Natural Science

Grade 8

Teacher's Guide

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Contents

1 Photosynthesis and respiration

Chapter overview

2 weeks

This chapter provides learners with an introduction to, and revision of, the concepts in photosynthesis and respiration in preparation for a study of the ecosystem. Learners have already looked at photosynthesis and respiration in previous grades. They know that respiration is one of the seven life processes of living things. They have also been introduced to photosynthesis in the context of green plants and food chains in Gr. 5 and 6. The emphasis in this chapter is on the use of energy and on how radiant (light) energy is transferred to chemical potential energy and later released during respiration. This concept is developed within the scope of the CAPS prescriptions and will be used as a scaffold to explain the transfer of energy in the ecosystem in the subsequent chapter. As an introduction, teachers may want to watch or show the following video to the class: [1] bit.ly/17z96Vc

These tables and how to use them are explained in the Teachers' 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 **Photosynthesis** (3.5 hours)

Tasks	**Skills**	**Recommendation**
Activity: The seven life processes	Remembering, describing, writing	Optional (Revision)
Activity: Requirements and products of photosynthesis	Summarising, describing, writing	CAPS suggested
Investigation: Which leaves photosynthesise? (Test for the presence of starch)	Hypothesising, investigating, observing, measuring, analysing, writing, group work	CAPS suggested
Investigation: Why do bananas become sweeter as they ripen?	Hypothesising, investigating, observing, measuring, recording, analysing, writing, group work	Optional

1.2 **Respiration** (2.5 hours)

Tasks	**Skills**	**Recommendation**
Activity: Does our breath contain carbon dioxide? (Test for the presence of carbon dioxide using limewater)	Investigating, observing, measuring, recording, analysing, writing, group work	CAPS suggested
Activity: Requirements and products of respiration	Describing, writing	CAPS suggested

Key questions

- What drives life on Earth and in ecosystems?
- How do green plants photosynthesise when no other organism can make its own food?
- What do plants do with the food that they produce?
- Why do we need to eat food? What does it provide us with?
- We know respiration is one of the seven life processes, but what happens during respiration in organisms?

1.1 Photosynthesis

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, this is one website to start looking at: bit.ly/16zEuUf

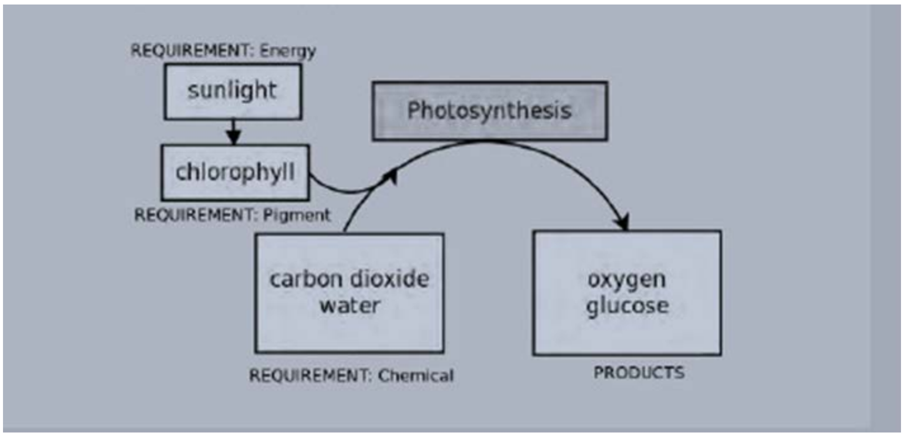
ACTIVITY: **The seven life processes (LB page 2)**

The seven life processes are: movement (moving), reproduction (reproducing), sense the environment (sensing), growth (growing), respiration, excretion (excreting), nutrition (feeding).

Ask your learners this as a revision of what they did in previous grades Some objects with kinetic energy are a moving car, a bouncing ball, a leaf blowing, a fan blowing, etc. Some objects with potential energy are a book on the table (it has gravitational potential energy as it can fall down to the ground), a bouncing ball when it is at the top of its bounce as it can also fall back down, a batteries, fossil fuels have and food have potential energy.

ACTIVITY: **Requirements and products of photosynthesis (LB page 4)**

The learner's diagram should look as follows:



Discuss this with your learners. The glucose is produced continuously during the day when the Sun is out and is not all used at once by the plant. The plant cannot have large amounts of glucose accumulating as this affects the water potential within the leaves, and so some is converted to starch to be stored until it is needed.

Discuss this as a class in the lead up to the investigation

Learners could suggest that they taste the substance to see if it is a starch or glucose. It is important that learners be made aware that we do not taste-test **unknown** substances due to the potential for poisoning. This specific point was included to allow teachers to reinforce this rule with learners and that we only ever do a taste test if we are sure that a substance is in fact edible.

Although this can be used as a fairly simple, physical test, it has several problems. For example, the temperature of the water will affect the rate at which it dissolves, as will the quantities used, etc. In discussing these points facilitate the discussion and lead learners to conclude it is not a very accurate test, although a simple physical one that can give a fairly good indication. This is a good opportunity to discuss kinetic energy and temperature of a solution

This is included as an introduction to the subsequent investigation. Teachers should let learners explore the possible ways in which to use this to test for starch.

Please emphasise to learners that they should refer to iodine solution, and not just iodine (which is a bluish black solid).

INVESTIGATION: Which leaves photosynthesise? (LB page 6)

You will need variegated and normal leaves for this investigation. Variegated leaves have white patterns (areas lacking chlorophyll) on them. There are many examples of South African plants that have variegated leaves, such as some geraniums, African violets, ivy, etc. You can also take a walk around your school property and surrounds to see if you can find any variegated leaves. Get learners to look at the leaves and discuss the investigation first. They can also do this in groups. This investigation can be done over 2 lessons. You should place one set of pot plants in the cupboard the day before you want to do part 1 of the investigation. After you have done part 1, you can do part 2 in the following lesson. In part 2, learners will need to write up an experimental report.

If you do not have time to do both parts of the investigation, a suggestion is to get your learners to read through Part 1, and then to conduct Part 2, where they have to write up their own report.

Possible answers include: 'To determine whether leaves photosynthesise in the dark or the light', or 'To investigate whether Light is necessary for Photosynthesis'.

The leaves in the light will test positive for starch as they photosynthesised, whereas the leaves in the dark will not photosynthesise and will test negative for starch.

Before starting this investigation, all plants must be placed in a dark cupboard for up to 48 hours prior to starting the investigation in order to ensure that the plants do not have starch in the leaves before the process begins.

Instead of a saucepan with water and a beaker with alcohol, teachers may use a beaker with water and a test tube with meths or alcohol. As long as the container holding the alcohol is safely contained within the water to prevent it from being directly heated or coming into contact with the flame. Teachers may also feel safer if they demonstrate this experiment.

Warning: The alcohol needs to be heated as well but it cannot be heated directly because it is extremely flammable. It therefore needs to be heated in a water bath.

The amount of iodine solution required to observe a result depends on the leaf tested. Some leaves may need to be flooded with iodine solution. Place the leave in a petri dish and cover the leaf with iodine.

A really good demonstration of the various experiments in this and subsequent sections is found at [2] bit.ly/177Z3ay. It starts off with carbon dioxide through limewater test and then demonstrates the starch test.

Learners must draw their own tables to record their observations. This being the first investigation that they will perform in high school, this activity will allow teachers to gauge their level of proficiency and abilities in this regard.

The hot water removes the waxy cuticle and the alcohol dissolves the chlorophyll, releasing the green colour of the leaf. After the leaves are taken from the ethyl alcohol they should be white. The chlorophyll needs to be removed from the leaf so it does not mask the colour change we expect with the iodine solution. When iodine is dropped on the leaf it turns blue-black in the presence of starch. This is an indicator to show that the leaf was photosynthesizing and producing glucose that was turned into starch.

1. This was done to allow some plants to photosynthesise and the others not. Those that were able to photosynthesise could produce starch and those that didn't only had small amounts of starch or no starch.
2. If the iodine changes from brownish-orange to dark blue-black that indicates that the leaf or other part of the plant contains starch and must have photosynthesised. If the iodine solution does not change colour, the leaf or other part of the plant does not contain starch and did not photosynthesise.

Learners need to apply what they have learnt in Part 1 to plan their own experiment in part 2 and write up an experimental report.

Geranium leaves are an excellent option for this investigation. The ivy has a very thick cuticle and the iodine can't penetrate the leaf easily. Variegated mint-leaf is also very good for this investigation, and is a plant found commonly in KwaZulu-Natal.

This activity may be done in groups or individually. Up until now learners have been provided with a framework in which to write up their results. For this investigation, they need to compile their own reports. Some examples of what learners might produce are included here:

Aim: To find out which parts of variegated leaves photosynthesise and store starch.

Hypothesis: The green parts of variegated leaves will turn blue-black in iodine solution indicating that they photosynthesise and store starch, whereas the white parts will not turn blue-black (will stay brown).

Materials and apparatus: This should be a similar list to what was used in Part 1. Learners must record the items in a bulleted list and take note of measurements.

Method: This should also be similar to Part 1. The steps in the method must be numbered. They must be written in full sentences. Learners must take note of what measurements they used.

Results: Learners should draw a table to record their results. They should provide headings for the columns and rows and also a heading for the table. Learners must make drawings of their leaves at the start of the experiment, indicating the different coloured regions as boiling in alcohol will remove the colour. They can then indicate the results on the drawings.

Discussion: Assess learners ability to explain their results. They should also make reference to the fact that the white parts of the leaves do not contain chlorophyll and therefore they do not photosynthesise. This also shows that chlorophyll is crucial for photosynthesis. Learners should explain anything that they might have improved on in their results.

Conclusion: This should be a short statement in which they answer their aim or investigative question.

INVESTIGATION: **Why do bananas become sweeter as they ripen? (LB page 8)**

It is not crucial to do this investigation if you do not have time. This is an **optional** extension of the starch test.

1. Learner-dependent answer

An example of a possible answer is: To investigate the presence of starch in ripe and unripe bananas; To investigate why bananas becomes sweeter as they ripen; etc.

1. If the unripe banana does not taste so sweet compared to the very sweet tasting ripe banana then perhaps it contains more starch, and less glucose. The starch test might show that the unripe banana contains more starch.

Learner-dependent answer

Learners should be able to describe the taste and texture of each banana: the ripe one being soft and sweet, and the unripe one being firm and not too sweet. Learners might say that the unripe banana contains more starch and less glucose as it is not as sweet as the ripe banana. But, this is not a very accurate test. The learners might also experience the tastes differently, making the results unreliable.

Learners should be able to quite easily see this based on the speed with which the iodine changes colour in the unripe banana.

1. Learner-dependent answer

Allow learners the freedom to tabulate their results in any way they choose as long as it is easy to interpret and understand. Use this as a teaching opportunity to help those who cannot do this and when everyone is done compare the different methods used in the class.

1. Learner-dependent answer.

You should use this comparison to help learners understand that reliability of an experiment rests on the fact that although different people perform the same test they should all reach very similar results.

2. The conclusion is that unripe bananas contain more starch than ripe bananas. This question was specifically included to introduce learners to the concept of validity and teachers are encouraged to allow learners to debate this issue in the class
3. As the bananas ripen, the starch is converted into glucose.

1.2 Respiration

The term respiration can refer to two distinct processes. In **physiology**, respiration refers to the transport of oxygen from the outside air to the cells and the transport of carbon dioxide out of the tissues and into the air. This is often confused with breathing, which is the movement of air in and out of the breathing organs, such as lungs or gills, and does not take place in all organisms, whereas respiration does. At a **biochemical** level, respiration refers to cellular respiration. This is the metabolic process in all organisms where oxygen is combined with glucose to release water and carbon dioxide and energy in the form of ATP (adenosine triphosphate). Cellular respiration takes place in individual cells within the organism whereas physiological respiration involves the bulk transport of gases and other compounds between the organism and the outside air.

In this section, we will be looking specifically at **cellular respiration** as we will be looking at the chemical reactions which release the energy in food. However, learners have not yet learnt about cells and so we will just refer to this as respiration. Should you wish to do so, you can make this distinction to your learners and introduce the term cellular respiration, however, it will only be clear once they have done cells in Gr. 9. They will study physiological respiration in Gr. 9 when they do body systems and also cover the circulatory and respiratory systems in detail.

An idea as introduction and/or conclusion to this section on Respiration is to let learners watch the YouTube video of a song about cell respiration: [3] bit.ly/1eupZUz. The initial explanation is simple and appropriate for this grade level but it might show some of the more inquisitive learners what actually happens during the 3 stages of respiration.

Photosynthesis requires sunlight and can only take place during daylight hours. Learners may get confused and think that because photosynthesis occurs during the day, that respiration only occurs during the night. Ensure that learners understand that respiration occurs constantly, during the day and night.

They are glucose (food) and oxygen. Next term in Matter and Materials, we will look at chemical reactions and define the 'ingredients' as reactants. You can also link back to this example of a chemical reaction (actually a series of reactions), when introducing the topic next term.

We also know that respiration releases energy. This energy is contained in the chemical bonds of ATP molecules. ATP is not energy itself, but instead it stores energy. The ATP molecules have chemical potential energy in their bonds.

When the ATP molecules are broken down they release the energy in order for other processes to take place.

Unlike photosynthesis, where we place sunlight energy above the arrow and not as one of the reactants in the equation, in respiration, we place energy here as a product. This is because the energy is actually contained within the molecules produced (ATP). However, at this level learners do not need to know this term, and we will only use the word energy in the equation. However, since this has the potential to cause misconceptions later, a note was included about the energy being contained within ATP molecules.

Ask your learners this question to see if they understand the concept. The by-products are carbon dioxide and water.

ACTIVITY: **Does our breath contain carbon dioxide? (LB page 11)**

You will need to prepare limewater prior to this activity. Here are instructions on how to do this:

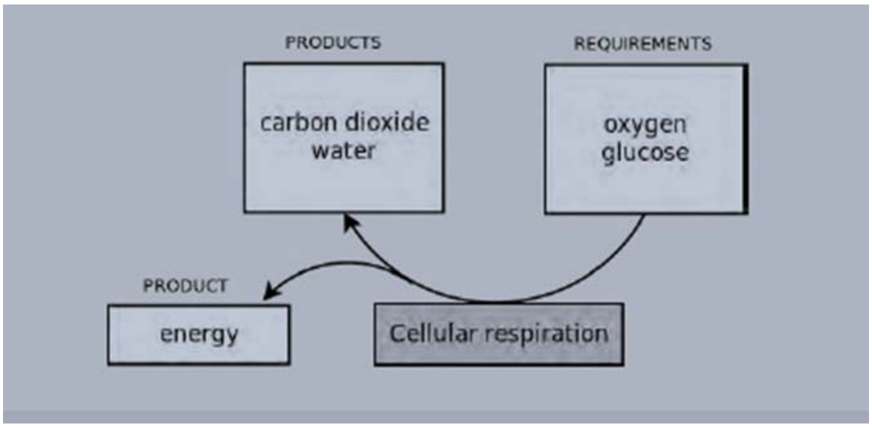
1. Place a few tablespoons of calcium hydroxide, $Ca(OH)_2$, in a clear 500 ml reagent bottle and fill with water. Shake or stir to make a cloudy suspension.
2. Leave the suspension to settle for a few days. The clear liquid above the solid $Ca(OH)_2$ is a saturated solution of $Ca(OH)_2$, also known as clear limewater.
3. Carefully decant as much of this as you need, without stirring up the solid $Ca(OH)_2$ sludge at the bottom.
4. To make more, simply add more water, shake it up and let it settle again. When the sludge dissolves completely, add more solid $Ca(OH)_2$.

For health reasons, there should be one straw or rubber tube per learner.

Pharmacies are generally quite helpful and will assist schools in purchasing low cost syringes. Technology teachers at your school might also have syringes for their syringe mechanics lessons. An alternative to a large syringe is to use a bicycle pump or balloon blower. **Safety warning:** remove the needles from the syringes, if there are any, before you hand out the syringes in class.

1. The clear limewater turned cloudy white. This means our breath contains carbon dioxide from respiration.
2. The clear limewater did not change and remained clear. Some might notice a very slight change, which indicates that there is a small amount of carbon dioxide present in atmospheric air
3. As air contains such a small percentage of carbon dioxide, there is not enough to cause a noticeable difference in the limewater. Discuss with your learners why they think that the limewater turned cloudy with your breath but not with the air, even though air does contain carbon dioxide. Point out that air from your lungs contains a much higher percentage of carbon dioxide from respiration and this can turn the limewater cloudy in a shorter time than atmospheric air will.
4. a) Glucose and oxygen.
   b) Energy, carbon dioxide and water

ACTIVITY: **Requirements and products of Respiration (LB page 12)**



This is what the learner's diagrams should look like.

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 links between different concepts. Often a concept map has a "focus question" from which the other concepts radiate. 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: "Respiration takes place in all organisms, releases energy from food".

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 for summarising information and understanding how different concepts link together. Real understanding and knowledge comes from grappling with the subject matter, and not just memorizing facts.

Below is the complete concept map with the answers filled in. Make sure your learners understand what a concept map is and that they have filled in the correct concepts into the empty spaces. Learners might battle to do this, especially to fill in "Potential energy" as the type of energy in food. Help them by reminding them of the two types of energy, namely kinetic energy and potential energy. You can ask them questions such as, "What do plants get from the Sun which is used for photosynthesis?" (Solar energy), "What do plants get from the soil that they use for photosynthesis?" (water), etc. "Knowledge is real knowledge only when it is acquired by the efforts of your intellect, not by memory." – Henry David Thoreau

Revision

1 a) Depending on what he planted the beans in, he might have noticed a root and first leaves forming.
   b) The young bean plants would have formed small leaves but the plants would slowly start to die.
   c) The bean plants would die as the leaves would not have enough radiant energy to allow them to photosynthesise and produce glucose for the plants to use to grow and develop.
   d) He should have put the plants in a place where they would get enough radiant energy (sunlight) to allow them to photosynthesise.

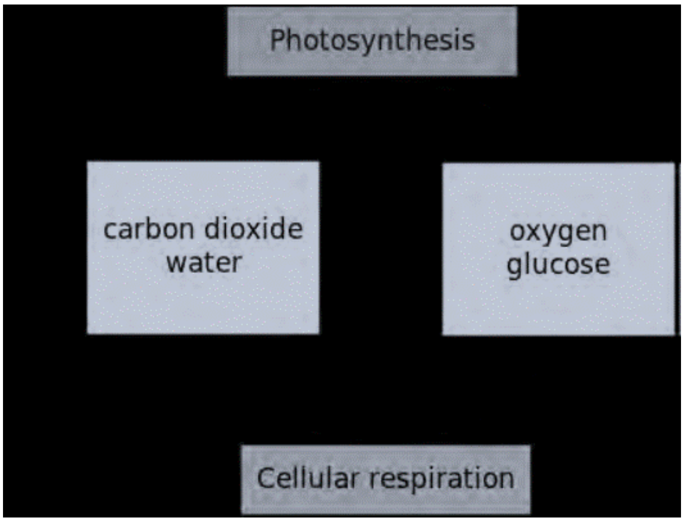
2. Carbon dioxide, sunlight and water

3 a) The plant converts the glucose to starch as it is easier to store. Therefore, the leaves will indicate a high starch content.
   b) The chlorophyll must be removed by first dipping the leaf into boiling water for 1-2 minutes to remove the waxy top layer. Then the leaf must be placed in alcohol and this is heated over water to remove the chlorophyll. The leaf is then removed and dipped into hot water to soften it as the ethanol will make the leaf brittle. Iodine solution is dripped on it. Iodine changes from orange-brown to dark blue-black in the presence of starch and when it is dripped onto the leaf it changes to dark blue/black indicating that starch is present

4. Plants only photosynthesise during the day, and not at night. This is because they need sunlight energy to photosynthesise. Plants respire all day and all night. All living organisms need to undergo respiration to release energy from chemical potential energy and perform the seven life processes.

5
   a) The learners wanted to collect any gas that formed from the solution in Test Tube A and bubble it through the limewater. If the limewater changed from clear to cloudy white then this would indicate the presence of carbon dioxide. (This question tests the learner's ability to follow the logic of the experiment and to link the theory learnt and the practical application of it.)
   b) The learners did not want to lose any of the gas that might potentially form before it had time to bubble through the limewater. It is also important to make sure that the only thing affecting the limewater was the gas released in the experiment, and not carbon dioxide from the atmosphere. (This question tests the practical understanding of the process that was undertaken.)
   c) It is test tube B as it contained clear limewater to start which has gone milky. It is from Setup 2 as there is yeast and sugar in test tube A in set-up 2 so the yeast ferments the sugar and releases carbon dioxide which turns the limewater milky.
   d) The yeast needs to act on the sugar to form the carbon dioxide. When the sugar was not available it could not react and could not produce carbon dioxide

6.



7. An example of a table is given here. (Take not that learners have not yet started to call the starting ingredients reactants)

Table of differences between photosynthesis and respiration		
Characteristic	**Photosynthesis**	**Respiration**
Starting ingredients/ requirements (reactants)	Carbon dioxide, sunlight energy and water	Glucose and oxygen
End products/what the process produces	Glucose and oxygen	Energy, carbon dioxide and water
Organisms in which this process takes place	Green plants	All living organisms
When this process takes place	During the daytime/when there is sunlight	All the time as organisms continuously respire

Assessment Rubric 4 can be used to mark this table if you would like a more in-depth assessment.

2 **Interactions and interdependence**

Chapter overview

5 weeks

Learners are introduced to the basic concepts of ecology and the four levels in which ecological interactions are grouped for research and studying purposes. This is made explicit in the text in this introductory section and learners are given short activities to allow for meaningful engagement with these concepts. Visit [1] slidesha.re/19dpf9k. The slides contain an overview of the concepts introduced in this section.

2.1 What is ecology? (0.5 hours)

Tasks	Skills	Recommendation
Activity: What is a population?	Identifying, observing, analysing, describing, writing	Optional
Activity: Check your understanding	Describing, writing, recalling	CAPS suggested

2.2 Ecosystems (4 hours)

Tasks	Skills	Recommendation
Activity: Abiotic components in a grassland ecosystem	Identifying, listing, describing, writing	CAPS suggested
Activity: Studying an ecosystem	Investigating, observing, taking measurements, describing, analysing, writing, working in groups	CAPS suggested
Activity: Identify the type of interaction between organisms	Identifying, writing	Optional

2.3 Feeding relationships (2 hours)

Tasks	Skills	Recommendation
Activity: Different types of consumers	Identifying, describing, writing	CAPS suggested
Activity: Different decomposers	Identifying, describing, writing	CAPS suggested

2.4 Energy flow: food chains and food webs (3 hours)

Tasks	Skills	Recommendation
Activity: Energy transfer in an ecosystem	Classifying, identifying, evaluating, describing, writing	CAPS suggested
Activity: Studying energy pyramids	Constructing, describing, writing	CAPS suggested
Activity: Identifying food chains and food webs	Identifying, describing, writing	CAPS suggested

2.5 **Balance in an ecosystem** (2 hours)

Tasks	Skills	Recommendation
Activity: The critically endangered Riverine Rabbit	Identifying, describing, writing	CAPS suggested
Activity: Assessing the impacts of a natural disaster	Describing, writing	CAPS suggested
Activity: Poaching in Southern Africa	Reading, interpreting, writing	CAPS suggested
Activity: Assess your impact on the environment	Identifying, interpreting, writing	Optional

2.6 **Adaptations** (2 hours)

Tasks	Skills	Recommendation
Activity: Distinguish between types of adaptations	Reading, identifying, describing, writing	Optional (CAPS suggested)
Activity: Why do animals migrate?	Identifying, describing, writing	Optional (CAPS suggested)
Activity: Living stones	Describing, writing, drawing, labelling	CAPS Suggested

2.7 **Conservation of the ecosystem** (1.5 hours)

Tasks	Skills	Recommendation
Activity: Why should we care?	Group work, research, public speaking, debating	CAPS suggested
Activity: Finding solutions to environmental problems	Writing, reflecting	CAPS suggested
Activity: Individuals who make a difference	Research, describing, writing	Optional (Extension)

Key questions

- What is ecology?
- We talk about the population of people in South Africa, but do other animals live in populations?
- What makes up an ecosystem? Are we part of an ecosystem?
- How are organisms linked by their feeding relationship to make food webs?
- Why do we need many more producers and fewer carnivores in a food web?
- How does an ecosystem remain balanced so that it can support all of the organisms that live there?
- We know that natural disasters can have a huge impact on ecosystems, but what are we as humans doing that upsets the fine balance in ecosystems?
- What does it mean if an organism is adapted to its environment?
- Why have some organisms become extinct?
- During the course of Earth's history, many organisms have become extinct, so what is different and worrying about the decreasing numbers of rhinos and elephants?
- How can we make a difference to conserve our own environments?

2.1 What is ecology?

Learners have already studied the biosphere in detail in Gr. 7. They have also looked at the concept of an ecosystem in the younger grades. We will now put these different levels together in a hierarchical organisation representing the study of ecology.

The website link provided in the visit box for our 'Breathing Earth' provides a very interesting simulation of how the population of the Earth, and also individual countries changes every second. If you have Internet access in your classroom and a projector, you could put this website up when you first introduce population and then leave it running during the lesson. At the end of the lesson, bring it up again to see how much the Earth's population has increased in just a short time such as your lesson.

ACTIVITY: **What is a population? (LB page 18 and 19)**

Discuss this with your class first and get their opinions. They should note that all the animals in a population are the same species and they can interact as they live in a specific area.

Figure 2.1 A population of hippos in the St Lucia estuary (river mouth) in KwaZulu-Natal.

Figure 2.2 A population of zebra in Kruger National Park.

Figure 2.3 A population of seals on Seal Island in False Bay.

Figure 2.4 A population of penguins at Boulders Beach.

Learners may not know the answers to these questions as we have not yet given the definition of a population, but this is meant as a discussion and for them to come to the conclusion of what defines a population without stating the definition up front.

1. All the animals are of the same species in a population. They are different ages, there are males and females.
2. No, they are not from the same population. Individuals in a population all live in a specific area and they can interact and breed with each other. They are not able to interbreed if they live in different areas.
3. A population does not have a specific size. Rather, it is defined by the area that you are talking about and whether the individuals can interact.

4. A population consists of organisms that live in the same space and at the same time. Individuals in a population interact with each other and are able to interbreed. Since the seals lived at different times, they cannot be part of the same population.
5. The number of hippos in the population would decrease. They might not necessarily all die, but the numbers would decline. The decline may be due to some individuals of the population migrating to other areas. The population would decrease because the environment cannot support the hippos anymore as there is not enough water in their habitat. (We will look more at balance in an ecosystem later in the chapter.)
6. Some possible reasons include: there are perhaps fewer predators and so fewer of the zebras are being eaten. There might perhaps be an increase in the number of females that are born and so more are reproducing. There might be an increase in the amount of food available, perhaps other populations of herbivores have decreased or there might have been particularly rainy seasons so there is lots of food (green grass). Disease may have decreased so fewer animals are dying, or the amount of hunting or poaching by humans may have decreased.

Discuss this with your learners and see what they come up with. They have looked at feeding relationships and ecosystems in previous grades and so this also links back to what they have studied before and requires them to apply what they already know to new situations.

Extension question to ask your learners: Another group of scientists wants to compare the population of penguins at Boulders Beach in Cape Town with another population in Antarctica. What are some aspects of each population that they could compare?

Discuss this with your learners. You can help them come to the answers by asking leading questions, such as, how would the scientists compare the habitats of the two populations? How would they compare how well the penguins are doing in each population?

Answer: Some aspects that they could compare between the populations are: growth rate of the population, the number of deaths and births in a given time frame, what the penguins in each population eat, what are the natural enemies/ predators of each population of penguins, which other species do the populations of penguins interact with in their environment, how many times per year do they reproduce, do they build shelters, is there any human impact on the penguins etc.

This is a possible extension activity if you would like to do it with your learners. This has only been included in the Teachers Guide as many learners might not be familiar with an underwater environment.

1. Different fish populations, turtles, seaweed, corals, sponges, plankton.
2. Some other examples include: crustaceans such as crabs or crayfish, jellyfish, octopus, other fish species, perhaps a reef shark.
3. It is a coral reef.
4. Some types of fish could eat other types of fish, the fish can eat the seaweed, the turtles eat the seaweed, the sponges filter the water for plankton.

ACTIVITY: Check your understanding (LB page 20)

This can be done as a short revision task in class or as homework to check what learners understand so far, or you can ask learners the questions orally in class.

Suggested answers have been given, but learners must be encouraged to use their own words.

1. The particular branch of science that studies how organisms interact with other organisms and their environment.
2. The process of interacting/influencing each other.
3. An individual life form, either a plant, animal, fungus, protist or bacteria.
4. A group of organisms of the same species that live in the same area at a specific point in time and they can interbreed with each other.
5. All the populations of organisms that interact in a certain area.
6. The different living things interact with the non-living things in their environment to make up an ecosystem.
7. All the ecosystems on Earth combined make up the biosphere.

2.2 Ecosystems

The article in the visit box is about scientists working in 'Green science', particularly studying the interactions between plants and their environment. A possible enrichment activity, or homework task is to get learners to read the article, and then this webpage has questions that you can ask your learners in an informal discussion: [2] bit.ly/15QvStw

ACTIVITY: **Abiotic components in a grassland ecosystem (LB page 21)**

1. Soil, rocks, water, wind/air, sunlight/temperature, clouds.
   a) The eagle uses the wind and air to soar and glide while hunting.
   b) The trees and grass are rooted in the soil so that they do not blow over and they can get water and use sunlight and carbon dioxide to make food.
   c) The mouse creates its home in the ground/dead stick/grass, it can store seeds and food in the soil and hide from predators.
   d) The worm and insect live in the soil.
3. The blue arrows describe the water cycle.

You can revise the water cycle here, namely: The water in the pond/dam evaporates as it changes from a liquid to a gas. The water vapour then condenses to form clouds as fine droplets of water. When the water droplets become big enough, they precipitate as rain. The water runs down the slopes and collects in the lower regions such as the pond.

4. The time of day will affect the temperature as this will affect how much heat energy the ecosystem receives from the Sun depending on the Earth's position. The time of year will also affect the temperature as the ecosystems distance from the sun changes. Weather conditions will also affect the temperature, for example if there are clouds, wind, or it is raining. The direction the area faces will also affect the temperature, for example if it is on a slope.
5. This grassland ecosystem has a sloped surface. There is a hill on the right hand side and the ground slopes downwards towards the pond. This shape and slope enables the water to run down when it rains and collect in the pond, thereby providing a collection of water for the ecosystem.

The arrow starting on the right above the buck should read '**Carbon dioxide** released during respiration in plants and animals.' The arrow ending on the right below the buck should read '**Oxygen** used by plants and animals during respiration.'

ACTIVITY: **Studying an ecosystem (LB page 22)**

This activity may be given to learners as a project. Learners will mark off parts of an ecosystem and must ideally be able to return to it regularly. You as the teacher must pre-visit the area and find a suitable area for marking off and studying, preferably near a stream or shore. Ensure that there is enough space for several classes to study the same area without damaging it. Identify organisms and find possible relationships between them. Show learners before the visit how to use equipment correctly and how to keep records. If you have microscopes, teach them how to use these to study soil samples and small organisms. During the visit, you will have to circulate and check on the groups of learners.

As many of the measurements taken will be new concepts and practices, you should explain the reasons for measuring different environmental conditions in the ecosystem. During the investigations it is also important to walk between groups to ensure that they are applying the newly learnt skills appropriately and taking accurate measurements.

The leaf litter and soil samples may be studied in the field but could also be studied in the class. If teachers have taught learners to use basic light microscopes they should encourage them to study these with the use of a microscope too.

Optional materials are: rain gauge, wire ring, binoculars, field guides.

Learner-dependent answer. If you can find moss or lichen, point out this interaction to learners which shows how a plant grows on a rock (interaction between biotic and abiotic). Similarly, plants (biotic) interact with the soil (abiotic) when they draw mineral salts and water from the soil.

Learner-dependent answer. Perhaps there are ants building a nest – point out these interactions to learners.

Learner-dependent answer. Lookout for any interactions between animals and with their abiotic environment and point these out to learners.

If you are able to take the temperature several times over the course of a day, use this information to plot a graph to show how the temperature changes over the course of the day.

Learners might have learned about soil types in previous grades in Earth and Beyond. This acts as a revision of what they have learned.

Learner-dependent answer. You can easily make your own rain gauges by cutting the top off a 2 litre plastic bottle and inverting the top half into the bottom half to form a tunnel. You can use a marker pen to write measurements on the side of the plastic bottle. See this link: 3 bit.ly/1cfqC8Q

1. Learner-dependent answer. They may describe the habitats/ecosystem as aquatic, terrestrial, or even a pond, grass, forest, etc.
2. Learner-dependent answer. Learners should take note of the water resources in their square, the slope of the land, and the type of soil and how this affects the organisms.
3. Learner-dependent answer. Learners should take note of any feeding relationships that may exist. We will be studying this in more detail next,
4. Learner-dependent answer. Perhaps there is litter which is blocking a stream, or that animals can eat and choke on. Perhaps there is a path that humans walk on, resulting in them trampling the plants so that nothing grows there. Learners could suggest putting some rubbish bins nearby, or perhaps mark off the area so that people have to walk around, etc.

5. Learner-dependent answer. Learners may observe that insects or other small animals scurried away from them when they approached their quadrant. or perhaps insects were drawn to the stakes and rope that was used to demarcate their area.

You may choose to use this practical activity for learners to submit a written account/ report of their work and to present their findings to the class in the form of a powerpoint presentation. Possible areas to evaluate might include:

- Title and purpose
- Procedures followed by the group (as awarded from observations by the teacher)
- Comparative data similarities to other groups in the class that measured in similar areas.
- Answer to the questions above.
- Oral presentation of their research as presented in their powerpoint slideshow to the class. They could include the different activities that will be conducted throughout this chapter, such as their work on the different food chains and the food web that exists in their marked off ecosystem and work on conservation of their marked off ecosystem.

2.3 Feeding relationships

Learners should have learned about food chains and food webs in previous grades. Therefore, some of this content is revision, but the concepts have also been extended to make it more engaging at this level.

Plants need water from the soil, carbon dioxide from the air, and sunlight energy from the sun.

ACTIVITY: **Different types of consumers (LB page 26)**

This activity is intended to build on previous knowledge of herbivores, omnivores and carnivores, and introduces concepts of insectivores and scavengers, which learners might have incidental knowledge of but might not have defined themselves. The activity requires that they engage with their existing knowledge and use this to define the terms. Teachers should walk between groups and ensure that they use scientific vocabulary as taught in this and previous sections as well as the New Word List, in their definitions.

1. A herbivore is an animal which feeds on plant material. Examples of herbivores are: elephant, duck, horse, buffalo, squirrel, grasshopper, rhino, zebra, cow, mouse, etc.
2. A carnivore is an animal which eats other animals (living or dead). Examples of carnivores are: lion, jackal, dolphin, crocodile, shark, leopard, mosquito, vulture, crab, seal, etc.
3. Buck, zebra, buffalo.
4. Vulture, jackal, crab.
5. The learners can research the eating habits of the chameleon, bat, praying mantis and swallow in groups, and report their findings to the rest of the class.
6. These animals all eat insects and other small invertebrates. They are called insectivores.
7. An animal which eats both plants and other animals is an omnivore. Examples are: pig, flamingo, mouse/rat.
8. Humans are omnivores.
9. An earthworm is a decomposer.
10. a) Learner-dependent answer.
    b) Learner-dependent answer.
    c) Learner-dependent answer.
    d) Learner-dependent answer. They might have seen earthworms or fungi.

Figure 2.11 A chameleon.

Figure 2.12 A bat.

Figure 2.13 A praying mantis.

Figure 2.14 A swallow.

ACTIVITY: **Different decomposers (LB page 29)**

1. They are mushrooms, so they are part of the Fungi kingdom.
2. The mushrooms are mostly growing on dead plant matter, such as dead tree logs and humus
3. We can call them decomposers.
4. Decomposers break down the matter in dead organisms to release the nutrients such as water and carbon, back into the ecosystem. These nutrients are therefore recycled and made available for other organisms to use. They also help to keep an ecosystem 'clean' as they make sure that dead and decaying material is not left lying around in an ecosystem for an extended period.

2.4 Energy flow: Food chains and food webs

ACTIVITY: Energy transfer in an ecosystem (LB page 30)

1. It is called a food chain.
2. The grass.
3. Consumers are the grasshopper, the mouse and the owl.
4. The grasshopper is the herbivore and the mouse and the owl are the carnivores.
5. The rat is an omnivore as it eats both plants and animals.
6. The arrows show the transfer of energy from one organism to the next. 7 Yes, it does make a difference. The arrows show the direction in which the energy is transferred as one organism eats the other one, always from the producers to the consumers.
7. Learner-dependent answer. Learner's food chains must start with a green plant (producer), or part of a green plant, such as a fruit or wheat. Make sure they have used the arrows in the correct direction, and that they have three levels of consumers.
8. Learner-dependent answer. They could say that decomposers would come at the end of the food chain as they break down the bodies of the dead organisms. Or they are often put at the side, with many arrows from all levels of the food chain as they break down all the dead organisms at every level.

Encourage learners to write the levels into the diagram. The grasshopper is the primary consumer, the rat is the secondary consumer and the owl is the tertiary consumer.

ACTIVITY: **Studying energy pyramids (LB page 31)**

1. The phytoplankton in the marine ecosystem and the trees in the savanna ecosystem.
2. The crustaceans in the marine ecosystem and the giraffe in the savanna ecosystem.
3. The organisms in each level use most of the energy (90%) to sustain their own life processes (such as breathing, moving, reproducing etc).

Therefore, only 10% is available to the next level which feeds on them. Learners might need help with this question, so ask them leading questions such as, what do the organisms in each level need energy for?

4. Energy flow in an ecosystem is very inefficient and only 10% of the energy from a trophic level is passed to the next level. Therefore, to provide enough energy for the subsequent trophic levels, there needs to be many plants as primary producers.
5. There are 5 in the marine and 3 in the savanna ecosystem.
6. Since only 10% of the energy produced by the consumers is passed on to the next level, the primary consumers need to eat a large amount of producers to get enough energy to live. In the same way, each level needs to be supported by a larger population that it feeds on as only 10% of energy is passed on to each level.
7. Learner-dependent answer

ACTIVITY: **Identifying food chains and food webs (LB page 34)**

1. A marine ecosystem.
2. There are several answers. Some examples include: phytoplankton krill fish penguin leopard seal phytoplankton zooplankton fish sea gull leopard seal phytoplankton krill blue whale seaweed crab squid penguin leopard seal seaweed crab squid elephant seal killer whale. It shows how the different food chains are connected.
3. Phytoplankton and seaweed
4. Krill, zooplankton and crab.
5. Killer whale and blue whale.

2.5 Balance in an ecosystem

Use this as an entry point into this section. The resources that organisms depend on are food, shelter and water. Ask learners questions such as, what would happen if there was a drought and all the grass died, or there was a fire that swept through and burned all the plants, or what happened if all the zebra got a disease and died? The ecosystem would become imbalanced in some way.

In Gr. 7 Life and Living, learners studied Biodiversity and Sexual Reproduction in Angiosperms, (including sections on pollination). If there is time, show learners this brief video about the mysterious disappearance of honeybees that has many people worried and alarmed! [4] bit.ly/147WFgZ Afterwards, lead a class discussion in which you ask the learners what effect the loss of honey bees would have on the ecosystem.

ACTIVITY: **The critically endangered Riverine Rabbit (LB page 35)**

Teachers should if possible download the poster about the Riverine Rabbits and the information leaflet at [5] bit.ly/16CawB4 to discuss in class.

- Habitat destruction is one of the main reasons, due to farming, fire and livestock (which may also cause erosion)
- Other animal species compete for their food.
- Floods kill their young and destroy their habitat.
- Natural predators kill them.
- They are killed in the road and by 4x4 vehicles in river beds.
- Hunters accidentally kill them, thinking they are eating crops.

ACTIVITY: **Assessing the impacts of a natural disaster (LB page 36)**

1. Drought is water shortage, when there is no rain for a long time.
2. A famine is a scarcity of food when there is starvation.
3. Drought makes plants die, so animals that eat them also die. This decreases food for humans, as crops and farm animals die as well.
4. Hungry and malnourished animals and humans are too weak to fight off disease.
5. It is usually reversible, but ecosystems can take a very long time to recover from severe droughts.

Perhaps discuss this with your learners before they write their answer down. Ecosystems are fairly robust and can cope with fluctuations in climate over the year. However, an imbalance results if the climate changes very suddenly or else changes and remains like that for a long period of time.

ACTIVITY: **Poaching in Southern Africa (LB page 37)**

1. Any meat obtained from wild animals that were trapped / snared/ poached, often illegally.
2. The San only took what they needed, their traps were well set and their numbers were small. Today's people set traps badly, so the wrong animals are killed and then often not eaten. There are also a lot more people doing it now.
3. Many people are poor and cannot afford to buy the more expensive meat in stores so rather buy much cheaper meat from illegal traders.
4. Learner-dependent answer. Note: Encourage learners to express their opinion about this and have a debate in class. Some will feel it's wrong to exclude people from traditional food sources, others feel it's more important to protect the animals and find other ways of helping people. Ask for suggestions to solve the problem: quotas / education programmes / help people to grow food or keep animals etc.
5. The illegal hunting of wild animals in areas for food or money.
6. When animals are poached, they are killed at a faster rate than their population can grow. They may become extinct.
7. The rhino is poached for its horn, elephants are poached for their tusks.
8. The natural predators of abalone have too little food so other species are eaten instead. this affects other populations too. Note: Local people who use Perlemoen as food for their families are also stopped from removing

9. The secondary consumers that eat them will have less food, so they eat more of other animals, which also become endangered. Secondary consumers that eat only these worms may become extinct directly.

ACTIVITY: **Assess your impact on the environment (LB page 39)**

1. You can also start this first part of the activity as a class discussion. Ask learners what types of water resources are polluted and how. What pollutes the air? Where does our waste from our homes go? Below are some points for the discussion.
   - Land pollution: In spite of recycling, much rubbish still goes to landfill sites, where chemicals seep into soil water and poison food chains.
   - Water pollution: Can be caused by car oil, people washing in rivers or using rivers as toilets. Some municipalities allow raw sewage into rivers / sea, others treat sewage first but still spill chemicals into rivers. Farmers spray crops to kill pests, but this also washes into rivers and damages ecosystems.
   - Air pollution: Comes from chemicals burnt by factories, coal stoves, car exhausts, insecticide sprays and burning old tyres, etc.
2. Learner-dependent answer.
3. Learner-dependent answer.
4. This links to the last section on conservation of ecosystems. Note: Some answers include that the first poster is trying to convince us to think twice before throwing something away. We should rather recycle it or think of how it can be reused. We can also buy things with the minimum packaging and reduce the number of plastic bags we use. The second poster is playing on the words of having a 'plan B'. In this case however, we have no plan B for planet Earth – there is no second Earth or any other planet that we can live on. We only have this planet and we need to look after it.

2.6 Adaptations

A very important note about this section is to point out the misconception that organisms adapt. This is incorrect as individual organisms do not adapt, it is the populations or species which adapt over time. Individual organisms have adaptations which make them better suited to their environment. The points in CAPS are a misconception and should be reworded as follows:

- Adaptation is the change in structural, functional and behavioural characteristics of organisms in a species. Adaptation usually takes place over many generations.
- Adaptation, over time, allows a species to survive in response to changing conditions in the environment
- Species that are unable to adapt to changes within the environment die out (become extinct)

Be sure to make it clear that it is **species or populations of organisms** that adapt, and not individual organisms.

ACTIVITY: Distinguish between types of adaptations (LB page 41)

1.

How is the species adapted to life in its habitat?	Body adapted to dig and reach into nests to get prey; little hair as lives in hot climate; has shovel-like claws and powerful short limbs, long sticky tongue to pick up and eat the ants.
What type(s) of adaptation is this?	**Structural**: longer snout and tongue; thick skin to protect it from termite and ant bites; powerful limbs to dig in any soil **Behavioural**: nocturnal – hunts at night when cool; hides in tunnels from predators

2.

How is the species adapted to life in its habitat?	Body adapted with grooves and ridges to channel tiny droplets to the mouth; the hind legs are longer and stronger to keep the beetle in this position for a long time.
What type(s) of adaptation is this?	**Structural**: grooves on body form channels to mouth; strong hind legs **Behavioural**: nocturnal habits, it stands in the specific position all night while water droplets condense on its body

3.

How is the species adapted to life in its habitat?	Body colour pattern helps it to blend into surroundings; also lighter colouring can face the fiercest angles from the sun if no shade; can extract water from plants that it eats
What type(s) of adaptation is this?	**Structural**: body colouring **Functional**: extract all available water from plants it eats; does not lose much water or energy as it does not sweat **Behavioural**: seeks shade during hottest hours of the day; turns the lightest part of its body to the sun if no shade is available; can change eating patterns if normal diet of grass is not available

4.

How is the species adapted to life in its habitat?	Ostriches have a long toe and claw to fight predators and escape; eggs remain dormant until heat of breeding male and female's bodies starts their development. Male and female share nesting duties. Their bodies are specially camouflaged: male has black feathers to be camouflaged at night when it is on the nest; female has speckled dusty coloured feathers to be camouflaged during the day when she is on the nest.

What type(s) of adaptation is this?	**Structural**: strong toe and leg muscles help it to run fast; male beak turns red to signal female that it is ready to breed. **Behavioural**: male sits on nest at night and female on nest during day as they take turns to nest; ostriches eat pebbles to help digestion as they do not have teeth; female lays just enough eggs to cover with body

5.

How is it adapted to life in its habitat?	Body adapted to mimic leaf or stick; moves very slowly to seem like a branch or leaf moving; nocturnal to avoid being seen in daylight by predators; stick insects can reproduce without male insects
What type(s) of adaptation is this?	**Structural**: body structured to resemble leaf or stick **Behavioural**: nocturnal as it feeds under cover of darkness; moves slowly to not attract predators

ACTIVITY: **Why do animals migrate? (LB page 43)**

Animals	*Description*	*Reason to migrate*
 *Wildebeest migrating in the Masai Mara.*	*Wildebeest migrate long distances each year which coincides with the pattern of rainfall and grass growth.*	*Find where the grass is growing and there are water sources*
 *The sardine run as sardines migrate along the South African coastline.*	*The sardine run occurs along the African coast during May to July each year when billions of sardines migrate to the north east coast of South Africa.*	*There are actually many theories about why the sardine run occurs, and it is still poorly understood. The most likely reason is that it is a seasonal reproductive migration.*

The more exposure to sunlight, the higher the rate of photosynthesis. Encourage your learners to take notes when you discuss topics in class.

The slippery surface also helps prevent monkeys and other small animals from climbing up and eating its leaves and fruit!

The fruit bats come to feed on the flowers and the nectar and in turn they pollinate the baobab flowers.

ACTIVITY: **Living stones (LB page 44)**

1. This is because they are plants, but they are camouflaged to look like stones or pebbles.
2. The Lithops plants are camouflaged to look like stones and blend in with their rocky soil that they grow in. The patterns look like different rocks/pebbles. They are therefore not usually seen by herbivores which might eat them. This adaptation protects them from being eaten.
3. Succulents are plants which are adapted to live in hot, arid environments and they have thickened, fleshy leaves and stems to store water.
4. The fact that the leaves are mostly underground helps the plant to conserve water because as little as possible is exposed to the hot environment so this reduces water loss. During drought, the leaves shrink even further underground to try to conserve water even more.
5. Most of the leaf and hence the green chlorophyll is located on the underneath side of the plant underground.
6. Learner-dependent answer
7. The upper part of the leaves acts as window and lets light through. As the interior of the leaves is transparent, the sunlight can travel through to the bottom parts of the leaves which are underground and contain the chlorophyll in order to photosynthesise. This allows the plant to have a coloured, patterned upper surface to camouflage it from herbivores, but still allows that sunlight to travel through for photosynthesis.

2.7 Conservation of the ecosystem

ACTIVITY: Why should we care? (LB page 47)

This is an optional, extension activity.

Learner-dependent answer.

Below is some extra information on the types of individuals who are actively involved in conservation, if you wish to discuss this further with your learners:

- Park rangers and conservationists work to save the environment. Research scientists inform park managers about conservation and investigate how climate change affects populations.
- Economists and scientists are trying to work out the 'costs' of big cities on the environment and how to sustain healthy ecosystems so that we and all living things can enjoy the benefits of healthy food, clean water and air.
- Other groups remove alien plants or track down poachers, especially regarding cycad and rhino poaching, which is escalating. You can help!
- Some people run campaigns to raise awareness about different environmental concerns, for example the poaching of endangered animals, or the drive to recycle cans, paper, bottles and plastic. Get involved!
- Climate change activists inform the public about global warming and the damages we are causing to our world by deforestation and pollution.

ACTIVITY: **Individuals who make a difference** **(LB page 47)**

This is an **optional, extension activity** to create awareness about what other individuals have done. If you do not have time to do it in class, learners could do it as a homework exercise.

Teacher's version
Remember that concept maps are different to mind maps in that concept maps have a hierarchical structure and show how concepts link together using arrows and linking words. Whereas mindmaps generally contain a central topic and individual branches coming out which do not necessarily link together.

Mindmaps 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. Learners might battle to find the other 2 levels in which we study ecology – help them by reminding them of the 4 levels, namely; populations, communities, ecosystems and the biosphere.

Revision

1. 1 – C
   2 – F
   3 – A
   4 – B
   5 – H
   6 – G
   7 – I
   8 – E
   9 – D
2. Abiotic factors are the non-living elements in the environment that have never and will never live. This includes gases, rocks and soil, water, temperature and weather conditions. Biotic factors are those factors that have once lived or that are living today. This includes past and present plants and plant materials, animals and microorganisms.
3. Population: the individuals of the same species that live in the same space and time and breed with each other form a population. Community: different populations of different species within the same area at the same time form a community.
4.
   - Competition: when organisms from different species compete for the same limited resource
   - Feeding relationships: there are many different types of feeding relationships between different organisms in an ecosystem, such as herbivory, predation, scavenging.
   - Symbiosis: when two (or more) organisms' actions have a positive, negative or neutral effect on other organisms from a different. The way in which they interact and the influence this has on the other species leads us to identify:
     - mutualism
     - parasitism
     - commensalism.
5. Producers: are organisms / plants that are able to produce their own energy from sunlight, water and carbon dioxide and do not need to consume other organisms to get energy.

Primary Consumers: need to consume plants in order to get energy. Secondary Consumers: need to consume primary consumers to get energy. Tertiary Consumers: consumers secondary consumers to get energy.

The trophic levels can be represented as a pyramid as there need to be more organisms in the bottom layer than in the layer above it. This is because only about 10% of the energy in each trophic level is available to the next level. The rest is used by the organisms for their own processes.

6. An insectivore eats insects and small invertebrates and is therefore a carnivore, as it eats other animals. The statement is therefore correct because carnivores get their energy from eating other animals and not plants.
7. a) Producers:
   b) Primary consumers:
   c) Secondary consumers:
   d) Scavengers:
   e) Decomposers:
   f) trees, shrubs, grasses
   g) zebra, elephant, termites
   h) cheetah, hyena
   i) vultures, hyenas
   j) bacteria, fungi
8. The zebra are primary consumers and use about 90% of the energy that they get from the grass, transferring about 10% to the cheetah to consume. There therefore need to be more zebras than cheetahs in order to make sure the cheetahs are supported in terms of food supply, and also that they do not eat all the zebras, causing the zebra population to die out.
9. The producers capture the energy from the sunlight and convert it to chemical potential energy in the form of glucose through the process of photosynthesis. In this way they place energy into the ecosystem which animals cannot do.
10. Learners should be able to identify the lack of dead animal carcases and manure, which indicates that the decomposers are working efficiently.
11. If all the zebra died, the ecosystem would become unbalanced. Firstly, the cheetah would not have a food source anymore and they would also in turn suffer and starve. The hyena would also have a depleted food source.

    There might perhaps be less dung for the dung beetle to use to lay its eggs. The grazing of the zebra also has an effect on the plants and so if the zebra all die out, the grass growth will increase.

12. In the short term, many of the animals would battle as the zebra and the elephant would have a reduced food source, especially the zebra which eat grass. Some of them might die. This in turn will affect the other predators. Many of the smaller organisms would also be burned. However, in the long term, this imbalance will normally be restored as the landscape recovers and the plants start to grow again after the first rains.
13. There are multiple food chains here.

Organism	**Adaptations**
A leopard.	The leopard is camouflaged due its colouring and spots. This helps it to hide away from prey so that it can get as close as possible before chasing. The leopard is adapted to run fast over short periods in order to catch its prey. It has a light, streamlined body with strong legs. It has a tail for balance to

	turn sharp corners while chasing.
A whale.	The whale is a mammal, so it does not have gills, but it can hold its breath for a long time underwater so that is can dive down and also catch prey/filter feed. It has a blowhole on top of its head for breathing. The blubber keeps it warm as it insulates it and also provides energy when diving and swimming in very cold seas. It has a strong tail, stream lined body and its forelimbs are flippers for swimming.
A Venus Flytrap.	This plant has adapted as it is carnivorous. It catches flies and has adapted to digest them. The red colouring inside the 'catchers' attracts the flies as it looks like meat. As soon as the flies land on the surface, the plant is triggered and the catchers clamp shut, catching the fly. The catchers are adapted with the spikes on the end to form a cage around the fly and keep it there while it is digested. The plant can also photosynthesise as it is green and contains chlorophyll
A dung beetle.	A dung beetle has adapted to its environment by using the dung from other big herbivores as a food source and to lay their eggs. They have adapted by being able to collect the dung and roll it into balls so that they can transport it to where it is needed. This also creates a warm, safe chamber in which to lay their eggs, feed the young and protect them. The dung beetles have strong front legs so that they can do the rolling. Their back legs have fine control of the dung ball.

15. The quiver tree has thick bloated branches and succulent leaves so that it can store water for the dry months. Its branches are covered in white powder to reflect heat away from plant which helps to reduce water loss. The leaves have few pores to also minimise loss of water. The tree can amputate leaves and branches if water is scarce.
16. Learners need to display the following:
    - recognition of the importance of valuing each species and their specific niche in their ecosystem
    - recognition that each species fill a specific place in the food chain and if one is removed it affects all the other species in that food chain / web / pyramid
    - each organism needs to be protected in order to preserve the entire ecosystem
    - the importance of preserving our diversity to ecotourism and for future generations to enjoy (we have not INHERITED the earth from our parents, we are CUSTODIANS of the earth for our children!).

3 Micro-organisms

Chapter overview

2 weeks

As an introduction, refer learners to the classification of living organisms that they would have done in Gr. 7 Life and Living. They should be familiar with the range of living organisms classified into the five kingdoms, namely plants, animals, bacteria, protists and fungi. Ask learners to explain what they understand about bacteria, protists and fungi. In previous chapters and grades, we have dealt extensively with organisms from the two kingdoms plants and animals. However, those that are not seen at a macroscopic level have not yet been studied in much detail. A more in-depth look at microorganisms is the focus of this chapter. In addition, we will look at which of these are harmful and which are useful. Learners have not yet been introduced to cells (which will follow in Gr. 9) so the classification should not go to cellular level. An excellent resource for teachers to use is: [1] bit.ly/13Q3DrA where Interactive Whiteboard lessons, videos, worksheets, etc. on microorganisms are available.

Note: Although CAPS spells 'micro-organisms' with a hyphen, which is accepted, it is not the most commonly used spelling. We have therefore used the spelling without the hyphen, namely 'microorganism' as this is what learners will mostly encounter in other resources, especially online.

3.1 Types of microorganisms (2 hours)

Tasks	Skills	Recommendation
Activity: What does 'microscopic' mean?	Observing, describing, writing	CAPS suggested
Activity: Classifying organisms	Classifying, writing	Optional (revision)
Activity: Calculating the size of an organism using a scale bar	Examining, analysing, calculating	CAPS suggested

3.2 Harmful microorganisms (2 hours)

Tasks	Skills	Recommendation
Activity: Where are pathogens found?	Identifying, writing	Optional
Activity: How easily do viruses spread?	Group work, analysing, discussing	Optional
Activity: HIV Research	Researching, discussing	CAPS suggested
Activity: Preventing the spread of diseases	Researching, writing	Optional (Extension)
Activity: Typhoid Mary	Researching, writing, discussing	Optional (Extension)
Activity: Research an infectious disease	Researching, writing	CAPS suggested

3.3 Useful microorganisms (2 hours)

Tasks	Skills	Recommendation
Investigation: Investigating the growth of yeast	Hypothesising, investigating, observing, measuring, recording, analysing, writing, group work	CAPS suggested
Activity: Careers as a natural scientist	Researching, discussing	CAPS suggested

Key questions

- What are microorganisms?
- Why do we need microorganisms on Earth?
- Are there microorganisms living in my body?
- How do we study microorganisms?
- What causes your body to get sick?
- Are microorganisms of any use to us?

3.1 Types of microorganisms

ACTIVITY: **What does 'microscopic' mean? (LB page 53)**

The intention of this short activity is to familiarise learners with the idea of microscopic objects and what this means. To be microscopic means that they need to be viewed under a microscope. The purpose is to show learners that many objects can be viewed under a microscope to see the detail, and there are many objects which can only be viewed under a microscope in order to be seen at all.

Provide learners with a range of different objects with fine detail, for example, newspaper, a cloth to view the individual threads, and if possible, grow some bread mould by leaving out a damp piece of bread in an enclosed container for a couple days prior to starting this activity.

The use of corrective glasses or contact lenses still constitutes 'naked eye' as it merely corrects vision to normal human accuracy. Make sure that learners requiring corrective glasses or contact lenses understand that they may keep their glasses on and it will still constitute a 'naked eye' observation.

1. It means viewing something using only your eyes; with nothing in front of your eyes to help you view something.
2. Learners should note that they were able to view more detail when viewing something using a hand lens and that things looked bigger.
3. A Microscopic Macroscopic
   B Macroscopic Microscopic
   C Macroscopic Microscopic
   D Microscopic Macroscopic

ACTIVITY: **Classifying organisms (LB page 55)**

This is optional revision of what learners have already covered in Gr. 7 on Biodiversity, and briefly mentioned in Chapter 2 this term.

1. Kingdoms.
2. Bacteria, Fungi and Protists
3. They are living. They perform all seven life processes (moving, respiring, sensing, growing, reproducing, excreting, feeding).

As discussed in this chapter, viruses are also microorganisms. There is much debate as to whether viruses are living or non-living. Viruses do not perform all seven life processes so they are not included in one of the five kingdoms.

ACTIVITY: **Calculating the size of an organism using a scale bar (LB page 57)**

1. Learner-dependent answer.

   Note: The answer will depend on the format in which the image is viewed (printed, photocopied, online, etc.) and the exact point that learners choose for the start and end of the organism. A small amount of variability is expected.

2. Learner-dependent answer

   Note: This will depend on the format in which the image is viewed (printed, photocopied, online, etc.)

3. The answer should be approximately 3.

   Note: The ratio should be constant no matter what size the image was printed! This is the power of using a scale bar. Encourage learners to round-off their answers to one decimal point in order to make their calculations easier. You can discuss with the class why learners may have slightly different answers.

4. The length of the organism is approximately 150_m.

   Note: teachers should accept any answers that are within the range of 120-180 _m. Learner's answers may differ. You may use this opportunity to discuss with learners why they think there is variation in their answers. Ask them to compare the length they measured to the length of their friends. Maybe some learners measured from the tips of the cilia and have a larger answer than others who chose not to include the cilia in their measurements.

5. There are 1000 _m in 1 mm.

6 Approximately 6.67 Oxytricha trifallax could lie end to end.

   Note: The answer is arrived at by dividing 1 000 by the size of one *Oxytricha trifallax*. Teachers should accept answers between 6 and 8.

7. a) Approximately 110 m

   Note: Accept answers between 100 and 120 m.

   b) Approximately 57 _m (0.057 mm)

   Note: Accept answers between 50-60 m

3.2 Harmful microorganisms

ACTIVITY: **Where are pathogens found? (LB page 58)**

1. Microorganisms that cause disease are found on many surfaces which come into contact with humans regularly, such as handrails, public keypads, etc.

They are also found in places which are unclean. Learners should be able to see that disease-causing microorganisms are found almost everywhere.

2. Learners need to come up with their own answers here based on the discussion about where pathogens are mostly found. They could conclude that they spread by humans coming into contact with surfaces and objects which have the pathogens on them.
3. To sterilise something means to make something very clean so that any microorganisms on the surface of an object or in a fluid are removed or killed.

ACTIVITY: **How easily do viruses spread? (LB page 59)**

This is an **optional** activity, but it is suggested if you have time in class.

This activity develops from the previous text about the spread of diseases. We will be looking at how viruses spread, and in particular sexually transmitted diseases (STD's). The aim of this activity is to open up discussion about choices of protection to prevent STD's, and importantly the freedom to say "no" and mean "no". Once the activity is completed it is very important to have a detailed discussion about the wider issues involved and the importance of learners having a clear concept of what they want before embarking in sexual activity. It provides the opportunity to discuss the issues and realities of both STD's and preventing unwanted pregnancies.

Birth control or contraception are methods or devices used to prevent pregnancy. However, some contraceptives (pills) may not prevent STDs, whereas some (condoms) may also PROTECT individuals from contracting STDs.

You are using acid to track the spread of STD's – the acid represents a microorganism that causes an STD. One person will be passing acid in the form of vinegar, as the children share their water. The water should be shared by pouring water into each other's cups, not by drinking! If they have been acidified they will pass the acid on to whoever they share their water with. By the end of the activity only those who do not accept from others will remain "disease free". This can either be related to abstinence, or could equally represent people who had safe sex and used protection to prevent the exchange of bodily fluids that may contain the microorganisms which cause STDs.

If possible, use a universal indicator

Instructions for the activity:

1. Divide the class into three groups: A, B and C. Each group will be given different instructions to carry out.
2. Brief each of the groups in private as follows (the other groups must not be able to hear the instructions given):
   a) Group A: Instruct them that no matter who offers to share their water with them, they must be very firm and polite but say "No". However, they should offer their water to people they want to give some to.
   b) They must NOT let anyone give them water.
   c) Group B: Instruct them they can share their water with whoever they want and they can choose if they wish to receive water from other members of the class. They can say yes or no.
   d) Group C: Instruct them that if anybody offers them water they should say "Yes". They must also try very hard to give a little of their water to as many people as they can. They must try to convince those that say no they should have some. (They are not allowed to give water if the person is definite about "no".)
   e) All groups should be encouraged to try to share a little water with as many people as they can but if someone is very firm about "no" they have to respect this.
3. You (the teacher) must also take part in the activity. Your cup must have acidified water (vinegar) in it. Make sure you get as many pupils as possible to have some, or target pupils you know have strong persuasive skills.
4. Once everyone has their instructions and a cup of water, go outside or in an open space to perform the activity.
5. Allow everyone to sensibly walk round, mingling all groups, offering to share their water.
6. After about 10 minutes ask the groups to gather into their designated groups A, B or C again. Place the cups in groups (A, B, C) on a table keeping the groups separate.

Now carefully add a few drops of indicator to every person's cup.

8. Get your class to observe patterns in colour and discuss what each group's secret instructions were.
9. What you should find is all those in group A should turn green if you used universal indicator. (If someone was persuaded to share you may have the odd red cup, this is really useful because it shows even more clearly the power of NO). Group B will have a mix of red and green liquid in cups depending if they said yes to some or no to everybody. All of group C should be red, i.e. contaminated with acid.

At this point, discuss what the different colours mean. You can use the following questions to guide the discussion, or else learners can answer them by themselves or in small groups.

Point out that only one person had the disease to start with but now everyone who has red liquid in their cup has it. Encourage discussion about how even your best friend may have slept with someone else and thus could pass the disease on to you. Therefore, the only safe way to prevent getting an STD is to abstain from sexual intercourse or from the use of male condoms and female condoms. It is useful to stress that girls have as much, if not even more right, to protect themselves from disease and pregnancy, and that it should be their choice as well, which must be equally respected.

You will get a lot of laughter, but it is a really dynamic way to generate discussion around this very important topic. Stress the importance of each person's right to choose whether they do or don't want to take part in sex at school age. Stress the benefits of waiting but also balance it with the sensible option of protected sex not just to prevent pregnancy. It is also important to stress that even if a girl is on contraception pills, these will not provide protection against STD's – only a condom will do this.

1. Group C should have the most red cups. This means that they were contaminated. They did not say 'No'.
2. The Human Immunodeficiency Virus (HIV).

   Note: Learners must not say AIDS here. AIDS is not a virus- it is a syndrome that can result from infection with HIV.

3. HIV spreads by sexual intercourse without protection or by coming into contact with an infected person's blood through an open wound. In the activity this was represented by mixing water with someone else.

   Note: HIV can also be transmitted from mother to child during pregnancy.

4. The virus can be prevented from spreading by abstinence (saying "No") or by using male or female condoms.

ACTIVITY: **HIV research (LB page 60)**

This can be done as a homework activity and then learners can report back to the class. A suggestion is to get different learners to research the different questions and then report back to the class and have a class discussion.

You must warn your learners to be sensitive about this topic. Encourage the use of scientific terms, great sensitivity to each other, and they must not laugh at what anyone says.

ACTIVITY: **Preventing the spread of diseases (LB page 61)**

1. There are various ways to prevent malaria. Several different medicines are available which can be taken before going to a high-risk area, which prevents someone from contracting the disease. One way to prevent the spread is to also minimise the bites that you are likely to get by using mosquito repellents and sleeping underneath mosquito nets at night.

   Another method is to actually eradicate the infected mosquitoes, for example by spraying breeding grounds. You can also regularly empty out containers that could could collect rain water and allow mosquitoes to breed.

2. The symptoms of these diseases include coughing and sneezing. So, when an infected person coughs or speaks, they spray out drops which can carry the microorganisms and spread them to another person. the infected person could wipe their mouth or eyes and then wipe another surface, thus also spreading the disease. Ways to prevent the spread are to cover your mouth when coughing or sneezing, washing your hands, and there are also various vaccinations available to prevent one from getting these diseases.

ACTIVITY: **Typhoid Mary (LB page 61)**

This can be done as an extension activity if you have time or else as a homework task.

1. They were showing how each time she made a meal she was transmitting typhoid to the family and people who would eat the food, and could potentially die from the disease.
2. She might not have washed her hands after going to the toilet and might in this way have spread the disease to the food she was preparing. The people eating the food would then have contracted the illness.
3. Learner-dependent answer but could include: No, she did not show any symptoms so she probably thought that they were accusing her of something that was not true. Yes, she did because she saw so many people getting sick around her but she was afraid to admit it.
4. If she did not believe the accusations then she probably thought that they were on a witchhunt and wanted to make her look guilty, so she refused. If she thought that she was in fact making people sick she might have been really scared that the truth would come out and she would have caused all the people to be sick. Either way she knew that they would use the results to take action against her, banishing her to a quarantine colony.
5. Yes and no. Yes they could have taken more care in explaining the dangers and getting her to understand the problem of her 'carrier status' (she carried the disease without getting sick), and No, she was infecting many others and making them sick so they were right to protect these people.

   The authorities had to weigh up Mary's basic right to privacy against those of all the other people who could potentially be harmed by her.

6. Learner-dependent answer.

   Note: This question was included to allow learners to think how they would have managed the situation differently and requires them to think about the ethical issues of the case.

7. Learner-dependent answer.

ACTIVITY: **Research an infectious disease (LB page 63)**

To make sure that all learners do not research the same diseases, a suggestion is to put everyone's names in a hat and then draw them out and assign the names to the various diseases as you go down the list. Learners can either prepare a written report, a poster or an oral presentation for this task. Learners may work in groups of 2-3 for this task.

Note that pneumonia appears in both the viral and bacterial column as the infection can be caused either by virus or bacterial infections.

3.3 Useful microorganisms

Decomposers break down dead, organic matter so that it does not clutter up an ecosystem and cause diseases, and in the process they recycle (return) nutrients to the ecosystem.

It is a mutualistic symbiotic relationship as both organisms benefit from the relationship. This links back to what learners covered in Chapter 2 and acts as a revision. Learners must be encouraged to take notes in class for these kinds of discussions.

INVESTIGATION: **Investigating the growth of yeast (LB page 65)**

Learners will investigate the conditions necessary for optimal yeast growth or fermentation. As learners have been exposed to similar investigations in this strand it is less guided as previous investigations.

- This investigation should run over two periods. There should be at least 2 / 3 days between these periods.
- The investigation will be done according to the scientific method
- The activity works well with packets of dry yeast that are readily available from supermarkets.
- The first part of the investigation will determine the sugar concentration needed for the yeast to grow and learners will receive more guidance.
- The second part will require learners to plan and execute their own investigation to determine the optimal temperature at which the yeast will grow.
- Teachers may therefore choose to use this for an informal practical assessment mark.
- This lesson may be used for a cooperative learning task where the two pairs of learners within the team of 4 could be tasked to work independently to complete different tasks and complete the mass and volume measurements. Teachers should if possible encourage this as it also minimises the use of apparatus and scales.
- If overflow pans are not available you can also use cake pans or foil pans that are readily available from supermarkets.

Before the investigation it may help learners to watchhttp://www.youtube.com/watch?v=PLG_bsJseCU or http://bit.ly/11OzWcR to see what happens when yeast and sugar are mixed.

Which concentration of sugar is best for yeast growth?

Learners should be able to explain that the yeast will use the sugar as a food source and produce carbon dioxide.

It would be an excellent data management activity to have learners record the different groups' data on the board in order to determine the mean (class average) for the class's balloon mass and volumes.

1. The answer would depend on the results from the investigation, but learners should be able to say that

the balloons filled up and became bigger (some more than others).
2. The answer would depend on the results from the investigation but they should be able to observe that the balloons with the small amount of sugar only increased a little bit but the ones with more sugar in increased more in size.
3. The answer would depend on the results from the investigation but learners should be able to say that the balloons with a greater concentration sugar were able to ferment more quickly or for a longer time than the ones with a smaller concentration of sugar.
4. Learner-dependent answer. Learners might indicate that they thought the balloons would just continue blowing up / increasing in size, or they may have hypothesised that once the sugar was used up the balloons would stay the same size (or even decrease).
5. The answer would depend on the results from the investigation but in most cases the balloons should have decreased in size.
6. The answer would depend on the results from the investigation but learners should be able to conclude that the sugar in the solution has all been used, so no new carbon dioxide was being made, and the carbon dioxide in the balloons slowly began to escape through the walls of the balloon.
7. The answer would depend on the results from the investigation but learners should be able to describe the light brown fizzy contents that has a distinct sour smell and flavour.

Learners may conclude that the more sugar was added the more gas was produced.

A simplified version of this investigation can also be done:

- Provide learners with 4 bottles.
- Dissolve half a packet of instant yeast into each of the 4 bottles.
- Mark the bottles A – D.
- Bottle A should have normal tap water with only the yeast dissolved in it. Stretch a balloon over the top of the bottle.
- Bottle B should have the yeast dissolved in lukewarm water (not too hot). Stretch a balloon over the top.
- Bottle C should have normal tap water with 10 ml of sugar dissolved with the 7 g (half a packet) of yeast. Stretch a balloon over the top.
- Bottle D should have 40°C water with 10 ml of sugar dissolved with the 7 g (half a packet) of yeast. Stretch a balloon over the top.
- The balloons will, of course, fill with carbon dioxide – with Bottle D filling the fastest as the conditions are most perfect for this in that bottle.

ACTIVITY: **Careers as a natural scientist (LB page 69)**

This is a suggested CAPS activity, but it is not for assessment purposes. Learners should start to learn about and explore various careers within the Natural Sciences. A variety of career options are suggested by this activity. Ideally all of the careers in the list should be represented by at least one student. This is a good chance for learners to explore their interests, so those who already have well-developed passions and interests should be encouraged to explore them further with this activity. If a learner has a career not on this list that is related to Natural Sciences they may talk about their choice instead.

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

Revision

1. Microorganisms cannot be seen with the naked eye and they have to be viewed through a microscope.
2. Bacteria, viruses and protists.
3. Fungi.
4. Some examples are bread, yoghurt, cheese, wine and beer.
5. Learner-dependent answer.

   Note: Learners should be able to show that the person might breathe in the virus/bacteria after someone has coughed without a hand or tissue in front of their mouths; touch another or touch an object where the bacteria is on; drink water that has not been sterilised; eat food that contains the virus / bacteria or have a mosquito or other insect bite the person.

6. People are indoors with windows and doors closed, and are more likely to huddle together, thus if someone sneezes it travels within the small confines of the room and fresh breezes do not come in from the windows and doors and blow the tiny droplets containing viruses away.
7. Either they would drink the water from a contaminated source without sterilising the water first, or they would eat fruit or vegetables that has been sprayed with this water and they might not wash it first before eating it and thus they get contaminated.
8. People in poverty cannot often get the medical help because they cannot afford to visit the doctor, live far away from clinics, have no transport or cannot travel fast enough to the hospitals to get their children treated in developing countries. The malaria in developing countries might be worsened by malnutrition and poor hygiene which might make the child too weak to survive. People living in developing countries might not be able to afford the preventative sprays that prevent the mosquitoes from biting them, and the soaps to wash away or kill bacteria. In poor communities, there is a huge lack in proper sanitation and sewage systems. This makes it much easier for disease-causing pathogens to travel in contaminated water and cause diarrhoea. Stagnant water areas are more common in third world countries which are ideal breeding grounds for mosquitoes.
9. You can wash your hands, sterilise or boil all utensils, don't leave food like meat and chicken out / in areas where bacteria can grow, take preventative measures such as using a condom during sex, having vaccinations.

   Note: Teachers can use their discretion and accept any other relevant measures that learners may mention.

10. Correct sugar solution, correct temperature: (fairly warm).

4 Atoms

Chapter overview

2 weeks

This chapter introduces the fundamental building blocks of matter and some of the important classification schemes scientists use to communicate about matter. One of the main challenges of this introduction (and this is true at all levels) is that learners are easily confused by the terminology. 'Atom' is often confused with 'molecule' and the distinction between element and compound is also one that learners find difficult to make. For this reason, these concepts and their explanations are repeated very often throughout the chapter. We have also included many diagrams of what the different classes of matter would look like at the atomic/molecular scale. Since these atoms and molecules are too small to see even with a microscope, science educationists use the adjective 'sub-microscopic' to refer to diagrams that depict entities on this scale. The ability to imagine chemical events as they would happen on the sub-microscopic scale lies at the heart of understanding chemistry and the importance of developing this skill cannot be overstated.

It is equally important for learners to be able to interpret and draw sub-microscopic diagrams. We have also built in activities where learners have to construct molecules using plasticine or play dough, to reinforce the skill. Play dough is easy and cheap to make; a recipe follows.

Play-dough recipe

Ingredients

- 1 cup flour
- 2 cups warm water
- 1 cup salt
- 2 tablespoons vegetable oil
- 1 tablespoon cream of tartar (optional for improved elasticity)
- food colouring in different colours

Method

1. Mix all of the ingredients together and stir over low heat. The dough will begin to thicken until it resembles mashed potatoes.
2. When the dough pulls away from the sides and clumps in the centre of the pan, remove the pan from the heat and allow the dough to cool enough to handle. Note: If the dough is still sticky, it simply needs to be cooked longer.
3. Turn the dough out onto a clean surface and knead vigorously until smooth. Divide the dough into balls for colouring.
4. Make a small depression in the centre of the ball and pour a little food colouring into it. Work the colour through the dough, adding more if you wish to increase the intensity of the colour.

4.1 The building blocks of matter (1 hour)

Tasks	Skills	Recommendation
Activity: A quick revision of the Periodic Table of Elements	Accessing and recalling information, sorting and classifying, writing	Suggested (optional revision)

4.2 Sub-atomic particles (1.5 hours)

Tasks	Skills	Recommendation
Activity: Make your own model of an atom	Reading, interpreting, accessing and recalling, making, drawing, labelling, communicating	CAPS suggested

4.3 Pure substances (3 hours)

Tasks	Skills	Recommendation
Activity: Studying representations of atoms and elements	Accessing and recalling information, interpreting, reading, writing	CAPS suggested
Activity: Atoms and molecules	Accessing and recalling information, revising	CAPS suggested
Activity: Writing and understanding simple chemical formulae	Accessing and recalling information, interpreting, sorting and classifying, reading, writing, making, drawing, communicating	CAPS suggested
Activity: Imagining the decomposition of water at the scale of molecules	Accessing and recalling information, interpreting, sorting and classifying, making, writing,	Optional
Investigation: The decomposition of copper chloride	Observing, recording information, interpreting,	CAPS suggested

4.4 Mixtures of elements and compounds (0.5 hours)

Tasks	Skills	Recommendation
Activity: Distinguishing between elements, compounds and mixtures	Sorting and classifying,	CAPS suggested

Key questions

- What is matter made up of, at the most basic level?
- What do elements look like at an atomic level?
- How are the atoms of one element different from the atoms of another element?
- Which table summarises all the elements known to humankind according to their chemical properties?
- Are atoms the smallest particles making up matter, or are they themselves made up of even smaller particles?
- What do scientists know about the 'inside' of the atom?
- Why do we say atoms are 'neutral'?
- When is a substance 'pure'?
- How is a compound different from an element?
- How is a molecule different from an atom?
- What holds molecules together?
- What happens to atoms and molecules during a chemical reaction?
- How is a mixture of elements different from a compound?

4.1 The building blocks of matter

This is synonymous with an element where all the atoms are identical (they are of the same kind).

Get learners to discuss this in class for a few minutes. You could steer the discussion with the following questions:

- Do you believe in vampires? (or fairies, zombies, the Easter Bunny, Thokoloshe, etc.)
- Do you think they really exist?
- When do we know something really exists? (When we have hard evidence for its existence.)
- Could it be that scientists did not believe in the existence of atoms because they could find no hard evidence for their existence?
- Why do you think scientists could not find evidence for the existence of atoms?
- Could it be because atoms are so incredibly small that they cannot be seen by the naked eye?

ACTIVITY: **A quick revision of the Periodic Table of Elements (LB page 77)**

This will help revise some of the concepts taught in Gr. 7 about elements and the Periodic Table.

1. This is an open-ended question for learners to show what they understand at this point about the Periodic Table, They may write explanations such as:
   - The Periodic Table lists all the elements that we know about on earth.
   - The Periodic Table classifies all the elements on earth.
   - The Periodic Table gives us information about the elements, such as their names, symbols and atomic numbers.
   - We can see patterns in the Periodic Table in terms of chemical and physical properties
2. Metals are found on the left and non-metals are found on the right
3. These are the semi-metals and they are found in between the metals and non-metals in a jagged line.
4. Any of the metals on the left hand side of the table, such as Li, Na, K, Ca, Mg, etc. and any of the non-metals on the right hand side, such as C, N, O, Cl, I, He, S, etc.
5. atomic number
6. Hydrogen is 1 and Carbon is 6.
7.

Name	**Symbol**	**Metal or non-metal?**
Hydrogen	H	Non-metal
Lithium	Li	Metal
Sodium	Na	Metal
Carbon	C	Non-metal
Silicon	Si	Semi-metal
Magnesium	Mg	Metal
Oxygen	O	Non-metal
Chlorine	Cl	Non-metal
Potassium	K	Metal
Boron	B	Semi-metal
Copper	Cu	Metal

Here we mention that atoms cannot be destroyed in **chemical reactions**. This refers to the conservation of mass during a chemical reaction. Atoms can however, be 'smashed' apart or split into smaller parts when enough kinetic energy is present, for example, in an atomic bomb. Although the name 'atom' is derived from the Greek word meaning 'indivisible', they are not truly indivisible

Get the learners to discuss this in class. Guide them towards the following ideas: Ask them to look at the map of Earth and work out what is exactly on the other side of the Earth from South Africa. If it was possible to make a tunnel through the centre of the Earth, where would the exit of the tunnel be? This is very difficult to do with a map, but with a globe one can easily see which part of the world lies opposite South Africa on the other side of the Earth.

Here are some things to help learners think about:

- A globe can show us the positions of the continents relative to each other much more realistically than any map ever could.
- a globe is more accurate than a flat map in terms of relative sizes of countries.
- A globe can also teach us about the movement of the Earth, how it spins on its own axis to create night and day.
- A globe can also show how the Earth moves around the Sun to create the seasons.
- We can also learn about latitude and longitude from a globe.

The 'Build an atom' link takes you to a website that draws a representative image of the atom, starting with hydrogen, the first element on the Periodic Table, and allows you to click through all the elements, or jump to a specific element. You could show it to the learners to introduce the next section on sub-atomic particles and then return again later to wrap up the section and reinforce all the new information.

4.2 Sub-atomic particles

In response to the "Did you know" margin box, the Higgs boson or Higgs particle was discovered in 2012. It was a huge scientific discovery. In short, the Higgs boson is a fundamental particle which plays a role in giving other particles its mass. The existence of the particle was first proposed in 1964 by a group of 6 physicists, one being Peter Higgs. Scientists searched for evidence of its existence for 50 years and eventually in July 2012 with the use of the Large Hadron Collider at CERN, they identified a particle which they thought was the Higgs boson, and have since confirmed this. Here are two sites if you would like to explore this further, either for your own interest or with your class: [1]bit.ly/163XeMI and [2]bit.ly/142RCzg .

Regarding the "take note": it is important to note that the elements are arranged by the order of increasing **atomic number** and NOT the increasing **atomic mass number**(even though the general trend is evident). Learners might infer that with each additional proton, elements further down the Periodic Table are heavier than those higher up, or towards the left. Atomic number and atomic mass number (not on their Periodic Tables) are only really dealt with in Gr. 10 so it is difficult to explain the difference. You could point out exceptions, disproving their assumption, for example, Argon – Potassium, Cobalt – Nickel, Tellerium – Iodine.

ACTIVITY: **Make your own model of an atom (LB page 81)**

You can use many different materials for this activity, such as playdough balls, beads, dried lentils or peas, pasta shells, etc. Assign learners different elements so that they will have different numbers of protons, neutrons and electrons to work with. They should choose one colour or type of object to represent each of the three types of sub-atomic particles. They must show the same number of each sub-atomic particle as they are dealing with neutral atoms (ie. the number of electrons equals the number of protons), and not with isotopes which have different numbers of neutrons.

Do you remember Dalton's 3 postulates from the beginning of the chapter? They are:

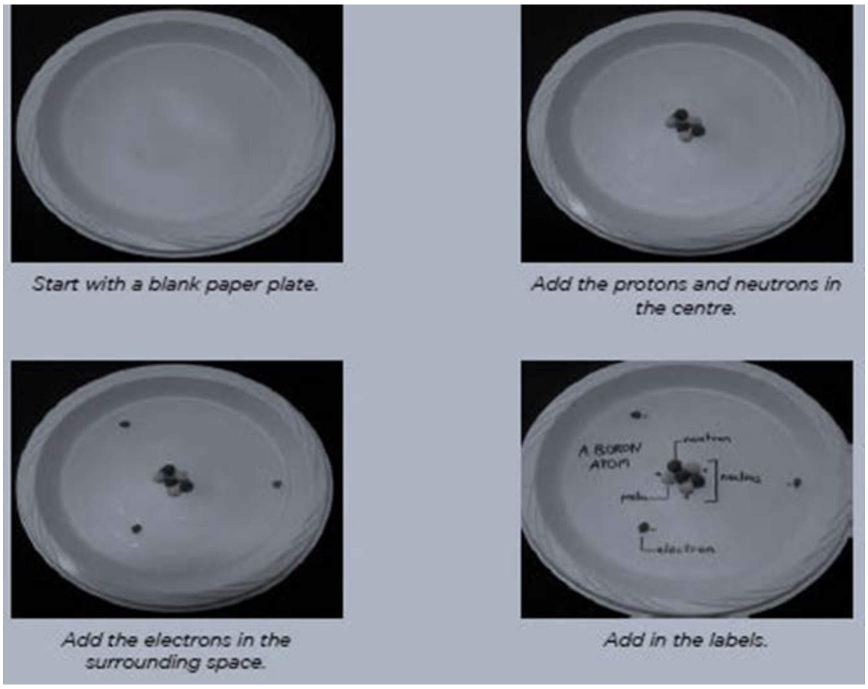
1. **Each element consists of indivisible, minute particles called atoms.**
2. **All atoms of a given element are identical.**
3. **Atoms of different elements have different masses.**

So, each element on the Periodic Table has its own type of atom. The atoms of different elements are different as they have different numbers of protons. Do you remember that we said the **atomic number** of an element is the number of protons in an atom of that element?

1. 7 protons
2. 16 protons

Learners should also be encouraged to take into account the size of the particles. So the objects they use for the protons and neutrons should be of a similar size, and the objects they use for electrons should be smaller.

Here are some photos to assist you in guiding the learners to construct their models. This example shows a boron atom as there are 3 protons.



1. Learner-dependent answer.
2. Learner-dependent answer.
3. Learner-dependent answer. This must be the same as the atomic number.
5. Learners must label the element they are doing, as well as the electrons, protons, neutrons and the nucleus.

Here is some general information on how to use simulations in the classroom: [3] bit.ly/14nA5RI . And this pdf contains more specific information for the teacher about the 'Build an atom' simulation [4] bit.ly/142dSct

The 'Just how small is an atom?' video is a nice animation that attempts to put the size of an atom and its sub-atomic particles into perspective by comparing it to real life objects like fruit, houses and cars. It is fast-paced and uses many metaphors, so could potentially be confusing and too abstract. You may want to watch it first and decide whether your learners would benefit from it.

4.3 Pure substances

Important note: In the previous section we used coloured circles/beads/balls/beans, etc to represent the different sub-atomic particles and to show how they are arranged in atoms. However, in this section as well as in the last chapter on chemical reactions, we will be using coloured circles/beads/balls/beans to represent whole atoms and the different colours and sizes will show different atoms in compounds and elements. It is important that learners realise at what scale you are working at when you draw different diagrams on the board or talk about the diagrams in this workbook.

ACTIVITY: **Studying representations of atoms and elements (LB page 83)**

1. Silver lies below copper on the Periodic Table, which means the atoms of silver are bigger than those of copper.
2. a) Learners may say they see pairs of atoms stuck together.
   b) They are relatively far apart.
   c) The substance is a gas.
   d) It is a pure substance because all the molecules look the same.
   e) Yes, they are.
   f) The elements.
   g) The substance is an element because it is made of only kind of atom. **Note:** This actually represents the diatomic elements, such as oxygen (O_2), nitrogen (N_2), hydrogen (H_2), which exist as diatomic (two atoms) molecules at room temperature.
   h) Yes, they can.

It is not important that learners answer this; it is meant to introduce the notion that both elements AND compounds can exist as molecules, but that the molecules of elements are fundamentally different from the molecules of compounds.

Learners must draw two circles joint to each other that are of the same size and colour. A suggestion is to get learners to create some of the diatomic molecules using the beads, playdough balls, etc. make sure that they know that the beads now represent whole atoms, and not sub-atomic particles.

ACTIVITY: **Atoms and molecules (LB page 84)**

This is a quick revision of what learners have just covered about atoms and molecules and being able to differentiate between the two.

1.

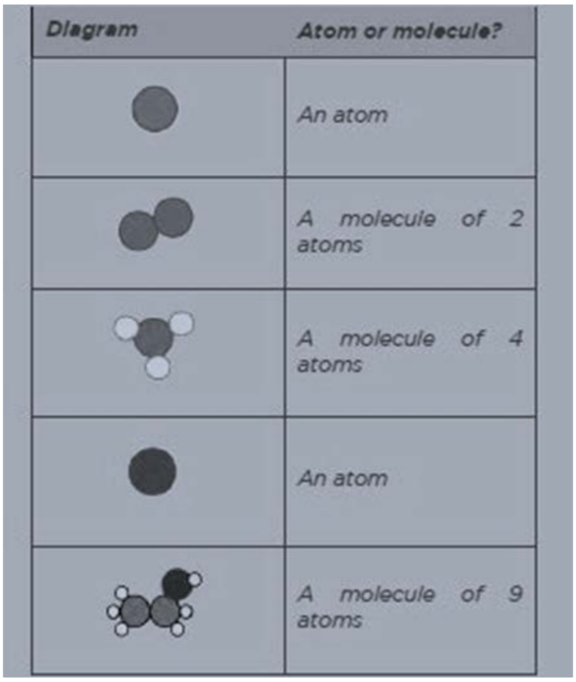


Diagram	Atom or molecule?
	An atom
	A molecule of 2 atoms
	A molecule of 4 atoms
	An atom
	A molecule of 9 atoms

2. a) 24 atoms.
   b) 3 different types of atoms make up this molecule.
   c) There are chemical bonds between the atoms.

As you are going through this content, get learners to make their own molecules using beads or play dough on the desk in front of them.

These bonds are known as covalent bonds but learners are not required to know this yet. You could also remind learners at this point that diagrams of molecules are just representations and we use different colours to distinguish between atoms of different elements. Oxygen atoms are not really red.

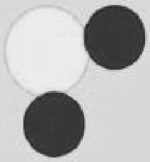
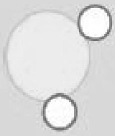
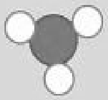
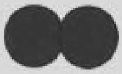
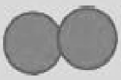
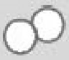
It tells us that one carbon (C) atom is bonded to two oxygen (O) atoms in CO_2. At this point, a suggestion is to write some chemical formulae up on the board and get learners to explain to you what they each tell you. Get learners to take notes in the side margins of their workbooks as you are discussing this in class. This will serve as an introduction to the next activity. For example, you can also write:

- H2 for hydrogen gas, meaning there are two hydrogen atoms bonded together. It is a diatomic molecule.
- NaCl for sodium chloride (table salt), meaning one sodium atom is bonded to one chlorine atom.
- KMnO4 is potassium permanganate. This could be slightly more challenging, but highlights that a molecule can consist of more than two different elements. Here one potassium, one manganese, one nitrogen and four oxygen atoms bonded together forming one molecule.

ACTIVITY: **Writing and understanding simple chemical formulae (LB page 85)**

At this stage it is not important that learners get the exact angles between the atoms correct, such as the angle between the hydrogen atoms in the water molecule, as they will only learn about what influences this later in Gr. 10-12.

The completed table should look as follows.

Name of substance	***Chemical formula***	***What it is made of?***	***What would a molecule of this compound look like (if we could see it)?***
Water	H_2O	*Two H atoms and one O atom*	
Carbon dioxide	CO_2	*Two O atoms and one C atom*	
Sulfur dioxide	SO_2	*Two O atoms and one S atom*	
Dihydrogen sulfide	H_2S	*Two H atoms and one S atom*	
Ammonia	NH_3	*One N atom and three H atoms*	
Oxygen gas	O_2	*Two O atoms*	
Nitrogen gas	N_2	*Two N atoms*	
Chlorine gas	Cl_2	*Two Cl atoms*	
Hydrogen gas	H_2	*Two H atoms*	

1. Hydrogen, H_2
   Oxygen, O_2
   Chlorine, Cl_2
   Nitrogen, N_2
2. Water, H_2O
   Carbon dioxide, CO_2
   Sulphur dioxide, SO_2
   Sodium chloride, NaCl
   Hydrogen sulphide, H_2S
   Ammonia, NH_3

Learners may say that magnets stick together because they attract each other. Point out to them that magnets will indeed attract each other if they are lined up correctly. Magnets can also repel each other if they are lined up differently. Learners will look more at magnetic forces in Gr. 9 in Energy and Change.

Two bonds. If you want to stretch the learners beyond curriculum requirements at this point, you could give a brief explanation of electron sharing. The details of this will only be explored in Gr. 10. These strong chemical bonds, called covalent bonds, are formed when atoms share their electrons. It explains why, after a decomposition reaction, atoms immediately re-form into something else: the electron sharing requirement that resulted in the original bond is still there; they just share electrons with a different atom.

If we had enough energy to break the O–H bonds, we would be able to separate the atoms from each other.

ACTIVITY: Imagining the decomposition of water at the scale of molecules (LB page 89)

This is an optional extension. Learners will look more at chemical reactions later in the term.

1. Four H atoms.
2. Two O atoms. 4
3. Two hydrogen molecules (H2) could be made from four H atoms.
4. One oxygen molecule (O2) could be made from two O atoms.
5. $2\ H_2O = 2\ H_2 + O_2$
6. Chemical equations will be properly introduced in the final chapter of Gr. 8 Matter and Materials, but this may be a good place to start sensitising the learners to it. You could explain that when there is just one molecule of a certain kind (the O_2 in the above example) we do not write a number in front of it in the chemical reaction. Balancing equations is not a requirement at this stage.
7. a) $C + O_2 = CO_2$
   b) The bond between the two oxygen atoms breaks.
   c) Two new carbon-oxygen bonds form when carbon dioxide is made.

INVESTIGATION: **The decomposition of copper chloride** (LB page 90)

We suggest doing this as a demonstration, or else setting up a few experiments around the class which different groups of learners can observe. The video in the visit box contains a simple demonstration of electrolysis using copper sulphate, instead of copper chloride. However, the observations will be the same – namely that copper metals coats the cathode, and you can observe the bubbles of gas at the anode (in the video this is oxygen gas, and not chlorine gas as in the investigation here in the workbook.

Instead of graphite electrodes you can also obtain carbon electrodes from used torch cells.

Wire lengths with crocodile clips at both ends are ideal. You will need these to construct an electrical circuit. Including a switch in the circuit is optional.

Copper chloride solution can be made by dissolving two teaspoons of copper(II) chloride in a cup of tap water.

1. Blue.
2. Dark grey or black.
3. The one electrode is covered in small bubbles, and the other is turning brown.
4. The solution is still blue.

If you have saved some of the original solution, the learners could compare the solution before and after the experiment. They may notice that the 'after' solution is not as blue as the 'before' solution. Get the learners to speculate why this might be. This is due to two reasons:

- The copper ions are coming out of solution as they accept electrons and become solid copper which precipitates as a reddish-brown substance on the cathode. (Learners don't know about ions or electron sharing yet so they might guess that copper atoms/particles come out of solution and accumulate on the electrode.)
- Chloride ions form chlorine gas, Cl_2, at the anode. (Learners can observe that gas bubbles form on the other electrode and possibly infer that this is chloride coming out of solution as chlorine gas.)
- Therefore, the concentration of the copper chloride solution is becoming weaker, causing it to become slightly less blue.
- One electrode is still dark grey or black. The other electrode is covered in a reddish-brown layer.
- You could point out that the electrode that remained grey-black was the one that had bubbles on it earlier. Get some of the learners to smell this electrode. They may be able to smell 'bleach', which is the smell of chlorine gas, Cl_2, forming. Ask learners to compare the colour of the layer with that of a copper coin. Could the deposit on the second electrode be copper?
- Yes, it is.
- Learners do not need to understand what is happening in the solution on an ionic level. The emphasis here is on demonstrating that a compound can be broken down into elements. However, an explanation of the electrolysis of copper(II) chloride solution is provided here for background, if you would like to extend your learners knowledge:
  - When the electrodes are attached to a power supply, the electrons move causing the electrode attached to the positive end of the battery to become positive. This is called the **anode**. The negatively charged chloride ions in solution are then attracted to the positive anode. The chloride ions give up their electrons and form chlorine gas, which is observed as bubbles.
  - The electrode that is attached to the negative end of the battery becomes negative. It is called the **cathode**. At the cathode, the positively charged copper ions in solution are attracted to the negative electrode. At the cathode, the copper ions gain electrons forming copper metal which deposits on the cathode. This is the brown coating which is observed.

(You can get learners to draw in the positive and negative signs and label the electrodes on the diagrams in their workbooks as an extension.)

	The copper chloride solution	**Electrode 1 (called the anode)**	**Electrode 2 (called the cathode)**
Before the experiment	The solution had an intense blue colour.	Dark grey surface.	Dark grey surface.
After the experiment	The solution was still blue, but the colour was less intense.	Dark grey surface but with a faint smell of bleach. During the reaction bubbles were observed.	Reddish-brown coating on the surface.

1. The copper chloride that was dissolved in it.
2. The copper chloride solution became less blue. That tells us that some of the copper chloride turned into something else.
3. Bubbles mean that a gas formed on the surface of the electrode. It smelled like bleach. Chlorine gas also smells like bleach, so it is possible that the gas we saw forming at the electrode may have been chlorine gas.

   Note: Chlorine is actually the active ingredient in bleach.

4. It is possible that the reddish-brown coating is copper.
5. The atoms in copper chloride were rearranged to make different materials: copper (Cu) and chlorine (Cl_2).

Conclusion

1. Learners' conclusions should contain at least two of the following:
   - It is possible to decompose copper chloride solution using electrical energy.
   - The compound copper chloride will decompose into copper metal (Cu) and chlorine gas (Cl2).
   - Both new materials are

4.4 Mixtures of elements and compounds

Diatomic molecules

ACTIVITY: **Distinguishing between elements, compounds and mixtures (LB page 93)**

The classifications are as follows:

a) B
b) C
c) E
d) D
e) A
f) B
g) A
h) E
i) C

j) E
k) B
l) D
m) D
n) D
o) D

Revision

1. Protons, neutrons and electrons.
2. Learners' diagrams must show the protons and neutrons clustered in the centre of the atom. These must be annotated separately (proton; neutron) as well as collectively (nucleus). The electrons should be annotated, placed outside the nucleus and the area represented by the 'electron cloud' should be large compared the to that represented by the nucleus. The atom should not have a distinct boundary. At this stage, we have only looked at neutral atoms (and not ions) and so the number of electrons should equal the number of protons.
3. a) Only SOME elements consist of molecules. Those which do not consist of molecules consist of atoms.
   b) Silver, Ag; Gold, Au; Iron, Fe

   Note: All the elements on the Periodic Table with the exception of those mentioned in the answer to question 3b fall into this category. Strictly speaking, S and P also form molecules (S_8 and P_4), but this is not examinable at this level.

   c) Oxygen, O_2, Hydrogen, H_2, Nitrogen, N_2

   Other examples are Cl_2, I_2, Br_2, and F_2. The colours are not important, but identical atoms such as the two N-atoms in N_2 should have the same colour.

4. Water, H_2O
   Carbon dioxide, CO_2, Ammonia, NH_3

   Note: Any other valid examples are permissible, but the examples learners are most likely to come up with are the ones contained in this chapter.

   Once again, the colours are not important, but identical atoms such as the two O-atoms in CO_2 should have the same colour.

5. The molecules of an element consist of one kind of atom, such as the molecules of N_2, for instance. N_2 molecules are made up of only nitrogen (N) atoms.

   Any suitable example is permissible.

   The molecules of a compound, on the other hand, consist of two or more different kinds of atoms, like CO_2, for example. CO_2 consists of carbon (C) and oxygen (O) atoms.

6. a) A, D and I
   b) C
   c) B, E, F, G and H
   d) A, C, D and I
   e) I
7. Mixtures can be separated by physical means (such as sieving, filtering, distillation, and so on), whereas compounds have to be separated by chemical means in a chemical reaction (such as electrolysis).

5 Particle model of matter

Chapter overview

5 weeks

This chapter builds on the introduction to the arrangement of particles in materials that was covered in the chapter 'Solids, Liquids and Gases' of the Gr. 6 Matter and Materials curriculum. In Gr. 6, no distinction was made between atoms and molecules. These were grouped, and the generic term 'particle' was used to refer to these fundamental building blocks of matter. This was the first introduction to the concept of matter particles. The behaviour of particles in each of the three different states of matter was used to explain the macroscopic properties of each state. In this chapter these ideas are further expanded, using the particle model of matter. Important links are made to new concepts such as diffusion, changes of state, density, expansion, contraction and gas pressure. The particle model of matter will be a strong theme throughout the rest of the Physical Sciences curriculum, especially if learners continue through to Gr. 10–12.

5.1 What is the particle model of matter? (1 hour)

Tasks	Skills	Recommendation
Activity: Changes of state revision	Accessing and recalling information, revising	CAPS suggested (revision)

5.2 Solids, liquids and gases (3 hours)

Tasks	Skills	Recommendation
Activity: Comparing solids, liquids and gases	Accessing and recalling information, comparing	CAPS suggested
Investigation: Comparing the diffusion of particles in a gas and in a liquid	Hypothesising, observing, identifying variables, recording information, comparing, interpreting information	CAPS suggested

5.3 Change of state (2 hours)

Tasks	Skills	Recommendation
Activity: Changes of state	Crossword puzzle, reading and writing, sorting and classifying	Optional revision
Investigation: What happens when we heat and then cool candle wax?	Predicting, hypothesising, planning investigation, drawing and labelling, observing, recording, analysing information	CAPS suggested
Activity: Hot water balloon	Observing, recording information	Optional extension

5.4 Density, mass and volume (1 hour)

Tasks	Skills	Recommendation
Activity: Which material is more dense?	Doing investigation, observing, comparing, communicating and group discussion	CAPS suggested

5.5 Density and states of matter (1 hour)

Tasks	Skills	Recommendation
Activity: Which has the highest density: a solid, a liquid or a gas?	Comparing, interpreting	CAPS suggested

5.6 Density of different materials (3 hours)

Tasks	Skills	Recommendation
Investigation: Comparing the densities of sand, flour, water and air	Hypothesising, identifying variables, planning investigation, doing investigation, observing, recording information, interpreting information	CAPS suggested
Activity: Rainbow density column	Demonstrating densities, comparing, observing, drawing, comparing	CAPS suggested
Activity: Some density calculations	Problem-solving, calculations	Optional extension

5.7 Expansion and contraction of materials (2 hours)

Tasks	Skills	Recommendation
Activity: How much longer?	Drawing graphs, interpreting information, predicting, demonstrating	CAPS suggested
Activity: How does a thermometer work?	Revision, comparing, identifying	CAPS suggested

5.8 Pressure (2 hours)

Tasks	Skills	Recommendation
Activity: Understanding gas pressure	Following instructions, observing, interpreting information	CAPS suggested

Key questions

- What is the particle model of matter?
- How small are atoms and molecules?
- How does the particle model of matter describe solids, liquids and gases?
- How does the particle model of matter help us understand the process of diffusion?
- How can materials be made to change their state?
- How does the particle model of matter help us to understand changes of state in materials, such as melting, evaporation, condensation and freezing?
- How are density, mass and volume related to each other?
- How do the densities of solids, liquids and gases compare?
- Which aspects of the particles in a given material influence the density of that material?
- Why does oil float on water? Is this related to density?
- How can the particle model of matter help us to understand expansion and contraction?

- How does a gas exert pressure?
- Is the pressure a gas exerts related to the number of gas particles? If so, how?
- What happens to pressure when we change its volume and temperature?

Solids, liquids and gases

Get learners to discuss this briefly in small groups and draw a table on the board to summarise learners' ideas. Out of the class, three groups could be chosen randomly, and each group could say what they know about one of the states.

Some of the properties that learners should already be familiar with are listed in the following table:

Gases	**Liquids**	**Solids**
Gases spread out and will escape if they are not in a closed container.	Liquids can flow to fill the container.	Solids keep their shape.
Gases can be compressed.	They cannot be compressed easily.	They cannot be compressed.
The particles are far apart and can move freely.	The particles are close together, but they can move around.	The particles are closely packed and cannot move from their positions.

5.1 What is the particle model of matter?

This links back to Gr. 6 Energy and Change where the topics of stored energy and movement energy were covered. In Term 3, Energy and Change, these concepts will be defined more formally as kinetic energy (movement energy) and potential energy (stored energy).

It is very important to note the misconception here that there is 'air' in between the particles. This is NOT true. The spaces between the particles are empty – called a vacuum. Take note to make sure you do not introduce this misconception.

ACTIVITY: **Changes of state revision (LB page 100)**

1. The process is called melting.
2. Freezing.
3. We can put it in a warm spot, or heat it in some other way.
4. It must first melt to become a liquid and then evaporate to become a gas.
5. Condensation.
6. Heating is adding energy
7. They vibrate or move faster.

This is because they now have more kinetic energy. This introduces the next topic and how we explain the changes of state using the particle model of matter.

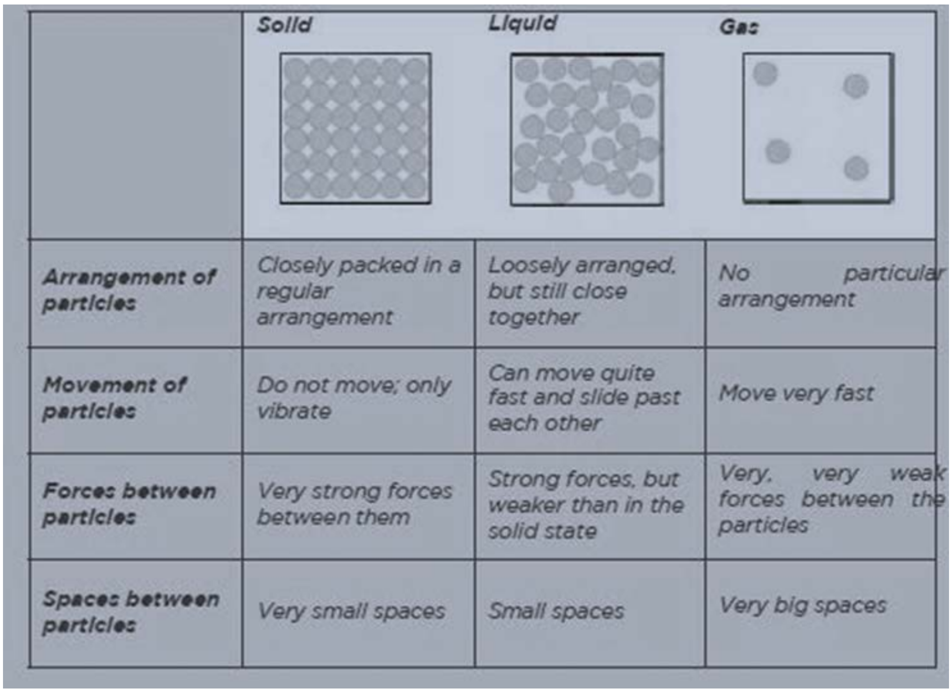
5.2 Solids, liquids and gases

Sodium chloride is NaCl. Ask learners why they think the chloride atoms are the bigger purple atoms and the sodium atoms are the smaller yellow ones in the submicroscopic view in the table. The colour does not make a difference, as long as all the same atoms are the same colour. However, the sizes show that chloride atoms are bigger than sodium atoms as can be seen from their arrangement on the Periodic Table. Point this out to learners if you have a Periodic Table stuck up in the class or they can turn to the front of their books to look at the table there.

This is a good demonstration for learners to try. Syringes are cheap and available at most pharmacies. Give each learner three syringes. Let them fill on with sand, one with water and one with air. They then close the nozzle of each syringe tightly with rubber or their finger and squeeze the plunger. Let them observe and try to explain their observations.

The answer is that the air is compressed so that a lot more air fits into the tank than if the air were not compressed. The scuba diver therefore has enough air to last up to an hour.

ACTIVITY: **Comparing solids, liquids and gases (LB page 104)**



	Solid	Liquid	Gas
Arrangement of particles	Closely packed in a regular arrangement	Loosely arranged, but still close together	No particular arrangement
Movement of particles	Do not move; only vibrate	Can move quite fast and slide past each other	Move very fast
Forces between particles	Very strong forces between them	Strong forces, but weaker than in the solid state	Very, very weak forces between the particles
Spaces between particles	Very small spaces	Small spaces	Very big spaces

These are extension questions to make sure learners can use what they have learnt about the particle model of matter to explain the observable properties of solids, liquids and gases

1. Solids have a fixed shape as their particles are arranged in a regular, fixed arrangement and they have strong forces holding them together, so the shape of the solid remains fixed. The particles in a gas do not have any particular arrangement and there are very, very weak forces between them. So, the particles in a gas can easily move around and fill the shape of the container they are in, meaning they have no fixed shape.
2. The particles in a gas have very large spaces between them, so the particles can be 'squashed' closer together, meaning the gas can easily be compressed to take up a smaller volume. Liquids have very small spaces between the particles and so it is much harder to 'squash' them together, so they are not easily compressed.
3. The cake flour is not a liquid, but a solid. Flour, and all powders, are solids made of very fine grains which are able to flow freely when they container is tilted or shaken. But these grains are solid.

This is a tricky question and you should discuss it in class. A common misconception among learners is that powders are liquids as you can 'pour' them and they take the shape of the container they are in. They are NOT liquids. Point out to learners that you cannot evaporate a powder, as you can with a liquid, the powder does not make your fingers wet when you touch it.

Get learners to briefly discuss what stink bombs are for. They may say a stink bomb can be used to play a prank on someone. The smelly particles mix with the air and when we breathe the air, we smell them.

INVESTIGATION: **Comparing the diffusion of particles in a gas and in a liquid (LB page 105)**

At this level, it is sufficient to compare the diffusion rates of liquids and gases qualitatively. We will not perform a controlled quantitative comparison of the diffusion rates. It would be possible to turn the investigation into a controlled experiment, if one used identical containers for comparing the rates of diffusion, and compared gases and liquids that have particles of similar size. It would also be necessary then to choose a gas that is coloured (e.g. bromine gas) so that learners can see the diffusion process inside the container as it progresses. It is important to note that bromine is a hazardous gas and is not freely available. It would only be advisable to use this example if you have the facilities and training to work safely with bromine. An alternative substance which will effectively demonstrate the diffusion of gases is hydrogen sulphide (H_2S). A few drops of hydrochloric acid on iron sulphide or sodium sulphide in a conical flask will produce H_2S. This can be used instead of the vanilla essence. It is important to note that H_2S has a very strong, pungent odour (characteristic rotten egg smell). It is not toxic at low concentrations, but it is important to make sure the room is well ventilated and that the windows are open. It may not be ideal to use H_2S as an example if the classroom is very small or crowded. You could also light a 'smoke bomb' (available from toy shops) outside the classroom if this is permitted at your school. The smoke mixing with air is an effective analogy of gases mixing, even though the smoke actually contains fine solid soot particles and is not strictly a gas.

If there is time it is recommended that you repeat the experiment in which gases are mixed (using vanilla essence in a saucer), but on a different day. During the repeat experiments, learners should be allowed to wave the odour particles towards the back of the classroom with their arms. Do this on a different day, to allow the vanilla smell to escape from the classroom, and from learners sensory receptors, between experiments.

Liquids mix relatively slowly when they are not stirred. It is quite possible that the liquids will not be fully mixed by the end of the lesson, and then learners should note this as an observation. Remind them to check again the following day to see if the colour has spread uniformly through the water.

Instruct the learners to smell the air and as soon as they can smell the vanilla essence they should quietly put up their hand (without waving it about). Ask the learners beforehand why they should not move while the vanilla essence particles are moving around the classroom. Answer: that would be the same as stirring the mixture, which would make it mix more quickly. It would therefore not be a fair test.

One learner could be tasked with writing the times on the board.

This is an opportunity for learners to see how the mixing time is influenced when they actively mix the air and vanilla essence particles. Get them to predict whether or not the smell will travel faster or more slowly and to discuss possible reasons for this.

1. Learners should write down what they see. These are possible observations:
   - It takes a long time for the two liquids to mix;
   - It looks as if the food colouring swirls around in the water.
   - At first, some parts of the water are more intensely coloured than others.
2. If the liquids are not fully mixed by the end of the lesson learners should note this as an observation.
3. Learner/class dependent answers.
4. Learner/class dependent answers.

5. An example of the type of table that learners could draw is given below.

Table to show the observations to smell vanilla essence with and without mixing the air		
Event	**Time measured without mixing (minutes)**	**Time measured with mixing (minutes)**
The first learner smelled the vanilla		
Approximately half the class smelled the vanilla		
Learners at the back of the class smelled the vanilla.		

Learners should be able to conclude that gases diffuse more quickly than liquids, and that if you mix or stir the air or liquid, then you speed up the rate of diffusion.

Get learners to discuss this briefly in small groups. Remind them of their observations when the food colouring was mixed with the water. Some ideas to mention are:

- When substances mix their particles intermingle.
- The process is not immediate but it takes time, because the particles have to travel from one point to another. (Ask learners if they think particles will travel in a straight line. What will happen if a gas particle collides with an air 'particle'?)

The mixture will have the same colour throughout. The last photo is almost like this, but not quite. Here is what the final drawing should look like. Note that there should be 10 yellow particles in the final container. They should be spread more or less evenly amongst the colourless particles.

No, it is not possible to predict how the food colouring/coloured liquid will swirl

Here we have to be careful not to use words that will leave learners with the impression that the particle has 'will' or moves 'with purpose'. Particles move randomly. If there was just one particle, it might actually follow a random path right out the window! It is because there are so many particles, moving in all directions, that some of them will reach our nose, or the other end of the classroom, over time

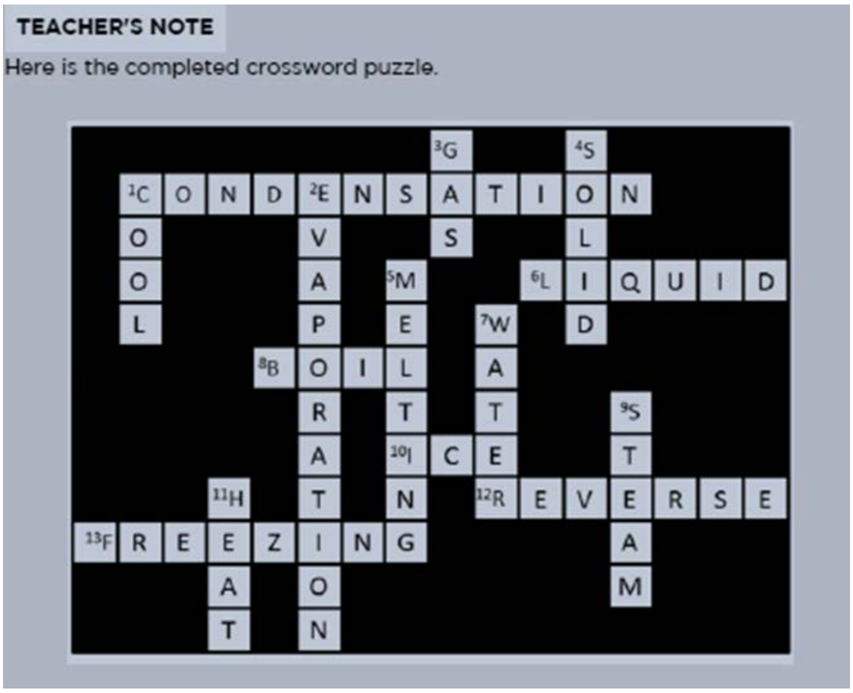
You can do a practical demonstration of this in class with your learners. Get a group of learners to stand in the middle of an open space. First let them simulate the particles in a liquid, so they should be fairly close together, but still moving around. Then get other learners to move through the crowd of learners in the middle. Get a couple of learners to do this so everyone has a chance.

Then get the learners in the middle to simulate the particles in a gas by spreading much further apart and moving around a lot more. They can also bump into each other. The other learners must now also move through the crowd, which should now be much easier and quicker for them to do.

5.3 Changes of state

ACTIVITY: **Changes of state (LB page 109)**

This is an optional revision activity of what learners should have covered in previous grades.



Get the learners to come up with some ideas in class. You should eventually guide them to realise that all changes of state involve changes in energy.

In the figure above, ask learners what they think the little lines around the particles represent. The lines get bigger and further apart as the particles go from solid to liquid to gas. This represent the amount of movement in the particles, as we will discuss in the following content. The kinetic energy of the particles increases as you add energy, and decreases as you remove energy.

A suggestion is to bring some ice to class and let it melt in a dish for learners to observe. Once the ice has melted, you can then leave the dish out in a hot place so that the next state change can take place and the water evaporates.

A suggestion is to do this quick and simple demonstration with your learners. Get groups to stand and hold hands. They can start off by swaying and moving their feet. Then they can start jumping. Then they can start jumping higher and swinging and twisting their bodies until they cannot hold each other's hands anymore. These kinds of fun, interactive learning activities make class more engaging and help concepts to stick in learners' minds. When they are standing in one spot but swaying and slightly moving their bodies while holding hands, this represents the solid state. When they are no longer holding hands and are able to move around, this represents the liquid state. Finally, to show evaporation: learners start running/moving around, one at a time. Let them run faster and faster, then break off from the swaying/jumping/moving learners in the central group – this represents a particle that has evaporated and is now in the gaseous state.

Discuss this with your class. They may simply answer that the sunshine dries the laundry faster, but ask them why they think this happens. It is because the heat from the Sun warms the molecules of the water that is in the wet clothing.

When the water molecules are heated, the molecules gain enough energy to escape from their liquid state and the water evaporates. This evaporation will happen much faster outside, in the sunshine, than inside. Encourage them to take down notes as you discuss things in class.

100°C

Learners may say that the bubbles are full of gas. Ask them to say which gas. The bubbles are filled with water molecules in the vapour (or gaseous) state. Learners often believe that the water molecules break up into hydrogen gas and oxygen gas when water boils. This is a very common misconception. This section presents an opportunity for learners to recognise that changes of state are physical changes. The molecules (particles) of a substance do not change their composition (that would represent a chemical change) during changes of state. The particles before and after the change of state are exactly the same, they are just in a different state.

INVESTIGATION: **What happens when we heat and then cool candle wax? (LB page 112)**

This is a relatively short investigation to do in class. Learners should be able to predict what will happen. The skills to focus on here are writing a method for an investigation and recording observations.

This can also be done as a demonstration in front of the class and they must observe the changes of state and record their observations. Learners must write the method themselves. They can either do this in groups and plan how they are going to do the investigation, or if you perform it as a demonstration in front of the class, then they can write the method for themselves afterwards.

You can also use ice in this investigation.

To observe and record the changes of state when candle wax is heated and when it is cooled.

A possible hypothesis is: The candle wax will melt when it is heated, and solidify when it is cooled again.

1. A possible method which learners might come up with, and which you can follow in class, is as follows: (The steps in a method must be numbered)
   - Place a piece of candle wax in the tin/foil dish
   - Place the wire gauze on the tripod stand with the tin/foil dish in top of the gauze.
   - Place the bunsen burner/spirit lamp underneath the tripod stand.
   - Light the bunsen burner and allow the tin to heat up.
   - Observe the change in state at the candle wax heats up.
   - Turn of the bunsen burner and allow the wax to cool down again.
   - Record the change of state
2. Learners must draw neat diagrams and label all the equipment used. The label lines must be parallel and drawn with a ruler
3. It is a solid at room temperature.
4. It melted.
5. It solidified.
6. The melting point of wax is higher than room temperature as it is a solid at room temperature and needs to be heated in order to melt.

A possible conclusion is: When candle wax is heated, energy is added and the particles start to vibrate faster and faster until they break free of their fixed positions in the solid state and enter the liquid state, resulting in the wax melting. When the wax is cooled again, energy is removed and the particles slow down and move slower and slower until the forces between them are strong enough to fix the particles into fixed positions in the solid state and the wax solidifies.

ACTIVITY: **Hot-water balloon (LB page 113)**

This is an optional activity. You need to be aware of the safety precautions and the fact that learners are working with hot, boiling materials. For this activity you would need access to a microwave oven. If you do not have one at school or at home, learners could do this activity as a homework assignment if they have microwave ovens at home. An alternative would be to place the balloon in a pot with boiling water for a few minutes.

1. The balloon expands.
2. It sounds as if it is raining inside the balloon.
3. The balloon shrinks

1. No, the balloon did not have any air inside it because all the air was squeezed out before we started to heat it.
2. The balloon expanded because the water inside evaporated, filling it with vapour (gas).
3. Water vapour or steam.

   Note: Here is another opportunity to address the misconception that water decomposes into hydrogen and oxygen gas when it boils.

4. It sounded as if it was raining inside the balloon
5. Water droplets falling inside the balloon.
6. The water vapour condensed inside the balloon to form droplets of liquid water.
7. It shrank back to its original size
8. Evaporation and condensation

5.4 Density, mass and volume

Do this calculation on the board. Learners need to be able to interchange between the units. 1000 x 1000 = 1 000 000 milligrams in a kilogram. You can also do some more examples, such as ask how many grams in 1.25 kg (1250 g), how many milligrams in 12.5 grams (12 500 mg)?

This is fundamentally different to weight, which is dependent on gravity, so the weight of an object will change when we are on Earth or on the Moon. Everyday language confuses the terms mass and weight, especially when talking about body 'weight'.

250 g = 0.25 kg.

Milk is 1 litre and juice is 1.5 litres.

ACTIVITY: **Which material is more dense? (LB page 114)**

This activity is included now to first introduce the concept of density. We will also look again at the densities of different materials. Learners will have to conduct their own investigation so going through this kind of activity will help them in thinking about the design for the investigation in the section on 'Densities of different materials.'

If you battle to find objects that are the same size, you can start off with some containers that are of equal volume and fill them with different substances. For example, you can use matchboxes (which will all have the same volume), and fill them with different substances such as sand, flour, sugar, cotton wool, etc.

If you do have access to a triple beam balance, do step 3 below and actually measure the mass of each object after arranging them in order of increasing density. This will help to consolidate the relationship between mass and density.

Encourage the learners to discuss the following: Why is sponge so light? Are there any similarities between the way sponge looks, and the way bread looks on the inside? Could this explain why a loaf of bread would be much lighter than a brick of the same size? Learners should be encouraged to notice similarities in the texture of substances of similar density. For instance, bread and sponge have holes or air pockets within the solid material. This means these substances would have less mass per unit volume than materials without holes.

You could bring a brick and a loaf of bread to class so learners can test this out for themselves by handling the two objects.

1. If they are the same size, it means they have the same volume.
2. The brick has more mass.
3. The brick would have the greater density. If we compare two objects of the same size, the one that is heavier (has more mass) has the greater density.

Here are some tips for teachers for the density simulation [1] bit.ly/1csJiSt

5.5 Density and states of matter

ACTIVITY: **Which has the highest density: a solid, a liquid or a gas? (LB page 118)**

This activity is used to explain the general property that solids are more dense than liquids which are more dense than gases. It is mentioned that the boxes contain the 'same material', which is important. Water, is specifically not mentioned in this activity, as it is an exception which will be discussed later. Water does not behave as other materials as the solid phase is actually less dense than the liquid phase in water. Make sure to not refer to water when going through this activity.

1. Container A contains the most particles and C the least.

Note: If learners are unsure, they can do a rough count or estimate of the number of particles in the containers. They must keep in mind that in reality, the number of particles would be impossible to count. It is important that they realise that the density of a gas is significantly lower than the densities of the other two phases.

2. The container with the most particles would contain the greatest mass; therefore A contains the greatest mass and C the smallest.
3. The solid has the highest density because it has the greatest mass. The gas has the lowest density because it has the smallest mass in the same volume.

If possible, play the video 'Light ice, heavy water' by Steve Spangler Science for your learners and ask them why the ice cube floats and the water sinks after watching the video. You can read about the explanation here:[2] www.stevespanglerscience.com/experiment/light-ice-cube-heavy-water [3] bit.ly/1cxOpA4

You could do the demonstration in the video yourself, in class. Do not tell the learners that

When the water freezes the particles have larger spaces between them. (Remind them this is a unique and unusual property of ice, that does not extend to all solids.) Once frozen, the same mass of water now occupies more volume. Water (liquid) is more dense than ice. The particles in water are packed closer together. This means more of them will fit into a given volume.

5.6 Density of different materials

The SI unit for density is kg/m^3. If you chose to do the density calculations in this section, we will mostly be using g/mL and kg/L as the units of measurement for density as the learners will be working with volumes that they measure in millilitres and litres. These are also accepted units of measurement for density.

INVESTIGATION: **Comparing the densities of sand, flour, water and air (LB page 120)**

Learners must design this investigation themselves. They can work in groups to do this. They should first discuss how they are going to do the investigation and write down their method in their notebook or on scrap paper. After completing the investigation they should then write up the method in the space provided here.

The list of materials should provide some guidance in terms of a possible procedure. Since density is mass divided by volume, learners could measure the mass of identical cups filled with sand, water and air, and calculate the approximate densities of each material. If you do not have access to a scale, then learners can just compare the densities of each material by holding the cups in their hands

1. If a fixed volume (same size cup) of each material is used, then volume is the constant or fixed variable. The cups must all be made of the same material so that they have the same masses.
2. The independent variable is the type of material.
3. Mass is measured and used to calculate density.

Learners must write the steps for their investigation in a numbered sequence. If you have access to a scale or triple beam balance, then they must measure the mass of each cup and use this to calculate the density. They will need to know the volume of the cups to do this. The volume might be written on the cups, but if not, ask them how they are going to determine the volume. A suggestion is to fill the cup with water, then pour this water into a container which has measurement (such as a beaker or measuring cylinder) and then record what the volume is.

If learners were able to measure the masses of the cups containing different materials, then they must calculate the densities using the equation$D = m/V$. An example of a calculation might look like this:

Mass of cup of flour = 150 g Volume of cup = 250 mL

$D = m/V$

$= 150/250$

$= 0,6$ g/mL

1. Learner-dependent answer
2. Learner-dependent answer.
3. Learner-dependent answer. They should include something about using the same cup for each measurement

This investigation should show that equal volumes of these different materials have different masses and therefore different densities. You can also point out that they also compared materials in different states, and they also compared two solids, namely sand and flour.

Bring cooking oil to class and demonstrate this by pouring some oil into a glass of water. Stir it to 'mix' the oil and the water and then allow them to separate out again into the different layers. The simulation link given in the visit box is quite fun for learners to experiment with and see what happens on a particle level when you mix oil, water and foam, and they can watch them separate out again.

The layer which is less dense will float on top of the layer that is more dense.

ACTIVITY: **Rainbow density column (LB page 122)**

This activity can be done as a fun demonstration for of the class. It gives a very clear illustration of the differences in density of different liquids. You do not have to use all of the items in the list of materials given below, as long as you have a few of different densities. Watch this Steve Spangler Science video in the visit box before doing this demonstration in class to get a good idea of how to demonstrate it correctly

If you have equal volumes of each liquid, the mass and density will be related and the heaviest liquids will be the most dense. Draw a table on the board to record the masses of each liquid.

If you are using the suggested liquids in the list given, the order to pour them in is as follows: honey, golden syrup, milk, dish washing liquid, water, vegetable oil, rubbing alcohol..

1. – 2. The honey is the most dense as it is at the bottom; the rubbing alcohol is the least dense as it floats on top of the other layers.
3. Yes, there is a relationship. In equal volumes of the liquids, the liquid that is the heaviest is the most dense.

   Note: This introduces the idea of equations to explain scientific phenomena (density = mass/volume). If the volume remains the same and the mass increases, then the density must also increase. Learners do not need to do calculations at this level, but if you would like to extend the exercise, you could work out the densities of each liquid using the measured mass and the volume for each liquid.

4. Dependent on objects used. If the suggested ones are used, the order would be: bolt, popcorn kernel, cherry tomato, beads, ping pong ball. The most dense objects will be at the bottom and the least dense at the top.
5. The objects drop to the different levels depending on their densities. The metal bolt is more dense than any of the liquids so it sinks to the bottom. The other objects will sink to the layer at which their density is equal to that of the liquid.

   Note: Learners might battle with this, but you can give them an example. For example, the plastic beads are less dense than water and the liquids below that, but they are more dense than the vegetable oil and the liquids above that. So, the beads will float on top of the water layer.

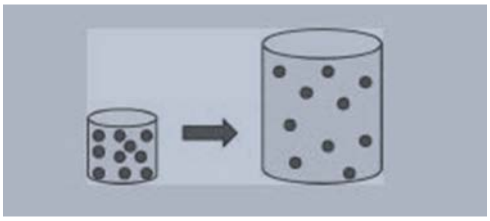
6. Depending on the objects used, but from the suggested list, those less dense than water are the ping pong ball and plastic beads, those more dense than water are the cherry tomato, popcorn kernels and bolt.

ACTIVITY: **Some density calculations (LB page 122)**

This is an optional extension activity if you would like to do some density calculations. Calculations will become an important part of physical sciences in Gr. 10-12 , so it is helpful if learners start using some of the simpler equations now.

1. D = m/V
   = 500/555
   = 0.9 g/mL
2. Chalk is more dense.
3. Density of glass = 2.6 g/mL. D = m/V
   V = m/D
   = 50/2.6
   = 19.2 mL
4. Density of glass = 2.6 g/mL. D = m/V
   V = m/D
   = 50/2.6
   = 19.2 mL

The learner's sketch should show 10 particles, spread out evenly to fill the larger container. Note that the particles should have the same size as before.



Get learners to discuss this question. They have learnt that particles move faster at higher temperatures. How would this affect the spaces between particles?

Most solids and liquids tend to become less dense as they warm up. The learners do not need to come to any conclusions at this point. The question will, however, help to introduce the concepts of contraction and expansion.

5.7 Expansion and contraction of materials

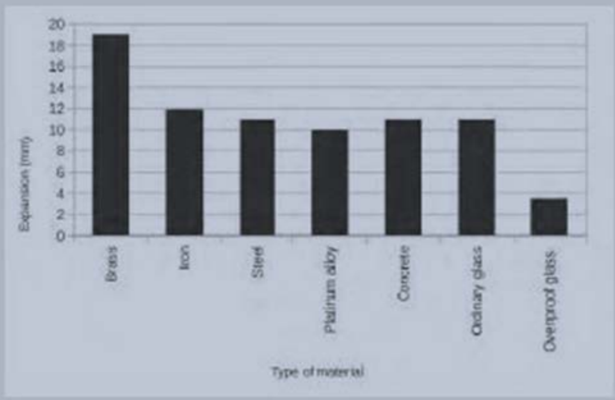
Get learners to question the possibility of new atoms forming inside the material as an explanation for the phenomenon of expansion. Guide them to the law of conservation of mass: matter cannot be created or destroyed. Materials expand and contract due to particles moving further apart or closer together, not because the number of particles increases or decreases

The road was built in segments, with small gaps between segments to allow for Expansion

ACTIVITY: **How much longer? (LB page 126)**

TEACHER'S NOTE

Here is the bar graph that learners must draw. Any appropriate title will do, for instance: Expansion of different materials when temperature is increased by 10°C (per 100 meters of material).



1. Brass
2. Ovenproof glass
3. Steel. It expands the same amount as concrete.
4. From the graph and the data in the table, we can see that brass expands much more than ordinary glass. When the weather is really hot, the brass expands so much that the window glass does not fit properly anymore and falls out.

You could advise the owner to try the following:

- Replace the brass frames with steel. Steels expands by the same amount as glass so the glass should stay in place.
- Replace the large windows with smaller windows. Smaller items expand less because there is less matter that can expand.

Note: In addition to the type of material, the amount of expansion also depends on how much material there is. This is why expansion is difficult to see in relatively small items. e.g. cooking pots. A key will still fit in a lock, even if the key has been lying in the hot sun, because expansion is not that noticeable in small items.

5. The ball does not fit through the ring when the ball has been heated. **Note:** This is a great way to demonstrate contraction and expansion if you have one of these at your school.

If you are doing a practical demonstration, get the learners to make a prediction before continuing with the demonstration. You can heat the ball in the flame of a Bunsen burner.

6. No, the brass ball cannot have a greater mass because it has not gained any mass.

The ball will contract to the same size as before because it has not gained or lost any mass.

Note: If doing the practical demonstration, get the learners to make a prediction in the time that it takes for the ball to cool down.

7. The ball will contract to the same size as before because it has not gained or lost any mass.

Note: If doing the practical demonstration, get the learners to make a prediction in the time that it takes for the ball to cool down.

Get learners to discuss this for a few minutes. Guide the discussion with the following questions: What are we adding to matter when we heat it? (Energy.) What do particles do when they are given more energy? (They move faster.) What happens to the spaces between the particles when they start to move faster and bump against each other with more force? (The spaces get bigger as the particles start moving apart.) Learners should be encouraged to take notes in discussions

Get learners to discuss this for a few minutes. Guide the discussion with the following questions: What are we taking away from matter when we cool it? (Energy.) What happens to particles when they lose energy? (They move more slowly.) What happens to the spaces between the particles when they start to move more slowly? (The spaces get smaller as the particles start moving closer together.)

ACTIVITY: **How does a thermometer work? (LB page 127)**

In Gr. 7 Matter and Materials, learners were introduced to the bulb thermometer and the idea that materials expand and contract due to changes in kinetic energy of the particles (the size and number of particles remains the same, only the spaces between the particles increase or decrease). If you have access to a Gr. 7 workbook, you can look at what they did. You can also download the PDFs of these books from the website and view the content online. In this activity these ideas are revisited and expanded upon, with the particle model as frame. Important links are established between expansion and contraction and their effects on the properties volume and density.

1. 20°C
2. The temperature reading on the thermometer on the right is 10°C.
3. Circle A is the correct one. The lower temperature has made the liquid inside the thermometer contract, so the particles are closer together. **Note:** This question provides an opportunity to identify learner misconceptions about expansion and contraction:
   - Answer B is incorrect because the particles are further apart than in the diagram on the left. The learner may be confusing the two concepts expansion and contraction.
   - Answer C is incorrect because the particles in the diagram appear to have grown larger. This is not possible since particles cannot gain mass (matter cannot be created or destroyed), nor can they gain volume. Their mass and volume are fixed, and expansion means they move further apart; the spaces between them get bigger.
   - Answer D is incorrect because the particles in the diagram appear to have grown smaller. For the same reasons as just mentioned, this is a misconception. The spaces between particles get smaller when a material contracts
4. No, the material cannot have less mass because it still has the same number of atoms as before and their mass is constant.

   Note: This is a good time to remind learners that matter cannot be created or destroyed.

5. Answer B would now represent the thermometer at a higher temperature of 30°C as the particles have gained more energy and therefore moving at greater speeds so they move further apart and the liquid expands.
6. The volume of the material increases, because the particles move further apart. The material expands.
7. The mass does not change but the volume increases, therefore the density must decrease.

   Note: It may help to refer back to the formula: density = mass/volume.

Most likely, the learners were unable to measure the mass of the air. If they managed to do so, it would probably have required quite a complicated process. They should be reminded that the air is not without mass, but that the mass of the air inside the cup is so small. (It is actually not possible to measure the mass of air when it is surrounded by more air. One way to measure the weight of air would be to do so in a vacuum. But this is beyond the scope of this discussion here for the learners.)The purpose of this short discussion is to prepare learners for the section about pressure. Measuring the pressure of a gas is one way to 'measure' how much gas we have.

5.8 Pressure

ACTIVITY: **Understanding gas pressure (LB page 130)**

One of the learners could bring their bicycle and pump to class to demonstrate the final activity.

1. It is easier to blow into the bag when it is 'empty', or when there is not much air in it and becomes increasingly more difficult to blow into as it fills with air.

   Note: If the bag is strong it may not be possible to pop it by blowing into it, because humans cannot blow with much force. A 'weak' bag may come apart at the seams or start to leak when the learners continue to force air into it beyond its capacity. Ask them to think about why this happens.

2. The balloon is difficult to blow into at first. Thereafter it becomes more easy to blow air into the balloon. When the balloon becomes stretched 'to capacity' with air, it becomes more and more difficult to blow more air into it.

   Note: The balloon is difficult to blow into at first because the material (rubber) that the balloon is made of is still very tight. It can be relaxed somewhat by stretching the balloon before blowing into it, but the first one or two 'blows' will require some effort.

   Note: After one week the balloon has become wrinkled and it is smaller than it was originally

3. b) It is impossible to blow up the balloon
   c) The balloon swells up and fills the inside of the bottle. 4a
4. b) At first it is easy to pump air into the tyre but, the more you pump, the more difficult it becomes.

1. Air particles are forced into the bag, balloon or tyre. The more you blow, the more particles are pushed into the bag, balloon or tyre. If there are more particles, there will be more collisions, and that means the pressure will be greater
2. When the bag contains as many particles as it possibly can and we try to force even more particles into the bag, the force of the collisions of the breaks
3. When the balloon contains as many particles as it possibly can, it will be stretched to its maximum size. If we try to force even more particles into the balloon, the force of the collisions of the particles against the inside of the balloon becomes too much and the balloon pops.

   Note: Actually, the polymer strands of the balloon tear apart as a result of the applied force

4. Air particles escaped through tiny openings in the material of the balloon. There are now fewer particles inside the balloon so there are fewer collisions against the inside. The force pushing against the inside of the balloon is smaller, therefore the pressure inside the balloon is smaller.

   Note: Learners may answer that the air inside the balloon has contracted and while this may be part of the explanation, there is another factor that contributes much more significantly to the shrinkage over time: air particles will slowly escape from the balloon over a period of time because the balloon polymer has tiny holes. These holes are much too small to see with the naked eye, but they are large enough for the air molecules to escape through.

5. The balloon does not inflate much because the bottle is already filled with air. There is no room for the balloon to expand inside the bottle. The air particles inside the bottle push back against the air particles inside the balloon. When the bottle has a hole in it, the air particles inside the bottle can be pushed out through the hole, as the balloon fills the space inside the bottle.
6. The more you pump, the more particles are pushed into the tyre. If there are more particles, there will be more collisions, and that means the pressure will be greater. The tyre will stretch to accommodate more air particles, but it will become more and more difficult (require more and more force) to stretch the tyre material.

The following two paragraphs are not required by CAPS but may be included as enrichment. This introduces some concepts to be dealt with in the later grades.

The gas will expand, filling the larger container

The density has decreased because the volume increased.

Revision

1. Use this question to see what learners understand by the model. They should mention something such as: The particle model of matter is a scientific theory which is used to explain how all matter (solids, liquids and gases) are made up of particles and how they behave in the different states. Learners could also mention something about the size of the particles, and that there are empty spaces between the particles.
2. Water is unusual in that the solid state is actually less dense than the liquid state and so ice floats on liquid water. This is because there are large spaces between the particles in the solid state, making the ice less dense.
3.

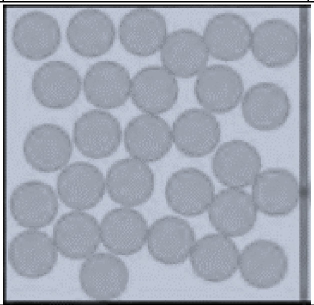
Change of state	**Explanation**
Melting	When heat is added and a solid changes to a liquid
Condensing	When heat is removed and a gas changes to a liquid
Evaporating	When heat is added and the particles at the surface of a liquid change to the gas state
Solidifying	When heat is removed and a liquid changes to a solid

4. When heat is added, the particles start to vibrate faster and faster (as they gain kinetic energy), until they move fast enough to overcome the forces holding them together in fixed positions in the solid. The particles are then able to move and slide past each other as they are not held in an orderly arrangement anymore in the solid, and the solid becomes a liquid.
5. During expansion, the spaces between the particles get bigger, and during contraction, the spaces between the particles get smaller.
6. When the metal expands (because it is heated) the particles will move further apart. The piece of metal will get bigger, but it will still have the same number of particles and so it will still have the same mass. The density of the metal has decreased.
7. Oil is less dense than water, so it floats on top of water.
8. Learner's picture should show random movement of the perfume particle, with many changes of direction
9. The petrol fumes around the petrol station are in the gas (or vapour) state. The particles in the gas can

move freely and diffuse into the air around the pumps. If you light a match close to the pumps, the petrol gas can be ignited and this can cause a fire or explosion.

Note: Usually the underground fuel tanks are safeguarded against explosions and fires. Some people say that small sparks (caused by static charges) from cell phones can also cause ignition of the petrol fumes, but scientists generally do not agree.

10. Air is a gas and water is a liquid. Gas particles have large spaces between them and that means they are easy to compress, or squeeze together. The spaces between liquid particles are so small that liquids cannot be compressed. That is why the plunger moves when there is air in the bicycle pump, but does not move much when the pump contains water.
11.

Diagram showing how the particles are arranged			
State of matter	**Solid**	**Liquid**	**Gas**
			
Arrangement of the particles	Very closely packed. Regular arrangement	Close together, but disordered.	Far apart and disordered.
Spaces between particles	Very small spaces	Small spaces.	Very large
Forces of attraction between particles	Strong	Strong but weaker than in solids	Very weak
Movement of particles	Vibration only	Sliding movement, random.	Fast and random movement
Shape	Fixed shape	No fixed shape. Depends on the container	No fixed shape
Volume	Fixed volume	Fixed volume	No fixed volume Depends on the container
Compressibility	Cannot be compressed	Slight compression is sometimes possible	Very compressible
Diffusion	Does not diffuse	Diffuses slowly	Diffuses quickly
Density compared to the other states	Highest density (except in the case of ice)	Almost as dense as the solid	Lowest density

6 Chemical reactions

Chapter overview

1 week

This chapter builds on the brief introduction to chemical reactions that was covered in Chapter 1 (Atoms) of Gr. 8 Matter and Materials, specifically the paragraph Pure Substances. The important message of this chapter is that atoms are rearranged during a chemical reaction. The atoms do not change, but how they are arranged in relation to each other does change. That means that the molecules change, even though the number of each kind of atom present at the start of the reaction, stays the same throughout. To help learners make this important conceptual connection, particle diagrams are used to represent some of the reactions in this chapter. Learners will also be given an opportunity to draw such diagrams themselves in the activities and review questions of this chapter.

The activity 'Can we use a chemical reaction to see inside an egg?' takes a few days. It is suggested that you start with it during the first lesson of this chapter. It will help to show learners that chemical change is usually observable on the macroscopic scale and that macroscopic observations provide evidence of activity on the level of particles.

It is also a good idea to make the limewater needed for the investigation 'Can clear limewater be used to detect carbon dioxide?'before you start this chapter. To make clear limewater follow the instructions below:

Instructions for making clear limewater

- Place a few tablespoons of calcium hydroxide, $Ca(OH)_2$, in a clear 500 ml reagent bottle and fill with water. Shake or stir to make a cloudy suspension.
- Leave the suspension to settle for a few days. The clear liquid above the solid $Ca(OH)_2$ is a saturated solution of Ca(OH)2, also known as clear limewater.
- Carefully decant as much of this as you need, without stirring up the solid $Ca(OH)_2$ sludge at the bottom.
- To make more, simply add more water, shake it up and let it settle again. When the sludge dissolves completely, simply add more solid $Ca(OH)_2$.

6.1 How do we know a chemical reaction has taken place? (1.5 hours)

Tasks	Skills	Recommendation
Activity: The difference between physical and chemical changes	Accessing and recalling information, sorting and classifying,	CAPS suggested
Activity: Can we use a chemical reaction to see inside an egg?	Observing, recording information, drawing and labelling, interpreting	CAPS suggested

6.2 Reactants and products (1.5 hours)

Tasks	Skills	Recommendation
Activity: Analysing the eggshell experiment	Interpreting, explaining chemical reaction	CAPS Suggested
Activity: Studying the fermentation reaction	Accessing and recalling information, interpreting	Optional
Activity: Some chemical reactions from Life and Living	Reinforcement, recalling information	CAPS suggested

Activity: Careers in chemistry	Accessing and recalling information, researching, reading and writing, communicating	Optional

Key questions

- What is a chemical reaction?
- What happens to atoms and the bonds between them during a chemical reaction?
- How can we identify the reactants and products of a reaction?
- What examples of chemical reactions are there in indigenous practices?

6.1 How do we know a chemical reaction has taken place?

Learners may remember that the rusting of iron is a chemical reaction, or they may cite some of the reactions from Chapter 1 as examples. Learners may also cite 'change of state' as a reaction. However, this is NOT a chemical reaction or change. Explain to your learners that it is only a physical change taking place not a chemical change.

Get learners to discuss this in small groups for a few minutes. Make a list on the board of all their suggestions which may include:

- The mixture may change and appear different. (In what way? There may be a colour change and bubbles or 'crystals' may form.)
- There may be an explosion.
- The mixture may change temperature, heating up or cooling down. This is NOT to be confused with physical changes during heating and cooling
- when a substance melts or solidifies for example.

Most practical manuals for introductory chemistry list only the three visual cues above as signs that a reaction has taken place. However, the non-visual signs below are also worth including here

ACTIVITY: **The difference between physical and chemical changes (LB page 138)**

This is a short activity to make sure that learners understand the difference between chemical and physical changes and uses examples from everyday life.

Here are the answers. Learners only need to state physical or chemical – some explanations have been provided as background for the teacher and if you wish to explain the changes further to your learners.

Change	**Is it a physical or chemical change?**
Cutting up potatoes into cubes	Physical
Boiling water in a pot on the stove	Physical
Frying eggs in a pan	Chemical (the egg proteins undergo a chemical change and crosslink to form a network)
Whipping egg whites	Physical (air is forced into the liquid, but no new substance is made)
Dissolving sugar in water	Physical (the sugar grains are dispersed within the water, but the individual sugar molecules are unchanged)
Burning gas in a gas cooker	Chemical (water vapour and carbon dioxide form)

Your ice cream melts in the sun	Physical
Milk turning sour	Chemical (lactic acid is produced)
An iron gate outside rusts	Chemical (iron oxide forms – this will be discussed in more detail in Gr. 9)

ACTIVITY: **Can we use a chemical reaction to see inside an egg (LB page 138)**

Start with this activity as soon as possible, because it takes a few days for the eggshell to dissolve completely. It is probably worthwhile to do the reaction in duplicate in case something goes wrong with the experiment. The egg is very delicate without its shell and may break and then it would be good to have a 'backup' egg.

1. a) The eggshell gradually becomes covered in bubbles.
   b) The bubbles are a sign of a chemical reaction taking place.
2. Note: It may be necessary to top up the vinegar if the reaction starts to slow down. Remember to return to the activity at the end of the week, when the eggshell has dissolved completely.
3. There is a foamy, brown layer floating on the vinegar.
4. The egg feels soft and wobbly. The shell disappeared because it has dissolved. In its place is a powdery coating.
5. The egg has lost its shell and we can see the egg white and the yolk inside.
6. The learners must draw pictures of the experiment at the beginning and at the end. The first picture should show an intact egg in a glass, covered with clear liquid vinegar. The second picture should show a transparent egg, with the white and the yolk clearly annotated, submerged in clear liquid vinegar with a brown layer floating on top.
7. The egg looks different. We also saw bubbles on the eggshell and afterwards there was a foamy, scummy layer floating on top of the vinegar.
8. The learner's paragraph should contain at least the following ideas:
   - The eggshell reacted with the vinegar and was 'eaten away'.
   - The eggshell dissolved in the vinegar.
   - The materials in the eggshell underwent a chemical change. They have changed into different materials.

6.2 Reactants and products

A compound is a material that consists of atoms of two or more elements that are chemically bonded together in a fixed ratio. Encourage your learners to make a note of this in the margin of their workbook.

Learner dependent answer. H_2O, CO_2, NaCl, etc

ACTIVITY: **Analysing the eggshell experiment (LB page 139)**

1. The eggshell (calcium carbonate) and vinegar (acetic acid).
2. They are calcium acetate, carbon dioxide and water.
3. Water is H2O and carbon dioxide is CO2
4. The eggshell (calcium carbonate) and vinegar (acetic acid).
5. Use this to assess learner's understanding so far. They should mention that the reactants are used to make the products.
6. They are calcium acetate, carbon dioxide and water

Teacher's guide for the PhET simulation in the visit box. [1] bit.ly/14AHLE9 Simulations are a powerful tool and we encourage you to use them if you have access to the Internet or encourage your learners to experiment with them outside of class. Learners can also access the site over their mobile phones by typing the bit.ly link into their address bar.

Get your learners to do these reactions themselves on their desks in front of them using beads/peas/lentils/balls and rearrange the atoms to make the products.

Oxygen and hydrogen.

Water.

This links back to what learners covered in Chapter 1 about diatomic molecules. These elements exist as diatomic molecules so they have two atoms joined together.

Acids taste sour.

The video on how fermentation works (5:39) is short and fun. The first two minutes give a brief description. During the rest of the video, the presenter demonstrates how to make your own ginger beer.

ACTIVITY: **Studying the fermentation reaction (LB page 141)**

Glucose is the reactant and alcohol and carbon dioxide are the products.

Learners must write glucose on the left and alcohol and then carbon dioxide on the right.

Learners would have first encountered bacteria in Gr. 7 Life and Living when studying biodiversity and the classification of organisms. They will look at microorganisms in more detail in Gr. 9 Life and Living.

This is an extension activity and can be performed if you have time in class. It may also be done as a **project.** We will also look at fermentation again in Matter and Materials next term. In fermentation, the glucose is incompletely broken down, so it yields less energy (in the form of ATP) than respiration.

Fermentation is also anaerobic meaning it does not require oxygen, whereas respiration requires oxygen. Alcohol is produced during fermentation. However, **ginger beer is non-alcoholic**. Although it is called 'beer', it is not alcoholic because it is not fermented for long enough.

A recipe for ginger beer is provided here. Learner must also research their own recipe in groups and write out the best recipe that they have. You can then either choose one of their recipes to use, or use this one, or you can test different recipes to see which one works best.

A step-by-step guide on making ginger beer. bit.ly/13teuIj

Materials

- 6 – 8 medium sized lemons
- grated rind of 2 lemons
- 250 ml (1 cup) of freshly squeezed lemon juice (from about 6 lemons)
- 2 thumb-sized pieces of fresh ginger
- 2 teaspoons of dried powder ginger
- 6 raisins
- 750 ml (3 cups) white sugar
- 5 litres of water
- 1 x 10 g sachet of instant (active dry) yeast
- grater

- lemon squeezer
- container or bucket
- wooden spoon
- large bottle
- several smaller bottles with lids
- balloons
- rubber bands

Instructions

1. Grate the lemon rind from 2 lemons into a large container or bucket.
2. Grate the fresh ginger as well using the coarse teeth of the grater.
3. Squeeze out the juice from about 6 lemons. You will need 250 ml. Add the juice to the mixture.
4. Add the dried ginger, raisins and sugar.
5. Add 1 litre of hot water (not boiling) and stir for about 3 minutes until the sugar has completely dissolved.
6. Add another 4 litres of warm water. Make sure the water is cool enough for you to hold a finger in it comfortably (otherwise the yeast will die!).
7. Sprinkle the sachet of dried yeast over the top of the water and leave it for a few minutes.
8. Stir everything with a wooden spoon.
9. Pour the liquid into a large bottle and attach a balloon over the neck of the bottle. Secure the balloon to the neck with a thick rubber band.
10. Place the bottle in a warm place but not in direct sunlight.
11. Let it stand for approximately 4 – 5 hours.
12. When the raisins float to the top the ginger beer is ready to drink.
13. Strain the liquid through a sieve. Make sure you work over a basin or similar area.
14. Pour the ginger beer into clean clear glass bottles and add a raisin to each bottle. Make sure that you do not fill the bottles completely but leave at least 7 – 10 cm between the liquid and the top of the bottle's neck.
15. Attach a balloon to the necks of half of the bottles and secure these with rubber bands.
16. Screw the lids onto the other half of the bottles.
17. Store the bottles away from heat or sunlight. (They do not need to be in a warm place.)
18 Leave it to stand overnight for at least 8 hours.
19. Gentle unscrew the caps. The gas inside will want to escape so do this slowly and carefully.

1. The chemical reaction occurs between sugar and fermenting fruit and the yeast. So the reactants are the sugar and fruit (ginger and raisins)..
2. The product is carbon dioxide (and a very small amount of alcohol).
3. It is the carbon dioxide gas that is was trapped in the liquid.
4. It is a result of the chemical reaction between the yeast, the sugar and the fermenting fruit.
5. The reactants are the wood and oxygen, and the products are the carbon dioxide and water.

ACTIVITY: **Some chemical reactions from Life and Living (LB page 143)**

This activity reinforces some concepts learned in the beginning of the year in Life and Living about respiration and photosynthesis. CAPS suggests doing the experiment again where you blow bubbles through lime water. We did this in Chapter 1 this year as an activity, but you can repeat it briefly here to show the results again if learners do not remember it well.

1. It turned a milky white colour.
2. The reactants are limewater (calcium hydroxide) and carbon dioxide and the products are calcium

carbonate and water

3. glucose + oxygen ! energy + carbon dioxide + water
4. The reactants are glucose and oxygen. The products are energy, carbon dioxide and water.
5. The reactants are carbon dioxide and water, the products are glucose and oxygen.

This section is not for assessment purposes, and you may be inclined to leave it out. However, we strongly encourage you to give your learners the opportunity to discover the applications of what they are learning in class in the world around them, even if it as a homework exercise. It is very important for learners to realise that what they learn in class extends far beyond the walls of your classroom. Encourage them to be curious!

Many learners might wonder, what is the difference between a chemist and a chemical engineer?

A **chemist** studies the composition and properties of matter. They use the knowledge they gain to develop new compounds, products and processes to improve our daily lives. A chemist requires an extensive knowledge of chemistry and must be competent in a laboratory. Chemists often research chemical reactions to be able to produce new materials and compounds. These could be new medicines, innovative building materials, new fuels that do not harm the environment, and many others. Researching new chemical reactions is complicated. The work is often researched in teams with other scientists and engineers.

A **chemical engineer** is usually involved in developing ways to produce the new compounds developed by the chemist on a large scale or to find ways of lowering the cost of producing those compounds. A chemical engineer needs a general knowledge of chemistry but also needs to know a lot about processes and what drives them.

A researcher works to discover something new, or a new way of doing things, while an engineer optimises a known process or figures out the best way to make a known compound.

Invite a chemist/engineer: 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 or engineer to come to your school and talk to your class about the work that chemists do. Alternatively, you could visit the chemist or engineer at their workplace and ask them to show you around. You could get your learners to prepare a few questions beforehand: 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. Learners could be required to write a short report on the information they have gathered. It is not for assessment purposes

Revision

1. Learner's answer should contain all of the ideas below:

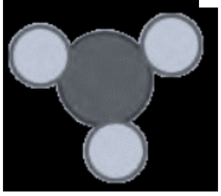
   We know a chemical reaction has taken place when one or more of the following occurs:
   - There has been a colour change inside the reaction flask.
   - A gas has formed. Usually we know a gas has formed when we can see bubbles.
   - A solid has formed. Usually we know that some solid material has formed when we can see a sludgy or cloudy deposit, or crystals forming.
   - Non-visual signs that help us to say whether or not there was a chemical reaction include:
   - Sometimes chemical changes can be smelled, for instance when a new
   - material is formed that has a strong smell.
   - Other chemical changes can be felt, for instance when the reaction causes heat to be released.
   - Some chemical changes can be heard, for instance when an explosion takes place.
2. Learners should mention that the reactants are those substances that are present before a chemical

reaction has taken place. They react to form the products.

3. Learners should mention that the products are the substances that form during a chemical reaction. They are present at the end of a chemical reaction.
4. Chemical bonds break between atoms in the reactants and new bonds form between atoms in the products.
5. a)

Name of compound	**Formula**
Methane	CH_4
Oxygen gas	O_2
Carbon dioxide	CO_2
Water	H_2O

   b) Methane (CH_4) and oxygen (O_2)
   c) Water (H_2O) and carbon dioxide (CO_2)
   d) The equation should read as follows: methane + oxygen + carbon dioxide + water.
6. a) The colours shown here are just a suggestion; what is important is that atoms of the same type should be the same size and colour, and the relative sizes of the atoms should reflect the fact that an H atom is smaller than an N atom.

Name of compound	**Diagram of one molecule of the compound**
Hydrogen gas, H_2	
Nitrogen gas, N_2	
Ammonia, N_3	

   b) An example of what learners should produce.
   c) Hydrogen and nitrogen
   d) Ammonia.
7. Carbon dioxide.
8. Limewater (calcium hydroxide) and carbon dioxide

7 Static electricity

Chapter overview

1 week

In previous grades the learners investigated circuits and current electricity. In this chapter they are introduced to static electricity. It explains how static electricity is caused by friction between objects and that charged objects are either positively or negatively charged. There are several activities in this chapter which illustrate the effects of static electricity.

An interesting article on how to encourage learners to pursue STEM (Science, Technology, Engineering and Mathematics) careers:[1] spectrum.ieee.org/at-work/education/the-stem-crisis-is-a-myth [2]bit.ly/19Bpoip

7.1 Friction and static electricity (3 hours)

Tasks	Skills	Recommendation
Activity: Sticky balloons	Observing, working in pairs	CAPS suggested
Activity: Turning the wheel	Observing, recording	CAPS suggested
Activity: Research the practical applications of static electricity	Researching, writing, summarising	Optional
Activity: Making a simple electroscope	Carrying out instructions, observing, predicting, explaining Optional	

Key questions

- What is static electricity?
- What is friction?
- Why does my hair stand on end and crackle when I pull a jersey off over my head?
- What is lightning?
- What does it mean to 'earth' an object?
- What does it mean when we say 'opposites attract'?

7.1 Friction and static electricity

ACTIVITY: **Sticky balloons (LB page 151)**

You can also do this activity using a plastic comb rather than balloons. Or else you can use pieces of paper instead of a learner's hair as not all hair will behave in the following way if it has product in it. You can then rather rub the balloon on a jersey and pick up pieces of paper.

1. – 3. Nothing happens
4. – 5. The hair should "rise" and stick to the balloon, or the pieces of paper will stick to the balloon
6. Rubbed it vigorously with the balloon.
7. The electrons are arranged in the space around the nucleus.
8. Positive charge.
9. Negative charge..
10. Neutrons are not charged. They are neutral.
11. The hair.

12. It has more positive charges.
13. The comb.
14. It has more negative charges.

ACTIVITY: **Turning the wheel (LB page 154)**

This is a fun demonstration of how like charges repel each other and unlike charges attract each other. If you have enough materials, allow the learners to try this themselves. If you don't have enough materials, do this as a demonstration but give the learners a chance to play a bit.

Practise this activity a few times first to make sure that you have the method right. Remember that it is quite easy to accidentally earth the rods so work with care. This will work best on a dry day. This will be dependent on the area which you live in.

At a brainstorming workshop with volunteer teachers and academics at the beginning of 2013, we filmed a quick demonstration of this task when the group was discussing it. You can view this short clip here: [3] bit.ly/1fFbbbJ

1. The rods now have opposite charges and so the second rod should be seen to 'pull' the other rod around in a circle
2. The learners should be able to pick up the pieces of paper with the charged rod.
3. When the rods are the same (i.e. both perspex) then the first rod should move away from the second and the top watch glass will turn in a circle.
4. When the two different materials are used then the first rod should move towards the plastic rod and the watch glass will turn in a circle towards the plastic rod
5. The pieces of paper were attracted to the plastic rod.
6. A positive charge.
7. A negative charge
8. When rubbing hair with the balloon, electrons are transferred from the hair to the balloon. The balloon now has a negative charge and the hair has a positive charge. They have opposite charges and so when the balloon is brought close to the hair again, they attract each other. Since the hair strands each have positive charges, like charges repel and the hair strands repel each other, also causing them to rise up.

The video in the Visit box shows how static electricity from the flowing petrol causes a spark which ignites the petrol fumes and leads to a large fire. It is an illustration of one of the dangers of static electricity.

The discharge of electrons from charged objects happens much more easily when the air is dry, which is why you are more likely to experience electrostatic sparks or shocks in dry weather. This is because when the weather is humid, the moisture in the air can collect on the surface of objects, and prevent the build-up of electrical charge. The charge dissipates through the moisture, which is a better conductor than air.

ACTIVITY: **Research the practical applications of static electricity (LB page 156)**

There are many different useful and damaging effects of static electricity. Here are some examples.

- useful: air filters remove smoke particles; spray painting; photocopying
- problems: dust on TV and computer screens; damage to electronic Equipment

If you do not have a Van de Graaff generator then you can use some of the videos provided here which show and explain how the generator works. If you do have a generator then allowing the learners to "play" with it will give them a good insight into the effects of static electricity. Allow learners to perform different activities, such as having their hair stand on end.

Let the learners hold onto the dome and then run the generator until their hair stands on end.

Tear up small pieces of paper and place them on the top of the uncharged dome, run the generator and the pieces will become charged and then fly off the generator. This is a good example of the pieces of paper becoming charged and then, because they all have the same charge, repelling each other.

When you touch the positively charged dome, electrons are transferred from you to the dome to discharge it. This causes you and your hair to become positively charged. The individual hair strands are then positively charged so they repel each other and stand on end.

They move apart as they now both have a positive charge and positive charges repel.

ACTIVITY: **Making a simple electroscope (LB page 157)**

If you cannot find glass jars with lids, it is possible to make lids. Use old plastic tub lids and cut out a circle the same size as the opening of the glass jar. Then use electrical tape (or even masking tape) to hold the plastic lid in place over the jar opening.

The copper does not have to be 14-gauge, but the thicker the piece, the better it holds its shape.

Detailed instructions and videos can be found on the Internet. Try video in the Visit box for an excellent description of the method

1. The two pieces of aluminium foil moved apart.
2. The aluminium foil pieces move back together.

   This next question is a test of the learners' understanding of the fact that positive charges do not move to cause charging, only electrons can move. But, a positively charged object can move. Learners often get confused with this.

   Give them a chance to reason out the answer themselves. Allow them to bring a positively charged object close to the electroscope to observe what happens and then try to figure out why the effect is seemingly the same. Rubbing a glass rod with the wool cloth will cause a positive charge to develop on the glass rod.

3. When a positively charged object is brought close to the electroscope the negative electrons are attracted towards the positively charged object and move up through the copper wire. This means that the pieces of aluminium have lost some electrons and so have an overall positive charge. Both pieces of aluminium foil are then positively charged. Like charges repel each other and so the pieces of aluminium foil move apart from each other.

Revision

1. An object which has a **negative** charge is said to have more electrons than protons.
2. An object which has a **positive** charge is said to have fewer electrons than protons.
3. Answer a.
4. Answer d.

5. 3 marks for each of the scenarios, 1 mark is awarded to the drawing and 2 marks to the explanation.

Charged spheres	Draw how they will move	Explanation

Learners must draw the spheres moving towards each other. The spheres have opposite charges, which attract, so they move towards each other.

Learners must then draw the spheres moving away from each other. The spheres have the same positive charge and like charges repel, so they move away from each other.

6. 3 marks for each of the objects, 1 mark is awarded to the calculation and 2 marks to the explanation.

Object	Overall charge	Why is it positive, negative or neutral?

Charge = 4 + (–4) = 0

It is neutral as there are equal numbers of positive and negative charges.

Charge = 3 + (–6) = -3

It is negatively charged as there are 3 more negative than positive charges.

Charge = 7 + (–3) = 4

It is positively charged as there are 4 more positive charges than negative charges.

7. Rubbing the ruler with a cloth transfers electrons from the cloth to the ruler so the ruler now has an excess of electrons and it is negatively charged.

   The pieces of paper are neutral. When the negatively charged ruler is brought near to the paper pieces, they are attracted to the ruler as the the electrons move around on the paper because of the large charge on the ruler. Electrons will move away from the ruler leaving a positive charge on the paper near the ruler, so they are attracted.

8. Friction between the floor and the trolley wheels causes a build-up of charge on the trolley. The charge is earthed by your body, causing the shock.
9. When you pull the jersey over your head the friction causes the jersey and your hair to become charged. The movement of electrons from your hair to the jersey releases energy in the form of light and sound.
10. When the truck is driving the movement of the petrol in the tank causes a build-up of charge which could cause a dangerous spark when the fuel is off-loaded. The chain earths the tank. The excess charge on the tank is allowed to dissipate to the road.
11. The girls are touching the hollow dome of a Van de Graaff generator. The dome is positively charged so electrons are transferred from their bodies to the dome to discharge it. This causes their bodies and hair to become positively charged. Their hair strands now repel each other as they are all positive (like charges repel) and they rise up.

8 Energy transfer in electrical systems

Chapter overview

3 weeks

This chapter builds on the work done in Grade 7. In Grade 7, learners investigated basic circuits, as well as energy transfers within a system. In Grade 8, learners will practice drawing electrical circuits using the correct circuit symbols. This was first introduced in primary school, so learners should be familiar with the circuit diagram symbols, however, some revision might be necessary. It is important to remind learners that circuit diagrams are just schematics of a circuit. When building a real circuit from a diagram, the real circuit will not look exactly the same as the diagram.

A common misconception which develops in circuit building is that black wires carry negative current and red wires carry positive current. This happens because of the colour coding often used on electrical meters to indicate polarity. In order to avoid this misconception, sometimes red wires can be used to connect the negative side of the battery to the negative side of the meters, or sometimes only use one colour of wire. This shows that the colour coding is arbitrary.

If you do not have sufficient equipment to allow all the learners to make all the circuits or you want to experiment with simulations, you can use the PhET simulation for building an electric circuit. You can use the PhET simulation software which can be downloaded from [1] bit.ly/GzA9d5 . You can then run an offline version on your computers. Alternatively, if you have an Internet connection, or if learners wish to use their mobile phones, these simulations will run directly within your browser from our website,[2] www.curious.org.za [3] www.curious.org.za

Before allowing your students to use the PhET simulations there are several things you should familiarise yourself with regarding the software. Make sure you know how to:

- Add components to a circuit. You need to click, hold down and drag the components from the side of the screen to where you want them.
- Connect components with wires. You can place a wire onto the screen and then drag the ends till they meet up with the component. Make sure that you are careful when connecting light bulbs. The system will create a short circuit if they are not connected correctly. This will require some practice.
- Delete wires or components or add parts. You can't just add after the circuit is built, just as in a real circuit you need to disconnect components to make space for new ones. Right-click with the mouse on the junction between two components and it will give you the option to disconnect. Right-click on the component itself, and you will be given the option to remove the entire component.
- Use the voltmeter and ammeter. The non-contact ammeter is very useful but the other one is more realistic.
- Clear the image to start something else. Your learners can save their circuits for future use if your lesson is interrupted and then load them again when you need them. If they need a blank screen in order to start again, then click on the "reset all" button.
- Reset the resistance of a resistor or light bulb or to change the potential difference of a battery. Right-click on the component and you will be given the option to adjust the settings.

If you teach only 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.

8.1 Circuits and current electricity (1 hour)

Tasks	Skills	Recommendation
Activity: A simple circuit	Recalling, identifying, interpreting, explaining	CAPS suggested

8.2 Components of a circuit (2 hours)

Tasks	Skills	Recommendation
Activity: Components in an electric circuit	Recalling, identifying, drawing	CAPS suggested
Activity: Recycling of batteries	Research, working in groups, explaining, writing	CAPS suggested
Activity: Resistance in a light bulb	Identifying, reasoning, interpreting, explaining	CAPS suggested

8.3 Effects of an electric current (6 hours)

Tasks	Skills	Recommendation
Activity: Heating a wire in a circuit	Following instructions, observing, interpreting, explaining	CAPS Suggested
Activity: Melting metal?	Following instructions, observing, interpreting, explaining	CAPS suggested
Activity: How are fuses used in everyday circuits?	Research, explaining, writing	CAPS suggested
Activity: Playing with plotting compasses	Drawing, describing, interpreting	CAPS suggested
Activity: Magnetic field around a conductor	Following instructions, drawing, describing, interpreting, explaining	CAPS suggested

Tasks	Skills	Recommendation
Activity: Making an electromagnet	Following instructions, interpreting, describing	CAPS suggested
Activity: Research the use of electromagnets	Research, working in groups, summarising, writing	CAPS suggested
Activity: Electrolysis	Observing, interpreting, describing, explaining	CAPS suggested

Key questions

- What is an electric current?
- What is an electric circuit?
- Where does the energy come from in a circuit?
- What are components?
- How do we draw electric circuits?
- What effects can an electric current produce?
- Why does the element in a light bulb glow and the element in a kettle become hot?
- What is an electromagnet and are they useful to us?

l How do you plate metal rings and earrings in gold to produce jewellery?

8.1 Circuits and current electricity

There is no need at this level to discuss the idea of conventional current. The idea of conventional current (the movement of positive charges) was developed prior to the discovery of electron movement. It was adopted as a convention so that all scientists working with electricity could communicate and compare research with ease. The mathematical models of electricity are also simpler when considering conventional current. The idea of conventional current and SI units and their importance will only be discussed in Grade 9.

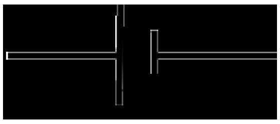
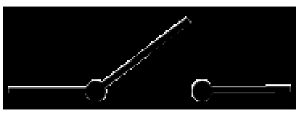
ACTIVITY: **A simple circuit (LB page 163)**

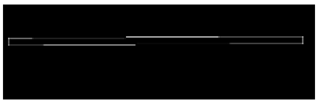
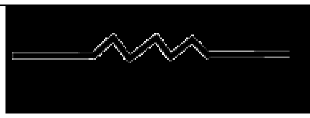
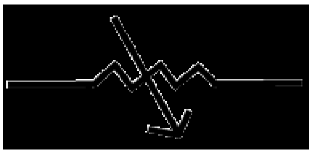
Some of these questions are revision of what learners should have covered in Gr 7 CAPS about energy transfers within a system. This acts as a revision exercise and to links back to prior knowledge to reinforce learning.

1. They are the battery, conducting wires, light bulb and switch.
2. It is closed as the switch is closed so it is a complete, unbroken pathway.
3. The battery.
4. The wires, made of metal.
5. Chemical potential energy.
6. Potential energy is transferred to kinetic energy of the electrons.
7. The bulb lights up, so it is light (and also heat).
8. The wasted energy is heat.

8.2 Components of a circuit

ACTIVITY: **Components in an electric circuit (LB page 164)**

Component	**Function**	**Symbol**
Cell	Energy source for a circuit.	
Torch bulb	Provides a light source.	
Open switch	An open switch breaks the circuit and prevents current from moving in the circuit.	

Closed switch	A closed switch completes the circuit and allows current to move in the circuit.	
Electrical wire	Conducts electricity in the circuit. Provides a pathway.	
Resistor	A component that opposes or inhibits electrical current in a circuit. It can also convert electrical energy to heat or light.	 Or 
Variable resistor	A resistor whose resistance can be adjusted higher or lower.	

4. There are 3 cells, 3 bulbs and 2 switches.
5. The one cell is in the wrong position as the two negative terminals are facing each other, instead of the negative terminal of one cell being connected to the positive terminal of the next cell
6. A switch provides an easy way of opening or closing the circuit and therefore controlling the electric circuit.
7. This is because metals are good conductors of electricity.

ACTIVITY: **Recycling of batteries (LB page 165)**

1. This activity is a good opportunity for both group work and individual work. The learners can do the research in a group but then write their paragraphs individually. Different learners in the same group may have different recycling centres closest to where they live. You can assess both the quality of their written response as well as the accuracy of their information.
2. Batteries contain toxic chemicals which can leak into the soil and contaminate the environment. Different batteries contain different substances. Lead-acid batteries, used in motor cars and other vehicles, are particularly damaging to the environment.
3. This answer will depend entirely on where the learner lives. Some areas will have little to no access to specialised collection points but most Pick 'n Pay, Spar and Woolworths stores now have battery recycling collection bins and there are various companies in the country which also offer this service.

Most municipal dumps also recycle batteries separately.

Some materials which do not conduct electricity are plastics, glass and ceramics.

This is because plastic is an electrical insulator and therefore insulates the wire.

Bring a kettle to school so that the learners can see the element inside the kettle. Also use a large, incandescent light bulb to show them the filament wire in the bulb as examples of resistors.

ACTIVITY: **Resistance in a light bulb (LB page 166)**

Try to have some incandescent light bulbs for the learners to hold and to look at. For extension you could ask the learners to research the use of argon gas rather than normal air for the gas inside the light bulb. Argon is used because it is an inert gas and will prevent oxidation of the filament, therefore lengthening the lifespan of the filament.

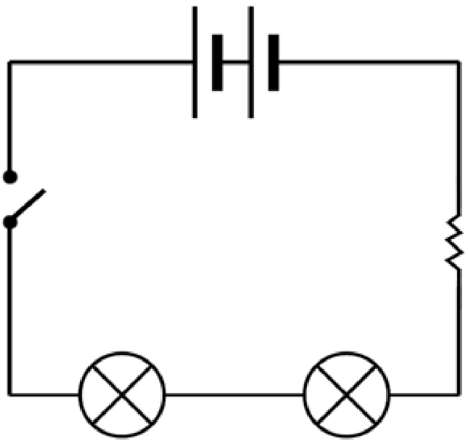
The questions in this activity would be discussed and answered as you go through it in class. Learners may not know the answers, but after discussing how a light bulb works with them, they should then write their own answers.

1. Electrical energy is transferred to heat and light.
2. Light is the useful output and heat is the wasted output.
3. **Note:** This is an extension question as learners will only cover factors affecting resistance later so discuss this as a class. This is to fit a longer length of tungsten within a small space to increase the resistance, and therefore brightness of the bulb.
4. Glass is an electrical insulator, so it will not conduct electricity and all the current will pass through the filament.
5. This is so that the electrical current can pass in through the electrical contact at number 10 and then through to the wire at number 7, which is touching the inside of the metal insulating cap.

The link in the Visit box is an interactive tutorial and set of activities and quizzes to revise electric circuits and circuit diagrams.

If you want to revise some of the concepts from previous years, you can discover more online at[4] www.curious.org.za [5] www.curious.org.za

Learner's diagram should look as follows:



8.3 Effects of an electric current

A useful video on heat for extra, background information [6] bit.ly/18K0Aov

ACTIVITY: **Heating a wire in a circuit (LB page 168)**

This activity is to demonstrate that an electric current travelling through a resistor will cause the resistor's temperature to increase.

Nichrome wire can be bought at any hardware store. Do not leave the circuit on for too long. You want the learners to feel the warmth from the wire, not to burn themselves. This experiment can also be performed with the graphite from a pencil which will emit light as well as heat.

3. The wire should be cold
6. The wire should be hotter than when they first touched it.

These questions can be used to assess whether learners have grasped the concept. They can be completed after the activity, or the next day in the following lesson as a revision of what was done, or as a homework task.

1. When the circuit is complete, there is a flow of charge (electric current). The electrons moving through the wire transferred energy to the wire in the form of heat. The particles in the wire therefore have more kinetic energy and so the temperature increases.
2. Examples include: iron, kettle, heater, geyser, toaster.
3. Iron: The metal part of the iron has a high resistance and so it gets hot. This allows us to smooth out the creases in material.

   Kettle: The element of the kettle has a high resistance and so it gets hot enough to boil the water.

   Heater: The element in a heater has a very high resistance and so it gets very hot. The element heats the air around the heater.

4. The electric current passes through the toaster and the element has a high resistance. Energy is transferred to the particles in the element so that they gain kinetic energy and the temperature of the wire increases. Some of the energy is also transferred as light to the surroundings and the wire glows

ACTIVITY: **Melting metal (LB page 169)**

Fuses are a practical application of the heating effect of an electric current. In this activity the learners will see that an electric current can melt a metal, not just warm it up. If you have enough equipment you could allow small groups of learners to complete this activity. Otherwise, use it as a demonstration.

The light bulb is included to show that the current is flowing while the steel wool is in place but not flowing when the steel wool melts. The variable resistor is used to show that when the resistance is high, the current is low enough that the fuse warms up but doesn't melt. When the resistance is lowered, the current increases until it melts the steel wool.

If you are demonstrating and you want to make the activity more exciting, you can use a small ball of steel wool instead of a wire. This should make the steel wool spark and burn. This should be done behind a screen as the sparks could land on a learner.

If you do not have a variable resistor then leave it out of the circuit and rather explain the concept. An ammeter is also not crucial in doing this activity as the light bulb can be used to indicate whether there is current or not.

2. This must not be very thick. Just a few strands will do.

5. The light bulb should glow and the steel wool should warm up but not melt
9. The steel wool melts/burns and breaks up and the light bulb stops glowing

2. The light bulb is a good indicator of whether or not there is a current in the circuit. If the light bulb glows it means there is electric current. If the light does not glow it means that there is no current (or there is a very small current).

   Note: Sometimes though there might still be a very small electric current, but it does not provide enough energy to cause the light bulb to glow. This is why the light bulb gives a good indication, but an ammeter will provide the most definitive indication of whether there is a current or not.

3. The current increases when the resistance decreased. The ammeter reading increases.
4. The current stops because the circuit has been broken. There is no longer a complete pathway for the electrons to move.

Either switch off the toaster and then unhook the toast (safest idea!) or use an insulator (plastic) utensil to unhook the toast.

ACTIVITY: **How are fuses used in everyday circuits? (LB page 170)**

This activity is an opportunity for individual research. There will be other opportunities for group research. It is important that each learner is able to do basic research so that they are able to contribute effectively to a group research task. The learner should write a short paragraph detailing their research. There are many different household appliances which use fuses.

Learners may choose any of them. Remember to make sure that all learners include references for any research they do. They need to learn from an early age to credit sources of information.

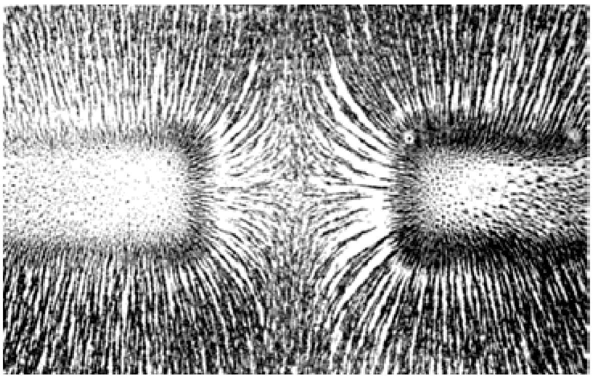
This answer will depend on the appliance chosen. Ensure that the paragraph doesn't only describe the appliance but also explains why the fuse is necessary to prevent accidents.

ACTIVITY: **Playing with plotting compasses and magnets (LB page 171)**

This activity allows the learners to see that a plotting compass will respond to a magnetic field. It will allow them to visualise the lines of the magnetic field around a bar magnet. Once the learners are convinced that the plotting compass can model a magnetic field, you can use the compasses to show them that there is a magnetic field around a current-carrying conductor.

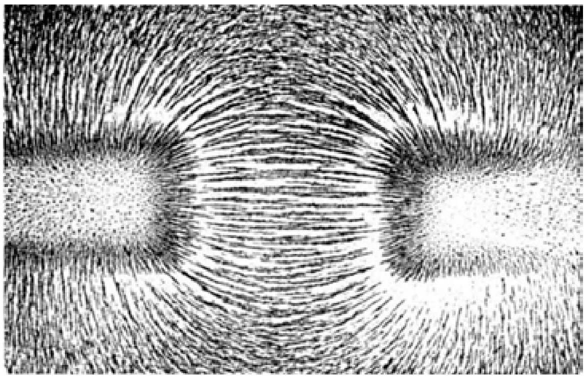
3. Do not assess drawing skills but make sure that the drawing clearly shows that the plotting compass needles have "lined" up and make a discernable pattern. It is not necessary at this stage to explain the pattern. It is just important that the learners realise that a plotting compass will respond to a magnetic field.
4. Learners should describe how they see the iron filings clump together into long lines indicating the magnetic field at each point.

As an extension to indicate to learners how two like poles repel each other, but two opposite poles attract each other, place two bar magnets on a surface with two like poles facing each other and sprinkle iron filings over the piece of paper. You should observe something similar to the photo below.



Magnetic field of bar magnets repelling.

Next, turn one magnet around so that opposite poles are now facing each other and sprinkle the filings over the paper again. You should observe a pattern similar to the photo below.



Magnetic field of bar magnets attracting.

ACTIVITY: **Magnetic field around a conductor (LB page 172)**

This activity will show the learners that the plotting compasses align with a magnetic field around a current-carrying conductor. It is important to make sure that the learners realise that it is a 3D magnetic field and that it surrounds the conducting wire. Learners often assume that the magnetic field only exists where the plotting compasses are placed.

3. The needles should point to magnetic north.
5. The drawing does not need to be assessed according to the learners drawing skills. What is important is that they see that the compass needles are aligned in a circle when the switch is closed
6. That there is a magnetic field around the wire.

ACTIVITY: **Making an electromagnet (LB page 173)**

If the learners' electromagnets are not strong enough to pick up the paperclips, suggest they use more batteries or add more coils of wire to the nail. Make sure that their coils are tightly packed, all in the same direction and do not overlap anywhere.

1. The paper clips should be attracted to the nail.
2. The electrical current in the coiled wire caused a magnetic field to form. The magnetic field attracted the metal in the paper clips.

3. The disconnected nail didn't attract the paper clips because there was no current in the wire and so there was no magnetic field.

ACTIVITY: **Research the use of electromagnets (LB page 173)**

Assign different applications to different groups so that you cover a range in the class.

Here is a general description of each application.

Speakers:
The voice coil of a speaker is an electromagnet. The power to the electromagnet is switched on and off in the same sequence as the incoming sound wave signal. This causes the magnetic field to switch on and off. When the magnetic field switches on and off the electromagnet moves backwards and forwards. This movement moves the diaphragm of the speaker and causes the air in front of the speaker to vibrate, causing a sound wave.

Electric bells:
The electric bell uses an electromagnet to move the striker backwards and forwards onto the bell itself. As the striker hits the bell the circuit is broken and the electromagnet switches off, a spring pulls the striker back into position, completing the circuit. When the circuit is complete the electromagnet switches back on and is attracted to the other magnet on the bell. The striker is then pulled to the bell. This process is completed until the bell is switched off.

Telephones:
The input sound from the person speaking is converted into an electrical signal which travels to the listener's device. The electrical signal has the same fluctuations and frequency as the speaker's voice. This current flows through a solenoid and causes an electromagnet to switch on and off. This causes the diaphragm to move in and out which causes a sound wave.

Magnetic trains (MAGLEV):
MAGLEV trains use the fact that magnets repel each other to power the trains. There are magnets on the track and on the bottom of the train. By alternating the current in the rails the train can be pulled forward by attraction between unlike poles and propelled forward by the repulsion of like poles. This website provides a good description: [7] bit.ly/1dTQQuM

Industrial lifters and separators :
Electromagnets can be used to separate ferromagnetic materials from non-magnetic materials. When the electromagnets are switched on they attract the magnetic materials but leave the non-magnetic materials behind. When the electromagnet is switched off, it releases the magnetic materials.

ACTIVITY: **Electrolysis (LB page 174)**

This activity will demonstrate the chemical effect of electricity. There is no need to explain the mechanism of the chemical reactions which occur. You might have already done this as a demonstration in Matter and Materials in Chapter 1 (Atoms). If you want to revise what you did then, you can explain why copper forms on the negative electrode and chlorine gas forms at the positive electrode.

If you don't have carbon electrodes then you can strip the wood from an HB pencil. Do this carefully so that the carbon rod in the centre doesn't break. You don't have to strip all the wood off the pencil. Strip off some from the bottom to allow it to make contact with the copper sulphate solution and enough wood off the top to allow the crocodile clip to grip the carbon. The pencil carbon is not pure and so won't work quite as effectively as pure carbon electrodes.

To make a copper chloride solution, dissolve 15 g of copper chloride in 100 ml of warm water.

This torch bulb is not strictly necessary. It is just to show that there is a current in the circuit and that there is still a complete pathway.

Nothing is happening at either electrode. This is because the current is not Flowing

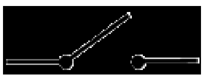
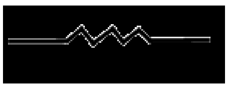
1. Yes.

NOTE: If the torch bulb does not glow then there is no current in the circuit. Make sure that the electrodes are not touching each other and neither are the crocodile clips. The crocodile clips must not be touching the solution either.

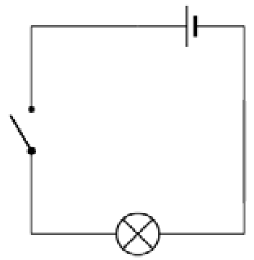
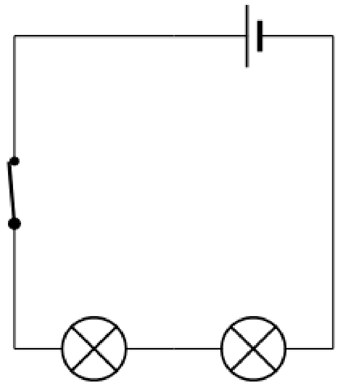
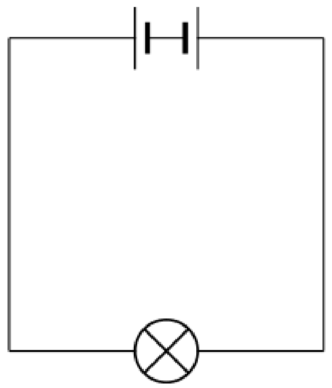
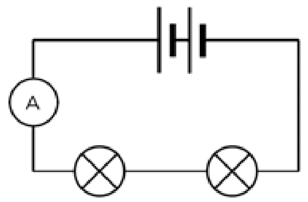
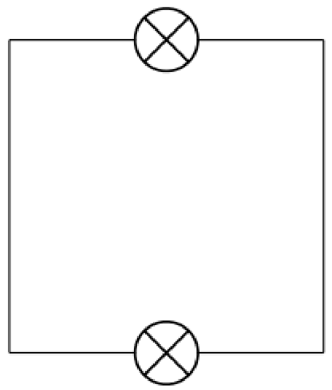
2. One of the electrodes should be developing a layer of copper and there should be bubbles developing at the other electrode.
3. Learners should be able to smell the chlorine gas.
4. The copper chloride solution is being chemically separated into pure, solid copper and chlorine gas.
5. Bubbles are no longer forming at the electrode because the reaction has stopped.
6. The electric current is separating the copper chloride.
7. It would cause a short circuit. The electrical current will then not move through the copper chloride and no separation will occur

Revision

1. An electric circuit is a closed, complete electric pathway or system for transferring electrical energy.
2. It has potential energy.
3. An electric current is the movement of charge/electrons. It is possible in metals as the electrons are delocalised, meaning they are not associated with an atom and are free to move through the wire.
4. There are many different materials which conduct electricity, any 3 can be listed, such as various metals.
5. There are many different materials which are insulators, any 3 can be listed, such as plastics, glass, ceramics.
6. This diagram should have the components connected in series with each other. There should be a gap in the circuit which can be filled by the different materials to be tested. A possible diagram is given here:
7.

A cell 	A light bulb 
A conducting wire 	An open switch 
A resistor 	A variable resistor 

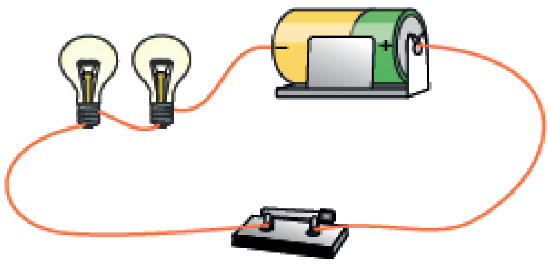
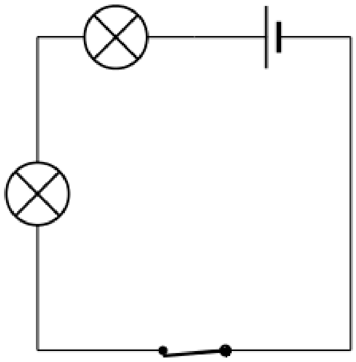
8.

Circuit	Glow/Not Glow	Explanation
	Will not glow.	The switch is open so the circuit is broken.
	Will glow.	The switch is closed and there is a complete circuit.
	Will not glow.	There is a closed circuit but the two negative terminals of the cells are connected, rather than a negative connected to a positive terminal.
	Will glow. There is a complete circuit with an energy source.	
	Will not glow.	There is a complete circuit but no energy source.

9. Setup B is the correct connection as there is one electrical contact point in the tip of the bulb and the

other point of contact is the metal casing.

10.

Image	Circuit diagram
	

11. A fuse is a safety device to prevent overheating in the circuit. A normal wire would not melt if overheated and so would not prevent damage or fires. You should not let him.
12. The aluminium foil can conduct electricity. This means that a short circuit has been created. The short circuit caused a large current which would have melted a fuse and broken the electric circuit. This would have caused the electricity to switch off.
13. A circuit breaker is advantageous to use over a fuse as a fuse needs to be replaced once the metal wire melts, whereas a circuit breaker automatically detects the fault in the circuit, breaks it, and can then be reset to start operating again, either manually or automatically once the fault has been repaired.
14. **Note:** 1 mark is for labelling the filament and 3 marks for the explanation. When an electric current passes through the tungsten filament, it experiences resistance as the tungsten has a high resistance. The tungsten wire therefore heats up as energy is transferred from the moving electrons to the wire. The wire heats up and also emits light.
15. a) Yes, there is.
    b) We know this because when there is current in an electric wire, it generates a magnetic field around it. The plotting compasses respond to the magnetic field as the arrows are all pointing around in a circle and not all the same way as they would do if there was no current.
16. To prevent corrosion and enhance its value.

9 Series and parallel circuits

Chapter overview

2 weeks

This chapter builds on the Gr 6 and 7 electric circuits work, and the previous chapter of this book. Up until now, we have only been looking at simple circuits. We will now examine the concept of series and parallel circuits. We will look at the difference between these two set-ups in circuits, specifically looking at the effects of adding resistors in series or in parallel and observing the change in brightness of bulbs. The use of ammeters has also been included in this chapter. However, if you do not have these instruments, you can simply do a qualitative study, using the brightness of the bulbs.

You can also use the PhET simulations where learners can build their own circuits and test them out, observing the effects when they add or remove various components. These simulations will run directly within your browser from our website, [1] www.curious.org.za . Here is a link to a guide (in pdf format) written by PhET in the use of some of the electric circuit simulations: phet.colorado.edu/files/teachers-guide/circuit-construction-kit-dc-guide.pdf

9.1 Series circuits (2.5 hours)

Tasks	Skills	Recommendation
Investigation: What happens when we add more resistors in series?	Investigating, hypothesising, following instructions, observing, interpreting, recording, analysing, writing, working in groups	CAPS suggested
Investigation: How does adding more cells in series affect the current?	Investigating, hypothesising, following instructions, observing, interpreting, recording, analysing, writing, working in groups	CAPS suggested
Investigation: Testing the current strength	Investigating, hypothesising, following instructions, observing, interpreting, recording, analysing, writing, working in groups	CAPS suggested

9.2 Parallel circuits (3 hours)

Tasks	Skills	Recommendation
Activity: Series or parallel?	Identifying, describing	CAPS suggested
Investigation: How does adding resistors in parallel affect the current strength?	Investigating, hypothesising, following instructions, observing, interpreting, recording, analysing, writing, working in groups	CAPS suggested
Investigation: What happens to the current strength when cells are connected in parallel?	Investigating, hypothesising, following instructions, observing, interpreting, recording, analysing, writing, working in groups	CAPS suggested

Investigation: Testing the current strength	Investigating, following instructions, observing, interpreting, recording, analysing, writing, working in groups	CAPS suggested
Activity: Which metals offer the most resistance?	Following instructions, observing, interpreting, working in groups	CAPS suggested

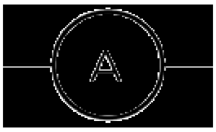
9.3 Other output devices (0.5 hours)

Tasks	Skills	Recommendation
Activity: Sankey diagrams	Drawing, explaining	CAPS suggested
Activity: History of electricity production	Research, summarising, working in groups, writing	CAPS suggested (can be done as homework task)
Activity: Careers	Research, writing	Optional

Key questions

- Are there different types of electric circuits?
- If all the light bulbs in a house are part of the same circuit, how can you switch one light off without the rest also turning off?
- What is a series circuit?
- What is a parallel circuit?
- What happens when you connect more components in series or in parallel?

9.1 Series circuits



Ammeters have an extremely low resistance because they must not alter the current they are measuring in any way.

INVESTIGATION: **What happens when we add more resistors in series? (LB page 181)**

The aim of this investigation is to show the learners that adding more resistors in series causes the overall resistance of the circuit to increase and that this reduces the current strength.

This is a good opportunity for group work if you have enough equipment, but make sure that each learner is able to connect an ammeter correctly and is able to read the ammeter scale accurately. If you do not have sufficient equipment for all the learners, you can do this experiment as a demonstration. Perhaps give several learners an opportunity to come up to the front and help to connect the ammeters. If you do not have any ammeters then you can use the brightness of the bulbs to indicate current strength. The larger the current, the brighter the bulb will glow. This means that if the bulb glows brightly, it must have a large current moving through it. If the bulb is dimmer, it means that there is a smaller current flowing through it.

If you do not have the physical apparatus for this investigation but you do have Internet access, use the PhET simulations found here: bit.ly/17vBMBX

The simulations are also useful because the ammeters (and voltmeters) commonly used in school laboratories are often not calibrated correctly or not serviced regularly and so often give slightly inaccurate results.

This is a learner-dependent answer. The hypothesis should relate the dependent and independent variables and make a prediction. The dependent variable will change as the independent variable is changed. Here is an example of a possible answer:

As the number of resistors increases, the current strength decreases.

It is important that the torch bulbs have the same resistance and are not randomly selected. The switch is not an essential part of this investigation. It can be left out of the circuit.

The brightness of the bulbs is a qualitative comparison. Learners should use "bright, brighter, brightest" as a way to describe the glowing bulbs. The graph should show the quantitative data of the ammeter reading and the number of bulbs. If you do not have an ammeter to take readings, either do not draw a graph, or change the graph to a bar graph which has bright, brighter, brightest as the values on the y-axis. This is not a particularly useful graph but will give the learners a chance to practice drawing a bar graph and give them a visual representation of the decrease in current strength as the number of bulbs increases.

These results are an example of possible results. The actual results obtained by the learners will differ but the trend should be similar. As the number of bulbs in series increases, both the ammeter reading and bulb brightness should decrease.

Number of bulbs in series	Brightness of bulbs	Reading on ammeter (A)
1	brightest	0,15
2	bright	0,07
3	dimmest	0,05

Using standard ammeters may not give perfect results and if the bulbs are allowed to heat up too much in between adding more bulbs, their resistance will be higher. It is important that the learners see a downward trend

1. The bulbs became dimmer as more bulbs were added.
2. The bulbs glowed with the same brightness.
3. The bulbs glowed with the same brightness.
4. If all the bulbs glow the same, it means that they all experience the same current. This means that the current is the same everywhere in a series circuit.
5. The ammeter reading decreased.

1. As more bulbs were added, the current decreased.
2. This answer will depend on the hypothesis written by the learner at the start of the investigation

INVESTIGATION: **How does adding more cells in series affect the current? (LB page 182)**

This investigation will show that adding more cells in series increases the current strength. Be careful with this activity because if you do not have enough resistance in your circuit, you can damage the torch light bulbs. Use at least two torch light bulbs or a torch light bulb and a resistor in order to keep the resistance high enough. If you have ammeters, you can use quantitative data to show that adding more cells in series increases the current strength. If you do not have ammeters, then use the brightness of the bulbs as qualitative data. Use terms such as dim, bright, brightest. The learners will not be able to draw effective graphs with the qualitative data, but you could give them the example data in the teacher's guide and ask them to draw a line graph if they need practice.

This answer is learner-dependant. They must mention how the dependent variable will be affected by the independent variable. Remember that the hypothesis does not need to be factually correct. They will prove or disprove it by completing the investigation. Here is an example of a possible hypothesis: As the number of cells connected in series increases, the current strength increases.

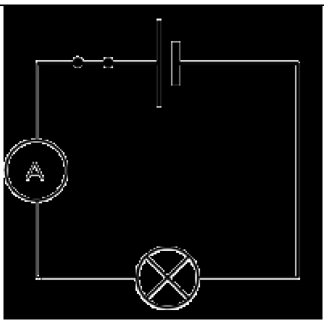
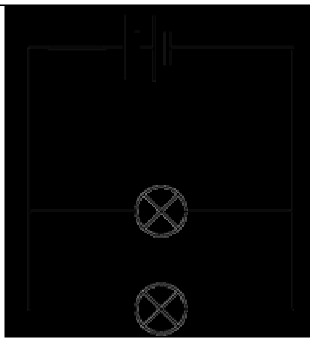
These results are example results. The actual results obtained by the learners will differ but the trend should be similar. As the number of cells increases, both the ammeter reading and the bulb brightness should increase.

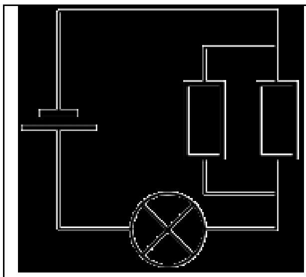
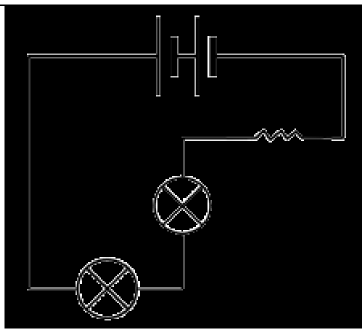
Number of cells in series	Brightness of bulbs	Reading on ammeter (A)
1	dimmest	0.07
2	bright	0.15
3	brightest	0.2

1. As the number of cells connected in series increases, so does the current strength.
2. This answer depends on the learner's original hypothesis

9.2 Parallel circuits

ACTIVITY: **Series or parallel? (LB page 184)**

	
Series	Parallel

	
Parallel	Series

INVESTIGATION: **How does adding resistors in parallel affect the current strength? (LB page 184)**

This investigation will show the learners that increasing the number of resistors in parallel to each other, causes the overall resistance of the circuit to decrease and the current strength to increase. There is no need to discuss how to calculate the effective resistance of a parallel circuit. The learners just need a qualitative understanding.

If you do not have physical apparatus for this investigation but you do have Internet access, use the PhET simulations found here: 3 bit.ly/17vBMBX

This is a learner dependant answer. Learners need to mention the independent and dependent variables. The dependent variable will change as the independent variable is changed.

Here are two examples of an acceptable hypothesis:

- As more bulbs are added in parallel, the current strength will decrease OR
- As more bulbs are added in parallel, the current strength will increase.

It is important that the torch bulbs are the same resistance and not randomly selected. The switch and ammeter are not strictly necessary for this experiment. They can be left out if you don't have enough switches or ammeters

The brightness of the bulbs is a qualitative description. The learners should use "bright, brighter, brightest" in order to describe the glowing bulbs

The graph will show the relationship between the main current (reading on the ammeter) and the number of bulbs connected in parallel. As more bulbs are connected in parallel, the current strength should increase because the overall resistance of the circuit decreases. This means that the graph should be a straight line with an increasing trend. Standard ammeters may not be accurate enough to produce a perfectly straight line. This is not as important as seeing the upward trend.

These results are just an example. The actual results will depend on the circuit set up by the learner.

Number of bulbs in parallel	**Brightness of bulbs**	**Reading on ammeter (A)**
1	dimmest	0.15
2	brighter	0.3
3	brightest	0.45

1. The bulbs became brighter as more bulbs were added.
2. The bulbs glowed with the same brightness.
3. The bulbs glowed with the same brightness.
4. As all the bulbs are identical, if they all glow the same brightness, then they all experience the same current. This means that the current is the same in each branch.
5. The ammeter reading increased.

1. As more bulbs were added, the current increased.
2. This answer will depend on the hypothesis written by the learner at the start of the investigation.

INVESTIGATION: **What happens to the current strength when cells are connected in parallel? (LB page 186)**

This is a learner-dependent answer. Learners need to identify the independent and dependent variables. The dependent variable will change as the independent variable is changed.

Here are two examples of an acceptable hypothesis:

- As more cells are added in parallel, the current strength will decrease OR
- As more cells are added in parallel, the current strength will increase.

The ammeter is not essential to the experiment. The brightness of the bulb can serve as a qualitative measure.

The brightness of the bulbs is a qualitative description. The learners should use "bright, brighter, brightest" in order to describe the glowing bulbs. The ammeter readings should stay the same.

1. The brightness of the bulbs should not change.
2. The ammeter readings are the same.
3. Adding cells in parallel does not change the overall current strength.

ACTIVITY: **Which metals offer the most resistance? (LB page 187)**

This activity only compares the effect of the type of material on resistance. The other factors that affect resistance will be covered in the Grade 9 Energy and Change syllabus.

Each metal will have a particular resistance based on the resistivity. You do not need to measure the resistance of each metal, all that is required is a qualitative description of the light bulb. The brighter the light bulb, the higher the current. If there is a high current it means that there is little resistance. So the brighter the bulb glows, the less resistance offered by the metal wire. The learners may make small mistakes if the brightness of the bulbs is difficult to distinguish.

Use whichever metal wires you have available. Try to get copper and nickel. You could twist aluminium foil into a wire (just make sure it is the same length and approximate thickness as the other metals). Aluminium wire will often ignite if placed in a circuit so test it beforehand and make sure that it does not get too hot. If you use the materials listed below, then nichrome will have the highest resistance, followed by zinc, then aluminium and copper has the lowest resistance of the four.

The actual length of wire that you use is not important, but they should all be the same length and thickness. If you cannot find these metals, any other combination of metals can be successfully used.

1. An example circuit diagram with the break in the circuit where metals are to be tested shown on the left.
2. High resistance opposes the movement of electrons, decreasing the current so there is less energy for the light bulb. The higher resistance wire will cause the bulb to be dimmer than the lower resistance wire.
3. Copper, aluminium, zinc and nichrome.
4. Copper has an extremely low resistance, and so has a minimal effect on the overall resistance of the circuit. Other materials would add to the overall resistance of the circuit, decreasing the maximum possible current in that circuit.

9.3 Other output devices

ACTIVITY: **Sankey diagrams (LB page 188)**

Sankey diagrams were first introduced in the Gr 7 CAPS workbook as a way of representing the transfers of energy within a system, specifically focusing on the transfer of input energy to useful and wasted output energy. They provide a very clear illustration of the process. This links back to the previous chapter to reinforce learning

The LED bulb is more efficient as more of the input energy is transferred to useful output (light) than is wasted as heat. In the filament light bulb, much more energy is wasted as heat.

Some are: motors, buzzers, beepers

ACTIVITY: **History of electricity production (LB page 188)**

The timeline does not need to be too specific. We want learners to realise that this was not an overnight discovery, but involved many people over a significant time. Here are some pertinent facts. This list is not complete and not all of the dates are necessary. Another useful resource is available here: http://bit.ly/1hmPfxF

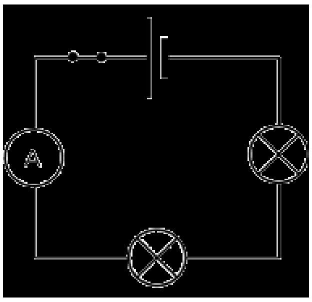
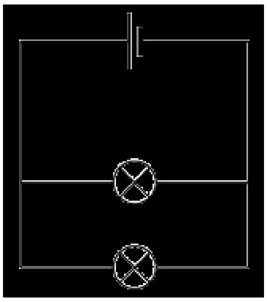
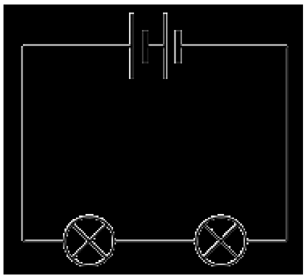
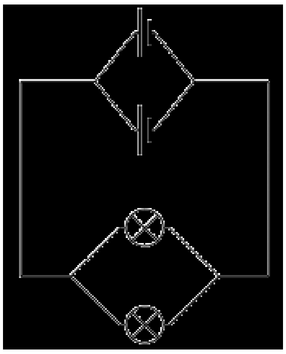
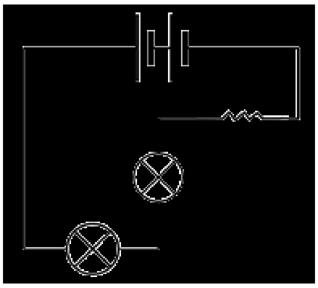
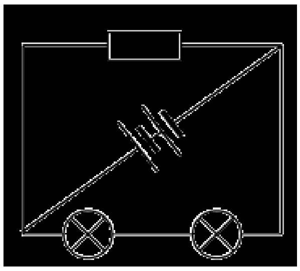
- 600 BC – Discovery that amber, rubbed with silk, would attract light objects such as feathers
- 1600 AD – William Gerbert coined the term electricity. He was the first to make a link between magnetism and electricity
- 1700s – Wimshurst machine, used to generate static electricity
- 1752 – Benjamin Franklin proved that lightning was a form of electricity
- 1800s – Sir Humphrey Davey discovered electrolysis; Volta created the first simple cell
- 1831 – Michael Faraday demonstrated electromagnetic induction
- 1825 – Ampère published his theories on electricity and magnetism. The unit of current, the ampere, is named after him.
- 1827 – George Ohm published his study of electricity. The unit of resistance, the ohm, is named after him
- 1831 – Charles Wheatstone and William Fothergill created the telegraph machine
- 1870 – Thomas Edison built a DC generator
- 1876 – Alexander Graham Bell invented the telephone which uses electricity to transfer speech
- 1878 – Joseph Swan demonstrated an electric light bulb
- 1880s – Nikola Tesla developed an AC generator
- 1881 – The first British public electricity generator was built in Surrey
- 1883 – Magnus Volk built the first electric train line
- 1896 – Nikola Tesla established hydroelectric power plants in America
- 1905 – Albert Einstein demonstrated the photoelectric effect which led to the production of photovoltaic cells

ACTIVITY: **Careers (LB page 188)**

1. The Eskom website has information regarding various careers and the Internet has many different sources.

Revision

1.

		
Series	Parallel	Series
		
Parallel	Series	Parallel

2. Brightest, bright, dim
3. The first circuit has the brightest bulb because it has the least resistance and so it has the highest current. The third circuit has the highest resistance because it has two resistors connected in series with the light bulb. The more resistors connected in series, the higher the resistance and the lower the current.
4. Dimmest, bright, brightest
5. The third circuit will have the brightest bulb because adding resistors in parallel lowers the overall resistance in the circuit. The current is therefore greater and the bulb shines brighter. The first circuit is the dimmest because it has no parallel branches, and so offers the highest resistance.
6. a) This circuit has both series components (the cell and bulb A are in series) and a parallel branch consisting of bulb B and C.
   b) Bulb A is the brightest, Bulbs B and C would have the same brightness as each other.
   c) If switch S is opened, then bulb C will not glow. Bulbs A and B would now have equal brightness but they would be dimmer than when the switch was closed. A and B would now be in series with each other and there is no parallel branch. The overall resistance of the circuit would therefore be higher, resulting in a smaller current.
7. a) A1 = A4. The total current flows through the circuit at both of these points.
   b) A1 = A2 + A3. The current splits between parallel branches in a circuit.

10 Visible light

Chapter overview

3 weeks

This chapter focuses on the visible light spectrum and how we see and interpret light. The concepts of absorption, reflection and refraction of light will be covered. Some of these concepts were first introduced in Gr 7 Energy and Change when talking about heat (the transfer of energy). This also links to what learners would have covered in Gr 7 Planet Earth and Beyond on solar energy, the seasons and life on Earth.

10.1 Radiation of light (1 hour)

Tasks	Skills	Recommendation
Activity: Making a pinhole camera	Following instructions, observing, describing	CAPS suggested

10.2 Spectrum of visible light (1 hour)

Tasks	Skills	Recommendation
Activity: Splitting white light	Following instructions, observing, describing, explaining	CAPS suggested
Activity: Colour spinning wheels	Follow instructions, measuring, observing, describing	Optional

10.3 Opaque and transparent objects (1 hour)

Tasks	Skills	Recommendation
Activity: Shadow play	Following instructions, observing, describing, comparing, explaining	CAPS suggested

10.4 Absorption of light (1 hour)

Tasks	Skills	Recommendation
Activity: Why do objects look red under red light?	Observing, explaining	CAPS suggested

10.5 Reflection of light (2 hours)

Tasks	Skills	Recommendation
Investigation: Is there a relationship between the angles of incidence and reflection?	Investigating, comparing, measuring, observing, describing, explaining	CAPS suggested Activity: Light reflection off aluminium foil

10.6 Seeing light (1 hour)

Tasks	Skills	Recommendation
Activity: Seeing colours	Interpreting, drawing	CAPS suggested

10.7 Refraction of light (2 hours)

Tasks	Skills	Recommendation
Investigation: Does light change	Investigating, comparing,	CAPS suggested

direction when it passes through a glass block?	measuring, analysing, describing, explaining	
Activity: Magic coin trick	Observing, describing, explaining	CAPS suggested
Activity: Diverging and converging light with lenses	Observing, describing, comparing, explaining	CAPS suggested
Activity: Research careers in optics	Researching, working in groups, writing	Optional

Note: An additional investigation has been included only in the Teacher's Guide in this section:

- Investigation: The refraction of light as it enters water (PhET simulation)
- This can be performed if you have an Internet connection, and is an alternative to the suggested investigation above.

Key questions

- Where does light come from?
- How does light travel?
- How do we see?
- Why do leaves look green?
- How do mirrors work?
- Why do my legs look crooked underwater?

10.1 Radiation of light

An exciting way to introduce this section is to turn your classroom into a camera obscura. Use black paper to cover all the windows and tape to block out any light coming in from under any doors. On one window, leave a small area of the window uncovered. Hang a white sheet in the centre of the room opposite to the exposed window. The view from outside should be projected onto the sheet. The image will be upside down. This is an inexpensive way to give the learners an opportunity to understand the rectilinear propagation of light.

ACTIVITY: **Make a pinhole camera (LB page 192)**

This activity allows the learners to produce images on a screen. The images formed by a pinhole camera can be used to explain and demonstrate that light travels in straight lines.

The Pringles chip can is the perfect shape for this activity. You could use any cardboard tube. Instead of the lid from the Pringles can you can use a piece of wax paper as the screen. This pinhole camera is essentially a miniature camera obscura.

If you are struggling with time, you could make one of these and demonstrate it to the learners instead of having each learner produce one.

You can also use black paper if you do not have aluminium foil. The foil is useful because it molds to the shape of the tube and helps prevent ambient light from entering.

You can also use black paper if you do not have aluminium foil. The foil is useful because it molds to the shape of the tube and helps prevent ambient light from entering.

1. Learners should see an image on the "screen". The lid/wax paper is the screen. The learners should

notice that the image is upside down.
2. When you move closer to the object, the image appears bigger than when you move further away.

10.2 Spectrum of visible light

ACTIVITY: **Splitting white light (LB page 195)**

This activity is very simple and usually gives clear results. Try to darken the room as much as possible in order to get clear spectra. A ray box and power source are not essential for this activity. You can make your own simple ray box by using a piece of cardboard with a small slit cut into it. Hold the cardboard in front of a light bulb and the light will shine through the slit in a single beam of light. Use a table lamp or set up a circuit with a high wattage light bulb as a source of light.

1. Remember that if you do not have a ray box then you can use a light bulb with a cardboard screen to produce a coherent beam of light.
3. Make sure that the learners rotate the prism until they get it at the right angle to refract the light and see the colours.

1. The drawing should show the beam of white light entering the prism, passing through and emerging on the other side as the 7 colours of the visible spectrum. This is a typical image, which learners will see later in the chapter when we discuss refraction of light. They must note the relative bending of red versus violet light.
2. The white light enters the prism, passes through it and emerges on the other side as a beam of seven colours (a rainbow).
3. Red, orange, yellow, green, blue, indigo, violet.
4. No, the order is always the same.
5. They tell us that white light is a mixture/blend/combination of the 7 colours of the visible spectrum.

ACTIVITY: **Colour spinning wheels (LB page 196)**

This is a very simple, fun activity to show that the 7 colours combine to make white light. You can either get learners to each make their own, or else make a couple before class yourself and hand them out for learners to experiment with.

To do this accurately, find the centre of the circle and mark a dot there. Then draw a straight line from the centre to the edge of the circle. Next, align the straight edge of a protractor with the line you just drew, placing the end of the protractor right on the center of your circle. Look for 52 degrees and make a dot to mark this angle. Draw a line from the centre dot to this dot on the edge. The angle you drew is 1/7 of the circle. Repeat this until you have measured and drawn all segments. A complete rotation is 360 degrees and 360/7 = 51.4 which is why each segment you draw should be about 52 degrees. The correct angle for 6 segments would be 60 degrees.

Learners should observe that the colours appear to 'mix'. Depending on the quality of the pens or pencils used, you should see a light grey. The goal is to see white, but this might take some more experimenting

10.3 Opaque and transparent substances

ACTIVITY: **Shadow play (LB page 198)**

This activity will show learners that opaque objects cast shadows. You can give them specific shapes to cut out from cardboard or allow them to be creative with their designs. Have them cut out various shapes of different sizes from cardboard. This will allow them to see that larger objects cast larger shadows. The learners can use a white piece of paper as a screen or use the wall of the classroom. If they hold the shape on the desk then the shadow would be cast on the desk but a screen would be more useful. The classroom should not be brightly lit when doing this activity as overhead lights may affect the shadows

4. The shadow forms on the side of the shape which is furthest from the light. It is a dark colour.
6. The shadow is formed on the side furthest from the light source. It is dark in colour and larger than the first shadow.
11. No shadow is formed by the clear plastic shape. There may be a slight outline of the shape as a shadow. This sometimes happens if the cut edges of the shape have curled over, the double thickness reduces the transparency. If any of the learners notice this you should explain it to them.
12. The shadow that forms is on the side opposite the light source but it is significantly lighter than the cardboard shadows. It has a darker outline and a lighter centre.

1. No, light did not pass through as it forms a shadow on the opposite wall.
2. It is opaque.
3. The larger the shape, the larger the shadow.
4. This is an example of the type of diagram the learners may draw. They need to show the opaque object between the light source and a screen. They need to show rays of light leaving the light source and moving in straight lines on either side of the shape.
5. The answer calls for learners to predict something they have not tested. The shadow should become larger if the object is closer to the light source and smaller if the object is further from the light source.
6. This answer is learner dependant because it depends on their prediction for question 5. Learners should describe seeing that the size of the shadow decreased as the distance increased or that the size of the shadow increased as the distance decreased.
7. The clear plastic is transparent.
8. No
9. Light travels in straight lines. It cannot bend around an object. Light cannot pass through the cardboard and so a shadow is formed. Light can pass through the clear plastic and so the area behind the plastic is bright.
10. It is neither completely transparent or completely opaque. The shopping bag is translucent or semi-transparent.
11. Some of the light can pass through the translucent plastic but not all of it, this means that the shadow is not as dark.

10.4 Absorption of light

The absorption of the different colours of light links back to Grade 7 Energy and Change. Learners will have learnt that matt black surfaces absorb heat from the Sun and that white and silver objects reflect the heat from the Sun. The energy which is reflected from surfaces can be seen as different colours. This is because each colour has its own frequency which is determined by the amount of energy of the released photons.

White objects do not absorb any of the colours but reflect all of them together and so the object appear white to our eyes.

ACTIVITY: **Why do objects look red under red light? (LB page 201)**

Try to use a dimly lit classroom for this activity so that the main source of light is the torch or light bulb.

1. White.
2. The normal light contains all 7 colours of the visible spectrum mixed together. All the colours are reflected from the page and enter our eyes. We see a white page.
3. The page looked red instead of white.
4. The red plastic only allowed red light to pass through it. Red light was reflected off the paper and so that is the only colour that reached the eye. The paper appears to be red.

10.5 Reflection of light

The photograph of the bridge in Italy is upside down.

INVESTIGATION: **Is there a relationship between the angles of incidence and reflections? (LB page 203)**

Learners will see that the angle of reflection is equal to the angle of incidence.

Learners must save some of the sheets for the next activity where you will use a piece of crumpled aluminium foil instead of the mirror. Another way to do this investigation is to use a sheet of corrugated cardboard instead of paper. Learners can then stick pins into the cardboard along the light ray and then draw in the lines later.

Learners will have their own versions. An example of an appropriate question would be: 'How is the angle of reflection related to the angle of incidence of the incident ray?' It is important that the question relates the two angles in some way.

A laser pointer also works very well instead of a ray box

The answers in the table will depend on the angles of incidence which the learners use for their investigation. It is important that they see that the angles of incidence and reflection are equal to each other in each repetition.

1. This answer would be learner-dependent as it would depend on the investigative question they chose.
2. This answer is learner dependent. An example of an improvement could be to use a protractor printed on the page already in order to measure the angles accurately

In reflection, the angle of reflection is always equal to the angle of incidence

ACTIVITY: **Light reflection off aluminium foil (LB page 206)**

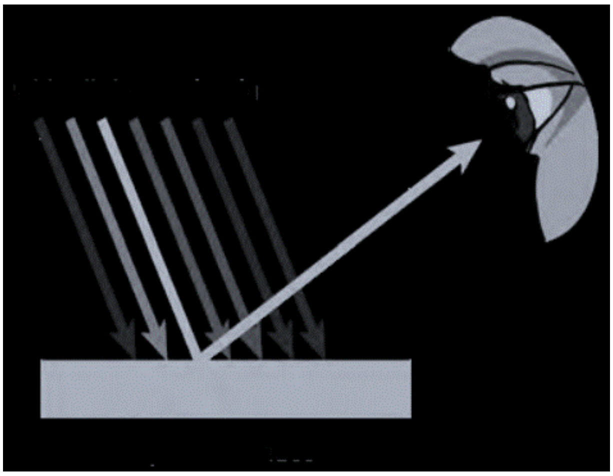
1. Learners should note that the reflected ray off the aluminium foil is scattered and does not provide one clear ray, as the mirror does.
2. This is because the aluminium foil is crinkled and provides a rough surface whereas the mirror is a smooth surface.

Here are the answers for what learners should draw.

Specular diffusion from a smooth surface	**Diffuse reflection from a rough surface.**
	

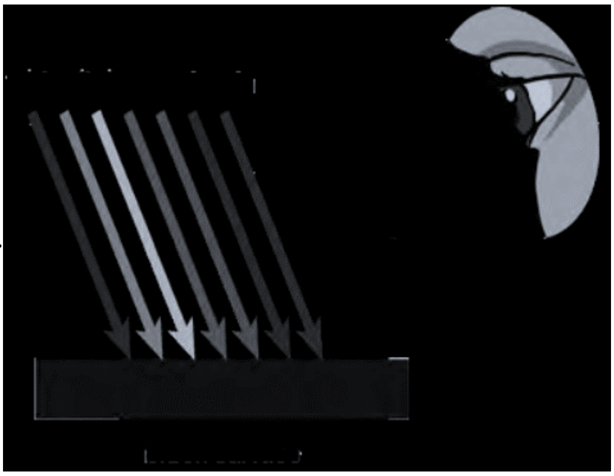
10.6 How do we see light?

ACTIVITY: **Seeing colours (LB page 209)**



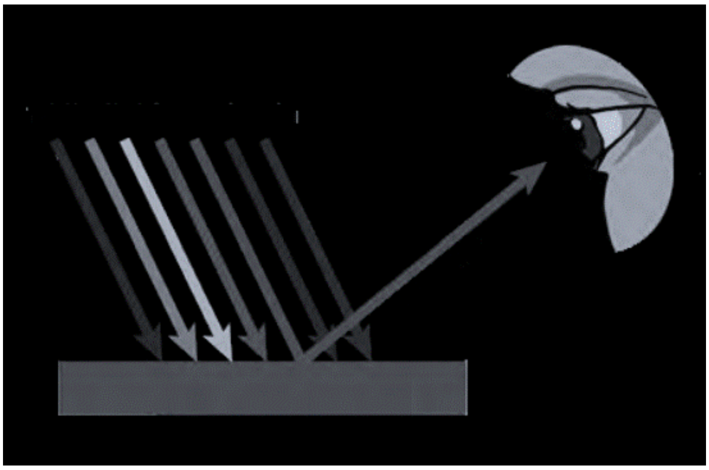
Light striking the yellow

petals.



Light striking the black centre.

The white light that strikes the sunflower has all the colours. The yellow petals absorb all the colours of the spectrum except yellow which is reflected into our eyes. The black centre absorbs all of the colours of the spectrum and does not reflect any light into our eyes, hence our brain interprets a lack of light/colour as black.



Light striking the blue car.

White light from the Sun hits the car. All of the colours of light, except blue, are absorbed by the surface of the car. Only blue light is reflected from the surface of the car and enters our eyes. Our brain can only see the blue light and so we perceive that the car is blue.

10.7 Refraction of light

You should do this in front of the class, or else put a glass of water in front of each learner. It is a really easy demonstration. All you need is a glass of water and a straw. If you do not have a straw, a pencil works really well.

INVESTIGATION: **What happens to light when it passes through a glass block? (LB page 211)**

You do not need a ray-box for this investigation. A laser, such as those found on keyrings, or a light bulb can be used. If you use a light bulb, you need to make a cardboard screen. Cut a thin slit into the cardboard and hold it in front of the light bulb, this will create a ray of light suitable for the investigation.

We are going to investigate what happens to a ray of light when it passes from air and into a glass block and then from the glass block back into air. We are going to use a glass block with parallel sides.

Before we start the investigation, we need to think about how we are going to determine if light changes direction or not. Do you remember in the investigation on reflection where we measured the angle of incidence and the angle of reflection? What did we find in this investigation?

The angle of incidence equals the angle of reflection.

Learners can come back to this diagram and mark in which is the more dense medium (glass) and which is the less dense medium (air). In this diagram, medium 1 is air and medium 2 is glass.

The refracted ray bent **towards** the normal line.

Learners can come back to this diagram and mark in which is the more dense medium (glass) and which is the less dense medium (air). In this diagram, medium 1 is now the glass and medium 2 is air.

Yes, it changes direction as the angle of incidence is not equal to the angle of refraction. The angle of incidence is smaller than the angle of refraction.

In which direction did the refracted ray change?

The refracted ray bent **away** from the normal line.

Learners must hypothesize about whether they think the light ray will change direction or not when it passes through the glass block.

1. Learners should note that angle 1 is equal to angle 4 and angle 2 is equal to angle 3 in all the sets of measurements.

   Note: Discuss this with your learners as to why angles 2 and 3 are equal. The explanation for this is to do with parallel lines and alternate angles. This links well with what learners would have covered in Mathematics in the beginning of the year. The normal lines are parallel and so the alternate angles between them are equal. You can draw this on the board to explain it in more detail and show that the normal lines are parallel as the corresponding angles are equal (they are 90°).

2. Angles 1 and 4 are the angles of incidence and angles 2 and 3 are the angles of refraction.
3. The angle of incidence is always different to the angle of refraction.
4. The light bends towards the normal line.

   Note: This is because the light is moving from a less dense to a more dense medium, which will be discussed later on.

5. Zero.

The angle of incidence is not equal to the angle of refraction. This means that the light ray changes direction when it passes from the air into the glass block, and again when it passes from the glass block back out into the air.

ACTIVITY: **Magic coin trick (LB page 214)**

This activity will show the learners that bending of light will affect what we are able to see. The coin is not visible until the water is added. The water causes the light rays from the coin to refract (bend) towards the learner's eye. This allows the learner to see the coin.

The learners should stick the coin to the bowl in order to keep the coin still when water is poured into the bowl. Often learners do not pour the water in gently and if the coin moves then it will affect the results.

1. Learners responses may vary slightly but they should all have seen the coin "appear" when the water was deep enough. When more water is added the entire coin can be seen.
2. The coin appears to be higher than it actually is.
3. When there is no water in the bowl there is no direct line of sight from the learner's eye to the coin. When water is added the light from the coin leaves the water and is refracted. The learner's brain detects the refracted light and as the brain knows light travels in straight lines, the coin appears to be higher in the water.

We used a triangular prism. Learners have already experimented with this to show that white light is actually composed of 7 different colours. However, you can repeat this activity again to explain why this happens in terms of refraction.

Red is at the top and violet is at the bottom.

No, it does not. It is the reverse order.

ACTIVITY: **Research careers in optics (LB page 217)**

Here is some information about each of these careers:

Optometry
Optometrists measure the efficiency of the patient's eyes. They examine eyes for vision problems, disease and other abnormal conditions. They test for proper depth and colour perception and the ability to focus and coordinate the eyes. They specialise in visual defects They are able to prescribe spectacles or contact lenses to rectify or alleviate visual defects such as far-sightedness, short-sightedness, astigmatism (image distortion) and presbyopia (far-sightedness as the result of age).

School Subjects
National Senior Certificate meeting degree requirements for a degree course National Senior Certificate meeting diploma requirements for a diploma course Each institution will have its own minimum entry requirements.

Compulsory Subjects: Mathematics, Physical Sciences Recommended Subjects: Life Sciences

Training
Degree: BOptometry – UJ, UFS, UL. The duration of the course is 4 years of full-time study. After the completion of the degree course, students may be expected to complete a one-year internship before registration as professional optometrists.

Diploma: N.Dip: Optical Dispensing and B.Tech – CPUT. The duration of the course is three years. A fourth year of study culminates in the BTech Optometry. During their third and fourth year, students have contact with patients. Students are required to complete a one-year internship.

Optometrists are required to register with the Interim National Medical and Dental Council (INMDC) of SA before they may practise.

Ophthalmology
Ophthalmologists diagnose and treat diseases of the eye, including glaucoma and cataracts, vision problems, such as near-sightedness, and eye injuries. Most ophthalmologists practice a combination of medicine and surgery, ranging from lens prescription and standard medical treatment to the most delicate and precise surgical manipulations.

School Subjects
National Senior Certificate meeting degree requirements for a degree course Each institution will have its own minimum entry requirements.

Compulsory Subjects: Mathematics, Physical Sciences Recommended Subjects: Life Sciences

Note: Competition to enter medical studies is stiff and there are usually many applicants with excellent grades who naturally would be given preference.

Training
MBChB degree at UP, UCT, UFS, Wits, US, UL, UKZN:

- Theoretical training: 6 years
- Student internship: 1 year
- Practical work at a hospital: 1 year (also known as the house doctor year).
- Post-graduate study for specialisation as an ophthalmologist: 3 – 5 years. Registration: on successful

completion of the examination to qualify as a specialist, the candidate must register with the International Medical and diagnostic Centre as an ophthalmologist.

A useful website: bit.ly/18SxQty

Optoelectronics
Optoelectronics is the study and application of electronic devices that source, detect and control light, usually considered a sub-field of photonics.

This career would require a degree in electrical engineering which could be obtained at any South African university. Entry requirements will depend on the institution involved.

Illumination engineering
illumination engineering is the study and use of lighting in various situations, buildings and community spaces, such as sports and recreational lighting, lighting industrial facilities, roadway lighting, museum lighting. Illumination engineering can be studied at university by pursuing a degree in electrical engineering. The Illumination Engineering Society of South Africa also offers courses, details are on their website.

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, including helping to identify possible planets around stars, analysing real life cancer data, looking at tropical cyclone data and listening to the calls from whales or bats.

Citizen science is scientific research that 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. http://bit.ly/14JxLsw

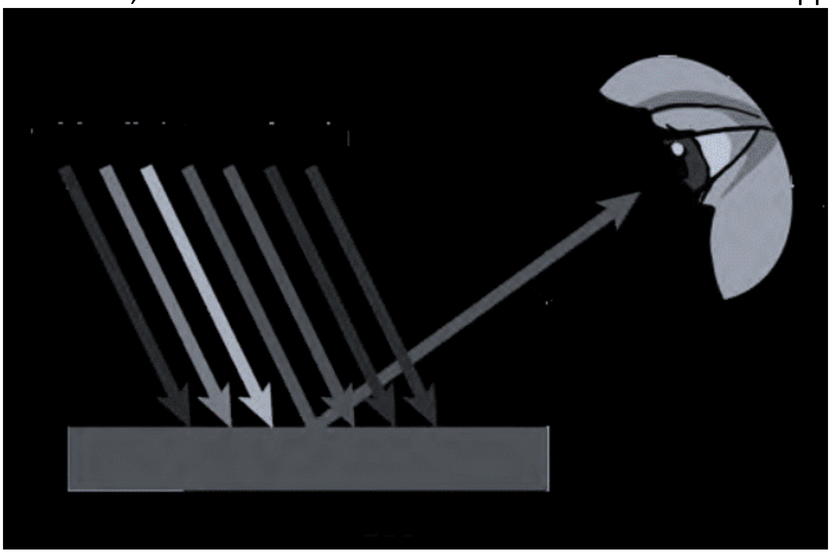
Revision

1. 1: C
   2: F
   3: A
   4: I
   5: L
   6: B
   7: K
   8: D
   9: J
   10: H
   11: E
   12: G
2. a) White light is made up of a spectrum of 7 colours.
   b) When the light passes from the air into the glass at an angle, it refracts and bends. The colours of the spectrum bend by different amounts causing the light to disperse. When the light leaves the other side of the prism, it refracts again and the colours bend even more and split up showing the seven colours.
   c) Colour 1 is red and colour 7 is violet as red light bends the least and violet light bends the most.
   d) Label 4, green.
   e) These rays are the result of some reflection off the inner surfaces of the prism as not all the light passes directly through.

Note: This is an extension question. 3

An opaque object casts a shadow as it does not let any light pass through it. The light is either reflected or absorbed. There will be a shadow on the opposite side to the light source as the light cannot reach there due to the object.

4. a) The light is reflected off the poles and then it reflects off the surface of the water and into our eyes.
   b) This is because the light rays are not reflected off a smooth surface, but rather an uneven surface, due to the ripples in the water. The light rays are scattered.
5. White is a combination of all of the colours in the visible spectrum. White objects reflect all the colours equally and so we see the mixture of colours as white. Black is an absence of colour. Black objects absorb all of the colours and reflect none. This means that we don't see any coloured light from that object.
6. Black: All the colours are absorbed; none are reflected.
   Yellow: All the colours except yellow are absorbed and the yellow is reflected.
   Green: All the colours except green are absorbed and the green is reflected. Blue: All the colours except blue are absorbed and the blue is reflected
   Red: All the colours except red are absorbed and the red is reflected. White: All the colours are reflected, none are absorbed and so the combined colours appear as white.



8. C
9. When light travels from a less dense into a more dense transparent medium, the light refracts and bends towards the normal line. When light travels from more dense to a less dense medium, it refracts and bends away from the normal line.
11. a) The ray of light. b)
    c) The block is more dense than air as when the light enters the block, the ray bends towards the normal line indicating that it travels more slowly. The ray then bends away from the normal line when it leaves the block and enters a less dense medium (the air) and travels faster.
    d) It must be a transparent medium, such as glass. e)
    f) 0.5 marks for each label. The learner's completed diagram with labels should look as follows:
12. C
13. This is due to refraction. The light that passes through the piece of glass is bent and so the image becomes distorted and looks as though the trunk is skew.
14. It must be convex.
16. Far-sightedness can be corrected using a convex lens. This is when the light focuses on a point behind the retina so the image is blurred. A convex lens is used to bend the light rays before they enter the

eye so that when they do pass through the lens in the eye they are focused clearly on the retina

11 The solar system

Chapter overview

3 weeks

The ordering of the chapter in Grade 8 Planet Earth and Beyond in CAPS is as follows:

1. The solar system
2. Beyond the solar system
3. Looking into space

Although this is the order in CAPS and it is the way in which the content has been ordered here in these workbooks, we suggest starting with Chapter 3 on 'Looking into space' first, and then going on to the other two chapters. This makes more sense conceptually to first learn about how we see into space, and then go on to look at the objects that have been observed in our solar system and beyond, making use of a variety of telescopes.

In Grade 6 learners covered material regarding the solar system, and in Grade 7, they focused on the Sun, Earth, Moon system. Learners should be familiar with the fact that the Sun is a star located at the centre of the solar system and they should understand that the planets orbit around the Sun. They should also be aware that there are two types of planets: smaller rocky planets and larger gas giants. In this chapter, the solar system is introduced in more detail, and the physical explanation for the two types of planets is summarised. They will compare the properties of the different planets, information that they will then use to explain why the Earth is presently the only planet suitable for life in our solar system. The main aims of this chapter are to ensure that learners understand the following:

- The Sun is a star and produces heat and light (energy) via nuclear reactions.
- The planets, dwarf planets and asteroids all orbit around the Sun, held in their orbits by the force of gravity.
- Different planets have different observed properties and characteristics.
- The Earth is located in a special zone around the Sun, where life is possible. Section 1.1 covers the properties of the Sun, section 1.2 introduces all the other objects in the solar system and section 1.3 covers our special place in the solar system.

Concept maps: The concept maps in these workbooks were created at Siyavula using an open source programme called CMapTools. You can download the programme 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

Citizen science offers you a free, easily accessible and inspiring opportunity to bring real science into the classroom. Find out more about incorporating real science into your classroom with Zooniverse citizen science projects at ZooTeach: bit.ly/H6krWT. ZooTeach is a website where teachers and educators can share high quality lesson plans and resources that complement the Zooniverse citizen science projects.

Did you know that these workbooks were created at Siyavula with the input from many contributors and volunteers? Just turn to the front to see the long list. Read more about Siyavula at our website: www.siyavula.com

11.1 The Sun (1.5 hours)

Tasks	Skills	Recommendation
Activity: Observing the Sun with a telescope	observing, describing	CAPS suggested

Activity: Observing the Sun with a pinhole camera	observing	Alternative to above activity
Activity: Sunspots	observing, identifying, analysing	Optional, extension

11.2 **Objects around the Sun** (6 hours)

Tasks	**Skills**	**Recommendation**
Activity: The scale of the solar system	simulating, visualising, taking measurements	CAPS suggested
Activity: Make a hanging solar system	simulating, visualising, taking measurements	CAPS suggested (also alternative to above activity)
Activity: Planetary temperatures	reading tables, labelling graphs	CAPS suggested
Activity: Comparing terrestrial planets and gas giants	comparing, recalling	Optional
Activity: Comparing the inner and outer planets	comparing, reading tables, analysing	CAPS suggested
Activity: Planetary holidays	writing, researching	CAPS suggested
Activity: Planet factsheet	writing, researching	CAPS suggested (also alternative to above activity)
Investigation: Impact craters	investigating, observing, taking measurements, analysing	CAPS suggested
Activity: A comet's ion tail	observing	CAPS suggested

11.3 **Earth's position in the solar system** (1.5 hours)

Tasks	**Skills**	**Recommendation**
Activity: The Sun's habitable zone	plotting graphs, interpreting graphs, analysing	CAPS suggested

Key questions

- How does the Sun produce its energy?
- How can we observe the Sun without damaging our eyes?
- What objects are in orbit around the Sun in our solar system?
- Why are there two types of planets?
- How do the planets in our solar system differ?
- What are asteroids and comets?
- What is the difference between a planet and a dwarf planet?
- Why is life possible on Earth?

11.1 The Sun

In this section students learn how the Sun produces its energy in its core and how this energy is transported to the surface and then into space. The effect that the Sun has on the Earth is also briefly mentioned. This section focuses on conducting observations of the Sun and looking at images of the Sun to study the surface features, including sunspots.

There are two activities in this section which involve observations of the Sun. It is very important that learners DO NOT LOOK DIRECTLY AT THE SUN, even with sunglasses on, as they may permanently damage their eyes.

Although the Sun is the brightest object in our sky, this is only because it is so close to us. The Sun is actually a medium-sized star of average brightness compared with other stars. If the sun were further away, it would look like a small point of light like the other stars in the sky.

At the temperatures encountered at the centre of the Sun the atoms are ionized and so nuclear fusion involves the merging of atomic nuclei rather than atoms.

Different studies of the transport of photons within the Sun estimate different travel times to reach the surface. Much older studies reported times of order of millions of years, but these have now all been revised downwards to either tens or hundreds of thousands of years.

Although we often say that the Sun "burns" its hydrogen fuel into helium, the Sun does not burn in the same way that a fire does, because it is not on fire. The energy generated from the Sun comes from fusing atomic nuclei together to form a new atomic nucleus. As a result of the extreme temperatures throughout the Sun, its gas glows, giving off light. Our usual experience of burning (or fire) is actually a chemical reaction where atoms combine to form molecules, e.g. when oxygen combines with carbon to form carbon dioxide.

ACTIVITY: **Observing the Sun using a telescope (LB page 227)**

This is an outdoors activity. You will need a telescope or binoculars for this activity. **An alternative activity is included after this,which does not need a telescope or binoculars.**You will be projecting an image of the Sun onto a white card or screen for your learners to observe.

If you do not have access to a telescope or binoculars it could be worth contacting a local amateur astronomy club as they are often keen to get involved in educational activities. It is vital that learners do not look directly at the Sun, with or without sunglasses. The projection method used in this activity is safe and also has the bonus that any sunspots on the Sun's surface can also be seen. Sunspots are regions of slightly lower temperature on the Sun's surface, and therefore appear darker. If you do not have access to a telescope, but do have Internet access, then an image of the Sun is posted daily at [1] 1.usa.gov/1a2n1cE

It is assumed that this will be a teacher-led demonstration, however, there is no reason why learners cannot contribute by building the shade collar and setting up the white card. If you are using binoculars instead of a telescope, be sure to cover one of the lenses so that only one side of the binoculars is used. When trying to point the telescope at the Sun, a useful trick is to watch the shadow of the telescope tube: if pointed directly toward the Sun, then the sides of the tube will cast no shadows. Preparing for the activity can sometimes take a bit of fiddling, so it is a good idea for you to set your learners a short task to do while you set up if you have not had the opportunity to set up ahead of time.

Sunspots are sometimes (not always) visible on the Sun's surface. You are more likely to see sunspots when the Sun is most active during solar maximum. The Sun's activity varies over an 11 year cycle. Solar maximum is currently predicted to be in 2013. Solar minimum is currently predicted to be in 2019. As an extension you could repeat this activity over the course of several days to see if any sunspots or sunspot groups change shape, size, or position over time.

Ask the learners to point out any interesting features they notice about the image. There may be sunspots (dark spots) visible. Also you should see that the image is brighter in the middle of the Sun's disc than at the edges. This is because when we look at the middle of the Sun's disc we can see deeper into the Sun than when we look towards the edge. The temperature of the Sun increases with increasing depth. At the centre of the Sun's disc we are seeing a hotter region. As the intensity of light is proportional to the temperature, the Sun looks brighter in the centre.

The spin of the Earth on its axis

ACTIVITY: **Observing the Sun with a pinhole camera (LB page 228)**

1. The image should get smaller and brighter.
3. The angles are equal. This links back to what learners covered last term in Energy and Change.

ACTIVITY: **Observing sunspots on the Sun's surface (LB page 230)**

This is an **additional, extension** activity. In this activity learners will look at images taken over three consecutive days in 2013. The images were taken using the Helioseismic and Magnetic Imager instrument on board the Solar Dynamics Observatory space satellite. In the images two major sunspot groups are visible, one in the Sun's northern hemisphere and one in the Sun's southern hemisphere. Learners should identify the two groups and observe that they move across the Sun from left to right in each successive image. The sunspots move like this because the Sun is rotating on its axis. You could begin this activity by asking learners if they noticed any features on the Sun's surface when they observed it in class, before asking them to look at the pictures below.

1. There are two main groups, one in the top half of the Sun and the other group in the bottom half.
2. They are moving across the Sun's disc from left to right.
3. The Sun is rotating on its own axis (once roughly every 25 days).
4. They are called Sunspots and they are regions where the temperature is cooler than the rest of the Sun's surface.

This is enrichment material to extend learners' knowledge beyond what they have covered in previous grades about the Sun. Here is a link to a pdf download for an activity to track sunspots in real time, using data from SOHO: 1.usa.gov/16mW96j

11.2 Objects around the Sun

This section covers all the objects in orbit around the Sun including the eight planets, dwarf planets, asteroids, Kuiper Belt and Oort Cloud and comets. Learners should be familiar with the eight planets in the solar system, which were covered in Gr 6, however it is very likely that they are unfamiliar with the remaining components of the solar system. The first half of this section is intended as revision, to remind learners about the properties of the eight planets. The two types of planets, the terrestrial (rocky) planets and gas giants are compared and contrasted in detail. The second half of this section covers the smaller bodies in the solar system such as dwarf planets, comets and asteroids. It should be stressed to learners that new discoveries are made all the time and so the numbers of moons discovered around planets and the number of dwarf planets in the solar system will change over time.

ACTIVITY: **The scale of the solar system (LB page 232)**

In this activity learners will get a sense of the scale of the solar system. Using a model where the Sun is scaled to the size of a grapefruit, the other planets areal so scaled down and are placed in orbit around the grapefruit Sun at the correctly scaled distance. This activity needs a lot of space. The distance you need from the Sun to Neptune is 321 m. The scaling used in this activity is 14 billion to one. You can change the scaling to suit the space you have available. A summary table is included here with the scaled sizes and distances for the planets for your reference. Learners can use a measuring tape to measure out the distances. If no measuring tape is available, the approximate distance in strides is also given.

Object	**Actual diameter (D) or distance from the Sun (d) (km)**	**Measurements scaled to in model**	**Model suggestion**
Sun	D = 1.4 x 10^6	10 cm	Grapefruit
Mercury	D = 4.9 x 10^3 d = 58 x 10^6	0.35 mm 4.2 m	Salt grain, 4 big strides
Venus	D = 12 x 10^3 d = 108 x 10^6	0.86 mm 7.7 m	Poppy seed, 8 big strides
Earth	D = 13 x $110^{3}{}_{3}$ d = 150 x 10^6	0.91 mm 10.7 m	Poppy seed, 11 big strides
Mars	D = 6.8 x 110^3 d = 228 x 10^6	0.48 mm 16.3 m	Salt grain, 16 big strides
Jupiter	D = 143 x 10^3 d = 778 x 10^6	10.0 mm 55.6 m	Small grape, 55 big strides
Saturn	D = 128 x 10^3 d = 1426 x 10^6	8.57 mm 102 m	Pea, 100 big strides
Uranus	D = 51 x 10^3 d = 2868 x 10^6	3.65 mm 205 m	Peppercorn, 200 big strides. About twice the length of a football pitch.
Neptune	D = 45 x 110^3 d= 4500 x 10^6	3.55 mm 321 m	Peppercorn, 320 big strides. About three times the length of a football pitch.
Alpha Centauri (nearest star)	D = 4.0 x 10^{13}	2900 km	Cape Town to Lusaka!

See the table provided.

ACTIVITY: **Make a hanging solar system (LB page 233)**

In this activity learners will work individually to make a hanging model of the solar system.

The planets orbit the Sun in a flat plane that includes the Sun.

The aim of this section is to remind learners about the two types of planets. They were introduced to the two planetary types, the inner rocky terrestrial planets and the outer gas giants in Grade 6. This section covers this information again and goes on to explain why there are two types of planets. For a summary of each planet's properties see [3] 1.usa.gov/1cO92WC

The gas giants are much larger than the terrestrial planets.

They all have rings.

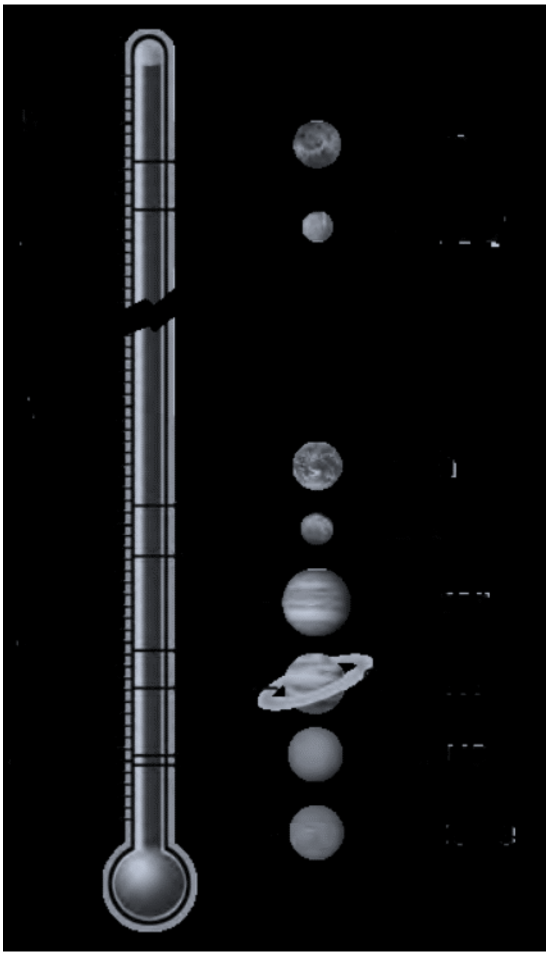
Uranus is on its side.

The terrestrial planets have no or few moons whereas the gas giants have lots of moons.

ACTIVITY: **Planetary temperatures (LB page 237)**

In this activity learners will compare the temperatures of the different planets. Using the table provided they must label each planet on the thermometer drawn below. This activity therefore requires that learners can read information from a table and also from a graph.

The labelled image:



1. Neptune.
2. It is the furthest planet from the Sun.
3. The average temperatures of the terrestrial planets are much higher than the average temperatures of the gas giants.
4. In general, the further away from the Sun a planet is, the lower its temperature.

Note: Venus is the exception because it has a very thick atmosphere and is undergoing a runaway greenhouse effect which learners will discover later on in this chapter.

ACTIVITY: **Comparing terrestrial planets and gas giants (LB page 238)**

In this activity learners must compare and contrast the two types of planet using the information already provided in this section.

Terrestrial Planets	**Gas Giants**
close to the Sun	far from the Sun

closely spaced orbits	widely spaced orbits
small masses	large masses
small radii	large radii
mainly rocky	mainly gaseous
solid surface	no solid surface
high density	low density
slower rotation	faster rotation
few or no moons	many moons
no rings	many rings
thin atmosphere	thick and dense atmosphere
warm	cold

Learner-dependent answer. Answer in text below.

ACTIVITY: **Comparing the inner and outer planets (LB page 238)**

In this activity learners will use the information provided in the table below to answer questions which compare the properties of the rocky planets and the gas giants. This is a good exercise to get learners to read information from tables and to look for patterns in data.

The day length given here is the average time in hours for the Sun to move from the noon position in the sky at a point on the equator back to the same position. This is not the same as the time for the planet to complete one revolution on its axis with respect to the stars. For example, the Earth completes one revolution on its axis with respect to the stars in 23.9 hours, however, because the Earth moves along in its orbit as it rotates, it actually takes 24 hours for the Sun to return to the same position in the sky again (which is how we conventionally define a day on Earth – from noon to noon).

1. Saturn would float on water as its density is less than that of water.

   Note: This links back to what learners covered in Term 2 in Matter and Materials on the Particle Model of Matter.

2. The inner rocky (terrestrial) planets are more dense than the outer gas giants, as the inner planets are made of solid rock, which is denser than gas.
3. Jupiter.
4. The gas giants tend to have the shortest days which means that these planets must spin on their axes faster than the terrestrial planets.
5. Mercury, because it is the closest planet to the Sun and has the least distance to cover.
6. Mercury.
7. An example graph is given below. You can use Assessment Rubric 3 at the back of your teachers guide if you would like to assess this translation task.

ACTIVITY: **Planetary holidays (LB page 243)**

This is a creative writing activity for learners to explore the solar system in an imaginative way. Learners will play the role of cosmic travel agents and will write a travel brochure for one of the planets in the solar system (not Earth!). This activity can be done as a team or individually. Encourage learners to research information about their chosen planet at the school or local library or on the Internet. Alternatively, they can use the information provided in this chapter. You could also provide some examples of travel brochures for them to look at as a guide. These are available free at travel agents. You could also ask the learners to present their work in class.

ACTIVITY: **Planet fact sheet (LB page 243)**

In this activity learners must summarise all the information they know about a particular planet on a one page fact sheet. This activity is easier than the Planetary holidays activity as it requires less imagination, and can therefore be done as an alternative activity.

INVESTIGATION: **Impact craters (LB page 244)**

In this activity, learners will investigate how craters are formed by dropping balls into a tray of sand. Although you can do this activity with flour, it works best with sand. There are two parts to this experiment. In the first part learners will investigate how the mass of an object affects the crater size formed. In the second part, learners will investigate how the height at which an object is dropped affects the size of the crater it leaves. You can use more objects in the investigation if you have time, and as an extension you can examine the effect of impact angle on the shape of the crater formed. You will need to experiment beforehand with the type of sand that you are using. Before your class performs this investigation, drop marbles into the sand that you have, to observe what kinds of craters the marbles leave. Experiment with the best possible option, for example, you might need to add some moisture to the sand so that you are able to see the craters.

Learner-dependent answer. Learners should give reasons for their answers.

1. While investigating the effect of object mass, the height that the objects are dropped from should remain constant. While investigating the effect of dropping height, the mass of the object being dropped should be kept constant.
2. In the first case – the mass of the object being dropped. In the second case – the height from which the object is dropped.

Learner-dependent answer. Answers might include conducting more measurements.

Learner dependent answer. Learners should summarise their results and provide a reason why they think they got the results they did.

1. The larger the mass of the impacting object, the larger the diameter of the crater.
2. The greater the height at which the object was dropped, the larger the size of the crater.
3. Objects dropped from greater heights hit the sand with a higher speed and therefore have greater energy (kinetic energy). As they have more energy they make a larger impact crater.

It tells us that craters on the surfaces of other planets are formed due to impacts. The impacting objects must have been travelling very fast or have been very massive, because the craters we observe on other planets are much larger than the craters made in this experiment.

Gravity (the gravitational pull of the Sun).

1. orbit around the Sun.
2. be large enough that its own gravity pulls it into a spherical shape.
3. clear out smaller objects in its orbit, by either flinging them into another orbit or by attracting and then sticking them to itself.

The Oort Cloud has not been observed. At this point, it is purely hypothetical although very likely. Its existence cannot be stated as fact since it has not yet been confirmed to exist. We therefore refer to the Oort Cloud as hypothetical or predicted.

ACTIVITY: **A comet's ion tail (LB page 248)**

In this activity learners will discover that a comet's ion tail always points away from the Sun, no matter which way the comet is travelling! You can either get learners to make their own comet tails or if you do not have many materials you can make one comet yourself and pass it around for the learners to see.

1. Directly away from you (as it is blown away by your breath).
2. It still moves directly away from you as it is blown away by your breath. It does not follow the direction of movement of the comet.

At the time of producing these workbooks, comet ISON was approaching very near to the Sun. Astronomers did not know if it would break up or not. Read more about it here [4] 1.usa.gov/15Xwsa1 and here [5] 1.usa.gov/174cdbK See if you can find out what happened to comet ISON in the beginning of 2014, and tell your learners about this, or set it as a fun, small homework task.

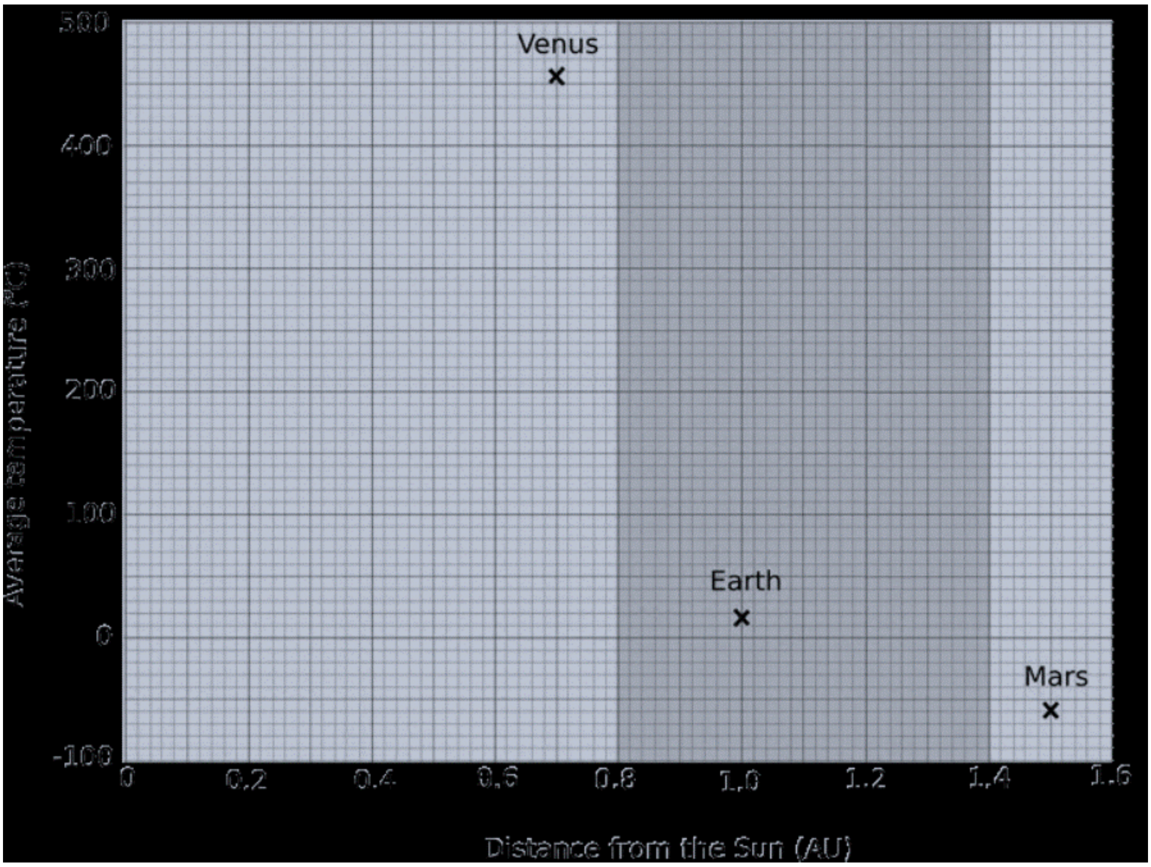
11.3 Earth's position in the solar system

In this section learners will discover just how fortunate they are to be on Earth, which is currently the only planet known to harbour life. They will consider the conditions thought necessary for life and compare those with the conditions found on Earth and on Earth's neighbours. A nice way to introduce this topic is to have a class discussion about whether learners think aliens exist on other planets and, if so, what they might be like. This could then lead into a discussion about what conditions learners think are necessary for life. Talking about aliens usually excites learners!

ACTIVITY: **The Sun's habitable zone (LB page 249)**

In this activity learners will plot a graph of distance versus temperature for the planets Venus, Earth and Mars. They will also be provided with information regarding the habitable zone around the Sun. Using this information learners will have to decide which of the three planets lie within the Sun's habitable zone.

Learners should plot the following points:



1. 464 °C.
2. No, it is too hot. Water boils at 100 °C.
3. -63 °C.
4. No, it is too cold. Water freezes at 0 °C.
5. 15 °C.
6. Yes, because the temperature on Earth is between water's melting and boiling points.
7. Only Earth.

You will probably find different quoted ranges for the habitable zone from different sources. This is because different scientists have used slightly different criteria to define what "habitable" means. Many studies focus on how life on Earth would be affected if the Earth were closer to or farther from the Sun.

However, the point at which life can no longer exist on Earth is uncertain.

Learner-dependent answer. This is also an ideal opportunity for a class discussion. Answers could include, sunlight for energy, oxygen, carbon (we are carbon based), liquid water. Note that other life forms might not be carbon based and that life comes in many forms like bacteria, animals and plants. Scientists are looking for more than just human-like beings and other forms of life that we find on Earth. Also, we are likely to be biased in what we think the conditions are that are needed for life, because we only know about life on Earth.

Revision

1. By nuclear fusion reactions, where hydrogen is converted to helium.
2. They are much cooler than the rest of the surface. A typical sunspot temperature is around 3 900 °C whereas the rest of the surface is around 5 500 °C. (Intensity is proportional to temperature).
3. The gravity between these objects and the Sun.
4. Mercury, Venus, Earth and Mars.
5. Jupiter, Saturn, Uranus, Neptune.

6. In between the orbits of Mars and Jupiter.
7. Out beyond the orbit of Neptune.
8. They are mostly made of hydrogen and helium which are the most abundant elements in the universe.
9. Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune.
10. Jupiter, Saturn, Uranus, Neptune.
11. Its atmosphere is so thick, there is a runaway greenhouse effect on the planet heating the planet to high temperatures.
12. Mars.
13. a) The hypothetical Oort Cloud.
    b) Comets and icy objects.
14. As comets come close to the Sun, the Sun's heat evaporates their surface, resulting in long bright tails which we can see. Far from the Sun it is too cold for the tails to form, so we have to wait until the comet is close enough to the Sun for it to form a tail before we can see it.
15. The official definition of a planet states that a planet must orbit the Sun, be large enough so that its own gravity squashes it into a spherical shape and that it has cleared out other objects from its orbital path. Pluto has not swept out other objects from its orbit and so it was downgraded from planet to dwarf planet status.
16. Earth has a moderate temperature, with liquid water on its surface. There is also abundant oxygen for respiration and plenty of sunlight (energy) for plants to grow.
17. It would eventually lose all its liquid water and therefore would not be able to sustain life.
18. a) Planets c, f and e.
    b) The orbits of these three planets lie within the habitable zone around the star. This is the zone which is the right distance from the star for water to exist as a liquid, making these planets possible candidates to support life.

12 Beyond the solar system

Chapter overview

3 weeks

Thus far, the learners have only been exposed to solar system astronomy. In this chapter learners will now be introduced to astronomy outside the solar system, which focuses on the studies of galaxies and the Universe. The main aims of this chapter are to ensure that learners understand the following:

- The Sun is our closest star, but if it were farther away, it would appear just like all the other stars in the sky at night.
- Stars are arranged in galaxies, held together by the force of gravity.
- Our own galaxy is called the Milky Way Galaxy.
- There are billions of other galaxies in the Universe and they come in a variety of shapes and sizes.
- The distances between stars and galaxies are enormous and so new units of measurement are needed because familiar units like kilometres are too small to be useful.
- On the largest scale, matter in the Universe is arranged rather like a bath sponge, into thin filamentary structures with large voids between them. If you have Internet access and a projector in your class, an interesting and fun way to introduce what lies beyond our solar system, and beyond the Milky Way, is to use this interactive animation 'Scale of the Universe', where you use a sliding scale to either zoom in or zoom out, available here: [1] bit.ly/1iaQkZV. Start with the human-sized scale and zoom out. For interest, you can also go back to the start and zoom in to get to the microscopic level and even smaller for learners to appreciate the size of atoms.

12.1 The Milky Way Galaxy (2.5 hours)

Tasks	Skills	Recommendation
Activity: Draw the Milky Way	observing, identifying, drawing	CAPS suggested
Activity: Make the Milky Way	observing, identifying, (modelling)	CAPS suggested

12.3 Light years, light hours and light minutes (3 hours)

Tasks	Skills	Recommendation
Activity: Travelling fast	calculating	CAPS suggested
Activity: Scale of the solar system	calculating, reading tables, analysing	CAPS suggested
Activity: Our closest stars	reading tables, analysing	CAPS suggested

12.4 What is beyond the Milky Way Galaxy? (2,5 hours)

Tasks	Skills	Recommendation
Activity: Comparing galaxies	observing, identifying, describing, ranking	Optional

Note: There are two optional, extension activities included in this section. They are:

- Activity: Wine glass gravitational lens
- Activity: The expanding Universe

Key questions

- How far is our second closest star, Proxima Centauri?

- What is a galaxy and how many different types of galaxy are there?
- Where is our Sun located within our own Milky Way Galaxy?
- How do galaxies arrange themselves on the largest scales in the Universe?
- How large is the observable Universe and how many galaxies does it contain?

12.1 The Milky Way Galaxy

In this section learners will discover that the Sun is one of about 200 billion stars in our home galaxy, the Milky Way. Learners will be introduced to the main features of the Milky Way Galaxy which include its central bulge, flat disk and spiral arms. Students will also learn the Sun's place within the Milky Way: we are not in the centre of our galaxy, but rather are out on the edge of our galaxy, about halfway out from the centre.

Some learners have difficulty in envisioning what they are actually looking at when they see the Milky Way in the sky at night. In fact, every individual star that we see in the sky at night is part of our Milky Way. If the Milky Way were spherical in shape, then we would not see the thin band of the Milky Way across the sky, stars would be more uniformly distributed across the whole sky. However, because the Milky Way is flat, when you look at the band of the Milky Way across the sky at night you are actually looking along the plane of the disk of the galaxy in towards the centre where there is a high density of stars. The density of stars is so high that they cannot be individually distinguished by the naked eye, and so the Milky Way appears as a white band of light across the sky.

Some of the arms have alternative names, a table is included here for reference in case other names are listed in books or online.

Common name	**Alternative name**
Norma Arm	3 kiloparsec Arm
Scutum-Crux Arm	Centaurus Arm
Sagittarius Arm	Sagittarius-Carina Arm
Orion Arm	Local Arm
Perseus Arm	–
Cygnus Arm	Outer Arm

If learners are familiar with scientific notation, then the above diameter of the Milky Way can be written as 9.5×10^{17} km.

ACTIVITY: **Draw the Milky Way (LB page 258)**

The aim of this activity is to reinforce the idea that the Milky Way Galaxy is a spiral galaxy with five major spiral arms in addition to some smaller arms. Learners will also be reminded that the Sun and Earth are not at the centre of the galaxy, but rather about half way out along a minor arm called the Orion Arm.

Learner-dependent answer. Ask learners to explain their answers. A typical response could be that we count the number of stars we see in each direction.

ACTIVITY: **Make the Milky Way (LB page 258)**

In this activity learners will make a model of the Milky Way. They must come up with the best materials they can think of and obtain for their models. For example, they can use cardboard, cotton wool balls and glitter. This can be done as a group model, where learners are given the task a couple days before the lesson and they must collect the materials, or else you can supply a selection of materials in class which they can then use to build the model. Encourage learners to be creative when thinking about the materials to use to represent the different components. The aim of this activity is to give learners a three dimensional view of the Milky Way, including the structure of the central bulge and the disk containing the spiral arms. The glitter is used to represent the distribution of stars and the colours are used to demonstrate how old and young stars are distributed in the galaxy. The life cycle of stars in not covered until Grade 9. Therefore, although you may want to mention that the stellar populations in the bulge and the disk of our galaxy are different, it is not essential to do so.

Examples of other materials to supply are:

- a bag of cotton balls or pillow stuffing
- glue
- string
- pencil
- red, blue, gold and silver glitter
- star sticker

Learners must come up with their own model designs. An example design is included here if you would prefer to make one which you then use to demonstrate to learners, instead of them making their own:

1. Build a dome of cotton balls in the centre of one side of the cardboard. Use glue to keep the cotton balls in place. The dome should be about 8 cm across and 4cm high.
2. Repeat on other side of the board. The cotton ball dome represents the bulge of our galaxy.
3. Pull the outer cotton balls into six spirals around the cotton ball dome. These represent the five major spiral arms found in the disk of our galaxy, in addition to the minor spiral arm that our Sun is found in.
4. Dribble glue on the spiral arms and sprinkle blue and silver glitter on the glue. These represent hot newly forming stars.
5. Dribble glue all over the cotton wool dome ball in the middle and sprinkle this glue with gold and red glitter to represent cooler, older stars.
6. Mark a position 8 cm from the centre inside one of the spiral arms.
7. Stick the star sticker on the spiral arm at the marked position. This marks the position of our Sun.
8. Make a hole in the centre of the model and thread it with a string so that it can be hung up.

1. The disk and the bulge.
2. In the disk.
3. Our Sun is located in a spiral arm.
4. Just over half way out from the centre.

12.2 Our nearest star

In this brief section learners will be introduced to the large distances found between stars in preparation for the following section on light hours, minutes and seconds.

The following is an **optional, extension activity** that you can do on scientific notation with your learners. Scientific notation is only covered in Gr 9 Mathematics, however. many of the numbers used in this chapter are very long, and so can be written in scientific notation. Also, if you do some of the subsequent activities doing calculations with a calculator, the answers will be given in scientific notation. It is therefore useful for learners to know what this is. You can use the following activity to explain scientific notation to learners and write some of the examples given in the tables on the board as examples.

12.3 Light years, light hours and light minutes

In this section, learners will be introduced to the concept of light years, light hours and light minutes. These units of distance are used for interstellar (between stars) and interplanetary (between planets) distances because the distances involved are huge and familiar units like metres and kilometres are just too small. Because of the references to time in each of these distance units, learners can often mistake these units as units of time rather than units of distance. It is important to address this misconception. For example, a light hour is the distance that light travels in one hour of time. Although time is involved the final measurement is actually a distance. A useful activity to introduce the topic is to ask learners how far they estimate they could walk, run and cycle in one hour. Although they have to use time in their estimation they should understand that they are estimating a distance. This example also includes the concept of speed. Learners should understand that if they move faster they will travel further in a given hour. Starting off by using activities that they are familiar with should prove useful when then going on to deal with the rather abstract concept of the speed of light.

This section is fairly mathematical, and learners will need a calculator to complete the activities. It is useful (although not essential) if learners understand scientific notation. Learners need to understand what a million, billion and trillion correspond to and so if in doubt it might prove useful to remind learners of the powers of ten involved for millions, billions and trillions. Formulae for calculations have been provided where necessary, and it is expected that most learners will be familiar with the formula speed = distance / time. If learners are unfamiliar with this concept it would be a useful exercise to explain this before starting on the exercises in this section

ACTIVITY: **Travelling fast (LB page 261)**

Mode of transport	**Speed (km/h)**	**Distance between Cape Town and Durban (km)**	**Time taken for the journey**
cheetah	120	1753	14.6 hours
peregrine falcon	389	1753	4.5 hours
high speed train	581	1753	3.0 hours
NASA's scramjet	7000	1753	15 minutes
International space station	27744	1753	3.8 minutes
light	1 079 252 850	1753	0.006 seconds

It is the distance that light travels in one minute.

A light minute is smaller because the light has less time to travel in a minute than an hour. So a light minute must be shorter because this represents the distance that light travels in a minute.

One minute.

ACTIVITY: **Scale of the solar system (LB page 263)**

Question 7 in the activity is an advanced question for able learners.

1. 8.32 light minutes.
2. 8.32 minutes.

3. We see the Sun as it was 8.32 minutes ago.
4. 30 times further. This is calculated by dividing the distance from the Sun to Neptune by the distance from the Sun to Earth: 4495/150 = 30.
5. 4.17 light hours.
6. 4.17 hours.
7. If you see the flare happen from Earth, then the flare happened 8 minutes ago. The light from the Sun showing the flare takes 4.2 hours to reach Neptune (about 4 hours 24 minutes), so your cousin will only see the flare in 4 hours 16 minutes time.

ACTIVITY: **Our closest stars (LB page 264)**

In this activity learners will get a feel for how "close" the nearest stars are to the Sun. The idea of this activity is to familiarise learners with the idea that stellar distances are generally measured in light years (rather than light minutes or hours which apply to solar system objects).

1. Proxima Centauri.
2. Sirius is 8.58 light years away.
3. Light takes 5.96 years to reach us from Barnard's star.
4. It means that the star is at the distance that light can travel in 8.58 years. It means that light takes 8.58 years to reach us on Earth from Sirius.

12.4 What is beyond the Milky Way Galaxy?

In this section learners will find out what lies beyond our own galaxy. They will learn that there are billions of other galaxies in our Universe of all shapes and sizes. They will learn about the different types of galaxies, i.e. ellipticals, spirals, barred spirals, lenticular and irregular types. Learners **do not** have to know the actual names of the different shapes (this is included for interest), but they must know the shape of the Milky Way Galaxy and understand that other galaxies have different shapes. The will also look at how galaxies are arranged in the Universe: into groups and clusters of galaxies, and finally they will look at the Universe on its grandest scale finding out how matter is arranged into voids and filaments.

Extra information on the different shapes of galaxies:

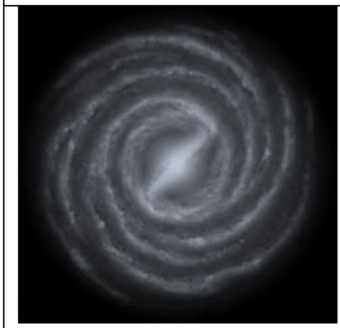
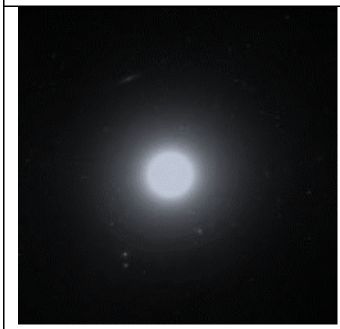
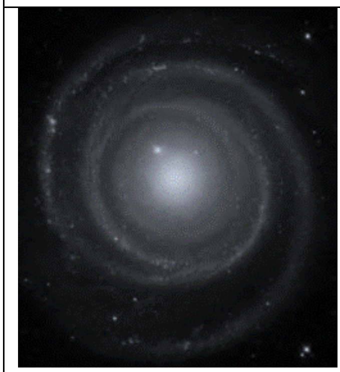
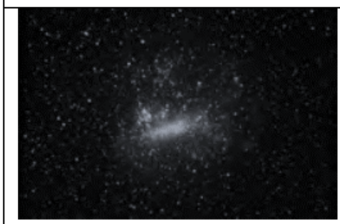
- Spiral galaxies have a central bulge and a flat disk with spiral arms.
- Some spiral galaxies have arms that do not start at the centre of the galaxy but start at the end of a bright straight bar that goes across the centre of the galaxy. These are called barred spiral galaxies.
- Elliptical galaxies look smooth and are shaped like giant rugby balls with no spiral arms. Some can be round and some can be very elongated. They contain old stars and have very little gas and dust.
- A lenticular galaxy is in between a spiral galaxy and an elliptical galaxy. They are disk galaxies (like spiral galaxies) but do not have defined arms as they have lost most of their dust and gas. As a result, there is little star formation happening and they consist of mostly old stars (like elliptical galaxies.)
- Irregular galaxies do not look like spirals or elliptical galaxies. Some (but not all) irregular galaxies are actually two or more galaxies in the process of colliding.

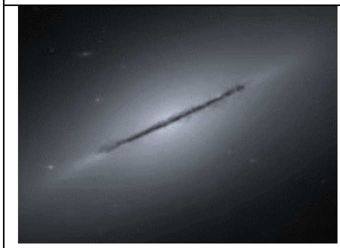
There is a really relevant link provided in the Visit box for the citizen science project, **Galaxy Zoo**. This is a really great way for you and learners to become actively involved in some real science research related to what you are doing in class. If you have Internet access and a projector in your class, a suggestion is to bring this site up and go through some of the galaxies with your learners and classify them according to their shapes.

Find out more about incorporating real science into your classroom with Zooniverse citizen science projects at the ZooTeach website: [2] bit.ly/H6krWT. Citizen science offers you a free, easily accessible and inspiring opportunity to bring real science into the classroom. ZooTeach is a website where teachers and educators can share high quality lesson plans and resources that complement the Zooniverse citizen science projects.

ACTIVITY: **Comparing galaxies (LB page 266)**

This is an optional, extension activity. In this activity learners will describe and compare the appearance of six different galaxies. They will also rank the galaxies in terms of increasing distance from Earth.

Galaxy name	**Galaxy type**
 Milky Way Galaxy.	Barred spiral galaxy (because it has spiral arms with a bright, central bar)
 Galaxy M 89, 60 million light years away.	Elliptical galaxy (because it is round and smooth with no spiral arms)
 Galaxy NGC 4622, 111 million light years away.	Spiral galaxy (because it has spiral arms)
 The Large Magellanic Cloud galaxy. This satellite galaxy of our own Milky Way is only 163 000 light	Irregular galaxy (it does not have spiral arms and is not a smooth oval shape like elliptical galaxies. It looks like an irregular shape)

years away.	
 The Spindle Galaxy, 44 million light years away.	Lenticular galaxy (because it is disc shaped, with a central bulge, but no spiral arms)

Extension content and activity

Galaxy clusters are beautiful yet peculiar objects. They seem to be full of a mysterious unseen type of matter which has not yet been identified. From its gravitational effects on the gas and galaxies in the cluster, astronomers estimate that this strange matter could be about five times more massive than all the galaxies and hot gas in a cluster combined. Astronomers have no idea what this mysterious matter is and call it **dark matter,** because they cannot see it. It turns out that this strange matter is not only found in clusters of galaxies, but is spread throughout space.

The galaxy cluster called Abell 2218. Each point of light is a galaxy.

If you look closely at the image of galaxy cluster Abell 2218, in addition to the galaxies that make up the cluster you can see thin arcs. These are images of distant galaxies behind the cluster that are distorted by matter in the cluster. The cluster of galaxies acts like a giant lens, bending and distorting the light coming from the more distant galaxies. The distant galaxies are not actually this funny shape, they are usually elliptical or spiral shaped. They just appear this way because of the lensing. Matter bends light, just like a lens does, although the effect is much weaker, otherwise our torches would have bent light beams. When matter acts to bend light astronomers refer to the matter as a gravitational lens. Clusters of galaxies make excellent gravitational lenses because they are so massive. Most of the lensing however does not come from the galaxies or the hot gas in the cluster, but from the unseen dark matter within the cluster.

Revision

1. Proxima Centauri. 4.24 light years away.
2. Alpha Centauri. Alpha Centauri is actually a multiple star system containing the stars Alpha Centauri A and B closely orbiting each other. To the naked eye these two stars look like a single star. Proxima Centauri is also thought to be a member of this star system but it is farther away from the other two stars.
3. A light year is the distance that light travels in one year.

4. A galaxy is a massive collection of stars, dust and gas held together by gravity. A typical galaxy contains hundreds of billions of stars.
5. It is located in the Orion spiral arm halfway out from the centre of the galaxy.
6. 200 billion.
7. Elliptical galaxies, spiral galaxies, barred spiral galaxies and irregular galaxies.
8. The Milky Way is a barred spiral galaxy.
9. Learners must draw the spiral shape of the galaxy from above. The exact positioning of the arms is not important, but learners must show the position of the Sun towards the edge of one of the arms, Orion. From the edge on, learners must show a flat disk with a bulge in the middle, and they must locate the position of the Sun towards the one side of the disk.
10. The Milky Way Galaxy is a flat disk and when you look at the band of the Milky Way across the sky at night you are actually looking along the plane of the disk of the Galaxy in towards the centre where there is a high density of stars.
11. A collection of galaxies, held together by gravity.
12. The Local Group.
13. A cluster of galaxies is a collection of 50 or more galaxies held together by gravity. Clusters of galaxies often group together to form larger structures called superclusters of galaxies.
14. The size of the observable Universe is 93 billion light years in diameter.
15. The Universe is made of thin walls called filaments which contain the galaxies and gas and dust. In between the filaments lie empty bubbles called voids.

13 Looking into space

Chapter overview

2 weeks

In Grades 6 and 7 learners covered material regarding the viewing of space and telescopes.

In Grade 6 they were introduced to telescopes including SALT and the SKA. In Grade 7, they focused on the historical development of modern astronomy including ancient observations and indigenous starlore all the way up to modern scientific developments. In this chapter the focus is on how we observe objects in space using telescopes. Some history showing how early astronomers viewed and interpreted the stars and planets in the sky is also included. Learners will have the opportunity to conduct their own observations of the Southern Cross as well as learn about the latest telescopes being developed in South Africa.

The main aims of this chapter are to ensure that learners understand the following:

- Early cultures studied the stars and planets using the naked eye. They often grouped stars together in patterns called constellations.
- Astronomers now use telescopes to study galaxies, stars and planets.
- Telescopes help astronomers see fainter objects, because they act as light collecting buckets.
- South Africa is host to the largest optical telescope in the southern hemisphere and will be hosting the majority of the largest radio telescope ever, the Square Kilometre Array (SKA). Section 3.1 covers the early observations of space and section 3.2 covers modern day telescopes.

13.1 Early viewing of space (2 hours)

Tasks	Skills	Recommendation
Activity: Using star maps to observe the night sky	observing, comparing	CAPS suggested
Activity: Observing the Southern Cross (Crux)	observing, comparing	CAPS suggested
Activity: Constellation starlore	researching, oral communication	CAPS suggested

13.2 Telescopes (4 hours)

Tasks	Skills	Recommendation
Activity: Telescopes as light buckets	observing, analysing, comparing	CAPS suggested
Activity: Comparing your eye with SALT	comparing, observing, calculating, estimating	Optional
Activity: Draw a telescope	drawing, labelling, describing	CAPS suggested
Activity: Telescope information poster	listing, researching,describing, writing	CAPS suggested
Activity: Careers in astronomy	discussing, analysing	CAPS suggested

Key questions

- How did early cultures observe and interpret the night sky?
- How does a telescope help us to see more objects in the sky and in greater detail?
- What kind of telescopes are there?
- Why is South Africa a good place for locating telescopes?

13.1 Early viewing of space

In Gr. 7 learners were introduced to indigenous knowledge about the stars and planets under the historical development of astronomy. This section focused primarily on the practical uses of star observations, such as timekeeping and navigation, along with an introduction to starlore associated with the Moon, Milky Way and other celestial bodies. In this section the focus will lie in the observations of constellations (and the planets) and starlore associated with one example constellation. A good way to introduce the topic of the early viewing of space, is to ask learners if they know of any stories about famous constellations or the planets. This facilitates discussions about constellations visible in the sky and how the stars are actually related in space.

ACTIVITY: **Using star maps to observe the night sky** (LB page 272)

In this activity learners will use the star map provided to identify three constellations in the night sky visible during September/October/November. If you want to generate a star map specific to your location and date you can freely download a sky map from [1] bit.ly/17e1jm3 . All you need to do is select the area from which you want to view, by clicking on 'select from map' or 'from database' and selecting your location. Your location will then be saved. You can then click on the 'Sky chart' link further down to view a map of the night's sky from your location at the current time. You can save and print this for learners. For example, here are the links to the sky maps for several places in South Africa. A suggestion is to also organise this activity as a field trip at night. Go beyond the city lights to an area where you are able to view the stars more clearly without light interference. Also take note of when the full Moon occurs, as reflected light from the Moon can also interfere with star gazing.

Location	**Link**
Bloemfontein	bit.ly/17GyAAH
Cape Town	bit.ly/1bSSCeq
Durban	bit.ly/17dZZ2m

ACTIVITY: Observing the Southern Cross (Crux) (LB page 273)

In this activity learners will observe the Southern Cross constellation at least three times during the months of September and October. Learners should make sure that they try to observe the constellation at the same time each night.

The constellation should appear to rotate in a clockwise direction over time. Inearly September its long axis is fairly horizontal in the sky but the constellation gradually rotates so that by early November its long axis is almost pointing downwards.

ACTIVITY: **Constellation starlore** (LB page 274)

This is a research activity for learners to complete. They will study ancient stories about a constellation of their choice. You can either provide them with books or printed resources or if they have access to the Internet you could ask them to conduct an online search. You may ask learners to pick South African stories, or if you want, you could extend their research to other countries for comparisons with South African starlore. You can ask learners to present their story to the class either as an oral presentation or a poster, or if you wish you can turn this into a writing task.

13.2 Telescopes

In Gr 6 learners were introduced to telescopes including the Southern African Large Telescope (SALT) and the Square Kilometre Array (SKA). In this section learners explore how telescopes work in more detail. There is a particular focus on comparing the telescope with our eye. Simple ray diagrams are shown which link to material covered in Gr 8 Energy and Change, Chapter 4 on Visible Light. Two case studies are explored in more detail: SALT and the SKA, and learners will find out why South Africa is an ideal location for professional telescopes.

By radiation, as electromagnetic waves travel in straight lines.

The image is inverted, it is upside down.

In the image above the tree is upside down in the top eye because images on the retina are upside down. In the bottom eye the tree is the right way up because the telescope inverts the image of the tree.

A biconvex lens.

The light is refracted and the light rays converge as the light passes from one medium to another.

ACTIVITY: **Telescopes as light buckets** (LB page 277)

In this activity learners will discover how a telescope collects more light than our eyes can and as a consequence can help us to see fainter and more distant objects. As well as demonstrating how telescopes collect light, this activity also shows learners how telescopes focus light from distant objects to a point. This activity introduces the concept of photons, or packets of light. This is not a formal part of the curriculum in Gr 8, and is not explained in detail. The idea that a finite amount of light hits a telescope mirror or eye per second is crucial to this activity and the understanding of why telescopes are useful. If you feel that you would rather omit the concept of photons, you could instead talk about the rice grains representing rays of light.

The wooden skewers used for making kebabs or sosaties are ideal for this activity.

1. The paper plate.
2. No.
3. Yes.
4. The telescope mirror has a curved surface and reflects the light hitting it, therefore causing the light to focus at a point.

ACTIVITY: **Compare your eye with SALT** (LB page 278)

This is an **optional** activity. In this activity learners work in pairs. Learners should estimate that their reaction time is of the order of 1/10th of a second. But as long as they estimate 1s or less this is perfectly fine. They will use this value as their eye's exposure time. In fact roughly every 1/15th of a second, the eye sends the brain another image. So the eye has about one-fifteenth of a second to collect light when making an image.

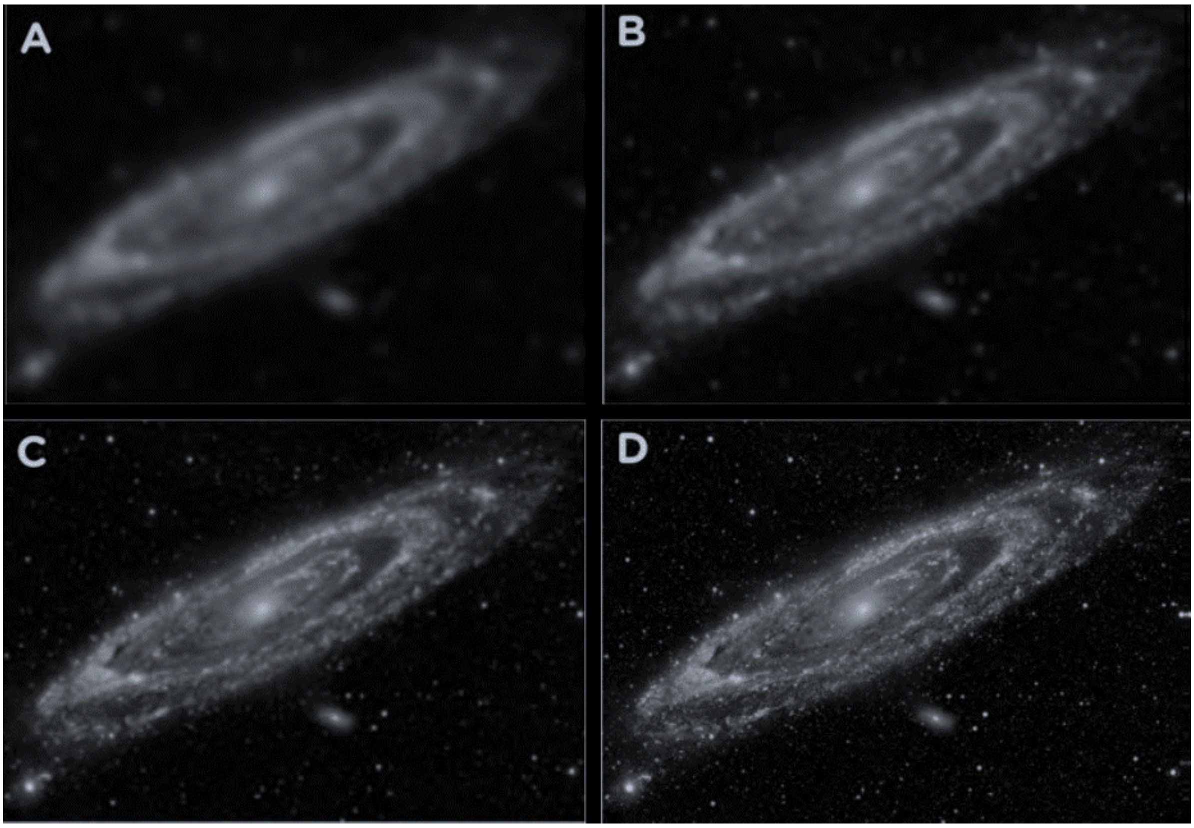
1. Light is collected over the area of your pupil and over the whole area of the telescope.
2. Learner-dependent answer. Assuming a pupil diameter of 0.5 cm and a SALT mirror diameter of 10 m the answer is 4 000 000 ((1000 cm x 1000 cm) / (0.5 cm x 0.5 cm))
3. It would increase. Note that this experiment shows us that we do not see or react instantaneously. It

takes time for the image of the moving pencil to be recorded and for us to react, so we do have a kind of exposure time.

4. Learner-dependent answer. Assuming a reaction time of 1/10th second and a SALT exposure time of 20 minutes the answer is 12,000 (20 x 60s / 0.1s).

Extension content on another advantage of telescopes, namely angular resolution
Telescopes also have another advantage over the eye. Telescopes can better distinguish between objects that are close together on the sky. The ability to see things that are close together as separate objects rather than seeing one smeared or fuzzy object results in a sharper image. In astronomy, "close together" means "separated by a small angle on the sky," so astronomers refer to the **angular resolution** of a telescope. The higher the angular resolution of a telescope, the better it is at seeing narrowly separated objects as individual objects and the sharper the images look.

The images below show what photographs of the same galaxy look like with different angular resolutions.



The same galaxy viewed with increasing angular resolution from (A) to (D). The image gets sharper with increasing angular resolution. In (A) the telescope is able to distinguish between objects separated by an angle of only 1/6 of a degree or more. In (D) the telescope can see objects separated by an angle of only 1/3600 of a degree or more.

In the following activity learners will measure the angular resolution of your eye and then compare it with that of the SALT telescope.

Misconceptions about magnification
Many students want to know how much a telescope "magnifies" an image as they think this is the most important characteristic of a telescope. Telescopes do magnify images, but this is not the main reason why they are so useful. After all, a magnified dim image would still be dim and difficult to make out and a magnified blurry image would still be blurry and wouldn't help you see anything. Astronomers care more about how much light the telescope can collect and also its angular resolution: how bright, sharp and clear its images are. These properties both depend upon the size of the collecting mirror or lens rather than the

magnification. With telescopes, bigger really is better.

Both of the lenses are convex lenses which means that they cause light rays to converge or come together.

No, Violet is bent the most. Bluer colours are slowed more than redder colours and so they are bent or refracted more.

Learner-dependent answer. Answers could include that the images could look colour-separated and blurry.

So that it does not block much light from the distant object as it travels to the primary mirror.

No, they do not, because they do not use a lens to collect and focus the light, but rather use mirrors which reflect light.

This is a good opportunity to get learners to think about the conditions needed to make good observations of very faint objects. You may need to lead the discussion. They should understand that ideally they should collect as much light from the object with minimal stray light from other sources. You can lead the discussion by first asking them what the air is like on the top of mountains and also what the weather is like and asking them about how bright they think the sky is up a mountain compared to in a city. Possible answers include:

1. They are far away from the light pollution from large cities and towns
2. They are above dust and other types of atmospheric pollution.
3. They are above low cloud.
4. The air is thinner and so there is less absorption of the starlight by the Earth's atmosphere.
5. There is less air turbulence resulting in sharper images.

It does not have a secondary mirror to reflect the light to an eyepiece, but rather a detector located at the focal point.

Background information
This is because the angular resolution depends not only on the diameter of the collecting mirror but also upon the wavelength of the light. The minimum angle at which two objects can be distinguished on the sky is proportional to the wavelength of light used and inversely proportional to the diameter of the collecting mirror. As radio waves are much longer than visible light, the diameter of the collecting mirror must increase to compensate if you require the same angular resolution.

ACTIVITY: **Careers in Astronomy** (LB page 289)

In this activity learners will discuss the sorts of jobs that are available in astronomy. As well as astronomers, facilities like SALT and the SKA need engineers, technicians, computer scientists, project managers, HR professionals, accountants and administrative staff. This is a creative and challenging activity for learners to imagine what contribution they could make to astronomy in South Africa.

ACTIVITY: **Draw a telescope** (LB page 289)

In this activity learners choose a telescope they want to focus on and a draw a picture of the telescope labelling the parts and describing what each part does. They can use the examples in this chapter or they can search online for examples of optical and radio telescopes.

ACTIVITY: **Telescope information poster** (LB page 290)

In this activity learners will make a poster about a specific telescope they have conducted research on. They can choose any type of telescope including ground-based and space telescopes. They should describe how the telescope works and provide some examples of the sorts of astronomy that the telescope is used for.

Revision

1. Constellations.
2. Learner-dependent answer. Answers could include, Orion, the Southern Cross, Pavo the Peacock, the Phoenix.
3. Refracting telescopes use lenses to collect and focus light.
4. Reflecting telescopes use mirrors to collect and focus light.
5. Examples include: the glass of the mirror does not have to be perfect throughout, only the surface has to be perfect. The mirror can be supported across the whole of its back so it won't sag. Making large mirrors is easier and cheaper than making big lenses. They do not suffer from chromatic aberration.
6. They collect radio waves.
7. Radio telescopes can be used when it is cloudy and they can be used both during the day and during the night whereas optical telescopes need clear skies and can only be used at night.
8. X-rays are absorbed by the Earth's atmosphere and so do not make it to the ground. So telescopes to detect X-rays must be placed above the Earth's atmosphere in space.
9. Because the images are not smeared out by the turbulence in the Earth's atmosphere.
10. To get a complete picture of the object they want to study.
11. The Southern African Large Telescope, SALT.
12. It is far from any cities and their associated light pollution, it is dry there, it is at high altitude.
13. 64 dishes.
14. 3000 dishes.
15. Answers could include: exoplanets, magnetism in space, pulsars and gravity, galaxy evolution and star formation.