit.ly/16sqS2d

1. Some of the advantages are listed here (there are others):
   - There are almost no greenhouse gas emissions (no carbon dioxide gas is given off)
   - There is no smoke pollution
   - A very small amount of radioactive material can be used to generate a very large amount of energy as it is an efficient fuel

- Nuclear power plants require less space, than for example a wind farm or coal station
- It produces small amounts of waste (although it is radioactive, which is a disadvantage – see below)
- The price of uranium does not fluctuate (go up and down) as much as coal and oil does, so it is more reliable.

2. Some of the disadvantages are listed here (there are others):
   - The nuclear waste produced is dangerous as it is radioactive and needs to be stored for long periods of time as the used fuel remains
   - radioactive for hundreds of years. There are environmental concerns about what is done with the radioactive waste as it damages plant and animal life.
   - The nuclear power plants are expensive to build.
   - There are many safety concerns about what happens if a plant is not maintained properly and there is a meltdown (such as what happened at the Fukushima nuclear reactor in Japan in 2011), or a reactor leaks. This is dangerous to the workers and the environment. An accident or mishap can have devastating effects for years, decades or even longer.
   - There are concerns about the general health of employees who work at nuclear power plants for extended periods.
3. Learner-dependent answer. Make sure that learners offer their opinions during the class discussion and that they are then able to justify their choices in their written answers.

The wind and water are not used up in the process, the source of water or wind is continuously being replenished, the water can be reused, so it is renewable.

ACTIVITY: A case study on biofuels LB page 174

1. Fair Oaks Farms in the United States of America.
2. They wanted to be more energy efficient, save money and also the neighbours were complaining about the smell of the tons of manure on the farm.
3. The renewable energy source is methane gas. It is a biofuel as it is obtained from animal waste and turned into a fuel source. It is renewable.
4. The farm sweeps up the manure from the barn floors. As the manure decomposes, it releases methane gas. The methane gas can be collected and stored.
5. Diesel is a fossil fuel which is a non-renewable energy source. Using less diesel means that the supply will last longer. The biofuel is renewable and so it is a more sustainable source.
6. The biogas/natural gas is about half the price of diesel, so it is much cheaper.
7. Learner-dependent answer.

Make sure that learners justify their answers. Essentially, South Africa could benefit as we have multiple livestock farms and agricultural areas which produce a lot of manure and other methane-rich material, which mostly just goes to waste at the moment and is not used. Investing in processes that harness the natural gas to use it to power the farms and delivery trucks would help save money, be more energy efficient and also have less of an effect on the environment than using petrol and diesel.

ACTIVITY: What are the advantages and disadvantages? LB page 176

While the learners are discussing in their groups, walk around and listen to some of the discussions. Try to make sure that each learner gets a chance to speak and that they are not being overshadowed by more confident learners. If groups are sitting quietly, ask leading questions to give their discussion direction.

If you can, give the learners some newsprint and pens so that they can write down their main ideas. They can then use these newsprints as visual aids during their report back. You can also extend this activity by comparing all the newsprints from the different groups at the end of the report back. Learners can then choose what they consider to be the best responses and a summary can be written down. You can display the summary in the classroom so that the learners can refer to it again.

1. A major advantage of non-renewable energy sources is the massive amounts of energy that they contain which is relatively easy to access. A disadvantage is that they produce excess greenhouse gases when they are burnt and that the supply is limited.
2. A major advantage of renewable energy sources is that the supply will not run out and so their use is sustainable. They are more environmentally friendly. A disadvantage of renewable energy sources is that they store smaller quantities of energy than non-renewable sources and so it takes more effort to access the stored energy.
3. Learners will provide their own interpretation of the information gathered in this discussion. They should mention the disadvantages of burning fossil fuels and then explain that it is often cheaper, and certainly easier to access large amounts of energy from burning fossil fuels than it is to use renewable sources. Wind, solar and hydroelectric power are expensive and sometimes the yield of energy from those sources is less cost-effective than using fossil fuels.
4. This answer depends on which 2 sources the learner chooses. Learners will discover that renewable sources are not used for large scale electricity production in South Africa. In fact most renewable sources are used in homes to run geysers and swimming pools. Coal is the main source of electricity in South Africa. Nuclear power is used to supplement coal fired power stations in South Africa.

Revision

1. Energy
2. It is something which has energy stored in it which can be used.
3. e
4. Non-renewable energy sources cannot be reused or replenished. There is a limited supply.
5. c and d
6. Wind
7. Coal, natural gas and oil are all examples of renewable energy resources. When they are burned they release energy. Coal, natural gas and oil are also known as fossil fuels. Wind and solar energy are examples of renewable energy sources because they can be replaced.
8. Burning fossil fuels releases greenhouse gases into the atmosphere, causing an excess in the atmosphere. These gases then trap more of the Sun's energy causing the Earth to warm up even more, and results in global warming.

9. Complete the following table. [18 marks]

Energy source	**Renewable or non-renewable**	**Disadvantage**	**Advantage**
Wind	Renewable Wind	Farms are noisy and take up a lot of space; Need strong winds	No greenhouse gases produced
Coal	Non-renewable	Burning releases greenhouse gases into the environment	Coal stores a lot of energy which is relatively easy to access
Uranium	Non-renewable	Production of nuclear waste which needs to be stored	Uranium has a vast amount of energy stored within
Water (Hydroelectric)	Renewable	Dams must be built and this damages/changes the landscape and affects ecosystems; Expensive to set up and maintain	Sustainable. No harmful emissions; Can be utilised anywhere there is enough water
Solar power	Renewable	Need a sunny climate all year round; expensive to set up	Non-polluting (no greenhouse gases) and renewable
Biofuels	Renewable	May affect food production and supply	Uses renewable biomass for energy

The advantages and disadvantages in the table are just some examples. Learners may write other reasonable answers.

10 Potential and kinetic energy

Chapter overview

2 weeks

This chapter builds on the basic concept of energy. The chapter explains the difference between kinetic and potential energy. The law of conservation of energy is also introduced: Energy cannot be created or destroyed but can be transferred from one part of the system to other parts. This is a crucial concept in Physics and it is important to make sure that the learners understand it.

We have also not made mention of the different "forms of energy" within this content. There is disagreement about what the "forms of energy" are, and how long the list should be or could be. The "forms of energy" language is a problem when teaching learners about energy. For example, learners can be asked to name the "form of energy" in various examples and often learners are just told which one and have to memorise the answer. They are disempowered by the question. Learners are still unable to work out what happens. Furthermore, not remembering the correct "form of energy" can cost learners marks in a test, but remembering the "form" correctly does not add anything to their understanding of energy or systems.

What we must focus on is systems which have different parts that learners can examine. It is sufficient to say that the potential energy in a system becomes the kinetic energy of some part of the system. We can have energy in a system in two forms – it can be stored in the system (potential energy) and it can cause changes in the system (kinetic energy). Therefore, the key concepts to focus on within these sections are: potential and kinetic energy, systems, transfer of energy between parts of a system and the conservation of energy.

10.1 **Potential energy** (1.5 hour)

Tasks	**Skills**	**Recommendation**
Investigation: How can we make the foam cup move further?	Planning, investigation, doing investigation, hypothesising, identifying variables and controls, measuring, recording, drawing graphs, analysing	CAPS Suggested
Activity: Elastic bands	Raising questions, carrying out instructions, measuring, recording, interpreting information	CAPS suggested
Activity: Reading a cereal box	Observing, comparing, interpreting information, drawing graphs	CAPS suggested

10.2 **Kinetic energy** (1 hour)

Tasks	**Skills**	**Recommendation**
Activity: Which objects have kinetic energy?	Observing, comparing, sorting and classifying	CAPS Suggested

10.3 Law of conservation of energy (0.5 hours)

10.4 Potential and kinetic energy in systems (3 hours)

Tasks	**Skills**	**Recommendation**
Activity: Identifying energy transfers in mechanical systems	Observing, interpreting, identifying and classifying	CAPS suggested
Investigation: The energy transfers when boiling water	Doing investigation, hypothesising, observing, identifying variables, recording, drawing graphs	CAPS suggested
Activity: An electric fan system	Building a circuit, identifying components and features	CAPS suggested
Activity: Flow diagrams for energy transfers	Identifying types of energy transfer, describing, drawing flow diagrams, communicating information	CAPS suggested

Key questions

- What is potential energy?
- What is kinetic energy?
- Where do we get energy from?
- How much energy do I need?
- Can energy be created or destroyed?
- What is a system?

10.1 Potential energy

Start this section by doing the investigations first and allowing the learners to draw their own conclusions. This will lead them to a better understanding of what energy is and what it can do rather than a verbal explanation. There are several activities which deal with potential energy. If you do not have enough time to do all of them, then choose at least one of them. You can base your choice on the resources that you have available at your school. Do not completely ignore the other activities, though. Take some time to talk through what the outcomes would have been and then you could ask the learners to answer the questions at home.

INVESTIGATION: How can we make the foam cup move further? LB page 180

It is important to emphasise the importance of independent and dependent variables. Take special care to explain the difference between the two variables. The **independent variable** is the variable that you chose to change while doing the experiment. The **dependent variable** is what result you measure in your experiment. Learners would have encountered variables in the previous strands by now. Each group will need a set up and they will roll the marble from different heights into the cup. The higher up the ramp the marble starts, the further the cup will move.

1. The height from which the marble is released to roll down the ramp. This is the independent variable because the learners are changing it to see how far the cup moves.
2. The distance that the cup moves. This would be the dependent variable because the distance depends on how high the marble was before it was released.

3. The size of the marble must stay the same.

The hypothesis should mention how the distance the cup moves would change if the height of the marble changes. Here are two possible examples:

- "The higher the marble is on the ramp, the further the cup will move."
- "The higher the marble is on the ramp, the less the cup will move." Both of the above hypotheses mention how the height of the marble is expected to affect the distance the cup moves.

The height of the ramp at each step will depend on what you use to prop it up with. Try and get blocks or books of equal thickness so that at each step the height increases by the same amount.

If you make bigger ramps, you can also perform more measurements at different positions up the ramp.

1. The height of the marble on the ramp.
2. The distance the cup moves.

The independent variable is plotted on the horizontal axis. In this example the scale could be increments of
5 cm. The dependent variable is always plotted on the y-axis.

1. The conclusion should mention that as the height of release increases, the distance that the cup moves increases.
2. This answer will depend on what the learner wrote for their hypothesis. If their hypothesis stated that the greater the height, the further the cup moves, then their hypothesis is shown to be true. If their hypothesis stated that the greater the height, the less the cup moves then their hypothesis has been proved to be false.

Discuss this with your class. The cup moves along the surface and it experiences friction as it rubs along the ground. This causes it to come to a standstill. Friction will only be covered in more detail in Gr. 8 when learners look at friction in terms of static electricity and how rubbing objects transfers electrons resulting in a charge. A small demonstration that learners can do to briefly look at friction is to rub their hands together and observe that their hands become warm. When surfaces in contact with each other move against each other, the friction between them transfers kinetic energy to heat.

The potential energy came from the arm which lifted it.

Discuss this with your learners. The answer is the sand which goes flying up. Ask your learners where is the energy now? The answer is the molecules of the sand are moving faster. A sensitive thermometer would show that the sand is a little warmer than it was. Also, the energy went into disturbing the air and your eardrums got that energy when you heard the bang.

Yes, it will be as it has more potential energy at a higher point so by the time it hits the ground it will be moving faster (more kinetic energy).

ACTIVITY: Elastic bands LB page 182

Try to get elastic bands of equal length and thickness. It is the only variable which really needs to be kept constant. If you are running short of time you can leave out this activity. Rather just discuss the conclusions one would draw from such an activity.

1. The parts of the system are the stiff fingers, rubber band, matchbox, table.
2. Stretching the elastic band so the movement of the fingers transfers potential energy to the elastic band which is now stretched.

The distances moved will depend on the type of elastic bands used and how rough the surface of the desk is. What is important is that the learners see that the small stretch moves the match box the shortest distance and the largest stretch moves the matchbox the furthest.

1. The distance the matchbox moves increases as you stretch the elastic band more.
2. The elastic band had to be pulled hard by the learners and they could not let go if they wanted to keep it stretched.
3. The matchbox transfers energy to the air and the table.

At this point it is important to note that the joule is a measure of energy. It is just a number that we calculate after a lot of careful measurements on changes in a system. A food joule is no different from an electrical joule, nor different to a joule that heats water, or a joule that comes from the Sun. It is important that learners realise that joules of energy from food are no different to joules of energy from Eskom. But, if we reinforce the concept of different "forms" of energy, then learners are given the reason to think that energy from food must be different to energy from Eskom, whereas it is not.

The main idea is to simplify the concepts around energy for learners by eliminating the long lists of "forms" of energy that appear in tests and rather shift the focus to systems, which have parts that learners can examine and understand. It is sufficient to say that the potential energy in a system becomes the kinetic energy of some part of the system.

ACTIVITY: Reading a cereal box LB page 185

Encourage the learners to bring in old cereal boxes well in advance of doing this activity. It would be a good idea to find some extras to bring to class for those who forget. You can even photocopy some of the cereal boxes and keep them for the following year.

If you want to extend this exercise you could ask the learners to compare their cereal with the rest of the class. Draw a table on the board with the different cereals and their energies. Get the class to draw a bar graph comparing the energies in the different cereals.

Each learner's answers will depend on the type of cereal that they have chosen. Make sure that the learners have kept their cereal box so that you can check their answers against the box details.

1. Learner-dependent answer. For example, Oats contains 1528 kJ per 100 g. This is 1528 000 J.
2. Learner-dependent answer. For example, Oats contains 611 kJ per 40 g serving. This is 611 000 J. Weetbix cereal contains 529 kJ (529 000 joules) of energy per serving.
3. Learner-dependent answer. For example, a female learner who is 13 and moderately active needs between 8 000 and 9 000 kJ per day.

4. Learner-dependent answer. Learners must choose the row which corresponds to their age and gender. They must then consider, honestly, how active they would consider themselves to be. They can then use their cereal to calculate the percentage.

Example calculation:

Let’s assume we have a male, aged 15 who is very active. His recommended daily allowance (RDA) would be between 11 000 – 13 000 kJ.

A serving of Nestle Milo Cereal contains 477 kJ. The percentage of RDA = 477/13 000 x 100 = 3,7%

An additional question to ask learners and have a class discussion is:

- Based on the percentage worked out in question 3, do you think this is a good cereal to eat for breakfast? Why do you think it's a good/bad cereal for breakfast?

The learners should decide whether their calculated percentage is low or high. If it is low, they could decide that it is better to eat a high energy meal for breakfast and then lower energy meals throughout the day, or they might indicate that they are hoping to lose/maintain weight and so a low percentage is a good thing.

If their calculated percentage is high, they could indicate that it is better to spread out their energy intake over the entire day rather than concentrate it in one meal.

The nutritional value of a cereal also does not only depend on how much energy it provides, but also what other nutritional ingredients it offers.

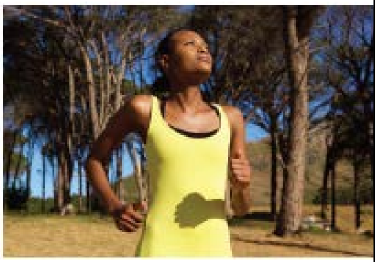
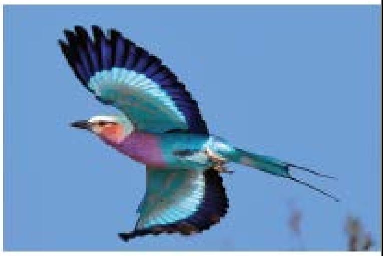
There are no incorrect answers to this question. It is based entirely on their own interpretation of their needs. This can be a very sensitive topic, don't spend too much time discussing weight loss programmes as this is not a weight counselling session and learners could get confused between healthy eating and excessive dieting.

Alternatively, ask several learners what the energy content is for their cereal and then ask which one provides the most potential energy and which one the least.

1. The values given on the box are in kJ and kCal so learners must convert the values by multiplying by 1000. The answers are 1492 000 J (1492 kJ)
2. The mass is 7.5 g, as the mass given on the box of 15 g is for 2 biscuits.
3. Energy for one biscuit = 224/2 = 112 kJ per biscuit.
4. Energy content for 5 biscuits = 112 x 5 = 560 kJ.

10.2 Kinetic energy

ACTIVITY: Which objects have kinetic energy? LB page 187

Object	Does it have kinetic energy? (Yes or no)	Give a reason for your answer.
A lady running. 	Yes	The lady is running and moving so she has kinetic energy.
A bird in flight. 	Yes	The bird is flying and moving in the air so it has kinetic energy.
A stop street sign. 	No	The sign does not move and so does not have kinetic energy.
A roller coaster. 	Yes	The roller coaster is moving and so has kinetic energy.
Two chairs.	No	The two chairs are stationary and so do not have kinetic energy.

		
An apple. 	No	The apple is still on the surface – it is not moving so does not have kinetic energy.
A helicopter. 	Yes	The helicopter is flying, so it has kinetic energy.

1. The bucket at the top of the ladder has more gravitational potential energy than the one at the bottom.
2. The car travelling at 200 km/h has more kinetic energy than when it is travelling slower.
3. It is kinetic energy as the air particles are moving.
4. It has potential energy as it has the potential to fall back down to the ground.
5. Now it has kinetic energy as it is moving.

At this level in Gr. 7, it is acceptable to state that the water has kinetic energy as it falls down (as it is moving). However, the water also still has potential energy as it falls. This is because as the water falls, it loses potential energy and gains kinetic energy as potential energy is transferred to kinetic energy. The total energy within the system is equal to the potential energy plus the kinetic energy as energy is conserved.

10.3 Law of conservation of energy

In CAPS, this section comes after the potential and kinetic energy in systems. However, it is more logical to first discuss how energy is conserved within systems and to then look at the examples of the systems in the next section. Take time to make sure that the learners understand the difference between laws and theories. Scientific theories are subject to development and new ideas are being developed all the time. Learners should be encouraged to see science as a developing discipline and not a static set of ideas. However, the science knowledge that we teach at school level is not in doubt. Most of it has been tested and known since the 1800's. You are encouraged to tell your learners something of the arguments and confusion among the people who were the first to investigate this knowledge, and also that current science in the academic world is constantly evolving.

10.4 Potential and kinetic energy in systems

The input energy is the movement (kinetic energy) of the worker's arms as he pulls on the rope

The different parts are the worker's arms pulling on the rope. the rope, the pulley, the heavy object and the surface of the Earth.

The kinetic energy is transferred to potential energy as the object is raised higher.

The hand throwing the ball and the ball are the parts involved.

The kinetic energy of your moving arm and hand as you throw the ball.

It is important to note that potential energy is relative to a reference point. So, in this example, if we consider the ground to be the reference point, then if you throw a ball upwards and catch it again in your hand, it always has potential energy as it is above the ground. Therefore, the ball has most potential energy when it is at the top of the throw when it stops briefly, before coming back down to the ground.

The ball has kinetic energy as it is moving upwards and then falling back downwards.

ACTIVITY: Identifying energy transfers in mechanical systems LB page 191

Learners may battle to do this at first, so you can go through one or two of the examples with them, and if possible, also perform the demonstration of bending the wire back and forth. The key is to first identify the parts that are involved and then how the energy is transferred from one part to another within the system.

Learners should note that the wire feels cold.

Learners should note that it feels warm.

1. It has potential energy.
2. The potential energy becomes kinetic energy.
3. The kinetic energy from her leg is transferred to the ball and makes the ball move. The ball now has kinetic energy.
4. This movement transfers potential energy to the bat.
5. As the bat swings down the potential energy becomes kinetic energy as the bat moves. When the bat hits the ball, it transfers the kinetic energy to the ball. The kinetic energy allows the ball to move through the air.
6. When the ruler is pulled back, the movement of the hand has kinetic energy which is transferred to the ruler. The ruler has gained potential energy and when it is released, the potential energy becomes kinetic energy as the ruler flicks backwards. The kinetic energy is transferred to the pellet and so the pellet moves across the room.

We will look more at heat as a form of energy transfer in the next chapter.

INVESTIGATION: The energy transfers when boiling water LB page 193

This investigation works best with water placed in a beaker and heated over a Bunsen burner using a tripod. However, if you don't have a Bunsen burner you can use a candle and a tin can. The candle will not provide a large amount of heat energy and so you should use a small amount of water so that it can reach boiling point within the lesson time. Remember to use an alcohol thermometer rather than a mercury thermometer.

Although this may seem like a very simple investigation, and learners have heated water before, the focus here is different in that we are investigating the energy transfers. This is also an opportunity for learners to practice recording, observing and translation skills, such as drawing a graph.

1. Time is the independent variable
2. The temperature of the water is being measured.
3. The amount/volume of the water must be kept constant

The hypothesis should mention how the dependent variable would change with a change in the independent variable and should mention which variables must remain constant.

In this investigation a suitable hypothesis could read: 'The temperature of the water will increase as time increases if the amount of water is kept constant' or 'The temperature of the water will decrease as time increases if the amount of water is kept constant.'

Remember that a hypothesis doesn't have to be correct. It is a prediction made before any investigation is done and so the outcome is not necessarily known beforehand. Do not discourage learners from developing their own hypotheses. Emphasise that a hypothesis is just as valuable if it is rejected after the investigation.

If you don't have Bunsen burners you can use spirit burners or a candle.

Make sure that learners observe that the temperature remains constant once the water starts to boil. Once the learners have completed their measurements, turn off the Bunsen burner and leave the water to cool while they carry on with the rest of the task and questions. They will then have to observe what happened to the water once it was left to stand.

If the water takes longer than to boil, ask the learners to add rows to the bottom of their tables. If it takes less, ignore the rest of the table. Each row must represent half a minute (30 seconds).

1. Time goes on the x-axis as this is the independent variable.
2. Temperature is the dependent variable.

Learners must provide a heading for their graph. for example: "The change in water temperature over time". The graph must show data points with a line of best fit drawn through them. The graph must also flatten out at the end as the water boils.

3. This may vary slightly depending on your area and altitude, but it is around 100°C.
4. When the water reaches boiling point, the temperature remains constant while the water is changing state from a liquid to a gas.

The reason we do a boiling point curve like this is so that the learners can see that the curve flattens out and temperature remains constant. This is how we find the boiling point of a liquid. It is useful to do a boiling point curve of another liquid as well, such as Coca Cola or orange/apple juice to get a similar shaped curve so that learners understand that at boiling point of that liquid the temperature remains constant for a while. If you leave it longer still the temperature will begin to fall as more water particles move into the atmosphere. This links back to what was covered in the previous term in Matter and Materials in Chapter 1 on the Properties of Materials.

1. Learner-dependent answer. The learners should conclude that the longer you keep the water over the flame, the higher the temperature of the water, until it reaches boiling point. At boiling point, the temperature remains constant as the water is changing state from a liquid to a solid.
2. Learner-dependent answer.

1. The energy for the temperature increase came from the burning gas in the Bunsen burner.
2. The thermal energy (kinetic and potential energy) of the flame in the Bunsen burner/candle is transferred to the water. The thermal energy of the water therefore increases and the temperature rises.
   Remember that temperature is a measure of the average kinetic energy of the particles.
3. It cooled down.
   This is because once the Bunsen burner is switched off, no more energy is supplied to the system and so the loss of energy is greater than the gain and the temperature decreases.
4. The thermal energy was then transferred from the water to the surrounding air.
5. The thermometer is resting on the bottom of the beaker and touching the side. This could give an inaccurate reading. The thermometer should either be held by the learner so that it does not touch the sides while they take the reading, or else clamped in a retort stand with the bulb in the water.

This is a fun simulation that learners can use to investigate potential and kinetic energy. There is the example in the introduction that can be used to show them how to use it, and then there is the track playground that allows you to create your own track. Click on the bar graph, or pie chart menu options for a real-time display of the fluctuations in potential, kinetic and thermal energy.

Once they have mastered the basics, and if there is more time you can show learners the more advanced skate park simulation. The graphs in this version do become slightly more involved but represent the features of the energy system beautifully. bit.ly/1fp5Oxk

PhET tips for teachers are available here: bit.ly/16B8r4D

An electric circuit is a system as it consists of different parts that do something, ie. make the light bulb glow. Ask learners to identify the different parts in this system. They are: the battery, the light bulb, the switch (paperclip) and the conducting wires.

The battery is the source of energy, potential energy is the input energy in this system.

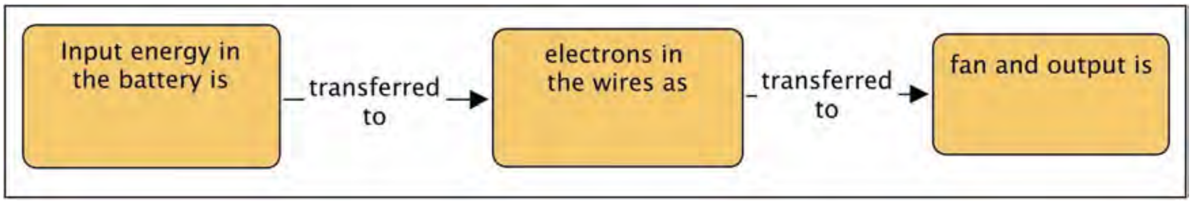
The output is that the light bulb lights up/glows.

ACTIVITY: An electric fan system LB page 196

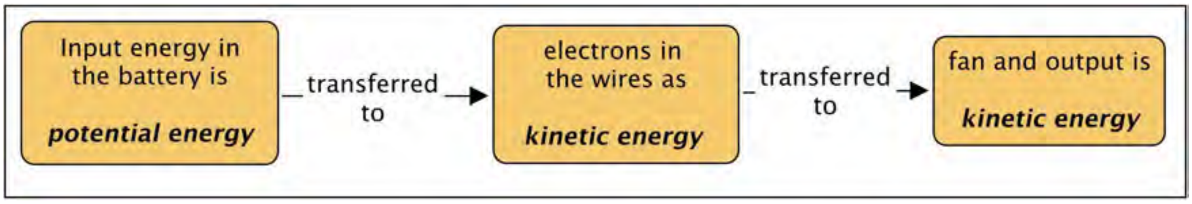
If possible, make this circuit in class with your learners so that they can observe the changes in the circuit and the movement of the fan. You can use any small device that rotates, such as a fan or a small motor. If you do have a small motor, you can attach a sucker stick to the rotating shaft with a piece of Prestik to make a fan.

You can also make your own switch, as described below.

1. The battery, the fan/motor, the switch, the wires.
2. The battery provides the input energy (potential energy).
3. The fan starts to turn/rotate/move.
4. Kinetic energy.
5.



The following shows the completed diagram with the answers learners should supply:

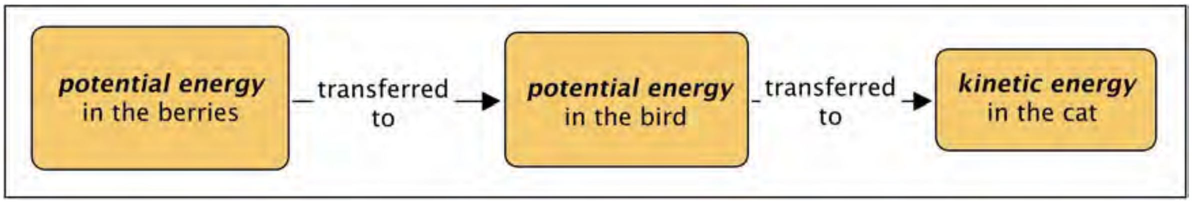


The battery has potential energy which is transferred to the electrons in the circuit. The electrons have kinetic energy which they transfer to the motor. The motor uses the kinetic energy to turn. The turning motor turns the blades of the fan.

The diagram is showing photosynthesis. The plant uses water, carbon dioxide and sunlight energy to produce glucose and oxygen.

ACTIVITY: Flow diagrams for energy transfers LB page 198

1. An example of the flow diagram learners could produce:



2. The berries have potential energy in them. The bird eats the berries and this energy is transferred to the bird as potential energy. Most of the energy is used by the bird and transferred as kinetic energy as it moves around. The bird is then eaten by a cat and the potential energy in the bird's flesh is transferred to the cat as potential energy which is then transferred to kinetic energy as the cat moves around and performs its life processes.

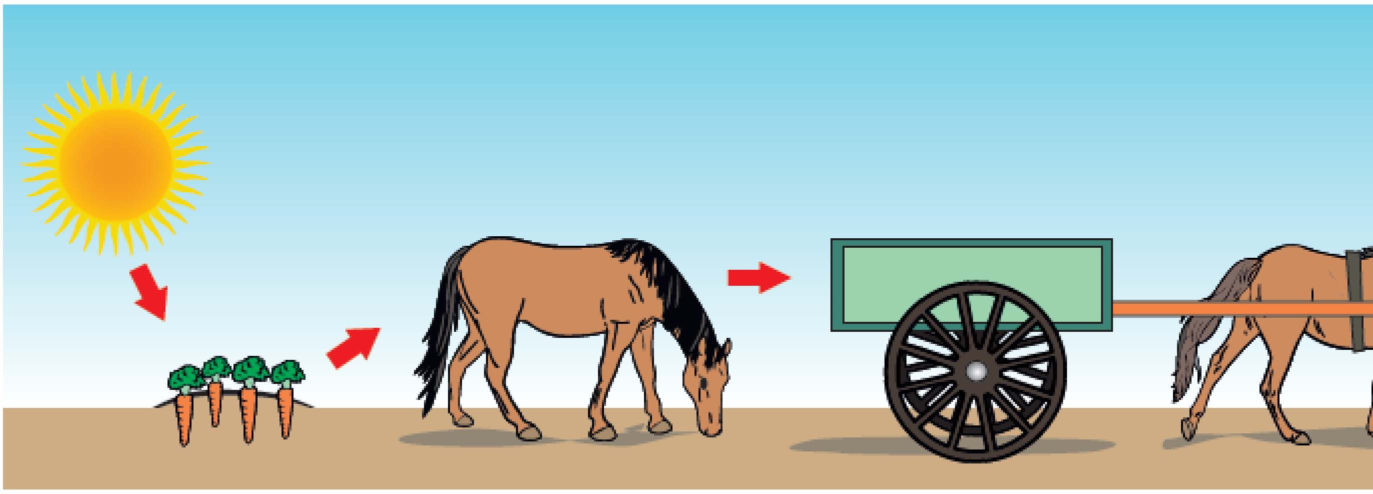
Although learners will only look at food chains and energy pyramids in more detail next year in Life and Living, this is an introduction to how not all the energy is transferred onto the cat as most of it is used by the bird as it moves around and performs its functions and processes.

3. An example of the flow diagram learners could produce:

potential energy in the berries —transferred to→ ***potential energy*** in the bird —transferred to→ ***kinetic energy*** in the cat

4. The battery/cell has potential energy which is transferred to kinetic energy in the alarm bell as the hammer moves back and forth to produce sound.

5.



No, this is not a food chain, as a food chain only shows the transfers of energy between organisms, highlighting the feeding relationships. This diagram also includes the Sun, as well as showing the horse moving a cart.

6. An example of the flow diagram learners could produce:

radiant energy from the sun —transferred to→ ***potential energy*** in the carrots —transferred to→ ***potential energy*** in the horse when it eats the food —transferred to→ ***kinetic energy*** in the horse and cart

7. The energy from the Sun is transferred to potential energy within the carrots as they photosynthesise and produce food. The horse then eats the carrots and this potential energy is transferred to potential energy within the horse. The horse then moves and pulls a cart, so the potential energy in the horse is transferred to kinetic energy in the horse and in the cart as it moves along.
8. Renewable.

9. a) The water has potential energy.
   b) The potential energy is transferred to kinetic energy as the water moves/flows down.
   c) It has kinetic energy.
   d) The electrical system is made up of the generator, the power lines and then the houses/ buildings in the city.
   e) The city gets electricity to run appliances, machines, equipment, lights and heating systems.

Revision

1. It is the energy stored inside a system. There are many different examples of potential energy. Some examples are: objects which are held above a surface, elastic bands which have been stretched, batteries contain potential energy.
2. It is the energy a system has because it is moving. There are many different examples of kinetic energy. Learners can use any moving object as an example.
3. Energy cannot be created or destroyed. It is transferred from one part of a system to another.
4. a) Ball A has more potential energy.
   b) Ball A is higher than ball B relative to the ground and so it has more stored energy.
5. a) A plant receives energy from the Sun and uses the energy to make food/sugar/glucose. The plant then changes some of the sugar into starch and stores it in leaves, fruit and other parts. The plant has potential energy which you can get when you eat the plant.
   b) After skydivers jump out of a helicopter or plane, potential energy is transferred to kinetic energy as they fall.
6. Learners must draw a Sun then a plant then either a person, or another animal which eats the plant and then a person which eats the animal.
7. a) At the top of her jump (as this is when she is the highest above the ground).
   b) She has the most kinetic energy just before she touches the ground/pad again (as this is where she will be moving the fastest).
   c) Yes, she does have both kinetic energy and potential energy at points during her jump. They are on the way up / on the way down (either).
8. a) Potential energy
   b) Potential energy
   c) Kinetic energy
   d) Both
   e) Potential energy
   f) Kinetic energy
9. a) They are an electrical system and a thermal system.
   b) The electric current transfers energy to the hot-wire in the kettle, which transfers energy to the water and so the water molecules get more and more kinetic energy until the water starts to boil.

11 Heat: Energy transfer

Chapter overview

2 weeks

In the last chapter we looked at thermal systems which transfer energy. This chapter expands on this and looks at the different ways that thermal energy is transferred between different objects.

It is important to understand the difference between heat, as a concept, and temperature. Temperature is a measure of how hot or cold an object is; it is a measure of the average kinetic energy of the particles of a substance. Heat is the energy transferred between two objects as a consequence of the temperature difference between them. It is also true when energy is transferred between a system and the environment as a consequence of the temperature difference between them. Temperature is measured in degrees Celsius (°C) or degrees Kelvin (K) while heat is measured in joules (J).

11.1 Heating as a transfer of energy (0.5 hours)

11.2 Conduction (2 hours)

Tasks	Skills	Recommendation
Activity: Conduction through a metal rod	Experimentation, observation	CAPS Suggested
Investigation: Do all materials conduct heat in the same way?	Hypothesising, investigating, evaluating	CAPS Suggested
Investigation: Which metals are the best conductors of heat?	Identifying, hypothesising, observation, writing, recording, drawing graphs, evaluating	CAPS suggested

11.3 Convection (2 hours)

Tasks	Skills	Recommendation
Activity: Convection in water	Experimenting, observation, comparing	CAPS suggested
Activity: Does smoke move up or down?	Observing, explaining	CAPS Suggested
Activity: Where do I put my radiator and air-conditioner?	Evaluating, drawing, discussing	CAPS suggested

11.4 Radiation (1.5 hours)

Tasks	Skills	Recommendation
Activity: Radiation from a candle	Observing, examining, explaining	CAPS suggested
Investigation: Which surfaces absorb the most radiation?	Measuring, recording, hypothesising, identifying, observing, drawing graphs	CAPS suggested

Key questions

- What is the difference between heat and temperature?
- How does a heater warm up a cold room?
- Why can the Sun make us warm?
- Why does my cold drink become warm?

11.1 Heating as a transfer of energy

Here is the completed table:

	Heat	**Temperature**
Definition	The transfer of energy from a hotter object to a colder object, or from a system to its surroundings	A measure of how hot or cold a substance feels. A measure of the average kinetic energy of the particles of a substance.
Unit of measurement	Joules	degrees Celsius
Symbol for unit	J	°C

11.2 Conduction

A suggestion to introduce this topic is to ask learners what happens to a metal teaspoon when they put it in their hot beverage. If possible, demonstrate this briefly in class, even with a hot glass of water and a metal rod. In addition, use a plastic teaspoon to demonstrate the difference as plastic is an insulator.

ACTIVITY: Conduction through a metal rod LB page 205

Set this demonstration up in front of the class as you start to talk about conduction.

Materials:

- Bunsen burner
- metal rod
- Vaseline
- paper clips, drawing pins or safety pins
- two wooden stands, or a stack of books or blocks of wood to create the two stands on either side
- 2 pegs

Instructions:

1. Set the apparatus up as shown in the diagram.
2. Cover the rod in Vaseline and place it between the two stands with pegs to prevent it from rolling and hold it in place. The rod must be extending past the left-hand upright and the Bunsen burner placed here so that the Vaseline does not melt due to radiation from the Bunsen burner, but rather conduction along the metal rod.
3. Attach the paper clips or drawing pins to the rod by sticking them into the Vaseline.
4. Light the Bunsen burner and heat the one end of the rod.
5. Watch as the paper pins or pins drop off one by one as the energy is conducted through the rod.

As an extension exercise you could include another investigation in which you measure the rate of energy conduction along a metal rod. Repeat the experiment placing drawing pins at 5 cm intervals on a long metal rod. Clamp the metal rod and heat one end over a Bunsen burner. Use a stopwatch to time how long it takes for each drawing pin to drop and record the results on a graph. This could be further extended by using different metals and putting all the results on a single set of axes. The gradient of the graphs would give the rate of heat conduction.

1. Energy is transferred to the metal of the rod just above it. The thermal energy of this part of the rod increases and the rod becomes hot.
2. The one closest to the Bunsen burner dropped off first.
3. The heat is transferred from where it is hottest to the colder end of the rod.

In response to the video in the margin box about why your carpet feels warmer than the tiles in winter, you can come back to this question after you have performed the following investigation, and also looked at the example of the cake tin and the cake straight out of the oven. You can lead the discussion in the following way:

- Start off by asking learners why they would prefer to stand on a carpet in winter rather than the tiles. They would probably answer that the carpet feels warmer.
- Follow this up by asking them what they think the temperatures of each surface is. Learners might say that they think the tiles are at a lower temperature than the carpet because it feels colder. This is incorrect as the tiles and the carpet will be at the same temperature as they have both been in the same environment for a while and so will be at the same temperature.
- However, if you pose this question to learners again after doing the following investigation and also after looking at the cake and cake tin example, they might then realise that this is another example of a difference in conductivity.
- Namely, the tiles and the carpet are both at the same temperature, but the tiles are a better conductor of energy and so they conduct heat at a faster rate away from your feet than the carpet would, making the tiles feel colder, when in actual fact they are at the same temperature.

INVESTIGATION: Do all materials conduct heat in the same way? LB page 206

This investigation will show the learners that metals conduct heat better than non-metals. If possible, watch the Veritasium video provided in the visit link before class about the misconceptions surrounding temperature and which demonstrates this activity. Start off by asking learners to feel the blocks and ask which one feels colder. The aluminium block will feel colder. Then ask them which block they think will melt the ice cube the fastest. as in the video, most people think that the ice cube will melt faster on the plastic block as it feels warmer than the aluminium block. However, this is a misconception, and will be demonstrated in the activity that it is in fact the aluminium block which causes the ice cube to melt faster as metals are better conductors of heat.

Learners might hypothesise that the ice cube will melt faster on the plastic than the aluminium block. If they do, make sure that they come back to reject their hypothesis and revise it.

You can use any piece of plastic and aluminium (or other metal) that you can find. if possible, use a circular ring to stop the melted water from spilling.

1. Learners will note that the plastic block feels warmer than the metal block.
2. The ice cube on the aluminium/metal block melts first.

3. Learner-dependent answer. Most people generally have the misconception that the ice cube will melt faster on the plastic block, rather than the metal block.

Metal is a better conductor of heat than plastic as the ice cube on the metal melted first.

We will discuss this in the next paragraph about why this happens.

The most likely answer is that the cake tin will give you a more serious burn.

For the next question, get learners to speculate about what they think about the **temperature** of the cake tin and the actual tin. Many people have the misconception that the tin is hotter than the cake as it **feels** hotter. They are actually at the same temperature as they have both been baking at 180 oC.

Yes, the cake and the tin are both at the same temperature as they have been baking at 180 oC. Learners might be inclined to say that the tin is at a higher temperature than the cake as it feels hotter and the metal tin will give you a more serious burn than the actual cake. This is a misconception and you must discuss this. As with the example of the aluminium and plastic block, the cake tin and the cake are at the same temperature. But, the metal tin conducts heat faster towards your hand than the cake does. Therefore, the metal tin will feel hotter and is more likely to give you a serious burn than the cake does. When you touch something, you do not actually feel the temperature. Rather you feel the rate at which heat is either conducted away from or towards you.

This links back to what we learnt in Matter and Materials about the properties of materials and how their properties determine their uses. Remind learners of the activities they did in Matter and Materials, especially linked to conductivity

INVESTIGATION: Which metals are the best conductors of heat? LB page 208

Now that we have established that metals conduct heat energy better than non-metals, the learners will investigate which metals are the best conductors of heat. This investigation requires more heat than the previous one and so the learners should not test the conduction with their fingers. Spend a few minutes before the learners begin by demonstrating the correct procedure for lighting a Bunsen burner. There are many different instructional videos on the Internet, such as the one identified in the visit box in the margin. Here is a list of instructions for your reference:

1. Ensure that you are working on an appropriate surface, such as a fireproof mat, and that it is clean and uncluttered.
2. Make sure that the gas tube is in good condition and not perishing.
3. Connect the to the gas outlet securely and make sure it won't easily come off if moving the Bunsen burner around.
4. Make sure that the collar at the base of the Bunsen burner and the air hole are closed.
5. First light your match, holding it away from the Bunsen burner.
6. Turn on the gas with your other hand and bring the match to the Bunsen burner to light it.
7. Adjust the air hole by opening it so that the flame becomes hotter.
8. Adjust the intensity of the flame using the collar at the bottom.

You can ask the learners to draw posters explaining how to light a Bunsen burner as an additional exercise if you feel they need the extra practice and reminders.

Remember that the tripods and metal rods that the learners use will get quite hot during this experiment. Make sure to allow the apparatus to cool before packing it away.

1. Material being tested i.e. iron, copper, brass or aluminium
2. This would be the independent variable
3. Time taken for the drawing pin to drop.
4. The dependent variable
5. Length and thickness of the material should be the same for each material used. Distance of the drawing pin from the heat source.
6. Constants
7. Learner-dependent answer. Learners can hypothesise about which metal they think will be the best conductor, for example, the copper rod will be the best conductor.

The materials listed here are a suggestion. You can use alternative apparatus to still do this investigation. For example, a spirit burner could also be used to heat the rods. If you do not have a tripod stand, you can place the metal rods on another stand, such as a block of wood, with the ends sticking out one side to still reach over the Bunsen burner. Paper clips can also be used instead of drawing pins. The type of metals are not important as long as you have different metals of the same length.

The cardboard is an insulator and will stop the heat from the rods transferring to the tripod itself. The loss of heat from the rods could affect the results.

1. The type of material should be on the horizontal axis. This is the independent variable. The time taken for the drawing pin to fall off should be on the vertical axis. This is the dependent variable.
2. The independent variable/type of material is not a number value and so it does not need a number line. A bar graph is used to represent non-number or non-continuous data.

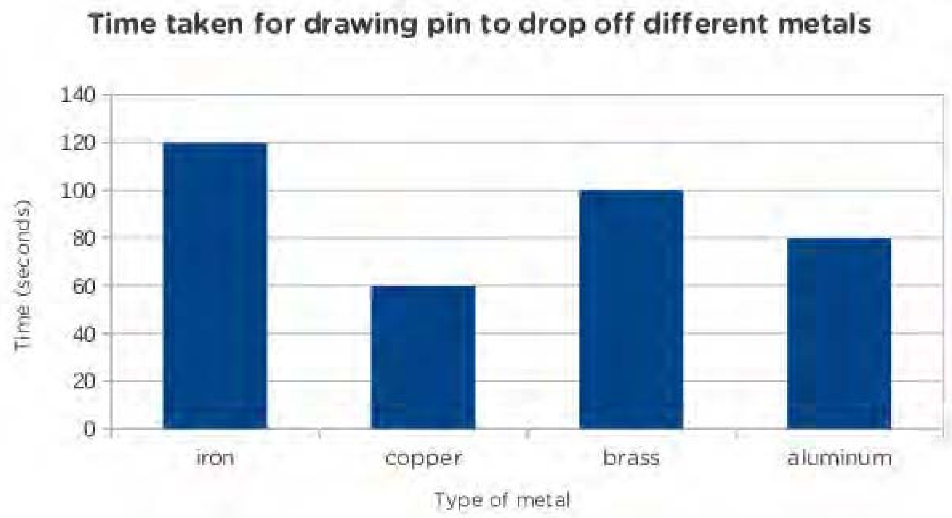
The independent variable is always drawn on the x-axis with the dependent variable on the y-axis. Both axes must be labelled and show the units of measurement. The graph should have a heading.

An example set of data is given here with the accompanying bar graph as a reference. Your results may vary from these presented here.

Type of metal	**Time taken for pin to drop off (seconds)**
Iron	60
Copper	30
Brass	50
Aluminium	40

1. The longest bar should be the iron.
2. The shortest bar should be the copper.
3. Activity-dependent answer.
4. The heat is transferred by conduction through the metal rod and to the Vaseline causing an increase in its temperature and then a change of state (solid to liquid).
5. The cardboard acts as an insulator to prevent heat from transferring to the stand from the rods. For the purpose of this experiment, the heat should transfer down to the different metal rods only.
6. This is so that the test is fair, otherwise some drawing pins might be stuck on better than others, leading to inaccurate results.

7. No, otherwise it would not be a fair test as the heat will have to be conducted further in some rods than in others, leading to inaccurate results.



1. Learner-dependent answer.
2. Learner-dependent answer. Examples include: repeating the same experiment three times and averaging the results, increasing the number of metals tested.

1. This answer will depend on their experimental results, and the exact metals which you used in the investigation.

11.3 Convection

As an introduction to this section, you can simulate the "sitting in a bath" concept by filling a rectangular plastic tub or small water tank with cold water and then pouring hot water into one side. Invite the learners to feel the cold side of the tub and then feel it a few minutes later.

If you can get hold of a lava lamp, this can make a very exciting introduction to the lesson. You can turn the lights off and place the lava lamp on your desk for when learners come into the class. You can then explain that you are going to find out why the blobs rise and then fall back down in the lava lamp. If you do not have a lava lamp, you can also play this video: [1] bit.ly/19BpDKm

ACTIVITY: Convection in water LB page 210

Take note that you need only a few grains of potassium permanganate, otherwise you will not see anything.

An alternative to the above materials is the following:

1. Cut the neck of a transparent 4- or 5-litre container.
2. Fill the container three quarters with cold tap water.
3. Put coloured hot water (can be coloured with food colouring) into a small bottle with a lid that is easy to remove. Close the lid.
4. Lower the small bottle into the container.
5. Gently open it once lowered, then gently take out your hand from the container, with the lid.
6. Observe that the coloured hot water rises from the small bottle, through the cold water, then drops down again as it cools on its way up – observe the convection currents.

Learners must not just throw the potassium permanganate into the water. It is important that they place it carefully in one side of the bottom of the beaker so that they can see how the currents in the water move.

1. Learners should see the purple from the dissolved potassium permanganate moving in a circle upwards through the water.
2. As the potassium permanganate dissolves in the water it is being dragged through the water.
3. The warm water is rising and being replaced by cooler water.
   Note: At this point the learners are not aware of the theory behind convection currents and so their answers will be quite simple.
4. The potassium permanganate will dissolve, but it will not form rising currents. It will diffuse evenly and densely at the bottom of the beaker. Over a long time, it will spread out evenly throughout the water.

ACTIVITY: Does smoke move up or down? LB page 212

The learners need to be careful with this experiment. It is easy to set the T-shaped cardboard alight with the candle and they should be careful not to burn their fingers when lighting the candles as well.

You can drip some wax onto the base and then stick the candle onto this to make it stand.

1. The smoke is drawn down under the cardboard and up next to the candle.
   Note: Some of the smoke particles may move upwards.
2. The candle heats the air above it which creates a convection current which draws the cooler air on the other side of the cardboard towards the candle. This movement of the air particles pulls the smoke particles with it. The smoke particles allow us to visualise the convection current.

ACTIVITY: Installation of air heating and cooling systems LB page 213

1–2. A heater should be placed near the floor. As it heats the air around it, the warm air will rise and be replaced by cool air. The cool air is then warmed and rises. This creates a convection current which will warm the entire room. The diagram should show the upward circulation of the warm air.

3. An air-conditioner should be placed near the ceiling. As it cools the warm air near the ceiling the cool air moves downward towards the floor and is replaced by warm air from below. The warm air is then cooled by the air-conditioner. This creates a convection current which will cool the entire room. The diagram should show the downward circulation of the cool air.

11.4 Radiation

ACTIVITY: Radiation from a candle LB page 214

A suggestion is to do this as a demonstration and get learners to come up in small groups. You can then control how close they put their hands to the flame. Take note that heat radiates **in all directions** around the source of thermal energy (including the top of the candle). What makes us feel the heat more at the top is the effect of convection currents of the hot air moving up. They should first hold their hands above the flame to feel the heat from convection. Then they should hold their hands next to it to feel the heat transfer from radiation. Finally, you can also demonstrate conduction using a metal spoon and holding it in the flame.

1. The air particles will move upwards.
2. Convection.
3. When you hold your hand above the candle, the warm air particles transfer the energy to your hand causing your hand to warm up and you feel the increase in temperature.
4. Yes
5. The energy is transferred by radiation.
6. It would also feel warm.
7. The energy was transferred by conduction.

8. The hand on the right holding the spoon represents conduction as the heat is transferred from the flame through the metal of the spoon. The hand above the candle represents convection as heat is transferred from the flame by moving air particles which warm up and rise. The hand above the candle will also experience heat from radiation as heat is radiated in all directions. The hand on the left next to the candle represents radiation as energy is transferred from the source through space to the hand.

INVESTIGATION: Which surfaces absorb the most radiation? LB page 215

This investigation looks at the way In which different materials absorb radiation or reflect it. It is important that the surface area of each material is kept the same so that the results are reliable. This investigation will work best on a hot, sunny day. Try to find the sunniest place you can on the school grounds in order to conduct this investigation.

Discuss this with your class as it is important that they understand why they are doing the investigation. When the paper envelope absorbs heat, the energy will then be transferred to the air inside the envelopes. This will then cause a rise in temperature which the thermometer will show. The more energy that is absorbed, the more that is transferred to the interior, and the higher the temperature. The paper that reflects the most energy will show the smallest increase in temperature.

1. The temperature of the substance.
2. The dependent variable.
3. The type of material.
4. Independent variable.
5. The surface area of each substance which is exposed to the Sun must be the same (that is, the size of the envelope). The length of time that the materials are exposed to the Sun.

Learner-dependent answer. The hypothesis could be: 'The shiny surface will absorb the least heat, and the black/dark-coloured paper will absorb the most.'

You can also extend the investigation by testing more colours, such as red and yellow to see how they compare.

The results for this experiment are dependent on the size of the paper envelope that the learners make as well as the amount of sunlight falling on the envelopes. The readings may also fluctuate from time to time as a result of cloud covering.

Time should be plotted on the horizontal axis with temperature on the vertical axis. Draw three different graphs for the three different materials. Comparing the slopes of the three graphs will allow the learners to determine which material warmed up fastest. The line with the steepest slope heated the fastest. The black paper should increase in temperature the fastest and so it would have the steepest curve. The aluminium envelope should increase in temperature the slowest and have the shallowest curve, with the white paper in between.

The graph should have a title. An example of a suitable title would be 'A comparison of the rate of temperature increase of different surfaces.'

1. Activity-dependent answer. The values obtained will depend on the size of the envelopes the learners make as well as the amount of sunlight to which the envelopes were exposed. It is important that they should see an increasing trend in the lines of the graph.
2. The graph representing the black paper should be the steepest graph. This means this envelope increased in temperature the fastest. This is because the black, matt colour absorbs the most radiation.
3. The envelope made out of aluminium foil should show the smallest increase in temperature as shiny surfaces reflect heat.

1. Learner-dependent answer. Learners should discuss the quality of their method and whether they got the results that they expected to get. They could suggest repeating the experiment three times and getting an average increase over time.
2. Learner-dependent answer. Some learners may get outliers but others may have clear results with a clear patterns.

Learners should conclude that black surfaces absorb the most radiation and therefore show the biggest and fastest increase in temperature, whereas shiny surfaces absorb the least, as they reflect the most.

The best colour to buy would be a white car because, as seen in the investigation, light colours absorb less heat than dark colours. So a light-coloured car will ideally remain the coolest on the inside.

Yes, it will help, as shiny surfaces are more reflective and so more radiant heat is reflected rather than absorbed, keeping the inside of the car cooler.

Revision

1.

 The heat from the Sun travels to Earth.	 Cooking food on a braai or fire.
Radiation	Convection (and also some radiation)
 Boiling water in a metal pot.	 A heater in a room.
Conduction (through the metal) and convection (in the water)	Radiation and convection

2. a) radiation
   b) conduction
   c) radiation
3. The energy is transferred from the cup to the hands by conduction.
   Note: One of the marks is for choosing the correct direction of the energy transfer. The second mark is for drawing it in the form of a flow chart.
4. Metals are good conductors of heat and so the heat from the water is transferred out of the geyser. A (shiny foil) insulating blanket could be used to wrap around the geyser. The air between the blanket and the geyser is a poor conductor of heat so the heat loss will be slower.
5. The heating element is at the bottom because as the element transfers energy to the water, the water expands and moves upwards and the colder water (slower moving particles) will sink to the bottom, forming a convection current This cycle will ensure that all the water is heated as quickly as possible. If the element was at the top, the water at the bottom would take much longer to boil.
   Note: Learners must mention the term convection current.
6. The water at the bottom of the pot gets hot and then moves to the top of the pot because of convection. This allows the cold water to sink to the bottom and heat up. This constant circulation allows all of the water to heat up and boil.

7. Normal ceramic cups are good conductors of heat and so the energy from the coffee is transferred quickly through the cup to the surroundings. The styrofoam is a poor conductor of heat and so it does not allow the energy from the coffee to move quickly to the surrounding air, so the coffee stays warmer for longer.
8. Air is trapped between the two blankets. The air is a very poor conductor of heat and so it becomes an extra insulating layer which slows down the loss of energy from your body. One blanket cannot trap as much air and so isn't as warm as two blankets.
9. Birds fluff up their feathers so that more air gets trapped between the feathers. The air is a poor conductor of heat and so the energy from the birds body is not transferred to the surroundings.
10. This is because cold air will move downwards, therefore cooling the room, and the hot air will rise and can therefore be removed by the air conditioner at the top of the room, near the ceiling.
11. The best choice to keep the house as warm as possible on the inside is a dark-coloured paint. This is because the dark colours absorb more radiant heat from the Sun during the day, than the light colours, which reflect heat. The dark paint will absorb the heat and it will be transferred to the air inside of the house, making it warmer, especially during winter.

12 Heat insulation and energy saving

Chapter overview

1 week

This chapter expands on the idea of energy transfer that the learners discovered in the previous chapter. It is very important to reinforce the idea that heat is the transfer of energy from a warm object or system to a colder object or the surroundings. It is to retard this process that we need insulation.

The previous chapter introduced the concept of heat and temperature and the different ways in which energy is transferred between objects. This chapter deals with the practical applications of heat, showing how we can harness the transfer of energy in order to warm our homes and to stop energy being transferred away from our homes in winter. Similarly, insulation is required to keep objects cool, for example a cooler box. The learners will investigate different materials in order to discover which materials are better insulators or conductors.

12.1 Why do we need insulating materials? (1 hour)

Tasks	Skills	Recommendation
Activity: How do solar water heaters work?	Examining, observing, explaining	CAPS suggested

12.2 Using insulating materials (5 hours)

Tasks	Skills	Recommendation
Activity: Keep your coffee hot and your cold-drink cold	Designing, group work, hypothesising, making, drawing, labelling,	CAPS Suggested
Investigation: Which is the best insulating material?	Observing, measuring, recording, plotting graphs, interpreting data	CAPS suggested
Activity: Building a hot box	Drawing, designing, labelling, making, observing	CAPS suggested
Activity: Keeping our homes warm Making,	Measuring, recording, plotting graphs, interpreting data	CAPS suggested

Note that CAPS suggests making a hot box OR building a model home. We have included both here for you to make a choice. There is also a substantial amount of time for this chapter, so you could also do both tasks with your learners.

Key questions

- How can you keep your tea warm?
- Can you use the same materials to keep your house warm in winter and cool in summer?
- How do insulating materials assist with saving energy?

12.1 Why do we need insulating materials?

ACTIVITY: How do solar water heaters work? LB page 220

Learners can discuss this in groups and then write down their own answers or do it individually.

1. A renewable energy source.
   Note: This links back to what learners covered in Chapter 1.
2. Radiation.
3. The reflector is a shiny surface, so it does not absorb the heat, but reflects the Sun's radiant energy back up and onto the tubes, increasing the amount of energy that the water in the tubes receive.
4. By conduction.
5. In between the inner and outer tank there is a thick layer of insulation. This does not conduct heat. The insulation helps to prevent the transfer of energy to the surroundings by conduction as the insulation material is a poor conductor of heat.
6. For energy to be transferred by conduction or convection, it requires a medium, such as air particles. However, there is a vacuum, so it helps to insulate the inner pipe.
7. This is because the dark material is much better at absorbing radiant heat and transferring it to the pipe, than a light material would be.
8. A convection current.
9. …
10. It is a very efficient system as all the materials are carefully chosen to either enhance energy transfer or prevent it, depending on what is needed in that part of the system. This helps to save electricity as solar power is used to heat water instead of relying on an electrical geyser. It is also cheaper as solar power is free, except for the installation of the actual solar heater.

12.2 Using insulating materials

Learners should write something about its being a poor conductor of heat or preventing energy transfer.

ACTIVITY: Keep your coffee hot and your cold-drink cold LB page 222

Learners must use their knowledge of the ways energy is transferred in order to come up with their own method for insulating their drinks. Let the learners be creative here, don't give them too many hints or suggestions. The activity will show you which learners have understood the energy transfer concepts from the previous chapter and which of them need more help.

There are different ways to manage this activity. You can provide the learners with a selection of materials that you want them to use or you can ask them to bring in their own materials. Making the learners bring in their own materials makes it more challenging for the learners. If you provide a selection of insulating materials, the learners will have a base from which to work and they are more likely to insulate the drink correctly the first time.

This activity is meant as an introduction to using insulating materials. The learners need to consider what they have learnt about conduction, convection and radiation in order to choose different materials for their activity.

Get the learners to develop a plan for their design before they insulate their cup. Ask them to come up with a hypothesis that they can test. Here are several hypotheses which the learners may come up with:

- "Wrapping aluminium foil around the cup will prevent energy transfer".
- "Covering the cup with cardboard will slow down heat loss."
- "Using corrugated cardboard as an insulator will slow down heat loss"
- "Wrapping a cup in layers of newspaper will prevent energy transfer."

The learners can then test their hypothesis and decide at the end whether or not it is true or false.

An additional exercise to do is to use the same size tins and wrap them in 3, 6 and 9 layers of newspaper. This clearly shows that newspaper is a very effective insulator, especially if layered.

These answers are learner-dependent because they are based on the learner's own choice of materials and the ambient temperatures at the time of the experiment.

1. Learner-dependent answer.
2. Learner-dependent answer.
3. Learner-dependent answer.
4. Learner-dependent answer.
5. Learner-dependent answer.
6. Learner-dependent answer.
7. Learner-dependent answer.
8. Learner-dependent answer.
9. Learner-dependent answer.
10. Learner-dependent answer.
11. The uninsulated cups act as controls for the activity. Without testing the uninsulated cups, we cannot be sure of whether or not the tea would have cooled down (or the cold drink warmed up) at the same rate without the extra insulating materials.
12. This answer will depend on the learners' hypotheses. If they hypothesise that their material will decrease heat loss and they can show that it does, their hypothesis is true. If they hypothesise that their material will decrease heat loss but the tea cools at the same rate as the control, their hypothesis is false.

INVESTIGATION: Which is the best insulating material? LB page 224

Aim

To investigate which materials are insulators of heat.

Make sure that the layers of newspaper, plastic and fabric are the same thickness so that the thickness of the material does NOT vary in the investigation.

1. Time
2. Temperature
3. Learners can use different colours for each type of material used.

The independent variable (time) must be plotted on the horizontal x-axis and the dependent variable (temperature) must be plotted on the vertical y-axis. The learners should plot each of the four graphs one-by-one in a different colour in order to distinguish between the lines. If they cannot use colour then make sure that they label each line carefully. The actual temperature of the water before it starts to cool will affect the results. Also, the ambient temperature of the room will also affect the temperature drop. What is important to notice is that the initial temperature drop is fast but then the rate of temperature drop decreases. This means that the shape of the graph will be a decreasing curve. Learners must provide a heading for the graph, such as 'Graph showing the decrease in temperature over time when using different materials as heat insulators'.

You can use Assessment Rubric 3 at the back of your Teacher's Guide if you wish to assess this graph.

1. The aluminium foil has the steepest curve. This might vary though depending on the actual foil and other materials which you used. **Note:** The answers here must correlate with the learner's results.
2. The steeper the curve the faster the temperature has dropped. The steep curve shows that heat has left the water quickly.
3. Activity-dependent answer.
4. This depends on the learner's results. Whichever material allowed the fastest decrease in temperature is the best conductor of heat as it means that heat was easily conducted out of the warm water.
5. The graph with the shallowest curve is the best insulator. This depends on what the learner's observed during their investigation.
6. Learners must suggest the insulator which had the shallowest curve on their graph

Learners must answer the question: Which is the best insulator? They can conclude from their results which is the best.

The thick layer of plastic acts as an insulator so heat from the surroundings is prevented/minimised from entering into the cooler box and the contents stay cold inside.

ACTIVITY: Building a hot box LB page 226

It would be best to do this activity as a demonstration. The quantity of blankets and towels required may be difficult for each learner to bring in to school. If you want the learners to try it then let them do it in groups. Ask learners to each bring in a towel or a blanket to school to make sure that each group has enough materials. A couple of old pillows in a box also works very well. You can also make smaller hotboxes with smaller boxes and strips of fabric rather than blankets and towels. The smaller hotboxes may not be sufficient insulation to keep a meal cooking, so you could use an ice cube and try to keep that cold. A hot box can keep cold items cold as it also prevents the transfer of heat from the surroundings into the box.

This activity provides one way to make a hotbox. You can also do this as a project where learners must design and build their own hot boxes and they can also do this in groups.

The materials and instructions for building this hotbox are provided only here in the Teachers Guide in case you want learners to design, make and test their own hot box, rather than one that you have made as a demonstration.

Materials:

- large cardboard box
- medium cardboard box (must fit inside the larger box)
- blankets
- towels
- rice and water brought to the boiling point for about five minutes. This will continue cooking if well insulated and the rice will be completely cooked after about 40 min.

Instructions:

1. Line the inside of the larger cardboard box with towels and blankets. Make sure that there is still room for the medium cardboard box to fit inside.
2. Put the medium cardboard box in the middle of the larger cardboard box.
3. Put a few small towels and blankets around the outside of the medium box. Pack the towels and blankets snugly so that the medium cardboard box cannot move around.
4. Put a pot of partially cooked rice inside the medium cardboard box, Wrap newspaper, towels and a blanket around the pot.
5. Close the lid of the medium cardboard box.
6. Put a layer of towels and blankets on top of the closed medium cardboard box and then close the large cardboard box as well. Put some more towels or blankets on top.
7. The rice will continue to cook in the hot box.
8. Learner-dependent answer. This links in with what learners do in Technology in terms of drawing their designs. Make sure that it is labelled and specifies the materials used.
9. This answer depends on the materials used. For example, towels and blankets are good insulators because air is trapped between the woven fibres as well as between the layers of the fabric. The cardboard box is also a better insulator than for example a metal box or container.
10. The food needs to be hot when it is put in so that the hotbox can trap the heat. If the food and water were cold, the hotbox would keep the heat out and the rice would not cook.
11. The hotbox can keep cold items cold for a longer period of time. This is because the insulating layers will prevent energy from the outside from entering the hotbox and so the interior can stay cool.

ACTIVITY: Keeping our homes warm LB page 226

1. The windows, door and roof.
2. By conduction.

The learners will now make model houses. The template is included below. If you can, photocopy the template for the learners as this would save some class time, preferably A3 size paper. If you cannot photocopy the template have the learners trace it onto a piece of paper. The learners can choose the number of windows in the house. The learners may choose to use thicker or thinner cardboard for the walls and roof. They may use fabric or cotton wool on the roof and the floor. They should try different things to regulate the internal temperature of their model house. The holes for the windows could be covered over with Cellotape to simulate glass.

As an extension exercise, if you have enough class time, it would be a good idea to have each learner or group of learners make several different models. Each model can have a different number of windows and have used different insulating methods. If you do not have enough class time for each group to do more than one model, encourage different learners or groups of learners to do different models and then have the groups compare their results with other groups.

As an extension exercise, ask learners what they can do to their model houses to prevent heat loss. Try out their suggestions and test then. An example of what learners could do is to line the inside of the house with cotton wool and then repeat the experiment to see if it makes a difference.

This graph is a line graph. The time should be on the horizontal axis and the temperature on the vertical axis. The temperature should rise and then reach a steady temperature. When the lamp is switched off the temperature should decrease and then reach a steady temperature again.

1. The energy from the lamp (Sun) transferred by radiation to the model house. The walls of the house conducted the energy through to the interior of the house. Convection of the warmer air inside the house made sure that the entire interior of the house warmed up.
2. The warm air inside the model house rises towards the roof because of convection. The energy from the warm air is transferred to the outside because it is conducted through the roof, walls and windows.
3. Learner-dependent answer. Each model house would need different interventions to improve their insulation. Some may suggest fewer windows; some may suggest using fabric on the walls or thickening the walls by using cardboard.
4. Learner-dependent answer. The answers will depend on the socio-economic circumstances of the learners. Suggestions may vary from fitting carpets and double glazing to using cloth or cardboard to seal gaps under doors.
5. Insulators prevent heat from leaving the house but, at the same time, they also prevent heat from entering a house. This means that the house should not take in as much heat during summer but in winter the heat is trapped inside.

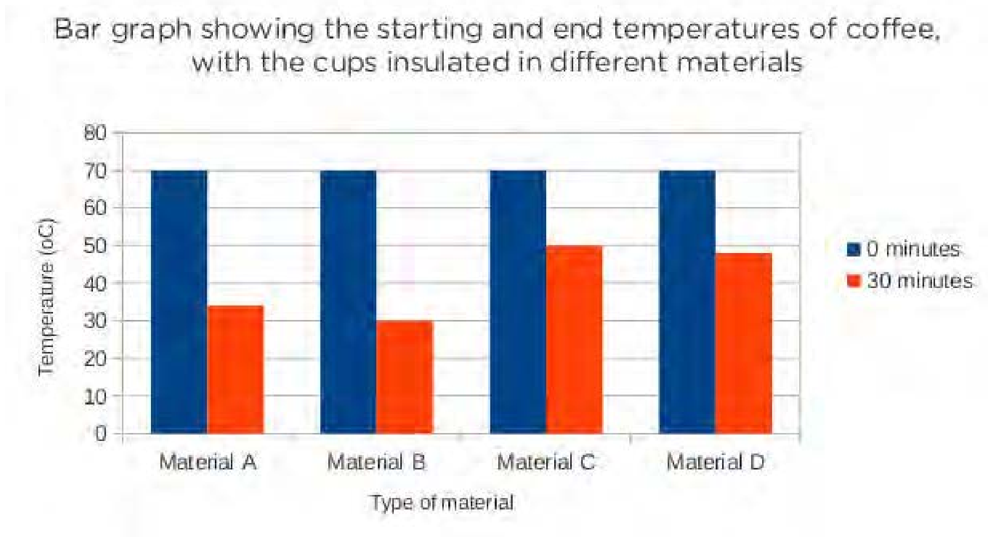
At this point you can also explain some of the new building regulations, such as requiring windows to be double glazed if they take up large areas in the house. This is to prevent energy loss. The thickness helps to reduce heat lost through conduction. This keeps the houses cooler in summer, but warmer in winter.

Revision

1. An insulator is a substance which resists the transfer of energy (heat or electricity) through it.
2. a) False. A tea cosy stops the heat from the tea from being transferred out of the tea to the surroundings.
   Note: 'Cold' cannot be transferred. Cold is a measure of temperature.
   b) False. The sun warms the earth through radiation which can travel through a vacuum.
   c) True
3. He should use the smaller double-paned window as he needs to prevent heat loss in a cold environment. The air space slows the heat loss from conduction because the air is a poor conductor of heat. Also, the smaller window means that there is a smaller surface area for heat to escape.
4. The coffee is very hot and the energy transfer to the surroundings needs to be reduced so that it stays hotter for longer. Paper is a poor conductor of heat. The corrugated cardboard allows a layer of air between the cardboard and the cup. Air is a poor conductor of heat. This means that less energy is transferred from the coffee to the person's hand and surroundings. Corrugated also means that there is less area of contact between the person's fingers and the cup. there is therefore less conduction so the person is less likely to burn their fingers.
5. a) The type of material is the independent variable.
   b) The temperature of the water is the dependent variable.
   c) Here is an example graph. Marks are allocated as follows:

      0.5 marks for each of the bars [0.5 x 8 = 4 marks] Appropriate heading [1 mark]

      1 mark each of the headings for the axes [1 x 2 = 2 marks] Putting the right variables on each axis. [1 mark]



Material C is your material.

d–e Material C shows the smallest drop in temperature which means that the material prevented the most energy from transferring to the surroundings.

6. The wool of the jersey acts as an insulating material as it is a poor conductor of heat. The thick jersey also traps a layer of air around the body. Energy from the body is transferred to this air via conduction. This warm air is unable to move away from the body because of the thick wool. The fibres of the wool trap air and the air is a poor conductor of heat.
7. a) The pink material is an insulator to prevent heat loss.
   b) The material is a poor conductor of heat and so it minimises heat from being transferred from the air in the house, through the roof and to the outside. The material also traps air in it, and the air is also a poor conductor of heat, increasing the insulation.
   c) It is probably being built in a cold climate as extra measures are being taken to reduce heat loss from the house
8. a) The plastic is an insulator. The runners bodies get very hot during their race and so their bodies try to cool down by sweating. If all that heat escapes their bodies, the runners will cool down too quickly, resulting in cramps and they could get sick. The plastic traps the heat below the blanket. The reflective surface stops the blanket from emitting any heat to the surroundings.
   b) This is open to interpretation by the learners. The main reason is that the plastic blankets are much cheaper and disposable, and since they might be handing them out to many runners, it is more economical.
9. a) The tank, the connecting pipes and the solar panel heater.
   b) This is because as the water in the tank cools, it moves to the bottom (convection current) so the pipe at the bottom funnels this water to the heater to be warmed again.
   c) Similarly to the previous question, the warm water is pumped from the solar panel heater and into the top of the tank. The warm water collects at the top of the tank as warm water rises (convection current). So, it makes sense to have the tap at the top of the tank to collect the water while it is warm. If the tap was at the bottom, the water would be colder.
   d) It should be covered in an insulating material to conserve heat inside the water and reduce heat loss to the surroundings by conduction.

13 Energy transfer to surroundings

Chapter overview

1 week

This chapter follows on from the last chapter where we mentioned that heat can be 'lost' as energy is transferred to the surroundings. This chapter now explains that within a system, there is useful energy which is transferred to the desired object or place, but no process is 100% efficient. Energy can be transferred to the surroundings rather than to the object or part of the system that you want it to transfer to. This is considered a waste of energy and systems are designed to try minimise this waste so that they are more efficient. There is always some loss of energy (wasted energy) and so there are always by-products to energy production. Some of the by-products are harmful to the environment.

Important to note is that CAPS makes the following statement:

- 'The output energy in a system is always less than the input energy, because some of the energy escapes to the environment.'
- This is **not correct** as the output energy is always equal to the input energy as energy is conserved within systems. The statement should rather state:
  - 'The output energy in a system is always less than the input energy, because some of the energy escapes to the environment.'
- The wasted energy is still part of the output energy from the system, it is just not useful.

13.1 Useful and "wasted" energy (3 hours)

Tasks	Skills	Recommendation
Activity: Useful outputs from energy systems	Accessing and recalling information, identifying and classifying	CAPS Suggested
Activity: Energy transfers in systems	Accessing and recalling information, identifying and classifying	CAPS suggested
Activity: Drawing Sankey diagrams	Interpreting, sorting and classifying, communicating information graphically	CAPS Suggested
Activity: Researching energy transfers	Researching, accessing and recalling information, interpreting, sorting and classifying, communicating information; written, graphically	CAPS suggested

Key questions

- What sort of useful energy output do some systems produce?
- What is meant by "wasted" energy?
- What is a Sankey diagram?
- How do we draw Sankey diagrams?

13.1 Useful and wasted energy

The learners will not have seen **Sankey diagrams** before. You should explain the usefulness of representing processes using pictures. Illustrations make a quick, visual impact on the viewer which makes it easier to understand a process. A Sankey diagram is a visual representation of an energy process showing the input energy and the output energy. Sankey diagrams should be drawn neatly and as close to scale as possible. Take the time to draw several examples on the board so that the learners see that all energy processes have more than one output energy type.

ACTIVITY: Useful outputs from energy systems   LB page 233

This is because energy is neither created nor destroyed, but is conserved within a system. So the input must equal the output energy in a system.

No, it is not efficient as a lot of the energy is wasted

It is lost as heat, as energy is transferred to the surrounding air.

The learners' diagrams should look as follows:

ACTIVITY: Researching energy transfers   LB page 237

This is a research activity. If your learners have access to the Internet and/or a library, allow them to spend some time researching the energy transfers in a power plant and a car engine. If your learners do not have access to the Internet, it would be a good idea to print out some information from various websites that can be handed out to the class. You could let the printed information circulate through the class so that you do not need as many copies. This will save on paper and printing costs.

In this activity, they will first see how the wasted energy can be in more than one form and how to represent this in a Sankey diagram for a car engine.

Learners will then research a power plant. You can get the learners to work in groups to find the information but make sure that each learner is able to write their own paragraph. This will give you a sense of whether or not the learner has understood what they have researched.

Here is a resource for reference: [1] bbc.in/15vnPFJ

The paragraph should include the following information:

- Coal is burnt and the energy is transferred to the water and used to boil the water. Some of the energy is lost during this process.
- The steam from the boiling water is used to turn the turbine. The kinetic energy of the steam is transferred to the turbine. Some of the energy is lost to the surroundings as sound and thermal energy.
- The kinetic energy of the turbine is transferred to the generator. Some of the energy is lost to the surroundings as sound and thermal energy.
- The kinetic energy of the generator is used to generate electricity.

Revision

1. In an energy system, some of the energy is transferred to the surroundings in ways which we did not intend or are not useful. This amount of energy serves no useful purpose and so it is "wasted".
2. In the chapter, learners used percentages to draw their Sankey diagrams. The following is an extension and starts off with a simple example which they have already seen in the chapter, namely a light bulb, but the energy transfers were represented as percentages. In the first example here, we now start off with 100 J instead of 100%. The Sankey diagram will be straightforward to draw. However, in the subsequent examples, the input energy is more than 100 J. Learners do not need to calculate the percentages, but the thickness of the arrows should be representative of the amount transferred.
3. [Diagrams to be inserted.]
4. a) The potential energy from the batteries in the torch is transferred to the filament of the bulb. The energy is transferred to the surroundings as thermal energy and light. Most of the energy is transferred as thermal energy which is not useful and only some of the energy is transferred as light.
   b) The energy from the TV is transferred to the surroundings as thermal energy, sound and light. The light and sound are useful because they are the images and sounds we want to hear. The heat is wasted energy.
   c) The energy from the hair dryer is used to heat the air and dry our hair. Two thirds of the energy is useful thermal energy but one third is transferred as sound, which is not useful to us.
5. A filament light bulb uses a metal filament and an energy saving light bulb uses a fluorescent gas to provide light.
6. A lot of the energy used to make a filament bulb glow is used to heat the metal to make the metal glow. This means that a lot of the energy is wasted as thermal energy when we actually want light. Energy saving bulbs don't have to heat the gas before it will glow and so it wastes less energy.
7. The heating element is placed at the bottom as this is more efficient because as the water warms up due to the transfer of energy, the heated water expands and moves upwards, and the cold water moves down in a convection current, thereby warming all the water.

This links back to the previous chapters so that knowledge is revised and reinforced.

14 The national electricity supply system

Chapter overview

1 week

This chapter revises some of the concepts covered in Gr. 6 Energy and Change on the supply of electricity. The learners should already have a basic knowledge of the national grid and this chapter will expand on those ideas and discuss how the national grid is a system to supply electricity. This chapter also introduces the concept of a dynamo and the role that Eskom plays in producing electricity. Learners will be given an opportunity to research different careers in the field of energy production.

If you only teach Natural Sciences, it is a good idea to check with the Technology teachers to see how these two curriculums complement each other, especially with regard to electricity. Some of the concepts which might be introduced for the first time in Natural Sciences, have already been covered in the Technology curriculum. Knowing what learners have already covered and been introduced to will help make your classes more efficient and more stimulating for learners.

14.1 Energy transfers in the national grid (2 hours)

Tasks	Skills	Recommendation
Activity: Overview of the national electricity grid	Accessing and recalling information, defining and describing, comparing, identifying	CAPS suggested
Activity: Turning a pinwheel	Making, observing, describing	CAPS Suggested
Activity: Energy transfers	Accessing and recalling information, interpreting, sorting and classifying, communicating information graphically	CAPS suggested

14.2 Conserving electricity in the home (1 hour)

Tasks	Skills	Recommendation
Activity: Geyser blankets and solar geysers	Accessing and recalling, explaining	CAPS Suggested
Activity: Conserving electricity	Sorting and classifying, problem-solving, describing	CAPS suggested
Activity: Writing a letter to your local newspaper	Accessing and recalling information, research, communicating in written form, identifying problems and issues, raising questions, problem-solving	Optional
Activity: Career research	Research, raising questions,	Optional

Key questions

- How does Eskom produce electricity?
- What energy is transferred during electricity generation?
- How does the electricity reach our homes?
- Can we use as much electricity as we like?
- How can we save electricity?

14.1 Energy transfers in the national grid

The visit box refers to an excellent video on the national grid and summarises where energy comes from, how it is harnessed, and how it is distributed. It links back to work covered in Gr. 5 and Gr. 6.

It does, however, refer to the national grid of only the UK and USA. You could use this as an opportunity to discuss the South African national grid in contrast to international electricity grids and supply systems. [1] bit.ly/1hniv7m

ACTIVITY: Overview of the national electricity grid LB page 242

Some of the questions here link back to what was covered in the earlier chapters this term, which serves to revise concepts and also create connections between concepts. This reinforces learning.

1. A system is a set of parts that function together as a whole.
2. The energy is conserved in a system, it is neither created nor destroyed.
3. Yes, it is a system as it is made up of different parts, such as the power station, transmission lines, buildings, which function together to generate and deliver electricity.
5. The power station.
6. The transmission power lines.
7. There are many useful outputs, such as lights in houses, schools, heaters, warming water in geysers, running any appliances or tools, etc.
8. Coal.
9. It is non-renewable as there is only a limited amount of coal on Earth. It is not being regenerated at a rate fast enough for it to be renewable.
10. The learners should write the letters in the approximate places as shown below:

Potential energy

It is transferred to kinetic energy.

ACTIVITY: Turning a pinwheel LB page 245

If you do not have enough time in class to have each learner make their own pinwheel, either make a few before class that the learners can use or just make one to use as a demonstration. You may also be able to purchase small pinwheels to save class time.

Some kettles may produce a weaker stream of steam and so it would be a good idea to test the kettle with a paper pinwheel before doing it with the class. You can also watch the video provided in the Visit box.

If the pin wheel which is made using the A5 paper is too large to turn in the steam from a kettle, then redo the activity using a smaller piece of paper. Starting with a smaller piece of paper will result in a smaller pinwheel. Take note that the commercial pinwheels made from plastic often curl and melt in the steam.

Make sure to point out the thermal system (the kettle and boiling water) and the mechanical system (the turning pinwheel) and how energy is transferred between these systems.

1. The pinwheel turned when it was placed in the steam.
2. The element in the kettle transfers energy to the water in the kettle. The water then gets to boiling point and changes phase to water vapour. The steam rises because of convection. The moving particles push against the blades of the pinwheel and cause the pinwheel to turn. The steam has a lot of kinetic energy which is transferred to the blades of the pinwheel causing it to turn. There is a transfer of energy between a thermal system and a mechanical system.

If possible, organise an excursion with your learners to a power station in your area. Here is a link to the Wikipedia article which lists all the power stations in South Africa. 2 bit.ly/15vo5Vk

Here is a table summarizing some of the various power stations in South Africa and and which province they are located in, for your reference.

Coal-powered stations	
Power station	**Province**
Arnot Power Station	Mpumalanga
Bloemfontein Power Station	Free State
Camden Power Station	Mpumalanga
Duvha Power Station	Mpumalanga
Kelvin Power Station	Gauteng
Lethabo Power Station	Free State
Matimba Power Station	Limpopo
Pretoria West Power Station	Gauteng

Hydroelectric power stations	
Power station	**Province**
Drakensberg Pumped Storage Scheme	Free State
Gariep Dam	Free State-Eastern Cape border
Ingula Pumped Storage Scheme	KwaZulu-Natal
Kouga Dam	Eastern Cape
Palmiet Pumped Storage Scheme	Western Cape
Steenbras Pumped Storage Scheme	Western Cape
Vanderkloof Dam	Northern Cape

ACTIVITY: Energy transfers LB page 247

The description of the production of electricity given in the text before this activity and the videos should give the learners enough information with which to draw a simple flow diagram showing how energy is transferred through the system, from the coal to the power lines.

This is an example of the type of flow diagram required. If learners are battling, start the diagram off with them by showing the first step and then they can complete it.

Take note that an electric generator is a device that converts mechanical energy into electrical energy, normally using electromagnetic induction. A dynamo was actually the precursor to the modern day electric generators. now, it can be considered as a type of generator that produces **direct** current, with the use of commutators. At this level though in Gr. 7, we are not explaining the difference between direct and alternating current. Generators are used all over the world now, and dynamos are considered to be an instrument of the past, however, they are still used in some instances where a low powered DC current is required, such as a bicycle light, as discussed here. Make sure that learners do not use the words generator and dynamo interchangeably as a dynamo is a type of generator, but it is incorrect to call a generator a dynamo.

The movement (kinetic energy) of the wheel is transferred to electrical energy.

The dynamo is used to generate electricity to power a light for the bicycle. This is useful as a battery will only last for a certain amount of time and run out. But, a dynamo will work whenever you are cycling as it just needs the movement of the wheel.

14.2 Conserving electricity in the home

ACTIVITY: Geyser blankets and solar geysers LB page 249

The part of the heating element which is not covered by the pot is transferring thermal energy to the air surrounding the element rather than to the pot and so a lot more energy is "wasted".

1. The thick fibre layer helps to reduce the energy loss by slowing down the conduction of heat from the water to the air. The shiny aluminium layer is not a good emitter of radiation and so less energy is lost through radiation.
2. The solar panels generate the required electricity and so it isn't generated by Eskom. It is the electricity supplied by Eskom that needs to be conserved. This also reduces the demand on non-renewable energy sources which have a negative impact on the environment.

ACTIVITY: Conserving electricity LB page 250

1. Learner-dependent answer.
2. This question links back to what learners covered in Chapter 1 on sources of energy. Burning fossil fuels releases greenhouse gases which contribute to the greenhouse effect in the atmosphere. This contributes to global warming. If we use electricity in our homes wisely and save electricity, we reduce the load on the coal-powered stations, and therefore help to reduce the emission of greenhouse gases.

3. Learners can suggest installing solar panels on the roofs of their house to rather make use of solar power as it is a renewable energy source. Electric geysers also use a huge amount of electricity to warm water, therefore installing a solar water heater (as discussed in Chapter 4), the family will reduce their load on the national supply system by rather using alternative energy sources.

ACTIVITY: Writing a letter to your local newspaper LB page 250

This is an optional activity aimed at creating awareness among learners about our country's reliance on fossil fuels and the negative environmental impact. This can also be done as a homework task.

Learners will need to write a letter to their local newspaper. Encourage learners to do some extra research about the area in which you live. For example, looking at the direct impacts of a coal station on your area, such as the possible effects of acid rain. Learners should research the renewable energy power stations that might already be in the area which could rather be expanded.

This is a creative writing piece but also a research task. Learners must reference any sources that they use. Learners must include in their letter, their motivation for why renewable energy sources should rather be explored. The scientific accuracy of their letters must also be assessed.

The purpose of this activity is to engage learners in constructive, problem-solving thinking.

Learner-dependent answer.

ACTIVITY: Career research LB page 251

Learners can also make a poster about the career and put them up for display in the classroom.

You can also contact some the engineering associations listed below:

Engineering Council of South Africa (ECSA)
Tel: (011) 607-9500 Fax: (011) 622-9295
E-mail: engineer@ecsa.co.za

South African Institute of Electrical Engineers
Tel: (011) 487-3003/6 / (011) 487-3002
http://www.saiee.org.za

Electrical Contractors Association of SA
Tel: (011) 392 0000

Learner-dependent answer.

The Zooniverse website provides a great overview of the various citizen science projects that learners can get involved in. There is a huge variety of projects, from helping to identify possible planets around stars, analysing real life cancer data, looking at tropical cyclone data, or listening to the calls from whales or bats. And there are also many others. Citizen science is scientific research which is conducted in whole or in part by nonprofessional scientists, specifically the general public.

Encouraging learners to get involved in some of these projects will open their eyes to the possibilities out there, and also add meaning and value to what they learn within the Natural Sciences classroom. bit.ly/14JxLsw

Revision

1. This is because the power lines make up a grid across the country which is a closed circuit. It is a system.
2. Coal.
3. Eskom is South Africa's public utility which produces the largest amount of electricity in South Africa
4.
   - The paragraph must contain the following points:
   - coal is mined and then delivered to the coal station
   - the coal is pulverised to make it finer
   - the coal is burned in a furnace
   - the energy is used to boil water
   - the steam turns the turbine
   - the turbine turns a generator which produces electricity
   - the electricity enters the wires of the national grid.
5. Any of the fossil fuels (natural gas and oil too), falling water in a hydropower plant, a wind turbine, or nuclear fuel.
6. a) A pie chart.
   b) 100%
   c) 67%
   d) Learners must add up the percentages for coal, oil and natural gas which is 67 + 19 + 2 = 88%
   e) Non-renewable, as this makes up 88% of our energy supply.
   f) Hydropower.
   g) Learners need to justify their answers. You should assess their reasoning and explanations of answers. Some points for answers in this question: Non-renewable energy sources are not sustainable in the long term as there is only a limited supply, they are not renewable.

   South Africa needs to think ahead to plan for when the supply of non-renewable energy sources runs out, by looking at alternative renewable solutions. The use of non-renewable energy sources has a negative impact on the environment due to the emission of greenhouse gases which contribute to global warming and acid rain which ruins crops and buildings.

7. An example of a table is given below. Learners must provide a heading for the table [1 mark] and column headings [1 mark each]. 2 marks are awarded to the correct data. 1 mark is for putting the percentage sign in the heading and not in each row.

Table showing the percentage breakdown for each source of energy supply in South Africa in 2010

Percentage breakdown for each source of energy supply in South Africa in 2010	
Energy supply source	**Percentage of energy supply in South Africa (%)**
Coal	67
Oil	19
Solid biomass and waste	10
Natural gas	2
Nuclear	<2
Hydro power	<1

8. Batteries run out quite quickly. Miners are underground for long periods of time and a dynamo does not run out of energy. The miner can just wind up the dynamo by hand again as soon as the electric light in the helmet begins to fade.
9. Learner-dependent answer. Possible answers include: switching off appliances after use. Switch off lights of unoccupied rooms. Switch off geyser. Use a geyser blanket. Install solar geysers.
10. a) **Note:** The bar graph should have a heading [1 mark] which indicates what the bar graph represents. An example heading could be "Amount of energy used by common household appliances in one hour.".
    The type of appliance should be listed on the horizontal x-axis [1 mark].
    The number of kilojoules should be plotted on the vertical y-axis [1 mark].
    The height of each bar should be correct according to the scale of the vertical axis [1 mark].
    There should be gaps between the bars of the graph [1 mark]. The electric stove.
    b) – c)Use a hot box to continue cooking the food once it has warmed up.

15 Relationship of the Sun to the Earth

Chapter overview

4 weeks

In Grade 6 learners covered material explaining how the spin of the Earth on its axis causes day and night. They also learnt that the Earth revolves around the Sun, completing one orbit every year. In this chapter we begin by reviewing this material before moving on to look at solar energy and the Earth's seasons. The main aims of this chapter are to ensure that learners understand the following:

- The Earth revolves (orbits) around the Sun in one year.
- The Earth's rotation axis is tilted relative to the plane of its orbit around the Sun.
- This tilt of the Earth is responsible for the seasons as the Earth orbits the Sun.
- The Sun provides energy that sustains all life on Earth.

Learners often battle with distinguishing between revolves and rotates as they confuse the words. If you find learners are battling with this, sometimes it helps to replace the word 'revolves' with 'orbits' so that the concept is clear and the learners are not confused by semantics. We have used the rotate and revolve here, as required by CAPS, but you can introduce this more slowly if you feel the wording is hindering your learners grasp of the concept.

It is important to address any misconceptions that learners may have regarding the cause of the seasons. Some common misconceptions are identified in section 1.1 and explanations are given.

At the end of section 1.1 there is a sub-section that covers the **Seasons on other planets.** It is included as an interesting and challenging extension. However, this section could cause confusion if the learners have not fully grasped why seasons occur on Earth, so do not attempt to include it if you have doubts about learner's comprehension of the previous material. This section is useful however as it helps learners to apply the knowledge they've gained about Earth to the other planets and gives learners a sense of the Earth's place within our solar system.

Concept maps: The concept maps in these workbooks were created using an open source programme called CMapTools. You can download it from this link if you would like to use it to create your own concept maps. bit.ly/1fMyJsQ

Do you think it is important to teach astronomy to learners at school? Read this interesting and informative article detailing the benefits and applications of astronomy. bit.ly/17iVgpw

15.1 Solar energy and the Earth's seasons (7 hours)

Tasks	Skills	Recommendation
Activity: Day and night revision exercise	Stating, remembering	Optional revision
Activity: Movement of a classroom Sun	Investigating, observing, analysing	CAPS Suggested
Activity: Daytime and nighttime	Investigating, observing, analysing	CAPS suggested
Activity: Which way does the	Observing, analysing	Extension

Earth rotate?		
Activity: Label the Earth	Identifying	CAPS suggested
Activity: What causes the seasons? Guesses.	Listing	Optional
Activity: The Earth's tilt	Investigating, observing, analysing	CAPS Suggested
Activity: Direct and indirect light	Working in pairs, investigating, observing, analysing, evaluating	CAPS suggested
Investigation: Direct and indirect light and its effect on temperature	Investigating, observing, taking measurements, recording, analysing	CAPS Suggested
Activity: Looking at sunlight hitting the Earth	Observing, analysing	CAPS suggested
Activity: Earth's seasons summary	Recalling, summarising	Optional

15.2 **Solar energy and life on Earth** (1 hour)

Tasks	**Skills**	**Recommendation**
Activity: Capturing the Sun's energy	Writing, interpreting, giving opinions	CAPS Suggested
Activity: What happens if the Sun stops shining?	Application, synthesis	Optional extension

15.3 **Stored solar energy** (4 hours)

Tasks	**Skills**	**Recommendation**
Activity: Going back in time	Recall, listening skills, comprehension	Optional
Activity: Coal formation flow diagram	Writing, ordering information, translating information	CAPS suggested
Activity: Forming coal	Translating information, comprehension	CAPS suggested
Activity: Explaining the flow of energy	Application, synthesis, comprehension	CAPS suggested
Investigation: The use of fossil fuels in my home	Gathering data, collecting data, reporting findings	CAPS Suggested (This can be used as a possible project)

Key questions

- Why do we have night and day?
- Why do we experience seasons on Earth?
- Do other planets have seasons too?
- How does the Sun influence life on Earth?

15.1 Solar energy and. the Earth's seasons

ACTIVITY: Day and night revision exercise LB page 258

1. To the East
2. To the West
3. At midday
4. Directly opposite your position on the other side of the globe
5. 24 hours (1 day)

ACTIVITY: Movement of a classroom Sun LB page 259

This is an active group activity for the whole class. Ensure that the balloon or ball you use can be seen clearly by all learners. The learners will be standing up and turning around on the spot so ensure that they have enough room to turn without hitting each other or falling over their chairs. If space is cramped it might be a good idea to stack all the chairs away for the activity, or else ten or so children can stand up at a time and move and after that they sit down and the next ten take a turn.

Ensure that the learners know the difference between turning in a clockwise and anti-clockwise direction before they complete the activity.

1. From right to left.
2. From left to right.
3. No, it was hanging in place.
4. The Sun appears to move from our perspective, but actually we are moving. The Earth is spinning on its axis and the Sun appears to move in the opposite direction from our spin.

ACTIVITY: Daytime and night-time LB page 260

This is an active group activity for the whole class. Ensure that the balloon or ball you use can be seen clearly by all learners. They will have to walk around the globe so ensure that there is space to do this. Ensure that the lamp or torch you use fully illuminates one half of the globe. If only a small portion of the globe is lit up, move the lamp further away and if necessary use a stronger light source.

ACTIVITY: Which way does the Earth rotate? LB page 261

This is a slightly more difficult activity. Ensure that the balloon or ball you use can be seen clearly by all learners. The learners will be standing up and turning around on the spot, ensure that they have enough room to turn without hitting each other or falling over their chairs. If space is cramped it might be a good idea to stack all the chairs away for the activity. Ensure that the learners know the difference between turning in a clockwise and anti-clockwise direction before they complete the activity.

It is the spinning of the Earth on its own axis. This axis is called the rotation axis.

This refers to the Earth travelling around the Sun in its orbit. One complete orbit is called a revolution.

A good way to introduce the concept of seasons is to have learners identify the traditional four seasons (spring, summer, autumn and winter). Ask them to describe the differences in weather and environment during the four seasons and ask them about the different activities they like to do in the different seasons (for example going to the beach in summer). You could then ask them roughly how long each of the seasons lasts and at what time of the year the different seasons occur. In a country as large as South Africa the climate varies considerably from place to place and while it may for example be spring-like in Pretoria, it could still be frosty in the Eastern Cape. Therefore, keep in mind that the four seasons (each lasting 3 months) have been defined mainly for temperate regions and the weather expected for "spring" (mild!) might not correspond exactly to the weather experienced in a given place in South Africa at a given time. Discussions in the chapter are therefore kept as general as possible focusing on average temperatures in summer and winter for the northern and southern hemispheres.

Before investigating what causes the seasons on Earth you could ask learners what they think causes the seasons and list all the answers on a blackboard, perhaps taking a class vote for each reason. After doing the activities listed in section 1.1 you should ask the learners to recast their votes. It is important that any misconceptions that learners may have regarding the cause of the seasons be addressed and some common misconceptions are explained in the teachers notes in section 1.1.

Radiation.

Learners will most probably have lots of different answers, accept all the answers and then carry out the activities in the chapter to investigate the true cause of the seasons.

ACTIVITY: Label the Earth LB page 263

If possible, bring some oranges to class and get learners to draw the different lines of latitude onto the oranges using a permanent marker and marking the North and South Pole and the Northern and Southern Hemisphere.

See Take Note: Insolation is not to be confused with insulation

ACTIVITY: What causes the seasons? Guesses! LB page 263

Two common misconceptions about the seasons to be aware of while going through this content with learners:

1. **Seasons are caused by the Earth being closer to the Sun in the summer and farther in the winter due to the Earth's oval orbit.**

   NO: In fact, the Earth's orbit around the Sun is elliptical but it is nearly a perfect circle; it is off by only 4%. Astronomers have calculated the resulting difference in incoming solar energy: it is only 7% which is very small and not sufficient to cause the variations in the temperatures associated with the seasons. If this change in distance were responsible for the seasons, then the Southern and Northern Hemispheres would experience summer and winter at the same time, which is not the case.

2. **The Earth's tilt brings the Earth significantly nearer to the Sun during the hotter times of the year.**

   NO: In fact, the tilt of the Earth is the cause of our seasons, but this tilt does not bring us significantly closer to the Sun. The distance from the Sun to the Earth is on average 149 000 000 km and any difference caused by the Earth's tilt is tiny (the change in distance is only about 0.003% of the distance between the Sun and the Earth). This is not sufficient to cause any differences in temperature.

ACTIVITY: The Earth's tilt LB page 266

This activity is designed to reinforce the idea that the Earth's axis always points in the same direction in space. The North Pole points towards the star Polaris (North Pole Star) and you can mention this to learners. Unfortunately, there is no southern equivalent of the North Pole Star.

1. ¼ of the orbit.
2. ¼ of the orbit.
3. Both represent 3 months.

ACTIVITY: Direct and indirect light LB page 267

Before starting this activity, explain what is meant by direct and indirect. The aim of this activity is to see how the energy from a torch is spread out when the light is shone directly and indirectly onto card. In this activity students will need to shine a torch onto black card. Learners will need to work in pairs so that one person can hold the torch and the other one can draw an outline of the beam of light.

This activity works best when the room is darkened, as it is easier to see the torch light. Some torches produce concentric rings rather than a smooth light distribution. If this is the case the learners should pick a given ring (say the outside one, or the one immediately inside this, whichever is easier to see) and stick to observing this ring in both cases. Learners should find that the direct light is more concentrated (spread over a smaller area) than indirect light.

1. Direct.
2. Indirect.
3. If the light is more concentrated, energy from the torch is more concentrated, and spread over a smaller area.
4. Direct. Because the energy from the light is spread over a smaller area, so each unit area receives more energy compared with the indirect case. As the brightness is proportional to the amount of energy received, so areas which receive more energy per unit area are brighter.

INVESTIGATION: Direct and indirect light and its effects on temperature LB page 267

The aim of this investigation is to demonstrate that direct light heats up an area more quickly than indirect light. It is assumed that this experiment will be a teacher led demonstration but with measurements taken by the learners, however, if you have enough equipment there is no reason why the learners cannot set up the experiment themselves. Strip thermometers are often used for taking children's temperatures and are available in most chemists. You can extend this activity if you wish by changing the angle at which the "indirect light" lamp points at the card in steps. Learners should find that shallower angles with respect to the surface produce lower temperature readings.

Ensure that the two lamps have bulbs of the same power installed in them. During the experiment the strip thermometers may become too hot. If this happens turn both the lamps off for about 5 minutes and let them cool down, then start the observation again.

Learner-dependent answer. Learners could state 'The direct light will heat the area more quickly.'

1. The distance of the lamp from the thermometer is kept constant. The power of the light bulbs used in the lamps is also kept constant. The amount of time that light is shone on each thermometer is also kept constant.

   These are called control variables.

2. The angle at which the light hits the card is changing, in the first case, A, the light is direct. In the second case, B, the light is indirect. This is the changing independent variable.
3. The temperature. This is the dependent variable.

The temperatures recorded are learner dependent. However, all learners should agree on the initial temperature of the thermometers. The thermometers should indicate the same initial temperature if they are calibrated correctly. The final temperature should be higher than the initial temperature, and the temperature of A should be higher than B. They should then work out the temperature difference by subtracting the initial temperature from the final temperature.

1. Direct light.
2. Indirect light.
3. Card A, this is because the light is shining directly onto it and so the energy is more concentrated.

Learner-dependent answer. Learners should clearly explain the reasoning behind their answers. Examples could include using more sensitive thermometers, repeating the observations and taking an average value for the temperatures.

Direct light heats the card more quickly as light is more concentrated and so more energy per unit area falls onto the card. This energy is what causes the heating and so if there is more energy per unit area falling on a surface then there will be more heating of that surface.

1. Summer because it is warmer.
2. Winter because it is cooler.

ACTIVITY: Looking at sunlight hitting the Earth LB page 270

The aim of this exercise is to introduce learners to the concept that sunlight hits the Earth at varying angles across the Earth's surface because it is curved. At the equator you can see that sunlight hits the Earth almost straight on, this is called direct light. Areas close to the equator are warm as the Sun's energy is concentrated in these regions. As the Earth is curved, not all of the Sun's rays hit it directly. Areas that are hit by indirect sunlight are cooler because the Sun's energy is spread out over a large area. The poles are always hit by indirect light which explains why it is cold at the North and South Poles.

In this example, the Southern Hemisphere is tilted towards the Sun. In the Northern Hemisphere most of the sunlight hits the surface of the Earth at a shallow slanted (oblique) angle relative to the Earth's surface, and so it receives more indirect light. The Southern Hemisphere receives lots of sunlight straight on (directly) and a little also hits at an oblique angle (indirectly) close to the South Pole. As the Southern Hemisphere receives more direct light it is summer there.

This exercise may prove a little harder for the learners as they have to visualise the angle at which the Sun's rays strike the Earth along a curved surface.

Encourage them to rotate the book around if needed so that the surface of the Earth is always horizontal.

1. More direct light.
2. The Southern Hemisphere receives more direct light as it is tilted towards the Sun.
3. The Northern Hemisphere receives more indirect light as it is tilted away from the Sun.
4. Because the equator receives more direct light where the solar energy is more concentrated and the poles receive only indirect light where solar energy is more spread out.
5. Summer.
6. Winter
7. The seasons would be reversed, it would be summer in the Northern Hemisphere and winter in the Southern Hemisphere.

Having discovered that the Earth is warmer close to the equator and cooler towards the poles you could start discussions related to this. For example, why is the world's population distributed the way it is? How long is the growing season for each region of the world? Tundra, Desert, Deciduous versus Coniferous versus Rain Forest. Why?

A nice arts and craft activity to reinforce the idea that the tilt of the Earth's rotation axis is responsible for the seasons is to have learners make a poster of the above figure, labelling the Earth and Sun, the equator, hemispheres, poles, tilt (towards, away, neither) and resulting seasons for each hemisphere at each position.

ACTIVITY: Earth's seasons summary LB page 272

1. At position 1, the Southern Hemisphere is tilted towards the Sun and experiences summer. This is called the summer solstice in the Southern Hemisphere and occurs around the date, 21 December. The Northern Hemisphere is tilted away from the Sun and experiences winter. This is called the winter solstice in the Northern Hemisphere.

2. At position 2, three months later, neither hemisphere is tilted more toward the Sun. Direct light only hits the Earth near the equator and indirect light hits nearly everywhere else. This is called an equinox. This causes mild temperatures in the north and south away from the equator.
3. Six months later, the Southern Hemisphere is tilted away from the Sun and experiences winter. This is called the winter solstice in the Southern Hemisphere and occurs around the date, 21 June. The Northern Hemisphere is tilted towards the Sun and experiences summer. This is called the summer solstice in the Northern Hemisphere.
4. Nine months later, either hemisphere is tilted more toward the Sun. Direct light only hits the Earth near the equator and indirect light hits nearly everywhere else. This causes mild temperatures in the north and south away from the equator.
5. The Earth is now back to its starting point again, having completed one revolution of the Sun in twelve months
6. Learner-dependent answer

It is important that we relate the learning in class to learners' everyday lives so that it is applicable to them. You can have a class discussion on this topic, but learners must also write down their own thoughts. Start off by asking learners what do they think we can learn from learning about the seasons?

Some of the benefits of learning about the seasons relate to indigenous knowledge, such as knowing when to plant crops, when to harvest and when to store food for the winter months. Before people had calendars, they used the seasons to mark the passage of time and know when a year had gone by and the cycle repeated again.

The following questions are challenging and can be used to test the most able learners and extend their thinking.

You can discuss this with your class. The Sun's path across the sky would be the same all year round and there would no longer be seasons as we know them. It would still be warm at the equator and cold at the poles however. The biggest impact on temperatures would be at the poles. Presently they have dark winters with extremely low temperatures followed by warmer temperatures and constant light in the summer. If there were no tilt, the polar regions would have much more uniform temperatures all year round and the Sun would always be low on the horizon. Across the Earth it would be like it is in the middle of autumn or spring all year.

There would still be some slight changes during the year. This is because the Earth-Sun distance varies during the year as the Earth's orbit around the Sun is not a perfect circle (it is slightly elliptical). Currently, the Earth is closest to the Sun in January and furthest away in July. With no tilt, this change in Earth-Sun distance during the year would produce a slight impact on the weather pattern. It must be emphasised that the effect would be tiny as the Earth-Sun distance does not vary significantly different during the year (147 million km in January 2013 compared to 152 million km in July 2013).

This is because it takes time for the land and sea to heat up or cool down. This is also explains why the seasons change gradually.

The video showing a year of the sky is very interesting. Each panel shows one day so there are 360 movie panels playing at once to show the sky over almost a whole year, as recorded in San Francisco. 28 July is shown in the upper left and January 1 is about half way down. The camera recorded an image every 10 seconds from sunrise to sunset. You can see the time going by in the bottom right. This video is useful to show learners how although each day lasts 24 hours, the amount of sunlight changes depending on the season. Although this video is for the Northern Hemisphere and we are in the Southern Hemisphere, it is still very interesting and can be used to demonstrate the difference in daylight hours very eloquently. You can ask the learners why they think the bottom videos (and soon the top videos) are the first to light. This is because it is dawn and the Sun rises earlier in the summer months of June, July and August in the Northern Hemisphere, so these panels light up earlier than the others for the winter months. The initial darkness in the middle depicts the delayed dawn and fewer daylight hours of winter.

This section is an extension which is not required by CAPS, but offers an opportunity to extend your learner's thinking, if you feel you have time in class and you need to assess the capabilities of your learners. Alternatively, learners can read it themselves in their own time.

15.2 Solar energy .and life on Earth

This section builds on what was done in Grades 4-6 on energy and photosynthesis to expand learners' understanding of these concepts and include the concept that the Sun's energy can be captured through photosynthesis and stored as carbohydrates to sustain life on Earth.

Earlier in Grade 7, in the Energy and Change section, the concept of fossil fuels was discussed with a focus on renewable versus non-renewable energy sources. This is extended here by looking into how fossil fuels were formed and how they captured the Sun's energy for use millions of years later. Learners need to realise how crucially important the Sun is for life on Earth.

In earlier grades energy transfer from producers to consumers, in food chains and food webs, were discussed. Here we look at capturing the energy from its source, the Sun, and storing it for later use. The overarching concept that energy cannot be created or destroyed, it can only be transferred from one form to another, should come through strongly in this section and the next one. **Misconception: The carbon in plants comes from the soil.**

This could be used as an introduction to the section. Ask learners what wood is made of (mainly carbon) and where the carbon comes from that a tree is made of. Learners might say the soil (which is incorrect). This could then lead into a discussion of photosynthesis (revision) and how energy is captured by plants. Learners could be lead to discover that plants take up atmospheric carbon from the carbon dioxide air and not from the soil – wood is composed mainly of carbon atoms which come from atmospheric carbon dioxide. This is how plants capture carbon and store it so that human and animals are able to use it. The take-up of carbon by plants is also important as it controls the amount of greenhouse gases in the atmosphere (CO_2 is a problematic greenhouse gas when in excess). When plants die and decompose to eventually form coal, the carbon remains in the fossil fuel which we harness later on. The same applies for oil and natural gas.

ACTIVITY: Capturing the Sun's energy LB page 276

Learner-dependent answer. It is not important whether the learner agrees with the statement or not, but rather what they write in their explanation. A possible explanation could be:

The Sun's energy is captured through a process called photosynthesis. Wheat plants use the energy to make carbohydrates which they store in their wheat kernels. The wheat kernels are ground to make flour for bread. The Sun's energy is therefore captured in the carbohydrates found in bread, so when the boy eats the bread, the energy from the carbohydrates is released.

ACTIVITY: What would happen if the Sun's rays were blocked from reaching Earth?

LB page 277

For this activity let the learners first discuss what they think would happen in pairs. Then give them time to write their answers down. Afterwards a class discussion could follow. Another suggestion is to have the learner discussion at the end of a lesson and then give them the exercise for homework. The class discussion could follow in the next lesson when the homework is checked. The answers to this activity will be learner-dependent, however, some suggestions are provided. The purpose of the activity is to generate discussion and not to have right and wrong answers. The suggestions provided here are based on what scientists believe happened after the major volcanic eruptions (for example, Mount Toba), in the past.

Something else to discuss, which links back to what learners covered briefly in Matter and Materials, is that the atmospheric dust and ash forms poisonous acid rain, which contaminates rivers, lakes and oceans, causing many plants and animals to die.

What do you think would happen?	
On the first day	It would be overcast as the ash and dust would block out the Sun's rays. It would be much cooler.
One week later	It would still be dark, where people have electricity they would have light. Fossil fuels will provide heat and light. Animals might die because of the cold. Plants would be affected as they would not be able to photosynthesise which would start to affect the quality of food higher up the food chain.
One month later	Most food crops will fail and plants that manage to fruit and seed will have lower abundance. All stored foods will be used until they run out. Animals will die when there are no more plants available. Weather patterns will have changed. Rainfall will change drastically and will be hugely reduced.
One year later	Many animal and plant species in the land and sea would have decreased in number, severely so in the case of animals or plants reliant on heat and rainfall for reproducing. People and animals will be struggling to find food and will have to expand their diet to include foods not usually eaten. There will be great competition for food at levels in the food chain where similar food types are eaten.

15.3 Stored solar energy

ACTIVITY: Going back in time LB page 278

This is an optional activity. This video is only 9 minutes long and gives a useful link between the Sun's energy and how it was captured long ago. It gives the conditions for the formation of fossil fuels and explains how coal was formed. Play this video to your learners and let them answer the questions afterwards. If video facilities are not available in your classroom, try to watch this video yourself and then use it to talk to the learners about the formation of fossil fuels. Alternatively, the text provides the information as well and can be used to facilitate a discussion before the activity is done.

1. A source of fuel/energy made from the fossilised remains of ancient plants and sea animals.
2. Non-renewable, it cannot be replaced once used up.
3. Saturated environment (lots of water), anaerobic conditions (lack of oxygen), increased/high pressure, increased/high temperature.
4. Swamps created areas of saturation and lack of oxygen (anaerobic conditions). As the plants died and layers upon layers were formed, the pressure on the lower layers increased. As the layers moved deeper in the Earth, they were subjected to increasingly high temperatures (it gets hotter the further down in the Earth's crust that you go).
5. Fossil fuels are important as they form a vital part of the economies and lifestyles of all people on Earth. They have stored energy which we now use to drive many machines, vehicles and processes in our lives.
6. Fossil fuels need millions of years to form.

ACTIVITY: Coal formation flow diagram LB page 279

The purpose of this activity is to practise the skill of identifying the most important facts from text and translating the information into a flow diagram. Learners also need to be able to extract the order of events from a paragraph.

- Fernlike plants lived on Earth millions of years ago
- Plants captured the Sun's energy through photosynthesis Earth became wetter and swamps formed
- Plants died forming thick layers of peat Water washed in silt and sand
- More plants grew and died More layers formed
- Layers were compressed and heated, squeezing out more and more moisture Peat turned into lignite
- Lignite turned into bituminous coal Bituminous coal turned into anthracite coal
- We call the separated components fractions, and the process, fractional distillation.

ACTIVITY: Forming coal LB page 281

The purpose of this activity is to support learners in making sense of information. Here they need to put information in order by applying what they know about the process of coal formation. If there are learners struggling to find the correct order, guide them by telling them to look at number of layers of coal formed. The learners should use the pictures to guide their discussion in the paragraph.

The correct order is: 4, 1, 3, 2

Millions of years ago ferns and trees grew in swamps. As they died, they formed thick layers of vegetation in the swamps. Rain and rivers washed in sand and soil, which covered the dead plant material. More plants grew, died and formed layers of dead plant material called peat. Over millions of years the peat layers got buried deeper within the Earth's crust, subjecting the layers to high temperatures and pressure. Over time, the peat turned into lignite. High temperatures and pressure squeezed and squeezed more water from the lignite and layers of bituminous coal and later anthracite was formed.

The video resource on the formation of fossil fuels from the activity done earlier in this section (bit.ly/1h8ncSi) can also be used here to help learners by providing them with a visual picture of how coal was formed. As an extension of this activity, learners could be asked to make up their own drawings for the formation of oil or gas.

The energy is stored in the form of potential energy in fossil fuels

ACTIVITY: Explaining the flow of energy LB page 282

This activity can be used to link what was done in the previous term on energy transfers within a system, with the content from this term. This will also give the learners the opportunity to revise what was done earlier in the year.

1. The energy from the Sun (or solar energy) was captured through the process of photosynthesis by sea plants. The marine animals obtained energy by eating the plants. Millions of years ago the sea animals and plants died in the oceans and were deposited on the ocean floor. They were covered with sand and silt and formed layers and layers of dead matter. Over time, and through the working of temperature and pressure, the remains were changed into crude oil and natural gas. Crude oil was extracted from the ground by mining and refined to make petrol, which is then used to fuel cars.
2. The Sun's radiant energy is transferred to chemical potential energy in the marine organisms and then stored within the oil. The potential energy in the oil/petrol is transferred to kinetic energy when the car moves.
3. We use petrol for transport, for example, to transport food from farms to cities (or any other link between transport and food can be supplied). Any appropriate answer of how we use petrol to sustain life can also be accepted.
4. Possible answer could be: The Sun is the source of solar energy. Plants capture the energy through photosynthesis. Ancient plants formed coal which stored the energy from the Sun. When the coal is burned, the energy which was stored millions of years ago, is released. This energy can be used for human activities, for example cooking. In this way the Sun's energy was transferred through plants and coal to be released from the coal by burning.

1. How did people react immediately, one year later, and 40 years after all the oil had disappeared?
2. How would this affect you?
3. How would this affect South Africa? How is South Africa different from the United States of America?

4. How would you and your family survive?
5. What jobs would be important in a world without oil?
6. Do you think countries should grow crops for fuel or food?
7. What is the effect on the animal populations?
8. What effect would this have on disease and combating diseases in hospitals?
9. How important is fuel for life on Earth?

l What would the effect be on recycling? Do you think we should recycle? What should we recycle and why?

INVESTIGATION: The use of fossil fuels in your home LB page 283

Learners should not focus only on the use of fossil fuels as an energy source, but they should also look at the many other ways that we use fossil fuels in our daily lives, such as our use and reliance on plastics, various chemicals, lubricating substances, etc. This has an impact when talking about our reliance on fossil fuels.

Provide some guidelines on the format of the reporting required. You can decide whether it must be a written report, a project to complete over the course of this chapter or term, a poster, an oral presentation, or a combination. You can use the various Assessment Rubrics at the back of your Teacher's Guide to assess learners' reports, projects or posters.

If time permits, a general class feedback discussion could follow when the learners hand in their reports. This would close the chapter reinforcing our responsibility to use fossil fuels wisely.

Discuss the formulation of an investigative question in class. Examples are: How much electricity does my household use in a month? How much petrol does my household use in a month? (In this case, public transport should also be included.) What other products do we use at home that are derived from fossil fuels? If learners choose to use electricity as a measure of the fossil fuel use, then they need to clearly state how this is related to fossil fuels, for example the burning of coal to generate electricity.

Below are some exemplar tables. These are not complete and should only be used to help learners think about what information they need. It might be necessary to discuss this in class before learners start working on it on their own.

Appliance	**Power (Watts)**	**Time used**	**Consumption (kWh)**	**Price per unit**
Geyser				
Stove				
Kettle				
Light bulbs				
etc.				

Mode of transport	**Distance**	**Fuel consumption***	**Litres of petrol used**	**Price per litre of petrol**
Car				
Bus				
Taxi				

* Take note that the average fuel consumption can be calculated as litres per 100 km. You can also then discuss with learners that the more you accelerate, the more fuel is used.

Household product	Fossil fuel source	Method of manufacture

Learners will need about a week to plan this investigation and gather the information. The activity can be handed out in the beginning of the section to allow enough time for learners to complete this investigation.

Revision

1. We have day and night because the Earth rotates on its axis. The side of the Earth facing the Sun is lit up it is daytime for this side. The side not facing the Sun is dark. It is night time for this side. Because the Earth is continually rotating each point on the Earth experiences successive daytime and night-time.
2. The Earth is spinning on its axis west to east (anti-clockwise). The Sun does not move, but it is rather due to the Earth's rotation.
3. Rotation is when an object spins around on its own axis. Revolution is when an object moves around (orbits/revolves) another object, such as the planets around the Sun.
4. 24 hours (actually 23 hours and 56 minutes!)
5. 365 ¼
6. Because of the extra ¼ days, which every 4 years adds up to a whole day.
7. It provides radiant energy to the Earth in the form of heat and light.
8. As the equator is always hit by direct rays from the Sun it is always warm as the solar energy is spread over a small surface area (intense). Areas that are hit by indirect light are cooler because the Sun's energy is spread out over a large area. The poles are always hit by indirect rays which explains why it is cold at the North and South Poles.
9. The seasons are caused by the tilt of the Earth's rotation axis relative to the Earth's orbital plane as it travels around the Sun. If the Northern Hemisphere is tilted towards the Sun at a particular point during the Earth's orbit, it receives more direct sunlight. In this case the solar energy is spread over a smaller area, is more intense and thus temperatures are warmer and it is summer. Meanwhile the Southern Hemisphere is tilted away from the Sun and receives indirect sunlight. In this case the solar energy is spread out over a larger area, it is less intense and thus temperatures are lower and it is winter in this hemisphere. Because the Earth's axis always tilts in the same direction in space, six months later the opposite hemisphere is tilted towards the Sun and the seasons are reversed in the two hemispheres.
10. If the change in distance were responsible for the seasons, then the Southern and Northern Hemispheres would experience summer and winter at the same time, which is not the case. The Earth's orbit around the Sun is elliptical but it is nearly a perfect circle; it is off by only 4% and the resulting difference in incoming solar radiation is only 7% which is very small and not sufficient to cause the variations in the temperatures associated with the seasons.
11. Crude oil was formed millions of years ago from the remains of sea animals and plants through the action of high temperature and pressure.
12. Millions of years ago interior areas of South Africa used to be a large inland lake which became a swamp.

13.

	When was it formed?	**What was it formed from?**	**What conditions were need for its formation?**	**Does South Africa have this natural resource?**	**Renewable or non-renewable resource?**
Coal	Millions of years ago	Remains of dead plants	High temperature and pressure	Yes	Non-renewable
Oil	Millions of years ago	Remains of dead sea animals	High temperature and pressures	No	Non-renewable
Natural gas	Millions of years ago	Remains of dead sea animals	High temperature and pressures	Yes	Non-renewable

14. Millions of years ago ancient plants used the Sun's energy, carbon dioxide and water to produce energy-rich glucose through photosynthesis. The glucose was stored in the plants. As the plants died their energy was transferred to the coal, natural gas or crude oil that was formed.
15. Learners should draw a flow diagram from the Sun to sea plants and sea creatures to natural gas (drawing can be an underground gas chamber) to a gas cooker showing the flame. Labels that should be included are: Sun (solar energy); Sea plants (capture the Sun's energy through photosynthesis); natural gas (formed over millions of years, stores the Sun's energy); gas cooker (releases the energy when the gas is burned).

16 Relationship of the Moon to the Earth

Chapter overview

2 weeks

In Gr. 4 learners covered the basic facts about the Moon: its lack of air and water, size relative to the Earth and its position with respect to the Sun. They also observed the Moon's phases. In Gr. 6 learners learnt about the Moon's motion in space: it revolves around the Earth while rotating on its spin axis. In this chapter, learners will develop an understanding of how the phases of the Moon are related to the relative positions of the Earth, Moon and Sun. They will also be introduced to the concept of gravity, (covered in more detail in Gr. 9: Energy and Change strand), and the influence of the Moon's and Sun's gravitational pulls on the Earth's oceans which result in tides.

The main aims of this chapter are to ensure that learners understand the following:

- The Moon is smaller than the Earth and orbits around the Earth in 27.3 days as the Earth revolves around the Sun.
- The Moon is held in orbit around the Earth by the force of gravity. In turn the Earth and all the other planets in the solar system are held in orbit around the Sun by the force of gravity.
- All masses experience the force of gravity, and the size of the force exerted is dependent upon the mass of the objects and their distance from each other.
- The combined gravitational pull of the Moon and the Sun on the Earth's oceans cause the ocean tides.

16.1 Relative positions (1.5 hours)

Tasks	Skills	Recommendation
Activity: Moon revision quiz	Recalling, stating	Optional revision
Activity: Observe the Moon	Observing	CAPS Suggested
Activity: Total Solar Eclipse	Observing, analysing	CAPS Suggested

Note: There are three additional activities included only in the Teacher's Guide in this section. They are:

- Activity: Google the Moon (Replacement activity for "Observe the Moon" if computers and the Internet are available.)
- Activity: Hands-on Moon Phases (Optional extension activity, revision of Gr. 6 material.)
- Activity: Month Long Moon Observation (Optional extension activity. This is a repeat of an activity done in Gr. 6. This reminds learners of the Moon's phases but does not yet link them to the relative positions of the Sun/Earth/Moon.)

16.2 Gravity (2 hours)

Tasks	Skills	Recommendation
Activity: Demonstrating the Moon's orbit around the Earth	Investigating, observing	CAPS suggested
Activity: How heavy would you be on other planets?	Calculating, measuring	CAPS Suggested

Note: There is an additional investigation included only in the Teacher's Guide in this section. It is:

- Investigation: Dropping objects (Optional extension activity)

16.3 Tides (2.5 hours)

Tasks	Skills	Recommendation
Activity: Reading a tide chart	Reading graphs	CAPS Suggested
Activity: Dance of the tides	Working in groups, investigating, analysing	CAPS Suggested
Activity: Spring and neap tides	Observing, analysing	CAPS suggested
Activity: The effect of tides on shoreline ecosystems	Researching, analysing, writing	CAPS suggested
Activity: How good a fisherman are you?	Analysing data	CAPS Suggested

Note: There are two additional activities included only in the Teacher's Guide in this section. They are:

- Activity: Tides poster (Optional, fun activity)
- Activity: Make a tide wheel (Optional activity)

Key questions

- How long does it take for the Moon to orbit the Earth?
- What keeps the Moon in orbit around the Earth?
- What causes tides on Earth?

16.1 Relative positions

ACTIVITY: Moon revision quiz LB page 287

This is an activity to review material covered in Grades 4 and 6. It is a short, optional activity.

ACTIVITY: Observe the Moon! LB page 288

In this activity learners look in detail at the surface features of the Moon. The photographs show images of both the near side and far side of the Moon which look quite different and learners should be encouraged to compare the two.

1. No, the surface is all solid rock and lunar soil (regolith).
2. Craters.
3. The near side has more maria.

ACTIVITY: Total solar eclipse LB page 290

In this activity, the idea that the apparent size of an object depends upon its distance from an observer is reinforced. Learners will find that although the Sun is much larger than the Moon, it appears about the same size in the sky because it is much more distant than the Moon.

1. The Sun is larger.
2. The Sun is further away.
3. They are almost the same.
4. Although the Sun is much larger than the Moon, it is much more distant. As objects appear to look smaller and smaller the further away they are, the Sun appears smaller than it is in reality. The Moon also appears smaller than it is in reality, however it is much closer to the Earth than the Sun is and so its apparent size isn't reduced as much as the Sun's is. Just by chance, the Sun and moon are currently at distances where they have the same angular size viewed from the Earth's surface.

A note about lunar phases
Learners will most likely be familiar with the change in the Moon's appearance over the course of a month, the lunar phases. Each lunar phase cycle from New Moon to New Moon takes 29.5 days, which is slightly longer than the Moon takes to complete one revolution around the Earth (27.3 days). This is because during the 27.3 days it takes for the Moon to revolve around the Earth, the Earth is moving along in its orbit. In order for the Moon to appear at the same phase as viewed by an observer on Earth it needs to travel slightly further than 360 degrees around the Earth and in order for it to be aligned such that there is a New Moon it takes about an extra 2 days. bit.ly/16C8LQB shows a nice animation demonstrating the difference between the orbital period of the Moon which defines the sidereal month (27.3 days) and the lunar phase cycle which defines the synodic month (29.5 days).

Observers on Earth see the same phase where ever they are positioned on Earth. However, the phases (apart from New Moon and Full Moon) look different to an observer in the Northern and Southern hemispheres. We in the Southern Hemisphere view the Moon "upside down". This is important to note because 99% of all textbooks and online references include the Northern Hemisphere view of the phases and this is not what learners will see when they view the Moon for themselves. An awareness of this is crucial to reduce learner confusion when looking online and in generic textbooks.

The activity below is an optional extension activity which links the relative positions of the Earth, Sun and Moon to the phases of the Moon observed. **Activity: Hands-on Moon Phases**

As the Moon revolves around the Earth, the side facing the Sun is always illuminated, just as Earth's daylight side is illuminated by the Sun. However, from the Earth's surface we do not see a half Moon lit up all the time. Instead, we see a change in the amount of the Moon which is lit up by the Sun.

In this activity learners will learn that the relative position of the Earth, Moon and Sun determine what phase of the Moon is observed. Learners will use a lamp to represent the Sun. The learners will represent the Earth and a styrofoam ball stuck on a pencil will represent the Moon. If you cannot get hold of a styrofoam ball, you can use an orange instead. They will vary the location of the Moon in its orbit around the Earth and observe the phase of the Moon. A dark room is needed for this activity. If necessary, darken the classroom with bin bags or curtains. In the centre of the room place an unshaded lamp to represent the Sun.

Ideally learners should work in pairs for this activity, so that one learner can draw their observations while the other learner holds the ball in place. Ensure that learners hold the balls slightly above their heads so that they do not cast shadows over the ball. In this exercise we make the assumption that the Earth remains in the same spot while the Moon orbits around the Earth.

Before starting the activity, explain to learners the names of the Moon phases and draw them on the blackboard: New Moon (entirely dark), Full Moon (entirely lit), Crescent Moon (mostly dark), Gibbous Moon (mostly lit) and First Quarter Moon (left half lit) and Third Quarter Moon (right half lit). [Note that the first and third quarter appearances listed here are for the Southern Hemisphere only.]

Materials:
- pencil (2 per pair)
- one lamp that can shine in all directions (i.e., a lamp base with a bare 100 to 150 Watt bulb and no lampshade)
- styrofoam balls (1 per pair)
- black plastic bags (and tape) or curtains to darken the classroom
- sheet of paper (1 per pair)

Instructions:
1. You will work in pairs for this activity.
2. Place a lamp representing the Sun in the centre of the classroom. Even for a large classroom, you should only use one bright lamp placed in the middle of the classroom otherwise you will have shadowing effects that may ruin the results.
3. Darken the room if needed by taping dark plastic bags to the windows or closing the curtains.
4. Stick one of the pencils into your styrofoam ball so that you can hold the ball up by the pencil end. This ball represents the Moon.
5. All learners must stand in a circle around the central light, with your partner next to you in the circle.
6. Directly face the light in front of you. One of you should hold the ball at arms length, slightly above your head, and the other should hold the pencil and paper. The person holding the ball represents the Earth.
7. If you are holding the ball, move the ball from left to right (keeping still) and observe how much of it is lit by the light as you move it around. Now let your partner do the same.
8. Look at the different phases of the Moon drawn on the blackboard by your teacher (New Moon, Full Moon, First quarter, Third quarter).
9. One of you should now hold the ball and position it until from your point of view it looks completely in shadow. This represents New Moon.
10. The member of the pair not holding the ball should now draw the relative positions of the Sun, Moon and Earth, and write down the Moon phase corresponding to these positions.
11. Swap the person holding the ball and the pen/paper, and position the ball such that it is fully lit and looks like a Full Moon. The member of the pair not holding the ball should now write down the relative positions of the Sun, Moon and Earth.
12. Repeat this for all the phases listed in 8.
13. Look at the crescent Moon on the blackboard. Find out what positions you can place the ball in to see it lit up like a crescent (less than half lit).

14. Swap positions again and this time find out what positions you can place the ball in to see it lit up in a gibbous phase (more than half lit).

Questions

1. In what position do you need to place the Moon in order to see a New Moon?
   The Moon needs to be placed directly in between the Sun and the Earth.
2. In what position do you need to place the Moon in order to see a full Moon?
   The ball needs to be place d directly it's ae from the Sun, with the Earth in between the two.
3. In what positions can you place the Moon in order to see a crescent?
   Any position as far as 90 degrees either side of the N ew Moon position (to the left or right).

An optional activity that learners may complete in their own time is a month-long Moon observation. They may have already completed this activity in Gr. 6, but it is added here in case you wish to conduct a Moon observation as an additional activity.

ACTIVITY: Demonstrating the Moon's orbit around the Earth LB page 293

In this activity learners will demonstrate the orbit of the Moon around the Earth using a ball tied to a rope swung around their heads. They will demonstrate what would happen to the Moon if there were no gravity by letting go of the rope.

Safety tip: Do this activity outside or in the school hall if possible so that learners can spread out. This will help them avoid hitting each other when the balls are released. If this is not possible take it in turns to do this demonstration or have only a few learners do this demonstration so that no one is hit by a flying ball!

1. The ball moves around in a complete circle.
2. The gravitational attraction between the Earth and the Moon.
3. If the rope is released the ball flies off in the direction it was travelling in just as the rope was released.
4. This represents that the gravity keeps the Moon in it's path around the Earth. Without it, the Moon would move away from its path.

The content here on weight is not specified for Gr. 7 level in CAPS, and only appears in Gr. 9 in CAPS. However, as learners confuse mass and weight very easily, this has been included as enrichment material at this level. You can decide whether you want to cover this content with your learners or not. It is not to be assessed in Gr. 7.

1. 50 kg, as the mass of an object is independent of position.
2. 600 N (60 x 10)
3. 100 N (60 x 10/6)
4. She would feel lighter on the Moon, even though her mass is the same on the Moon.

ACTIVITY: How much would you weigh on other planets? LB page 295

In this activity, learners calculate what their weight would be on the seven other planets in our solar system. Although their mass remains the same, they will "feel" lighter or heavier because of the differences in the gravitational field strength on the surfaces of the other planets. You should emphasise that their mass always remains the same, but only their weight varies. If you do not have access to weighing scales, you can either ask learners to estimate their mass or provide them with an example number.

Sample answers for a 50kg learner

Sample answers for a 50kg learner			
Planet	**Your mass (kilograms)**	**Strength of gravity relative to Earth**	**Your weight (Newtons)**
Earth	50	1	500
Mercury	50	0.378	189
Venus	50	0.907	453.5
Mars	50	0.377	188.5
Jupiter	50	2.36	1180
Saturn	50	0.916	458
Uranus	50	0.889	444.5
Neptune	50	1.12	560

1. You would feel heavier on Jupiter and Neptune.
2. You would feel lighter on Mercury, Venus, Mars, Saturn and Uranus.

A note on falling objects

A useful way to demonstrate the Earth's gravity is to look at falling objects. An optional extension activity is included below in which learners drop a variety of objects. You can take a vote from the class to see whether learners think that an apple or bag of sugar would hit the ground first. (Answer: they would hit the ground at the same time as long as air resistance is negligible.) It is very likely that learners will have the preconception that heavier items fall faster. It is not important at the moment that the learners answers are correct and do not try to lead them to the correct answer. They will hopefully discover it for themselves in the following experiment.

ACTIVITY: Reading a tide chart LB page 298

This activity provides a chart showing tidal data for one week in Cape Town. This activity gives learners the opportunity to read and interpret data from the chart.

1. Two
2. High tide
3. Two
4. Low tide
5. 0.7 m
6. Friday 3 May at 10.17 am
7. 1.35 m

8. a) At 11:47am
   b) At 6:05pm

Ask learners to give you their answer as to what causes the tides. You can write down all the answers. At this point it does not matter if the learners do not know what causes the tides, they will find out in the "Dance with the tides" activity. Once they have completed the activity, ask the learners again to see if they have changed their minds. At this point they should be aware that the gravitational pulls of the Moon and the Sun cause the tides.

ACTIVITY: Dance of the tides LB page 300

This activity requires learners to work in groups of six. One learner will represent the Earth, four learners will represent the Earth's oceans and one learner will represent the Moon. You could ask learners to wear coloured T-shirts (green for the Earth, blue for the oceans, grey for the Moon) or to pin drawings or photos of the object they are representing to their school shirts with safety pins to make it clear what they are representing.

In this activity learners will model how the Moon's gravitational pull causes tides on Earth. Be sure to explain to them that the scale of the model is not correct, for example the Moon and Earth sizes are not correct in relation to each other. You can ask learners how they think the Moon can influence the Earth. Explain that moons and planets can influence each other's spins and tilts from a distance via their gravitational pull. All objects that have mass have their own gravity, but only large objects, like planets, have enough gravity to influence each other from very large distances. Explain that you are going to model what effect the Moon's gravitational pull has on the Earth. Remember that the gravitational force exerted by an object diminishes as you go further from it.

Therefore, objects that are closer to the Moon experience a greater gravitational pull towards the Moon than objects that are further away.

Explain that the water from the oceans has "piled up" under the Moon and directly opposite the Moon. The two children standing beside "Earth" represent parts of the ocean where there is less water. You could ask the learners the following questions:

- Where are the oceans at the highest levels?
  At the oceans nearest and farthest from the "Moon".
- Are the coastal areas next to those "oceans" seeing a high or low tide?
  High.
- How many sides of the Earth experience high tide at the same time?
  Two (in general).
- Which parts of the Earth are experiencing high tide right now?
  The part that is under the piled-up oceans.
- Where is low tide?
  Near the oceans closest to Earth on either side.

The formation of the second ocean bulge is simplified in this model and ignores subtle motions of the Earth.

Ensure that learners can still find the sides of low and high tides even though they are less extreme.

1. Two
2. Under the Moon and on the side of the Earth directly opposite the Moon.
3. They remain under the Moon and directly opposite the Moon.
4. The high and low tide are on different parts of the surface of Earth now.
5. The Sun.
6. Yes, but the difference between high and low tide would not be as extreme. Since the Sun is so far away, the Sun's gravitational pull would give the tides only a third of their height.

In this activity we have ignored the motion of the Moon revolving around the Earth. The time of high tide changes each day because the Moon is moving around the Earth. If we had no Moon, the tide due to the Sun alone would occur at essentially the same time every day. This activity also ignores the friction between the water and solid Earth as it spins, which causes the tidal bulges (piled up ocean bulges) to lie ahead of the Earth-Moon line in the direction of the Earth's rotation.

The actual times of low and high tides at a particular place on Earth are influenced not only by the Earth's spin but also by the Moon's motion around the Earth in its orbit. As the Earth spins, the Moon also travels around the Earth. The Moon rises about an hour later each day, and high (and low) tides also occur roughly an hour later each day.

ACTIVITY: Spring and neap tides LB page 302

1. New and Full Moon.
2. First and third quarter.
3. New and full Moon.

Some additional activities are explained below.

ACTIVITY: The effects of tides on shoreline ecosystems LB page 305

This is an activity in which learners investigate what adaptions different shoreline animals have made in order to survive in the intertidal zone and write a summary of their findings. You can ask learners to look online for images and examples if they have access to the Internet. Alternatively they can consult the school or local library or you can provide them with specific examples. Some images have been provided here as a starting point. This can also be used as a research task.

Learners can use any of the examples given in this activity or those that they have read about. Answers could include animals that avoid drying out by burrowing, or by closing their shells or plants that are covered in mucus. Answers could also include animals and plants that avoid being washed away by having strong "feet" that attach tightly to rocks.

Here is some extra information about the different animals found in different areas in the intertidal zone: