Natural Science

Grade 9

Teacher's Guide

Natural Science Grade 9 Teacher's Guide

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Contents

STRAND Planet Earth and Beyond

1 The biosphere

Unit overview

2 weeks

This unit introduces learners to the cell. They may have encountered the cell before, but here we will look at the structure of cells, including the organelles common to most eukaryotic cells. We will also look at the differences between plant and animal cells. Later we look at the hierarchical organisation of cells into tissues then into organs then into systems and then into an organism. Some information has been included on specialised cells. This was thought to be important to introduce the idea of a biological structure being adapted to its function to ensure functional efficiency. To be able to describe and explain how a structure is adapted to its perform its functions is an important skill in Life Sciences, especially if learners carry on with the subject in Grades 10–12. This is an ideal opportunity to start practising and also to realise that there is huge variety in the types, sizes, and shapes of cells – dependant on their function.

Learners also have to make a 3D model of a cell in this unit. This activity may be treated as a project. A suggestion is to turn to this activity at the start so that learners are aware of this and can start thinking about their models at home and what they could use to make them as you are going through the content and learning about the cell. You could then set a deadline for the model, for example one week after you finish this unit (that is, three weeks from when you start this unit), for them to have completed their models.

1.1 **Cell structure** (2,5 hours)

Tasks	Skills	Recommendation
Activity: Brainstorm the seven functions of life	Recalling information, listing	Optional
Activity: Summarise what you have learnt	Recalling information, identifying, writing	CAPS suggested

1.2 **Differences between plant and animal cells** (2 hours)

Tasks	Skills	Recommendation
Activity: Identify differences between plant and animal cells	Comparing, identifying, describing, writing	CAPS suggested
Activity: Comparing plant and animal cells	Comparing, describing	CAPS suggested
Activity: Cell 3D model	Planning, constructing, identifying, describing	CAPS suggested

1.3 **Cells in tissues, organs and systems** (1,5 hours)

Tasks	Skills	Recommendation
Activity: Evaluating microscopic images	Examining, observing, comparing	CAPs suggested
Activity: Making a wet mount with onion and cheek cells	Preparing and examining specimens, observing, recording, writing	CAPS suggested

Activity: Research the discovery of light and electron microscopes	Researching, writing	CAPS suggested

Key questions

- What are cells?
- Why are cells so small?
- What does it mean to be microscopic?
- Are there different types of cells?
- What is inside a cell and why is it there?
- Are plant and animal cells the same?

1.1 Cell structure

For many interesting articles about science and science-related jobs that are classified according to topics, and tips on. how to incorporate the articles into your classroom and what questions to ask, visit the following website: https://www.sciencenewsforstudents.org/. If you are interested in incorporating real-world science into your classroom, make sure to visit this website.

What are cells?

In Grade 7 learners should have learnt about the classification system of. organisms into the five kingdoms, namely; Bacteria, Protista, Fungi, Plants and Animals. This is a good opportunity to remind learners of this and ask them if they remember what the five kingdoms are.

ACTIVITY Brainstorm the seven functions of life (LB page 3)

1. Movement
   Respiration
   Sense
   Growth
   Reproduction
   Excretion
   Nutrition
2. Cells are the smallest unit of life and are therefore living.

When talking about the answer for question 2 of this activity, use the time and give learners a chance to express their opinions. At this time they would not yet learned about cells in great detail, so they might not yet agree with the fact that an individual cell is living. Allow learners to express their opinions and justify them.

You can also come back to this question at the end of the unit and reflect on the answers to see if the learners might have changed their minds.

Different types of cells

As a starting point for this section, you may want to ask these types of questions: Do you think all cells are the same? If they are not the same, can you think of reasons why they differ or how they might differ?

Discuss your thoughts with the class.

Ask your learners to describe the differences in shape between the nerve cells and the red blood cells in the images. Take note however, that the images have been coloured in afterwards – these are not the real colours of the cells, so guide learner not say that nerve cells are green, and so on.

As an extension ask them how they think the shape helps with the function of the cells. Describing how the structure of a particular biological component is suited to (adapted to) its function (i.e. functional efficiency) is a very important skill in Life Sciences and should be developed from early on. You can give brief descriptions of the function of the cells:

Nerve cells transmit (send) messages throughout the body from the brain to perform functions. So, the fact that nerve cells are elongated (like long thin wires) and branched, helps them to send these messages over long distances and make connection with many other cells.

Red blood cells carry oxygen from the lungs to the rest of the body. Their shape is adapted to carry oxygen and pass easily through very narrow capillaries to get to the individual cells. Red blood cells also do not have a nucleus so that there is more space for oxygen to be transported.

As an introduction to the cell organelles teachers might want to show learners. one or two of the YouTube songs included in the margin. They offer a fun entry-point into this topic.

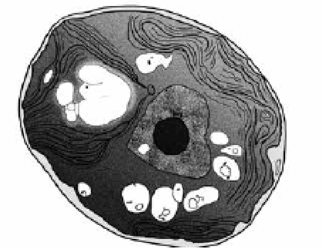
Cell structure

To explain the idea of 'selective permeability', you could use the analogy of a gate and security wall around someone's home – explain that only certain people get access to a private home and the gate serves to deny access. to undesirable people. Also waste products in the form of garbage bags are put outside the perimeter fencing to be removed and food and water is allowed to enter. As with viruses and diseases, thieves and criminals can however still penetrate the home's defences and will then attack the owners/cell organelles.

Cytoplasm

The cytoplasm is often referred to as the jelly-like substance within cells. This is. only partly true as the cytoplasm actually consists of the jelly-like substance (called cytosol) and all the cell organelles (except the nucleus). The term for the combined cytoplasm (cytosol + organelles) and the nucleus (containing nucleoplasm) is protoplasm. You should be aware of this when introducing the cytoplasm to learners so that this misconception can be avoided later on in their school career.

In this image of a plant cell, there are several vacuoles present, as is the case in many plant cells. The nucleus, with its dark nucleolus is also very clear. You can come back to this image a bit later to look at the nucleus again. If learners ask what the grey-white structure in the top left hand side is, this is a starch grain. Plants store starch grains within the cytoplasm. You can get your learners to. provide labels for the vacuoles and cytoplasm in this image. Also visible is the cell wall of the plant cell - the cell membrane is the inner, more folded boundary, whereas the cell wall is the light grey, more rigid structure on the outside. Faintly visible are several mitochondria, for example the grey oval structures at the bottom left. Come back to this image once you have done these structures to add these labels in.



Micrograph of a plant cell

Studying micrographs is a very important skill to develop for later in Life Sciences. Learners are often only exposed to schematic diagrams of cells which present an idealised view of the cell. They then find it very difficult to identify. these structures within a micrograph of an actual cell. Encourage your learners to take note of how the diagram below was drawn and how it differs to the micrograph of the nucleus. Remind your learners that a micrograph is a photograph taken through a microscope, and in this case, a transmission electron microscope.

Mitochondria

You can use this opportunity to revise what is meant by stored potential energy and the fact that food is seen as a fuel for our bodies.

A muscle cell will contain more mitochondria as muscle cells need a huge supply of energy for movement. You can point this out in the following image of mouse. heart muscle tissue. Cardiac muscle tissue is very active and therefore needs a big energy supply, hence the frequency of mitochondria present in the tissue, as shown in the Learner's Book.

With reference to the Did you know fact in the margin about mitochondrial DNA, learners may ask what we can deduce from the fact that there is such a thing. One theory is that mitochondria originated from bacteria that invaded ancient eukaryotic cells and started living in a symbiotic relationship with the host, eventually losing its ability to live independently. This idea is still very controversial and not universally accepted. MtDNA seems to have an influence in gene expression and can be used to trace maternal lineage, since we inherit. all of it from our mothers, not fathers.

ACTIVITY Summarise what you have learnt (LB page 7)

Cell Structure	Function(s)
Cell membrane	regulates/controls passage of substances in and out of cell
Cytoplasm	where many of the chemical reactions and processes in the cell takes place
Nucleus	contains DNA (hereditary material) of cell and controls the cell's activity
Mitochondrion	releases energy from food for the cell
Vacuole	stores substances, water, nutrients

1.2 Difference between plant and animal cells

ACTIVITY Identify differences between plant and animal cells LB page 7

Plant cells	**Animal cells**
Plant cells have a regular shape and structure and keep their shape easily A thick outer layer (two 'layers' enclose the cell although this is not very evident in the image) Green chloroplasts for photosynthesis.	Animal cells have an irregular shape and structure and bend and fold easily Thin outer layer (only a cell membrane encloses the cell.) No green chloroplasts can be seen.

Cell wall and vacuoles

Plants have cell walls to provide support and some learners might remember the vacuoles.

ACTIVITY Comparing plant and animal cells LB page 9

1. An example of the type of table that learners might produce is given below. Learners might present the information in a slightly different layout, which should be encouraged, if it is logical and legible. For example, they might not have the first column with the characteristic.

Table summarising the differences between plant and animal cells		
Characteristic	**Animal cells**	**Plant cells**
Shape	Have an irregular shape	Have a rigid, regular shape
Cell wall	Do not have a cell wall, only a cell membrane	Have both a cell membrane and a cell wall.
Vacuoles	Have small vacuoles, which are often temporary or absent	Have large vacuoles
Chloroplasts	Do not have chloroplasts	Have chloroplasts to photosynthesise

2. Here are the labels for the animal and plant cell diagrams.

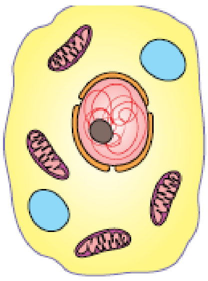


Figure 1.12: A typical animal cell.

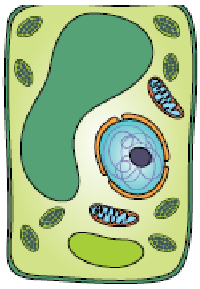


Figure 1.13: A typical plant cell.

ACTIVITY 3D model of a cell LB page 9

This activity can be used as a project. Encourage learners to be creative when doing this task. They could make cell pizzas (with different toppings representing the organelles), cell jellies (with different fruits representing the organelles), or they may wish to use recycled items to represent the different functions of the organelles (such as batteries to represent mitochondria). The possibilities are endless.

Learners could create cell models out of playdough as an alternative option. Different colours can be created using different food colouring.

The recipe for playdough is as follows:

- 1 cup plain flour
- $\frac{1}{2}$ cup of salt
- 2 tablespoons of cream of tartar (optional)
- 1 tablespoons of cooking oil
- food colouring
- 1 cup of boiling water

1. Add all the ingredients in a large bowl and mix together until it starts to bond together and becomes hard to mix.
2. Take it out of the bowl and throw it on a board (or other surface for this purpose). (It will be hot when

you take it out of the bowl so be careful.)
3. Knead the dough until it takes on the look and consistency of play dough.
4. Add the food colouring to get the colour you want.
5. Keep the playdough in an airtight container in the fridge before use.

Although there is a general assessment rubric for models supplied in the Appendix of the Teacher's Guide, here is a more detailed rubric that you can use to assess your learners' models out of 40 marks. You can photocopy this rubric if you wish to provide it to your learners so that they know how they will be assessed.

TOTAL [40 marks]

Aspect	**4**	**3**	**2**	**1**
Model construction	Materials carefully chosen and modified to resemble organelle	Materials were well chosen and tried to modify some to resemble organelle	Appropriate materials chosen and organelles and their functions were fairly accurately represented	Inappropriate materials chosen, model did not represent structure or function of the organelles
Model presentation	Model represented in creative, carefully planned way; headings and labels added; clearly and correctly presented and in 3D	Cell model is almost complete and mostly correctly presented; it is mostly 3D	Cell model is fairly correctly presented but not complete and missing more than 3 organelles; more than half is 3D	Cell model is missing more than 5 organelles; it is not 3D and is poorly presented
Representation of organelles	Organelles are the appropriate size in proportion to the rest of the cell structures. All 7 minimum organelles are present	1 or 2 organelles are not appropriately proportioned or do not have correct size orshape; Not all 7 minimum organelles present	3-6 organelles are not appropriately proportioned and incorrect size/shape used; 3-6 organelles missing from list	Representation seems careless and rushed; many organelles missing or incorrectly included; lacks planning
Labelling of organelles	Organelle flags or a key is used successfully and all organelles are clearly labelled	1-2 flags are missing or incorrectly placed; few spelling errors	3-6 flags are missing or incorrectly placed; many spelling errors	If flags are included they are incorrectly placed; many spelling errors
Understanding of organelles	Displays a clear understanding of all 7 organelles and their function(s) in the cell	Displays a good understanding of at least 5 cell organelles and their function(s)	Displays a fair understanding of at least 3 of the organelles and their function(s)	Displays very little understanding of organelles and their function(s)

Class presentation	Presentation is well planned and confidently given; learner is an expert on the cell	Presentation is mostly clear displaying confidence; Not sure of 1-2 things	Presentation is at times unclear or unprepared; learner is unsure of most of the organelles and cell structure	Unclear or unprepared presentation; learner mostly unsure of organelles and cell structure
Drawing of cell	Cell is drawn accurately and neatly; excellent detail	Cell drawing is good and clear though missing 1-2 organelles; fairly neat. Includes 1-2 inaccuracies	Cell drawing is fairly good but missing 3-5 organelles and includes 3-5 inaccuracies	Very basic cell drawing showing very few organelles and many inaccuracies; untidy and poorly presented
Scientific method used to label drawing	Label lines are neatly drawn with a ruled; they do not cross and labels are grouped neatly on one side of the drawing; heading supplied; no spelling errors in labels	Label lines neatly drawn though not always with ruler; 1-2 cross; heading supplied but 1-2 spelling errors. Label lines not grouped on one side but placed around the drawing	Label lines either drawn by hand or missing; if included they cross; labels are placed all over the drawing, not neatly on one side	No lines included and no labels included
Rubric handed in with cell model and self-assessment completed	Rubric handed in; very good self-assessment and accurate grasp of their abilities and challenges	Rubric handed in with fairly good self-assessment completed. Fairly accurate assessment	Rubric handed in with some self-assessment done but it is unrealistic and a poor portrayal of their model	Learner handed in the rubric with the cell model but did not assess themselves on it
Handed in on time	Handed in on due date	Handed in one day after due date	Handed in two days after due date	Handed in three or more days after due date

1.3 Cells in tissues, organs and systems

Observing cells under a microscope

This section on microscopy is meant as an introduction as learners will need to be able to use microscopes later in this unit, as well as if they carry on with Life Sciences in Grade 10. Learning how to use an instrument is a very good skill. In Grade 10 Life Sciences, learners will look at the different types of microscopes in more detail. Here, only light and electron microscopes are mentioned briefly.

Learners would have been introduced to the atom in Grade 8 Matter and Materials and perhaps before. The atom is the building block of all matter. The ability to visualise columns of atoms under a transmission electron microscope indicates how extremely powerful and high resolution these instruments are. A useful site for information about microscopy:2 bit.ly/13ZkGaV

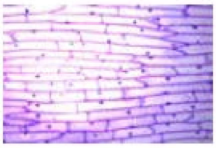
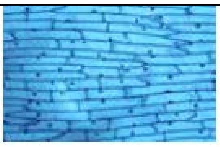
If microscopes are not available in your school, try building one with the learners' help! If Robert Hooke could do it without the wonderful technological marvels we have in our lives today, so can we!3 bit.ly/19bsOcQ or 4 bit.ly/16IIkfZ

Alternatively, organise to visit a school where microscopes are available and work alongside the learners at that school, or organise times when your school's learners can use the equipment when the laboratory is not being used.

ACTIVITY Evaluating microscopic images LB page 12

This is an extension activity. It is optional and does not need to be done. However, if you do not have microscopes to work with at Grade 9 level, this does provide an opportunity to get some experience with working with microscopes and troubleshooting problems, without actually using a real one.

1. Learners need to explain that the image is sharp and in focus, that there is enough light shone on the specimen and that the contrast is clearly well achieved to show the structures of the cells.
2. Learners might battle with the last image about contrast as this is quite tricky to understand, so you might have to explain the answer to them. The difference between brightness and darkness is that brightness refers to how light or dark an image is, whereas contrast refers to the difference in lighting between different areas of the specimen.

Image	**What is wrong with the image?**	**How could the image have been adjusted and corrected, using what part of the microscope?**
	The image is fuzzy.	This image could have been focused using the fine and coarse adjustment screws.
	The image is very dark.	The brightness of the image could have been adjusted by changing the brightness of the lamp or moving the mirror to reflect more light onto the slide. The brightness can also be adjusted using the diaphragm and condenser apertures.
	This image has poor contrast.	The contrast of the image can also be adjusted by changing the intensity of the light and the diaphragm aperture.

Learners may battle with the last image about contrast as this is quite tricky to understand, so you might have to explain the answer to them. The difference between brightness and darkness is that brightness refers to how light or dark an image is, whereas contrast refers to the difference in lighting between different areas of the specimen.

Before starting this activity, you could ask your learners why they think you are going to be making wet mounts, and not another type of mount, and what advantages using a liquid has. Have this as a class discussion and encourage your learners to take notes, either in a separate notebook or in the margin spaces within the workbook. We use liquid because:

The liquid helps to support the specimen - remember, in our case it will only be a few cells so would be quite easily damaged.

The slide will have a special glass coverslip on top of the specimen. When we use the liquid, it fills the space between the specimen on the slide and the coverslip.

The liquid allows light to pass through the glass slide and coverslip.

The liquid prevents the specimens from drying out or blowing off the side.

If we are using a stain instead of water, the stain lets the cell structures and organelles (the cell membranes and nuclei) stand out prominently allowing us to see it easily.

ACTIVITY Making a wet mount with onion and cheek cells LB page 13

This activity will show learners how to prepare onion cells in a step-by-step manner, and will then challenge them to prepare their own cheek cells (using an ice cream stick or your own nail for collection) in order to study it under a microscope.

Very important: Make sure learners use clean, sterile sticks and that they do not re-use them and swop them.

If your class does not have access to a microscope, learners may still practice preparing a wet mount, and then examine the images at the end of the exercise.

Risk assessment: Some people are allergic to iodine and/or shellfish. If any learners are allergic to iodine or shellfish DO NOT use the iodine solution to stain your specimens. Methylene blue and crystal violet are harmful and can be irritants. Avoid contact with the skin.

Learners must gently scratch the inside of their cheeks to collect some cheek cells and then wipe the toothpick on the slide and cover with a drop of water. (Please ensure that learners scrape with the broad side of the toothpick, slowly and gently, so that they do not injure themselves!) Alternatively, learners can use old wooden ice cream sticks. The water droplet will most likely contain several cheek cells. It is going to be near impossible to see the cheek cells in water. You should use a stain to colour contrast the cells, namely methylene blue or iodine solution. These cells are MUCH smaller than onion cells and the learners may battle to find them - look for tiny blue/yellow 'flakes' that are not lying on top of each other and magnify a small group of 3-4 cells.

1. Learners should be able to identify some of the following main differences and similarities between onion and cheek cells as:

- The onion cells have a thick cell wall and a cell membrane. The animal cells only have a cell membrane.
- The onion cells have a regular shape whereas the cheek cells have a irregular shape and seem more flimsy.
- In the onion cells they might notice a large vacuole which might not be as visible in the cheek cells. Cheek cells do not have vacuoles.
- Both onion and cheek cells have a nucleus and nuclear membrane.
- Both cells also have a cytoplasm and some might say that they see organelles inside this.

ACTIVITY Research the discovery of light and electron microscopes LB page 15

This is an optional activity which learners can do outside of class if you have time.

Cells differ in shape and size/Stem cells

The syllabus does not require great detail on stem cells, but this is an exciting field of science that is growing rapidly. The potential uses of stem cell technology may capture the imagination and inspire learners. As a possible extension activity, get learners to do some reading about the topic of stem cell research. Then they can write down some of the main points and also write about their own opinions and feelings about the topic. The last step is to have a class discussion. Encourage each learner to give their opinion. You could do this as a class debate and break learners up into groups, or else just go around the class and ask each learner for their opinion and why.

Alternatively, you may wish to share the following exciting possibilities with learners. In the future stem cell therapy may be able to treat many different diseases, such as:

- certain cancers (such as leukaemia, a cancer of the blood)
- diabetes mellitus (where cells that produce the hormone (insulin) that controls our blood sugar are destroyed and no longer work)
- spinal injuries and paralysis
- organ damage that requires organ transplants
- genetic diseases
- degenerative diseases (such as Parkinson's disease, where neurons in voluntary movement areas of the brain die)

Alternatively, if resources cannot be found or if the terminology of stem cell research is too complex, this video on stem cells explains what the different stem cells are, what their normal role is in the normal body, and also explains some potential uses of stem cell technology 5 bit.ly/15qjJHX .

Microscopic and macroscopic organisms

Please ensure that learners understand the difference between microscopic and macroscopic and unicellular (single-celled) and multicellular (many-celled) organisms. Microscopic organisms are too small to be seen with the naked eye. Macroscopic organisms can be seen with the naked eye. Unicellular organisms consist of one cell, multicellular organisms are made up of many cells. Learners can easily become confused and think that all microscopic organisms are unicellular, but this is not the case! There are many multicellular organisms that are too small to be seen.

Organisation of cells in macroscopic organisms

In teaching this section, you may consider the example of the school as a 'living organism' in which:

Each learner represents a single cell working on their own within a team.

- The classes are formed from groups of learners = tissues
- The grades are formed from groups of classes = organs

The Grade 7 - 9 and Grade 10 - 12 are seen as the GET and FET phases, thus a phase = organ system

All the phases working together in school = organism

Throughout this year, we are going to develop the skill of designing and making concept maps in Natural Sciences. The "Key concepts" listed above is a summary written out in full sentences. A concept map provides another way of representing information (ideas and concepts) in a more visual way. The benefits of a concept map are that it allows one to show the linkages between different concepts. Often a concept map has a "focus question" around which the other concepts radiate. In these books the focus question will be the main topic for the unit. 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 unit 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: "Cells in plants have some differences as only plants have chloroplasts for photosynthesis".

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 learn and make sense of. Concept mapping is one tool to use to summarise information and understand how different concepts link together. Real understanding and knowledge comes from grappling with the subject matter, and not just memorising facts.

To learn more about concept maps and how they encourage learner understanding, visit this site: [6] bit.ly/17e2g7V

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

Revision

1. Learner-dependent answer. They should mention that cells are the smallest things that can live independently and are the most simple functional and structural unit that makes up all organisms.
2. Selectively permeable means the membrane only allows certain substances to pass into and out of the cell.
3. Prokaryotic cells do not have a nucleus or membranes around the organelles, whereas eukaryotes have a nucleus and membrane bound organelles. May also refer to DNA being loose or enclosed in a membrane.
4. The nucleus controls all the processes inside the cell and the DNA carries the inherited characteristics of the organism.
5. mitochondrion
6.
   - Both cells have a cell membrane, cytoplasm and a nucleus.
   - Plant cells have an additional cell wall that provides shape and rigidity to the cell.
   - Plant cells have large vacuoles and contain chloroplasts.
   - Animal cells do not have cell walls and have a more irregular shape.
   - Animal cells do not always have vacuoles and when these are present they are short-lived and much smaller than those in plant cells.
7. Learners should receive marks for following these drawing guidelines:
   - The drawing should be made with pencil and the labels should be added in pen.
   - The size of the drawing should be proportional
   - The title of the drawing should be clear and descriptive.
   - Lines used for labelling should end at or be just inside the feature being identified and should not use arrows.
   - Label lines should be drawn with a ruler and pen and should never cross.
   - Lines used for labelling should be parallel to the bottom of the page / horizontally and neatly spaced at the same vertical margin to the one side of the drawing.
   - The magnification, title and labels should be neatly written in print not cursive.

- There should be no noticeable erasure marks left.
- The drawings should be accurate and correctly labelled.

8.
    - smooth muscle tissue: contract and enables movement
    - nerve cell: receives and helps the body respond to stimuli
    - red blood cells: carry oxygen around the body in mammals

9. Macroscopic organisms consist of many different organ systems that are made of individual organs that work together in a very particular way. These are formed from tissues that are in turned created when groups of specialised cells function together in a specific way.

2 Systems in the human body

Unit overview

2 weeks

This unit is intended to give an overview of the main systems in the human body, and the basic structure and function of the associated organs. The focus in each system will be to look at the main processes, the main components, and then some of the potential health issues associated with the system.

2.1 Body systems (Introduction)

Tasks	Skills	Recommendation
Activity: Research and writing about health issues	Researching, summarising, describing, suggesting, writing, presenting	CAPS suggested

2.2 The digestive system (1 hour)

Tasks	Skills	Recommendation
Activity: Flow diagram of the digestive system	Summarising, describing, writing	Optional

2.3 The circulatory system (0.5 hours)

Tasks	Skills	Recommendation
Activity: Chart the circulatory system	Summarising, describing, writing	Optional

2.4 The respiratory system (0.5 hours)

Tasks	Skills	Recommendation
Summary Diagram	Summarising, describing, writing	CAPS suggested

2.5 The musculoskeletal system (1 hour)

Tasks	Skills	Recommendation
Summary Diagram	Summarising, describing, writing	CAPS suggested

2.6 The excretory system (1 hour)

Tasks	Skills	Recommendation
Activity: Differentiating between excretion and egestion	Comparing, identifying, describing	Optional
Summary Diagram	Summarising, describing, writing	CAPS suggested

2.7 The nervous system (1 hour)

Tasks	Skills	Recommendation
Summary Diagram	Summarising, describing, writing	CAPS suggested

2.8 The reproductive system (1 hour)

Tasks	Skills	Recommendation
Activity: Defining the main processes involved in	Identifying, writing	Optional

reproduction		

CAPS suggests that you make a large outline of the human body for this section and draw each system on to it as it is dealt with. You can do this by getting large sheets of recycled paper and tracing around one of the learners. A suggestion is to rather do one for each system and stick these up around the class. Alternatively, provided here is a page which you can photocopy and each learner can do their own summary after each system. You can hand these out after each system and learners can do the following:

- Give the diagram a heading.
- Add a short description of the main purpose of the system.
- Make basic sketches in the correct places to show where the different organs and structures of the system are situated in the body.
- Add labels for each of the different structures in the system.
- Next to each structure's label write short bullet points to describe the function of that particular structure.
- Below the diagram list some of the health issues that relate to the system.

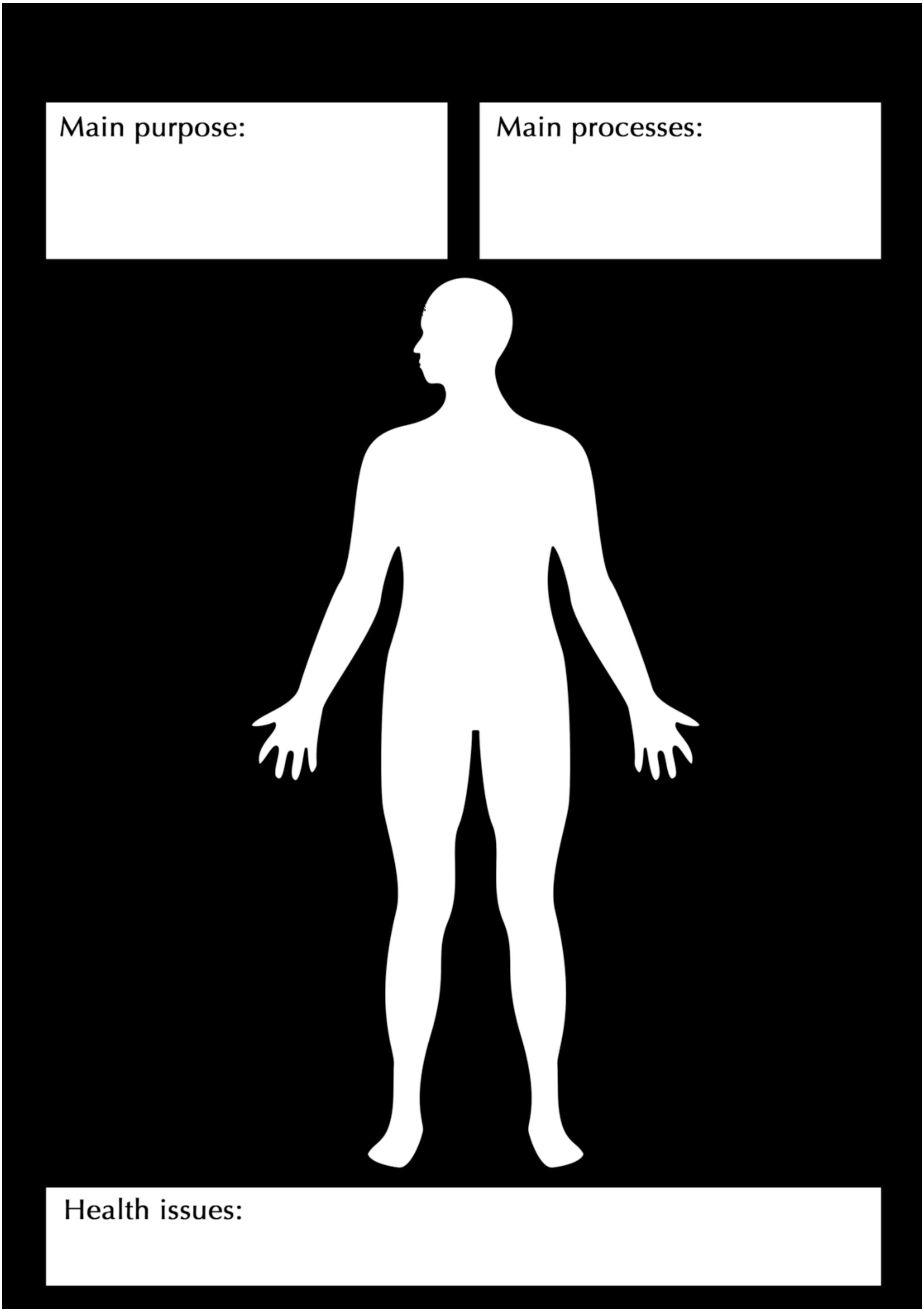
As this unit is meant as an overview of the different body systems, we suggest doing this for the systems which will not be discussed in detail later, namely do it for:

- musculoskeletal system
- excretory system
- nervous system

The respiratory system also lacks an activity, so you may also wish to do a summary diagram for this section. You can also get learners to complete a summary diagram for each system as a homework exercise. But there is limited time for this unit, and many systems to cover!

The activities and summary diagrams you decide on are your choice.

Following is the page to photocopy for learners to summarise a system:



Key questions

- How does the body do the things it does, such as breathe, move and think?
- What happens when one of the systems in our bodies does not work properly and has a 'system error'?

- Is it possible to prevent ourselves from getting sick?
- How can you best look after your body?

2.1 Body systems

You could use the criteria on page xx to draw up a large table to summarise all the organ systems as you work through them, perhaps on the one side of the board or on a large poster.

ACTIVITY: Research and writing about health issues (LB page 22)

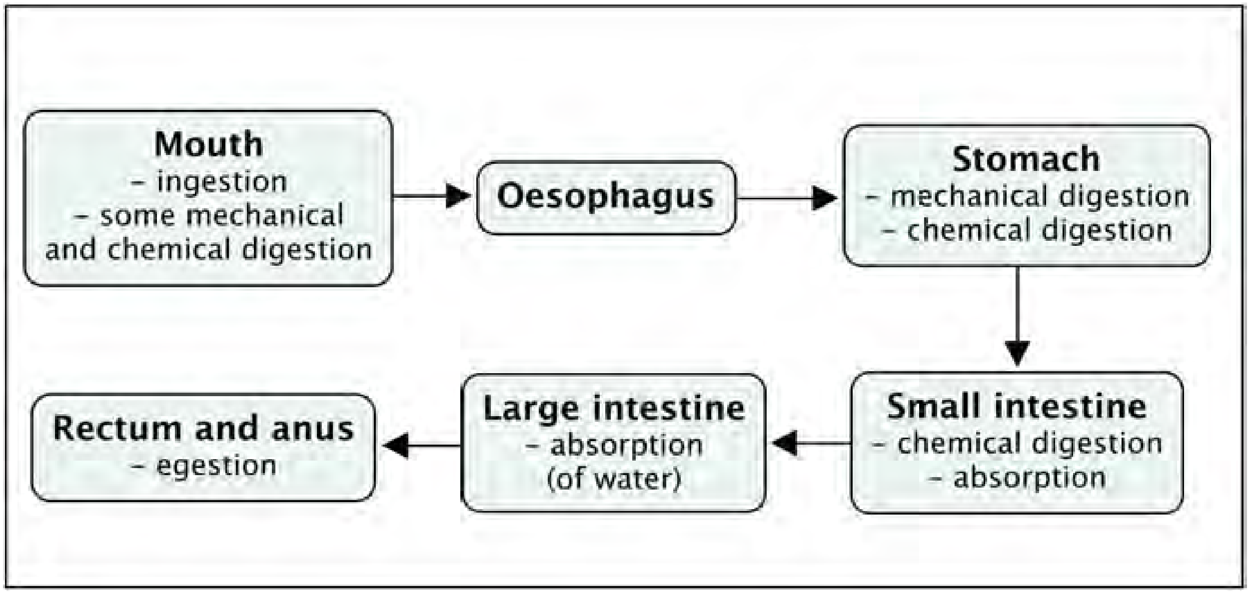
A suggestion is to assign different issues to different learners in your class so that you get a range of research posters to stick up. This can be done at the end of this section, but has been included here so that learners are aware of it. You may choose to use this poster and presentation for an informal assessment mark.

2.2 The digestive system

After learners have done this initial thought exercise, a fun suggestion to introduce the digestive system is to bring out a tube (either a hosepipe, or even a piece of rope, but a tube is ideal), that is 9m long to represent the digestive system. Explain to learners that the digestive system is like one long tube of different organs and this is all coiled up inside of you. Along this tube different processes occur to digest the food we eat (namely ingestion, digestion, absorption and egestion). Then explain to learners that we will be looking at what happens along this tube. You can even drape the tube up over the board in the front of the classroom for the rest of this section.

ACTIVITY: Flow diagram of the digestive system (LB page 24)

1.–2. The learners' flow diagrams could look something like this one below. An idea is to draw this up on the board and get learners to swap books with each other to check if they produced something similar and logical.



2.3 The circulatory system

The circulatory system includes blood as well as lymph, however at this level, only the blood circulatory system will be dealt with.

Main processes in the circulatory system

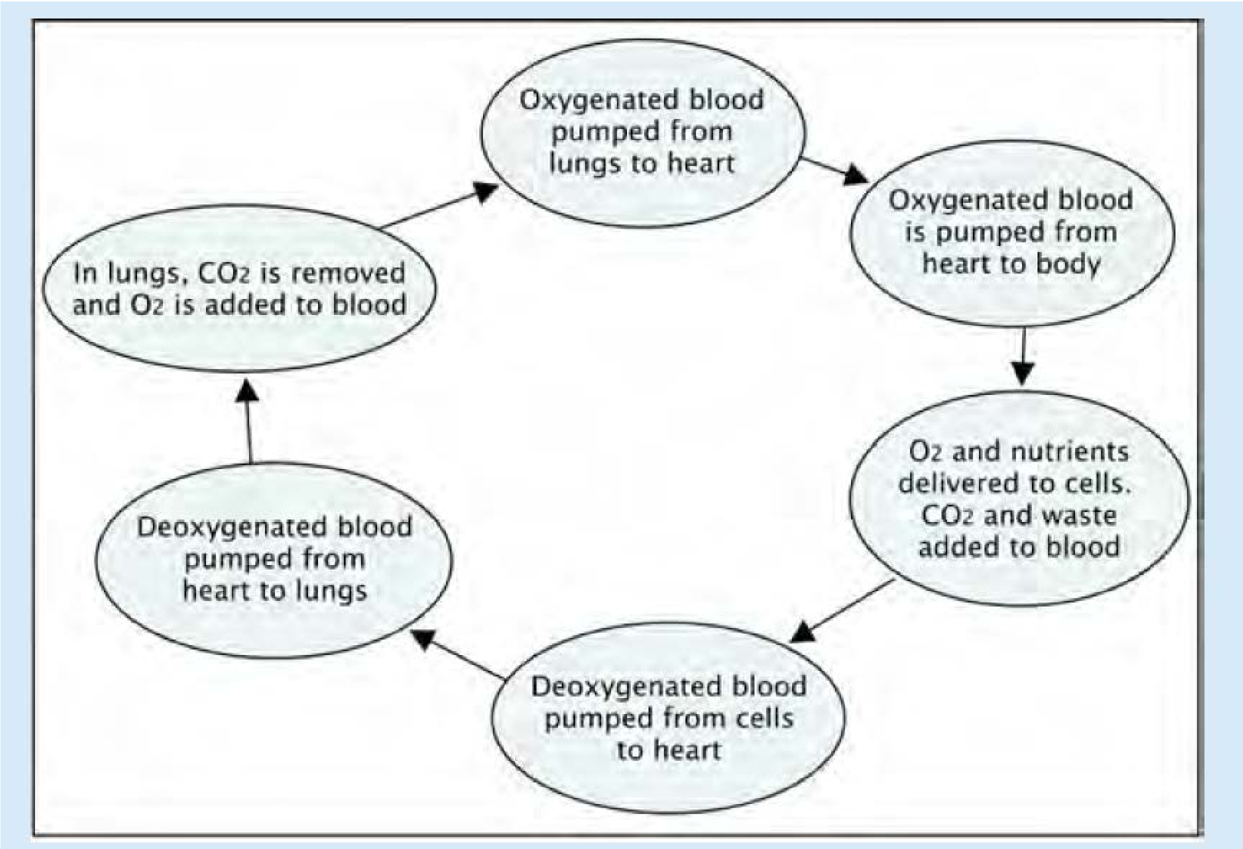
Why not play one of the videos in class like this one bit.ly/16IIBPU while the learners are working on their activities in order to help them remember important terminology.

ACTIVITY: Chart the circulatory system (LB page 27)

Learner-dependent answer

There is a difference between a flow chart and a circular diagram: a flow chart shows a process from beginning to end and arrows start at one point and end at another. A circular diagram shows a process that occurs over and over again, which forms a cycle.

A flow chart could look like the one below. Perhaps let your learners try it themselves first and then draw one on the board. Do not just draw it on the board for them to copy - they must first try it themselves.

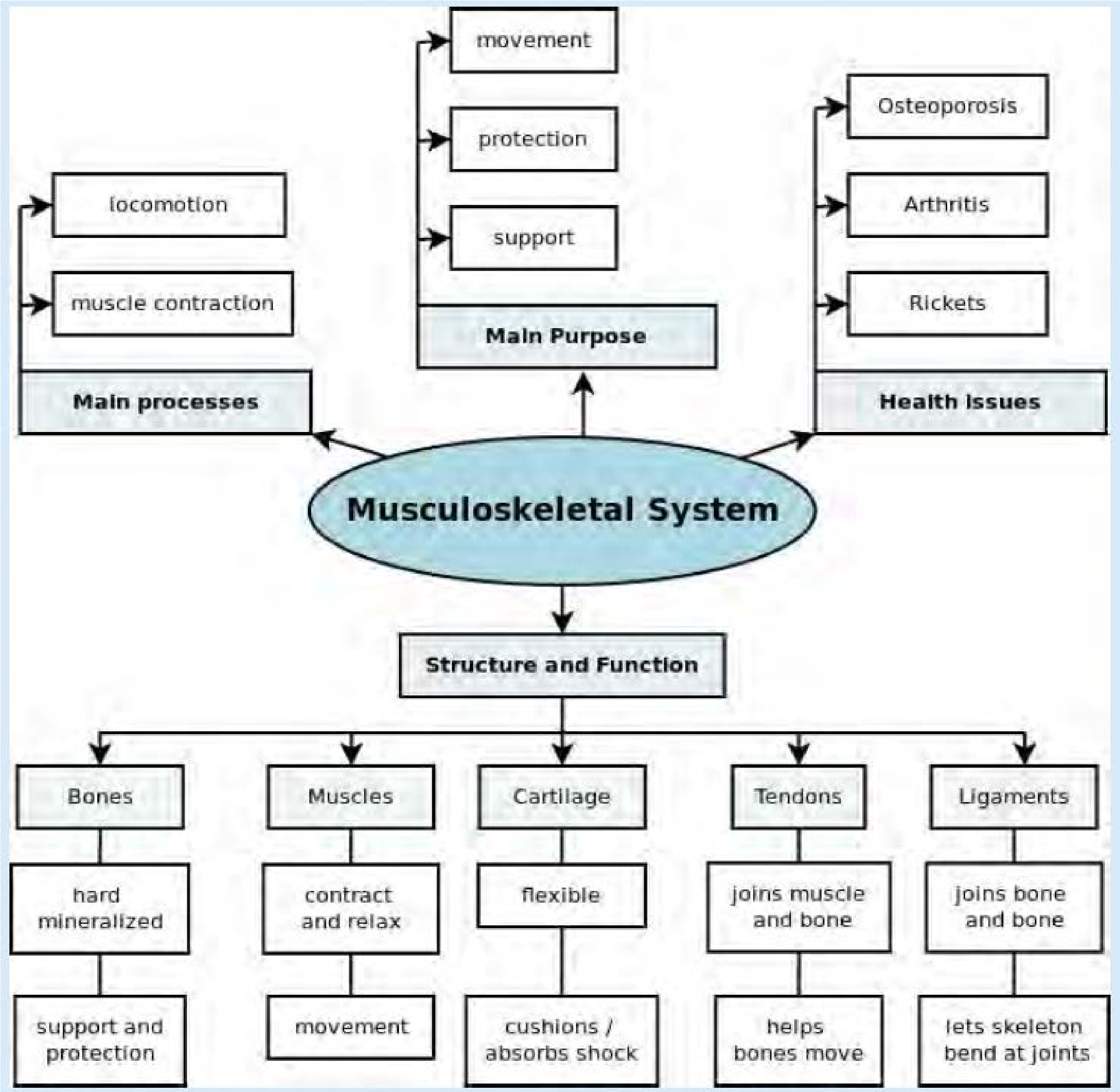


2.4 The respiratory system

2.5 The musculoskeletal system

Ask your learners this question to get their answers. The answer is that plants only have movement as they are able to change shape and grow, and even change direction in response to a light or water source, but they are rooted to one place - they cannot locomote (move from place to place). Encourage learners to take notes on this discussion either in a separate notebook or in the margins of the learner's book.

An alternative to doing the summary diagram with the human body outline at the end of this system, is to get learners to produce a mind map. It is important that learners are exposed to and get experience with different techniques to summarise information and help them study or learn. This is crucial for later grades. Below is an example of a mind map that a learner may construct:



2.6 The excretory system

ACTIVITY: Differentiating between excretion and egestion (LB page 33)

1. Egestion is the removal of undigested material (solid waste) from the digestive tract via the anus.
2. Excretion is the removal of metabolic waste products from the metabolism which takes place in cells in the form of urine and sweat and exhalation

2.7 The nervous system

A fun idea is to play the song of the nervous system in the visit box as learners come into the class and sit down.

Teachers may want to use this opportunity to discuss the topic of drug abuse. If you would like to explain some of the effects of drugs and alcohol on the brain to your learners, here are some:

- Drugs like methamphetamines (tik) and cocaine make the user feel a huge sense of reward causing these drugs to become addictive.
- People also use drugs as a stimulant - using caffeine, cocaine and amphetamines to speed up their reactions.
- Alcohol and marijuana (dagga) have the opposite effect on the brain and slow it down - these are called sedatives and hypnotics.
- Hallucinogens like LSD and Ecstasy, and also more recently the drugs Woonga and Nyaope, make you see things that are not real.
- Morphine and heroin are used to relieve severe pain and when misused slow down the user's reactions.

It may be useful to explain to learners that the same drug may be useful and beneficial when used properly and at the correct dosage, or abused when it is used inappropriately, or in excessive amounts.

2.8 The reproductive system

As this will be dealt with in the next unit, a simple activity can be done now for learners to look up these new terms and write down definitions.

ACTIVITY: Defining the main processes involved in reproduction (LB page 41)

The muscles in the uterus are some of the strongest in the human body. This is because they need to be able to grow and contract to contain a growing foetus and to push the foetus out during labour.

1. Copulation is the act of sexual intercourse (procreation) when a man inserts his penis into a woman's vagina.
2. This is the release of the sperm into the woman's cervix during sexual intercourse.
3. This is when a mature ovum (female egg cell) is released from the ovary once a month.
4. If the ovum is not fertilised, the lining of the uterus is shed during menstruation.
5. When a male (sperm cell) and female (egg cell) gamete fuse (come together) during copulation.
6. In the reproductive system, this refers to the process when the fertilized egg implants (attaches firmly into) the uterus lining.

Revision

1. Breaking food into small soluble parts that can be transported in the blood and absorbed by the cells.
2. Ingestion, Digestion, Absorption and Egestion.
3.
   - Mouth and oesophagus: food is chewed in the mouth and passed through the oesophagus to the stomach
   - Stomach: bolus enters the stomach where it is mechanically digested through churning and chemically digested by gastric juices in the stomach.
   - Small intestine: most of the chemical digestion and absorption takes place in the small intestine where food is chemically broken into tiny pieces to be absorbed by the walls of the small intestine and transported in the blood to the cells.
   - Large intestine: water that is left after digestion in the small intestines are absorbed in the large intestine and indigestible fibre is left to pass through and faeces are formed.
   - Rectum and anus: undigested fibre and substances (faeces) passes from the large intestine to the rectum and anus from where it is egested.
4. Babies who have diarrhoea lose large quantities of undigested nutrients and water in this way. Their bodies quickly dehydrate and they become too listless to feed or drink, dehydrating their bodies even further. If they do not get medical attention they may die. This can be prevented by sterilizing their bottles and feeding equipment to prevent the transfer of the bacteria that cause diarrhoea.
5. Inhalation: breathing in; exhalation: breathing out.
6. Egestion is the removal of undigested substances and fibre from the body; Excretion is the removal of waste products of metabolism, including cellular respiration. Since carbon dioxide is a waste product of cellular respiration it is excreted.
7. Learner-dependent answer
8. Breathing: taking air into and out of the body through the mouth, trachea, bronchi and lungs. Respiration: occurs at the cellular level when oxygen is taken into the cells where it is used to release energy from food; carbon dioxide is a by-product of this and it is returned to the blood and sent to the lungs to be exhaled.
9. Muscles contract and relax to move the bones at the joints and allow for locomotion. Tendons and ligaments are also used.
10. Bones are an attachment place for muscles and provide protection and support.
11. Learners were exposed to various negative effects and should refer to these in this answer. These may include any of the following among others:
    - Dependence on the drug / alcohol make it almost impossible to withstand cravings and the addict will do almost anything to get money to buy more.
    - Organ damage and ultimately organ failure and death.
    - Reduced brain activity and harm to brain cells, leading to seizures, impaired vision and motor coordination, blackouts, etc.
    - If using intravenously the user stands a big chance of infection by HIV and other infectious diseases.
    - Stimulant drugs like nicotine and cocaine affect the respiratory system.
    - Smoking also affect almost every other system in the body - vascular, skin, etc
    - etc
12. If a pregnant woman used alcohol during the pregnancy, this may cause deficiencies, Foetal Alcohol Syndrome and physical and central nervous system abnormalities in the baby. These effects are permanent and irreversible.

3 Human reproduction

Unit overview

2 weeks

After looking at several of the organ systems within the human body in overview in Unit 2, the next three Units will now look at some of these systems in more detail.

This Unit on "Human reproduction" starts off by looking at the purpose of reproduction and how humans mature during puberty in order to be able to reproduce. This will be very relevant to your learners as they are in this stage in their lives at the moment.

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

Some tips for when teaching human reproduction:

1. Respect your learners' questions and concerns. Some of them may not have had an opportunity before to ask questions about reproduction, especially if their parents did not feel comfortable discussing this with them. This is a sensitive topic, and learners might be embarrassed to ask questions. Encourage your learners to ask questions and not be embarrassed. Learners must be told to phrase their questions carefully and to use scientific words, with no vulgar expressions. You yourself, as the teacher, must only use scientific terms.
2. Discuss processes openly so that learners are comfortable within the classroom environment to talk and learn about reproduction and how it influences their lives. Discourage and discipline any laughing or disrespectful behaviour from other students.
3. Possibly bring in a guest speaker. Learners might feel more comfortable asking a stranger questions. Also, if you bring in an expert, such as a gynaecologist or midwife, learners might take the subject more seriously. item If necessary, you can separate boys and girls. For example, if you are showing a graphic video about the female reproductive organs, it might be useful to have the boys watch a similar video in another room that explains the male reproductive organs.
4. Avoid portraying the reproductive system in a negative light or as "forbidden" as this will only add to some of the discomfort that learners might already feel. At this stage in their lives, learners are already very interested in reproduction and the changes that their bodies are going through. This is natural and should be embraced so that they are educated and can make informed choices about their sexual health going forward.
5. Here is a website to do some further reading: bit.ly/1cfWcTS

3.1 Purpose and puberty (2 hours)

Tasks	**Skills**	**Recommendation**
Activity: Reflecting on population growth	Identifying, predicting, writing	Optional

3.2 Reproductive organs (1 hour)

Tasks	Skills	Recommendation
Activity: Identify the role of the male and female bodies in reproduction	Identifying, writing	CAPS suggested
Activity: Identify structure and function	Identifying, describing, explaining, writing	CAPS suggested

Activity: Comparing the reproductive organs	Comparing, summarising, writing	CAPS suggested

3.3 Stages of reproduction (3 hours)

Tasks	Skills	Recommendation
Activity: Flow diagram of the pathway of sperm	Summarising, describing	CAPS suggested
Activity: Comparing fertilisation and menstruation	Comparing, summarising, drawing	CAPS suggested
Activity: Debate Surrogacy	Working in groups, discussing, debating, presenting, writing	CAPS suggested
Activity: Describing different contraceptives	Identifying, describing	Optional
Activity: Forum discussion	Working in groups, discussing, debating, presenting, writing	Optional

Key questions

- What is puberty and what does it mean when we "reach puberty"?
- Why do we all go through puberty at different times and rates?
- What changes take place inside our bodies during puberty?
- What do our reproductive organs look like when they are mature?
- How does reproduction occur?
- What is menstruation and why does it occur once a month?
- How does a baby grow inside a woman's uterus?
- Are there ways to prevent pregnancy and the transmission of STDs?

3.1 Purpose and puberty

ACTIVITY: Reflecting on population growth (LB page 45)

You can use this section to open up discussion about population growth and population control. At the end of the Unit there is a debate regarding contraceptives, but teachers may choose to include a discussion on the different ethical points of view regarding contraceptives at this point already.

An interesting suggestion if you have an internet connection and a projector or smartboard to display a website, is to open up the link provided here in the visit box on our "Breathing Earth". This simulation very clearly shows how our population is growing. You can open up the link at the start of the lesson and leave it running for the duration. Then at the end of the lesson, you can see how much the population of the world has grown during your one lesson.

Alternatively, if you do not have an internet connection in your classroom, ask some of your learners to take out their mobile phones and go to the site. Even if you only have a few mobile phones within the classroom, you can get learners to each take a look at the site at the start and end of the lesson. Do not be afraid to embrace the technology that your learners are using on a daily basis!

They most likely have their cellphones in their pockets in class anyway, unless cellphones have been banned during school hours.

These questions are meant to stimulate discussion within your class. You can go through these as a class or learners can then do them individually and then discuss their answers.

1. Learner-dependent answer. Might include: more people so more manpower and more taxes; might include religious or cultural bias; etc.
2. Advantages: lower population growth; lower pressure on the country's resources; lower drain on resources, particularly on the education resources; higher standard of living for families
   Disadvantages: fewer people to pay taxes; religious or cultural non-compliance might lead to revolt
3. With fewer resources to go around many might starve and since they might not have work or social grants to support them. Unemployment would increase even more. This might also lead to increased crime as people try to provide for themselves and their children, as well as drug and alcohol abuse as a coping mechanism.
4. a) Africa has the largest population growth rate. This can be seen as it has the largest number of countries which are coloured green and yellow which shows the highest annual percentage growth rate.
   b) Learners need to look at the legend to see that light purple means a growth rate of "< 3%". This means the growth rate is negative which means the population size is decreasing each year.
   c) Learner-dependent answer.

3.2 Reproductive organs

ACTIVITY: Identify the role of the male and female bodies in reproduction (LB page 48)

1. The male body has to produce sperm and deliver this sperm to the female body in order for it to come into contact with the female egg (ovum).
2. The female body has to produce ova (egg cells). Once a month, one egg cell is released and if a sperm cell penetrates the outer layer of the egg cell, fertilisation can take place. This may then lead to pregnancy and the female body adapts to provide for all the needs of the unborn baby before giving birth.

ACTIVITY: Identify structure and function (LB page 49)

This question starts to delve into the relationship of structures that are adapted to function. Learners need to LINK structure to function when examining any organ. This is an extension activity and requires learners to apply the knowledge they have just learnt.

Reproductive organ	**Function**	**Adaptation**
Penis	During sexual intercourse, the penis becomes erect and delivers the sperm into the cervix of the vagina.	The penis is on the outside of the male body, and it is elongated so that it can insert into the vagina and deliver the sperm into cervix. The penis contains the urethra and becomes erect so that it can insert into the vagina.

Testes and scrotum	The testes produce the sperm and the scrotum hold the testes outside of the body.	The testes need to be at 35 °C, which is lower than body temperature, in order to produce sperm. The testes are therefore outside of the male body and hang in the scrotum, which can adjust the temperature of the testes so that the right temperature is maintained in order to produce sperm.

ACTIVITY: Comparing the reproductive organs (LB page 50)

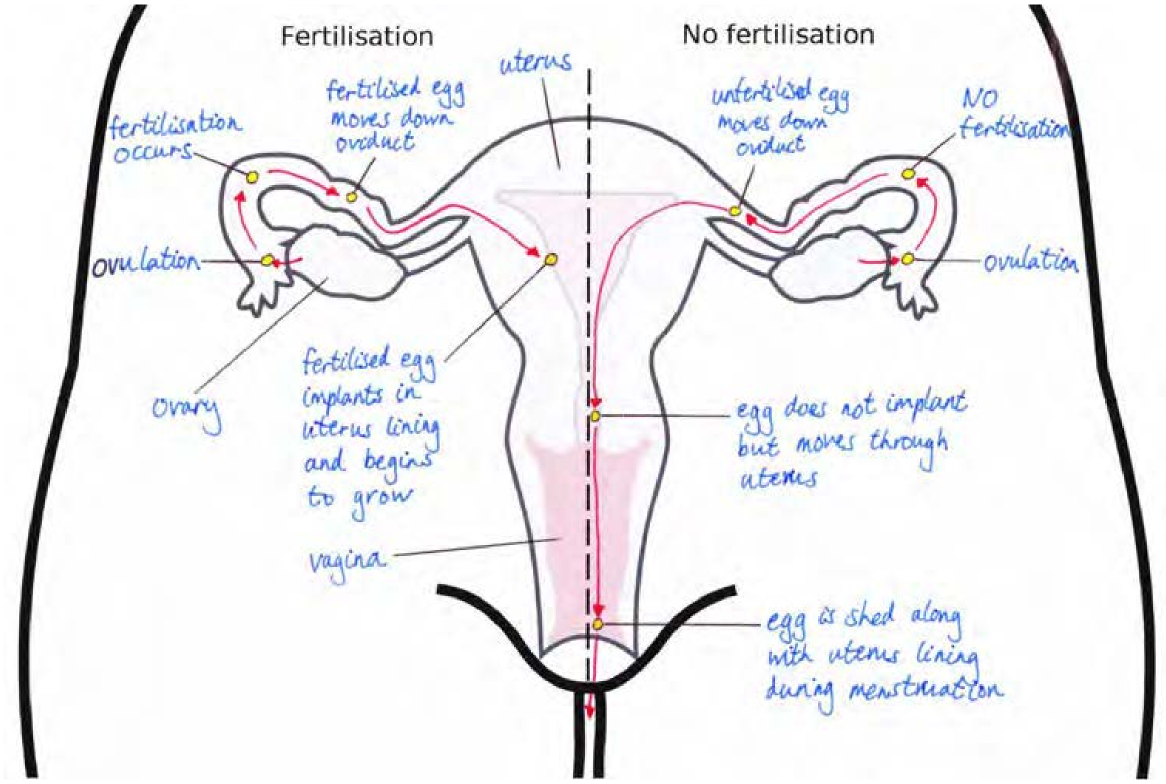
1. The vagina is elastic and muscular, so it can contain the penis during intercourse to prevent the sperm from running out. The cervix is situated at the top of the vagina approximately where the penis' ejaculated sperm will be. It is tightly closed to protect the uterus. It carries the sperm into the uterus which has a thick, blood-rich lining, ready for the implantation of the fertilised egg.
2. The uterus needs to protect and carry the unborn child during pregnancy and it needs to contract and push out the baby during childbirth.
3. A possible table that learners may produce: and

Characteristic	**Ovaries**	**Testes**
Position	Inside the body	Outside the body
Hormones produced	Oestrogen	Testosterone
When gametes are produced	Females are born with ova in their ovaries which mature once puberty is reached	Males only start to produce sperm once they reach puberty
Number of gametes released/produced	Release one ovum per month	Produce thousands of sperm daily
Hormone influence	Hormones in the ovaries stimulate the ovum which are already present so that they mature	Only start to produce sperm under the influence of the hormones

3.3 Stages of reproduction

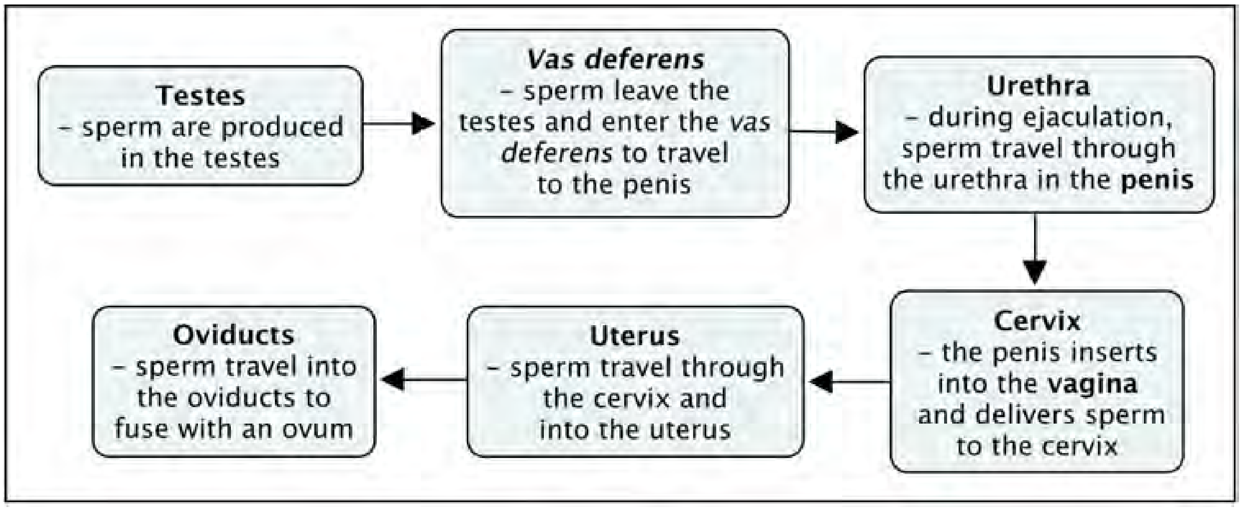
ACTIVITY: Comparing fertilisation and menstruation (LB page 51)

The following diagram shows an example of something that the learners might produce. Learners might battle to do this. A suggestion is to produce a sketch on the board and go through it with them, filling in the annotations. Do not simply draw it up and get learners to copy down the answers. Ask for their input and possibly get different learners to come up to the board to draw in different stages.



ACTIVITY: Flow diagram of the pathway of sperm (LB page 52)

The following flow chart can be used as a reference for learners' flow charts:



ACTIVITY: Debate surrogacy (LB page 53)

This is an **optional activity**, depending on your class.

ACTIVITY: Describing different contraceptives (LB page 54)

It may be possible to get examples of these different types of contraceptives for the learners to have a look at. Many clinics will have samples that can be used for educational purposes. They are normally very willing to hand out stock that has passed its expiry date and is **only** to be used for educational purposes.

Contraceptive	Description	Classification
Male condoms	These thin sheaths of rubber are placed over the erect penis before inserting it into the vagina. When the male ejaculates the sperm and seminal fluid is caught in the condom and cannot enter the cervix.	Barrier
Diaphragm	The diaphragm is a small rubber cap that is placed at the entrance to the uterus before sexual intercourse to create a seal and prevent sperm from entering the uterus.	Barrier
Tubal ligation in women	A surgical procedure in women in which the the oviducts are cut and tied which prevents mature eggs from reaching the uterus for fertilisation.	Sterilisation
Oral contraceptive pill	Often referred to as "the Pill", it is taken every day by mouth. It contains a combination of female hormones which prevents ovulation each month.	Hormonal
Female intra-uterine device (IUD)	A small 'T'-shaped device is inserted into the uterus and prevent fertilisation. It is a long-acting, reversible contraception as the device may be removed again. It is not suitable for women who have not yet had a baby and must be inserted by a doctor.	Intra-uterine device
Vasectomy	A surgical procedure in males in which the vas deferens is cut and tied. Sperm are therefore prevented from becoming part of the ejaculate.	Sterilisation

Some intra-uterine devices can also be classified as hormonal as they contain progesterone. The progesterone also prevents fertilisation, by increasing the cervical mucous, suppressing the endometrium and sometimes also inhibiting ovulation. The IUDs with copper are non-hormonal and also prevent fertilisation as the copper acts as a natural spermicide within the uterus.

Choices regarding unwanted pregnancies

The following activity will require learners to do some research and interviews and then come back into class to hold a forum discussion. A suggestion is to get learners to start doing some research and thinking about the topics in the days leading up to this lesson. Below is some more information on each of the types of choices a woman is faced with when she experiences an unwanted pregnancy. Read through this first so that you are familiar with the choices before the lesson so that you can help learners with their forum discussions.

- **Adoption**: Many couples in South Africa cannot have children of their own for different reasons and therefore choose to adopt children as their own.
  There are different organisations that help pregnant mothers who want to give their unborn children up for adoption. The Department of Social Services also helps pregnant mothers in the process of adoption. Adoptive parents typically have to go through a very strict screening process to make sure that they will be fit to raise a young child. When a mother (and where possible the father) signs that their baby will be given up for adoption, they have 60 days in which to change their minds before the adoption goes through. During this time, the baby will be placed in special foster care facilities or with foster families who will care for him or her until they can go to their adoptive parents.
- **Leaving the baby in a place of safety:** Sometimes the parents of a newborn baby, for various reasons, want to get rid of the baby. As a result, many babies are found abandoned. Many organisations in South Africa are trying to provide a safe haven for unwanted babies. One way they approach this, is to provide a baby-safe drop off site where the mother and/or father can place their unwanted baby in a special window with a safety flap on the outside. However, this option has many legal complications. Legally, the babies cannot easily be adopted because they do not often have birth certificates. Since the parents usually cannot be found, they cannot sign adoption papers. Although social workers will try and find the parents to get them to sign the adoption papers, after a few months they may put the baby forward for adoption without the parents' signatures. The best option is therefore to go to a social worker and ask them to help organise the adoption. This also protects the rights of the child.
- unwanted or unplanned pregnancy she is often filled with feelings of panic, anxiety and fear for the future - for her and her unborn child. She may fear that her parents or partner will abandon her and that she will then be on her own and will have to care for the baby on her own. However, if she is able to talk to her parents and partner, they may be able to find a solution to the situation that will enable her to keep her baby. She may be able to raise her child with the help of her or her partner's extended family. The most important thing is to face her fear and discuss the situ ation to reach a suitable decision.
- **Abortion:** Some women choose to have an abortion to end their pregnancies. During an abortion, the developing embryo is removed from the mother's womb. Chemical or physical processes can be used, depending on the age of the embryo. Abortions can be risky, especially if they are performed by untrained, unqualified abortionists. During an abortion the mother may lose a lot of blood. Her cervix may also be damaged or torn, or the uterus itself may be damaged during the procedure. These complications are not common when the abortion is performed by properly trained and qualified doctors and nurses in a clean, sterile medical facility. However, sometimes pregnant woman go to places where unqualified or untrained people perform the abortions. They are typically performed in unclean, unhygienic conditions by people without the proper medical training to know what to do in case of an emergency. Complications are very common here, with many of the woman experiencing infections due to the dirty, unsterilised equipment. If someone is considering an abortion, it is therefore very important that they go to a professional abortion clinic that meets very high medical standards of cleanliness and well-trained staff. They should also speak to a caring professional first, as aborting a child may have long term effects, like feelings of guilt.

ACTIVITY: Forum discussion (LB page 56)

Learner-dependent answer.

This activity relates to Life Orientation. This activity was specifically included at the end of the section to allow for research to occur before the forum discussion. Break the class up into groups of 6 and allow them to move into different areas of the classroom, or perhaps even move outside if space permits. Each group must then conduct their forum discussion according to the instructions and guidelines below. You, the teacher, can spend a little time with each group to make sure they are on track and discussing the topic. Use the notes provided on the different options for an unwanted pregnancy if you need to provide a group with some background information or some guidelines about what to discuss. Encourage learners to express their points of view and why they believe something.

An alternative is to have one discussion forum in the front of the class and give different learners the chance to sit up front on the panel, and you can be the moderator.

This activity does not need to be assessed and is more for personal education, and a chance for learners to practise debating.

Revision

1. For females, these include: breasts develop, pubic hair starts to grow, underarm hair grows, body shape changes, ovaries mature, acne develops in some individuals. For males, these include: penis grows and becomes larger, testes mature, pubic hair starts to grow, facial hair grows, underarm, chest and back hair grows, voice deepens, acne develops in some individuals.
2. At the onset of puberty, hormones are released into the blood (these hormones were not specifically named at this level). These hormones travel in the blood and stimulate the reproductive organs. In females, the ovaries are stimulated to produce oestrogen and in males, the testes are stimulated to produce testosterone.
3. When the egg has been fertilised by a sperm (ie fertilisation), the woman is now pregnant.
4. It can be true if the girl has sex before her reproductive organs have matured and therefore before she is able to ovulate. In this instance she will not be able to fall pregnant. If the woman's reproductive organs have matured and she has started to menstruate and ovulate, then she can fall pregnant after sexual intercourse, even if it is the first time. Thus in this instance the myth is not true.
5. Learners need to indicate that once someone knows the facts about conception they will be able to take (realistic) precautions to avoid unwanted pregnancies and disease. The will also not believe all the myths and make sensible decisions.
6. Someone who has many sexual partners stands a high risk of contracting an STD. To prevent this and to prevent an unwanted pregnancy, learners should be able to say that they should use a condom during intercourse.

They could also possibly suggest that the person limits the number of sexual partners that they have, and if they are in a relationship, then both of them should remain faithful to one partner. Alternatively, if they do continue with many partners, the person should try to establish the status of these partners before intercourse, and still use a condom. The person should also be advised to have regular check-ups in order to know his or her status.

7. Learner-dependent answer.

   Learners should be able to see the different points of view regarding this issue and reference the debate on this topic that was held earlier in this Unit. There is no right answer, rather the focus should be on the fact that learners can justify their opinions and express themselves. They should draw on this and write their letter in this frame of reference. NB: Learners are not criticising anyone's religion or culture in this activity.

8. Learner-dependent answer. Check that learners are able to justify their answer and provide a reason for what they think.
9. Learners should refer to the diet and lifestyle choices of the pregnant mother, specifically noting that pregnant mothers who consume drugs and alcohol, also pass these on to the unborn baby through the placenta, resulting in irreversible damage to the unborn child. The mother should therefore avoid these during pregnancy.

Note: This last question does not need to be assessed.

4 Circulatory and respiratory systems

Unit overview

1.5 weeks

Learners would have already had an overview of the circulatory and respiratory systems in Unit 2. However, the overview introduced them in isolation, whereas these two systems are very tightly integrated. This Unit will look at these processes and associated organs in more detail and how the two systems are linked.

4.1 Breathing (1 hour)

Tasks	Skills	Recommendation
Activity: Main components in the circulatory and respiratory systems	Identifying	CAPS suggested
Activity: Summarise breathing using a flow chart	Summarising, explaining	CAPS suggested

4.2 Gaseous exchange in the lungs (1.5 hours)

Tasks	Skills	Recommendation
Activity: Lung dissection	Dissecting, observing, describing, interpreting, explaining	CAPS suggested
Activity: Drawing gaseous exchange in the alveoli	Drawing, summarising	CAPS suggested

4.3 Circulation and respiration (2 hours)

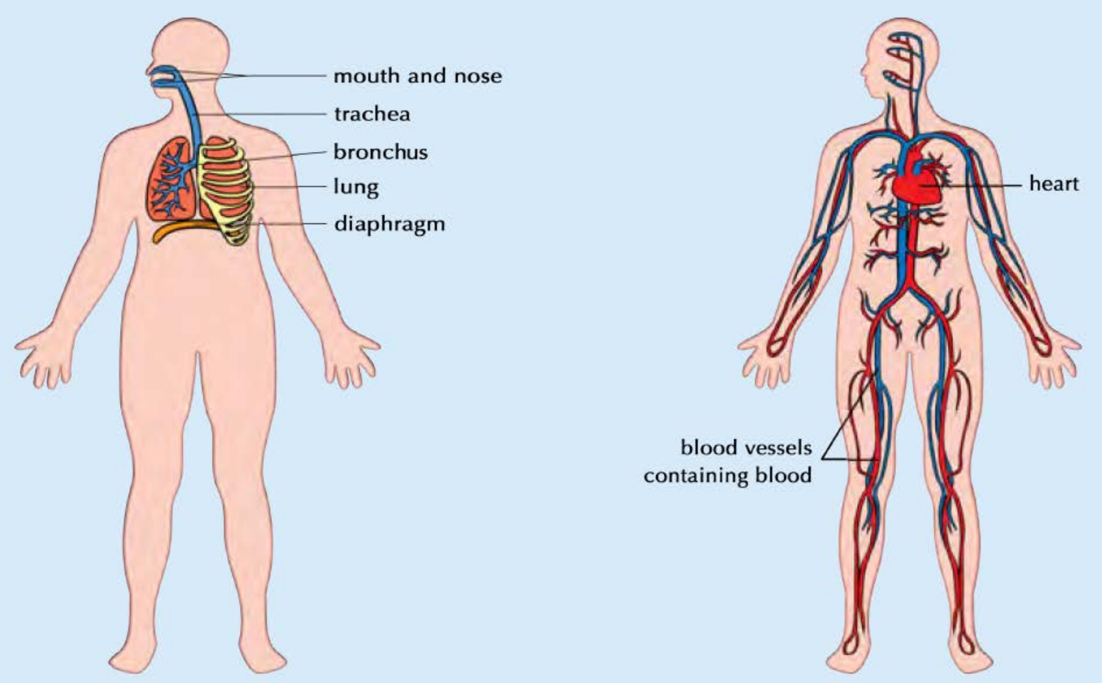
Tasks	Skills	Recommendation
Activity: Heart dissection	Dissecting, observing, describing, interpreting, explaining	CAPS suggested
Activity: Feel your blood rushing through your body!	Measuring, calculating	CAPS suggested
Activity: Tabulating differences between the blood vessels	Comparing, describing, summarising, interpreting	CAPS suggested
Activity: A circulation simulation!	Working in groups	Optional
Activity: Homework activity to measure your resting heart rate	Measuring, calculating	CAPS suggested
Investigation: Measuring and comparing heart rates before and after exercise	Planning, investigating, predicting, measuring, comparing, tabulating, constructing graphs, summarising, interpreting, writing	CAPS suggested

Key questions

- Why do we have to breathe?
- Are our lungs like big balloons in our chest, or what do they look like?
- How does the oxygen in the air that we breathe in pass from our lungs into our blood?
- How does blood move around our bodies and get to each cell to deliver oxygen?
- We know that carbon dioxide is produced as a waste product in cellular respiration, so how is it removed from our bodies?
- How are the circulatory and respiratory systems linked?

ACTIVITY: Main components in the circulatory and respiratory systems (LB page 60)

The labels for the diagrams should be as follows:



4.1 Breathing

Teachers should try and make sure the learners understand the concept that the volume of the chest cavity changes the air pressure in the lungs and results in inhalation and exhalation. During inhalation, the chest cavity expands (gets bigger). When this happens the air pressure inside the lung decreases (because there is the same amount of air in a bigger space). In order to equalise with the air outside, air rushes in to the lungs. Similarly, when the chest cavity contracts (becomes smaller) during exhalation, the air pressure inside increases, and the air is pushed out to equalise with the atmosphere. In order to explain this concept to learners you can use the example of a syringe.

(**Note**: Remove the needles from the syringes beforehand.) Air acts like the liquid in this case. If you pull back on a syringe you increase the volume in the syringe, and liquid moves into the syringe. If you push back on the syringe to decrease the volume, you will push the liquid out. The syringe example may help learners to understand that air is "sucked in" and "pushed out" by the changes in volume.

ACTIVITY: Summarise breathing using a flow chart (LB page 62)

Learners should show the following in a cycle: Rib muscles contract ! rib cage moves up and out ! diaphragm contracts ! diaphragm moves downwards (flattens) ! rib cage volume increases ! lungs expand ! take in more oxygen ! rib muscles relax ! rib cage moves downwards and inwards ! diaphragm relaxes ! rib cage volume decreases ! this pushes out the air from the lungs.

4.2 Gaseous exchange in the lungs

It is possible to learn about the function of lungs from the diagrams and pictures supplied in the workbook. However, dissecting the real organ is hugely beneficial to the learners and will help them to understand the structure of the lungs and how this relates to their function. If, however, you are not able to do the dissection, you can watch some of the videos supplied.

ACTIVITY: Lung dissection (LB page 63)

The materials will depend on how many lungs you are able to obtain and how many learners are willing to do the dissecting. A suggestion is to break learners up into groups, or else do the dissection as a demonstration in front of the class, especially if you have a big class or many Grade 8 classes. The following materials are required for each dissection, whether in a group or to be done as a demonstration.

Sometimes the main sections of lung tissue are cut into at the abattoir (as part of the inspection process). You can approach the butcher well in advance and discuss what you need so that they can limit damage to the material and provide lungs as whole as possible. Butchers often refer to it as 'pluck' which contains the lungs and part of the heart.

Ethical issues

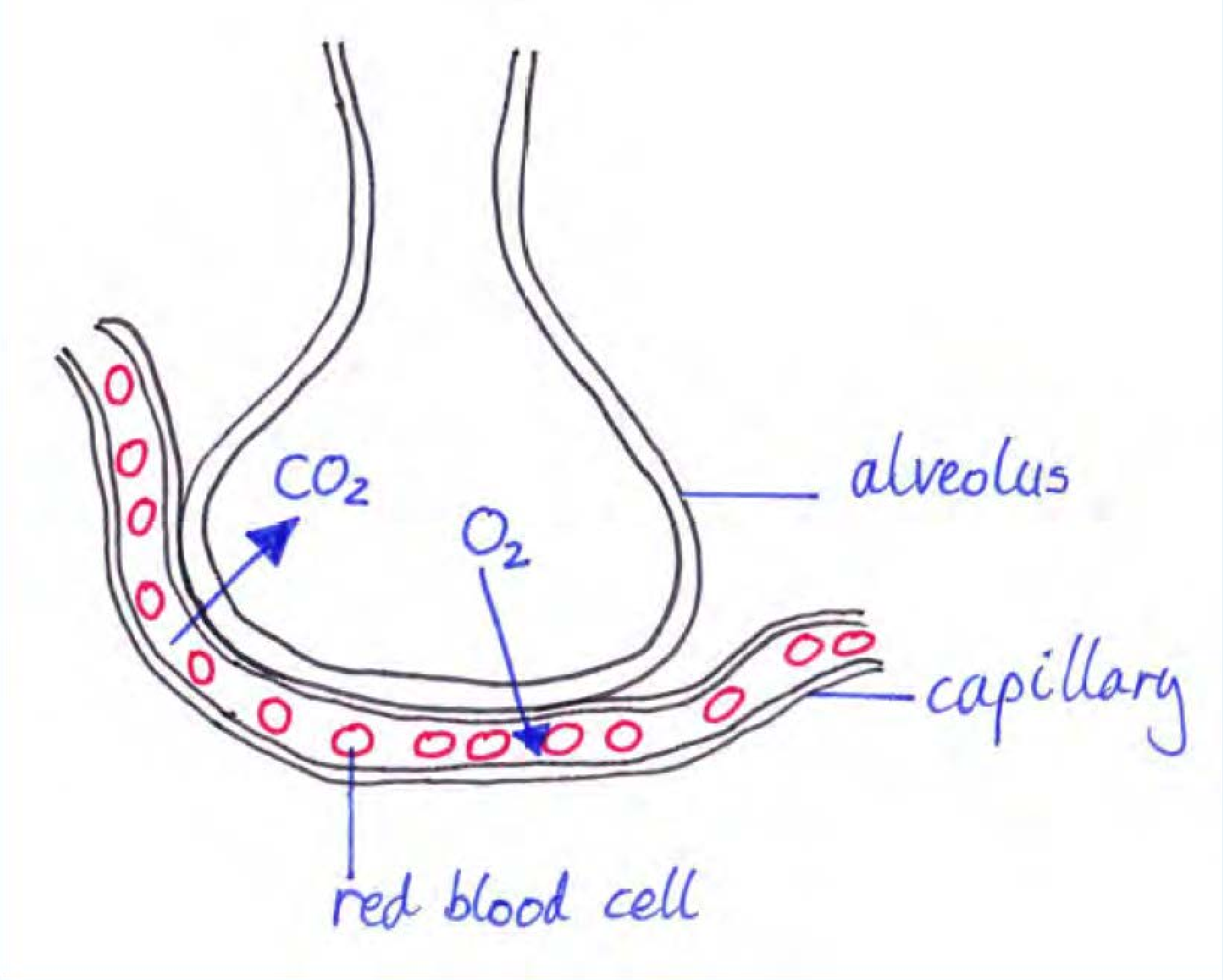
Before starting this lesson, find out if any learners are sensitive to the use of animal products in this way, or even to the fact that animals are farmed for human consumption. Some learners may also have religious or cultural objections to the dissection and handling of animal parts, especially cows and pigs. You need to be aware of these issues and be sensitive to them.

The hard rings in the trachea are made of cartilage and keep the trachea open so air can move freely. Encourage learners to make notes of their observations throughout the dissection.

1. Learner-dependent answer.
2. The semicircular rings of cartilage.
3. The lung tissue is spongy. Learners might also observe other blood vessels within the lung tissue and notice some of the bigger tubes running through the tissue.
4. Learners should see that the piece of tissue floats. This is because the lung tissue, even after an animal has died, contains a large amount of air within all the alveoli, which makes it float in water.
5. When learners blew into the lungs, they should note that they expand, but they are still soft to touch. Once inflated and left to lie on the table, some of the air will escape as the tissue relaxes down, but not completely, and learners might have to squeeze the lung to deflate it. Inflated lungs are paler/more cream coloured (as blood vessels on the surface are squashed flat and blood moves further into the lungs).
6. In humans, the diaphragm relaxes and therefore moves upwards and the rib cage also moves down and in. This reduces the volume of the chest cavity, increasing the pressure on the lungs and therefore forces the air out of the lungs.

ACTIVITY: Drawing gaseous exchange in the alveoli (LB page 65)

The following diagram gives an example of something the learners might produce. You can also draw this up on the board when describing oxygen and carbon dioxide diffusion.



Possible headings that learners might write are:

- Gaseous exchange within the lungs
- Diffusion of carbon dioxide and oxygen within the lungs
- Diffusion of CO_2 and O_2 between the alveolus and capillary, etc

4.3 Circulation and respiration

The video link in the visit box on respiration is quite long (about 25 minutes), but it could be a very good summary lesson.

In the video in the visit box showing how blood is circulated through the heart, learners do not need to know about the heart valves and electrical control at this stage - this is for interest only.

ACTIVITY: Heart dissection (LB page 66)

Learners will look at the heart in much more detail in Grade 10 Life Sciences where the detailed structure of the heart will be studied, including the valves. This activity is meant as an introduction to the structure of the heart and for learners to experience a dissection. We suggest doing this as a demonstration as learners will do this practical in Grade 10 Life Sciences again.

It is important to be tolerant of learners religious, cultural or personal beliefs which may prevent them from participating in this dissection, particularly if pig is used. A suggestion is to break learners up into groups, or else do the dissection as a demonstration in front of the class. The following materials are required for each dissection, whether in a group or when done as a demonstration. The number of groups will depend on how many hearts you are able to obtain and how many learners are willing to do the dissecting. For learners who are unwilling to handle the hearts, but still want to be involved, they could take photographs of the heart at different stages of the dissection using a digital camera or their mobile phone cameras.

Sometimes butchers will cut the blood vessels off the top of the heart, and may also remove the atria and cut into the ventricles at the abattoir. Discuss your needs with the butcher beforehand so that they can preserve the heart as much as possible. You can sometimes even obtain the heart and lungs together (usually referred to as a 'pluck'), which is useful to see how the blood vessels connect the organs. If you obtain hearts with long blood vessels, attached, cut off some of these sections to keep for studies of veins and arteries. As with the lung dissection, be sensitive to ethical issues and learners' concerns around the use of animal products in this way.

Learners should be able to feel the valves at the base of the aorta. These will become visible later when viewing the internal structure of the heart.

The heart muscle also needs a supply of blood and oxygen in order to function. This is supplied by the coronary arteries. Learners should be encouraged to take notes in their workbooks or a separate notebook throughout the dissection.

To locate which side is which in the heart, learners must hold the heart so that the coronary artery runs diagonally across the heart - this will be the the front. Then the left / right ventricles are on either side of the coronary arteries.

The aortic valve prevents the backflow of blood into the heart once it has been pumped out and into the aorta to travel to the rest of the body.

At this stage, you can also point out some of the other valves to the learners. This detail is not necessary to know, but it is very interesting when thinking about how the heart functions as a very efficient pump. Look at the areas where the atria and ventricles join to locate the bicuspid valve between the left atrium and ventricle, and the tricuspid valve between the right atrium and ventricle. They should be visible as thin flaps of tissue with tough "threads" or cords attached to the base of the flaps. The *tri*cuspid valve on the right should have 3 flaps and the *b*icuspid valve on the left should have 2.

1. Learner-dependent answer.
2. The ventricles have much thicker walls than the atria. This is because the ventricles need to pump the blood much further and with more force to the rest of the body, compared to the atria, which only pump blood into the ventricles.
3. The left ventricle should be thicker than the right ventricle. The left ventricle has to pump blood to the whole body (systemic circuit), while the right ventricle only has to pump blood to the lungs (pulmonary circuit).

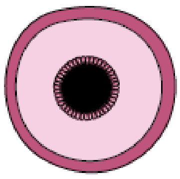
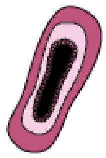
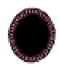
ACTIVITY: Feel your blood rushing through your body! (LB page 69)

Later in this Unit learners are going do an investigation into their heart rate at rest and after exercise and they will then need to be quite skilled in taking their pulse and determining their heart rate. This activity is therefore included in preparation for this. You can get learners to all find their pulse in the way they find easiest. Once they have done this, get them to count their heart rate while you time for 30 seconds, indicating "Stop" and "Start". To obtain their heart rate at beats per minute, learners then multiply by 2.

1. Learner-dependent answer
2. Learner-dependent answer. Learners have to multiply the number of heart beats in 30 seconds by two to calculate beats per minute.

Other units of measurement which indicate a rate are for example: km/h (kilometers per hour), m/s (meters per second), flow rate of a river in l/s (litres per second), etc.

ACTIVITY: Tabulating differences between the blood vessels (LB page 70)

Blood vessel type	**Artery**	**Vein**	**Capillary**
Image			
Function	Transport blood to the rest of the body	Transport blood from the body to the lungs	Transport blood from arteries to veins
Type of blood transported	Oxygenated	Deoxygenated	Mixed
Exceptions	Pulmonary arteries transport deoxygenated blood	Pulmonary veins transport oxygenated blood	N/A

ACTIVITY: A circulation simulation! (LB page 71)

Where possible teachers should set up the following activity in advance of the class arriving. It is aimed specifically at 'kinetic' learners to make them 'walk the circulatory system' in order to remember how it works.

Materials needed:

- 3 hula hoops, or something similar
- white A4 sheets
- coloured paper
- red and blue string
- prestik

Preparation for the lesson:

1. Cut up coloured paper into blocks - you will need two different colours
2. there should be enough blocks for each learner in the class to have at least one of each colour.
3. one colour will represent oxygen and the other colour will represent carbon dioxide.
1. Make the following signs on the back of recycled A4 pages - write in a clear, neat font so everyone can see it.
2. Left side of heart
3. Right side of heart
4. Lungs
5. Arms and hands

6. Legs and feet
7. Brain
8. Stomach
9. Kidneys
10. Face

[There are many other body parts that could be included and teachers are welcome to add to this list. For the purposes of this activity though time constraints were considered and it was decided to add only those listed here.]

1. Obtain the use of a large, open space, either in your classroom, a hall, or outside on the grass. Imagine a huge person is lying out on the space.
2. Lay out 2 hula hoops to represent the left and right side of the heart.
3. Place one more hula hoop above this to represent the lungs.
4. Lay out the signs on the A4 pages to illustrate where each of the body parts will be in relation to the heart and lungs.
5. Stick red wool (for oxygen carrying vessels) and blue wool (for carbon dioxide carrying vessels) with prestik or sellotape to the A4 posters (and between them) forming a large circulatory system as in the diagram in the activity.
6. Leave a pile of red and blue blocks of paper at each body part - it works well if you put these in ice-cream or yoghurt tubs
7. Learners start off in the lungs and will walk along the red lines to their different body parts as if they are traveling in the blood vessel to deliver oxygen. When they have delivered their oxygen (by dropping off the red blocks and picking up blue blocks) they will then travel along the blue lines to deliver carbon dioxide to the lungs and to get more oxygen.
8. As one learner leaves the lungs, send another one off so that you have several learners walking through the system at any one point.
9. If you have a large class, let a couple of learners walk through at a time. If you make the layout really big, then the whole class can form a long line of individual blood cells and move through in a line.

Make sure learners are able to visualise that they are forming a complete cycle or system which repeats. If they are battling, you can walk through it with them first to explain. The first time you could even demonstrate the activity by starting in the lungs and getting learners to instruct you on where to walk to next.

ACTIVITY: Homework activity to measure your resting heart rate (LB page 72)

Get learners to do this activity in the 3 days leading up to the lesson where you will investigate the effect of exercise on heart rate.

INVESTIGATION: Measuring and comparing heart rates before and after exercise **(LB page 72)**

For this investigation, the basic instructions are given below, and then learners will have to design the investigation themselves. A suggestion is to break your class up into big groups of at least 10 learners. They can then discuss how they are going to do the investigation. Each learner must write down their own method and design after they have discussed how they are going to do the recordings within their group. The only materials that learners will need are timing devices - you can either provide some stopwatches, or learners can use the stopwatch on their mobile phones. If learners opt to run for example, suggest running on the spot, as it will be difficult otherwise to control how far or fast individual learners will run in 2 minutes. In general, fitter people have a slower resting heart rate and return to their resting heart rate faster than unfit people after a bout of exercise, but the focus for this activity should be that learners take objective measurements and analyse the data that they collect appropriately. Therefore if the findings of the investigation do not agree with the expected results, full credit should still be given for an accurate interpretation.

This is the first investigation that learners will be conducting in Grade 9. An interesting video to watch beforehand about the scientific method is given in the visit box and titled "The times and troubles of the Scientific Method". It could be an interesting class exercise to watch this video first and then have a class discussion about learners' understanding of the scientific method. At school level, the scientific method is taught in specific steps, but it is very important for learners to also understand how science discoveries often take place at university level and that they often happen by chance or as a side result of another experiment.

The aim could vary slightly from one group to the next, but in general the aim is to see what the effect is of exercise on heart rate and to make deductions about class fitness.

A possible extension
Investigate how quickly a learner's heart rate returns to resting heart rate after physical activity. This will indicate how much their heart rate increased during the exercise as you will measure before and after activity. But then you can also measure the heart rate at 1 minute intervals after the exercise to see how quickly the heart rate decreases to resting rate again. This gives a more rounded measure of fitness level as the faster a person is able to recover, the more fit they are. This should only be done as an extension if you feel your learners are capable and have time to do it within the lesson. This graph would be a line graph.

A possible hypothesis which learners might propose is: "Heart rate increases after exercise."

1. The independent variable is the type of activity - exercise or resting.

   The dependent variable is the heart rate as this will depend on whether the learner is at rest or has done physical activity (and how vigorous the physical activity was).

   There are several controlled variables: Learners of the same age, about the same mass, all girls / boys, all about the same fitness level, all doing the same type of exercise, all doing it for 2 minutes.

2. Learner-dependent answer

Make sure learners discuss all aspects of the investigation. You can help learners with this part of their discussion in their groups by pointing out questions that they should answer when writing their method. For example, how will we do the recording? This will depend on how many skipping ropes are available if they are to be used. Will one learner skip at a time while the others watch and record the time? Or if the learners are to jog on the spot for 2 minutes, then perhaps 5 learners can jog at once while the other 5 do the recordings. Learners must specify how they will record heart rate and where. Will it be on the wrist or the neck? Is it best to record heart rate for 10 (or 15) seconds and multiply 6 (or 4) to get the beats per minute? This is because if they record the heart rate for a whole minute after exercise, the rate might have started to slow down already by the end of the minute and therefore not be an accurate reflection of the heart rate immediately after exercise. 1. Design a table that will record the heart rate of the 10 learners when at rest and after 2 minutes of physical activity (skipping or jogging on the spot). Remember to give your table a heading.

Learner-dependent answer

A possible table that learners may produce could look as follows:

Table showing the heart rate of 10 learners before and after 2 minutes of skipping		
Learner name	**Heart rate before (beats/min)**	**Heart rate after (beats/min)**
Megan		
Thembile		
etc.		

Learners may also come up with additional columns. For example, they may add a column to calculate the change in heart rate from before exercise to immediately after exercise.

Learners may not understand how a double bar graph is different from a bar graph, and also may not understand what is meant by two sets of data. An example of a double bar graph would be the minimum and maximum temperatures on different days of the week. In this example, the day of the week is the independent variable, and we are looking at two dependent variables (two sets of data) - namely the maximum and minimum temperatures. For a graph like this, one would indicate "days of the week" on the x-axis, and you would have two bars next to each other for each day. One would show the minimum temperature and one would show the maximum temperature. The bars showing the two temperatures would touch, and the days of the week would be separated by a space.

Learners might find this difficult to answer, but it is crucial that they understand the types of graphs and when each one should be used. In this investigation, we want to show the data for each learner along the independent axis (x-axis). The learners are not related in any way, nor are they numerical values - they are discrete categories described by words (ie. the name of the learner). We will therefore use a bar graph. In this investigation we will actually be using a double bar graph. There will be two bars for each learner - the first bar being the heart rate before exercise and the second bar being the heart rate after exercise.

Learners can distinguish between the before and after readings by creating a key where the one set of data is in one colour or pattern and the other set is in another colour or pattern.

When looking at learners' graphs or helping them to draw them, make sure they have the heart rate in beats/min on the dependent y-axis and the learners names on the independent x-axis. Each learner will have two bars, one for heart rate before exercise and one for heart rate after exercise. For each learner, these two bars should be touching, but there should be a space between the sets of bars for each learner. As a suggestion, if using the graph paper provided here, in order to fit 10 learners along the x-axis it is best to make each bar 2 blocks wide (the smallest blocks), with 1 or 2 blocks in between each learner. If you have graph paper available, perhaps provide learners with a sheet to practice on and once they know how to draw their graph, they can copy it into the workbook here.

1. Learner-dependent answer
2. Learner-dependent answer
3. Learner-dependent answer
4. Learners should deduce that the fitter an individual is, the smaller the increase in the heart rate from before to after physical activity. Learners that are unfit will sometimes show a bigger increase in heart rate after the physical activity (provided that the activity was carried out to the same level of effort).

It is vitally important that learners report their actual findings. If they do not come up with results that agree with what they are expecting to find, it is FAR better that they report what they found than that they "tweak" their results or try to alter their discussion or hypothesis to fit in with what is expected. Full credit and praise should be given to an investigation that was carried out well and truthfully reported, rather than one in which certain information or findings are made up or changed. If students know what they are expecting and think that there is something wrong with their results, they should be encouraged to make suggestions in the discussion section that follows as to why they didn't see what they were expecting to see.

The learners may also notice a trend in the resting heart rates of the members of their group that were recorded in the three days prior to this activity, and they are welcome to hypothesise and make observations. They are likely to notice for example, that the fittest members had the lowest resting heart rates.

Assess whether learners have adequately discussed their results. As previously mentioned, their actual results may not agree with what they *should* find. In this case they still deserve full credit for their observations. However, they also need to show that they know what should have happened, based on their research around the topic. They should point out that fitter individuals have a stronger heart compared to unfit individuals. Like all muscles, the heart becomes stronger as a result of exercise, therefore, it can pump more blood through the body with every beat. As a result, during exercise, a fit heart does not need to pump as fast to deliver the same amount of blood that an unfit heart would, and it does so with less strain. Assess whether learners have pointed out any shortcomings in their investigation and if they have made suggestions. Learners should also discuss some of the benefits of exercise for the cardiovascular system, such as decreasing the risk of heart attack and other heart diseases.

1. Learner-dependent answer

Revision

1. Learner-dependent answer
2. a) alveoli
   b) arteries
   c) capillaries, cells
   d) diffuses, capillaries/bloodstream
   e) veins, deoxygenated, lungs
   f) mitochondria, energy, respiration

	Inhaling	**Exhaling**
Chest volume	Expands	Becomes smaller
Pressure on lungs	Decreases	Increases
Air movement	Moves into lungs	Moves out of lungs

3.

L	breathing	a	arteries, veins and capillaries
n	diaphragm	b	the type of tissue that keeps the trachea open
I	alveoli	c	tubes leading from the trachea into the lungs
E	trachea	d	the movement of particles from a high to a low concentration through a semi-permeable membrane
K	heart	e	the tube that carries air to and from the mouth to the bronchi

h	veins	f	blood vessels that transport blood away from the heart
J	respiration	h	blood vessels that carry blood towards the heart
b	cartilage	i	small grape-like bunches at the ends of the bronchiole
C	bronchi	j	the process that takes place in mitochondria to release energy for cells to use
m	capillaries	k	the organ responsible for pumping blood throughout the body
a	types of blood vessels	l	inhaling and exhaling
d	diffusion	m	blood vessels surround cells to allow for diffusion
F	arteries	n	a large dome-shaped muscle across the bottom of the rib cage

4. This shows a bronchiole and alveoli. This is evident as there is one main tube which is the bronchiole. There are several alveoli present, which are the sac-like structures within the lungs. You can also see that these are tiny sacs as in the bottom left, the sacs have been shown as open. You can also see the network of capillaries which surround the alveoli bringing deoxygenated blood to the lungs to become oxygenated.
5. The capillaries are very small and thin-walled so that they can branch between the cells of the tissues and come into close contact with the cells to allow for diffusion. This also allows the capillaries to reach all the cells within the body to deliver oxygen and nutrients and remove waste products.

5 Digestive system

Unit overview

1.5 weeks

Learners have already been introduced to the digestive system in Unit 2. This Unit focuses more on a healthy diet and the different components making up a healthy diet. Learners will be required to conduct some food tests to investigate which foods contain which components, such as starch and fats.

The Unit will also look at the alimentary canal and digestion in more detail to see how the food we eat becomes a form which can be absorbed into our bodies. In Gr 6 CAPS, learners do an introduction to nutrition and learn about the basic food groups.

5.1 Healthy diet (3 hours)

Tasks	Skills	Recommendation
Activity: Comparing healthy and unhealthy foods	Working in pairs, comparing, describing, categorizing	CAPS suggested
Activity: Comparing meals	Comparing, describing, explaining	CAPS suggested
Investigation: Which foods contain starch and fats and oils?	Investigating, observing, interpreting, describing, writing, explaining	CAPS suggested
Activity: How does your diet affect your health in the short and long term?	Researching, interpreting, predicting, explaining	CAPS suggested

5.2 Digestion and the alimentary canal (1.5 hours)

Tasks	Skills	Recommendation
Activity: The different organs in the digestive system	Identifying	CAPS suggested
Activity: A digestion simulation	Working in groups, observing, describing, interpreting, comparing, writing	CAPS suggested

Key questions

- Why do we need to follow a healthy diet? What does a healthy diet consist of?
- What makes one type of food healthy and another type of food unhealthy?
- Is it possible to prevent things like diarrhoea or constipation? What about ulcers?
- Why do we need to digest food?
- How is food digested in our bodies?
- Where does the digested food go?

5.1 A healthy diet

ACTIVITY: Comparing healthy and unhealthy foods (LB page 79)

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

ACTIVITY: Comparing meals (LB page 82)

This is an **optional** activity, which can also be done as a class discussion if you do not have time in class.

1. The fruit salad is healthier as it contains a variety of fresh fruits which are high in fibre and packed with healthy vitamins. Fruit salad will satisfy some of your requirement of fruit and vegetables for the day. The fruit loops are unhealthy as they contain a lot of sugars and artificial colourants and flavourings. They have limited nutritional value in terms of vitamins and minerals.
2. The omelette is the healthier option. As with the egg salad, this meal contains fresh salad and the eggs are a source of protein. The omelette possibly has meat or mushrooms and cheese which also adds to the nutritional content. The hamburger is unhealthy as although it contains meat, starch and cheese, the way it was probably prepared is unhealthy as the meat is fried in oil. There is also no fresh fruit or vegetables.
3. The beef, peas and rice is the healthier option for supper as the meal contains starch (rice), meat for protein (beef) as well as vegetables (peas). The other meal is less healthy as it only contains one food group, namely protein from the chicken pieces.

INVESTIGATION: Which foods contain starch and fats and oils? **(LB page 83)**

Learners will need to use the dropper to add a couple drops of the iodine solution to the food substance to be tested in a petri dish. Let them practise on a small piece of white paper, so they see the colour change before trying it on the food. Starch hold the fibres in paper together.

The aim of this investigation is to find out whether starch or fats and oils, or both are present in certain foods.

The hypothesis for this investigation will be learner-dependent.

This will vary depending on what food substances you provide to learners. An example of a hypothesis for this investigation is: "The iodine solution will turn blue-black when added to the potato, bread and apple, indicating these foods contain starch. The emulsion from the cheese, yoghurt, butter and peanut butter will turn milky white, indicating the presence of fats".

The aim of your investigation is to find out whether starch or fats and oils, or both are present in certain foods.

The materials and apparatus used in this investigation will be learner-dependent.

An example that learners could provide:

- samples (small) of the following foods - learners identify which foods they are testing for starch and fats.
- iodine solution with dropper
- petri dish
- forceps
- test tubes
- paper
- ethanol

The method the learners will follow in this investigation will be learner-dependent.

Learners need to write the method in a list of numbered steps. Learners need to indicate that they collected the food samples and placed them in different petri dishes (bowls if these were not available).

They then dropped iodine solution in turn on each of these samples observing and recording the results. They must then indicate how they did the fat emulsion test, by placing small pieces of the food substances in a test tube, adding ethanol and crushing and stirring with the rod or another rounded, hard object. They should then pour the mixture onto paper and allowed the ethanol to evaporate and record the results.

Learners could draw a table to record their results and observations, or just list the foods which tested positive or negative for each substance. An example of the layout for a learners table could be:

Table to indicate the presence of starch or fats and oils in various food substances				
Food substance	**Result of iodine test**	**Contains starch?**	**Result of emulsion test**	**Contains fats?**
Bread	Turned blue-black	Yes	No murky, white colour	No
Apple	Parts of apple turned blue-black	Yes	No murky, white colour	No
Cheese	Remained orange-brown/did not turn blue-black	No	Emulsion turned murky, white colour	Yes
etc.				

Learners should discuss which types of foods contained starch and fats and which did not. They could note that plant material in particular contains starch because the plants photosynthesize specifically to produce glucose that are the building blocks for carbohydrates. Animal products (such as the ham and boiled egg) do not contain starch. Learners should also discuss any unusual findings which they did not expect and whether this could be a result of inaccuracy or contamination. Learners should also evaluate their results and whether they could have done anything to improve the investigation, such as possibly repeating the tests.

Learners must refer back to their hypothesis in the conclusion and either reject or accept it.

ACTIVITY: How does your diet affect your health in the short and long term? (LB page 85)

Learners could do this as a quick class discussion as you go through the different conditions.

Name of health issue	**Description**	**What does this person have a deficiency or surplus of in their diet?**
Osteoporosis	Osteoporosis is a disease, most common in older women, where the bones become fragile and are more likely to break. Usually the bones lose density and become porous.	The main contributing factor is not enough calcium or Vitamin D in the diet. This can also be a genetic, inherited trait.
Anemia	Anemia is a condition of the blood when there are not enough healthy red blood cells. A patient feels tired and weak as the tissues and organs in the body are not able to get enough	Too little iron in the diet. Iron is needed for healthy red blood cells to deliver oxygen to the tissues. Blood loss can also result in anemia, but this does not refer to diet.

	oxygen.	
Marasmus	This is a severe form of malnutrition due to starvation. The person becomes extremely thin (emaciated).	A severe deficiency of nearly all nutrients, especially protein and carbohydrates.
Constipation	A person has constipation when they have a bowel movement less than 3 times per week. The person may have hard stools and difficulty and pain when passing stools.	A diet lacking fibre. Fibre helps to produce stools and stimulate the digestive system. Not drinking enough fluids (water) can also cause constipation.

5.2 Digestion and the alimentary canal

Mechanical digestion does not change the chemical properties of the food. Rather, it changes the physical properties by breaking large pieces up into small pieces, therefore it can also be called physical digestion.

ACTIVITY: The different organs in the digestive system (LB page 86)

Learners must draw straight, parallel label lines with a ruler and labels should be written one underneath the other. In this image, the liver is the large red organ next to the stomach, and the gallbladder is the small green part in front of it. The liver produces bile which it then secretes into the gallbladder to be stored before it enters the digestive tract. Bile helps with fat digestion. The pancreas, the yellow organ below the stomach in the diagram, is another organ which plays an important role in digestion as it produces the enzymes for chemical digestion which are secreted into the small intestine. The liver, pancreas and gallbladder are accessory organs to the digestive system. However, they are not part of the alimentary canal. Make learners aware that there is a difference in discussing the digestive system (including these accessory organs) and the alimentary canal (which only focuses on the organs and structures through which food passes and not the liver, pancreas and gallbladder).

Although CAPS states that no detail of how the different parts of the alimentary canal are structurally adapted to suit their function, some of this information has been included in the following activity. It was felt that it is necessary to start developing this skill as learners will often have to describe structural adaptations for function in Life Sciences Grade 10–12. This skill is often poorly developed in learners and so it is beneficial to start introducing learner to this kind of reasoning and explanations of biological structures from early on. This is an **optional activity**.

ACTIVITY: A digestion simulation (LB page 87)

Objectives for this activity:

- Learn about how the different parts are structurally adapted to their function.
- Describe the parts of the alimentary canal and what each part's functions are.
- Understand physical and chemical digestion.
- Discuss how food travels from ingestion to digestion to absorption and egestion.
- Make observations regarding the process of digestion.

A suggestion is to make learners work in groups and produce one model per group. This way they will be able to discuss the model with each other as they are going along and there might also be less mess. Set up a workstation for each group prior to the lesson with the required materials laid out. The materials below are suggestions to be used to create a model of each part. However, you can also use other materials if you have more appropriate ideas or access to other materials in your classroom. Alternatively, you could also do this activity as a demonstration in the front of the class, discussing the model and structures as you go along. If you are not able to physically produce the model of digestion with your learners in class, you can still read through the activity and learners can still answer the questions and you can discuss the structural adaptations.

Learners need to cut up the food with the scissors, break it up with the pestle and mash it with the potato masher. They then squirt water all over it and use their hands to make the food into a ball.

1. – 3. The scissors, pestle and potato masher is mechanically breaking down the food into smaller particles (mechanical digestion). The water (saliva) sprayed on the food is covering it and starting to digest some of it (chemical digestion).
4. The scissors are like the incisors that cut the food, the pestle is the pre-molars and the potato masher represents the molars. The water sprayed on the food is the saliva that starts chemical digestion. The hands making the ball with the food represents the action of the tongue and soft palate in making the bolus.

One learner should hold the cardboard roll/tube with the one end in the bag while another learner tips the mixing bowl so that the food bolus rolls down the tube and into the bag.

1.–2. The ball of food is being transported from the mouth to the stomach.
3. Learner-dependent answer

In the human body, the oesophagus transports the food (bolus) from the mouth to the stomach just like the cardboard tube allows the ball of food to travel from the mixing bowl representing the mouth to the Ziplock bag representing the stomach. Learners should note the downfall of this part of the model as food does not 'roll' down the oesophagus as they have done here in the simulation. Rather, the food is moved down by the peristaltic actions of the muscles surrounding the oesophagus. Learners should think up alternative ways to simulate or represent this action, such as using a plastic tube which is not hard and using your hands to squeeze the food down the tube and out the other side into the bag.

Learners need to pour the digestive juices onto the food and then seal the stomach / Ziplock bag. They then simulate the stomach churning by shaking and churning the Ziplock bag with the food inside. This should go on for quite a while as the food often remains in the stomach for long periods.

1.–4. The churning and shaking is physically breaking up the food through mechanical digestion. The coke, vinegar or lemon juice aids chemical digestion.
5. The stomach muscles churn and move the food around to break it up through mechanical digestion just like your hands when they are churning and moving the food to break it up in the bag. The coke, vinegar or lemon juice added to the stomach represent the gastric juices which the stomach secretes from its walls to cause chemical digestion.

Learners need to let the food mixed with the digestive juices, run from the Ziplock into the stocking. It shouldn't be excessively runny but make sure they are working over a large dish to catch the excess liquid. They should be squirting small amounts of bicarbonate dissolved in water into the syringe to simulate the digestive enzymes being added to the small intestine. You may want to explain how peristalsis works by showing how the muscles around the small intestine squeeze rhythmically to push the food from the stomach through the entire intestine. Let learners use their hands to simulate peristalsis - if one hand is squeezing tightly around the small intestine the other releases and relaxes around the small intestine.

1.–5. The food is mixing with the bicarbonate of soda dissolved in water and moving through the small intestine. The food takes a very long time to move through the small intestine and the liquid is running through the stockings and into the large dish or onto the table.

6. When food arrives in the small intestine digestive enzymes are secreted from the pancreas and bile from the gallbladder. This is represented by the bicarbonate of soda mixture which is squirted into the stocking. These enzymes digest the food particles that are then able to be absorbed by the cells in the walls of the small intestine. The molecules move into the capillaries and blood stream that surrounds the small intestine. As learners squeeze the food along, some of the liquid runs out of the stocking and this represents the molecules being absorbed into the bloodstream. Learners could also compare the length of the small intestine to the long stocking being used. At the end of the process the food that is left is dryer and can move out of the small intestine as undigested waste that gets egested. In the same way the food that is left in the stocking is moved to the open end of the stocking and released.

Revision

1. A healthy diet provides all the nutrients, such as carbohydrates, proteins, fats, vitamins, minerals and fibre that are needed for well-being, and contains them in correct amounts/ proportions.
2.

Food item	***Nutrients***	***Food item***	***Nutrients***
Fried chips.	*Carbohydrates (starch), oil from frying.*	*Strawberries.*	*Vitamins (especially vitamin C) and minerals, carbohydrates (sugar), water.*
Chicken pieces.	*Protein and fats.*	*Digestive biscuits.*	*Carbohydrates, fibre.*
Butternut.	*Vitamins and minerals, starch.*	*Yoghurt.*	*Minerals (calcium), protein, fats, water.*
Assorted nuts	*Fats and oils, protein, vitamins and minerals.*	*Split peas and lentils.*	*Protein, fibre, starch, vitamins and minerals.*
Green beans.	*Vitamins and minerals, protein, carbohydrates, fibre*	*Margarine.*	*Fats and oils.*

3. The starch test will indicate whether a food contains starch - if you drop iodine solution on the food and the iodine turns from brownish-orange to blue-black then the food contains starch. Food that will possibly test positive for starch in the above examples are: green beans, split peas and lentils, butternut, digestive biscuits, fried chips.
4. Take-away food is usually cooked in large quantities of oil and contain many additives and fats to make it last longer and taste stronger which might not be good for the body.
5. Heat can break down some vitamins and boiling dissolves them and minerals out of the food, so it's better to eat them raw.
6. Food that is digested over a long period of time has all the beneficial nutrients removed from it rather than travelling through the digestive system really fast and having only a part of the nutritional value of the food absorbed from it.

6 Compounds

Unit overview

1 week

1. This Unit starts with a review of the main concepts surrounding Compounds, covered in Grade 8 Matter and Materials.
2. This is followed by a section on the Periodic Table, first introduced in Grade 7 Matter and Materials.
   a) New information includes the terms *Group* and *Period* and the observation that elements from the same group exhibit similar chemical behaviour. You could discuss the Periodic Table being a classification table of the elements; an organising framework which helps us understand their properties, and their similarities and differences. Learners will be exposed to different formats of the Periodic Table. The idea is that learners should realise that information on the table can be added or taken away, depending on the purpose for which it will be used. This does not, however, alter the positions of the elements on the table, which are fixed.
   b) It is an expectation of CAPS that learners should know the names and formulae of the first 20 elements on the table (as well as Fe, Cu and Zn). CAPS does not require that learners memorise the atomic number of each element, which would imply that the exact position of each of the 20 elements on the table is not examinable.
   c) An important issue to note is that, according to CAPS: "each element on the Periodic Table (in its own block) has an atomic number (smaller number), mass number (larger number), name and symbol". This statement is not entirely correct. The larger number usually indicated on the table is NOT the mass number (defined as the sum of the number of protons and the number of neutrons), but rather the average atomic mass (this number is usually rounded to the nearest whole number, or to one decimal place). To understand the subtle but significant difference between mass number and average atomic mass, we need to provide some background: At this point the learners are under the impression that all atoms of a given element are identical. This is not strictly true. All elements exist as two or more isotopes. Isotopes are variants of a particular chemical element: while all isotopes of a given element share the same number of protons and electrons, each isotope differs from the others in its number of neutrons. Hence, it would not make sense to indicate the mass number on the table, as the mass number is different for each different isotope of a chemical element. The average atomic mass is a number that takes into account the masses of all the different isotopes of a given element AND the proportion in which each is found in the natural state of that element. The reason why it is important not to conflate the two concepts, mass number and average atomic mass, is because this manifests as a misconception at the higher levels, when it becomes important for learners to know the difference between them. In the text below, we will be using the term 'atomic mass' instead of 'mass number', because it is a more correct description of the 'larger number' that usually appears on the Periodic Table.
3. In the final section of the Unit we return to chemical formulae, which received perfunctory treatment in Grade 8 Matter and Materials (*Atoms*).
4. We have once again included many 'sub-microscopic' diagrams to help learners imagine the small entities dealt with in this Unit. Learners will almost certainly need help switching between the symbolic (formulae) and sub-microscopic (molecular diagrams) representations. This is a very important skill that should receive careful attention at this point, as it will improve learners' chances of mastering the complexities of the subject at the higher levels. We have once again included activities where learners have to construct molecules using plasticine or play dough, to reinforce this skill.

The play dough recipe provided in Grade 8 Matter and Materials is included here for easy reference.

Play dough recipe

Ingredients:

- 2 cups 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, 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 for longer.
3. Turn the dough out onto a clean surface and knead until smooth. Divide the dough into balls for colouring.
4. Make a small depression in the centre of the ball and pour some food colouring into it. Work the colour through the dough, adding more if you want a more intense colour.

6.1 Elements and compounds (0.5 hours)

Tasks	**Skills**	**Recommendation**
Activity: Writing formulae and revision	Writing symbols/formulae, interpreting diagram	Optional (Revision)

6.2 The Periodic Table (1 hour)

Tasks	**Skills**	**Recommendation**
Activity: Elements on the Periodic Table	Memorising names and symbols of the first 20 elements	CAPS suggested

6.3 Names of compounds (1.5 hours)

Tasks	**Skills**	**Recommendation**
Activity: Naming compounds of metals and non-metals	Interpreting, writing names	CAPS suggested
Activity: Writing names from the formulae of compounds	Interpreting, naming compounds, building models, drawing	CAPS suggested
Activity: Writing formulae from the names of compounds	Interpreting, writing formulae, building models, drawing	CAPS suggested

Key questions

- What is a compound?
- How is a compound different from an element?
- How is a mixture of elements different from a compound?
- What does the position of an element on the Periodic Table tell us about its properties?
- Where do we find metals, non-metals and semi-metals on the Periodic Table?
- What are the vertical columns of the Periodic Table called?

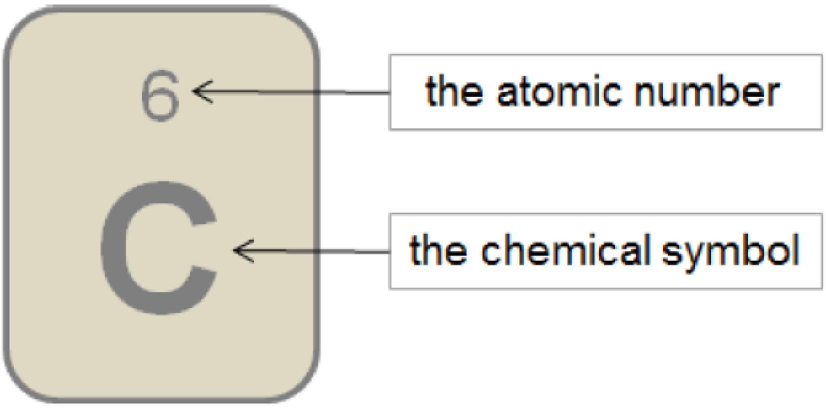
- What are the horizontal rows of the Periodic Table called?
- What do elements belonging to the same 'group' of the Periodic Table have in common?
- What additional information about an element can we find on the Periodic Table?
- What does the formula of a compound tell us about it?

6.1 The Periodic Table of Elements

The first part of this section is a revision of what learners should have covered in previous grades.

What information can we find on the Periodic Table?

In the diagram on page 101of the Learner's Book:



An example of one of the tiles on the Periodic Table

C is carbon. It has 6 protons (indicated by the atomic number). The atomic number (Z) is usually written at the top of each tile for an element in the Periodic Table, and the larger atomic mass number (A) is written at the bottom of each tile.

Refer learners to the Periodic Table on page xx of the Learner's Book. The table contains only the chemical symbol and atomic number of each element.

Learners should draw the following:

Vertical	**Horizontal**
[aw of vertical line]	[aw of horizontal line]

There are 18 groups. The first period is at the top of the table. The first element in the third period is sodium (Na). C, carbon is in Group 14 and in the second period.

ACTIVITY: Elements on the Periodic Table (LB page 104)

Atomic number	**Chemical symbol**	**Element name**
1	H	Hydrogen
2	He	Helium
3	Li	Lithium
4	Be	Beryllium
5	B	Boron
6	C	Carbon

7	N	Nitrogen
8	O	Oxygen
9	F	Fluorine
10	Ne	Neon
11	Na	Sodium
12	Mg	Magnesium
13	Al	Aluminium
14	Si	Silicon
15	P	Phosphorus
16	S	Sulfur
17	Cl	Chlorine
18	Ar	Argon
19	K	Potassium
20	Ca	Calcium

Atomic number	**Chemical symbol**	**Element name**
26	Fe	Iron
29	Cu	Copper
30	Zn	Zinc

This also serves as a revision of what learners covered in Grade 8 about the atom.

1. It tells us how many protons are in the atoms.
2. There are 8 protons (atomic number is 8).
3. There are also 8 neutrons.

   Learners will learn about isotopes only in later grades, for now it is enough to know that the atomic mass gives an indication of the number of nucleons (protons and neutrons), so for oxygen, the atomic mass is 15.999 (rounded to the nearest integer it is 16), so the number of neutrons = 16 - 8, which is 8.

4. There will be 8 electrons.

   At this stage, learners have not yet learned about ions, and so we only consider neutral atoms in which the number of electrons equals the number of protons.

5. Electrons are negatively charged and protons are positively charged.
6. The protons and neutrons are clustered together in the centre, forming the nucleus, and the electrons occupy a much large space/cloud/area around the nucleus.
7. Learners must draw a central nucleus with 8 protons and 8 neutrons, with 8 electrons forming a cloud around the nucleus. An example model of a nitrogen atom is given below as a reference:

The metals of Group 1 are called the **alkali metals**. The name and chemical symbol of the lightest member of the group is Lithium (Li).

Here is a video to assist teachers in demonstrating the properties of alkali metals, including burning in air, and reaction with water. It is a long video but worth a watch. bit.ly/11YFtOe

Ask learners firstly why they think it might be stored in oil and not water, for example. This is because it reacts very well with water and it also reacts slowly over time with oxygen in the air, so it is best to store it in oil. Next, ask learners why they think the piece of lithium metal floats in the bottle of oil. This is because lithium is the lightest metal in the universe and it is lighter and less dense than oil, so it floats. This links back to the particle model of matter and what learners covered in Grade 8 on density of different materials.

The other product that forms is lithium hydroxide. Its formula in the chemical equation above is LiOH.

Learners should write the following word equation: lithium + water = lithium oxide + hydrogen gas.

The reactants are lithium and water and the products are lithium hydroxide and hydrogen gas.

6.2 Elements and compounds

This first section is a revision of what learners should have covered in previous grades. It spans several pages, but it is mostly revision and has been included as a reference for learners. You will need to decide, based on your class, about how much time you need to dedicate revising these topics, or whether you get your learners to read over the content and complete the activity at the end.

Learners need to be made aware that compounds may occur as two types of structures, namely molecules and lattices:

1. When a compound is made up entirely of non-metals (CO_2, H_2O, or NH_3, for example), the smallest unit of that compound will be a molecule.
2. However, when a compound is made up of a metal and a non-metal (NaCl, or CuO, for instance), the type of bonding in the compound is different.

During bonding, the metal and non-metal atoms exchange electrons to form ions. Due to opposite charges attracting, these ions pack together in vast three-dimensional crystals or lattices, rather than forming simple molecules.

In this section we have included a brief mention of crystal lattices to avoid the misconception later that NaCl and other ionic compounds consist of molecules.

Learners should know that NaCl, for instance, consists of a regular arrangement of sodium and chloride atoms combined in a 1:1 ratio, packed to form a crystal structure.

Ask learners the following questions:

What is the formula of hydrogen peroxide? Can you remember the name of the compound with the formula CO_2?

Answer: The formula of hydrogen peroxide is H_2O_2. The formula CO_2 is carbon dioxide.

What formula represents one 'formula unit' of the type of iron oxide in the diagram on page 108?

Answer: FeO

Discuss this with your class. Encourage them to take notes during your discussions.

- The bond between the two red atoms broke.
- The black atom moved in between the two red atoms.
- Two new bonds formed: between the black atom and each of the two red atoms.

ACTIVITY: Writing formulae and revision (LB page 108)

Learners must use this information to write the formula of each compound in the final column, on the right

Name of substance	**What it is made of?**	**Chemical formula**
Water	2 H atoms and 1 O atom	H_2O
Carbon dioxide	1 C atom and 2 O atoms	CO_2
Ammonia	1 N atom and 3 H atoms	NH_3

Methane	1 C atom and 4 H atoms	CH_4

1. A chemical bond holds the atoms together.
2. The reactants are carbon (grey circle) and oxygen (red circles) and the product is carbon dioxide.
3. The two circles each represent an oxygen atom as oxygen is a diatomic molecule meaning it exists as two oxygen atoms bonded together in diatomic molecules.
4. It means that for every 1 magnesium atom, there is 1 oxygen atom joined to it in a chemical bond.

6.3 Names of compounds

CAPS require that learners make models (using beads, beans, plasticine or playdough) of several elements and compounds. We have intentionally steered away from including activities in which 'molecules' of ionic compounds such as NaCl and CuO are required to be built or drawn. The reason for omissions of this kind ties in with the earlier note in which it was explained that ionic compounds form lattices rather than molecules. Their fundamental units are not called molecules, but 'formula units'.

Type 1: Compounds that contain a metal and a non-metal

These compounds are called ionic compounds because of the type of bonding involved. CAPS do not make a distinction between covalent and ionic compounds at this level. On the one hand this is understandable. Learners have not yet learnt about ionic and covalent bonding in compounds and would therefore not be able to understand the distinction between ionic and covalent compounds. On the other hand, without some distinction being made explicit, learners will fail to understand why MgO is named magnesium oxide when CO is named carbon monoxide, or $MgCl_2$ is called magnesium chloride, but SCl_2 is called sulfur dichloride. For this reason, we have decided to make a distinction between compounds that contain a metal and a non-metal (ionic compounds) and compounds that contain only non-metals (covalent compounds). These are not the only possible combinations of elements possible – a semi-metal could combine with a non-metal, for instance in silicon dioxide (SiO_2) - but the two types of compounds discussed here represent the two most common types of combinations of elements.

ACTIVITY: Naming compounds of metals and non-metals (LB page 110)

Formula	***Which elements does it consist of?***	***Name***
Li_2O	*2 Lithium and 1 oxygen*	*Lithium oxide*
KCl	*1 Potassium and 1 chlorine*	*Potassium chloride*
CuO	*1 Copper and 1 oxygen*	*Copper oxide*
NaBr	*1 Sodium and 1 bromine*	*Sodium bromide*

Type 2: Compounds that contain only non-metals

ACTIVITY: Writing names from the formulae of compounds (LB page 111)

Formula of the compound	***Name of the compound***	***Picture of one molecule of the compound***
CO_2	*carbon dioxide*	*[aw of molecule]*
H_2O	*hydrogen dioxide (water)*	*[aw of molecule]*
PF_3	*phosphorous trifluoride*	*[aw of molecule]*
SF_4	*sulfur tetrafluoride*	*[aw of molecule]*
CCl_4	*carbon tetrachloride*	*[aw of molecule]*

The colours of the atoms are not important, as long as atoms of the same element are the same colour.

The sizes are not critical, but you may want to suggest to learners that the elements higher up on the Periodic Table will tend to be smaller than those lower down. If learners are unsure how to place the atoms, draw their attention to the tip given earlier: The atom that comes first in the name (or formula) must be placed at the centre of the molecule. All the other atoms must be bonded to the central atom.

ACTIVITY: Writing formulae from the names of compounds (LB page 112)

Formula of the compound	Name of the compound	Picture of one molecule of the compound
HF	hydrogen fluoride	
H_2S	dihydrogen sulfide	
SO_3	sulfur trioxide	
CO	carbon monoxide	

The colours of the atoms are not important, as long as atoms of the same element are the same colour. The sizes are not critical, but you may want to suggest to learners that the elements higher up on the Periodic Table will tend to be smaller than those lower down.

Revision

1. a) C and D
   b) A
   c) B
   d) B and D
   e) NH_3
   f) N_2 and H_2
   g) A, B and D
   h) C
2.

Formula of the compound	Name of the compound	Picture of one molecule of the compound
NH_3	ammonia	[aw of compound]
CO_2	carbon dioxide	[aw of compound]
$CuCl_2$	copper(II) chloride	[aw of compound]
SO_2	sulfur dioxide	[aw of compound]

3.

Formula of the compound	Name of the compound
NaCl	sodium chloride
N_2O	dinitrogen monoxide
SO_3	sulfur trioxide
CO	carbon monoxide

4. a) CO and H_2O
   b) carbon monoxide and water
   c) CO_2 and H_2
   d) carbon dioxide and hydrogen
5.

Chemical formula	What it is made of?
H_2O	2 hydrogen atoms and 1 oxygen atom
SF_4	1 sulfur atom and 4 fluorine atoms
NO_2	1 nitrogen atom and 2 oxygen atoms
Fe_2O_3	2 iron atoms and 3 oxygen atoms
Na_2O	2 sodium atoms 1 oxygen atom

7 Chemical reactions

Unit overview

1 week

This Unit builds on the introduction to chemical equations given in Unit 1 and 3 of Grade 8 Matter and Materials. By this stage, learners should know that atoms are rearranged during a chemical reaction. The atoms do not change; only their arrangement in relation to each other changes.

Learners were introduced to particle diagrams in Grade 8 and this skill will be further reinforced in this Unit. We have tried to introduce learners to the idea that chemical reactions can be thought of in different ways. Ultimately, they have to be able to write chemical equations, but this is a very complex skill. By starting with word equations and progressing to submicroscopic representations (picture equations) before translating the latter to the symbolic format (chemical equations), we hope to build/scaffold the learning of chemical equations as well as develop learners' ability to imagine events on the submicroscopic scale.

7.1 Thinking about chemical equations (0.5 hours)

Tasks	Skills	Recommendation
Activity: Drawing water	Drawing	Optional (Suggested)

7.2 How do we represent chemical equations? (1 hour)

Tasks	Skills	Recommendation
Activity: Identifying the different types of equations	Identifying, sorting and classifying, interpreting	Optional (Suggested)

7.3 Balanced equations (1.5 hours)

Tasks	Skills	Recommendation
Activity: When is a reaction balanced?	Interpreting, writing formulae, balancing equations	Optional (suggested)
Activity: Magnesium burning in oxygen	Interpreting, writing formulae, balancing equations	CAPS suggested
Activity: Iron reacts with oxygen	Interpreting, writing formulae, balancing equations, comparing	CAPS suggested
Activity:Copper reacts with oxygen	Interpreting, writing formulae, balancing equations, comparing, drawing	CAPS suggested

Key questions

- What is a chemical reaction?
- How can we represent what happens in a chemical reaction?
- What do the different symbols in a chemical reaction equation mean?
- What do the numbers in a chemical reaction mean?
- What does it mean to balance a chemical equation?
- How can we tell if a reaction is balanced?
- How do we translate between word equations, picture equations and chemical equations?

7.1 How do we represent chemical reactions?

Get learners to first take some notes and describe what they think a chemical reaction is. You can even just ask them the question and get their definitions.

The reactants of the word equation: hydrogen + oxygen *!* water are hydrogen and oxygen.

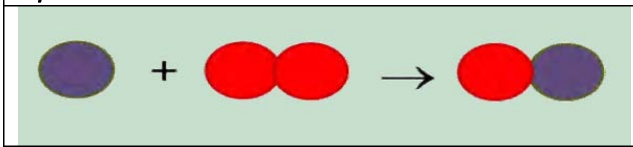
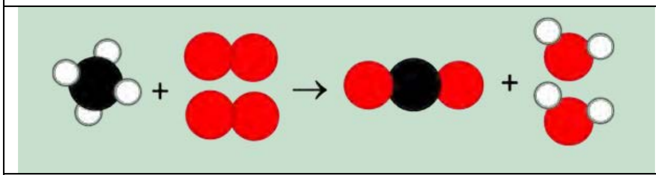
The product is water.

A picture equation is a submicroscopic representation because it shows the particles.

The product is H_2O. The reactants are H_2 and O_2.

$2 H_2 + O_2 = 2 H_2O$ is a symbolic representation because it uses formulae (symbols).

ACTIVITY: Identifying the different types of equations (LB page 119)

Equation	***Type of equation***
	*Picture equation*
carbon dioxide + water ! glucose + oxygen	*Word equation*
Fe + O_2 *!* Fe_2O_3	*Symbolic/chemical equation*
	*Picture equation*
$C_6H_{12}O_6 + 6O_2$ *!* $6CO_2 + 6H_2O$	*Symbolic/chemical equation*

1. Photosynthesis.
2. Cellular respiration.

7.2 Balanced equations

When learners draw a diatomic molecule, the two atoms must be **touching** to show that they are chemically bonded, otherwise it is wrong.

There are four H atoms on the left and four H atoms on the right.

There are two O atoms on the left and two O atoms on the right.

ACTIVITY: When is a reaction balanced? (LB page 120)

1. Submicroscopic, because it shows the particles.
2. $C + O_2 = CO_2$
3. C and O_2
4. CO_2
5. One C atom on the left and one C atom on the right.
6. Two O atoms on the left and two O atoms on the right.
7. Yes, the reaction is balanced because equal numbers of the same kinds of atoms are on both sides of the reaction equation.

Either get learners to write down their own definitions and then read them out to the class, or they can just volunteer answers. You can get learners to start with: We say an equation is balanced when... A potential answer is: "We say a reaction is balanced when the total numbers and types of atoms in the reactants are equal to those in the products".

ACTIVITY: Magnesium burning in oxygen (LB page 121)

1. The reactants are magnesium and oxygen.
2. The product is magnesium oxide.
3. Symbolic, because it uses formulae (symbols).
4.

Number of atoms	**Reactants**	**Products**
Mg	1	1
O	2	1

5. No, the equation is not balanced because the numbers of the atoms are not the same in the reactants and products.

Ask learners why they it is not allowed to change the formula of a compound when balancing chemical equations. Is MgO the same as MgO_2? Remind them of the earlier example of H_2O and H_2O_2, which were not the same compound. MgO and Mg O_2 cannot be the same compound because they do not have the same chemical formula. The ratio of Mg and O atoms are different in the two compounds. (The compound Mg O_2 does not even exist, but you do not have to go into this.)

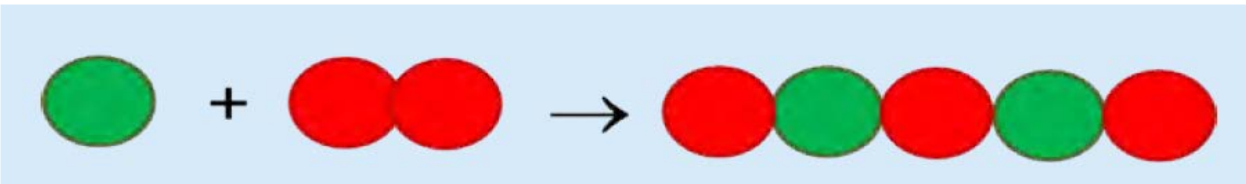
When you convert the play dough 'reactants' to 'products', there are no unused 'atoms' left behind afterwards. Get learners to actually do this activity and practice making the equation using balanced numbers of atoms.

Write this up on the board and explain again how the equation is balanced:

$2\ Mg + O_2 = 2\ MgO$

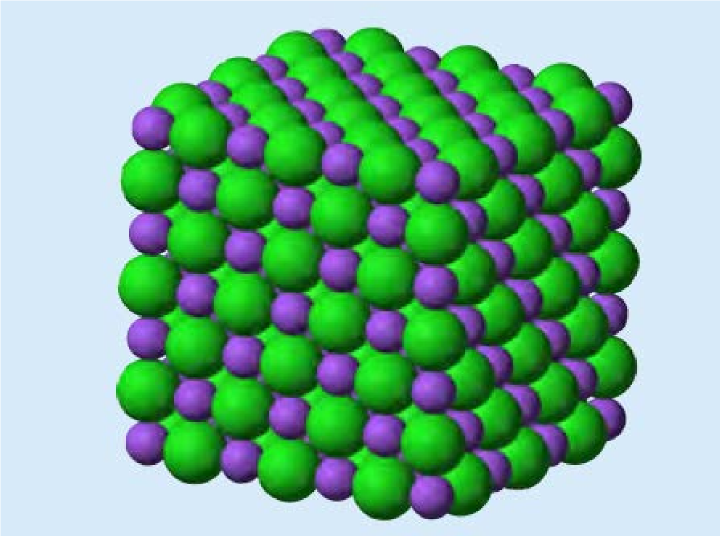
ACTIVITY: Iron reacts with oxygen (LB page 121)

Learner's diagram should look like this. They may find it difficult to convert the equations into diagrams. Help them to interpret the formulae in the following way: Fe on its own means there is just one atom of iron (Fe). O_2 means there must be two atoms of O, linked up to form a molecule. Fe_2O_3 means two Fe atoms and three O atoms are clustered together.



The colours are not important, as long as all the atoms of the same element are the same colour.

The arrangement of the atoms in the Fe_2O_3 'cluster' is also not important. Since Fe_2O_3 is an ionic compound, we would not ordinarily speak of a 'molecule' of Fe_2O_3. Like all other ionic compounds, it consists of large clusters of Fe_{3-} and O_{2-} ions in a regular crystalline packing that extends in three dimensions, much like the ionic lattice of NaCl in the picture below (shown in Unit 1 also).



It is not recommended that you mention this information here, as it more likely to confuse learners at this point than add to their understanding of balancing equations.

Number of atoms	**Reactants**	**Products**
Fe	1	
O	2	

The equation is not balanced because the numbers of the atoms are not the same in the reactants and products.

To balance the equation:

Changes made	**Is this change allowed? Yes/no?**	**Reason**
Add one Fe atom on the reactant side.	Yes	The Fe atom is already a reactant.
Change O_2 to O_3 on the reactant side of the equation.	No	Changes to formulae are not allowed.

1. $2 Fe + O_3$! Fe_2O_3
2. Yes.
3. Yes.
4. No, because a formula was changed.

Changes made	**Is this change allowed? Yes/no?**	**Reason**
Add one Fe atom on the reactant side.	Yes	The Fe atom is already a reactant.
Add one O atom on the reactant side.	No	Adding single atoms is not allowed, unless they are already in the reaction AS SINGLE ATOMS.

1. Two Fe + O + O2 ! Fe2O3
2. Yes.
3. Yes.
4. No, because adding formulae is not allowed.

Changes made	Is this change allowed? Yes/no?	Reason
Add three Fe atoms on the reactant side.	Yes	The Fe atom is already a reactant.
Add two O_2 molecule on the reactant side.	Yes	The O_2 molecule is already a reactant.
Add one Fe_2O_3 on the product side.	Yes	Fe_2O_3 is already a product.

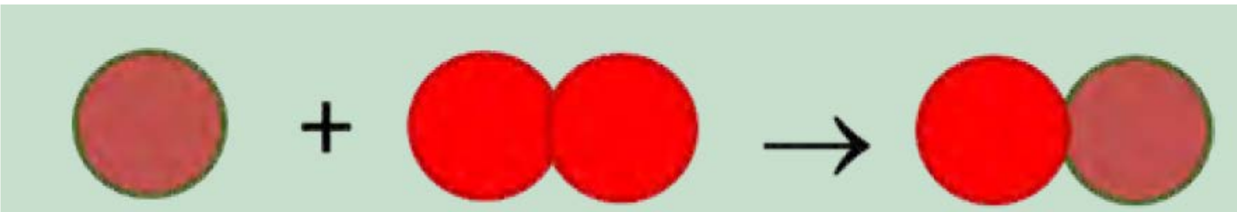
1. $4\ Fe + 3\ O_2 = 2\ Fe_2O_3$
2. Yes.
3. No.
4. Yes, because none of the rules for balancing equations were broken.
5. Plan C
6. Learners should be encouraged to try out other possibilities. They should come to the conclusion that the reaction proposed in Plan C is the only correct one.

ACTIVITY: Copper reacts with oxygen (LB page 123)

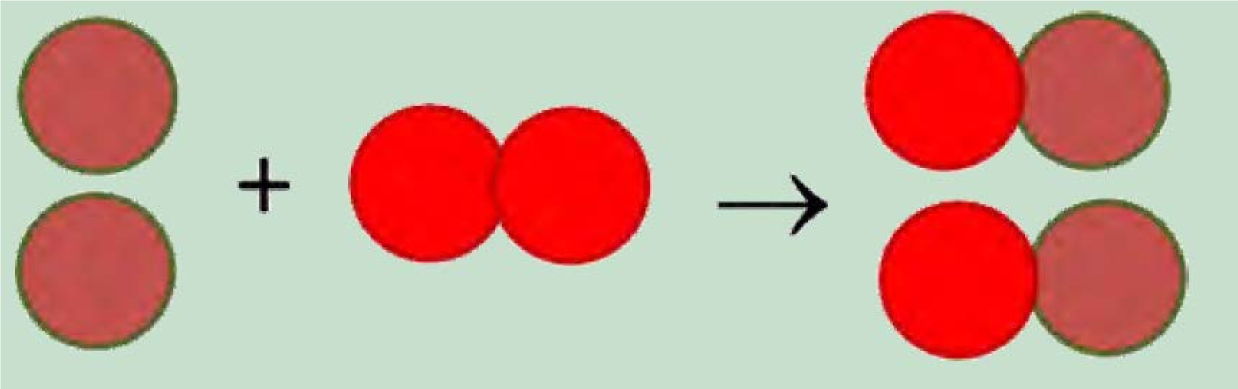
1. Learners should fill in the answers as follows:

2.

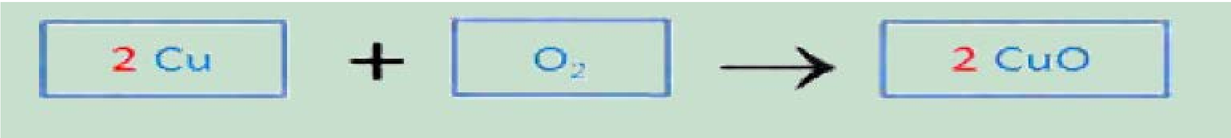
3. The learners' drawing should look similar to the following. Colours do not have to be the same as shown here, but they must show a difference between the different elements. If learners do not have different coloured pencils, they can also use different patterns to distinguish the different atoms.



4.



5.



Revision

1. This is because it will change the formula of the compound which then represents a different compound, and not the one involved in the reaction.
2. $C + O_2 = CO_2$
3. $2H_2 + O_2 = 2H_2O$
4. a) C and H_2O.

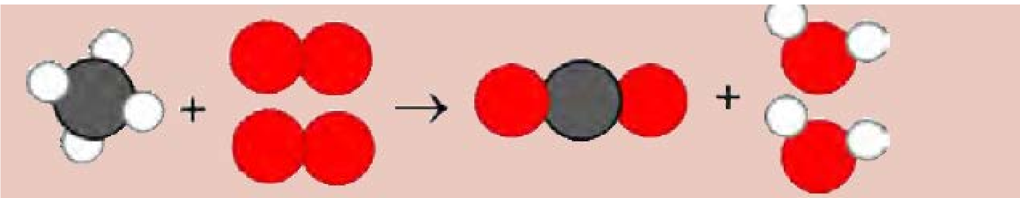
   Note: Learners do not need to know this equation; it is here just to practise balancing equations.

   b) carbon and water
   c) CO and H_2
   d) carbon monoxide and hydrogen
5. **Note:** Learners do not need to know this equation; it is here just to practise balancing equations.

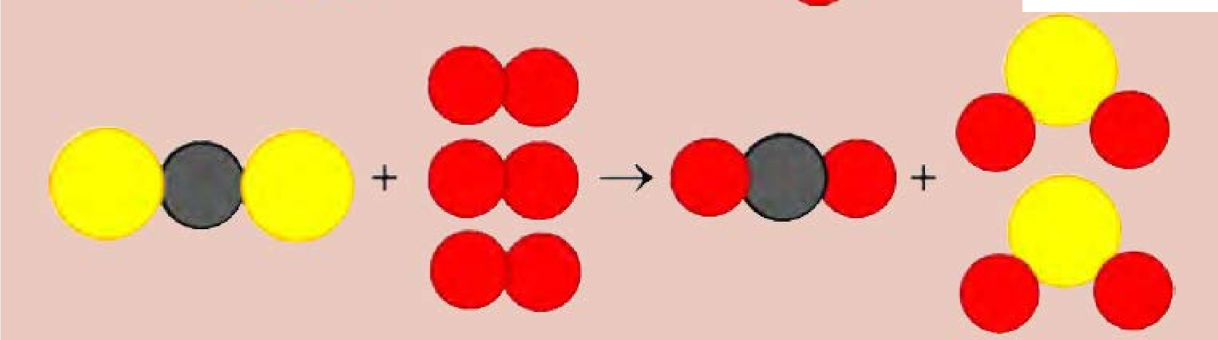
Number of atoms	In the reactants	In the product
Nitrogen (N)	2	2
Oxygen (O)	2	2
Bromine (Br)	2	2

6. a) carbon monoxide + oxygen = carbon dioxide
   b) magnesium + oxygen = magnesium oxide
7. a) $S + O_2 = SO_2$
   b) $CO + H_2O = CO_2 + H_2$
8. a) $2\ H_2O = 2\ H_2 + O_2$
   b) $2\ CO + O_2 = 2\ C\ O_2$
9. a) iron + oxygen = iron oxide
   b) It is a brown, rusty coating (rust).
   c) magnesium + oxygen = magnesium oxide
   d) It is a white powder.
10.

a)



b)



8 Reactions of metals with oxygen

Unit overview

1.5 weeks

In this unit learners will again encounter the reactions of selected metals with oxygen that were used as examples in the previous Unit. In this Unit, however, there will be a greater focus on the actual reactions – these should be demonstrated to the class – and the commonalities between them. Once again, the writing of chemical equations will be scaffolded by the process of starting with a word equation (macroscopic representation) and progressing through a picture equation (submicroscopic representation) to end at the chemical equation (symbolic representation).

The content has also been presented in a slightly different order to CAPS in that the example reactions are first explored, and then the general reaction of metals with oxygen is explained, once learners have already seen example chemical equations.

8.1 The reaction of iron with oxygen (1 hour)

Tasks	Skills	Recommendation
Activity: Three different levels of interpretation in science	Sorting and classifying, interpreting, identifying	Optional (Revision)
Activity: The reaction of iron with oxygen	Demonstration of steel wool burning, observing, recording, communicating, describing	CAPS suggested

8.2 The reaction with magnesium and oxygen (1 hour)

Tasks	Skills	Recommendation
Activity: The reaction of magnesium with oxygen	Demonstration of magnesium burning, observing, recording, communicating, describing	CAPS suggested

8.3 The general reaction of metals with oxygen (0.5 hours)

(Questions within the text)

8.4 The formation of rust (1.5 hour)

Tasks	Skills	Recommendation
Activity: The reaction between iron and oxygen in air	Demonstrating, observing, recording, describing,	Optional (suggested)
Activity: Why is rust a problem?	Identifying problems and issues	Optional (suggested)

8.5 Ways to prevent rust (0.5 hours)

(Questions within the text)

Key questions

- What happens when a metal reacts with oxygen?
- What is the product called?
- How can we represent the general reaction between a metal and oxygen?
- What is a combustion reaction?
- What is rust and how does it form?
- How can iron be made more rust-resistant?

In the previous Unit, we learnt how to write and balance equations. The three examples we learnt about were:

- magnesium + oxygen = magnesium oxide
- iron + oxygen = iron oxide
- copper + oxygen = copper oxide

Magnesium is group 2, iron is group 8 and copper is group 11. This is important as elements in the same group will react similarly.

The metals are located on the left of the Periodic Table.

The names of the products of the three reactions all have 'oxide' in their name. The products are: magnesium oxide, iron oxide, copper oxide.

8.1 The reaction of iron with oxygen

ACTIVITY: The reaction of iron with oxygen (LB page 129)

It is recommended that you demonstrate this reaction to the learners, because of the hazards involved when burning metals.

Safety precautions to observe during the demonstrations:

1. Wear safety goggles and a protective coat.
2. Exercise caution when burning the steel wool, as sparks may be produced.

Learners should be cautioned against standing too close during the demonstration.

3. Place a clean beaker or watch glass underneath to catch any metal oxide that forms during the reaction. Students can examine the reaction product afterwards to formulate their observations.

Questions

1. Steel wool is an alloy made mostly of iron.

   Note: The other elements in steel include carbon, manganese, phosphorus, sulphur, silicon, and traces of oxygen, nitrogen and aluminium. Learners do not need to know the names of the other elements in steel wool.

2. Learners' observations may include any of the following: The steel wool consists of thin threads of iron. It looks like hair made of metal. Depending on the state of the steel wool, learners may describe it as shiny, or dull grey, metallic, or even rusty. Encourage creative descriptions.
3. Oxygen gas can not be seen or directly observed and so it cannot be described.
4.
   - Learners may see the steel wool burning and bright orange sparks falling. They may even notice some smoke.
   - Learners may hear the crackling sound of the steel wool burning.
   - Learners may notice a metallic smell in the air.
   - Learners may experience the heat from the combustion reaction.
5. The product is a reddish-brown, crumbly solid.

8.2 The reaction of magnesium with oxygen

ACTIVITY: The reaction of magnesium with oxygen (LB page 130)

It is recommended that you demonstrate the reaction to the learners, because of the hazards involved with burning metals.

Instructions:
1. Wear safety goggles and a protective coat.
2. Caution learners not to look directly at the intense white flame produced by the burning magnesium.
3. Place a clean beaker or watch glass underneath to catch any metal oxide that forms during each reaction. Students can examine the reaction product afterwards to formulate their observations.
4. You may want to retain the product of the magnesium combustion reaction for a follow-up experiment in the Unit *Reactions of acids with metal oxides.*
5. You can also mix the product in water at this stage and test if it is an acid or base.

Questions
1. The magnesium is in the form of magnesium 'ribbon'.
2. Combustion reactions.
3. Learners' observations may include any of the following: The magnesium ribbon looks like a thin strip of metal. It looks like metal tape. Depending on the state of the ribbon, learners may describe it as shiny, or dark grey, black, metallic, or even tarnished. Encourage creative descriptions.
4. xygen gas can not be seen or directly observed and so it cannot be described.
5.
   - Learners may see the magnesium burning with a blinding white light. They may notice some smoke.
   - Learners may hear crackling or hissing as the magnesium burns.
   - Learners may notice a hot, metallic smell in the air.
   - Learners may experience the heat from the combustion reaction.
6. The product is a soft, white, powdery solid.

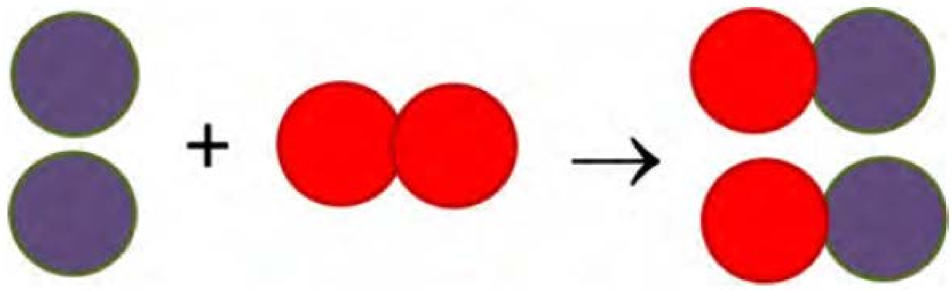
8.3 The general reaction of metals with oxygen

The word equation

The word equations are:
- iron + oxygen = iron oxide
- magnesium + oxygen = magnesium oxide

You can write these on the board.

The picture equation
The product for the following picture equation is magnesium oxide (MgO).



Remember that when we represent a chemical reaction as a particle diagram we are operating on the submicroscopic level.

The chemical equation
Remind learners that the numbers inside a chemical formula are called coefficients and subscripts, respectively.

The product of the following reaction is calcium oxide.

$2 Ca + O_2 = 2 CaO$

Point out to learners that both calcium and magnesium are from Group 2.

On page 131 of the learner's book is a suggested way to assist learners to write formulae. Once learners have learnt about valencies in Grade 10-12, they will be able to use this information to write the formulae of compounds. for now though, this is sufficient.

Learners use rule 1 to write two examples of metal oxides from group 1. Any two of the following are acceptable: Li_2O, Na_2O, K_2O, Rb_2O, Cs_2O

Learners use rule 2 to write two examples of metal oxides from group 2. Any two of the following are acceptable: BeO, MgO, CaO, SeO, BaO

Learners should write the following in line with the respective pictures on page xx of the Learner's Book:
l iron + oxygen = iron oxide
l $4 Fe + 3 O_2 = 2 Fe2O_3$

8.4 The formation of rust

ACTIVITY: The reaction between iron and oxygen in air (LB page 132)

Here is a suggested activity for you to show how rust forms. This is not required by CAPS. It can be set up as a demonstration. You can then compare this reaction with the one that you did previously where iron was burned in oxygen in a combustion reaction.

This experiment will require a place where it can remain undisturbed for two or three days. It may be worth setting up this experiment at the start of this section. Take note: The test tube may be difficult to clean at the end of this experiment.

1. They are a silvery colour.
2. Iron and oxygen (and water).

3. The water.
4. It is a browny, red colour.

Rust is a form of iron oxide

Remind learners of where else they have heard the term 'corrosive' used before in Matter and Materials. It is used to describe strong acids and bases which learners were first introduced to in Grade 7 Matter and Materials and will look at again later in this term.

ACTIVITY: Why is rust a problem? (LB page 40)

This links to what learners have done in previous grades about the properties of materials.

1. Iron is a metal, so it is hard, strong and flexible.
2. Tools, locks, hinges, screws and nails, garage doors... the list of items is almost endless!
3. No, they will not be as strong. Rust is a different compound to the element iron and so it has different properties. It starts to weaken the objects.

8.5 Ways to prevent rust

To prevent rust from forming, we would need to put something between the oxygen and iron so they cannot make contact.

Paint provides a barrier to rust/Other metals as barriers to rust

Ask learners why they think it is especially important for taps in bathrooms and basin to be protected from rust. This is because they are in a moist, humid environment and water makes iron more prone to rust.

Zinc is found in Group 12 of the Periodic Table.

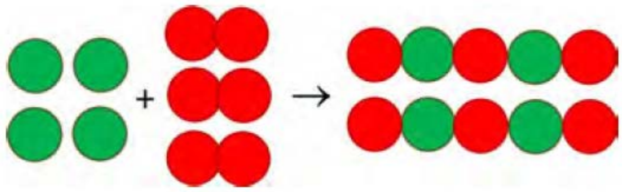
In the illustration on page xx of the Learner's Book, the steel that is exposed to the air by the scratch in the coating will rust over time.

If you would like to read more about why apples turn brown to explain this to your learners in more detail, visit this website: bit.ly/13unyg1

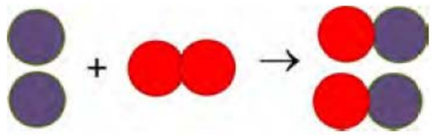
Revision

1. a) combustion
   b) oxygen
   c iron
   d) copper oxide
   e) rust
   f) galvanised
   g) corrosion
   h) corrosive
   i) metal oxide
2.
   l paint
   l chromium
   l zinc

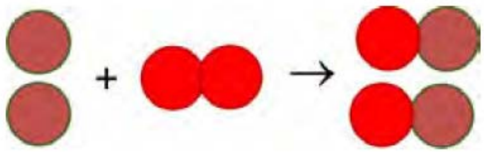
3.

Word equation	iron + oxygen = iron oxide
Chemical equation	$4\ Fe + 3\ O_2 = 2\ Fe_2O_3$
Picture equation	

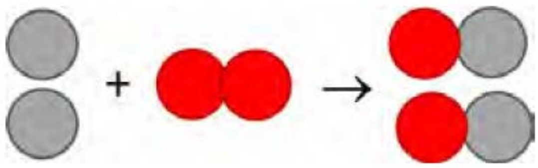
4.

Word equation	magnesium + oxygen = magnesium oxide
Chemical equation	$2\ Mg + O_2 = 2\ MgO$
Picture equation	

5.

Word equation	copper + oxygen = copper oxide
Chemical equation	$2\ Cu + O_2 = 2\ CuO$
Picture equation	

6.

Word equation	zinc + oxygen = zinc oxide
Chemical equation	$2\ Zn + O_2 = 2\ ZnO$
Picture equation	

9 Reactions of non-metals with oxygen

Unit overview

1 week

In this Unit learners encounter the reactions of the non-metals, carbon and sulfur [**Note:** The internationally accepted spelling is now 'sulfur', not 'sulphur',] with oxygen. Once again, the translation between word equation, picture equation and chemical equation is reinforced with exercises and examples.

There are no demonstrations prescribed by CAPS for this Unit, but we have included colourful photographs to provide learners with some experience of the splendour of these reactions. Since chemical reactions can seem quite abstract to learners and learning about them in isolation may seem to them as if it lacks relevance, we have also attempted to provide some real-world context to the examples in this Unit.

At the end of the Unit a few additional non-metals and their reactions with oxygen have been included as enrichment. You may choose to omit these, but they do highlight an important point, namely that not all non-metals form non-metal dioxides when they react with oxygen. Since both central examples of this Unit result in non-metal dioxides (viz. CO_2 and SO_2), one should be mindful of the possible introduction of a misconception in this regard.

9.1 The general reaction of non-metals with oxygen (0.5 hours)

9.2 The reaction of carbon with oxygen (1 hour)

Tasks	Skills	Recommendation
Activity: Coal burning in air	Drawing, balancing chemical equations	Optional (suggested)

9.3 The reaction of sulfur with oxygen (1 hour)

Tasks	Skills	Recommendation
Activity: The reaction between sulfur and oxygen	Analysing, balancing chemical equations, drawing, modeling	CAPS suggested

9.4 Other non-metal oxides (0.5 hours)

This is an optional, extension section.

Key questions

- What happens when a non-metal and oxygen react?
- What is the product called?
- How should we write equations for the reactions of carbon and sulfur with oxygen?
- Do all non-metals form dioxides with oxygen?

9.1 The general reaction of non-metals with oxygen

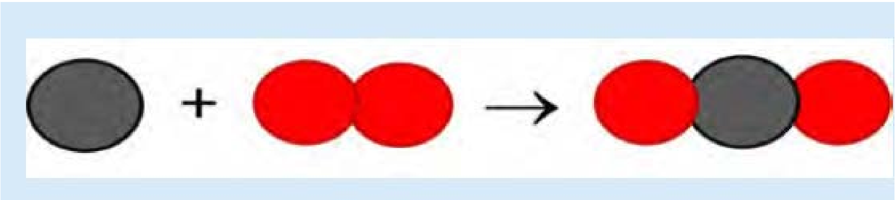
An important chemical difference between metal and non-metal oxides is that when metal oxides dissolve in water, they form basic solutions and when non-metal oxides dissolve in water, they form acidic solution.

9.2 The reaction of carbon with oxygen

Learners should have encountered the topics coal, fossil fuels, renewable and non-renewable energy sources and electricity generation in previous grades (specifically in Gr 6 and 7 Energy and Change) and they will also look at it again next term.

ACTIVITY: Coal burning in air (LB page 140)

In the picture equation here, the black atoms are carbon (C) and the red atoms are oxygen (O). If learners do not have coloured pens or pencils, they can use patterns and shading to differentiate between different atoms.



The chemical equation is $C + O_2$ *!* CO_2. This equation is already balanced.

Carbon is found in Group 14 on the Periodic Table.

Wind energy, solar energy, biofuels, nuclear energy (the latter is not strictly renewable). This content is not included in CAPS (as part of the Grade 9 Matter and Materials requirements). The question has been included in an attempt to create some relevance. The topic of chemical reactions is an abstract one and it often helps to provide some real-world applications to link it to other, less abstract including learners' own experience. This will also link to what learners will cover next term in Energy and Change.

9.3 The reaction of sulfur with oxygen

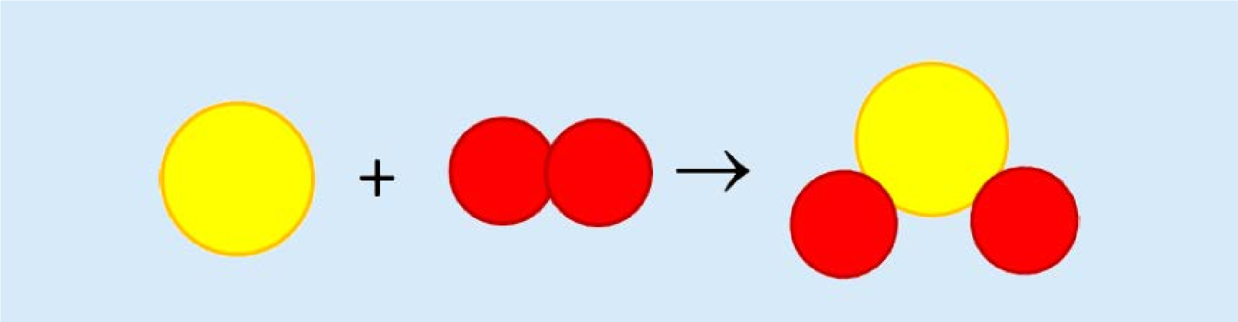
The non-metal is Sulfur (S). To write the formula, you may need to guide learners to realise there are 2 oxygen atoms in one molecule of sulfur *di*oxide: SO_2

The equation on page xx of the Learner's Book should read: sulfur + oxygen *!* sulfur dioxide

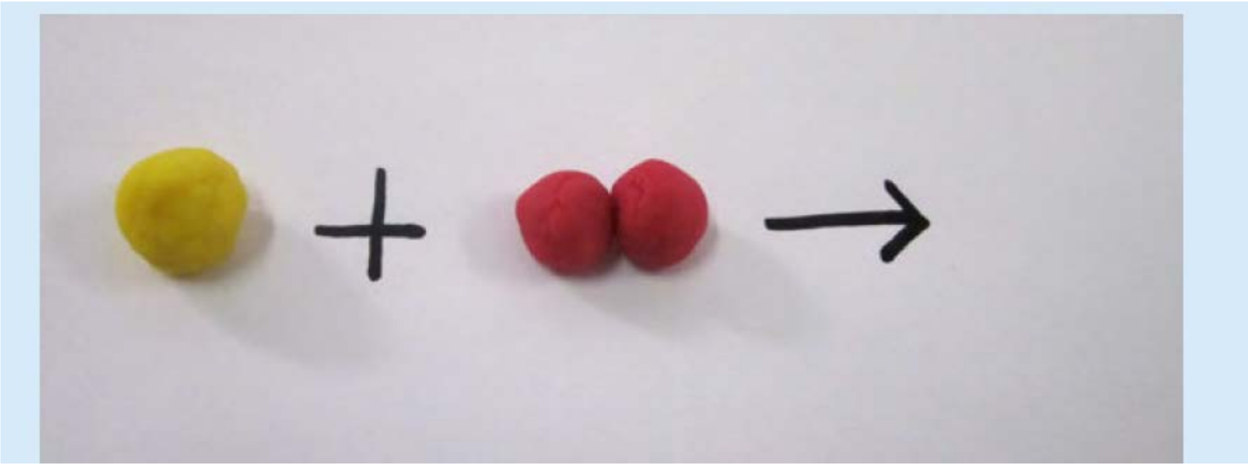
ACTIVITY: The reaction between sulfur and oxygen (LB page 141)

1. Group 16
2. Sulfur (S) and oxygen (O_2)
3. Sulfur dioxide (SO_2)
4. $S + O_2 = SO_2$
5. When both sides of the reaction have the same number of the same types of atoms.
6. The reaction is balanced because it has the same number of S and O atoms on either side of the equation.
7. The picture equation for the reaction is shown below. Colours are not important as long as all atoms of the same element have the same colour. In our example, the sulfur atoms are yellow and the oxygen atoms are red. Chemists have evidence that the actual shape of the SO_2 molecule is not linear; in other words, the atoms do not all lie in a straight line as they do in CO_2. Instead, the SO_2 molecule is believed to have a bent shape, as it appears in the picture equation.

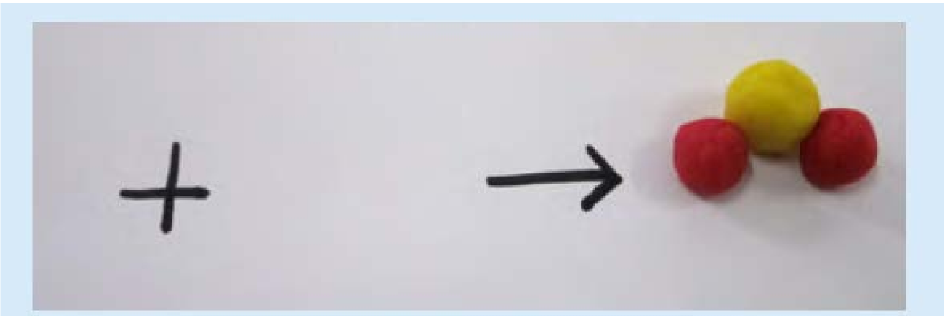
Since the explanation for this shape requires some understanding of bonding models, which are beyond the scope of this level of the curriculum, we recommend that you do not 'go there', but accept 'linear' drawings of the SO_2 molecule as correct.



9. Provide play dough or modelling clay for this part of the activity. You can also get learners to construct the equation by using sheets of white paper and drawing a '+' and '='.



Then they must rearrange the atoms to form the product as shown here:



You can also repeat this exercise with the other reactions covered so far.

Challenge question: This is an extension question.

1 bond was broken (between the oxygen atoms) and 2 bonds were formed (1 between each of the oxygen atoms and the sulfur atom).

9.4 Other non-metal oxides

Important note: This is not required by CAPS but is offered as enrichment.

Get learners to discuss this for a moment. You may want to ask if water (H_2O) is a non-metal oxide. Point out that hydrogen (H) is a non-metal and that water should be a non-metal oxide. Is it a dioxide? No, because it contains only one oxygen. This is important in highlighting how the non-metals in different groups react differently with oxygen.

Ask your learners this question to see what they can remember. Compounds that are *reactive* will readily react with many other substances.

There are 2 phosphorus and 5 oxygen atoms.

Diphosphorus pentoxide

phosphorus + oxygen = diphosphorus pentoxide

The reaction between hydrogen and oxygen

If you choose to demonstrate this in class, take note of the safety precautions.

This is a very explosive reaction, and everyone present should wear safety goggles.

The reaction is between hydrogen and oxygen: $2\ H_2 + O_2 = 2\ H_2O$.

You can also get learners to practice rearranging the atoms with this equation, making sure they have a balanced equation.

The common name is water and the systematic name is dihydrogen monoxide.

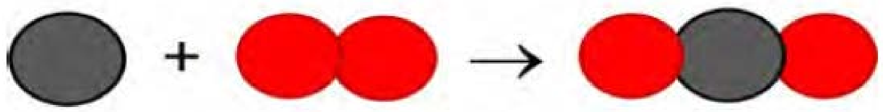
Revision

1. a) reactive
   b) unreactive or inert
   c) non-metal oxide
   d) oxidised
2. a) Learners' paragraphs should contain at least the following ideas:
   - The systematic name of a compound is the name that is recognized by IUPAC.
   - IUPAC refers to the International Union of Pure and Applied Chemistry.
   - The systematic name of any given compound should be unique so that the compound cannot be confused with any other compound.

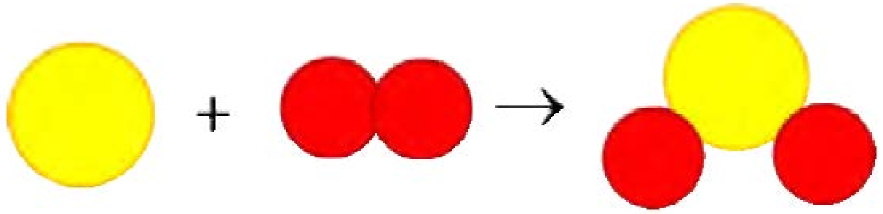
   b) Learners' paragraphs should contain at least the following ideas:
   - A preservative is a chemical compound that is added to a product (such as a foodstuff or a beverage) to make it last longer.
   - Most preservatives are poisonous to microorganisms, but are added in such small quantities that they are not harmful to humans.
   - SO_2 is used as a preservative in many foods, including dried fruit and wine.

   c) Learners' paragraphs should contain at least the following ideas:
   - Non-renewable energy sources refer to sources that can be used up, such as fossil fuels.
   - Coal, oil and natural gas are examples of non-renewable fuels.
   - The energy in these energy sources comes from the energy stored in plants and other living organisms that were fossilised over millions of years.

3. a) The reaction between carbon and oxygen:

Word equation	carbon + oxygen = carbon dioxide
Chemical equation	$C + O_2 = CO_2$
Picture equation	

b) The reaction between sulfur and oxygen:

Word equation	sulfur + oxygen = sulfur dioxide
Chemical equation	$S + O_2 = SO_2$
Picture equation	

10 Acids, bases and the pH value

Unit overview

1 week

In this unit, learners are introduced to the pH scale and learn how to measure and interpret pH values. There are two activities around pH measurement in this Unit: One is a paper activity and one is an investigation using indicators.

There is an introductory activity on measurement – this helps to link this content to what learners might be doing in other subjects, such as Mathematics and Technology, and also to what they already know about measurement.

The investigation uses universal indicator paper and red cabbage paper to measure the pH of a selection of household products. If you do not have universal indicator paper, but have universal indicator solution, you could easily adapt the activity in the following way: Instead of using paper, learners should add 2 – 3 drops of universal indicator solution to their test solutions, note and record the resulting colours. Red cabbage solution can also be used instead of paper. It would be best to add approximately 1 ml of each test solution to 2 ml portions of the red cabbage water.

To make red cabbage indicator paper, follow the instructions below:

1. Cut a large red cabbage into thin slices and place it in a pot.
2. Add just enough water to cover the cabbage slices.
3. Boil it over low heat for approximately 30 minutes, adding water to keep the cabbage covered if necessary.
4. Remove the pot from the heat and let it cool completely.
5. Strain the juice off the cabbage slices into a large shallow dish. The boiled cabbage slices can be eaten (or placed in the compost).
6. Place sheets of absorbent paper (kitchen towel, coffee filters or filter paper) in the cabbage water.
7. After 30 minutes, remove the paper and leave it in a warm place to dry. You can also dry the paper with a hair dryer, but do not leave it in direct sunlight.
8. When the paper has completely dried, cut it into strips (approximately 1 cm wide). The strips will keep for a long time if stored in a dry place. The time indicated for this Unit is 1 week and so a suggested 1.5 hours has been allocated to each section. However, as there are only two key tasks in this Unit, you might progress through it at a faster rate than 1 week, and then move onto the next Unit dealing with the reactions of acids with bases, which requires more time.

10.1 What is the pH value? (1.5 hours)

Tasks	**Skills**	**Recommendation**
Activity: Measuring instruments and units	Identifying, observing,	Optional (CAPS suggested)
Activity: The pH scale	Observing, identifying, remembering	Optional (CAPS suggested)

10.2 Indicators (1.5 hours)

Tasks	**Skills**	**Recommendation**
Investigation: Universal indicator paper and red cabbage indicator paper	Testing, observing, measuring, recording, analysing, interpreting	CAPS suggested

Key questions

- What measurement can we use to decide whether something is an acid or a base?
- What does 'the pH scale' refer to?
- How can we measure the pH of a substance?
- What does it mean if a substance has a pH below 7?
- What does it mean if a substance has a pH above 7?
- What does it mean when a substance has a pH equal to 7?
- How does a universal indicator respond to substances that are acidic, basic, or neutral?

10.1 What is the pH value?

A word or two on measurement

This section briefly creates the link between what learners might have done in other subjects and in previous grades about measurement and scales, especially Mathematics. It is used to show that many things can be measured and is used to introduce the idea of measuring how acidic or basic a substance is, as before this we only ever classified a substance as an acid or a base and did not make reference to a scale.

ACTIVITY: The pH scale (LB page 147)

1.

Name of substance	**Approximate pH**
Gastric acid	1
Lemon juice	2
Orange juice	3
Distilled water	7
Baking soda (solution)	9
Ammonia solution	11
Soapy water	12
Bleach	13

2. Learners should circle orange juice, lemon juice and gastric acid in red.
3. Lowest value: 1 (gastric acid); Highest value: 3 (orange juice)
4. Below 7
5. Learners should circle bicarbonate of soda, soapy water, bleach and ammonia solution in blue.
6. Lowest value: 9 (baking soda); Highest value: 13 (bleach)
7. Above 7
8. Water is neither an acid nor a base. Water is a neutral substance.
9. Water has a pH equal to 7.
10. Lemon juice is more acidic.
11. Lemon juice has a lower pH.

10.2 Indicators

What is an acid-base-indicator?

The red cabbage indicator will be blue, green or yellow when it is mixed with a base.

INVESTIGATION: Universal indicator paper and red cabbage indicator paper **(LB page 151)**

Learners can formulate their own question, but it should be something along the following lines: Can universal indicator paper and red cabbage indicator paper show us whether one substance is more acidic or basic than another?

Learners should make their own prediction/hypothesis.

Identify variables

1. We will change the substances that we are testing. The independent variable is the one that is changed.
2. We will measure the pH. This is the dependent variable.
3. The controlled variable is the type of indicator that we are using in the measurement, namely the universal indicator paper or the red cabbage paper.

Questions

1. Learners should list all the substances that gave pH measurements below 7.
2. Learners should list all the substances that gave pH measurements above 7.
3. Learners should list all the substances that gave pH measurements equal to 7.
4. Activity-dependent answer.
5. Activity-dependent answer.
6. Activity-dependent answer.
7. The red cabbage paper should turn a red-pink colour in an acid.
8. The red cabbage paper should turn a blue-green colour in a base.
9. The red cabbage paper should turn (or remain) purple with neutral substances.
10. Learner-dependent answer. Allow learners to express an opinion here, backed by one or two sentences as motivation.

Conclusions

1. Learner-dependent answer. They should note that universal indicator allows them to measure the pH of individual substances. By arranging the substances in order of increasing pH, they can rank the substances from most acidic to most basic. They should note that red cabbage indicator does give a range of colours with varying pH, but that it is not as effective as universal indicator for measuring pH.

Extension question

Learners could discuss this question in class if there is time. The important thing here is that each of the colours of the red cabbage indicator needs to be standardised/linked to a specific pH value or range of values. Hence, if we had a range of samples of known pH, we could 'calibrate' the red cabbage solution, by mixing it with each of the pH standards and carefully noting the colour. This would allow us to produce a colour chart, that we could then use in the same way as the one that is available for universal indicator and other commercial indicators.

How else can we measure pH?

In the illustrations on page xx of the Learner's Book, the solution on the left has a pH of 7.053 so it is neutral. The solution on the right has a pH of 10.33 so it is basic.

pH meters work as follows: When the sensor is dipped into the test solution, it sends a signal to the electronic circuitry of the pH meter, which is converted to a pH reading on a small LCD screen.

Revision

1. a) indicator or acid-base indicator
   b) 0; 14
   c) Acids
   d) 7 and 14
   e) Neutral
2. a) The pH will be equal to 7.
   b) The pH will decrease.
   c) We would have to add a base.
   d) We would have to add a large amount of a strong base.
3. a) Solution A is most acidic. Red cabbage water turns red in acidic solutions.
   b) Solution C is most basic. When red cabbage water turns green we know we have a basic solution.
   c) Solution B is neutral, because the colour of the red cabbage water is purple in the solution. This is the colour red cabbage water will have in neutral solutions.
   d) The red colour of the solution would change. When we add a base to an acid, the acid loses some of its power. The acid makes the base lose some of its potency too. The mixture will be less acidic than solution A and less basic than solution C. If we added enough base for the mixture of the two solutions to be neutral, the solution will turn purple.
4. a) A, F and D
   b) B and E
   c) C
   d)

Solution	**Colour of the solution**	**Approximate pH range of the solution**
D	Red	1–3
F	Orange	4–5
A	Yellow	5–6
C	Green	7
B	Blue	8–10
E	Purple	11–14

11 Reactions of acids with bases

Unit overview

2 weeks

The central challenge of this Unit is to establish that acid-base reactions are *exchange* reactions. A fragment of the acid is exchanged with a fragment of the base and a salt and water are the resulting products of the reaction. The type of salt that forms depends on the identities of the acid and the base that were combined during the reaction.

Once learners understand this, they have taken an important step to understanding acid-base chemistry. We will spend some time developing a frame for explaining this at the start of the Unit, to which we will return frequently.

In light of the fact that learners have yet to learn about cations and anions, we have considered it pedagogically justifiable to make the following simplifications to currently accepted acid-base theory, in order to bring the concept of *exchange* across to the learners:

- Acids can be thought of as contributing H (instead of H+); and
- Bases can be thought of as contributing O or OH (instead of O_2 and OH^-).
- Water (H_2O) is a combination of 2 H and 1 O, or alternatively 1 H and 1 OH.

We are well aware that writing H + OH = H_2O has no meaning in science and for this reason we have avoided this usage in the text. But we do consider the use of simplified symbols (H instead of H+ and so forth) to have an advantage over their scientifically correct (but potentially confusing) counterparts in this context.

There is also a danger that misconceptions and sloppy usage of symbols may result further down the line, when simplifying in this way. However, we feel these risks are counterbalanced by the greater likelihood of learners *understanding the concept of exchange* if the symbols they work with are not cluttered with additional information – like the charges on the ions – that have no meaning for them yet.

Other skills that will be reinforced in this Unit are:

- writing chemical formulae;
- converting between word equations and chemical equations; and
- balancing chemical equations.

A word of caution: Acid-base reactions are *neutralisation* reactions. However, this does not mean that the mixture of an acid with a base will be a neutral solution and you should avoid language that reinforces this notion. Even if equivalent quantities (stoichiometric quantities) of the acid and base are mixed – which would imply that both have been *neutralised* – the resulting solution will only be neutral (i.e. pH = 7) under very special circumstances. The reason is that not all salts are 'neutral substances'; in fact most salts have acid-base properties of their own. The chemistry required for learners to understand this is beyond them at this stage and will only be dealt with in Physical Sciences in Grade 12.

Our suggestion is that you simply refrain from calling salts 'neutral substances'. If questions arise around the issue you could point out that the salts they will encounter in this Unit may be neutral substances, but that this is not true of all salts.

Take note that although there is no section specifically named 'Applications' as indicated in CAPS, this content has rather been dealt with under other sections where it is more appropriate.

11.1 Neutralisation and pH (1.5 hours)

Tasks	Skills	Recommendation
Investigation: The reaction between vinegar and baking soda	Hypothesising, measuring, preparing, observing, comparing, recording, plotting graphs	CAPS suggested
Activity: CO_2 bubbled through water	Observing, measuring, comparing	Optional
Activity: What is acid rain?	Observing, reading, researching, interpreting, analysing, summarizing	CAPS suggested

11.2 The general reaction of an acid with a metal oxide (1.5 hours)

Tasks	Skills	Recommendation
Investigation: The reaction between magnesium oxide and hydrochloric acid	Hypothesising, preparing, observing, measuring, recording, plotting graphs	CAPS suggested
Activity: Writing the chemical equation	Writing and balancing chemical equations	Optional (suggested)

11.3 The general reaction of an acid with a metal hydroxide (1.5 hours)

Tasks	Skills	Recommendation
Investigation: The reaction between sodium hydroxide and hydrochloric acid	Hypothesising, preparing, measuring, observing, measuring, recording, plotting graphs	CAPS suggested
Activity: Writing the chemical equation	Writing and balancing chemical equations	Optional (suggested

11.4 The general reaction of an acid with a metal carbonate (1.5 hours)

Tasks	Skills	Recommendation
Investigation: The reaction between calcium carbonate (chalk) and hydrochloric acid	Hypothesising, preparing, comparing, measuring, recording, plotting graphs	CAPS suggested
Activity: Writing the chemical equation	Writing and balancing chemical equations	Optional (suggested)

Key questions

- What is the reaction between an acid and a base called?
- What happens to the pH when an acid and a base are mixed?
- Does the reaction between an acid and a base always give a neutral mixture, in other words a mixture with pH = 7?
- Which factors will determine the pH of the final solution when an acid and a base are mixed?
- Is there a way to predict which classes of compounds will tend to be acids and which will tend to be bases?
- Are metal oxides, metal hydroxides and metal carbonates acidic or basic? Which pH range will their solutions fall into?
- What products can we expect when a metal oxide, a metal hydroxide or a metal carbonate react with an acid?

- Are there general equations to explain these reactions?
- How does acid rain form?

11.1 Neutralisation and pH

For some of the investigations in this Unit, you will be using droppers or syringes to measure out quantities. Tell learners that they may not use droppers or syringes to squirt water at other learners! There are many reasons why this is not a good idea. The most important reason is that the dropper or syringe **may contain acid**, that could end up in someone's eye where it could cause permanent damage or even blindness. So, squirting each other with the droppers or syringes **is not allowed**.

Get learners to discuss this in class or in small groups. Allow them to speculate and guide them to recall their Grade 7 learning: An acid will lose its potency when it is mixed with a base and vice versa. So the acid will be weakened by the base and the base will be weakened by the acid. 'Weaken', however, is a term best avoided, because 'weak' and 'strong' have very specific meanings when speaking about acids and bases. In a sense their acid-base properties will be destroyed, because they will be converted to products that won't be acids or bases. (Often the salt that results from the reaction between an acid and a base will have acid-base properties of its own, but we will not be discussing that now.)

A drop of vinegar of your tongue would taste sour, therefore it is an acid.

Baking soda is a base.

INVESTIGATION: The reaction between vinegar and bicarbonate of soda **(LB page 159)**

Quantities for this investigation are as follows: Every 1 g of bicarbonate of soda will require approximately 15 ml of vinegar for complete neutralisation. We recommend that you measure out 1 teaspoon of bicarbonate of soda and approximately 50 ml vinegar for each group.

Investigative question

1. A possible answer is: What will happen to the pH of the solution if we add vinegar to bicarbonate of soda?

Overview of the investigation

1. In the range pH > 7
2. The pH will decrease.

Hypothesis

1. When we add vinegar to baking soda, the pH of the mixture will decrease.

Results

Learners must draw a graph with the 'number of teaspoons of vinegar added' on the x-axis (independent variable) and the pH of the solution on the y-axis (dependent variable).

Non-metal oxides form acidic solutions

Some non-metal oxides include CO_2 and SO_2.

ACTIVITY: CO_2 bubbled through water (LB page 163)

A variation of this activity is if you have liquid universal indicator, you can add it to the tap water at the start to show the pH is 7 (it should be green). Then as you blow into the water, the universal indicator will change colour. Make sure you use a clear glass so learners can observe the colour change as it becomes more yellow. This links to the next activity on acid rain and how it forms.

Instructions
1. We could measure the pH of the water with universal indicator paper.
2. The pH will be below 7.

ACTIVITY: What is acid rain? (LB page 164)

1. They are sulfur dioxide (SO_2), carbon dioxide (CO_2) and nitrogen dioxide (NO_2).
2. The main sources of these gases which contribute to acid rain are from human activity, such as electricity generation in fossil fuel power plants (especially coal), factories emitting smoke and the exhaust fumes from motor vehicles. Acid rain can also occur due to natural phenomena, such as volcanoes which emit sulfur dioxide into the atmosphere. Some processes in the ocean and in wetlands also produce the gases which form acids.
3. $SO_2 + H_2O = H_2SO_3$
   $CO_2 + H_2O = H_2CO_3$
4. Sulphurous acid and carbonic acid.
5. The impacts include:
   - damage of plant life, both wilderness areas and also crops, depending on where the rain falls
   - the rain leaches into soil and makes it more acidic; this kills microorganisms living in the soil, and damages plants further by contaminating soil water
   - the rain can fall into various water sources and also run off into water sources such as rivers, lakes and dams; this causes the water to become more acidic; aquatic animals and plants can die; human water sources become too acidic as well
6. Acids are corrosive and so they can corrode surfaces over time.
7. Learners need to justify their answers. They may say that it helps the local environment as the gases are carried further away and therefore do not pollute the town or city that the factory is in or near. But this does not do anything to minimize the acid rain that could potentially form as the same amount of gases are still emitted; they are just carried further away. The acid rain therefore can still form and fall on the vegetation and areas outside of the towns and cities.
8. There are several solutions to minimising the formation of acid rain. For example, coal-powered stations can use filters and other processes in their smoke towers to remove sulfur gases before the smoke is released into the atmosphere. Countries can take bigger steps by signing treaties to reduce their sulfur and other greenhouse gas emissions. The move towards using renewable energy sources will also help to reduce the reliance on coal and other fossil fuels, thereby reducing the emission of acid-producing gases into the atmosphere.

Metal oxides, metal hydroxides and metal carbonates form basic solutions
Examples of metal oxides from group 1 include any of the following: Li_2O, Na_2O, K_2O, Rb_2O, Cs_2O.

Examples of metal oxides from group 2 include any of the following: BeO, MgO, CaO, SeO, BaO

The pH of a solution of a metal oxide in water will be above 7.

Examples of metal hydroxides from group 1 include any of the following: LiOH, NaOH, KOH, RbOH, CsOH.

Examples of metal hydroxides from group 2 include any of the following: $Be(OH)^2$, $Mg(OH)^2$, $Ca(OH)^2$, $Sr(OH)^2$, $Ba(OH)^2$.

The pH of a solution of a metal hydroxide will be above 7.

Examples of metal carbonates from group 1 include any of the following: Li_2CO_3, Na_2CO_3, K_2CO_3, Rb_2CO_3, Cs_2CO_3.

Examples of metal carbonates from group 2 include any of the following: $BeCO_3$, $MgCO_3$, $CaCO_3$, $SrCO_3$, BaCO3.

The pH of a solution of a metal carbonate will be above 7.

11.2 The general reaction of an acid with a metal oxide

INVESTIGATION: The reaction between magnesium oxide and hydrochloric acid **(LB page 165)**

This investigation requires magnesium oxide from the reaction when magnesium ribbon burns in oxygen. If you have set some aside from the earlier activity '*The reaction of magnesium with oxygen*' (Unit 3), learners can use it for this investigation. If you did not, you can easily repeat that demonstration to produce more white magnesium oxide powder for this next investigation. This investigation is also suitable to scale up as a demonstration.

Investigative question

1. When magnesium oxide is dissolved in water, will the resulting solution be acidic, basic or neutral?
2. When a solution of magnesium oxide is treated with hydrochloric acid, will the pH of the mixture increase, decrease, or stay the same?

Overview of the investigation

1. In the range pH > 7
2. The pH will decrease

Hypothesis

1. When magnesium oxide is dissolved in water, the resulting solution will be basic (have a pH > 7).
2. When a solution of magnesium oxide is treated with hydrochloric acid, the pH of the mixture will decrease.

Notes for the investigation

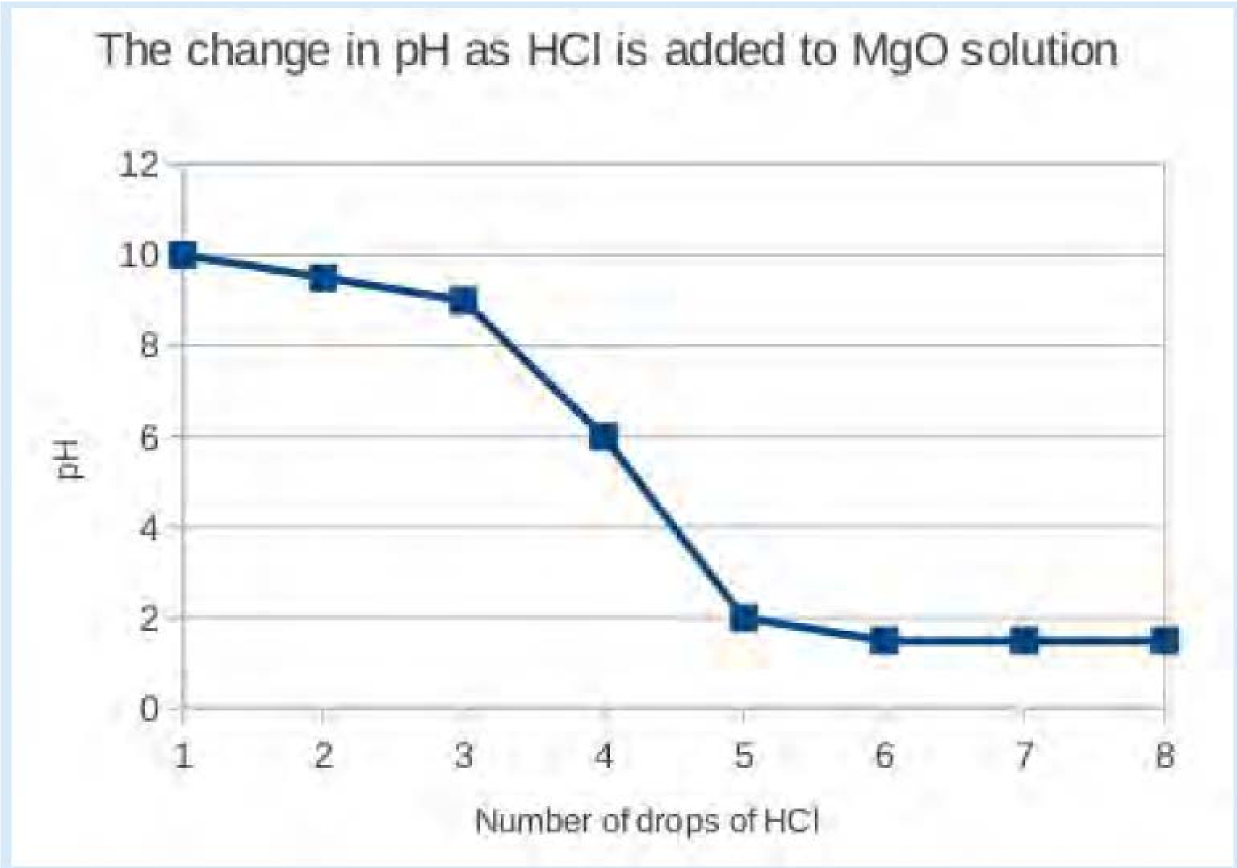
- **Learners must not dilute hydrochloric acid themselves** as it reacts strongly with water. Make sure to add the acid slowly to the water and **NOT** the other way around.
- To prepare 0.1 M HCl solution, carefully add approximately 10 ml concentrated hydrochloric acid (33% or 11 M) to 1 liter of tap water. It is recommended that you wear safety goggles and protective gloves during this step and that you rinse away any acid spills with cold tap water. Since this is just a qualitative experiment, it is not necessary to use distilled water for the solution. It is also not required that you measure the volumes with extreme accuracy.
- The following guide will help you to determine quantities: The magnesium oxide prepared from a 1 cm length of magnesium ribbon will require approximately 8 ml of 0.1 M hydrochloric acid for complete neutralisation. If the learners work in small groups and each group dissolves a small quantity of MgO (the size of a match head) in 2 ml of water, they will only need a few drops of HCl solution to neutralise all the MgO.
- If you have universal indicator **solution**, this will work very nicely as you can observe the colour changes as you add the drops.

- If you decide to give the learners droppers to measure out the HCl, you will have to enforce very strict rules for handling the droppers. Learners find the temptation to squirt water at each other very difficult to resist and they must be made aware of the **hazards of accidentally squirting acid** at another learner.
- Remind learners to use the colour guide for universal indicator provided at the start of the Unit. If you have the budget, a good idea would be to make a number of colour photocopies of the chart and to have them laminated so they will last longer.
- Remind learners to prepare a table for their results beforehand.

Results

1. Learner-dependent answer
2. a) Number of drops of HCl
   b) pH

The number of drops of HCl should be on the x-axis of the graph and pH should be on the y-axis. There should be a general trend downwards (since acid is added to a base, we can expect the pH to drop), but it should not be linear. This experiment is a very rudimentary 'titration', and an example of a titration curve from this experiment is given here:



It is therefore not expected that learners' curves will be linear, but rather that there will be a gradual decline in pH at first, followed by a rapid drop when all the base has been neutralised. After this the curve levels out again.

ACTIVITY: Writing the chemical equation (LB page 168)

1. HCl
2. Magnesium oxide (MgO)
3. Learners try to predict the products of the reaction. We know that water will be one of the products.
4. Mg
5. 2 Cl (we used 2 HCl)
6. $MgCl_2$
7. a) 2 H atoms left and 2 H atoms right. The Hs are balanced.
   b) 2 Cl atoms left and 2 Cl atoms right. The Cls are balanced.
   c) 1 O atoms left and 1 O atoms right. The Os are balanced.

11.3 The general reaction of an acid with a metal hydroxide

INVESTIGATION: The reaction between sodium hydroxide and hydrochloric acid **(LB page 169)**

Notes for the investigation:

- The same cautions regarding droppers and syringes apply to this activity.
  You will need to enforce very strict rules for handling these items or learners may find the temptation to squirt water at each other very difficult to resist.
- Remember to provide learners with a colour guide for universal indicator, if you have this.
- Remind learners to draw a results table before they start the experiment.

Investigative question

1. Here are some ideas:
   - When sodium hydroxide is dissolved in water, will the resulting solution be acidic, basic or neutral?
   - When a solution of sodium hydroxide is treated with hydrochloric acid, will the pH of the mixture increase, decrease or stay the same?
   - Will it be possible to neutralise all the sodium hydroxide by adding hydrochloric acid?

Overview of the investigation

1. In the range $pH > 7$
2. The pH will decrease

Hypothesis

Some ideas:

- Sodium hydroxide solution will have a pH greater than 7.
- When a solution of sodium hydroxide is treated with hydrochloric acid, the pH of the mixture will decrease.
- By adding hydrochloric acid to the sodium hydroxide solution, it should be able to decrease the pH to 7 and even below 7.

Prepare 0.1 M NaOH solution by dissolving approximately 4 g of NaOH pellets in 1 litre of cold tap water. Wear safety goggles and gloves since there is a chance the sodium hydroxide solution could splash upwards.

Method

1.–8. Instructions for preparation are given with the previous investigation: *The reaction between magnesium oxide and hydrochloric acid*

9. Learner dependent answer. Should be around 2 ml.
10. NaCl forms in this reaction and the idea is for learners to let it dry out in the window sill and examine it later. It is probably not a good idea to let them taste it, as there is a possibility that not all of the acid or base has been neutralised.

Results

1. Learner-dependent answer
2. a) Volume of HCl
   b) pH

The volume of HCl added should be on the x-axis of the graph and pH should be on the y-axis. There should be a general trend downwards (since acid is added to a base, we can expect the pH to drop), but it should not be linear. See comments and graph provided with the previous investigation.

11.4 The general reaction of an acid with a metal carbonate

INVESTIGATION: The reaction between calcium carbonate (chalk) and hydrochloric acid **(LB page 172)**

Grind up a few pieces of white chalk for this experiment. The calcium carbonate will not actually dissolve well in water, but it should be possible to determine that the solution is basic, from the tiny amount of calcium carbonate that will dissolve when the chalk dust is suspended in water. Learners will need their colour charts and results tables before they start.

Investigative questions

1. Some ideas:
   - When calcium carbonate is dissolved in water, will the resulting solution be acidic, basic or neutral?
   - When a solution of calcium carbonate is treated with hydrochloric acid, will the pH of the mixture increase, decrease or stay the same?
   - Will it be possible to neutralise all the calcium carbonate by adding hydrochloric acid? (Be careful not to introduce misconceptions here)
   - What other products will form when calcium carbonate reacts with hydrochloric acid?

Overview of the investigation

1. In the range pH > 7
2. The pH will decrease

Hypothesis

Some ideas:

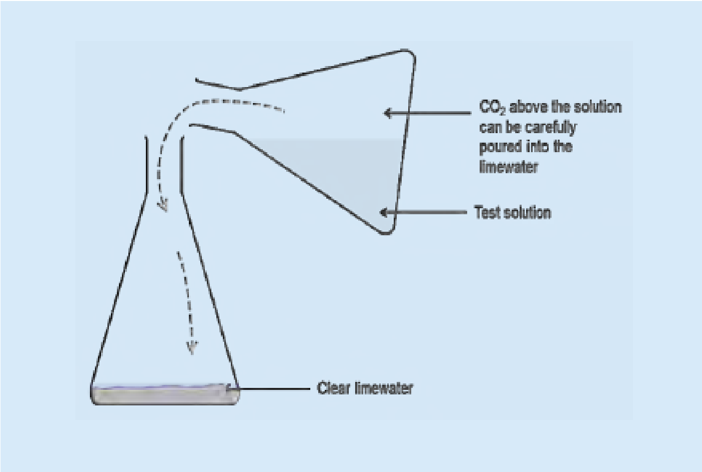
- Calcium carbonate solution will have a pH greater than 7
- When calcium carbonate is treated with hydrochloric acid, the pH of the mixture will decrease
- By adding hydrochloric acid to the calcium carbonate, it should be able to decrease the pH to 7 and even below 7

Method

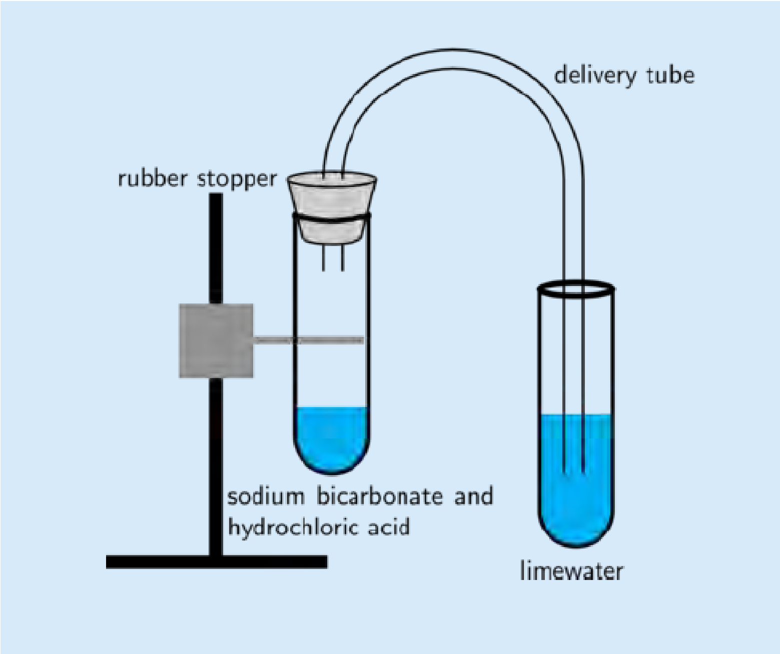
Carbon dioxide, CO_2

Perform the experiment in a conical flask, as follows:

l $_2$ into another conical flask containing lime water (see diagram below). The CO_2 gas should be poured out. Shake the conical flask containing the lime water and CO_2 to facilitate mixing. Allow the learners to make their observations.$_2$ is denser than air and will remain in the conical flask for a few minutes before diffusing into the air. It is during this time that you should pour it over into the lime water. Be careful not to let any of the test solution flow over into the clear lime water. Only the CO:



Alternatively, you could use a setup like the one shown in the diagram below:



These experiments can also be done using combo plates.

Results

1. Learner-dependent answer.
2. a) Volume of HCl
   b) pH

ACTIVITY: Writing the chemical equation (LB page 174)

1. HCl
2. Calcium carbonate ($CaCO_3$)
3. Learners try to predict the products of the reaction. We know that water and carbon dioxide will be two of the products.
4. Ca
5. 2 HCl are needed, so 2 Cl will remain.
6. $CaCl_2$
7. $2\ HCl + CaCO_3 = CaCl_2 + H_2O + CO_2$
8. a) 2 H left and 2 H right. The Hs are balanced.
   b 2 Cl left and 2 Cl right. The Cls are balanced.
   c) O left and 3 O right. The Os are balanced.
   d) 1 C left and 1 C right. The Cs are balanced.

Applications for calcium carbonate

$CaCO_3$ forms a basic solution in water so it is used if the pH is too low (too acidic) and you want to make the pool water more basic.

Revision

1. a) pH
   b) sulfuric acid
   c) HCl
   d) acid
   e) water
   f) carbon dioxide
   g) basic; greater
   h) neutralisation
   i) acidic
2. a) Learner's paragraph should contain at least the following ideas:
   - When an acid and a base are mixed, the acid will lose some of its 'acidity' and the base will lose some of its 'basicity'.
   - If they are mixed in the right amounts, they will **neutralise** each other.
   - The products of the reaction will be a salt and water.

   b) Learner's paragraph should contain at least the following ideas:
   - Certain industries (and even some natural phenomena like volcanic eruptions) produce non-metal oxides as waste products.
   - Non-metal oxides form acidic solutions when they dissolve in atmospheric water droplets.
   - These acidic solutions rain down onto the Earth's surface and can cause damage to buildings, plant life and acidify water source
3. a) Word equation: hydrochloric acid + magnesium oxide = magnesium chloride + water
   Chemical equation: $2\ HCl + MgO = MgCl_2 + H_2O$
   General equation: acid + metal oxide = salt + water

   b) Word equation: hydrochloric acid + sodium hydroxide = sodium chloride + water
   Chemical equation: $HCl + NaOH = NaCl + H_2O$
   General equation: acid + metal hydroxide = salt + water

   c) Word equation: hydrochloric acid + calcium carbonate = calcium chloride + water + carbon dioxide
   Chemical equation: $2\ HCl + CaCO_3 = CaCl_2 + H_2O + CO_2$
   General equation: acid + metal carbonate = salt + water + carbon dioxide

   d) Word equation: hydrochloric acid + magnesium hydroxide = magnesium chloride + water
   Chemical equation: $2\ HCl + Mg(OH)^2 = MgCl_2 + 2\ H_2O$
   General equation: acid + metal hydroxide = salt + water

   e) Word equation: hydrochloric acid + calcium oxide = calcium chloride + water
   Chemical equation: $2\ HCl + CaO = CaCl_2 + H_2O$
   General equation: acid + metal oxide = salt + water

   f) Word equation: hydrochloric acid + potassium hydroxide = potassium chloride + water
   Chemical equation: $HCl + KOH = KCl + H_2O$
   General equation: acid + metal hydroxide = salt + water

   g) Word equation: hydrochloric acid + sodium carbonate = sodium chloride + water + carbon dioxide
   Chemical equation: $2\ HCl + Na_2CO_3 = 2\ NaCl + H_2O + CO_2$
   General equation: acid + metal carbonate = salt + water + carbon dioxide

12 Reactions of acids with metals

Unit overview

0.5 week

This is a short Unit to conclude the series of reactions that learners will have been exposed to this term. The last reactions to look at are those between an acid and a metal. At the end of this Unit, there is a short activity on some of the careers in the chemical industry. Although this is not for assessment purposes, if you do not have time to do it in class, we encourage you to encourage or get your learners to do it as a homework activity. Seeing the real world application for what they learn in the classroom is a very important part of the learning process and in discovering what is possible through science and technology.

12.1 The reaction of an acid with a metal (1.5 hours)

Tasks	Skills	Recommendation
Activity: Testing for hydrogen gas	Remembering, balancing chemical equations	Optional
Investigation: The reaction between magnesium and hydrochloric acid	Hypothesising, preparing, measuring, observing, interpreting	CAPS suggested
Activity: Writing the chemical equation	Writing and balancing chemical equations	Optional (suggested)
Activity: Other careers in chemistry	Researching, comparing, describing	Optional

Key questions

- What do we get when a metal reacts with an acid?
- What is the general equation for the reaction between a metal and an acid?
- How do we write the word equation and the balanced chemical equation?
- How can we test for the presence of hydrogen gas?

12.1 The reaction of an acid with a metal

ACTIVITY: Testing for hydrogen gas (LB page 180)

This activity introduces the test for hydrogen gas. It is **optional**. However, the test will be used in the following investigation so if you do not do this activity in class, a suggestion is for learners to do it in their own time, or to just explain the hydrogen test briefly before proceeding to the investigation.

1. H_2
2. That means each molecule of hydrogen gas consists of two H atoms.
3. Hydrogen can be found in the top left-hand corner of the periodic table.
4. Density is the mass of a substance in a given space (volume).
5. $2H_2 + O_2 = 2H_2O$

INVESTIGATION: The reaction between magnesium and hydrochloric acid **(LB page 181)**

It is recommended that you demonstrate this reaction to learners. There are many ways to perform this demonstration and if you have a tried and trusted method, you should use it by all means. For example, a simple method is to place diluted HCl in a test tube, add a piece of magnesium and then bring a glowing splint to the neck of the test tube so that it goes 'pop' in the presence of the hydrogen gas that is produced. The method we have included here does not require anything too complicated and it has the added fun aspect of blowing hydrogen bubbles and popping them with a candle flame.

Investigative question

One possible question would be: What products will form when magnesium reacts with hydrochloric acid?

Hypothesis

Some ideas:

- When magnesium reacts with hydrochloric acid, a gas is released.
- When magnesium reacts with hydrochloric acid, hydrogen gas is released.

Materials

To prepare dilute hydrochloric acid solution, slowly and carefully add approximately 100 ml concentrated hydrochloric acid (33% or 11 M) to 900 ml of cold tap water. It is recommended that you wear safety goggles and protective gloves during this step and that you rinse away any acid spills with cold tap water. Since this is just a qualitative experiment, it is not necessary to use distilled water for the solution. It is also not required that you measure the volumes with extreme accuracy. Be careful when handling this solution; even though it is dilute it can still cause burns.

The quantities for this experiment are as follows: 1 g of magnesium will require approximately 42 ml of 1 M hydrochloric acid to be consumed. Just more than 900 ml of hydrogen gas will be produced by these quantities of reactants.

Method

1. The pH of the 1 M HCl solution will be below 1. Since this solution is still very corrosive, it is recommended that you choose one responsible learner to perform the pH measurement on behalf of the class.
2. A possible extension is to hold a cold piece of metal or glass above the place where you burst the bubbles so that the water vapour that forms during the reaction condenses on the metal or glass.

Results and observations

Learners should note that there is a 'pop' sound when the candle bursts the bubbles. They should note that when HCl is added to the magnesium pieces, the solution bubbles as the gas is produced.

Questions

1. Bubbles formed on the surface of the magnesium pieces.
2. Bubbles came out of the end of the gas delivery tube.
3. The gas in the soap bubbles is less dense than air. **Note:** Learners may say 'lighter' than air; you can use the opportunity to remind them that less dense substances will float on substances of higher density.
4. Hydrogen gas (H_2). Hydrogen is less dense than air so it made soap bubbles and floated upwards which made the characteristic 'pop' sound when a candle was brought near to the bubbles.
5. The pH increased.
6. When the pH increases, it means there is less acid in the solution. The hydrochloric acid was being used up in the reaction with magnesium.
7. Learner dependent answer.

ACTIVITY: Writing the chemical equation (LB page 184)

1. HCl
2. Magnesium (Mg)

3. H_2
4. 2 Cl
5. $MgCl_2$
6. a) 2 H left and 2 H right. The Hs are balanced.
   b) 2 Cl left and 2 Cl right. The Cls are balanced.
   c) 1 Mg left and 1 Mg right. The Mgs are balanced.
7. hydrochloric acid + magnesium = magnesium chloride + hydrogen gas

Chemist or Pharmacist?
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 only 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!

Chemists are people who have studied chemistry and can use their specialist knowledge of chemical reactions 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.

Pharmacists also study chemistry, but combine this with other subjects like pharmacology, physiology and biochemistry. Pharmacists are health professionals and have specialist training in the health sciences as well as the chemical sciences. Their key responsibility is to ensure the safe and effective use of pharmaceutical drugs. They use their knowledge of medicines and the human body to dispense prescriptions from a licensed pharmacy. Job opportunities for pharmacists also include clinical services, reviewing medications for safety and efficacy and providing drug information where it is needed.

ACTIVITY: Other careers in chemistry (LB page 185)

This is an **optional** activity, which is not for assessment. A suggestion is that if you do not have time to do it in class, learners should still be encouraged to do it outside of class as it is important that they see how and where chemistry can take them after school.

Revision

1. a) hydrogen
   b) diatomic
   c) density
2. Learner's paragraph should contain at least the following:
   - Hydrogen gas is less dense than air.
   - Substances of lesser density always float on substances of greater density.
3. Learner's paragraph should contain at least the following:
   - The first sign to look out for is bubbles. The presence of bubbles signals that a gas is formed during the reaction.
   - To confirm whether the gas is hydrogen, collect a small amount in a test tube. Hold a glowing splint at the opening of the test tube when you release the gas. If the gas ignites with a characteristic 'pop' sound, we will know it is hydrogen.
4. The pH will increase. In the reaction, the acid is changed into something else that is not an acid. That means the pH must increase.
5.

Word equation	hydrochloric acid + magnesium = magnesium chloride + hydrogen gas
Chemical equation	2 HCl + Mg = $MgCl_2$ + $2H_2$
General equation	acid + metal = salt + hydrogen

6.

Word equation	hydrochloric acid + zinc = zinc chloride + hydrogen gas
Chemical equation	2 HCl + Zn = $ZnCl_2$ + H_2
General equation	acid + metal = salt + hydrogen

7. Only one example has been provided in this table as an example of what learners may write. There are, however, other suitable reactions which they have also learnt about this term. You must check that the reactions they provide are balanced.

The mark allocation is 1 mark for each of the general word equations and 2 marks for the example (only 1 mark if it is not correctly balanced).

Type of chemical reaction	**General word equation**	**Example (balanced equation)**
metals with oxygen	metal + oxygen = metal oxide	$2Mg + O_2 = 2MgO$
non-metals with oxygen	non-metal + oxygen = non-metal oxide	$C + O_2 = CO_2$
acids with metal oxides	acid + metal oxide = salt + water	$2HCl + MgO = MgCl_2 + H_2O$
acids with metal hydroxides	acid + metal hydroxide = salt + water	$HCl + NaOH = NaCl + H_2O$
acids with metal carbonates	acid + metal carbonate = salt + carbon dioxide + water	$2HCl + CaCO_3 = CaCl_2 + CO_2 + H_2O$
acids with metals	acid + metal = salt + hydrogen gas	$2HCl + Mg = MgCl_2 + H_2$

13 Forces

Unit overview

2 weeks

This unit introduces learners to the concept of a force. Learners would have been exposed to some of the concepts around forces in previous grades, for example:

- Grade 8 **Static electricity** introduced learners to friction and electrostatic force; and
- Grade 8 **Energy transfer in electrical systems** introduced learners to the attraction and repulsion forces between magnets when looking at the magnetic effect of an electric current.

Learners will discover that there are two main categories of forces, namely contact and non-contact forces. They will be introduced to the concept of force fields. This Unit has many opportunities for getting the learners to engage physically with the concepts. Have learners pull and push objects and move each other around the classroom or outside in the school grounds. Have them push against buildings to experience the resistance offered by surfaces. Allow them to walk on different surfaces and feel the effects of friction.

There are many tasks included in this Unit. You might not have time to cover all of them. Some are extension tasks and some tasks are revision from Grade 7 and 8. You will need to assess the requirements and capabilities of your class in order to decide which tasks to perform. There is a lot of content to cover in this Unit and many concepts form the foundation for what learners will cover in Physical Sciences in Grade 10-12. You might need to spend more than the allocated 2 weeks of time that is specified in CAPS. Some of the other Units in this term might not require as much time.

13.1 Types of forces (1.5 hours)

Tasks	Skills	Recommendation
Activity: What can forces do?	Group work, following instructions, doing and observing	CAPS suggested
Activity: Is it a push or a pull?	Accessing and recalling, identifying, sorting and classifying, describing, explaining	CAPS suggested
Activity: Pairs of forces	Group work, interpreting (scenarios and images) describing, explaining	CAPS suggested
Activity: Can forces act over a distance?	Demonstrating, observing, describing, explaining	Optional
Additional/alternative task:		
Activity: Tug of war		Optional extension making use of PhET simulations.

13.2 Contact forces (1 hour)

Tasks	Skills	Recommendation
Investigation: What is the relationship between the normal force and friction?	Carrying out investigation, observing, recording, analysing, interpreting, drawing conclusion	CAPS suggested (extension)
Additional/alternative task:		
Activity: Friction		Optional extension making use of PhET simulations.

13.3 Field (non-contact) forces (3.5 hours)

Tasks	Skills	Recommendation
Investigation: Dropping objects	Group work, predicting, hypothesising, carrying out investigation, observing, recording, comparing, interpreting, drawing conclusion	CAPS suggested
Investigation: What is the relationship between the mass of an object and its weight?	Hypothesising, measuring, recording, drawing graph, interpreting, calculating, drawing conclusion	CAPS suggested
Activity: Weight and mass calculations	Calculating	CAPS suggested
Activity: How much would you weigh on other planets?	Measuring, calculating, interpreting information	
in table	Optional/additional	
Investigation: Magnetic or non-magnetic materials	Hypothesising, observing, recording, drawing conclusion	CAPS suggested
Activity: Can a magnetic force act through substances?	Carrying out activity, observing, recording, describing, explaining	CAPS suggested
Activity: Visualising magnetic fields	Carrying out activity, observing, recording, drawing representations, communicating (graphically) describing, explaining	CAPS suggested
Activity: Charging objects	Group work, following instructions, observing, describing, explaining,	CAPS suggested
Activity: Turning the wheel	Observing, describing	CAPS suggested
Activity: Van de Graaff generator	Observing, describing	Optional extension

Key questions

- What is a force?
- What effect can a force have on an object?
- Do forces have to be between objects which are touching?

13.1 Types of forces

Have you noticed that one of the **Did you know** margin boxes in these workbooks contains a drawing of Newton?

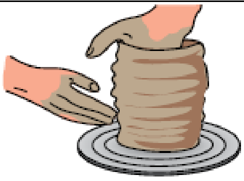
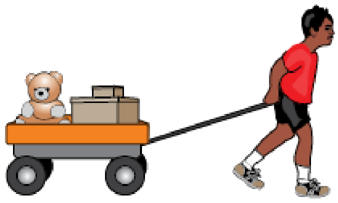
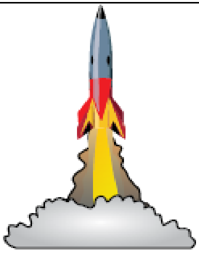
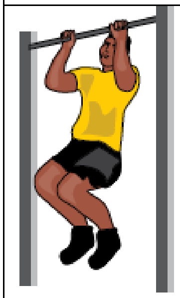
ACTIVITY: What can forces do? (LB page 194)

1. – 2. Learners are able to cause the ball to move.
3. Pushing the ball changes its direction as it is moving.
4. Learners are able to slow the ball down or stop it.

5. Learners are able to make the ball move faster.
6. Exerting forces on the putty or playdough changes its shape and it remains deformed. Exerting forces on the balloon also changes its shape, but it resumes its shape again once you stop exerting a force on it.
7. Yes, you can change their motion by causing them to move. No, you are not able to change the shape.

Effects of forces

ACTIVITY: Is it a push or a pull? (LB page 196)

Action	**Push or pull?**	**Effect**
 Kicking a ball.	Push	Kicking the ball causes the direction and speed of the ball to change.
 Moulding clay.	Push	The push exerted on the clay changes the shape of the clay.
 Playing with a toy wagon.	Pull	Pulling changes the motion of the wagon.
 A rocket blasting off into space.	Push	Pushing force changes the motion of the rocket (accelerates it)
 Exercising on a bar.	Pull	Pulling upwards changes the motion of the boy's body.

These questions on identifying the object experiencing the force and the agent causing the force are conceptually important when applying Newton's laws in later grades.

1. The soccer ball is experiencing the force and the girl's foot is the agent applying the force.
2. The clay is experiencing the force and the hands are the agent.

Pairs of forces

ACTIVITY: Pairs of forces (LB page 197)

1. Learner-dependent answer. Learners may note that they feel the wall pushing back on their hands.
2. Yes, it is pushing back.
   The force experienced by the learners is equal in magnitude and opposite in direction, which will be discussed later.
3. Yes.
4. Yes

5.– 6. The learner in the middle remains stationary.

7. The middle learner will move in the direction of the stronger force.

8.–9. The middle learner remains stationary.
   This is important for later. It is important to identify the forces on a specific object

10. The middle learner will move in the direction of the stronger force.
11. These forces are both acting in the same direction and so the learner moves in the direction of the push and pull.

When both learners pushed or pulled with an equal force, nothing happened as the learner in the middle remained stationary. When one of the learners pushed or pulled harder than the other learner, the learner in the middle moved in the direction of the bigger force.

If you have a rope, you can get the learners to have a tug-of-war outside on the school field. You can have the children on one side pull while the other side remains idle. Then have both sides pull at the same time. This would be a good way to have the learners feel the effects of the forces on their own bodies.

Representing forces
This is an optional activity which you can do with learners if you have internet access to run the PhET simulations.

ACTIVITY: Can forces act over a distance? (LB page 198)

This is a short, optional activity to introduce the idea of different types of forces. It can be done as a brief demonstration in front of the class to save time.

1.–2. The bar magnets move towards each other

3. The magnets try to push each other away.

4.–5. The paper clips are attracted to the bar magnet.

Questions

1. No.
2. Yes
3. The magnet exerted a force on the other magnet or the paper clips.

13.2 Contact forces

Friction

Learners must draw the arrow in the opposite direction to the red arrow.

INVESTIGATION: What is the relationship between the normal force and friction? **(LB page 200)**

This investigation will show the students that the frictional force is related to the **normal force.** The normal force is the reaction of the surface to the weight of an object.

As long as you have a scale you can use any objects as mass pieces. The learners will need to use the spring balances to measure the forces that they exert on the blocks. It is important that they measure the force as the block starts moving, because the reading will drop once the block is moving since kinetic friction is less than static friction.

Learners have already been introduced to weight in previous grades and will cover it in more detail in the next section where they will actually calculate gravitational acceleration for themselves. For now, just use the value of $g = 9,8\ m/s^2$ and then you can refer back to this investigation when learners work out gravitational acceleration for themselves later on.

Any mass measuring device would be suitable for this investigation.

The results obtained will depend on the mass of blocks used and the surface on which the investigation is carried out. It is important that the learners see that as the mass increases, the normal force increases and the reading on the spring balance, measured as the block begins to move, also increases.

Results

1. The size of the frictional force.
2. The normal force as a result of the mass of the blocks.

Analysis

1. An example free-body diagram. The weight and normal force must have arrows of equal size. The pulling force must be equal in size to the friction as the diagram represents that object just as it is about to start moving.
2. The object is on a flat surface so the normal force equals the weight.
   Increasing the mass increases the weight as W = m x g; therefore the normal force increases.
3. Repeating the experiment increases the reliability of the results.
4. The shape should be a straight line through the origin. The actual shape will depend on the accuracy of the learners' results and plotting. It is only important that the graph shows an increasing trend so that the relationship between the normal force and friction can be established.
5. The shape tells us that as the normal force increases, so does the size of the friction force.
6. Yes, this will affect the result as the frictional force between different kinds of surfaces is different, for example between smooth and rough surfaces.

Conclusion

1. The friction force increases as the normal force of the object increases.
2. When the block is moving at constant speed, the friction decreases, compared to the friction that has to be overcome to make the block move.

Static friction is the maximum friction reading just as the block starts to move. Then, when the block is moving at a constant speed, the friction decreases and is called moving friction. In the first part of the investigation, we only measured the average static friction with different masses. This extension will show learners that once the object starts to move, the friction decreases.

This is an optional activity which you can do with learners if you have internet access to run the PhET simulations.

Provide the class with play dough and have them form balls which they can then compress in their hands as in the picture below.

13.3 Field (non-contact) forces

You can demonstrate the gravitational effect by dropping objects of different masses from an equal height. Use a tennis ball and a balled-up piece of paper (so that they are approx. the same size and shape). Drop them from the same height and see if the learners can see a difference in the way that they fall. Ask the learners why they think the objects fell. Is something pushing them down? Or pulling them down? Get them to discuss their ideas with each other.

The simulations provided in this Unit are very worthwhile looking at if you have internet access. Otherwise, encourage learners to interact with them in their own time at home or on their mobile phones.

Learners have already come across gravity in Planet Earth and Beyond in previous grades.

Strictly speaking, when talking about "gravity" we are specifically referring to the gravitational force of attraction that occurs between the Earth (or another celestial body like a planet) and other objects, as opposed to the gravitational force in general which acts between any two objects with mass. For example, we would refer to the gravitational force acting to attract objects to the Moon as the gravitational force due to the Moon.

The Earth has a much larger mass than a person or a desk and so it is accelerated by a much smaller amount even though the force exerted on the Earth by a desk is the same size as the force exerted on the desk by the Earth (just in opposite directions). This is why the Earth does not move noticeably.

The PhET simulation in the visit box can be used to demonstrate very easily how the gravitational force between two objects increases with mass and decreases as the distance between the objects increases. You can turn off the values and use the position of the little figures tugging on the ropes to demonstrate the relationships qualitatively.

INVESTIGATION: Dropping objects **(LB page 205)**

A note on falling objects

A useful way to demonstrate the Earth's gravity is to look at falling objects. An optional extension activity is included below in which learners drop a variety of objects. You can take a vote from the class to see whether learners think that an apple or bag of sugar would hit the ground first. (Answer: they would hit the ground at the same time as long as air resistance is negligible.) It is very likely that learners will have the preconception that heavier items fall faster. It is not important at the moment that the learners' answers are correct and do not try to lead them to the correct answer. They will hopefully discover it for themselves in the following experiment.

In this investigation learners need to work in pairs. They will initially drop a whole apple and half an apple from the same height at the same time. They will then further experiment with balls of different masses (but the same size) and balls of the same mass (but different volumes). It is very hard to drop objects at exactly the same time so that they hit the floor simultaneously so let the learners repeat the experiment several times until they are confident that they are dropping the objects at the same time. If it is hard for them to see which object hits the ground first, suggest to learners that they listen for the number of sounds they hear – one or two – when the objects hit. Learners might need to repeat this investigation many times since it most likely contradicts their preconceptions. Safety tip: It is probably a good idea to have the apples cut in half ahead of time.

Once the learners have finished their experiment you can demonstrate the effects of air resistance by dropping a hammer and a feather. Have the learners take a vote on what will happen when you drop the hammer and feather. Be ready to explain to learners that air resistance slows the fall of the feather and that if there were no air resistance the two would fall at the same rate and hit the floor at the same time.

Results and observations
1. The height at which objects are dropped.
2. The type objects that are being dropped, in particular the mass and volume of the objects.

Evaluation
Learner dependent answer. Example answers could include: It is difficult to drop objects at exactly the same time. It would be better to drop the objects from a greater height. Air resistance could have affected the results and it would be better to drop the objects in a vacuum.

Conclusion
Learners should have found that the half apple and the whole apple hit the floor at the same time. They should also have found that the balls of the same mass hit the floor at the same time and also the balls of the same volume hit the floor at the same time. From this they should conclude that all objects dropped fall at the same rate no matter what their shape or size if air resistance can be ignored.

Advanced
The objects *accelerate* at the same rate). In the case of the hammer and feather drop, learners should have found that the hammer landed first. This is because of the effects of air resistance slowing the feather's fall.

Questions
1. They should have both landed at the same (or close to the same) time.
2. They should have both landed at the same time.
3. They should have both landed at the same time.
4. In an ideal situation, all objects dropped from the same height will land at the same time. This is because the Earth's gravitational force causes each object to get faster by the same amount every second, no matter how heavy it is or what its volume is.

   Advanced Teacher's Note:
   According to the Universal Law of Gravitation, the Earth's gravitational force pulls down on an object with a force that is proportional to the mass of the object and the mass of the Earth. In all cases the mass of the Earth is the same and so any differences in the gravitational force on objects on Earth depends only upon the difference in the mass of the objects being dropped.

   According to Newton's second law, the net force exerted on an object, F, is given by $F=ma$ where m is the mass of the object and a is the acceleration produced by the net force F.

5. In a real situation, the air around us affects how objects fall. As an object moves through the air, and experiences air resistance. The feather is much lighter than the hammer and so the effect of air resistance is much larger on the feather. The net force acting downwards on a falling object is the gravitational force minus force due to air resistance. As the feather is much lighter than the hammer,

the net force acting on it will be less and so it will experience a smaller acceleration towards the ground and fall more slowly.

Advanced Teacher's Note:
Air resistance is a drag force acting to slow the object down. The size of the force depends upon the velocity of the falling object squared, the surface area of the falling object, and the density of the fluid it is falling in (in this case air). Very light objects are slowed by air resistance, like feathers or thin sheets of paper. This is because their gravitational force is very small compared to the air resistance. Very large objects are also slowed by air resistance. This explains why a parachute slows your fall. Before you open a parachute air resistance is small. After opening, the wide parachute experiences greater air resistance which then slows you down.

It is very important that learners understand the difference between mass and weight. In science, weight is a force, but learners are used to using the word "weight" when describing their mass. Weight is the force experienced by an object due to gravity. On Earth, all objects are attracted downwards towards the centre of the Earth and our weight is an indication of the size of that attraction. Weight will vary depending on our position in space but our mass should remain constant regardless of our position.

The statement "My weight increased by 2 kgs over the holiday period as I ate too much food." is incorrect as the relative is equating her/his weight with kilograms. Kilograms are a measure of mass, not weight. Her mass might have increased by 2 kilograms.

The Earth is much larger than the Moon and so the gravitational force between the Earth and the block will be greater than the force between the Moon and the block.

INVESTIGATION: What is the relationship between the mass of an object and its weight? **(LB page 207)**

Hypothesis
Learner-dependent answer

Materials and apparatus
Any mass meter can be used to measure the mass of the objects. Kitchen scales or electronic scales can also be used.

Results
An example of the results if using the suggested mass pieces:

Mass (kg)	**Weight (N)**
0.5	4.8
1	9.8
1.5	14.7
2	19.6

1. Weight
2. Mass

   Therefore, weight is on y-axis versus mass on the x-axis

3.–4. The gradient should be 9,8.

You may need to remind the learners about calculating the gradient of a straight line. They should have covered this topic in Mathematics but it would be useful to remind them. They need to choose two co-ordinates on their straight line. They can choose any two coordinates which should be labelled as (x_1 ; y_1) and (x_2 ; y_2). The formula for the gradient of a straight line is gradient = rise/run = ($y_2 - y_1$)/($x_2 - x_1$)

Example calculation: gradient = (9,8 – 4,8)/(1 – 0.5) = 9,8

Learners may not get the correct answer for the gradient if they have not plotted correctly or if the spring balances are not calibrated properly. They may get an answer closer to 10. The gradient of the graph gives the gravitational acceleration on Earth. This will be explained in the text after the investigation.

Conclusion
The weight of an object is directly proportional to the object's mass.

ACTIVITY: Weight and mass calculations (LB page 209)

This is a short activity to practice some calculations. Learners can complete this as a homework task.

1. weight = 1485 x 9,8 = 14553N
2. 50 kg as the mass of an object is independent of position.
3. weight on Moon = 78 X 1,6 = 124,8 N
   Sam is incorrect.
4. mass = 220 g = 0.22 kg.
   weight on Earth = 0.22 x 9,8 = 2,156 N
   weight on Moon = 0,22 x 1,6 = 0,352 N
5. mass = 1340 / 1,6 = 837.5 kg

The PhET simulation listed in the visit link can be used to easily show how the weight of objects change. This simulation can be used at many different levels, depending on the complexity of the concepts that you want to illustrate. A link to a pdf containing teaching tips from the PhET team is available here: bit.ly/1hYg37K

ACTIVITY: How much would you weigh on other planets? (LB page 210)

This is an **optional** activity. In this activity, learners calculate what their weight would be on the seven other planets in our solar system. Although their mass remains the same, they will "feel" lighter or heavier because of the differences in the gravitational field strength on the surfaces of the other planets. You should emphasise that their mass always remains the same, but only their weight varies. If you do not have access to weighing scales you can either ask learners to estimate their mass or provide them with an example number.

1.–2. Example answers for a 50kg learner:

Planet	**Your mass (kg)**	**Value of g (m/s^2)**	**Your weight (N)**
Earth	50	9,8	490
Mercury	50	3,6	180
Venus	50	8,8	440
Mars	50	3,8	190
Jupiter	50	26	1300

Saturn	50	11,2	560
Uranus	50	10,5	525
Neptune	50	13,3	665

Questions

1. You would feel heavier on Jupiter and Neptune.
2. You would feel lighter on Mercury, Venus, Mars, Saturn and Uranus.

A note on weightlessness

The term "weightless" causes a lot of confusion for learners. The confusion of a person's actual weight with one's feeling of weight is the source of many misconceptions. Weightlessness refers only to someone's sensation of their weight, or lack thereof. Weightlessness is a feeling experienced by someone when there are no external objects touching the person exerting a push or pull upon them (we call these contact forces because they arise due to things being in contact or touching each other).

The weight of a person is the force of gravitational attraction to the Earth that person experiences. Someone in free-fall, feels weightless but they have not lost their weight. They are still experiencing the Earth's gravitational attraction.

Learners are also often confused as to why astronauts in orbit around the Earth float in their spacecraft. One common misconception is that there is no gravity in space and so the astronauts can float. In actual fact, in low Earth orbit the Earth's gravity is about 90% of its strength at the surface of Earth.

The only reason the astronauts float is because they are in free-fall and their spacecraft is also in free-fall with them, falling at the same rate. Therefore, the astronauts appear to float when compared with the spacecraft because they are both falling at the same rate. Another example is how orbiting spacecraft are essentially in free-fall as there is 'nothing' retarding their motion towards to centre of the Earth, but because of their orbital velocity, they never actually move closer to the Earth.

Magnetic forces

INVESTIGATION: Magnetic or non-magnetic materials **(LB page 211)**

Hypothesis

Learner-dependent answer. There are many different possible hypotheses for this investigation. An example would be: Only some materials are magnetic.

Method

Learners should notice that the non-metals are not attracted to the magnets and that the copper, even though it is a metal, is not attracted.

Results

Material	**Magnetic (YES/NO)**
Paper	NO
Wood	NO
Plastic	NO
Iron	YES
Aluminium	NO
Steel	YES

Copper	NO

Conclusion
Not all materials are magnetic. Only some metals, such as iron, are magnetic.

ACTIVITY: Can a magnetic force act through substances? (LB page 212)

Magnetic forces are non-contact forces and can act over a distance. However, normal magnets do not have very strong magnetic fields. The further an object is from the magnet, the weaker the force experienced. A magnet should be able to act through most substances. If the object placed between the magnet and the metal is too thick, then the metal might be too far away from the magnet to experience a strong enough force. This lack of attraction is then due to the strength of the magnetic field and not the "blocking" ability of the material. In this investigation you can investigate this by using a thin piece of wood and a thick piece of wood. The magnetic field can act through the thin wood which means wood is not a "blocker" of magnetic force. So if the thick wood prevents the paper clips from being attracte,d it can be seen that it is the distance between

Instructions
1. The two poles repel each other. There is a "pushing" force.
2. The two poles repel each other. There is a "pushing" force.
3. The two poles attract each other. There is a pulling force between the poles.

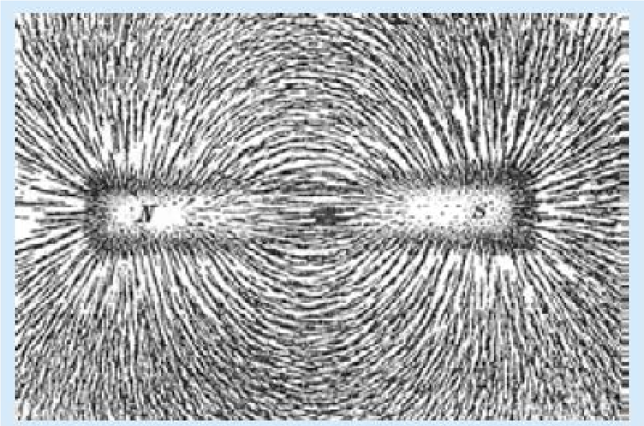
4.–5. The magnet should work through any of the materials, as long as they are thin enough. It is the distance between the magnet and the paper clips that will affect the attraction. So the thin piece of wood should not prevent the attraction but the thicker wood will keep the paper clips far enough away from the magnet to make the attraction too weak to pick up the paper clips.

Questions
1. The only material which may have prevented the magnet from picking up the paper clips is the thick piece of wood.
2. It acts over a distance. It is strongest closer to the magnet and weaker as you move further away from the magnet.

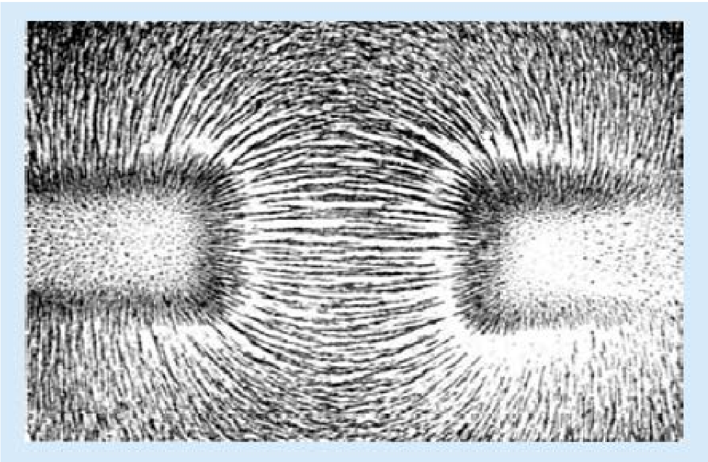
ACTIVITY: Visualising magnetic fields (LB page 213)

The iron filings align with the magnetic field. Explain to the learners that the iron filings show a two-dimensional view of the field but the field is actually all around the magnet, in three dimensions.

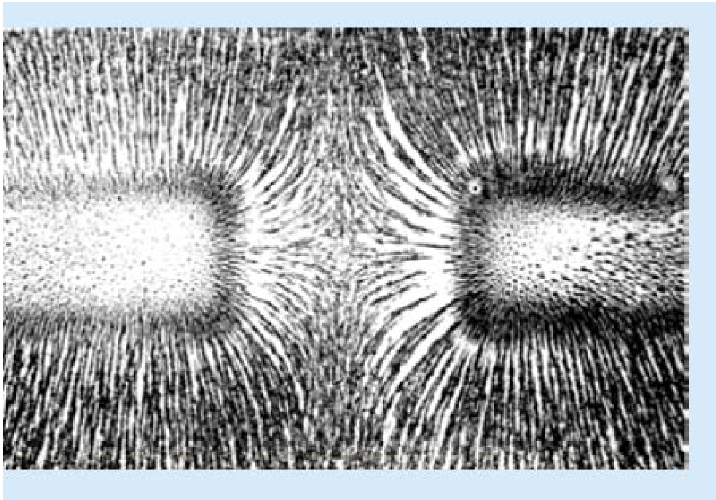
Instructions
This shows the pattern around a bar magnet.



The pattern between two opposite poles attracting.



The pattern between two like poles repelling



Electrostatic forces

Even though these experiments were done in Grade 8, it is important for the learners to do them again as an activity. This will help them to understand how the electroscope and Van de Graaff generators work.

ACTIVITY: Charging objects (LB page 215)

You can also do this activity using a plastic comb rather than balloons. Otherwise you can use pieces of paper instead of a learner's hair as not all hair will behave in the following way.

Instructions

1.–3. Nothing happens.
4.–5. The hair should "rise" and stick to the balloon.
6. Nothing happens.
7.–8. The pieces of paper stick to the glass rod.
9.– 1. The stream of water bends towards the glass rod.

Questions

1. Rubbed it vigorously with the balloon.
2. Electrons are transferred from the glass rod to the knitted fabric because of friction. The glass rod becomes positively charged and the wool becomes negatively charged.
3. The water has positive and negative charges. The negative charges were attracted to the positively charged rod.

The electrons in an atom are positioned in the space around the nucleus.

A proton carries a positive charge.

An electron carries a negative charge.

Neutrons are not charged. They are neutral.

Refer learners to the diagram on page 216 of the LB. Explain that the hair gave up some of its electrons. It thus has more positive charges. The comb gained more electrons. It has more negative charges.

ACTIVITY: Turning the wheel (LB page 217)

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. Practice 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 in which you live.

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: [6] bit.ly/1fFbbbJ

The second perspex rod should repel the first one as they have like charges, so learners should see the second rod 'pushing' the first one around in a circle. You might need to rub the first perspex rod again, in between attempts, as the charge does dissipate.

The rods now have opposite charges and so the second rod should be seen to 'pull' the other rod around in a circle.

The learners should be able to pick up the pieces of paper with the charged rod.

Questions

1. When the rods are the same (both perspex), the first rod should move away from the second and the top watch glass will turn in a circle.
2. 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.
3. The pieces of paper were attracted to the rod.

When the perspex rods were rubbed with the cloth, electrons were transferred from the perspex to the cloth, thus the perspex rods now have a positive charge. When the plastic rod was rubbed with the cloth, electrons were transferred from the cloth to the plastic rod, thus the plastic rod now has a negative charge.

ACTIVITY: Van de Graaff generator (LB page 219)

This is an **optional extension** activity. The Van de Graaff generator can be used for all sorts of fun activities. You can use it to explain various static electricity concepts. There are several websites with ideas and suggestions for fun activities and videos of demonstrations, such as this one: bit.ly/19TuryU

The purpose of this activity is to show how sparks are made so that you can go on to explain how lightning works. If you do not have a Van de Graaff generator then use a video clip (such as this one bit.ly/1bYvJdy from the internet.

Revision

1. a) Force.
   b) Field.
   c) Free-fall
   d) Poles.
   e) Charge.
2. a) B
   b) B
   c) A
   d) C
   e) B
   f) C
3. a) False. A force can make a motionless object move.
   b) True
   c) True
   d) False. A friction force slows down or stops an object because of the surfaces rubbing against each other
   e) False. Lightning is an application of an electrostatic force.
4. a) The image on the left shows a push and on the right shows a pull.
   b) 1 mark is allocated to drawing a dot for the desk.

   1 mark is allocated for the correct values used.

   2 marks are allocated to the correct direction of the arrows and the arrow lengths to show the difference in magnitude of the forces.

   50 N to the right.

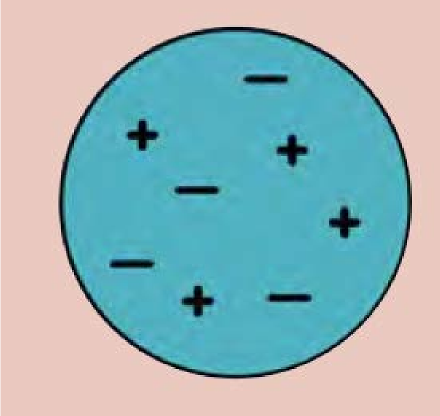
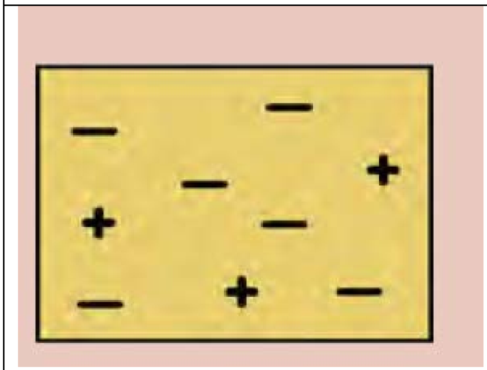
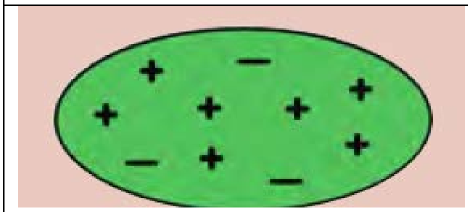
5. a) 110 N
   b) 30 N
6.
   - change in motion (faster or slower)
   - change in direction
   - change in shape
7. Image A shows the object at rest and image B and C shows the object with different forces applied to it. Image B shows compression forces applied to compress the object. Image C shows tension forces applied to stretch the object.
8. Table showing the difference between mass and weight.

	Mass	**Weight**
Definition	Mass is determined by the amount of matter that an object is made up of, and it remains constant no matter where it is measured.	The weight of an object is determined by the gravitational force exerted on it by the Earth or other large object, such as the Moon or another planet. The weight varies depending on where it is determined and the strength of the gravitational force.
Units	kilograms (kg)	newtons (N)

9. W = m x g, where W is the weight of the object in N, m is the mass of the object in kg and g is the gravitational acceleration in m/s^2.
10. The distance between the objects, as the closer they are, the stronger the force, and the mass of the objects as the greater the mass, the stronger the force.
11. a) Learners must provide the formula, then substitute with the values and provide the answer with the units.
    W = m x g
    = 80 x 9,8
    = 784 N
    b) Learners must draw a bar graph with gaps between the bars [2 marks], provide a heading [1 mark], x-axis label [1 mark], y-axis label with units [1 mark], appropriate vertical scale [1 mark], accuracy of plotting [2 marks].

    c) His weight is the smallest on Mercury as Mercury is the smallest planet in mass.
12. Learner's own work.
13. Photo A shows the magnetic field between two opposite poles which are attracting each other. Photo B shows the magnetic field between two like poles (either north and north or south and south) which are repelling each other.

14. 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.

15. a) Electrons are transferred from the jersey to the balloon. Protons are not transferred. Electrons are negatively charged and thus the balloon picks up a negative charge.
    b) Friction.
    c) Electrostatic force.
    d) Attractive.
16. 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.
17. Friction between the water and air particles in the clouds causes a build-up of negative charge. When there is a large excess charge in the clouds, the excess charge moves through the air to the ground and discharges. This discharge forms a bright spark as the energy which is released by the moving charges is in the form of heat, light and sound. This is lightning.
18. The learners are playing outside during a lightning storm, which is dangerous. Furthermore, they are underneath a tree, which is even more dangerous as the lightning strikes tall objects, such as trees, and so they are at risk of getting shocked.

14 Electric cells as energy systems

Unit overview

0.5 weeks

This is a very short Unit with only 1.5 hours of teaching time allocated to it. We revisit the idea of a system and energy transfers within a system focusing on electric cells. The concept of a system, looking at potential and kinetic energy and conservation of energy within a system, was first introduced in Gr 7 Energy and Change. In Gr 8 Energy and Change, learners would have also looked at energy transfers within an electrical system. The focus of this Unit however, is on electric cells.

We will start off by looking at a simple electric cell made using an acidic fruit to explain what happens within a cell in an electric cell, and then we will make a more complex electric cell using copper and zinc plates as electrodes. It is important to make the distinction between a cell and a battery as these words are often used interchangeably. A battery is two or more cells that are connected together.

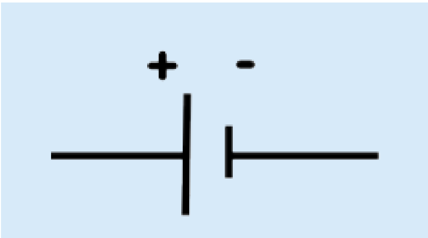
14.1 Electric cells (1.5 hours)

Tasks	Skills	Recommendation
Activity: Fruit cell	Following instructions, observing, analysing, explaining	CAPS suggested
Activity: Zinc-copper cell	Following instructions, observing, taking measurements, analysing, explaining	CAPS suggested

Key questions

- Where does an electric circuit get its energy from?
- What is inside a battery?
- How can we build our own electric cells?
- How does an electric cell supply energy?

Remind learners that the symbol for an electric cell is:



2.1 Electric cells

The source of energy in an electric circuit is an electric cell. A system can be described as a set of parts working together as a whole.

ACTIVITY: Fruit cell (LB page 226)

The citric acid in the lemon acts as an electrolyte. When two different metal electrodes are placed into the acidic lemon solution, and the circuit is closed, electrons flow from the one electrode to the other. This flow of electrons is called electric current.

This is a fun activity for the learners and is easily accessible if you do not have the equipment to make the zinc/copper cell in the next activity.

The ammeter is optional. You can use the LED light instead of an ammeter to indicate that current is present. However, depending on the fruit that you use, the current might not be strong enough to make the LED light glow, and therefore an ammeter is a more sensitive measure of whether there is current.

Connect several of the learner's fruit cells in series until the LED bulb lights up.

Note that incandescent light bulbs from torches are not used as the lemon battery will not produce a high enough potential difference to light them up. Instead of a copper nail or copper strip, you can also use a copper coin or piece of copper wire. Instead of a zinc nail, you can also use a steel or iron nail. It is important to highlight to learners that TWO different conductors/metals must be used in the cell. If two of the same metals are used, a potential difference is not created, and the electrons will not flow. As an extension, you can also use different types of fruit to see which ones produce the best cells. What do you notice?

1.–5. There should be a small reading on the ammeter and the light bulb might glow. The size of the reading will depend on the size of the lemon and the quality of the connections. Make sure that the zinc and copper are not touching each other inside the lemon.
6. Learner-dependent answer.
7. A battery.
8. No you are not able to light up the LED bulb using two nails of the same type of metal. If two of the same metals are used, a potential difference is not created, and the electrons will not flow.
9. Learners should see that the further the nails are pushed into the lemon, the greater the current. This is because the length of the electrodes exposed to the electrolyte is greater (there is increased surface area in contact with the electrolyte).

   Placing the nails in different positions also has an effect, as the closer the electrodes are to each other, the less resistance there is, and therefore a greater current.

This is a good opportunity also to discuss a fair test as learners must change only one variable at a time.

A further extension is to use different electrodes. For example, replace the zinc nail or strip with a magnesium strip. Learners can then observe and compare the ammeter readings and draw further conclusions about how the type of material of the conductor has an effect.

ACTIVITY: Zinc-copper cell (LB page 228)

Materials

Prepare 1 M zinc sulphate and 1 M copper sulphate solutions beforehand. A 1 molar (M) solution contains 1 mole of solute dissolved in 1 litre of solution:

- To make a 1 M solution of copper sulphate, dissolve 250 g of hydrated copper sulphate ($CuSO_4.5H_2O$) in distilled water and then add more water until you have 1 litre.
- To make a 1 M solution of zinc sulphate, dissolve 288g of hydrated zinc sulphate ($ZnSO_4.7H_2O$) in distilled water and then add more water until you have 1 litre.

The exact concentration of sodium sulphate or sodium chloride is not too important.

If you have a sensitive measuring balance, measure the mass of the electrodes before the experiment, and then again one day later, to show the change in mass. This will highlight the fact that a chemical reaction has taken place. If your solutions are concentrated enough, the bulb should glow, otherwise you can also connect more than one cell in series, as was done with the lemons.

If you do not have enough materials for each learner to build a cell, you can do this as a demonstration or else set up a couple of workstations for a group of learners to observe.

Instructions
If you have a sensitive measuring balance, measure the mass of the copper and zinc plates and get learners to record this.

1.–3. Learners should fill the salt bridge with the sodium sulphate solution and then plug the ends with cotton wool. Inserting the salt bridge can be a difficult manoeuvre so make sure that they practise it a bit first and use enough cotton wool. If you do not have a U-bend tube then use strips of filter paper or a cloth soaked with saturated sodium sulphate solution.
4. No, there is no reading on the ammeter.
5. Yes, there is a reading on the ammeter.
6.–7. Learners' own answers.

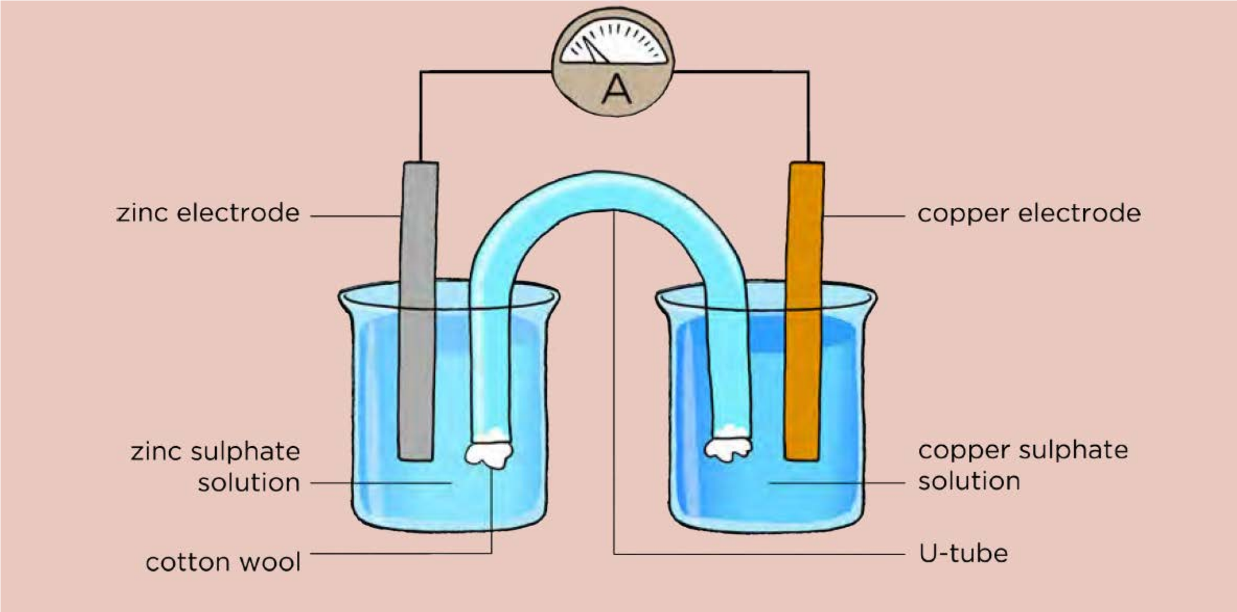
If you measured the mass of the electrodes at the beginning of the experiment, take the ammeter away and connect the copper and zinc plates to each other directly using copper wire. Leave to stand for about one day.

After a day, remove the two plates and rinse them first with distilled water, then with alcohol, and finally with ether. Dry the plates using a hair dryer. Weigh the zinc and copper plates and get learners to record their mass again. Has the mass of the plates changed from the original measurements? Yes, the mass should have changed. The mass of the zinc plate decreased, while the mass of the copper plate increased. Discuss this with your class. The changes in mass have occurred as chemical reactions have taken place in the solutions. This is discussed more in the text after the activity.

Questions
1. The ammeter should measure a current in the circuit. The voltmeter should register a potential difference across the two electrodes.
2. The ammeter reading tells us that there are electrons moving through the external circuit. There is a current.

Revision

1. The paragraph should mention that an electrical cell is a system in which chemical reactions occur. The chemical reactions set up a potential difference across the cell, which makes the electrons move around the circuit (electric current).
2. A cell is a system in which chemical reactions occur. A battery is a number of cells connected together.
3. If you make several lemon cells and connect them in series with a light bulb.
4. You can connect an ammeter to measure current or use a torch light bulb. If the bulb glows then there is a current flowing. Or you can use a voltmeter to measure the potential difference.
5. One mark is allocated to each of the correct labels, one mark to placing the salt bridge with the ends in each solution, one mark for including an ammeter in the correct position with the symbol A and one mark for placing the electrodes in the right solutions. A reference diagram is supplied here:


zinc electrode
copper electrode
zinc sulphate solution
copper sulphate solution
cotton wool
U-tube
A

15 Resistance

Unit overview

1 week

This Unit starts off by explaining the meaning of resistance in an electric circuit. Learners will then look at the use of resistors. This is a revision of some of the concepts covered in Gr 8 Energy and Change when looking at the *Energy transfers within an electrical system* (Unit 2). For an easy reference to what learners covered in the previous grade, you can visit the website www.curious.org.za where this content is located online, and navigate to the relevant grade and Unit.

This year, the concept of resistance will be extended by looking at the factors that affect resistance in a resistor, namely:

- the type of material of which the conductor is made
- the thickness of the conductor
- the length of the conductor
- the temperature of the conductor.

These will be investigated experimentally. Learners must be able to explain the relationships between these factors and the resistance offered by the resistor. It is not necessary to show experimentally how temperature affects resistance, but the concept must still be covered. CAPS suggests investigating at least one of the other factors. All three investigations have been included in this workbook so that you have the choice as to which one you would like to conduct with your class, or, if time permits, you can conduct all three investigations. Three hours have been allocated to this section in CAPS, so you should have time to perform more than one of the investigations. In the workbook, they have been presented as three separate investigations, but you can also perform them concurrently, or allocate a different investigation to different groups. The groups can then report back to the class on their findings and you can subsequently summarise the effects on the board.

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.

15.1 What is resistance?

This is included as an introduction.

15.2 Uses of resistors (1 hour)

Tasks	Skills	Recommendation
Activity: Useful resistance	Recalling, identifying, describing	CAPS suggested
Activity: Make your own rheostat	Following instructions, predicting, observing, explaining	Optional
Activity: Comparing a LED to a filament light bulb	Describing, drawing, explaining, comparing	CAPS suggested

15.3 Factors that affect resistance (2 hours)

Tasks	Skills	Recommendation
Investigation: How does the material of the resistor affect the	Hypothesising, identifying variables, following instructions,	CAPS suggested

resistance?	drawing, observing, describing, analysing, concluding	
Investigation: How does the thickness of the conductor affect the resistance?	Hypothesising, identifying variables, following instructions, drawing, observing, describing, analysing, concluding	CAPS suggested
Investigation: How does the length of a conductor affect the resistance of the conductor?	Hypothesising, identifying variables, following instructions, drawing, observing, describing, analysing, concluding	CAPS suggested

Key questions

- What is resistance?
- What do we use resistors for?
- Does length affect resistance?
- Does temperature affect resistance?
- Does the type of resistor material affect resistance?
- Does the thickness of a resistor affect the resistance?

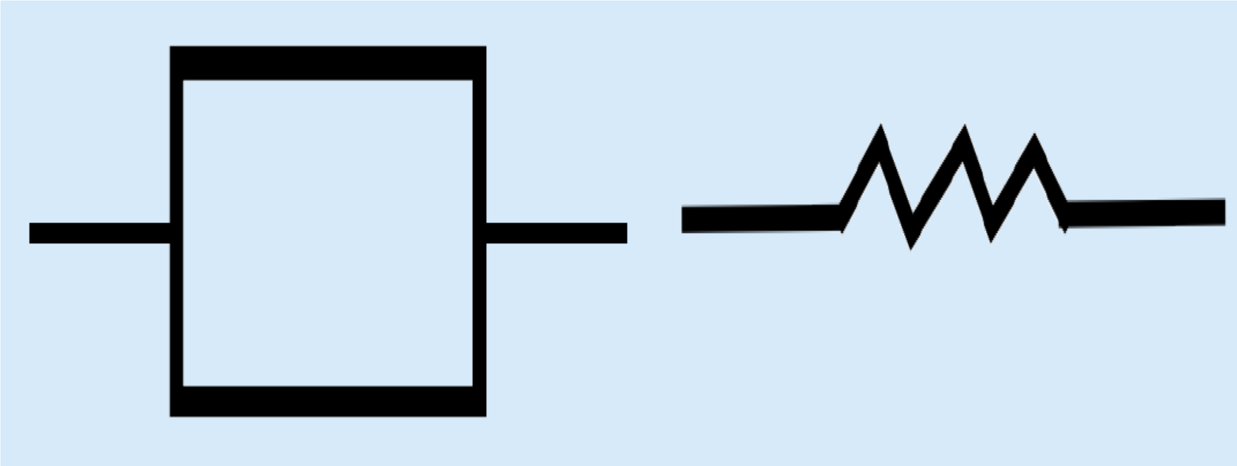
15.1 What is resistance?

A good way to introduce this topic is to act out the following situation with your learners which is explained in the learner's book. You can even just create an imaginary field by drawing a square with chalk on the ground and then a narrow corridor coming off of it. Tell learners to first walk around randomly in the field and then when you signal (indicating that a potential difference has been applied across the wire), they all need to move towards the corridor and get through it. You can make the corridor start off wide and become narrower to further illustrate how the resistance to their movement increases as the corridor becomes narrower. This demonstrates only one of the factors influencing resistance (namely, the width of the conductor), but can be used to introduce the idea of resistance.

We have revised the concept of electric current and how electrons move within a conducting wire before introducing the idea of resistance in an electric circuit.

An electrical conductor is a type of material or object which allows electric charge to pass through it. You can also remind learners at this point that electrical insulators are non-conductors as they do not allow electric charge through them.

There are two symbols used to represent resistors, but the one most commonly used is the one using a block.



15.2 Uses of resistors

Discuss this with your class as they might not have conducted these investigations in the previous grade. When the resistance in a circuit increases, the current decreases. Adding more resistance increases the opposition to the flow of charge so it is more difficult for charge to move through the circuit.

Therefore, there is less current (as current is the rate of flow of charge). We say that the current is inversely proportional to the resistance, meaning as the resistance increases, the current decreases.

ACTIVITY: Useful resistance (LB page 233)

This activity links back to the work done in Grade 8 Energy and Change. The difference between "useful" and "wasted" energy is highlighted again. The learners should see that resistors can be used to provide useful energy transfers.

1. Electrical energy.
2. Thermal energy.

Questions

1. Electrical energy is transferred to heat and light.
2. Light is the useful output energy and heat is the wasted output energy.
3. 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.
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.
5. Heat.
6. Light.

ACTIVITY: Make your own rheostat (LB page 235)

If you have rheostats in your laboratory, then you may choose to simply demonstrate how the resistance is varied by changing the position of the slider. The position of the slider affects the length of the resistor coil. Because length is a factor which affects resistance, the shorter the coil, the less resistance; the longer the coil, the greater the resistance.

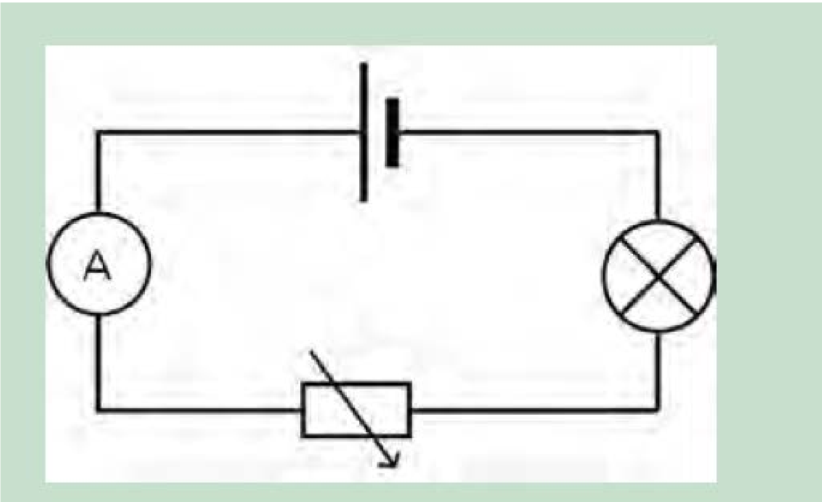
If you do not have a graphite rod, a graphite pencil can be used. Sharpen the pencil on both sides and carve the wood from the pencil at various points along the length of the pencil. This is easier than trying to remove the entire graphite rod from the pencil. The graphite is soft and often breaks into pieces if you try to remove the entire thing.

The ammeter is not strictly necessary. If you do not have one, then the learners can use the brightness of the bulb as an indication of the strength of the current.

Instructions

1. Yes. The light bulb glows and the ammeter has a reading on it.
2. Learners' predictions will vary. They should refer to how they think the length of graphite will affect the current strength.

3.–4. The shorter the length, the smaller the resistance, so the current strength is greater. By changing the length, the resistance has changed.

5. 

When the resistance is increased, the current decreases, and so the brightness of the bulb decreases.

ACTIVITY: Comparing an LED to a filament light bulb (LB page 236)

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

Questions

1. a) If 100 J of electrical energy is transferred to the LED then the LED transfers 75 J of energy as light and 25 J of energy as heat.
   b) The LED is efficient. The main purpose of the LED is to produce light, most of the energy transferred by the LED produces light and only a small percentage is "wasted" as heat (25 %).
2. a) If 100J of energy is transferred to the light bulb then 90% of the energy is transferred to the surroundings as "wasted" heat. Only 10% of the energy is used to produce light.
   b) The incandescent light bulb is inefficient. The purpose of the incandescent light bulb is to produce light. 90% of the energy it transfers is wasted and only 10% is useful light.
3. LEDs, as they are more energy efficient. The useful output energy is greater than the wasted output energy.

15.3 Factors that affect resistors

It is not necessary to test each of the factors which affect resistance. Testing the type of material is the easiest method for the learners to pursue in class. As an extension, you could have the learners do a small project on how the cross-sectional area of the material affects resistance or how temperature affects resistance.

INVESTIGATION: How does the material of the resistor affect the resistance? **(LB page 237)**

Hypothesis

Possible hypotheses are: Different conductors will provide different

Variables

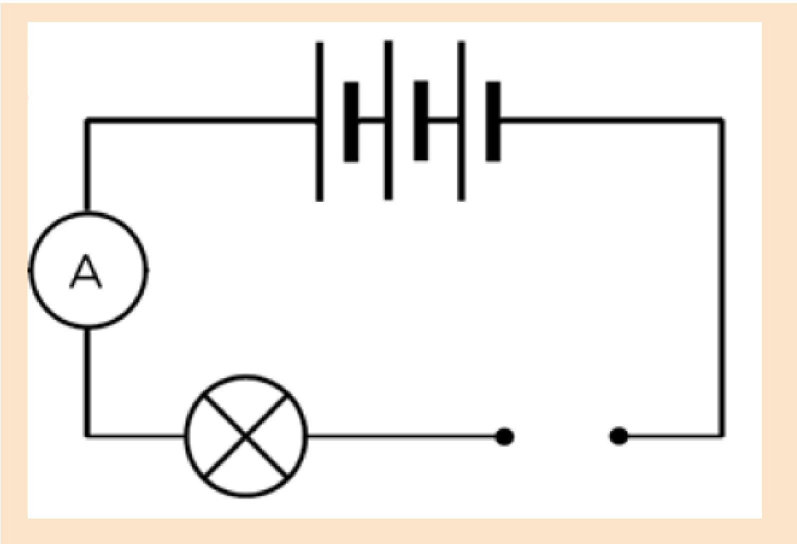
1. The materials we test would all need to have the same length and thickness and be kept at the same temperature. The number of batteries used to provide energy in the circuit.
2. The independent variable is the type of material.
3. The dependent variable is the amount of resistance provided by the material, as indicated by the change in current.

This experiment does not measure resistance directly, but rather uses ammeter readings. Later in this investigation, learners are required to draw a bar graph. The bar graph will have ammeter readings (current) on the y-axis.

Use whichever metals you have available. Good materials to use are copper (a thicker gauge than those in the normal conducting wires), nickel, nichrome and iron.

Results

1. Here is an example of a circuit diagram. The way in which learners represent the connection points for the material to be tested may vary.



2. An example table is shown here:

Table showing the ammeter readings for each type of conducting material tested	
Conducting material	**Ammeter reading (A)**
Copper	
Nickel	
Nichrome	
Iron	

Learners must provide a heading for the table and each column, and the unit must be in the heading. You can also use Assessment Rubric 4 at the back of your Teacher's Guide for a more detailed assessment.

3. Learners must provide a heading for the graph, such as 'Graph showing the current in an electric circuit with different types of conducting materials being tested.' The type of material must be on the x-axis and the ammeter reading on the y-axis. The bars must not be touching in this type of bar graph as the data is not continuous. For a more detailed assessment, refer to Assessment Rubric 3.

Analysis and evaluation

1. This will depend on the materials used, but the material which has the lowest ammeter reading, and therefore the lowest current, has the highest resistance.
2. This will depend on the materials used, but the material with the highest ammeter reading will have the lowest resistance.
3. Learners' responses will vary, but the learners should mention that it is difficult to control the temperature of the conductors and that they should read the ammeter reading immediately upon adding their test material to the circuit.

Conclusions

1. The type of material from which the resistor is made affects the resistance. Different materials offer different amounts of resistance.
2. Length and thickness can also affect amount of resistance. We only want to test one variable at a time and therefore other variables must remain

Thickness of the conductor

INVESTIGATION: How does the thickness of the conductor affect the resistance? **(LB page 239)**

Possible hypotheses are:

- The thicker the conductor, the smaller the resistance.
- The thinner the conductor, the smaller the resistance.

Variables

1. The wires used must all be of the same material (for example, copper), the same length and the same temperature. The number of batteries used to provide energy in the circuit.
2. The independent variable is the thickness of the wire.
3. The dependent variable is the amount of resistance provided by the different wires, as measured by changes in current.

Results

A suggestion is to use three equal lengths of copper wire with different thicknesses.

An example table is shown here:

Table showing the ammeter readings for each thickness of wire used	
Wires of different thicknesses	**Ammeter reading (A)**
1 (thickest)	
2	
3 (thinnest)	

Learners must provide a heading for the table and each column, and the unit must be in the heading. You can also use Assessment Rubric 4 at the back of your Teacher's Guide for a more detailed assessment.

Analysis and evaluation

1. The thinnest wire offers the most resistance.
2. The thickest wire offers the least resistance.
3. Learners' responses will vary but the learners should mention that it is difficult to control the temperature of the conductors and that they should read the ammeter reading immediately upon adding their wire to the circuit.

Conclusion

1. The thickness of the wire does affect the resistance. The thinner the wire, the higher the resistance.
2. Learner-dependent answer.

Optional, online simulation:

If you have access to the Internet for your students, then you can do the activities listed in this subsection. The simulation referred to in the activity can be found here bit.ly/1cXLK35

Alternatively, the PhET simulation for investigating resistance in a wire listed in the Visit box can also be used.

The simulation opens by showing the value of the resistance of a 50 cm length of 26 SWG constantan wire as being 1,585 ohms. This resistance is given to three decimal places and shown in the yellow area of the display screen. There is a reset button at the top of the screen which will set the simulation back to the resistance of a 50 cm length of 26 SWG constantan wire.

There are various sliders on the screen where you can adjust the length, material type and cross-sectional area of the resistor. Take some time to familiarise yourself with the simulation before allowing the learners to use the simulation.

Here is an example of the investigation you could do.

INVESTIGATION: How does the length of a conductor affect the resistance of the conductor? **(LB page 241)**

Hypothesis
A possible hypothesis is: The longer the length of the conductor, the higher the resistance.

Materials and apparatus
The wire must be without any insulation. Copper wire often has varnish as insulation and therefore will not work. Nichrome or constantan wire work well (between 28 and 32 SWG – the SWG rating indicates the cross-sectional area of the wire). Other wires can also be used. The length is a suggestion only. If you are only able to obtain smaller lengths, the learners will take fewer readings. If you do not have an ammeter, use a light bulb as an indicator of current strength. You want about 3 V for this circuit so any combination of cells which provide 3 V would work, or a low voltage power supply.

Variables
1. The wires used must all be of the same material (for example, copper). The number of batteries used to provide energy in the circuit.
2. The independent variable is the length of the wire.
3. The dependent variable is the amount of resistance provided by the different length of the wire, as measured by changes in current.

Results
The results obtained in this investigation will depend on the type of material chosen and the SWG rating of the wire chosen.

The graph should have the independent variable (length) on the x-axis and the dependent variable (ammeter reading) on the y-axis. The graph should show that as the length of the resistance wire increases, the ammeter reading decreases. It is unlikely to be a straight line. Learners must provide a heading, such as "Graph showing the change in current in a circuit as the length of a conducting wire is varied."

As an extension, learners can rather calculate the resistance using the formula $R = V/I$ and then plot resistance versus length directly.

Conclusions
1. There is a relationship between the length of the resistor and the current strength. Increasing the length of the conductor decreases the current strength.
2. Current is affected by resistance. If the current has decreased, it must mean that the resistance has increased.

3. Increasing the length of the resistor increases the resistance of the resistor.

Optional, online simulation

If you have access to the Internet for your students, you can do an online simulation. The simulation referred to in the activity can be found here: [1] bit.ly/1cXLK35

Alternatively, the PhET simulation for investigating resistance in a wire listed in the previous visit box can also be used.

The simulation opens by showing the value of the resistance of a 50 cm length of 26 SWG constantan wire as being 1,585 ohms. This resistance is given to three decimal places and shown in the yellow area of the display screen. There is a reset button at the top of the screen which will set the simulation back to the resistance of a 50 cm length of 26 SWG constantan wire. There are various sliders on the screen where you can adjust the length, material type and cross-sectional area of the resistor. Take some time to familiarise yourself with the simulation before allowing the learners to use the simulation.

Here is an example of the investigation you could do.

Revision

1. Kettle, stove top plate, light bulb, heaters.
2. a) The element has a high resistance as it is opposing the electric current which causes the wire to heat up and glow.
   b) he electrical energy is transferred to the heating element. The heating element has a high resistance and so a lot of energy is transferred. The element glows and warms up. The heating element becomes very hot and transfers that energy to the bread to toast it.
   c) The light given off by the element can be considered as wasted energy as this is not used to toast the bread.
3.
   - length of material
   - type of material
   - temperature of resistor
   - cross-sectional area of resistor
4. Wire B has the higher resistance as it is longer. The longer the resistor, the higher the resistance as the electrons have further to move through the wire.
5. Wire A has the lower resistance. It has a thicker diameter and so there is less resistance as there is more space for the electrons to move through the wire.
6. a) This increases the surface area for heating. It allows a longer resistor in a smaller area to increase the efficiency of the stove.
   b) Electrical energy.
   c) Light and heat.
   d) The purpose of the heating element is to heat food. Most of the energy transferred to the element is used to heat the element. This means that most of the energy is useful. The energy which is used to produce light is not useful, but it is a small amount compared to the heat.

16 Series and parallel circuits

Unit overview

2 weeks

Learners have already been introduced to series and parallel circuits in Grade 8. However, they will now learn more detail about how the circuits function. They will be introduced to the concept of potential difference. It would be useful to revise some of the investigations covered in the Grade 8 syllabus as activities this year. Some of these activities have been included here in the Grade 9 workbook again. You can easily access the Grade 8 content online at [1] www.curious.org.za. This will help learners to remember and revise the concepts that they learnt a full year ago. If you feel that learners already grasp these concepts, then rather spend more time on the investigations. As an extension, you can do more calculations in class. Some calculations have been included here, such as calculating resistance given the potential difference and current.

Note: In CAPS, the term 'voltage' is predominantly used. However, in these workbooks, the term 'potential difference' is used as this is the correct scientific term. Potential difference is also the term used in FET level and beyond.

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.

A useful device to use in the investigations and activities in this Unit is a multimeter. Find out more about multimeters and how to use them in this video: [2] bit.ly/16qtjg6 Remember that you just need to type this link into the address bar in your Internet browser and press enter, in order to access the video.

16.1 Series circuits (3 hours)

Tasks	Skills	Recommendation
Investigation: What is the effect of the number of cells connected in series on current and potential difference?	Investigating, predicting, hypothesising, taking readings, observing, analysing and displaying data	CAPS suggested
Investigation: The effect of the number of cells connected in series on current strength and potential difference	Investigating, predicting, hypothesising, analysing, concluding	Optional PhET simulation investigation
Activity: Increasing the resistance in a series circuit	Following instructions, observing, describing, explaining	CAPS suggested
Investigation: Measuring the potential difference across components in a series circuit	Investigating, predicting, hypothesising, taking readings, observing, calculating, analysing	CAPS suggested
Activity: Check your knowledge of series circuits	Comparing, predicting, analysing, explaining	Optional revision
Activity: Current in a series circuit	Recalling, following instructions, drawing, taking readings, analysing, concluding	CAPS suggested

16.2 **Parallel circuits** (3 hours)

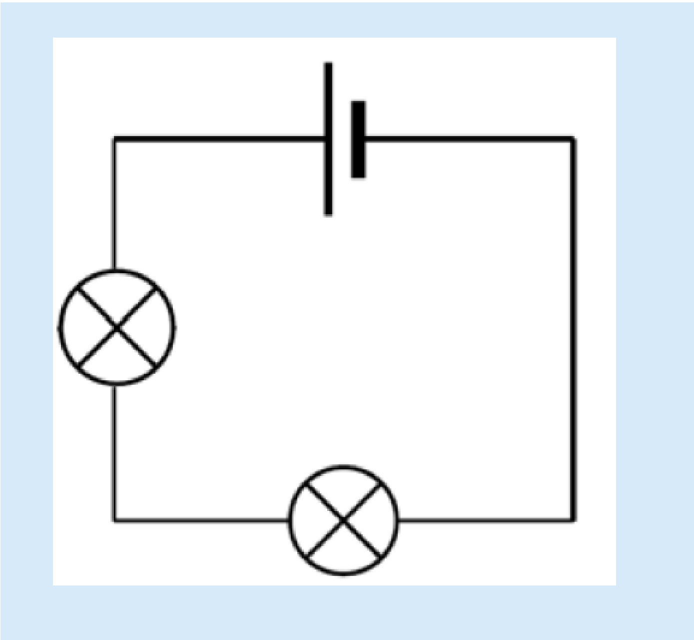
Tasks	Skills	Recommendation
Investigation: What happens to the current and potential difference in a circuit when adding cells in parallel?	Investigating, predicting, hypothesising, taking readings, drawing, observing, analysing	CAPS suggested
Activity: Adding resistors in parallel	Following instructions, observing, describing, explaining	CAPS suggested
Activity: Current in a parallel circuit	Recalling, following instructions, drawing, taking readings, calculating	CAPS suggested
Investigation: Measuring the potential difference across components in a parallel circuit	Investigating, predicting, hypothesising, taking readings, drawing, observing, analysing	CAPS suggested
Activity: Series and parallel circuits	Following instructions, observing, describing, explaining	CAPS suggested.

Key questions

- What happens when we add cells in series or parallel?
- What happens when we add resistors in series or parallel?
- What is potential difference?
- How do we connect ammeters and voltmeters in circuits?

16.1 Series circuits

The circuit diagram for the circuit on page 247 of the Learner's Book is as follows:



There is one cell and there are two resistors (light bulbs).

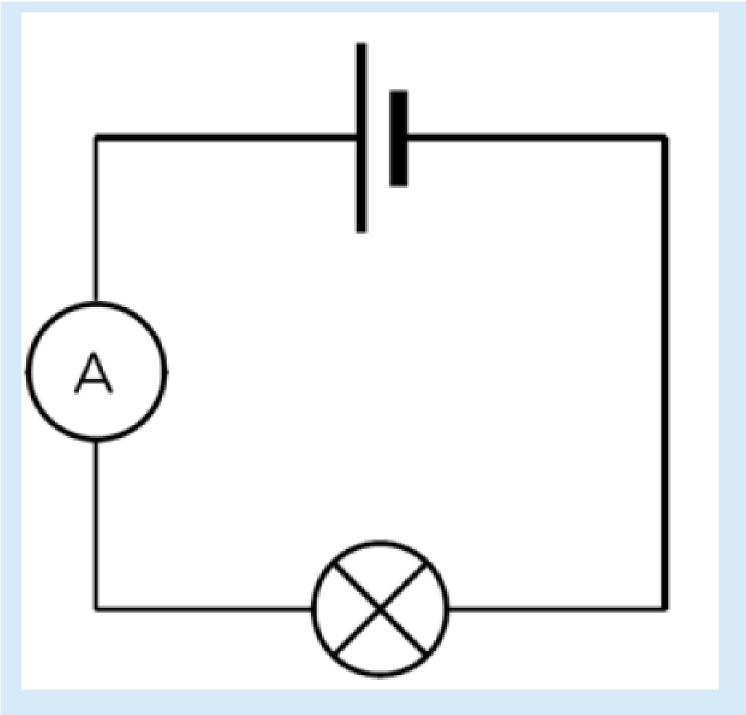
What is potential difference?

There Is a useful video to watch in order to explain potential difference and current to your learners, in terms of the analogy of a river. This video was not included in the Learner's Book as some of the concepts are beyond the scope of the curriculum at this stage, such as a coulomb of charge. bit.ly/Havmzk

Explain to the learners that if you connected the voltmeter in series in a circuit it would affect the current in the circuit as the voltmeter provides a very high resistance. So the current would not flow through the circuit, or there would be a very small current.

We use an ammeter to measure the current in a circuit. The ammeter is connected in series because we need to measure the current, so all the current must flow through the ammeter. The ammeter has a very small resistance so that it does not oppose the current and affect the reading.

The circuit should look as follows with the ammeter in series:



Cells in series

If you do not have sufficient equipment to allow all the learners to attempt these circuits, use the PhET simulation software which can be obtained from bit.ly/17vBMBX.

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 and 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 to 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.

INVESTIGATION: What is the effect of the number of cells connected in series on current strength and potential difference? **(LB page 252)**

Possible hypothesis
Increasing the number of cells connected in series will increase the current strength and potential difference in the circuit. Remember that a hypothesis does not have to be "correct"; it only needs to mention which variables are being considered and the relationship that is expected to be observed.

Results
Learners should plot the number of cells along the x-axis as this is the independent variable. Learners can draw two separate graphs. The plotted points must be visible and learners must draw a line of best fit. Learners must provide a heading for their graph.

Adding more cells in series increases the brightness of the bulb. Connecting more cells in series into a circuit increases the current strength in the circuit and the potential difference across the cells.

INVESTIGATION: The effect of the number of cells connected in series on current strength and potential difference **(LB page 254)**

This is an optional investigation. This is essentially the same as the previous investigation but relies solely on the PhET simulation software. The PhET simulation gives concise results which are easier to graph and does not require actual lab equipment.

Possible hypothesis
Increasing the number of cells connected in series will increase the current strength and potential difference in the circuit.

Conclusion
Connecting more cells in series into a circuit increases the current strength in the circuit and the potential difference across the cells.

Resistors in series

This is a revision activity of what learners covered in Grade 8. It can also be done concurrently with the following investigation to look at the effect on the potential difference.

The switch is not an essential part of this investigation. It can be left out of the circuit. If you do not have an ammeter, then use the brightness of the bulbs to indicate current strength.

Questions
1. The brightness of the bulbs decreased and so did the ammeter reading.
2. As the number of light bulbs increased, the resistance in the circuit increased. The increase in resistance caused the current to decrease.

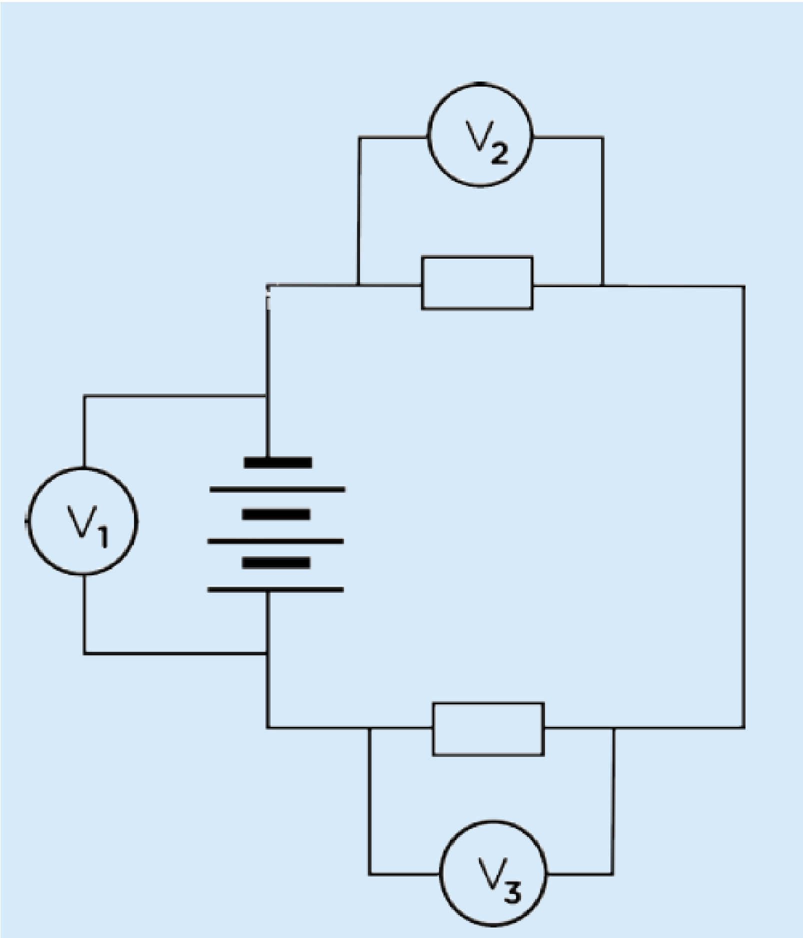
INVESTIGATION: Measuring the potential difference across components in a series circuit **(LB page 256)**

This will have to be a demonstration if you do not have enough equipment for the learners to do this in small groups. If you have access to the Internet, allow the learners to use the PhET simulations. Their results will also be more accurate as laboratory voltmeters might not be calibrated accurately enough.

If you do not have two different resistors, you can just use two light bulbs, but you will not then be able to make a direct comparison between potential difference and resistance if you do not know the resistances.

If the learners are doing this investigation in small groups, make sure that their circuits are correct and that the voltmeters are connected in parallel.

Results and observations



The orientation of the components in the circuit is not important. The battery can be drawn at the top, bottom or right-hand side of the circuit diagram. It is important that the learners have used the correct symbols; that the resistors and cells are in series with each other; and that the voltmeters are connected in parallel to the components they are measuring.

These readings will depend on the experimental set-up available in your school lab or on the PhET simulations. The trend should be that the readings on V_2 and V_3 add up to V_1.

Questions

1. Learners responses may vary but they should notice that the readings on V_2 and V_3 are less than that on V_1.

2. This answer will depend on the accuracy of the readings on the voltmeters. The learners should see that the sum of V_2 and V_3 is equal to the reading on V_1 (that is, V_2 and $V_3 = V_1$).
3. The resistor with the higher resistance has the higher potential difference across it.

Conclusion

The total potential difference across the battery is equal to the sum of the potential differences across each of the resistors. A resistor with a higher resistance will have a higher potential difference.

The potential differences across the two resistors must add together to give the potential difference across the battery. This means that the missing reading is 9 – 4 = 5 V.

ACTIVITY: Check your knowledge of series circuits (LB page 258)

This activity will allow the learners to practice and test their understanding of the concepts they have learnt so far. Let each learner make their own predictions. If you have access to the PhET software, allow each learner to set up the circuits using PhET to test their predictions. If you do not have enough equipment to allow individual learners to build the circuits, either build one set of circuits to demonstrate to the class or allow them to work in small groups. If the learners are in groups, make sure that each learner gets a turn to build a circuit in order to make sure they have the skills to do so. Learners should be left to make their own predictions without any help. This will also teach them the idea of making predictions (hypotheses) and testing them, the essence of scientific exploration. As a result, the predictions will be learner-dependent.

Instructions

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

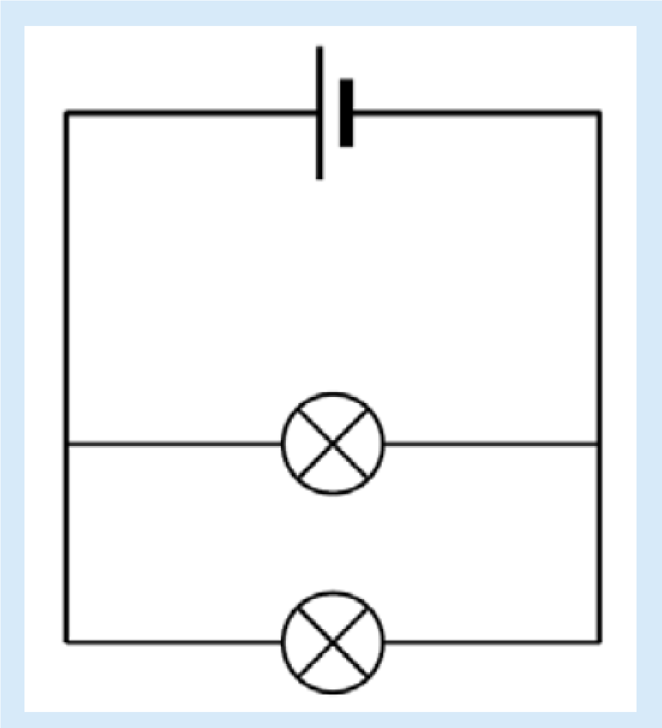
The brightest bulb should be in circuit III as it has the largest current with the least resistance. The dimmest bulb should be circuit VII as it has the smallest current with the largest resistance. The bulbs in circuits I, V and IX should be the same brightness if they are of the same resistance. Learners can test their predictions by setting up PhET simulations. Use the following website: bit.ly/17vBMBX

ACTIVITY: Current in a series circuit (LB page 259)

This is a revision activity as learners will have covered this in Grade 8. The ammeter readings should be the same at any point in the series circuit. The current strength is the same at any point in a series circuit.

TEACHER'S NOTE:

The circuit diagram should look as follows:



16.2 Parallel circuits

Cells in parallel

INVESTIGATION: What happens to the current and potential difference in a circuit when adding cells in parallel? **(LB page 260)**

If you do not have sufficient equipment to allow all the learners to attempt these circuits, use the PhET simulation software which can be obtained from bit.ly/17vBMBX

A possible answer: Increasing the number of cells connected in parallel will increase the current and potential difference in the circuit.

Remember that the hypothesis does not have to be "correct", but it must just mention the variables that are to be investigated and the relationship which is expected to be observe.

Connecting more cells in parallel into a circuit does not affect the current strength and the potential difference in the circuit.

When we connect cells in parallel we supply alternative pathways for the current to follow. This means that each of the cells last longer than if they were in a series circuit. Also if one cell fails, the circuit will still have another cell.

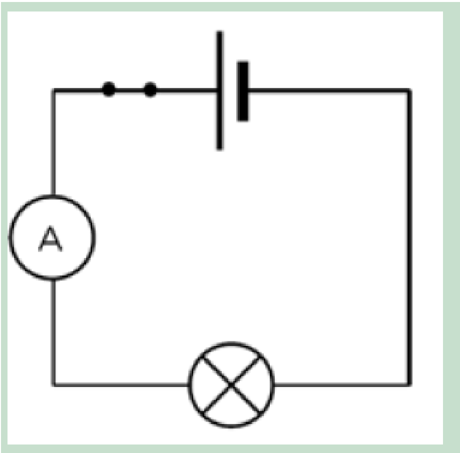
Resistors in parallel

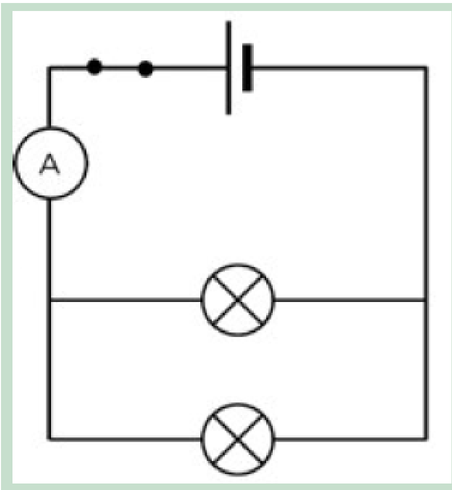
ACTIVITY: Adding resistors in parallel (LB page 262)

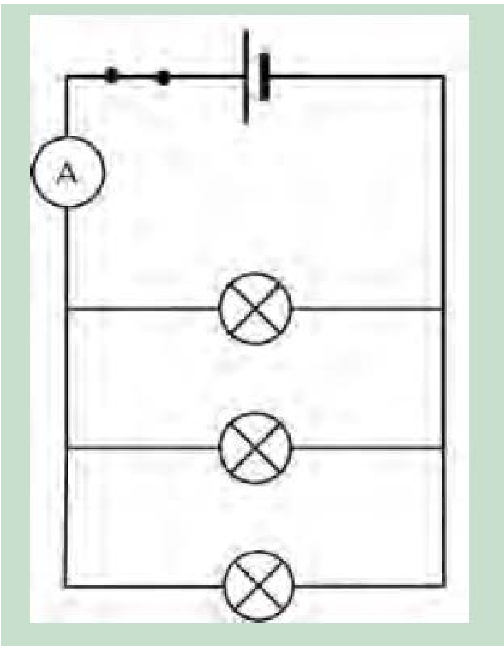
This activity is a revision of the investigation completed in Grade 8. The learners might have forgotten what happens in a parallel circuit and it is worth repeating the activity.

The switch and ammeter are not strictly necessary for this experiment. They can be left out if you do not have enough switches or ammeters.

Instructions

1.–3. 

4.–7. 

8.–11. 

Questions

1. The brightness increased and so did the ammeter reading.
2. As more resistors were added in parallel, the resistance of the circuit decreased as the current is

provided with alternative pathways, and the current increases with each resistor in parallel.

ACTIVITY: Current in a parallel circuit (LB page 262)

This is also a revision activity of what learners covered in Grade 8.

TEACHER'S NOTE

An example table is:

Table showing the ammeter readings at different positions in a parallel circuit	
Position of ammeter in circuit	**Ammeter reading (A)**
between the cells and first pathway	
in the first pathway	
in the second pathway	
in the third pathway	
between the first pathway and the cells	

Questions

1. The current in the main branch is bigger than the current in each pathway.
2. Learners should note that the currents in each pathway through the bulbs add up to the total current.
3. a) A1 = A4
   b) A1 = A2 + A3
   c) A4 = A2 + A3

INVESTIGATION: Measuring the potential difference across components in a parallel circuit **(LB page 265)**

If you do not have sufficient equipment to allow all the learners to attempt these circuits, use the PhET simulation software which can be obtained from bit.ly/17vBMBX

It would be sensible to use PhET simulations for this investigation because of the large amount of equipment required. If you do not have access to the PhET simulations, it would be a good idea to do this as a demonstration.

Hypothesis

This is learner dependent. The learners must state the relationship that they expect to see between the potential difference across the individual resistors and the potential difference across the battery. An example could be: The potential difference across each resistor is equal to the potential difference across the battery.

Materials and apparatus

You should use light bulbs or resistors of different strengths to demonstrate that the potential difference across each is still the same when they are connected in parallel.

If the learners are doing this investigation in small groups, make sure that their circuits are correct and that the voltmeters are connected in parallel.

Results

These readings will depend on the experimental setup available in your school lab or on the PhET simulations. The trend should be that the readings on V_2 and V_3 and V_1 are equal and that A_2 and A_3 add up to A_1.

1. Learners' responses may vary but they should notice that the readings on V_1, V_2 and V_3 are equal.
2. This answer will depend on the accuracy of the readings on the ammeters. The learners should see that the sum of A_2 and A_3 is equal to the reading on A_1.
3. The electrons have more than one path to follow, so some travel through the first path and the rest travel through the second path. All of the electrons travel through A_1.

Conclusion
The potential difference is the same across the battery and each resistor in parallel in a parallel circuit.

Extension
This is an extension to do some calculations which is not required at this level. However, they are very simple equations and also highlights to learners that one can calculate the resistance. It is also important that learners realise that they will do many calculations in Grades 10–12 should they carry on with Physical Sciences.

The video listed in the Visit box on 'Voltage, current and resistance' provides a clear explanation of the relationship between these concepts. The video also makes use of the PhET simulation to build electric circuits, available at this link: [4] bit.ly/1gqqTIa Watch the video to get a sense of how to use simulations in your classroom to explain and teach concepts.

Resistance of bulb 1 = V_2/A_2

Resistance of bulb 2 = V_3/A3

ACTIVITY: Series and parallel circuits (LB page 267)

This activity will show the learners the advantage of using a parallel circuit in a household circuit. When one light bulb is removed from a series circuit, the single pathway is broken and current no longer moves through the circuit.

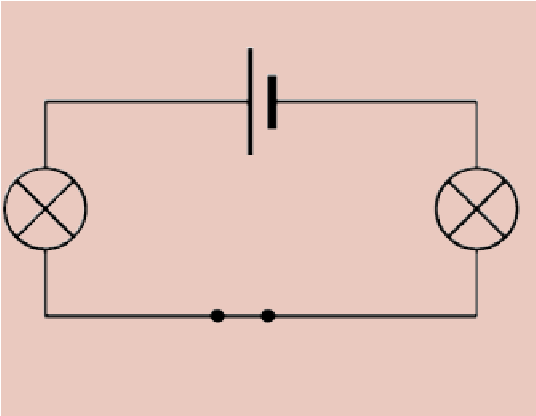
When one light bulb is removed from a parallel circuit, there is still a complete pathway for the current to move through and so the other light bulbs still function.

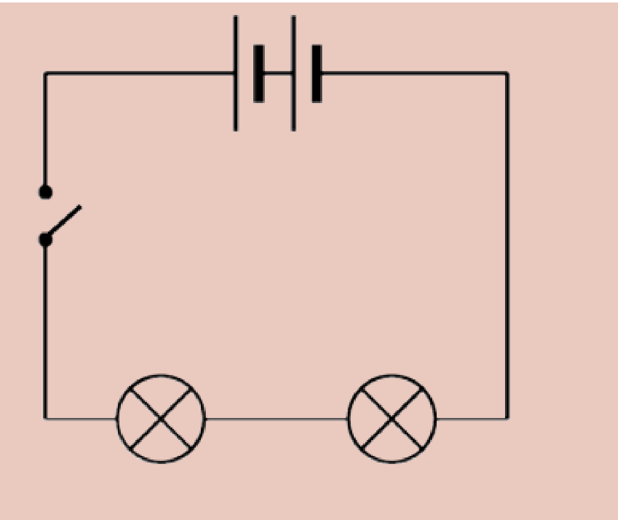
If you do not have sufficient equipment to allow all the learners to attempt these circuits. Use the PhET simulation software which can be obtained from [5] bit.ly/17vBMBX

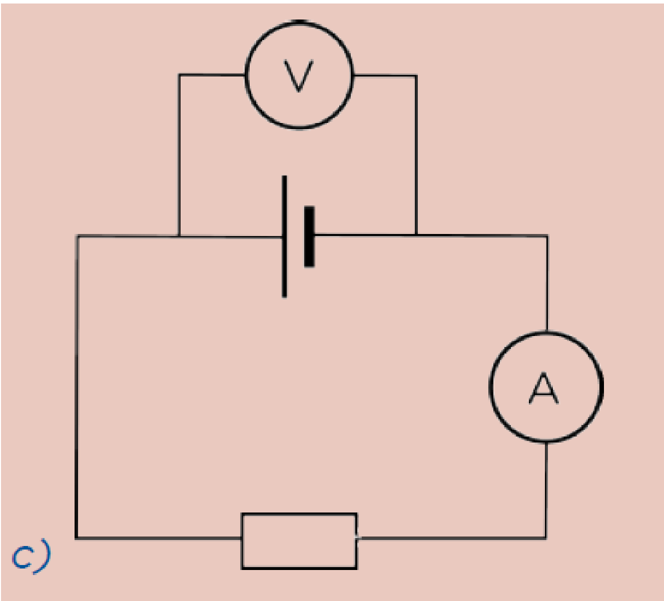
Instructions
1. Both torch lights are shining.
2. Both torch lights are no longer shining.
3. Both torch lights are shining.
4. The torch light bulb left in the circuit is still shining.

Questions
1. The single pathway in the series circuit was broken by the removal of the light bulb. This means that current can no longer move through the circuit and it stops working.
2. One of the pathways was broken by the removal of the light bulb but the other pathway provided an alternative for the current to travel through.
3. The parallel circuit would be more useful because light bulbs often break or fuse. If we use a parallel circuit, the rest of the light bulbs and appliances in the house can still function. If we use a series circuit, one broken appliance would mean that everything would stop working.

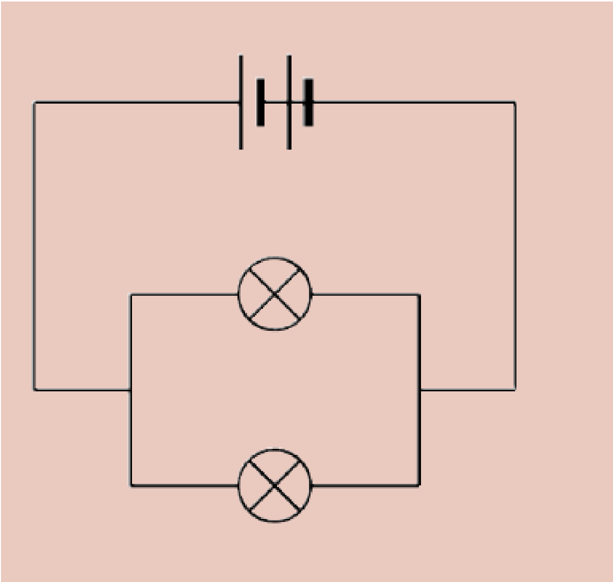
Revision

1. a) 

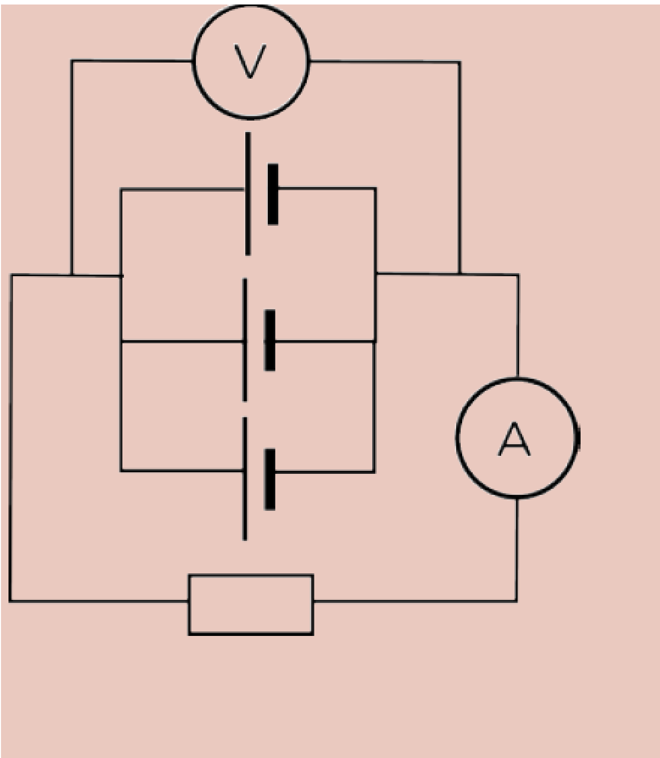
b) 

c) 

d)



e)



2. There are 3 cells in series with 1 bulb and a switch, there are two bulbs in parallel and a switch in series with one bulb.
3. a) The rest of the light bulbs stop working.
   b) The light bulbs are connected in series with each other. If one breaks, the circuit is broken and no current moves through the circuit.
4. This enables you to switch one light on in a room without turning all the lights on. If one part of the parallel circuit breaks, the rest of the circuit can still function as the other pathways are still complete.
5. a) $A_2 = 3$ A

   Note: There are many different possible variations on the diagrams in this question. You can change the values or the layout of the circuits in order to give extra practice to any learners that are struggling with this concept.

   b) The current is the same at all points in a series circuit.

6. a) A_1 = 7 A
   b) The current in a series circuits splits through each parallel branch such that the total current in the main circuit is equal to the sum of the currents in each branch.
7. a) V_3 = 4 A
   b) The potential differences across the battery in a series circuit is equal to the sum of the potential differences across each resistor.
8. a) V_2 and V_3 = 10 V.
   b) The potential difference across the battery in a parallel circuit is equal to the potential difference across each resistor in parallel.
   c) No bulbs will glow.
   d) Two bulbs will glow.
9. The value is 1,5 V.
10. a) V_2 and V_3 = 9 V. A_3 = 4 A.
    b) It would show 6 A.
    c) When switch S_2 is opened, the circuit becomes a series circuit and all the current goes through the one branch, through A_2, so A_1 and A_2 will show the same reading, 6 A.
    d) Bulb A has the higher resistance.
    e) Bulb A has the smaller current which goes through it, and therefore it must have the higher resistance as the larger the resistance, the smaller the current (they are inversely proportional).
    f) This is an extension question as the learners are not required to be able to calculate resistance. An example was covered in the content.
       Resistance in Bulb A = V/I = 9/2 = 4.5 Ω
       Resistance in Bulb B = V/I = 9/4 = 2.25 Ω

17 Safety with electricity

Unit overview

0.5 weeks

This is a short unit on safety practices and devices associated with electricity. It is important that learners understand the dangers associated with electricity and how accidents and faults can be avoided.

Learners are introduced to various safety devices which are commonly used in appliances and circuitry in order to reduce the risk of electric shocks. Many of these safety devices will be unfamiliar to the learners as they are inside electrical appliances and not seen. It is very important that all learners are able to safely connect a three-pin plug because short circuits can be caused by faulty wiring of plugs.

CAPS dedicates half a week (1.5 hours) to this Unit. However, there are several activities which are worth doing, and also suggested in CAPS. A recommendation is to spend slightly more time than is allocated in CAPS on this Unit, and slightly less time on Unit 7 on the 'Cost of electrical power' as this Unit does not actually need 2 weeks to teach.

A suggestion is to invite in a certified electrician to share case studies of dangers of faulty electricity and discuss briefly the legislation regarding certifying a house before selling it.

17.1 Safety practices (1 hour)

Tasks	Skills	Recommendation
Activity: Making your own fuse	Demonstration, following instructions, observing, describing, drawing, explaining	CAPS suggested
Activity: Drawing circuit diagrams with fuses	Accessing and recalling information, communicating (graphically)	CAPS suggested
Activity: Wiring a 3-pin plug	Following instructions, observing, recording, describing	CAPS suggested
Activity: Wiring a house	Accessing and recalling information, communicating (graphically)	CAPS suggested

17.2 Illegal connections (0.5 hours)

Tasks	Skills	Recommendation
Activity: Case study on illegal electricity connections	Accessing and recalling information, interpreting, explaining	CAPS suggested

Key questions

- How safe is my electricity connection?
- What is a short circuit?
- Why do plugs have three wires?

17.1 Safety practices

ACTIVITY: Making your own fuse (LB page 274)

This is a simple way to demonstrate how a fuse works. Learners will make a small fuse from steel wool. Make sure that you use a heat resistant tile or block under the fuse because it will become hot and burn up. An old ceramic tile or piece of wood would work best.

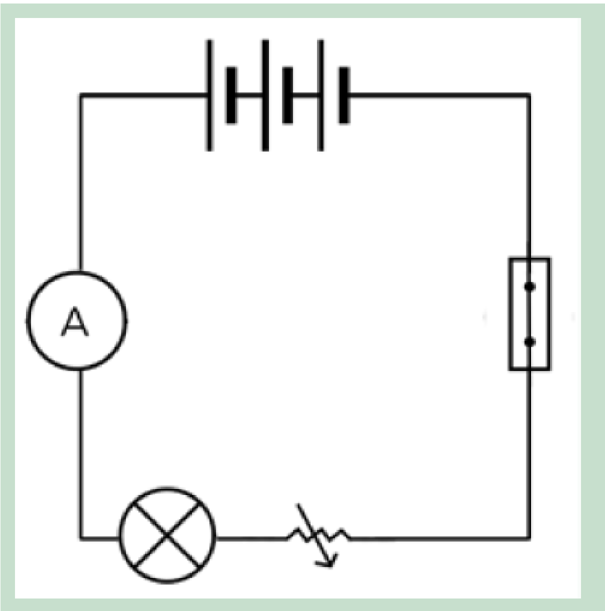
Fuses are a practical application of the heating effect of an electric current. If you have enough equipment you could allow small groups of learners to complete this activity. Otherwise, use it as a demonstration.

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 speeds up until it melts the steel wool.

If you are demonstrating and you want to make the activity more exciting then 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.

Questions

1. 

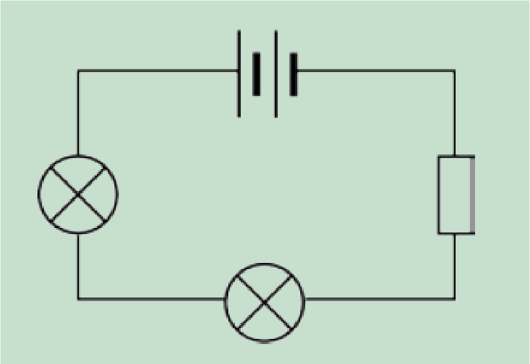
2. The light bulb is a good indicator of whether or not there is a current in the circuit. If the light bulb glows it means there is electric current. If the light does not glow it means that there is no current (or there is a very small current).

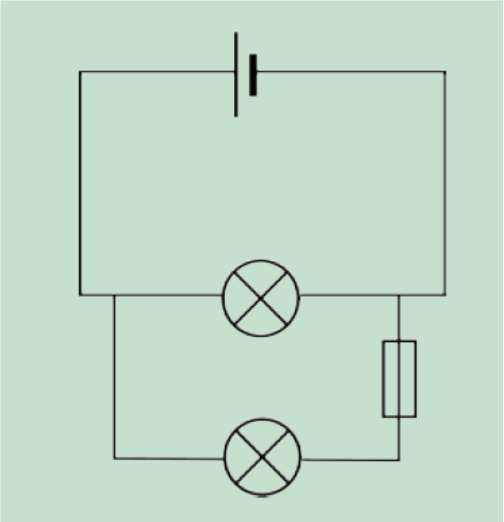
   Note: Sometimes though there might still be a very small electric current, but it does not provide enough energy to cause the light bulb to glow. This is why the light bulb gives a good indication, but an ammeter will provide the most definitive indication of whether there is a current or not.

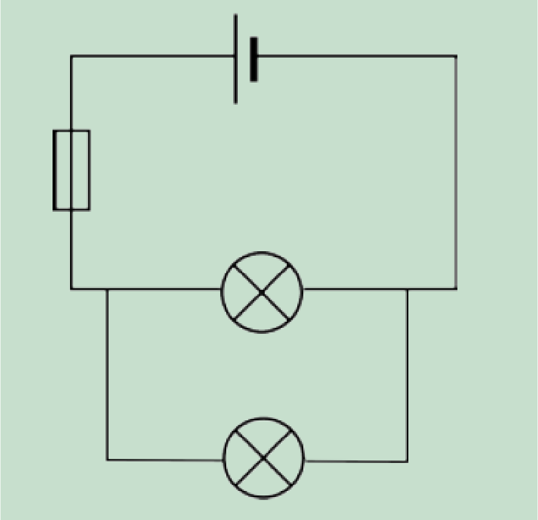
3. The current increases when the resistance decreased. The ammeter reading increases.

4. The current stops because the circuit has been broken. There is no longer a complete pathway for the electrons to move.

ACTIVITY: Drawing circuit diagrams with fuses (LB page 276)

1. 

2. 

3. 

Circuit breakers

A good idea is to identify the circuit/distribution board in your school and take learners to see it so that they can see the switches.

Wiring a 3-pin plug (LB page 279)

Wire	Colour
Neutral wire	Blue
Earth wire	Green-and-yellow striped
Live wire	Brown

It is important that the learners get to practise this themselves. You do not need a 3-pin plug for each child. Divide the class into small groups and give each group one set of apparatus. Each learner in the group can then have a turn to wire the plug and then undo the plug for the next learner to have a turn.

Stress the importance of stripping the wires carefully. If the copper wires are cut or damaged then it can lead to an unsafe plug being used.

Materials

1. The green-and-yellow earth wire is always connected to the uppermost pin.
2. When viewed from the underneath of the plug, the blue neutral wire is always attached to the pin on the right.
3. When viewed from the underneath of the plug, the brown live wire is always connected to the pin on the left.

Learners must note that here in the activity they used plugs which are not connected to an electrical appliance. So, when using an actual electrical appliance, they must make sure that the appliance is not turned on or does not have any other connection. They must also work on a dry surface.

ACTIVITY: Wiring a house (LB page 280)

It is not necessary for the learners to build a model of this circuit. The learners need to plan how they can set up a circuit for the house which would allow each room to have a light which switches on and off without breaking the entire circuit. In other words, they will need to set up a parallel circuit with switches in each branch. The house should have a main switch capable of switching off all of the lights and a fuse, in case of overload.

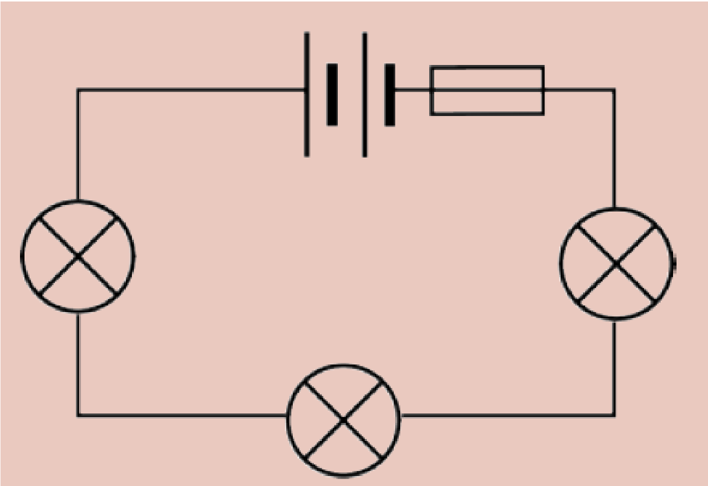
17.2 Illegal connections

ACTIVITY: Case study on illegal electricity connections (LB page 281)

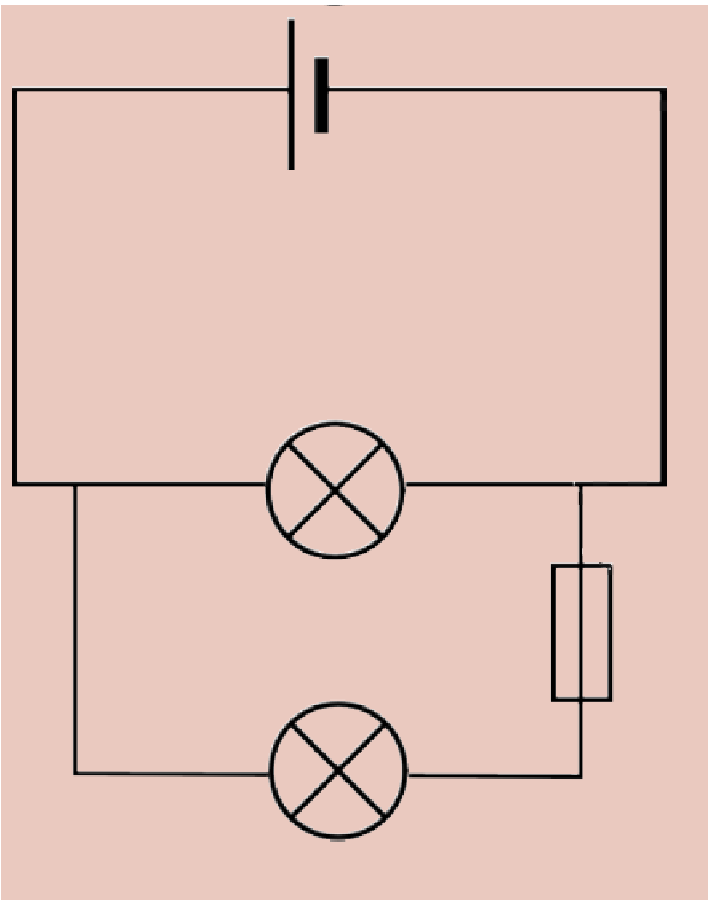
1. An informal settlement is a settlement that has not been planned by city planners. This means that there are no proper roads or housing developments. There are also no sanitary, water or electrical services in place before people settle on the land.
2. The residents settled on privately owned land which did not have electrical connections on site.
3. The wires are not always insulated and touching live electrical wire can cause electrical shock.
4. The illegal connections can electrocute passers-by, cause fires, and the wires hung very low over the main road which would then catch on trucks passing through.
5. Eskom is not being paid for the electricity used by the residents. This means that they are losing money because they are indirectly providing the electricity.

Revision

1. A fuse is a low resistance wire which will melt if the current is too strong. The fuse melts and breaks the circuit. This stops the electric current and prevents fires or other safety hazards.
2. The 3 A fuse would burn out and the fan would not work.
3. The fuse should have a rating higher than 8 A so that it would only burn out if the current was bigger than 8 A.
4. The circuit breaker can be reset but the fuse is destroyed and so needs to be replaced each time.
5. If the problem is not fixed then the current will still be too big and the new fuse will also "blow". The circuit might be dangerous to operate. You might risk an electric shock.
6. A short circuit is an alternative pathway with an extremely low resistance. All of the current will move through the short circuit. Because of the low resistance the current increases and can cause an overload on the circuit.
7. The current is very strong in the short circuit and there is a danger of electrocution. If someone touches the short circuit or acts as the short circuit then they could get badly hurt or killed.
8. Brown.
9. Make sure that the electrical supply is switched off. Work on a dry surface.
10. The green and yellow wire is the earth wire. It ensures that any surge in current due to an electrical fault is safely grounded.
11. Learners must draw a basic outline of a plug with three circles. The top wire is the green-yellow striped earth wire. The blue neutral wire is always attached to the pin on the right when viewed from the bottom. The brown live wire is always connected to the pin on the left when viewed from the bottom.
12. a)



b)



18 Energy and the national electricity grid

Unit overview

1 week

This Unit revises the work covered in Grades 7 and 8, with an emphasis on nuclear fuel. Try to arrange an excursion to a power plant or ask if an engineer is able to come to the school to explain how the power plant operates and to answer questions posed by the learners. This would provide an opportunity for the learners to ask questions about careers in the electrical industry. Here is a link to the Wikipedia article which lists all the power stations in South Africa.bit.ly/15vo5Vk

Here is a table summarising some of the various power stations in South Africa and which province they are located in, for your reference. The only nuclear power station is Koeberg Power Station in Cape Town.

Coal-powered stations

Power station	Province
Arnot Power Station	Mpumalanga
Bloemfontein Power Station	Free State
Camden Power Station	Mpumalanga
Duvha Power Station	Mpumalanga
Kelvin Power Station	Gauteng
Lethabo Power Station	Free State
Matimba Power Station	Limpopo
Pretoria West Power Station	Gauteng

Hydroelectric Power Stations

Power station	Province
Drakensberg Pumped Storage Scheme	Free State
Gariep Dam	Free State-Eastern Cape border
Ingula Pumped Storage Scheme	Kwa-Zulu Natal
Kouga Dam	Eastern Cape
Palmiet Pumped Storage Scheme	Western Cape
Steenbras Pumped Storage Scheme	Western Cape
Vanderkloof Dam	Northern Cape

18.1 Electricity generation (1 hour)

Tasks	Skills	Recommendation
Activity: Hydroelectric power	Following instructions, observing, identifying, describing, explaining	CAPS suggested
Activity: Alternative energy power stations	Research, summarising, comparing, discussing, writing	CAPS suggested (this can be used as a possible project)

18.2 Nuclear power in South Africa (1.5 hours)

Tasks	Skills	Recommendation
Activity: Advantages and disadvantages of nuclear power	Researching, comparing, discussing, debating, writing, working in groups	CAPS suggested

18.3 National electricity grid (0.5 hours)

Key questions

- How is electricity generated in a power station?
- What energy sources are used in South Africa to generate electricity?

- Is nuclear energy the best way to solve the energy crisis?
- What are the advantages and disadvantages of nuclear power?
- How is electricity distributed from power stations to our homes?

18.1 Electricity generation

Coal is a non-renewable energy source as there is a finite amount and it cannot be replenished.

Discuss the disadvantages of South Africa's reliance on coal as the main source of energy in power stations with your class. This is revision of what learners have covered in previous grades. The main disadvantages are:

- The use of coal is not sustainable as coal is a non-renewable energy source.
- The use of coal has serious negative environmental impacts. Burning coal releases greenhouse gases which build up in the atmosphere. This contributes to the formation of acid rain and the greenhouse effect, leading to global warming.

Alternative energy sources include:

- wind
- falling water (hydroelectric)
- sun-heated steam
- nuclear fission
- tidal energy (waves in the sea)
- biofuels.

ACTIVITY: Hydroelectric power (LB page 287)

If you cannot findt an aluminium foil plate, you could use thick cardboard.

The cardboard wheel will not last long when exposed to water, so you will have to take that into account. You cannot use the same wheel over again.

Questions

1. The wheel turns.
2. The mass piece is pulled upwards by the turning pencil, as the string wraps around the pencil.
3. The water has gravitational potential energy which is converted to kinetic energy as it falls from the tap. The kinetic energy is transferred to the blades of the wheel. The kinetic energy of the turning blades is transferred to the pencil. The spinning pencil pulls the string upwards, which pulls the mass piece. The kinetic energy of the pencil is transferred to the gravitational potential energy of the mass piece as it moves upwards.
4. **Note:** The following questions can be used as a revision task the next day in class or as a homework task. The water has gravitational potential energy.
   a) The gravitational potential energy is transferred to kinetic energy as the water moves/flows down.
   b) It has kinetic energy.
   c) The electrical system is made up of the generator, the power lines and then the houses/buildings in the city.
   d) The city gets electricity to run appliances, machines, equipment, lights and heating systems.

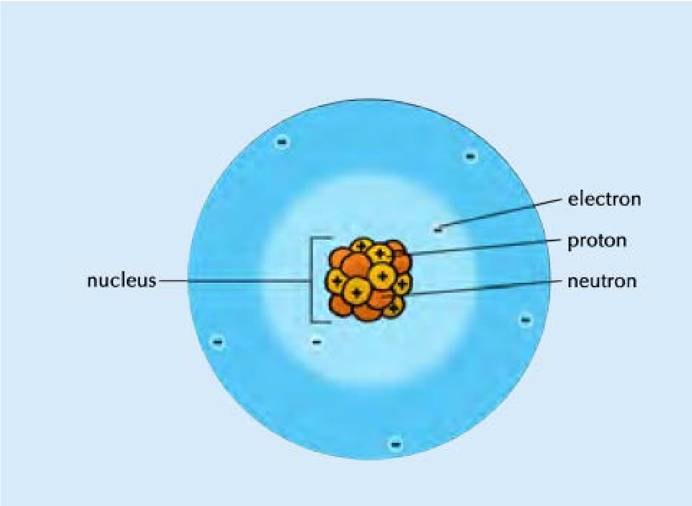
ACTIVITY: Alternative energy power stations (LB page 291)

This can be used as a possible research project where learners research one of the alternative power stations in South Africa and present a poster on their findings. They must find out information about the sustainability and environmental impact of the alternative energy power station and compare this to a coal-powered power station.

Learner-dependent answer.

18.2 Nuclear power in South Africa

The labelled atom should look as follows:



ACTIVITY: Advantages and disadvantages of nuclear power (LB page 293)

The biggest advantage is that nuclear power does not depend on fossil fuels. Fossil fuel power stations release huge amounts of carbon dioxide into the atmosphere which contribute to the greenhouse effect and climate change. It is therefore also not affected by the constantly changing oil and gas price. The use of nuclear fuel is also very efficient as huge amounts of electricity are generated using only a small amount of fuel. This is due to the extremely large amounts of energy released during nuclear fission. We are not about to run out of nuclear fuel.

Research and debate

The debate over whether or not nuclear energy is the answer to a growing international energy crisis is very relevant. This is an opportunity for the learners to do some research into the pros and cons of increasing the world's reliance on nuclear energy. It would be a good idea to encourage the learners to find reputable sources of information. They should look at articles and research written by scientists and those with real expertise and knowledge rather than lay people. Arrange the class into two groups; those for the use of nuclear energy and those against the use of nuclear energy. Allow each group to research evidence to support their stance and then let them debate as a class.

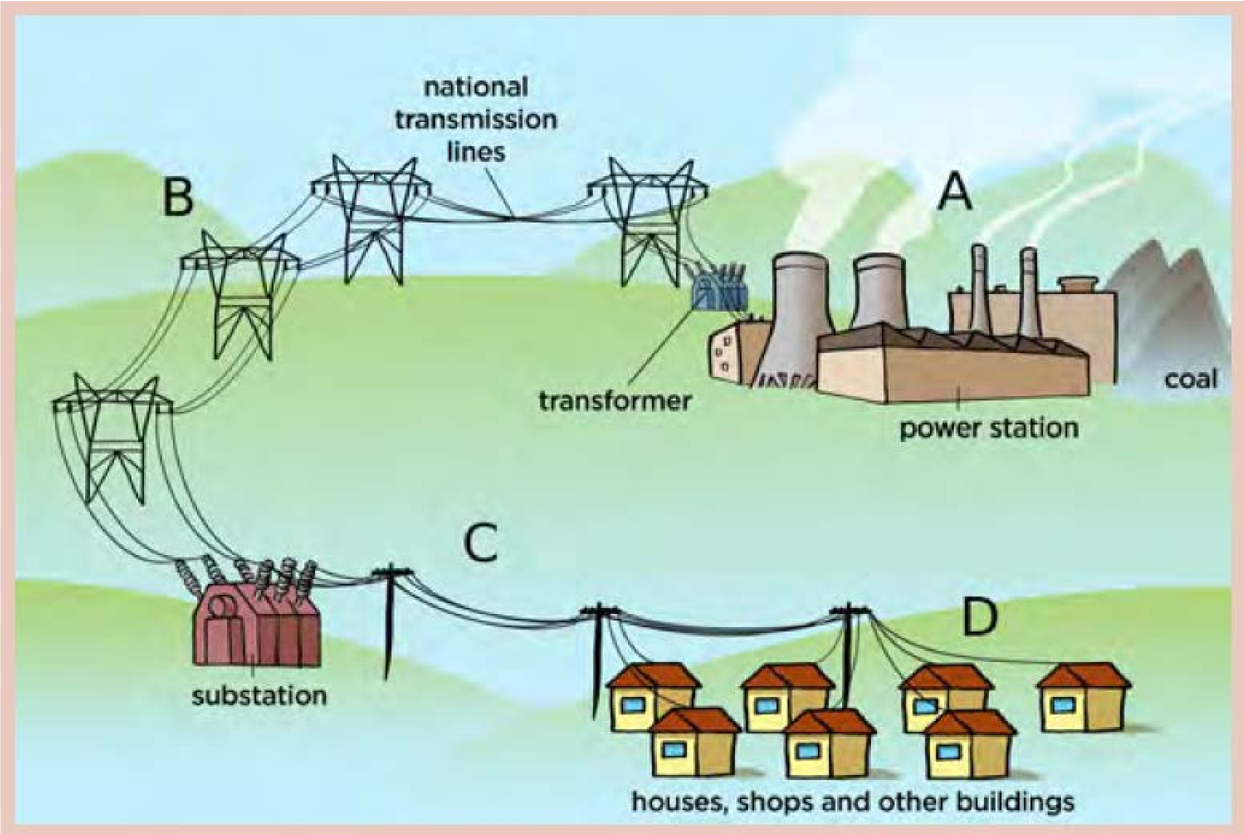
There is no correct conclusion to the debate. It would be interesting to see if the research and debate causes some of them to change their stance, whether they are for or against. A suggestion is to watch the TED talk on nuclear energy.

18.3 National electricity grid

Transferring electricity at very high currents through wires that have resistance would cause the wires to become hot and so a lot of energy would be wasted in the form of heat to the surroundings.

Revision

1. This is because the power lines make up a grid across the country which is a closed circuit. It is a system.
2. Coal.
3. This is because the main source of energy is still coal. Any other form of energy is an alternative to the main form of coal.
4. The paragraph must contain the following points:
   - the coal is mined and delivered to the coal station
   - the coal is pulverised to make it finer
   - the coal is burned in a furnace
   - the energy is used to boil water
   - the steam turns the turbine
   - the turbine turns a generator which produces electricity
5. The coal is burned and releases energy. The energy released by the burning coal is used to heat the water. The water particles have enough energy to change from liquid to vapour. The steam rises and the kinetic energy of the steam particles is transferred to the blades of the turbine. The turbine blades gain kinetic energy and turn.
6. Nuclear power is the use of nuclear reactions (nuclear fission) to produce useful heat and radiation.
7. In Koeberg, just outside Cape Town.
8. Nuclear fission is when an atomic nucleus is split into two smaller nuclei and nuclear fusion is when two atomic nuclei are joined together to form a bigger one.
9. The paragraph should include the following points:
   - Coal-fired power station burns coal to produce heat needed to boil water to produce the steam that turns the turbine.
   - Nuclear power stations use nuclear fuel to generate heat by nuclear fission to heat the water to produce steam to push the blades of the turbine.
   - Both stations turn a turbine which turns a generator.
10. Learners should discuss how the mining of coal damages the environment. They must also discuss the fact that the burning of fossil fuels generates an increase in the amount of greenhouse gases in the atmosphere which contributes to climate change. Learners can discuss the fact that nuclear fuels do not generate greenhouse gases. However, the spent nuclear fuel is still radioactive and therefore needs to be stored safely for very long periods of time so that it does not damage the environment or any organisms.
11. a) France.
    b) t is 5 %.
    c) Not all countries have nuclear power stations, so only those with nuclear power are shown here.
    d) Learners must draw a bar graph with the bars which do not touch [1 mark]. They must provide a heading [1 mark], labels for each of the axes [2 marks], and plot the correct percentages for each country listed [3 marks].
12. The national grid is a system as it is made of different parts working together to deliver electricity. A change in one part of the grid will affect other parts.

13. 

14. There is resistance in the transmission lines. If the current is very high then a lot of energy is lost to the lines in the form of heat. It is expensive to produce electricity and we don't want to waste any. If the current is low then less energy is wasted in the lines.
15. Transformers are used to change the voltage from high to a low voltage so that the appliances in our homes are not damaged.
16. The sensitive circuits in a computer require small currents. A power surge puts a large current into the circuit. This can damage the wiring in the circuit and stop it from working.

19 Cost of electrical energy

Unit overview

2 weeks

This unit deals with the costs involved when using electricity. Some learners will have prepaid electricity meters in their homes, while others will be billed monthly according to their usage. Whichever way they are billed, they need to have an understanding of how the charges are calculated. In order to simplify the calculations, we need to assign a tariff. Eskom uses a sliding tariff scale and so it can sometimes be tricky to calculate exact costs.

IMPORTANT NOTE:

This Unit has been called '**Cost of electrical energy**' and not 'Cost of electrical power' as in CAPS. We do not pay for power, we pay for electrical energy.

The following statements in CAPS are **incorrect**:

- consumers pay for the quantity of *power* they use
- quantity of electrical *power* used is measured in kWh (kilowatt hour).

The points should rather read:

- consumers pay for the quantity of *energy* they use
- quantity of electrical *energy* used is measured in kWh (kilowatt hour).

The kilowatt hour is not a measure of power (which is measured in watts). 1 kWh is equal to 3,6 million joules. Joules is the SI unit of energy, but it is a small unit and is therefore not a suitable unit to use on electricity bills. We therefore use the kilowatt hour to measure the energy consumed.

19.1 What is electrical power? (1 hour)

Tasks	Skills	Recommendation
Activity: Power rating of different appliances	Observing, researching, comparing, listing, calculating	CAPS suggested

19.2 The cost of energy consumption (5 hours)

Tasks	Skills	Recommendation
Activity: Calculating energy consumption	Comparing, calculating	CAPS suggested
Activity: Calculating the cost of electrical energy	Comparing, calculating, analysing, justifying, explaining	CAPS suggested
Activity: Home survey	Researching, collecting data, calculating, analysing	CAPS suggested
Activity: Comparing the energy efficiency of different light bulbs	Comparing, describing, calculating, explaining	CAPS suggested
Activity: Career research	Researching, working in groups, writing, presenting	CAPS suggested

Key questions

- What is electrical power?
- How do we measure electrical power?
- Do different appliances use different amounts of energy?
- How do we know how much power we are using?

- How do we measure our use of electrical energy?
- How can we work out how much our electricity costs?
- How can we reduce our energy consumption?

19.1 What is electrical power?

Refer learners to the pictures on page 300 of the Learner's Book. The electric pan uses much more power than the fan.

ACTIVITY: Power rating of different appliances (LB page 301)

If possible, bring some different appliances to class, such as a kettle, toaster or iron, to show learners the labels with the power ratings on them. You can also walk around the school and identify the different power ratings on appliances around the school. Bring newspapers to school to use the advertisements section to allow learners to also study the appliances and to identify the power ratings. Bring in different light bulbs which have different power ratings to show these to learners.

Below are the power ratings for the appliances given here. Learners must also identify others.

Appliance	**Power (W)**
Toaster	700
Electric beater	175
Television	54
Urn	1 500

Questions

1.

Joules (J)	**Kilojoules (kJ)**
120	0,12
34 000	34
1 230	1,23
24 600	24,6

2.

Watts (W)	**Kilowatts (kW)**
1 760	1,76
4 560	4,56
25	0,025
560	0,56

3. Learner-dependent answer, depending on the appliances listed. Learners will find that appliances which provide heat use much more energy than appliances, like a fan or radio, which supply movement and sound respectively.
4. Appliances involving heating, such as kettles, toasters, irons, heaters, use a lot of power.
5. a) power = energy/time = 180 000 / 1 800 = 100 W
   b) power = energy/time = 100 000 000 / 60 = 1 666 666,67 W

19.2 The cost of energy consumption

ACTIVITY: Calculating energy consumption (LB page 303)

Seconds (s)	Minutes (min)	Hours (h)
620	10,33	0,172
120	2	0,033
7 620	127	2,12
56 400	940	15,67
16 200	270	4,5
44 100	735	12,25

Questions

1. 3600 W = 3,6 kW; energy consumption = power x time = 3,6 x 1 = 3,6 kWh
2. 2200 W = 2,2 kW; 6 minutes = 0.1 hours; energy consumption = 2,2 x 0.1 = 0,22 kWh
3. 3600 W = 3,6 kW; energy consumption = 3,6 X 1,5 = 5,4 kWh
4. **120 W light bulb:** 120 W = 0,12 kW; energy consumption = 0,12 x 2 = 0,24 kWh.
   60 W light bulb: 60 W = 0,06 kW; energy consumption = 0,06 x 3,5 = 0,21 kWh
   Therefore, the 120 W light bulb uses more power.

ACTIVITY: Calculating the cost of energy consumption (LB page 306)

The unit price of electricity varies with consumption. The price indicated here was as it was in 2013 for a particular usage. You can also use other rates in your calculations with your class and specify them upfront.

Questions

1. cost = 320 kWh x 71,65
   = 22928 cents
   = R229,28
2. 12 minutes = 0,2 hours
   1 360 W = 1,36 kW
   6 000 W = 6 kW
   microwave oven: cost = 1,36 x 0,2 x 71,65 = 19,49 cents = R0,19
   conventional oven: cost = 6 x 1 x 71,65 = 429,9 cents = R4,30
   The microwave is cheaper to run than a conventional oven.
3. 100 W = 0,1 kW
   40 W = 0,04 kW
   incandescent light bulb = 0,1 x 1 x 71,65 = 7,165 cents = R0,07
   fluorescent light bulb = 0,04 x 1 x 71,65 = 2,866 cents = R0,03
   The fluorescent light bulb is cheaper.
4. R15 = 1 500 cents
   105 W = 0,105 kW
   Number of kWh = 1500/71,65 = 20,94 kWh
   number of hours = 20,94/0,105 = 199,43 hours
5. 1600 W = 1,6 kW
   30 minutes = 0.5 hours
   cost = 1,6 x 0.5 x 71,65
   = 57,32 cents = R0,57

6. 4800 W = 4,8 kW
   cost = 4,8 x 2,5 x 71,65
   = 537,375 cents
   = R5,37
7. A family can install a solar water heater to use to heat water instead of a geyser. This uses solar power and therefore reduces the family's energy consumption, saving electricity and money.

ACTIVITY: Home survey (LB page 307)

1. The length of the table will depend on the number of appliances in each learner's home. Learners' answers will vary. They should perform a separate calculation for each appliance in their home and then add the amounts together to get the total cost of electricity.
2. Here is an example of what a calculation might look like for a light bulb of 120 W which runs for 2 hours per day. You should encourage learners to follow these steps:

   Step 1: Write down the formula
   cost = power rating x time x price

   Step 2: List all the given values in a problem
   power rating = 120 W = 0,12 kW

   time = 2 hours

   price = 71,65 c/kWh

   Step 3: Substitute the given values into the formula to find the unknown
   cost = 0,12 x 2 x 71,65

   = 17,196 cents

   Step 4: Write down the solution on its own line with the units.
   Cost of electricity is 17 cents (R0,17)

   All of these answers will depend of the electrical appliances used in the learner's home. It is important to check that they are using the formula correctly and that they are converting watts to kilowatts and cents into rands.

Questions
1. Learner-dependent answer.
2. Learner-dependent answer.
3. This answer is learner-dependent. Some learners might only have a few electrical appliances and would not be in a position to reduce usage. Some learners may indicate that they could be more efficient in their use of electricity. They could switch off unnecessary lighting. Use blankets and other forms of insulation rather than using electrical heaters in winter etc. You may find that some learners are already using geyser blankets and solar panels. Those learners may indicate that they are already doing what they can to reduce electricity use.

ACTIVITY: Comparing the energy efficiency of different light bulbs (LB page 307)

More information comparing these three types of lights is available here: bit.ly/17ytE0y

Questions

1. LED
2. incandescent
3. These three light bulbs all emit the same number of lumens, so they can all provide the same amount of light.
4. LED: cost = 0,008 x 5 x 365 x 71,65 = 1046,09 cents = R10,46
   Fluorescent: cost = 0,015 x 5 x 365 x 71,65 = 1962,42 cents = R19,61
   Incandescent: cost = 0,06 5 x 365 x 71,65 = 784,68 cents = R78,46
5. The answer is learner-dependant. Learners should recognise that the LEDs are cheaper to run from day-to-day, although their initial cost is relatively expensive.
6. The LED light uses less electricity for the same light output. This means that less electricity is consumed. If everyone is using LED lights, the overall demand for electricity would be lower and so if less electricity is produced there would be less pollution.

ACTIVITY: Career research (LB page 308)

This is an opportunity for the learners to be made aware of the many different career paths available in the electrical energy sector. There is a short list of suggested careers to research, but encourage the learners to find more. Have the learners work in small groups to do their research and then have then report their findings back to the class.

Questions

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

The Zooniverse website provides a great overview of the various citizen science projects that learners can get involved in. There is a huge variety of projects, from helping to identify possible planets around stars, analysing real life cancer data, looking at tropical cyclone data, or listening to the calls from whales or bats. And there are also many others. Citizen science is scientific research which is conducted in whole or in part by nonprofessional scientists, specifically the general public. Encouraging learners to get involved in some of these projects will open their eyes to the possibilities out there, and also add meaning and value to what they learn within the Natural Sciences classroom. bit.ly/14JxLsw

Revision

1. a) 1400 W
   b) 120 W
2. Energy saver globe, incandescent light bulb, fridge, toaster, microwave, vacuum cleaner, washing machine, kettle, stove.
3. Learners should explain that it is the amount of electrical energy transferred per second.
4. 1 watt of power is equal to 1 joule of energy supplied in 1 second.
5. This means that the stove uses more power than the microwave as the stove uses 3600 joules of energy per second, whereas a microwave uses 1200 joules of energy per second.

6.

Joules (J)	Kilojoules (kJ)
145	0,145
134 000	134
1 650	1,65
32 120	32,12
Watts (W)	**Kilowatts (kW)**
1 850	1,85
3 790	3,79
32	0,032
485	0,485

7. power rating = 1500 / 1000 = 1,5 kW
   time = 3 x 28 = 84 hours
   energy consumption = 1,5 x 84 = 126 kWh
8. power rating = 1000/1000 = 1 kW
   time = 1 x 31 = 31 hours
   energy consumption = 1 x 31 = 31 kWh
9. a) Energy consumed = 4566 – 3456 = 1110 kWh
   b) energy = 1110 kWh
      price = 71,65 c/kWh
      Cost = 1110 x 71,65 = 79531,5 cents = R795,32
10. a) power rating = 120 W = 0,12 kW
       time = 8 hours
       energy = power x time = 0,12 x 8 = 0,96 kWh
    b) Cost = 0.96 x 71,65 = 68,784 cents = R0,69
11. a) time = 8 x 5 x 5 = 200 minutes = 3,33 hours per 5 day school week.
    b) power rating = 2 600 W = 2,6 kW
       time = 3,33 hours
       energy = 2,6 x 3,33 = 8,66 kWh
    c) cost = 8,66 x 71,65 = 620,35 cents = R6,20
12. a) cost = R35 = 3500 cents
       power rating = 230 W = 0,23 kW
       price of electricity = 71,65 c/kWh
       Number of available units (kWh) on voucher = 3500/71,65 = 48,85 kWh
       time = energy/power = 48,85 kWh / 0,23 kW = 212 hours
    b) Number of available units (kWh) on voucher = 3500/71,65 = 48,85 kWh
       power rating for one bulb = 60 W = 0,06 kW
       power rating for six bulbs = 0,06 x 6 = 0,36 kW
       time = energy/power = 48,85 / 0,36 = 135,69 hours
13. Both light bulbs produce the same amount of light but because the power rating of the LED is lower, the cost of the electricity to run the light is less. The LED is cheaper to use. Learners may also mention that CFLs contain mercury while LEDs do not.
14. cost = R4,84 = 484 cents
    power rating = 4 500 W = 4,5 kW
    cost = energy consumed x price per unit
    energy consumed = cost/price per unit = 484/71,65 = 6,755 kWh
    time = energy/power = 6,755/4,5 = 1,5 hours

20 The Earth as a system

Unit overview

1 week

In Grade 7 the learners investigated the relationship between the Earth and the Sun, day and night, the seasons and how the Sun's energy is utilised by plants, and how fossil fuels are formed. In Grade 8 they looked at the Earth as part of a bigger system, namely the solar system. This year they will study the Earth as a system itself and the different parts that make up this system. 'Systems' is an important theme that runs through all of science and here we learn about systems in yet another application.

In the first Unit the parts of the Earth's system (the spheres) and how the parts work together are examined. The hydrosphere and water cycle were studied in earlier grades and revised here. The biosphere is also studied throughout Natural Sciences. The remaining two spheres are investigated this year – the lithosphere (Unit 2 and 3) and the atmosphere (Unit 4). In the lithosphere we look at how rocks are formed, the minerals found in rocks, how we extract these minerals and the impact our interactions with the lithosphere has on the other spheres. The layers of the atmosphere are studied in the last Unit.

The study of the lithosphere and atmosphere links up with what learners have learnt about the atom and compounds in the Energy and Change section, as well as phases of matter and knowledge about gases, like oxygen, carbon dioxide and methane.

This will prepare learners for study in Grade 10 and further, where the different branches of Natural Sciences separate into Life Sciences (Biology and Environmental Sciences), Physical Sciences (Chemistry and Physics) and Earth Sciences (Geography).

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.[1] cmap.ihmc.us/download/

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:[2] www.zooteach.org/ . ZooTeach is a website where teachers and educators can share high quality lesson plans and resources that complement the Zooniverse citizen science projects.

20.1 Spheres of the Earth (3 hours)

Tasks	Skills	Recommendation
Activity: Exploring the spheres of the Earth	Observation, data collection, writing	CAPS suggested
Activity: Interaction between the spheres	Application	CAPS suggested
Activity: Identifying the interactions of the spheres on Earth	Interpreting information, analysis	CAPS suggested
Activity: Upsetting the balance	Analysis, Application, Prediction	CAPS suggested

Key questions

- What are the different parts of the Earth?
- How do these parts interact?
- Why can we refer to the Earth as a system?

20.1 Spheres of the Earth

An interesting study was done by a research team in Arizona, USA, where they built a self-contained facility called Biosphere 2 to study the relationship between living things and their environment. The facility had absolutely no contact with anything on Earth, except the Sun. The first group of people lived inside, without exiting, for 2 years. The project wasn't as successful as they planned and they realised that we do not know enough about the interactions between the systems on Earth. The project is still ongoing and used for extensive research. More information is available here ([3] bit.ly/1eZtvZj). This can be given as an extension reading for your learners.

This is a very short (2:07 min) video of the four spheres of the Earth. [4] abt.cm/16Ghu5N. It summarises what was covered so far in this Unit. If you have facilities, this can be played to the class at the end of the lesson. If not, the content is covered in the text in this section.

ACTIVITY: Exploring the spheres of the Earth (LB page 320)

This activity is only about identifying the different spheres. The next section will look at the interactions of the spheres. You can use the examples which the learners have chosen to build the next lesson upon.

Learner-dependent answer. The learners needs to be able to identify the various spheres within the example they have chosen, for example: A plant in a pot.

The soil/sand is part of the lithosphere. The soil contains water, which is part of the hydrosphere, the plant is part of the biosphere and the air around the plant is part of the atmosphere. The plant takes in carbon dioxide and gives off oxygen when photosynthesis takes place, and the reverse during respiration.

Oxygen and carbon dioxide are part of the atmosphere.

Alternative options are: A tree growing on the school grounds, a frog in a pond, etc.

Instead of being a written task, you can also ask learners to do a small poster with a drawing of their example, with annotations describing the different sphere.

Interaction between the spheres

This section can be covered by doing the activity and giving learners the opportunity to discover the interaction between the different spheres. The activity also links up with the previous activity where they explored the different spheres.

ACTIVITY: Interaction between the spheres (LB page 320)

1. Biosphere – the tree, grasses and other plants
   Lithosphere – the sand, rocks and minerals in the soil
   Hydrosphere – the groundwater (or water in the soil)
   Atmosphere – the air around the tree
2. They will wither and die. They need water to photosynthesise.
3. The trees and other plants (biosphere) interact with the hydrosphere when they absorb water through their roots.
4. The plants will not flourish; their growth will be affected as photosynthesis will be affected. Depending on how dramatically levels change, the plants might die.
5. The carbon dioxide in the atmosphere is needed by the plants for photosynthesis. The plants also

produce oxygen, which is given off into the atmosphere.

6. Yes, the minerals (lithosphere) in the soil are dissolved in the groundwater (hydrosphere). The groundwater (hydrosphere) also wets the soil (lithosphere) so that the roots of the plants can absorb it.
7. Learner-dependent answer. Any three combinations can be described. For example:
   - The pot plant (biosphere) absorbs water (hydrosphere) through its roots and uses it for photosynthesis.
   - The plant (biosphere) uses carbon dioxide (atmosphere) and gives off oxygen (atmosphere) during photosynthesis.
   - The plant (biosphere) uses the soil, sand and rocks (lithosphere) to anchor itself.
   - The minerals (lithosphere) dissolve in the groundwater (hydrosphere) so that the plant (biosphere) can absorb it.

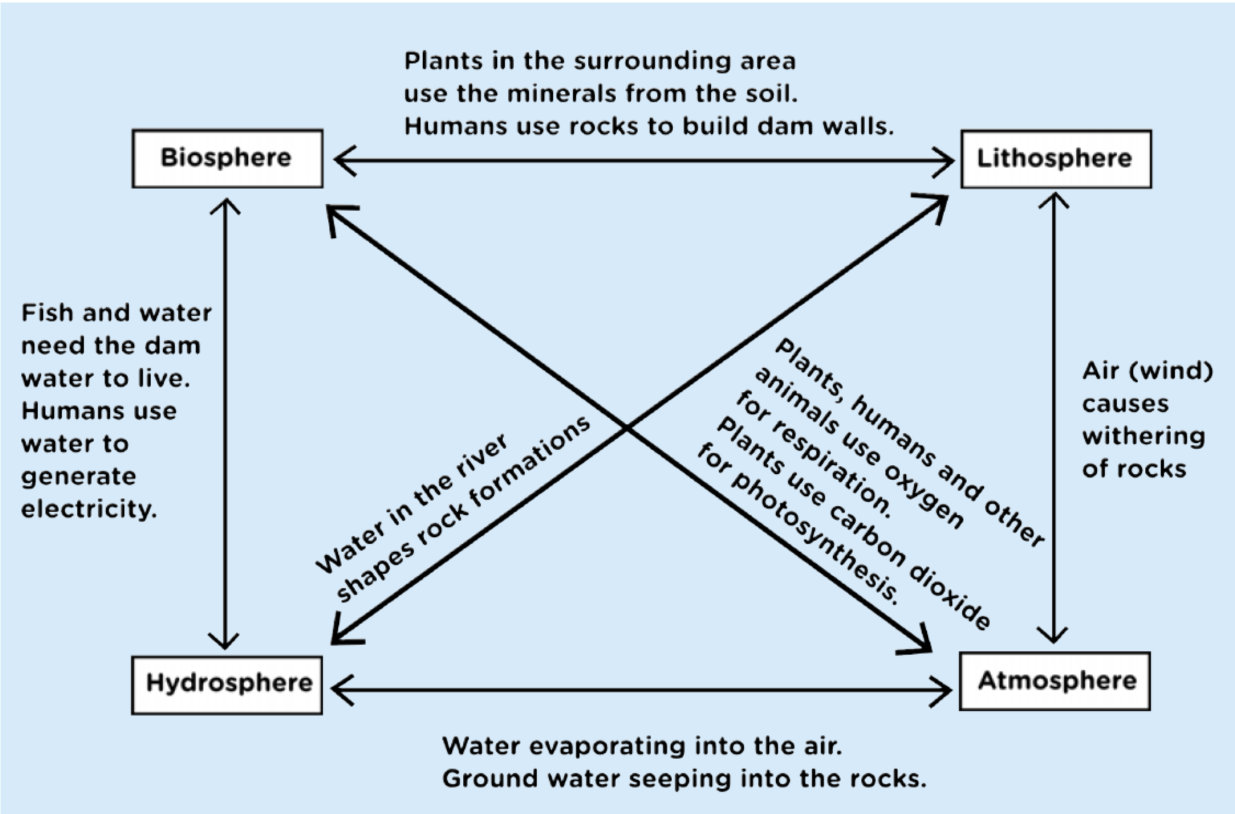
The easiest interactions to describe are those between the biosphere and the other spheres respectively. In the next activity the idea is to explore the interaction between the other spheres as well.

ACTIVITY: Identifying the interactions of the spheres on Earth (LB page 321)

For this activity let the learners discuss amongst themselves first. The activity can be part of your teaching. The idea is that the learners discover the interactions by themselves (with your guidance) before you 'give them the answers'. Give them 5 minutes to talk to each other and then another 10 minutes so that they can complete the map. Afterwards the interactions can be discussed as a class.

They might need some assistance in how to complete the map. One example is given. It might be necessary to do one more example as a class before they try it on their own.

1.–2. Learner-dependent answer. Some possible solutions are given below. Learners could also include other options.



Upsetting the balance

ACTIVITY: Upsetting the balance (LB page 323)

This activity will require the learners to think and apply what they have learnt in the section so far as well as knowledge from previous Units. You could use the activity to guide a classroom discussion, or let the learners work in pairs or small groups. The important message for this section is that a disturbance in one of the spheres has an effect on all the others. The disturbance can be due to natural causes, or due to the influence of human interactions. As humans we have a responsibility to understand how the interactions work, what impact humans have on the planet, and what we need to do today to make life possible for future generations.

Questions

1. Biosphere – plants
   Hydrosphere – river and snow
   Lithosphere – rocks, soil, mountains
   Atmosphere – air
2. a) Learners could suggest that the ecosystem would be destroyed as the earth would be mined, plants and animals would lose their habitat, the water could be polluted from the mining, as well as the atmosphere from exhaust gases from vehicles and machinery.
   b) Global climate change would follow, for example, the snow woulf melt, the river might dry up, the plants and animals would suffer from an increase in average temperature.
3. Learner-dependent answer. Learners must discuss this and write down some of their thoughts. Some points to raise include being environmentally aware of our impact, assessing our impact before embarking on a project such as a new mine, looking for alternative solutions, such as renewable energy sources.

Revision

1. The lithosphere consists of solid rock: mountains, sand and minerals.
   The hydrosphere consists of water in all its forms: ice, snow, lakes, dams, rivers and the ocean.
   The atmosphere is a layer of gases around the Earth, for example carbon dioxide, oxygen and nitrogen.
   The biosphere consists of all living plants and animals and their interactions with the rocks, soil, air and water: all plants and animals on land, underground and in water – plants, animals, and humans are part of the biosphere.
2. a) The copper (mineral, lithosphere) in this area is extracted by humans (biosphere) through mining activity.
   Mining activities need a lot of water (hydrosphere).
   A lot of dust is created during mining activities polluting the air (atmosphere). Additional carbon dioxide is also formed due to the mine trucks driving in and out of the mine daily. Mines use a lot of energy to drive the machinery and electricity generation has negative effects on the environment.
   The shape of the landscape (lithosphere) was changed due to the actions of humans (biosphere).
   b) The sand (lithosphere) is blown by the wind (moving air, atmosphere) to form sand dunes.
   Very little water (hydrosphere) is available in desert areas. On occasion it will rain (hydrosphere), or there might be underground water (hydrosphere) sources which plants (trees at the foothills of the dune, biosphere) will use. Some desert animals like insects or snakes (biosphere) may be found under the sand (lithosphere) which provides them with protection from the heat of the Sun.

3. In a dry area, evaporation of water droplets (hydrosphere) take place fast because the air (lithosphere) is quite dry and the air temperature is high. Alternatively, in a humid area, evaporation will not take place as fast.

21 The lithosphere

Unit overview

2 weeks

TEACHER'S NOTE

The focus for this Unit is the lithosphere and the processes involved in its formation. The lithosphere is part of a larger sphere called the geosphere. The geosphere consists of the three concentric layers of the Earth: the core, the mantle and the crust. The lithosphere refers to the outer part of the geosphere, which includes the upper part of the mantle and the crust. The lithosphere is also part of the Earth where the rock cycle is found.

The first section on 'What is the lithosphere?' gets learners to investigate their environment first, discovering that the lithosphere is found all around them. We then step back and look at the concentric layers which make up the Earth. This gives the background information need to introduce the rock cycle which involves the upper part of the mantle and the crust. The three rock types are introduced, which is followed by investigating what rocks are really made of – minerals. This sets the scene for the next Unit on mining the mineral resources.

21.1 What is the lithosphere? (2 hours)

Tasks	Skills	Recommendation
Activity: Investigating stones	Observation, writing, describing	CAPS suggested
Activity: Build a 3D model of the Earth	Design, making a model, applying knowledge, translating information	Optional
This can be used as a project to be conducted throughout the term.		
Activity: The layers inside the Earth	Classification, comprehension	CAPS suggested

21.2 The rock cycle (4 hours)

Tasks	Skills	Recommendation
Activity: Summarising the rock cycle	Recall, comprehension	CAPS suggested
Activity: Explaining the rock cycle	Writing, comprehension	CAPS suggested
Activity: Building a model of the formation of sedimentary rock	Making a model, translating information	CAPS suggested
Activity: Comparing the properties of igneous rocks	Comparing, observation, application	Optional
Activity: Classifying rocks	Classification, organising information, making deductions	Optional extension
Activity: What minerals are found on Earth?	Researching, reading, writing	CAPS suggested

Key questions

- What does the centre of the Earth look like?
- Why is it important to know about the structure of the Earth?
- Why is there so much variety in the rocks you see around you?
- How do rocks form?
- Why do we need to know about rocks?

- Why are rocks important?

21.1 What is the lithosphere?

ACTIVITY: Investigating stones (LB page 327)

During this activity learners will be required to observe carefully and put their observations into words. Encourage learners to look carefully and to capture as much detail as possible.

This activity can be done as an introduction to the section, before the content is discussed. Learners need to be asked before the lesson to bring these items to school. Some learners might be tempted to bring in pieces of brick and cement as examples of rock. Make sure to point out to learners that concrete and brick are made-made materials, although they have similar properties to rocks.

Alternatively, learners can be sent out onto the school grounds to find the items (about 10 minutes). You could also bring items to school yourself, ensuring that there are at least 4 items per learner. Otherwise, you could place the different items at different stations (for example, 10 similar stones at station 1, 10 sand samples at station 2, etc.) and let the learners move from one station to the next. Each learner will then have his/her own stone to observe at each station.

Give them 3 minutes at each station to do the observations. Learners can also attempt to crush some of the samples using a hammer and by wrapping the sample in paper towel to avoid pieces flying off in different directions. This can also be performed outside.

If learners are not able to bring stones to the classroom, the pictures provided in this section can be used. Use this as a last resort only.

The aim of the activity is for the learners to examine real artifacts and practice writing down their observations. They should realise that all the different types of stone form part of the lithosphere, including sand which is made from stone worn down by wind and water. The lithosphere is found all around us.

The activity can lead into a discussion of one or more of the following questions:
1. What types of stone found on Earth have we not collected in the activity? (molten rock, rock from the seafloor, etc.)
2. What do we use the lithosphere for? (minerals, fuels, plant nutrients, building materials, etc.)
3. What is rock or stone actually made of? Learners might say sand. If so, the follow-up question is 'What is sand made of?' Learners might not have the answer here. The idea is not to give them the answer yet, but to keep this as an open question which will be answered at the end of this Unit and the next Unit on mining the lithosphere. The activity is meant to be exploratory and not necessarily meant to provide the answers at this stage.

It sets the scene for the two major topics: Different types of rocks (the rock cycle, Unit 2) and the minerals found in rocks (what they are and how we mine them, Unit 3).

An example of what learners might write for 'Sand' is given below.

	Location	**Shape and colour**	**Texture**	**Composition**
	Describe where you have found your sample.	Describe the size, shape and colour	Describe the texture and hardness.	Can you see more than one part? Describe what it is made up of.

Sand	At building site next door to our house.	The sand has small round grains of about 1 mm in diameter on average. It is cream coloured with some darker brown grains.	The grains are all more or less the same size. The sand is dry, so it feels smooth and soft. The grains are hard but break up even further when I hit it with a hammer.	All the grains look the same, except for the variations in colour. The grains are not connected/ stuck to each other and are free flowing.

Inside the Earth

A large poster that you can print and put up in your classroom for this section: [1] bit.ly/1a9QXOn

Learners may have already learnt about this in previous grades in Social Sciences.

ACTIVITY: Build a 3D-model of the Earth (LB page 329)

This activity can be used as a project which can be completed over the course of the term. For this project learners can work in pairs. They need to build a labelled model of the Earth and do some additional reading to find out more about each of the layers. You can put the models up for display in your classroom and refer to them in further teaching. Coloured paper or painted papier mâché can be used as alternatives to other expensive materials. You can use Assessment Rubric 7 at the back of your Teacher's Guide to assess their models.

How to make papier mâché (video). [2] bit.ly/Hr23rj

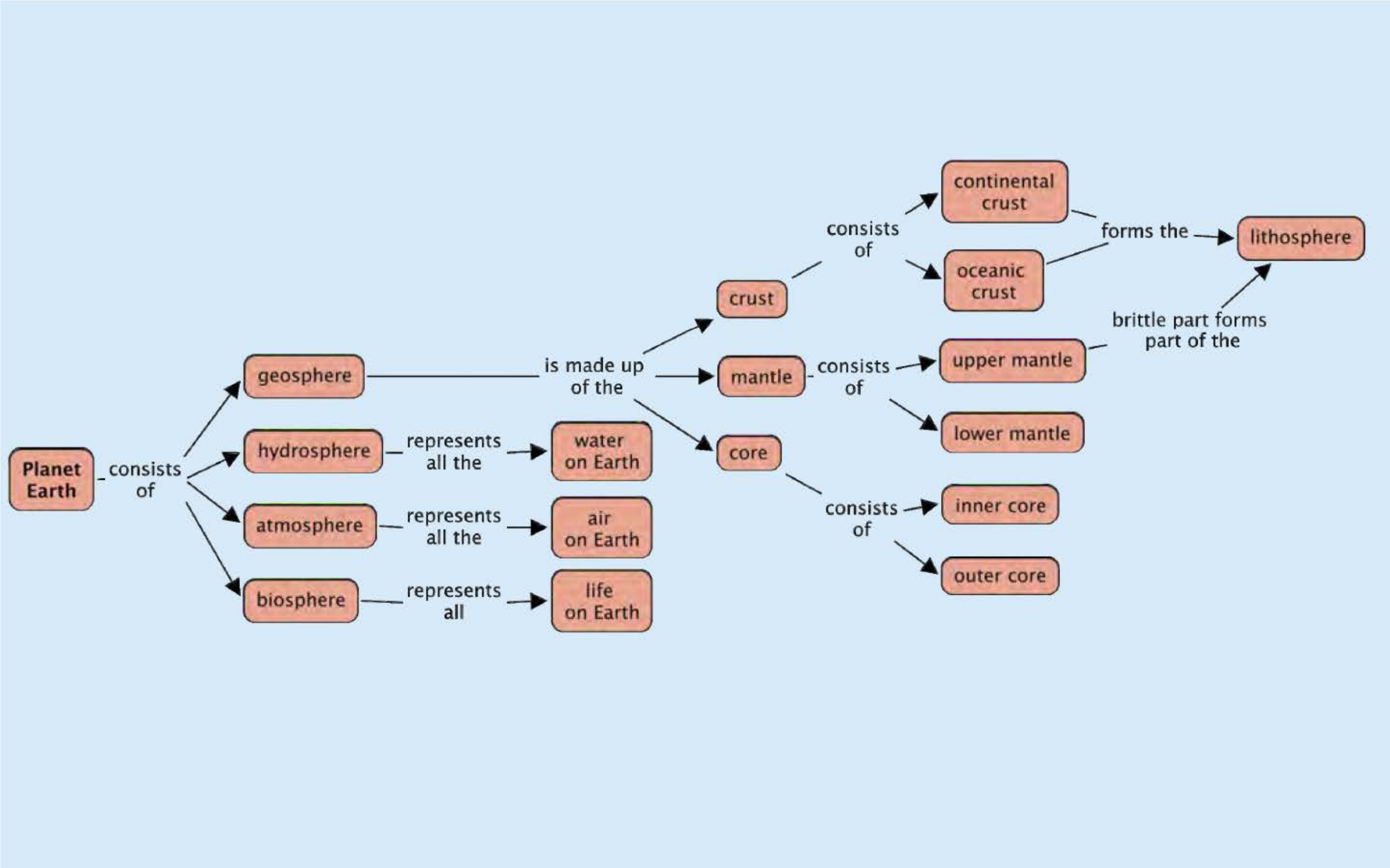
ACTIVITY: The layers inside the Earth (LB page 330)

The aim of this activity is to provide learners with some structure to make sense of all the new terminology that is introduced in this section. Some of the terms might be familiar, but learners might not have had to link it all up.

This map will be used later in the Unit again. This activity tests learner's ability to comprehend and then translate the information into a visual map. This is quite a simple activity in the sense that the basic structure of the map is provided, but later they will be required to provide their own structure. This is not a concept map, but rather a topic map to show learners how the different terms are related.

The learners have been exposed to various kinds of maps over the past 3 years in Natural Sciences. These are all attempts to support them in developing different ways of organising information to enable them to learn better. The different maps could also help learners develop their own way of summarizing information for studying purposes.

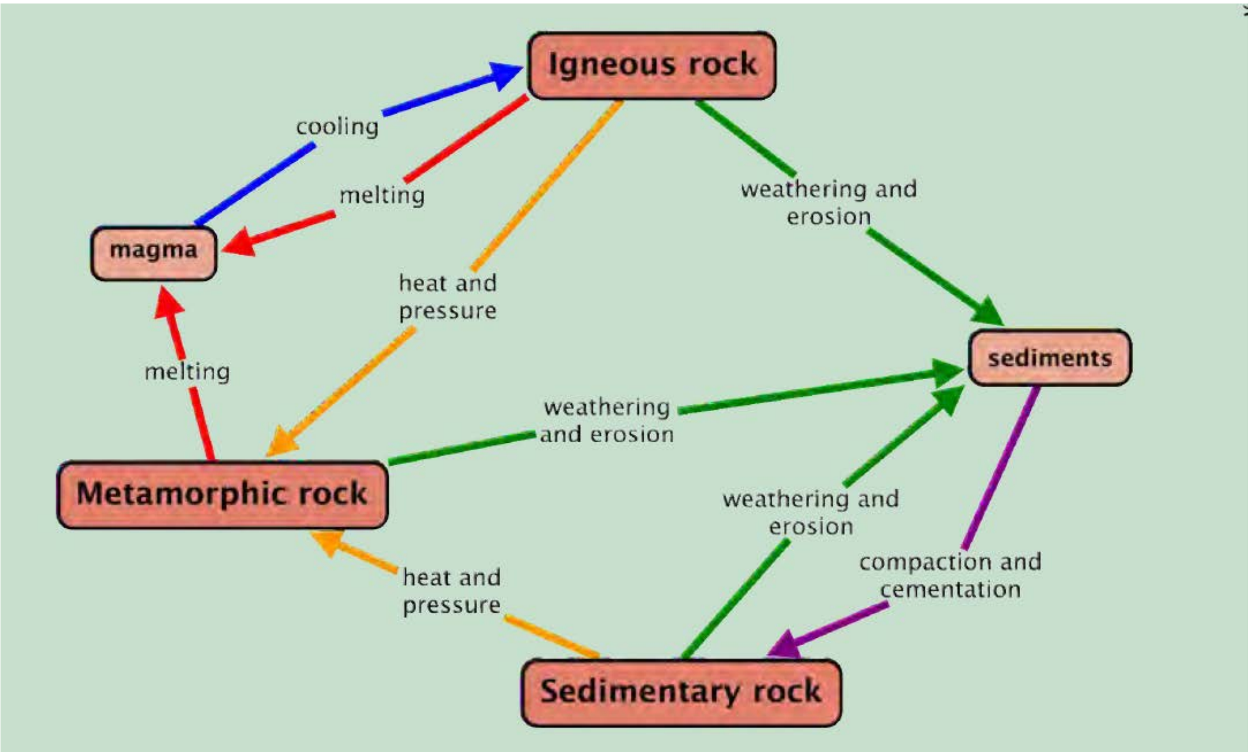
The completed topic map:


Planet Earth
consists of
geosphere
hydrosphere
atmosphere
biosphere
represents all the
water on Earth
represents all the
air on Earth
represents all
life on Earth
is made up of the
crust
mantle
core
consists of
continental crust
oceanic crust
forms the
lithosphere
consists of
upper mantle
lower mantle
brittle part forms part of the
consists of
inner core
outer core

21.2 The rock cycle

How does the rock cycle work?

ACTIVITY: Summarising the rock cycle (LB page 332)

1. 

2. Cooling.
3. Igneous, metamorphic as well as sedimentary (all rock types).
4. Increased temperature and pressure.
5. It is the action of wind and water which cracks and breaks up pieces of rock.
6. It is a process where the particles are compressed closer together (for example through the action of pressure).
7. Sedimentary rock.
8. Magma is molten (melted) rock. It is called lava when it flows onto the surface of the Earth. Magma and lava form igneous rock when they cool, either above or below the Earth's surface.

ACTIVITY: Explaining the rock cycle (LB page 333)

This is an alternative activity to the preceding one. It can be used instead of the previous one, or if you feel that your learners need more practice in writing about what they have learnt, then this is an ideal homework exercise. It could also be used as a quick class test, to check for understanding. Learners can assess their own writing, or swap with a friend.

Learner-dependent answer. Ensure that learners use the terms correctly and that the process is explained accurately. Learners should NOT copy the text from the workbook, but should write this in their own words.

The diagram on the rock cycle can be used as a guide as to what their labelled diagrams should look like.

Use the following as a guide for the answer:

The rock cycle is the natural, continuous process in which rocks form, are broken down and re-form over long periods of time.

There are three rock types: igneous, sedimentary and metamorphic rocks. The rock cycle can be explained in the following steps:

- molten rock from the mantle (magma) pushes up through the crust
- pools of magma cool down slowly in the crust to form igneous rocks, like granite
- some magma escapes to the surface as lava in the form of a volcano
- lava cools to form igneous rocks
- the rate at which the lava cools affects the properties of the rocks formed
- rocks on the surface of the Earth are weathered by heat (expansion), cold (contraction), wind and water to form smaller particles
- wind and water transport these particles to floodplains and the sea by erosion
- the particles are laid down as sediments
- the sediments are covered by more layers of sediment
- the pressure of many layers turns the lower layers into sedimentary rock like sandstone
- magma heats the surrounding rock and changes its chemical structure to form metamorphic rock like slate from shale or marble from limestone
- some rock is pushed below the crust, melts and becomes magma again

Sedimentary rock

Learners do not need to memorise the different names for all the examples of rocks in the following three sections, but they should be able to name one or two examples for each rock type. It is important to realise that rocks are used as materials in our daily lives. Many of the words will be familiar as they are referred to in everyday language (limestone, granite, etc.) so it will be good for learners to know the origins of these stones. This section links up with what is covered in the Matter and Materials strand. Stone is a natural material and resource that humans have used in the past and are still using today. The usefulness of a particular material, stone in this case, is due to its properties.

An easy demonstration to show the concept of deposition is to mix some soil in water in a glass jar and then place it on the table in front of the class and allow the particles to settle at the bottom through the course of the class. You can then also pour in different colours of sand or soil to illustrate the different sedimentary layers.

The video link provided in the **Visit** box on the 'Formation of sedimentary rock under the sea' provides a clear and easy to understand demonstration of how sediment is deposited on the bottom of the sea in layers. You can even construct something similar to this model in your classroom to show learners.

ACTIVITY: Modelling the formation of sedimentary rock (LB page 337)

This activity can be done as a classroom demonstration. Pile books on top of a few slices of bread until they cannot be compressed further. Let the learners make observations and draw what they observe. Also show them the layers afterwards – the different layers are not distinguishable any more, they merge into one mass.

This is a good opportunity to discuss how models are used in Science to represent and explain what happens in reality. This model shows how different layers of sediment are deposited, represented by the different layers of brown and white bread. Initially the layers are quite loose, but over time as more layers are added, the bottom layers become compressed. This is represented in the model by adding on more books to increase the pressure on the layers. More books are added to represent the passing of time and more pressure.

Eventually the layers of rock are squashed (cementation has taken place) and it is not as easy to recognise the different layers, as in sedimentary rock.

Metamorphic rock

A suggestion is to get samples of slate, marble, sandstone and granite from natural stone tile shops for learners to look at and handle.

Igneous rock

Pumice rock is formed when volcanoes explode. A lot of gas is trapped in magma. The gas is under pressure when the magma is under the surface. When it breaks through the surface the pressure is released in a very short period of time. The suddenly exploding gas is forced up and out of the volcano, taking along all the molten rock around it. This is observed as an explosion of gas and molten rock that can be thrown kilometres away from the volcano. The magma cools very rapidly and can form rocks ranging from small pebbles to rocks the size of a house. This process can very effectively (and dramatically) be demonstrated by using fizzy drinks. Fizzy drinks have gas dissolved under pressure. When the cap of a fizzy drink bottle is opened, the gas can escape very quickly. If the bottle is shaken before opening it, the effect of a volcanic explosion can be shown. This can be a very messy demonstration that should be done outside.

Once the demonstration is done, the analogy explaining the formation of pumice rock should be consolidated in class. Learners should note that the liquid is shot up and out of the bottle. They need to imagine that it is hot lava with gas dissolved in it. When the magma breaks through the crust, it explodes with a lot of force. The lava is shot up high into the air and will cool down very quickly to form rocks. Rocks are strewn over a very large area around the volcano.

WARNING: This demonstration should be done outside, and learners should stay clear of the area.

ACTIVITY: Comparing the properties of igneous rocks (LB page 341)

This is an optional activity.

Sample 1 is basalt, sample 2 is obsidian, sample 3 is granite and sample 4 is pumice.

Sample	**Where was the sample formed? Extrusively or intrusively**	**How quickly did it cool? What evidence do you have for your answer?**	**Was air trapped when it was formed? What evidence do you have for your answer?**	**Describe the colour**
Sample 1	Extrusively	Very fine crystals	No, no visible holes	Dark, green-grey
Sample 2	Extrusively	Fast, no visible crystals	No, no visible holes	Shiny black
Sample 3	Intrusively	Slowly, there are large interlocking crystals	No, no visible holes	Mottled with yellow-brown, white and black
Sample 4	Extrusively	Fast, there are no crystals	Yes, there are holes in the rock where gas bubbles were trapped	Grey-black

ACTIVITY: Classifying rocks (LB page 342)

This can be used as an optional, extension project.

Rocks contain minerals
CAPS places this section directly after discussing the core, mantle and crust.

We have moved it to the end of the Unit so that learners have a bit more knowledge about the different rock types. Placing it here also prepare learners for the next Unit on mining these minerals.

ACTIVITY: What minerals are found on Earth? (LB page 343)

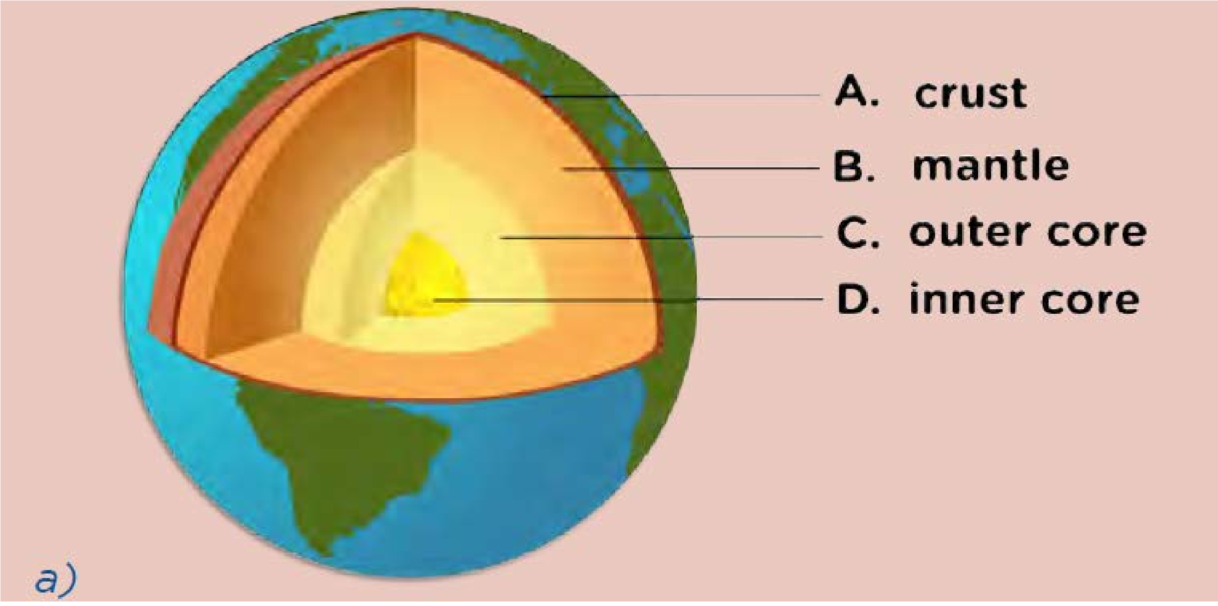
This can be used as a research project. It can be presented as a written report.

A useful resource giving the relevant information for this activity can be found here: [4] rsc.li/17rVgrL

This link also includes a very useful worksheet that can be used as an end of section exercise.

Revision

1. a)



   b) C (the outer core) is liquid and D (the inner core) is solid.
   c) Magma or molten rock.
   d) sand, stone, rocks, pebbles, clay (any three).
2. Rocks are formed through many different processes resulting in a large variety of different combinations of rock minerals.
3. a) Sedimentary rock. The layers of sediment can be seen forming at the bottom of the ocean.
   b) Sedimentation and cementation.
   c) The rocks will become hotter and more pressure will be applied. The rocks will become more compact and the chemical compounds in the rocks will change. Metamorphic rock will form.
4. When animals or plants die, their remains often end up on the ground and are covered by sand over time. The sand gets compacted and eventually becomes sedimentary rock, with the fossilised remains of the plant or animal still inside the rock.
5. Granite is intrusive igneous rock. It forms as magma beneath the surface of the Earth, cools slowly and forms large crystals. Pumice is extrusive igneous rock which forms when magma pushes out of the crust to the surface of the Earth and cools very quickly, trapping bubbles of gas.
6. a) (Fe_2O_3)
   b) Sedimentary hematite crystals formed as evaporating oceans left deposits of iron in the sedimentary layers. The iron then combined with oxygen molecules created by the process of photosynthesis. Also accept an answer where learners explain part of the rock cycle, from magma to sedimentary rock.
   c) Iron is used to make steel, stainless steel, cars [any appropriate application]

22 Mining of mineral resources

Unit overview

2 weeks

In this Unit we build on what was done in the previous two Units. After learning that rocks contain minerals, we now explore how the minerals may be extracted so that they may be utilised. Mining plays an important role in the wealth of a country. Learners will therefore learn about the mining industry in South Africa and the impact that mining may have on a country and the globe.

The mining industry is an important industry in South Africa. It involves a number of industries working together. Exploration is followed by excavation, which is followed by crushing and milling to reduce the size of the rocks. This is followed by extraction (removing the valuable minerals from the ore) and finally refining. Each of these processes are discussed in this Unit. The idea is not that learners should know all the terms off by heart, but rather that they grasp the bigger picture. A number of different processes are needed with each one dependent on the efficiency of the step before. The flow diagram exercise towards the end of the Unit is meant to consolidate the Unit content and help learners realise the continuous nature of many industrial processes.

A research project is also included in this Unit. Let the learners choose one industry and research the different aspects of mining covered in this Unit for their chosen industry. The following mining industries can be researched: gold, iron, copper, diamond, phosphate, coal, manganese, chromium or platinum group metals (PGMs). Learners could also choose their own.

The projects need to be handed out in the beginning of the term/Unit.

Learners can then present their projects at the end of the Unit, by doing a poster or an oral, or both. For the orals, we suggest you work with the language department so that learners can be assessed there as well. If posters are done, then we suggest you put these up for display for the whole school to see.

Learners can stand at their posters during breaks where learners from other grades have the opportunity to come and have a look at their work and ask questions about it.

The project has a two-way purpose, firstly for learners to continue learning about doing research, finding information and presenting the information to others, and secondly, for learners to explore careers in this industry. Part of what they should include in their research is a section on careers in mining.

Allow for some time at the beginning of this Unit to introduce the topic and the research project, and at the end for some feedback from the research projects.

22.1 Exploration: Finding minerals (0.5 hours)

Tasks	Skills	Recommendation
Activity: Mining in South Africa	Finding information, presenting information, group work, analysis, synthesis, application	CAPS suggested
Project to be handed out at the beginning of the Unit.		
Activity: Minerals and the right to own them	Debating, discussing	Optional

22.2 Extracting ores (0.5 hours)

Tasks	Skills	Recommendation
Activity: Gold mining in South Africa	Recall, comprehension, application	CAPS suggested

22.3 Crushing and milling (0.5 hours)

(Perform demonstration with choc-chip biscuits in class to demonstrate crushing and milling)

22.4 Separating minerals from waste (1.5 hours)

Tasks	Skills	Recommendation
Activity: Separating beads	Group work, design, experimentation	CAPS suggested
Activity: Separating peanuts and raisins	Prediction, discovery, observation, explanation	CAPS suggested

22.5 Refining minerals (1 hour)

Tasks	Skills	Recommendation
Activity: Separating lead from lead oxide	Observation, application	CAPS suggested

22.6 Mining in South Africa (2 hours)

Tasks	Skills	Recommendation
Activity: Create your own mining map	Translating information, application	CAPS suggested
Activity: Drawing a mining flow diagram	Translating information, ordering information	CAPS suggested
Activity: What would we do without mining?	Formulating an argument, group work, presentation skills, summarizing information, synthesis	CAPS suggested

Note: Allow for time at the end of this Unit for learners to present their research projects.

Key questions

- How do we know where to mine?
- How do we get the valuable ore-rich rocks out of the ground?
- How do we get the minerals or metals out of the ore?
- How do we separate minerals from waste rock?
- How do we refine minerals?
- Where in South Africa are the mineral-rich deposits suitable for mining?
- What do we mine in South Africa?
- What is the impact of mining?

ACTIVITY: Mining in South Africa (LB page 349)

This project should be handed out in the beginning of the Unit so that learners have time to work on it. Information for the project is provided in the sections in the Unit, but learners also need to find information on their own.

Guiding questions are provided to help learners.

You can use Assessment Rubric 8 (Poster), 9 (Oral presentation) and 10 (Group work) to assess this project.

22.1 Exploration: Finding minerals

Methods of exploration

ACTIVITY: Minerals and the right to own them (LB page 351)

This is an optional activity to conduct as a class discussion, or as small group discussions.

22.2 Extracting ores

Surface mining

This is revision of what learners have covered in previous grades. Coal is formed from fossilised plant matter which is compressed and heated over millions of years to eventually form coal.

Underground mining

Shaft mining

ACTIVITY: Gold mining in South Africa (LB page 354)

1. Underground mining or shaft mining.
2. Igneous rock, or metamorphic rock.
3. Jewellery, ornaments and decoration, electronics in computers and cell phones.
4. Yes it is. The mines are very deep, of the deepest in the world. Mining deep underground is difficult and dangerous because of the heat and lack of oxygen. Rocks can also collapse because of the pressure.
5.
    1. Air supply and air conditioners/heat control
    2. Lift to take miners into the mine or down the vertical shaft
    3. Headgear
    4. Horizontal tunnel
    5. Removal of ore
    6. Mine dump
    7. Ore body

22.3 Crushing and milling

This section looks at methods to get very large rocks crushed and ground until it is as fine as powder. The first concept that needs to come across here is that minerals are inside rocks and by crushing rocks, the minerals are exposed at the surface of the rock fragment. Only then can chemicals be used to extract the mineral. An analogy with a choc chip biscuit is used to demonstrate this principle. The second concept is that a lot of energy is needed to break rocks.

This is a very energy-intensive step in the mining industry, and one of the reasons why mining is so expensive.

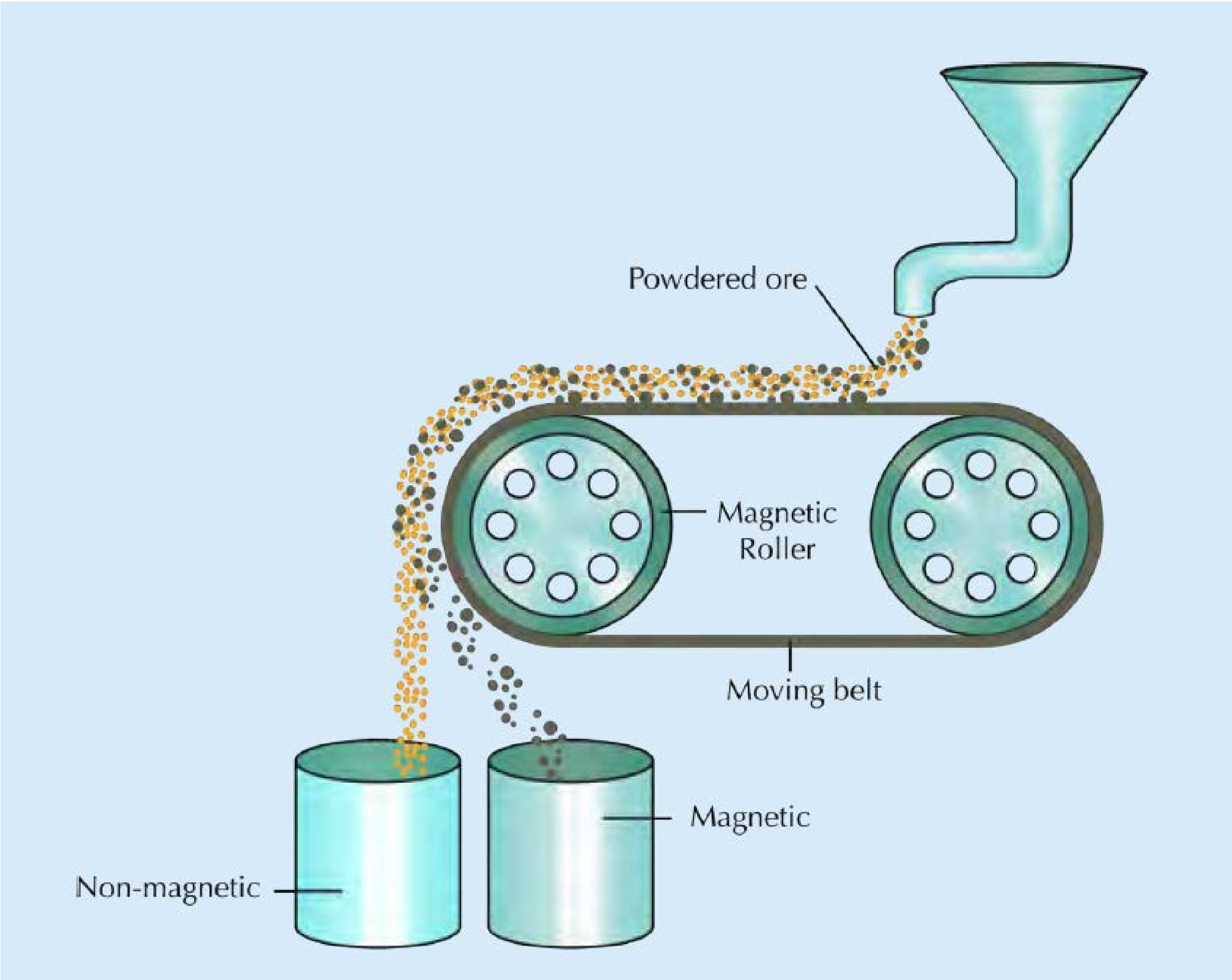
This lesson can be introduced by demonstrating the principle explained above to the class. Use choc chip biscuits and crush them with your fingers. This is to get the minerals (choc chips) out. The next step is to separate the choc chips from the crumbs – also a step in the mining process.

You can demonstrate this to your class by placing some pieces of broken up biscuit into a plastic container with some marbles or ball bearings. Place the lid on the container and then shake it so that the marbles help to crush and break up the biscuit pieces even further.

22.4 Separating minerals from waste

Magnetic separation

The labelled diagram is provided here:



The magnetic iron ore will fall into the container on the right as it is attracted to the magnetic roller and travels around the bend of the magnet for a longer period, whereas the non-magnetic waste drops straight down due to gravity, as the magnet turns, and falls into the first container on the left.

ACTIVITY: Separating beads (LB page 359)

Let the learners work in groups of three. The value of the activity is the process of doing it, and not so much the end product. Learners will want to separate every single bead in the process and this is not possible, nor does it happen in the mining industry. Valuable materials do end up as waste.

When choosing beads to separate, ensure that there are a variety of shapes, round and flat, small and large. Most plastic beads will float on water, but metallic ones will sink. The piece of carpet is provided to make the tray rough, but still smooth enough for round beads to roll off, and flat beads to stick.

Choose the smallest flattest beads to represent the valuable materials.They will remain on the carpet in the tray more easily.

Learners might want to use the cups to separate by size. This is a great option.

If magnetic beads are included, provide the learners with a magnet.

To separate by density, learners can drop the beads into water – some beads will float and others will sink. To separate by size, learners can use the mesh and let the smaller beads fall through into the cup, with the larger ones staying behind.

As an extension, include some beads which are identical in shape and size, but different colours. At this point, learners will want to hand sort them. Tell learners that hand sorting, although effective and is used by individuals, it is a very time-consuming process and therefore almost never done in the mining industry. Ask learners if they have any other ideas. This is where chemical properties come in. For example, tell learners that one colour bead reacts with an acid and the other does not. Get learners to discuss how they would then separate the beads knowing this. A real world example is that silver reacts with chlorine, but gold does not.

This activity can also be done as a class demonstration and some flow diagrams can be designed. The learners can then vote which one they think would work best.

Optional is a sheet of paper for each learner for planning and making observations.

Questions

1. Learner-dependent answer. Learners could have used the mesh and let the smaller beads fall through.
2. Learner-dependent answer. For example, some beads might have been flat and would therefore stick to the carpet, whereas the round ones would roll off.
3. Some beads float and others sink.
4. The magnet can be used to lift magnetic beads out of the other beads.

Flotation

ACTIVITY: Separating peanuts and raisins (LB page 361)

The focus of this activity is to illustrate the principle of flotation and for learners to practice explaining their observations. They will have to apply what they know about density to be able to explain what they see. This activity can also be modified by letting the learners predict what they think will happen before they add the peanuts and raisins to the tap water; and again before they add it to the soda water. The outcome might not be what they expected and the value of the activity is for them to try to explain what they see.

The peanuts will float because they are oily and the bubbles stick to them. This reduces the density of the peanuts so that they are able to float.

The activity can be done as a classroom demonstration, but it is more effective if done by the learners in pairs. The one learner can use the tap water, and the other the soda water. A suggestions is to buy packets of peanuts and raisins separately, otherwise oil from the peanuts can coat the raisins, causing some of the raisins to rise. The raisins can also be rinsed in acidulated water because they are often dressed with oil before sale for visual enhancement.

Learners should observe that the peanuts and raisins sink to the bottom in the tap water and remain there since they are more dense than water. However, in the soda water, the peanuts and raisins initially sink to the bottom, but then the peanuts start to rise. Small bubbles from the soda water attach to the peanuts' oily surface and cause them to rise to the surface.

The name for the force that is holding atoms together in a compound is called a chemical bond.

22.5 Refining minerals

Extraction of iron

ACTIVITY: Separating lead from lead oxide (LB page 363)

For safety reasons, this experiment should rather be demonstrated. Ensure that you wear safety glasses when performing this experiment. It is quite easy to do, but takes a long time to actually react. The blow pipe needs to redirect the flame into the hollow in the block. Blow through the top of the blue part of the flame. Use a straw to extend the blow pipe so that you can stand a bit further away from the flame. Ensure that a steady stream of heat gets right into the middle of the mixture so that it glows red hot for a while. The video link in the

Visit box also shows how the experiment is performed (and the mistakes made). The product can clearly be seen in the video.

Questions

1. The mixture heats up and starts to glow. At the end of the reaction the red colour of the lead oxide has changed to a grey colour and a solid pellet of lead has formed.
2. $2PbO + C = 2Pb + CO_2$
3. Carbon dioxide is a greenhouse gas and large-scale production will negatively influence the environment and contribute to global warming.

22.6 Mining in South Africa

ACTIVITY: Create your own mining map (LB page 366)

Learners need to develop their own symbols for each mineral that is mined, and also colour code the map. The map is blank and so they must find out where each town is located and add it to the map. Let them also fill in the name of the city/town/area in which they live. If there are mining activities in your area which is not indicated on this table, let the learners add it to the list. The list provided is not exhaustive, but it is still fairly long. If you want to make the activity simpler, learners can also chose a certain number of minerals to represent.

Questions

1. Learner-dependent answer.
2. Most of them are all together in one area in the shape of an arch, mainly in the Free State.
3. Diamonds from inland were washed to the coast by rivers. These diamonds are now mined from alluvial deposits at the coast.
4. Learner-dependent answer. Accept any mining industry as long as an appropriate reason is given. For example, coal mining because it provides us with energy.

ACTIVITY: Drawing a mining flow diagram (LB page 368)

This activity is meant to consolidate the knowledge from this Unit. Each industry will have its own unique flow diagram. The idea is for the learners to realise that it is a continuous system where the one process feeds into the next one to produce a useful end product. This activity links up with the research project and should give learners a good guide for doing and presenting their research projects.

The answers depend on the mineral chosen. Below is an example: Coal mining: Finding coal seams through exploration in Mpumalanga, Free State and KwaZulu Natal

ACTIVITY: What would we do without mining? (LB page 369)

There are no specific answers for this activity. It is an open discussion. We suggest that you discuss the impact of mining in South Africa through this activity. The idea is that learners should come up with all the issues and think about the impact of what we as humans do. The answer to solving the issues is not necessarily to close down all mining activity.

As an alternative you can get the learners to write a paragraph on each issue, after discussing it in their groups, instead of presenting it in the classroom.

Revision

1. a) Al_2O_3: Aluminium oxide
   SiO_2: Silicon dioxide
   TiO_2: Titanium dioxide
   Fe_2O_3: Iron(III) oxide
   b) Open pit mining/surface mining.
   c) Sand. Learners could also answer quartzite or quartz.
   d) Lime is added to react with the sand (SiO2) to form slag. Slag is used for making roads.
   e) Haematite or magnetite.
   f) Magnetic separation, as iron is magnetic, whereas the other minerals are not.
2. a) Iron ore, coke and lime are added to the top of a furnace.
   b) Hot air is blown in from the bottom.
   c) The furnace operates at a high temperature (around 1200 °C).
   d) Iron ore reacts with carbon/coke to form iron metal and carbon dioxide.
   e) The iron is tapped off at the bottom of the furnace.
   f) Slag is a by-product which is also collected and can be used for building roads.
3. $2Fe_2O_3 + 3C = 4Fe + 3CO_2$
4. CO_2, a greenhouse gas, is given off in large quantities. This contributes to global warming.
5. a) Igneous rock; it was a volcano.
   b) They could not mine any deeper and they had exhausted the minerals that could be reached from the surface.
   c) Fertilisers.
   d) It changed dramatically because an entire koppie, called Loolekop, was removed due to the mining activity.
   e) The igneous rock in the pipe cooled slowly allowing large crystals to grow over time.
   f) Dust pollution, noise pollution, changing the landscape, carbon dioxide emissions (any three).

23 The atmosphere

Unit overview

2 weeks

The first Unit in the Planet Earth and Beyond strand looked at the spheres of the Earth. The atmosphere was briefly introduced in this Unit and is now covered in more detail.

The atmosphere is the layer of gases around the Earth. The important concepts that need to be understood in this Unit are:

- the air we breathe does not contain 'nothing', but rather an important mix of gases which support and sustain life on Earth
- gravity causes the density gradient in the atmosphere, and makes the atmosphere 'stick' to Earth
- the temperature in the atmosphere varies with altitude as a result of radiation from the Earth, the specific gases present at different altitudes, chemical reactions taking place in the atmosphere, and the energy from the Sun.

The concept of space and the 'nothingness' that we breathe might be difficult for learners to comprehend. We have included a number of models and pictures to help them visualise the vastness of space, and understand that the atmosphere, which surrounds us, is required for life on this planet.

A common misconception is that land plants generate most of the oxygen in the atmosphere, whereas this actually occurs in the oceans where 70% of the planet's oxygen supply is produced.

Direct sunlight does not heat the atmosphere. Only a small portion of the heating can be accounted for by direct sunlight, most of the heating is through conduction, convection and re-radiation of the Sun's energy.

Another misconception is that greenhouse gases make up a major part of the atmosphere. Nitrogen and oxygen make up 99% of the atmosphere while other gases, including greenhouse gases, make up only about 1%.

23.1 What is the atmosphere? (1 hour)

Tasks	Skills	Recommendation
Activity: How thick is the atmosphere compared to the size of the Earth?	Measurement, interpretation, representing information	CAPS suggested

23.2 The troposphere (0.5 hours)

Tasks	Skills	Recommendation
Activity: Drawing a graph of the temperature gradient in the troposphere	Drawing graphs, doing calculations, measuring	CAPS suggested

23.3 The stratosphere (0.5 hours)

23.4 The mesosphere (0.5 hours)

23.5 The thermosphere (1 hour)

Tasks	Skills	Recommendation
Activity (model building): How thick are the layers of the	Building a model, drawing diagrams, data handling	CAPS suggested

atmosphere?		

23.6 The greenhouse effect (2.5 hours)

Tasks	Skills	Recommendation
Activity: Comparing the Earth, Mars and Venus	Interpreting data, providing explanations, application	CAPS suggested
Investigation: A model of the greenhouse effect	Building a model, data collection, data analysis, interpreting results, drawing conclusions	CAPS suggested
Investigation: Ice core analysis	Interpreting data, formulating, investigative questions, drawing conclusions, representing data	CAPS suggested

Key questions

- What is the atmosphere?
- What makes up the atmosphere?
- Does the atmosphere change as you go further from the Earth's surface?
- Can the atmosphere be divided into different layers?
- Where does the atmosphere end?
- What important aspect of the atmosphere allows life to exist on earth?
- What is the greenhouse effect?
- How do humans contribute to the greenhouse effect?

23.1 What is the atmosphere?

ACTIVITY: How thick is the atmosphere compared to the size of the Earth? (LB page 375)

1. – 2. a) 6400 km.
   b) About 480-600 km (accept any answer within this range).
   c) Learner-dependent answer.

The atmosphere is denser closer to the surface than further away. This can be indicated by using darker going to lighter colours, or using more dots and fewer dots, or any other way of indicating that the atmosphere is denser at the bottom. A scale needs to be included. A possible diagram could look like this:

Scale drawing of the Earth and the surrounding atmosphere. 1 block = 400 km.

Scale drawing showing the thickness of the atmosphere relative to the thickness of the Earth.

23.2 The troposphere

The boundaries between the layers in the atmosphere are not as clear as the boundaries between liquids. The values are often given as a range and the transitions take place in zones called pauses, for example the tropopause is the zone in-between the troposphere and the stratosphere.

ACTIVITY: Drawing a graph of the temperature gradient in the troposphere (LB page 378)

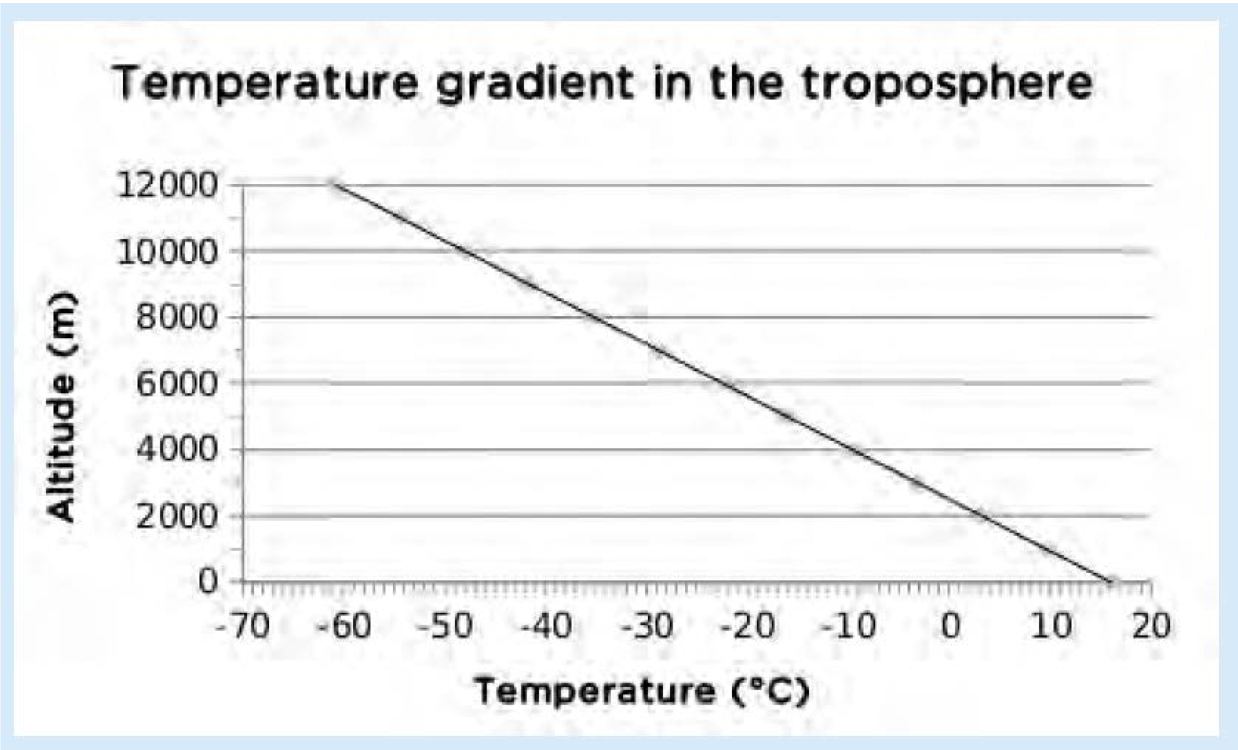
If you would like to assess learners' tables and graphs you can use Assessment Rubric 3 and 4 to do so. As an extension you could get the learners to draw a similar graph for the change in pressure as you move through the troposphere.

They will have to first find out what the pressure gradient is in the atmosphere.

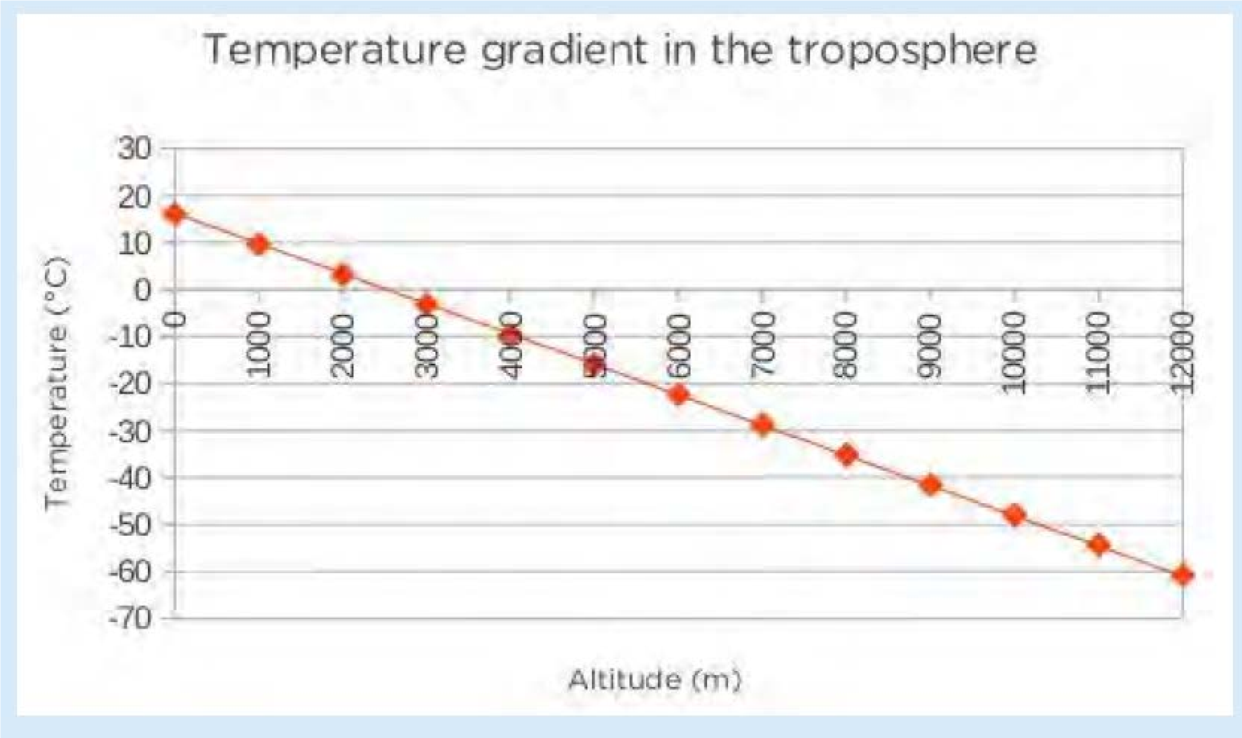
An example table is given below:

Change in temperature as altitude increases in the troposphere	
Altitude (m)	**Temperature °C)**
0	16
1000	9.6
2000	3.2
3000	–3.2
4000	–9.6
5000	–16
6000	–22.4
7000	–28.8
8000	–35.2
9000	–41.6
10 000	–48
11 000	–54.4
12 000	–60.8

An example graph is given below:



An alternative graph with the altitude on the x-axis is shown below:



23.3 The stratosphere

Discuss this with your class as it provides a good opportunity to revise some of the concepts learned in Gr 8 on the particle model of matter, as well as extend this knowledge. As the weather balloon rises higher and higher in the atmosphere, the pressure decreases. The volume of gas inside the balloon therefore increases and the balloon expands. Eventually it gets to a point where the balloon material cannot stretch anymore and the balloon bursts. This usually happens between 25 and 30 km above the Earth's surface. You can also explain to learners that the radiosonde has a small parachute attached to it which opens up when it begins to fall back to Earth. This is to slow its fall so that it does not crash down and cause damage to someone or something. Also, these sensors are never retrieved. Scientists don't need to retrieve them to get the information back because data will have been sent by radio signals.

What happens to ozone in the atmosphere?

This is extension content on what happens to ozone in the atmosphere and is not prescribed by CAPS. However, it is within the learners' capacity to understand it, given what they have learned in Matter and Materials. For more information about ozone you can visit [1] bit.ly/17oaroh

A chemical bond holds the oxygen atoms together in a molecule.

A diatomic molecule is the term given to a molecule of oxygen which consists of two atoms of the same element bonded together.

23.4 The mesosphere

The mesosphere extends from around 50 km to 80 km above the Earth's surface.

23.5 The thermosphere

ACTIVITY: How thick are the layers of the atmosphere? (LB page 383)

This activity demonstrates the relative thickness of the layers of the atmosphere. Learners might not realise how thin the troposphere, the layer in which we live, is compared to the rest of the atmosphere. After this activity they should have a better comprehension of the thickness of the layers of the atmosphere relative to each other.

Alternative materials are different types of dry breakfast cereals, or different shapes of pasta (shells, screws, macaroni, gnocchi, etc. Any tall, thin transparent container can be used.)

Questions

1. Learners draw a diagram on graph paper. They must indicate what scale they have used, for example, 1 block or cm represents 20 km, etc. To indicate density, learners can use darker and lighter colours or use lots of dots at the bottom and gradually fewer dots higher up.
2. This answer depends on the model made.
   Peas – troposphere
   Corn – stratosphere
   Samp – mesosphere
   Beans – thermosphere
3. This can be calculated, for example: 10 km / 0,5 cm = 20 km/cm.
4. It is three times thicker.
5. It is seven times thicker.
6. Troposphere
7. Troposphere
8. Thermosphere
9. Mesosphere
10. Troposphere. It is the thinnest layer.

23.6 The greenhouse effect

ACTIVITY: Comparing Earth, Mars and Venus (LB page 385)

1. Venus' atmosphere is made up of mainly carbon dioxide. Earth's atmosphere contains very little carbon dioxide. Earth's atmosphere is made up of mainly nitrogen and Venus has very little nitrogen. Earth's atmosphere contains a lot of oxygen, whereas Venus contains only trace amounts (very little). Argon is present at a low level for both planets.
   Venus has no methane.
2. Venus and Mars have very similar atmospheres. Most of their atmospheres are made up of carbon dioxide, with very low levels of all the other gases.
   Neither of them contain methane.
3. Earth's atmosphere contains almost no carbon dioxide, but has a lot of nitrogen and oxygen, whereas the atmospheres of Mars and Venus consist primarily of carbon dioxide and a few other gases.
4. Oxygen is produced by the oceans and plants on Earth. Venus and Mars have no liquid water and there is no life on the planet, so oxygen cannot be produced in large quantities.
5. Methane gas is produced by animals and by decomposing plant and animal matter. There is no life on Venus and Mars and nothing present on these planets which can produce methane.

6. The temperatures will be very high. Venus has a lot of carbon dioxide which traps the heat of the Sun and makes the surface temperature high.
   Venus is closer to the Sun than the Earth is, and therefore receives more radiation.

INVESTIGATION: A model of the greenhouse effect (LB page 387)

CAPS prescribes plastic bags. We have used plastic cold drink bottles as it makes data collection easier.

You can make the holes in the lids of the bottles beforehand using a knife or by hammering a nail in through the lid. Otherwise learners will need to do this and you will need a hammer, a nail about the width of the thermometer and a wooden block to hammer into.

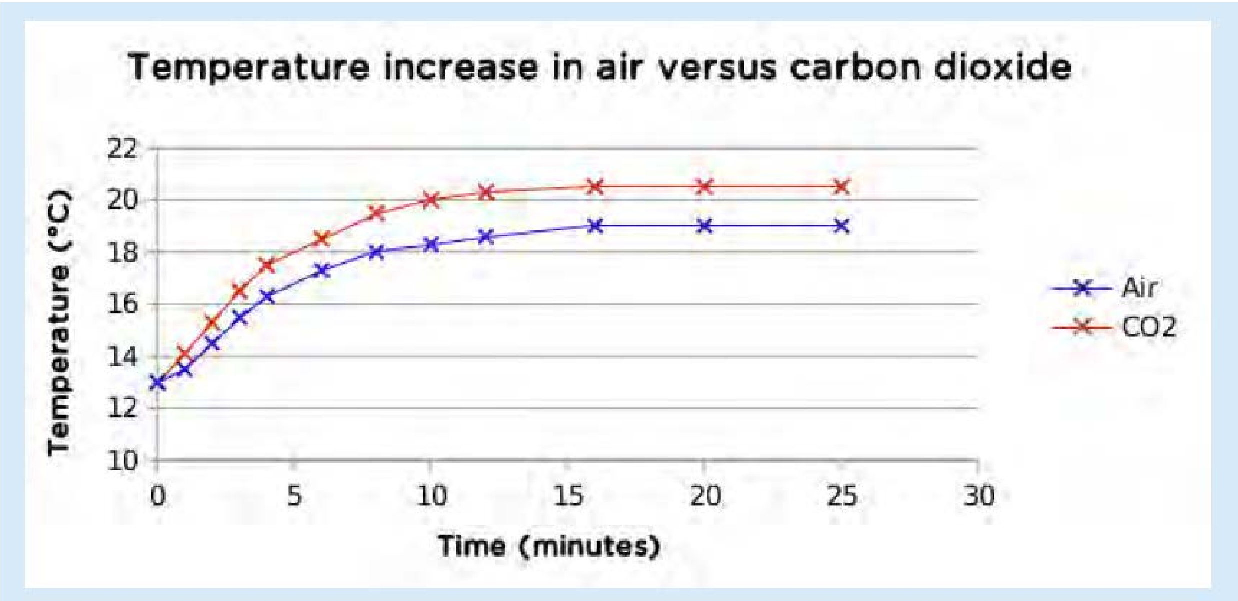
You can prepare and collect small bottles of carbon dioxide beforehand, otherwise learners will need to do this. To collect a bottle of carbon dioxide, add one tablespoon of bicarbonate of soda to the small bottle. Add 10-20 ml of vinegar and place the lid back on. Hold the mouth of the small bottle over the CO_2 container and pour the carbon dioxide into the large bottle. Carbon dioxide is denser than air and can therefore be poured into the large bottle. Add more vinegar when the effervescence stops. Repeat 2-3 times until the large bottle is full. If a burning match at the mouth of the bottle goes out immediately, the bottle is full.

Aim
A possible answer is 'To determine whether carbon dioxide or air traps more heat.

Hypothesis
Learner-dependent answer.

Results
Learners should draw both graphs on the same set of axes, or if not, then both graphs should have the same scales so that the graphs can be compared,

An example graph is shown here:



Both graphs follow a similar trend, but the carbon dioxide graph flattens out at a higher temperature. This means that carbon dioxide has trapped more heat than air. Although it is only a small difference (1,5°C), it is significant. The temperature change takes place quite quickly (within 20 minutes) and can easily be demonstrated within one lesson.

The temperature in the carbon dioxide bottle increased more than in the bottle with air.

In both cases the temperature increased quickly, and then stabilised from about 15 minutes.

Conclusion
The carbon dioxide has trapped more heat than the air.

Extension investigation
This is an optional extension in which learners must design their own experiment to answer one of the following questions. They can then write up an experimental report. You can use Assessment Rubric 2 to assess learners' work.

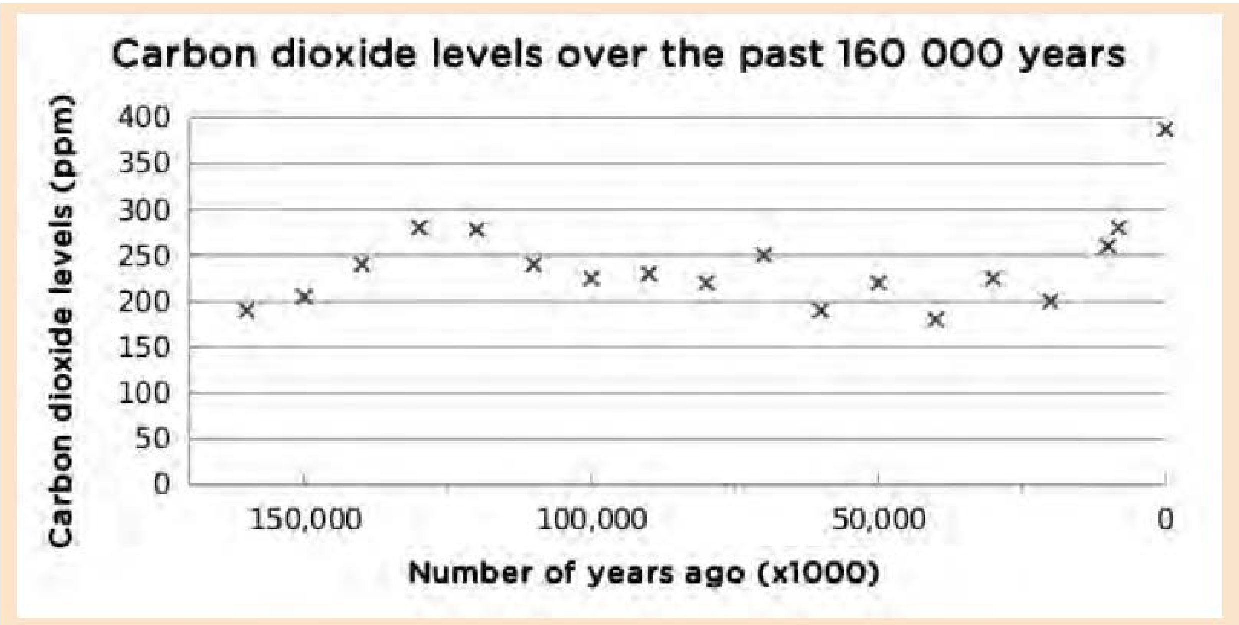
Global warming

Learners should have seen from the last investigation that if the levels of carbon dioxide and other greenhouse gases increase in the atmosphere, then the temperature will increase as greenhouse gases trap more heat.

INVESTIGATION: Ice core analysis **(LB page 390)**

Investigative question
How has the level of carbon dioxide in the atmosphere changed over the past 160 000 years?

Analysis
1. An example of the graph that learners produce is shown here:



2. Pockets of CO_2 are trapped in the ice. These pockets provide a record of CO_2 levels in the air atmosphere at that time. When we analyse ice from 160 000 ago, we can determine the level of CO_2present in the atmosphere at that time. Higher levels of CO_2 mean that the greenhouse effect is stronger and the Earth heats up more.

Conclusion
1. The levels of CO_2 have risen/doubled over the past 160 000 years.
2. Increase in ocean temperatures, ice caps melting, increase in sea level, change in weather patterns,

change in crop production, possible food scarcity/hunger, some areas become wetter, others dryer, animal and plant

Concept map

It is important that learners complete this concept map to consolidate what they have learned. They can either do it as a homework exercise or if enough time is available, a whole period can be dedicated to this activity. Learners have been exposed to many concept maps up until now and have had to make their own from scratch for some of the smaller Units. Learners now have to put these skills into practice for a more complex concept map. This will be good preparation for learners' examinations. There are no right and wrong answers for the concept map. An example concept map is provided here. If learners are battling, you could use this following map as a guide and with the class, draw a concept map on the board. However, do not just draw it up for learners to copy down. Learners must be actively involved in the construction. You may also come up with alternative ways of presenting the concepts.

Revision

1. a) A – troposphere B – stratosphere
   C – mesosphere D – thermosphere
   b) A – The temperature decreases with altitude from about 16°C to -60°C.
   B – The temperature increases with altitude from -60°C to 0°C.
   C – The temperature decreases with altitude from 0°C to -90°C.
   D – The temperature increases with altitude from -90°C to 1000°C.
   c) The troposphere is heated mainly through radiation of the Sun's energy by the Earth. The further you move away from the Earth, the less radiation energy there is to heat the atmosphere. Temperature will therefore decrease with altitude.
   d) The troposphere because it is the closest to the Earth and the Earth's gravity pulls the gases in the atmosphere towards the surface.
   e) The troposphere. It is warm enough and has enough oxygen for respiration. At this level, life is also protected from UV radiation.
   f) D
   g) C
   h) D
   i) A
   j) D
   k) B
   l) A
   m) B
2. Venus is closer to the Sun. Both have CO_2, but Venus's atmosphere is much denser. The greenhouse effect is much more dominant, resulting in a much hotter surface temperature. Mars has lots of CO_2, but it is not very dense and therefore the greenhouse effect is not observed.
3. Earth has enough oxygen and not a lot of CO_2. There are just enough greenhouse gases to ensure that the Earth is kept warm enough. It has just the right balance between CO_2 and oxygen/other gases.
4. a) Industries, human activities, burning of fossil fuels, more cars/vehicles (any two).
   b) It is the gradual increase in the temperature of the Earth's atmosphere.
   c) Higher levels of CO_2 means that the greenhouse effect will increase and temperatures on Earth will rise. If this continues over a long time, ice will melt, water levels will rise, coastlines will change, weather patterns will be influenced, crop production will be affected, and it could lead to the extinction of animal and plant species that are unable to adapt.

24 Birth, life and death of a star

Unit overview

1 week

In Grades 6 and 8 learners covered material regarding the solar system including the Sun. In Grade 7, they focused on the system which includes the Sun, Earth and Moon. Learners should be familiar with the fact that the Sun is a star and produces heat and light (energy) via nuclear reactions. In this Unit the focus is on the life cycle of stars, including how they are born and die. The exact evolution that a star follows depends on the initial mass of the star. The Sun's evolution is presented as an example.

The main aims of this Unit are to ensure that learners understand the following:

- stars are born in vast clouds of gas and dust
- stars spend most of their lives on the *main sequence* fusing hydrogen gas to helium gas
- stars eventually swell up to form a red giant star
- stars like the Sun end their lives as planetary nebulae and white dwarfs

Some learners may ask why stars look 'spiky' in the photographs from telescopes, but in the diagrams shown here, they are presented as spheres.

Watch this video to find out and explain to your learners: bit.ly/16iqmkW

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

24.1 The birth of a star (0.5 hours)

24.2 Life of a star (1 hour)

Tasks	Skills	Recommendation
Activity: Observing Orion in the spring sky	Observing	CAPS suggested

24.3 Death of a star (1.5 hours)

Tasks	Skills	Recommendation
Activity: Life cycle of a Sun-like star	Observing, investigating	CAPS suggested
Activity: The life cycle of the Sun	Observing, writing	CAPS suggested
Activity: Flow diagram poster showing the lifecycle of a Sun-like star	Writing, drawing, sequencing	CAPS suggested

A good way to introduce the topic of stellar evolution is to start by asking learners how long they think stars last. Many will answer forever. Many people are unaware that, like humans, stars are born, live their lives and then die. You can also ask them what is meant by 'living' when referring to a star, after all, stars do not perform the seven life processes, as taught in Life and Living.

Astronomers generally consider stars that are undergoing nuclear reactions in their cores to be living stars.

Stars are also compared in terms of relative concepts, such as:

- young and old
- cool and hot
- how big they are
- how massive they are (the mass is important in terms of looking at how stars die)

Key questions

- Where are stars born?
- Can we talk about a star as 'living'?
- How long do stars like the Sun live?
- How do stars spend most of their life?
- Why are stars different colours?
- How do stars die?

24.1 The birth of a star

In this section learners will discover that stars are born in giant clouds of dust and gas, called nebulae, in space. In order to understand how collapsing gas clouds heat up to eventually form stars, learners need to understand that compressing a gas heats it up and that allowing a gas to expand cools it down.

If they are unfamiliar with this concept a good analogy is to think about over-inflating a bicycle tyre (without bursting it). You could demonstrate this in class by getting learners to slightly over-inflate a tyre. They will find that the pump and tyre get hot!

In the case of inflating a tyre, you are forcing more and more molecules into a given volume (assuming that the tyre is now at full capacity). So you are compressing or squeezing the gas. Each molecule has a certain amount of kinetic energy. As more molecules are forced in by the pump, the air in the tyre is compressed and the total thermal energy increases because there are more molecules colliding inside the tyre. As more particles are contained in the same volume, the air's temperature in the tyre increases. As you deflate the tyre, you allow the gas to expand, the molecules are more spread out. There is then less thermal energy and so the temperature decreases. You could let students feel the air as it is released from the tyre – it should be colder than the ambient air as it is rapidly expanding as it escapes from the tyre.

The image shown on page xx of the Learner's Book of the Large Magellanic Cloud, a satellite galaxy to the Milky Way, illustrates very clearly, an example of sequential star formation, where new star birth is triggered by the previous generation of massive stars.

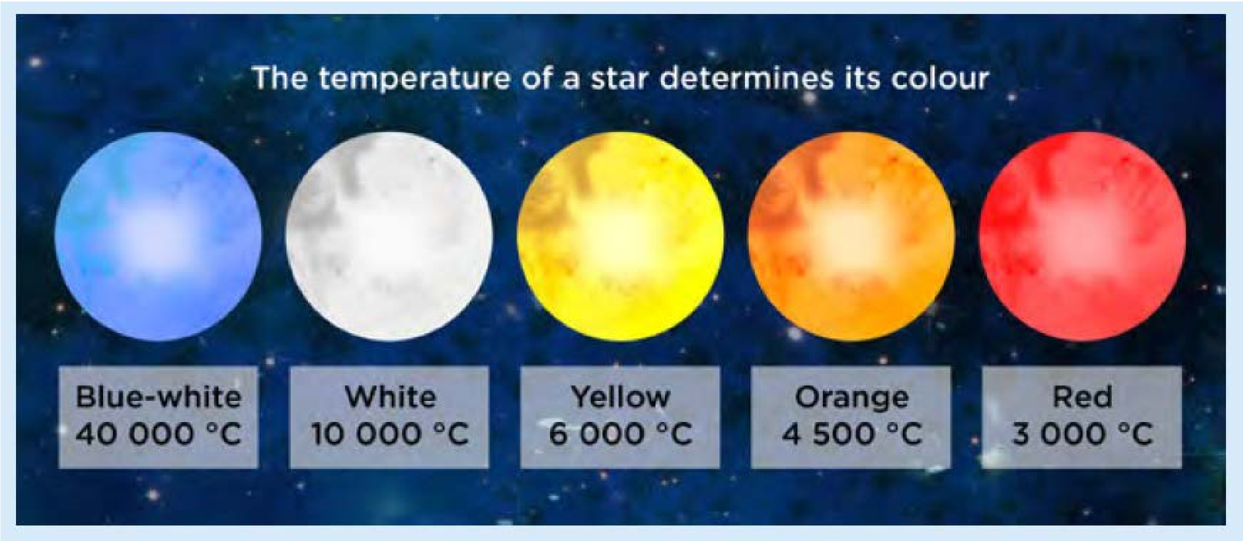
You can point some of these observations out to learners:

- Just below the cluster of hot stars in the top left, is an area of brightly emitting hydrogen gas, illuminated by the nearby hot stars.
- Further to the right are several smaller dark dust clouds with odd shapes. They can be seen silhouetted against the glowing gas. Several of these dark clouds have a bright rim as they are illuminated and being evaporated due to the action of radiation from neighbouring hot stars.
- The region around the cluster of hot stars in the image is relatively clear of gas as the stellar winds and radiation from the stars have pushed the gas away.
- When this gas collides with and compresses surrounding dense clouds, the clouds can collapse under their own gravity and start to form new stars.
- The cluster of new stars in the upper left may have been formed this way, as it is located on the rim of the large central interstellar bubble of the complex. The stars in this cluster are now beginning to clear away the cloud from their birth and are producing new opportunities for subsequent star birth.
- Learners may ask why some of these images have black boxes in the top, right corner, as though some of the image is missing. These strange, stair-shaped images come from the Hubble Telescope's Wide Field and Planetary Camera 2, or WFPC2. WFPC2 consists of four cameras, each of which takes a picture of a section of the target. It is like taking four pictures of a single scene, then putting them together to create the whole picture. But one of WFPC2's cameras, the top right, takes a magnified view of the section it is observing, to allow astronomers to study that section in finer detail. When the images are processed, that magnified section is shrunk down to the same size as the other sections, so

that it fits into the image, resulting in the stair-shaped pattern. You can read more about it here: bit.ly/Hszbz3

24.2 Life of a star

The following image shows the correct labels for the temperatures of different stars:



The yellow star represents our Sun.

ACTIVITY: Observing Orion in the spring sky (LB page 401)

1. Betelgeuse is red and Rigel is blue in colour.
2. Rigel is much hotter than Betelgeuse, hence it is bluer.

A red giant glows red because it has cooled compared to when it was a main sequence star. It is called a giant because the outer layers have expanded outwards and the star has got much larger than it was when it was a main sequence star.

The animation listed in the **Visit** box provides a very useful tool to give learners a sense of the scale of the Universe. If possible, you can project it up in your classroom and scale through it from a human all the way out until you get to some of the massive super giants, and then beyond. You will also be able to see the scale of some of the objects mentioned in this Unit, such as the Crab Nebula, the Large Magellanic Cloud and Pillars of Creation.

24.3 Death of a star

In this section learners will discover how stars die. The focus is on the death of a low mass star like the Sun. However, for completeness, the way that high mass stars die is also briefly mentioned. There are two activities in this section related to the life of Sun-like stars. Both of these are intended to help learners remember and understand the sequence of phases that a star like the Sun undergoes during its life. There is a lot of unfamiliar terminology in stellar evolution and it can be confusing for learners. Hopefully by doing activities rather than simply reading about the different stages in a Sun-like star's evolution, learners will find the subject easier to understand.

ACTIVITY: Life cycle of a Sun-like star (LB page 405)

This activity can be performed in pairs or small groups. This activity demonstrates the life of a Sun-like star using a yellow balloon to represent the Sun. Learners must follow the instructions to demonstrate each of the phases that a star like the Sun goes through during its life. This activity is best completed in pairs where one member "gives the orders" and the other member completes the activity. If you have time you can repeat the activity, swapping the pairs around.

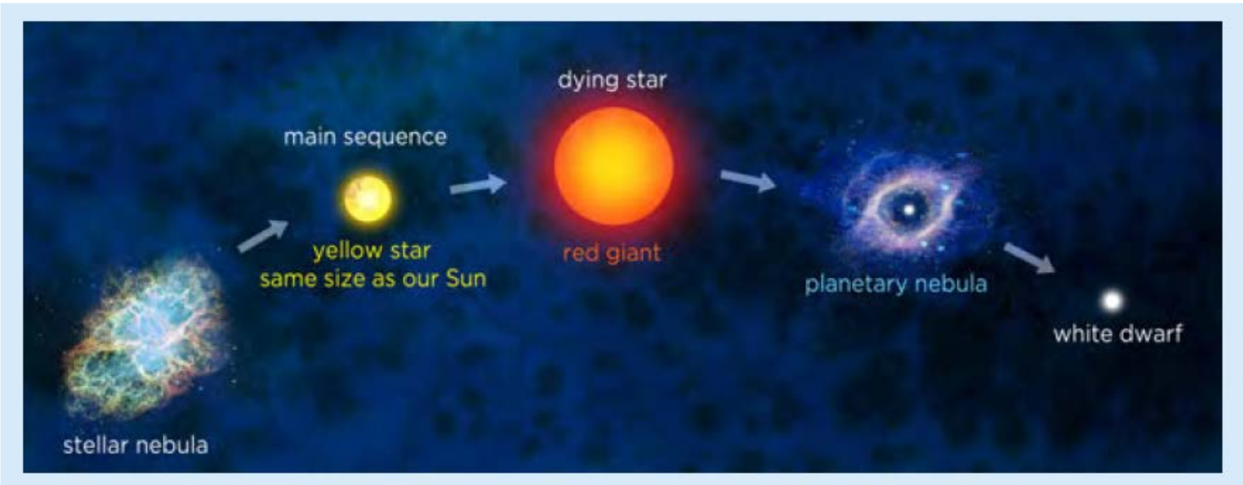
ACTIVITY: The life cycle of the Sun (LB page 407)

1. The Sun is currently about halfway through its lifetime as a main sequence star. In about 4.5 billion years' time the Sun will swell up to form a red giant star engulfing the Earth as it does so.
2. After the Sun has become a red giant, it will eventually become unstable and puff off its outer layers forming a beautiful planetarynebula. The central core of the Sun will be left exposed in the centre of the planetary nebula.
3. Once the fuel runs out in the core of the Sun, nuclear reactions will stop. The Sun will then have become a hot white dwarf star, left behind at the centre of the planetary nebula.
4. As there are no ongoing nuclear reactions, as the white dwarf shines it slowly cools and will eventually form a black dwarf.

ACTIVITY: Flow diagram poster showing the life of a Sun-like star (LB page 407)

In this activity learners will make a poster showing the different stages of stellar evolution experienced by a Sun-like star. The idea is to create a flow diagram showing which stage leads on to the next. Learners can use photographs or pictures printed from the Internet or they may draw their own pictures depending on time and resources available.

An example is presented below for guidance:



If learners have access to the Internet, they can print out images of the various stages. otherwise they can use the reference diagrams in the workbook to draw pictures.

Questions

1. In vast cold clouds of gas and dust called nebulae.
2. It is called a red giant because it is red in colour and much larger than a main sequence star.
3. A white dwarf star.
4. A glowing nebula formed by an expanding shell of gas around an aging star.
5. About the size of the Earth.

The following content on supernovae is not in CAPS, but has been included here as the stellar evolution discussed previously explains small and medium-sized stars. Giant stars have a different end, as discussed here. The temperature in the cores of these super giants gets high enough for them to fuse elements heavier than hydrogen and helium.

A black hole is a region of space where gravity is so strong that even light cannot escape. The gravity is so strong because matter has been squeezed into a tiny space. This can happen when a star dies. As light cannot escape you cannot actually see a black hole. Black holes can be detected by their gravitational effects on nearby visible objects, or in the case of a black hole that is actively absorbing material from its surroundings, the material may emit light before it is sucked into the black hole. As well as stellar mass black holes, there are much more massive black holes in the centres of galaxies, called supermassive black holes.

Revision

1. Nebulae (singular nebula).
2. It is called a protostar.
3. If there is enough gas and dust for the temperature to become hot enough for nuclear reactions to start, the protostar will then technically be called a star.
4. A white star is hotter than a yellow star.
5. A main sequence star burns hydrogen to helium at its core. This is called nuclear fusion.
6. A red giant.
7. Low mass stars eject their outer layers forming a planetary nebula.
8. A white dwarf.
9. A stellar nebula is where stars are born, whereas a planetary nebula is what a star forms at the end of its life.
10. a)

Label	**Stage**
A	Stellar nebula
B	Main sequence star/Yellow star
C	Red giant
D	Planetary nebula
E	White dwarf

b) When the hydrogen in the centre of the star is depleted, the star's core shrinks and heats up. The outer part of the star, which is still mostly hydrogen, starts to expand. The star becomes larger, brighter and its surface temperature cools so it glows red. The star is now a red giant star.

c) Gravity causes the star to collapse inwards and form a very dense star.

d) The energy of the white dwarf will have become depleted and it stops emitting light and becomes a black dwarf star forever more.

11. Supernovae explosions (singular supernova).