

Natural Sciences Teacher's Guide

Grade 8-A (CAPS)

sasol
reaching new frontiers



EXPLORE
A World Without Boundaries



basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

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1	H	2
3	Li	Be
11	Na	Mg
19	K	Ca
37	Rb	Sr
55	Cs	Ba
87	Fr	Ra
57	La	Ce
89	Ac	Th

Periodic Table of the Elements

No	Element
4	Be
12	Mg
20	Ca
39	Sr
57-71	La-Lu
89-103	Ac-Lr
58	Ce
91	Pa
92	U
60	Pr
93	Np
61	Nd
94	Pm
62	Sm
95	Am
63	Eu
96	Cm
64	Gd
97	Bk
65	Tb
98	Cf
66	Dy
99	Es
67	Ho
100	Fm
68	Er
101	Md
69	Tm
102	No
70	Yb
103	Lr

18

2	He
5	B
13	Al
14	Si
15	P
16	S
17	Cl
18	Ar
13	C
14	N
15	O
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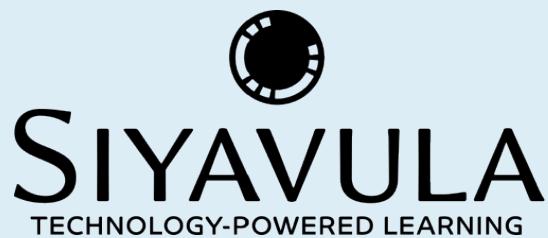
□ Transition Metal
■ Metalloid
■ Non-metal
■ Noble Gas
■ Lanthanide
■ Actinide

Natural Sciences

Grade 8-A

CAPS

developed by



funded by



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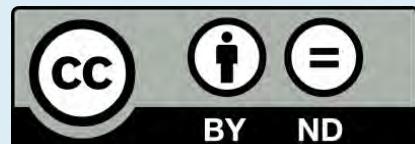
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AUTHORS' LIST

This book was written by Siyavula with the help, insight and collaboration of volunteer educators, academics, students and a diverse group of contributors. Siyavula believes in the power of community and collaboration by working with volunteers and networking across the country, enabled through our use of technology and online tools. The vision is to create and use open educational resources to transform the way we teach and learn, especially in South Africa.

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To learn more about the project and the Sasol Inzalo Foundation, visit the website at:

www.sasolinzalofoundation.org.za

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Teacher's Guide Overview

Curious? Discover the possibilities!

VISIT

Carl Sagan was an astronomer, astrophysicist, cosmologist, author, science popularizer and science communicator. Watch one of his most pertinent messages for humanity here bit.ly/1bbVDqg



Asking questions and discovering our world around us has been central to human nature throughout our history. Over time, this search to understand our natural and physical world through observation, testing and refining ideas, has evolved into what we loosely think of as 'science' today. Key to this, is that science is a continuous revision in progress, it is a mechanism rather than a product, it is a way of thinking rather than a collection of knowledge, whose driving force is not certainty in a truth, but rather being comfortable with uncertainty, thereby cultivating curiosity.

However, as Carl Sagan famously said in 1994:

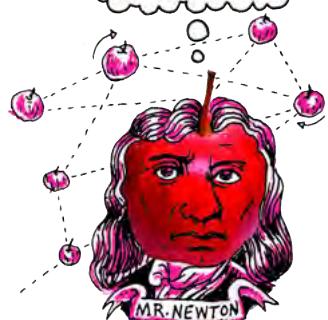
"We live in a society absolutely dependent on science and technology, and yet have cleverly arranged things so that almost no one understands science and technology. That's a clear prescription for disaster."

We need to replace fear of the unknown and the difficult with curiosity, as Marie Curie said:

"Nothing in life is to be feared, it is only to be understood. Now is the time to understand more, so that we may fear less."

DID YOU KNOW?

Marie Curie was a chemist and physicist famous for becoming the first person to be awarded two Nobel Prizes.



We would like to instill this sense of curiosity and an enquiring mind in learners. Science, technology, engineering and mathematics are not subjects to be feared, rather they are tools to unlock the potential of the world around you, to create solutions to problems, to discover the possibilities.

But, how do we practically do this in our classrooms? We would like this workbook to become a tool that you can use to do this. The theme for the presentation of this content in Gr 7-9 Natural Sciences is 'Curious? Discover the possibilities.' We have shown everyday science and objects with 'doodles' over them to show how if you are curious, intrigued and investigate the world around you, there are many possibilities for discovery. Sometimes these doodles are science or technology related, and sometimes they are more fantastical and fun. Learners should be inspired to discover, but also imagine the possibilities, as Freeman Dyson said:

"The glory of science is to imagine more than we can prove."

Learners must be encouraged to 'doodle' themselves, take notes during your class discussions, write down their observations, reflect on what they have learned. They must not be afraid of drawing and writing in these books. Science is also about being creative in your thinking.

We have aimed to present the content in an investigative, questioning way. At the beginning of each chapter, the topics are introduced by asking questions to which you will discover the answers as you go through the chapter. In teaching learners to ask questions, make observations, think freely and creatively, they

will be rewarded. Although, possibly not every time - it requires patience and determination. Although your learners will be exploring science and the world around us within a classroom context where assessment is integral, keep in mind this idea from Claude Levi-Strauss, when instilling the ethos of science in your learners:

"The scientist is not a person who gives the right answers, but one who asks the right questions."

Science is relevant to everyone. Scientific principles, knowledge and skills can be applied in creative and exciting ways to solve problems and advance our world. It is not just a subject restricted to our classrooms, but reaches far beyond, and within. Ultimately, we also want learners to embark on a personal discovery and be curious about their own potential and possibilities for the future.

Albert Einstein certainly did this when he observed:

"The most beautiful experience we can have is the mysterious - the fundamental emotion which stands at the cradle of true art and true science."

The Natural Sciences curriculum

As learners enter the Senior Phase in their schooling, the focus is now purely on Natural Sciences within this subject, and Technology is a separate subject. However, there are close links between the content in both of these subjects as they complement each other. The Natural Sciences curriculum also links to what learners cover in Social Sciences and Life Orientation. Whether you are a subject specialist teacher, or a class teacher, it is worthwhile to take note of where Natural Sciences overlaps with and integrates with some of the other subjects that learners are covering.

Organisation of the curriculum

In the Natural Sciences curriculum, the knowledge strands below are used as a tool for organising and grouping the content.

Natural Sciences Knowledge Strands

- Life and Living
- Matter and Materials
- Energy and Change
- Planet Earth and Beyond

These knowledge strands follow on from Gr 4-6. The strands also link into each other, and these have been pointed out both within the learners' workbook and here in the teachers guide.

We have also produced **concept maps** which show the progression of concepts across the grades, within a strand, and how they build upon each other. These concept maps are useful tools for teaching to see what learners should have covered in previous grades, and where they are going in the future.

TAKE NOTE

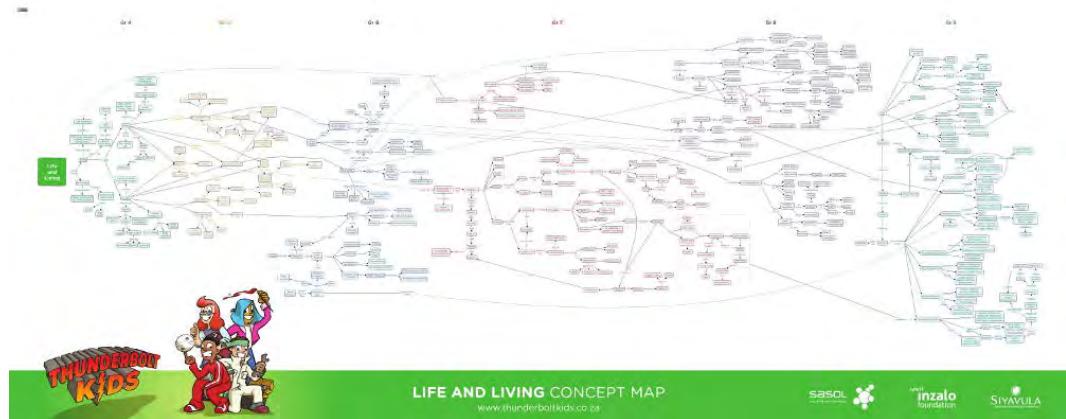
Albert Einstein repeatedly did poorly at school, dropped out at 16 and failed his first university entrance examinations. Every child deserves a chance to become someone, sometime in some place.



VISIT

If you would like to see what learners covered in Gr 4-6 with the Thunderbolt Kids, visit www.thunderboltkids.co.za





Allocation of teaching time

The time allocation for Natural Sciences is as follows:

- 10 weeks per term with 3 hours per week
- Grades 7, 8 and 9 have been designed to be completed within 34 weeks
- Terms 1 and 3's work will cover 9 weeks each with 3 hours (1 week) allocated to assessment within each of these terms
- Terms 2 and 4's work will cover 8 weeks each, with 2 weeks allocated to revision and examinations at the end of each of these terms

Below is a summary of the time allocations per topic in Grade 8. This time allocation is a guideline for how many weeks should be spent on each topic (chapter).

Life and Living

Chapter	Time allocation
1. Photosynthesis and respiration	2 weeks
2. Interactions and interdependence within the environment	5 weeks
3. Microorganisms	2 weeks

Matter and Materials

Chapter	Time allocation
1. Atoms	2 weeks
2. Particle model of matter	5 weeks
3. Chemical reactions	1 week

Energy and Change

Chapter	Time allocation
1. Static electricity	1 week
2. Energy transfer in electrical systems	3 weeks
3. Series and parallel circuits	2 weeks
4. Visible light	3 weeks

Planet Earth and Beyond

Chapter	Time allocation
1. The solar system	3 weeks
2. Beyond the solar system	3 weeks
3. Looking into space	2 weeks

We have provided a finer breakdown of the time into the number of hours to spend on each section within a chapter in the Chapter overviews in the Teacher's Guide. However, again, this is a guideline or suggestion and should be applied flexibly according to circumstances in the classroom and to accommodate the interests of your learners.

Specific aims

There are three specific aims in Natural Sciences which are covered in these workbooks in the range of tasks provided and in the way the content is presented.

Specific Aim 1: 'Doing Science'

Learners should be able to complete investigations, analyse problems and use practical processes and skills in evaluating solutions.

There are many practical tasks within this workbook that provide the opportunity to conduct investigations to answer questions using the scientific method, to use scientific apparatus, instruments and materials and to develop a range of process skills, such as observing, measuring, identifying problems and issues, predicting, hypothesizing, recording, interpreting and communicating information. The skills associated with each task in this workbook have been identified in the chapter overviews in this Teacher's Guide.

Learners also need to be aware of the ethical concerns and values that underpin any science work that they do, as well as health and safety precautions. Where appropriate, these have been pointed out in the learners' workbook and in this Teacher's Guide.

Specific Aim 2: 'Knowing the subject content and making connections'

Learners should have a grasp of scientific, technological and environmental knowledge to be able to apply it in new contexts.

In teaching and discovering the content in Natural Sciences, the aim for learners is not to just recall facts, but to also use the knowledge to make connections between the ideas and concepts in their minds. Most of the activities in this workbook have questions at the end which aim to consolidate the knowledge and skills learned in the task, and also help learners to make connections with what they have previously learned.

There are many opportunities for discussion when going through the content in these workbooks. This is often highlighted in the Teacher's Guide with suggestions for how to lead the discussion and what questions to ask your learners to stimulate their minds and create links between what they are learning. There are often questions within the learners' workbooks which relate what they are learning at that point to previously acquired knowledge and experience.

Many of the links between content and also between strands and grades are pointed out within this Teacher's Guide. We suggest also making use of the concept maps when creating a clear picture in your own mind of the framework of knowledge that learners should have up to that point about a particular topic.

Specific Aim 3: 'Understanding the uses of Science'

Learners should understand the uses of Natural Sciences and indigenous knowledge in society and the environment.

There is a strong emphasis in these workbooks to show that science is relevant to our everyday lives, and it is not restricted to what we learn within the classroom. Rather, we are learning about the natural and physical world around us and how it works, as well as how our own bodies function.

These workbooks aim to show learners that many of the issues in our world can be solved through scientific discovery and pursuit. For example, improving water quality, conserving our environment, finding renewable energy sources and medical research into cures for diseases. Where appropriate, the history of various scientific discoveries and inventions, as well as the scientists involved, have been discussed.

These workbooks also aim to highlight the beauty, diversity and scientific achievements, discoveries and possibilities in our country, South Africa. An appreciation of local indigenous knowledge is very important. When going through particular topics in class, encourage your learners to talk about their own experiences so that learners are exposed to the indigenous knowledge of different cultures, to different belief systems and worldviews.

Understanding how scientific discovery has shaped and influenced local and global communities will enable learners to see the connections between Science and Society. This will help to reinforce that Science is practical and relevant, and it can be used as a tool together with other subjects like Mathematics and Technology to find solutions and understand our world.

How to use this workbook

We would like these Curious workbooks and Teacher's Guides to become a tool for you in your classrooms to teach, explore and discover Natural Sciences.

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- **Remix** - the right to combine the original or revised content with other content to create something new (for example if you want to include one of your own activities or content into this existing content)
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We would also love it if you told us how you are using this content as it helps us refine our processes.

Structure of the book

There is an A and a B book for the Natural Sciences content.

The A book covers term 1 and 2:

- Life and Living
- Matter and Materials

The B book covers terms 3 and 4:

- Energy and Change
- Planet Earth and Beyond

These books are an amalgamation between workbooks and textbooks. They have spaces for learners to write and draw whilst completing their tasks. Learners must be encouraged to write in these books, take notes, and make them their own. These workbooks also contain the content to support the various tasks. This makes these books slightly longer than usual.

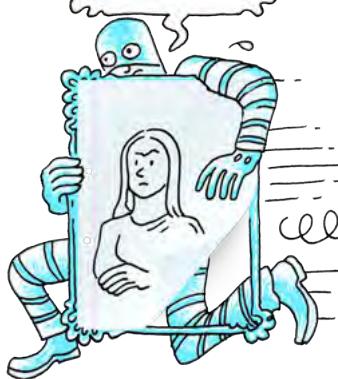
The beginning of each chapter starts off with **KEY QUESTIONS**. These introduce the content that will be covered in the chapter, but rather phrased as questions. This reinforces the idea of questioning, being curious and the investigative nature of science to discover the world around us and how it works.

The content and various **ACTIVITIES** and **INVESTIGATIONS** follow:

- **Investigations** are those tasks where learners will be using the scientific method to answer a question, test a hypothesis, etc. These are science experiments.
- **Activities** are all other tasks where the learner is required to do something whether it is making a model, researching a topic, discussing an idea, doing calculations, filling in a table, doing a play, writing a poem, etc.

TAKE NOTE

A suggestion is to use the concept maps as a self-study homework exercise for learners to go over what they have learned in the chapter.



At the end of each chapter there is a **SUMMARY**, where the **KEY CONCEPTS** highlight the main points from the chapter. Following this, there is a **CONCEPT MAP** for each chapter. One of the aims for these workbooks is to also teach various methods of studying and taking notes. Producing concept maps is one way to consolidate information. Throughout the year, the skill of making concept maps will be taught as the maps have more and more for the learners to fill in themselves as the year progresses.

Lastly, there is **REVISION** at the end of each chapter. There are mark allocations for these questions. These revision exercises can be used as formal or informal assessment.

At the end of each strand there is a **GLOSSARY** which contains the definitions for all the **NEW WORDS** which are highlighted throughout that strand.

Going through the content

These workbooks are a tool for you to use in your classroom and to assist you in your teaching. You will still need to plan your lessons and decide which activities you would like to do. There are sometimes more activities provided than what is possible within the time allocation. We have specifically done this to give teachers a choice, providing different levels of tasks.

The tasks which are suggested in CAPS have been identified here in the teachers guide, and we have marked those that are **optional** or **extensions**.

When going through the content in class and you are using the workbook, there are various questions within the content. These questions are aimed at stimulating class discussions where learners can take notes, or they link back to what learners have already done. The answers are provided in the Teacher's Guide. Use these questions to check learners understanding and keep engaged with the content.

The various activities and investigations often contain questions at the end. The questions can often be used as a separate activity, even the next day in class or as homework, to reinforce what was learned.

Teacher's notes

The way this Teacher's Guide is structured to provide the content of the learner's book, but with all the model solutions written in italic blue text, and with many **Teacher's notes** embedded within the content.

An example of a teacher's note:

TEACHER'S NOTE

This is an example of what a teacher's note looks like. It can contain:

- chapter overviews
- suggestions on how to introduce a topic
- guidelines for setting up or demonstrating a practical task
- general tips for teaching the content
- extra background information on a topic
- misconceptions which can easily be introduced to learners, or which learners might already have

At the beginning of each chapter, there is a **CHAPTER OVERVIEW**. This is crucial for your planning. This overview contains:

- the number of weeks allocated to the chapter, as suggested in CAPS
- an introduction to the chapter, highlighting any links to previous content that learners have already covered, or anything to be aware of when going through the content
- tables highlighting the various tasks for the chapter

The tables for each section can be used to plan your lessons. We have suggested an **hours break down** to spend on each section within the chapter, based on how much content there is to cover, and the number of tasks. This is only a suggested guideline.

Within each table, we have listed the different Activities and Investigations and the **process skills** associated with each task.

The third column contains the Recommendation for the task. These recommendations are, in order of priority:

- **CAPS suggested** (a task suggested in CAPS)
- **Suggested** (a task we suggest doing, but is not suggested in CAPS)
- **Optional** (an additional activity which is optional if you have time or would rather do this than the other suggested tasks)
- **Extension** (an additional activity which is optional and also an extension)

An example of one of these tables is given below:

1.1 Cell structure (2.5 hours)

Tasks	Skills	Recommendation
Activity: Brainstorm the Seven Functions of Life	Recalling information	Optional (Revision)
Activity: Summarise what you have learnt	Recalling information, identifying, writing	Suggested
Activity: Cell 3D model	Planning, identifying, describing	CAPS suggested

You will need to look at how many hours you have for each section, and then decide which tasks you would like to do with your learners. These tables provide a useful overview and will also help you choose tasks so that you cover a range of process skills and specific aims.

Assessment

The assessment guidelines for Gr 7-9 Natural Sciences are outlined in CAPS on page 85.

There are many opportunities for informal assessment within these workbooks. Any of the tasks can be chosen to continuously monitor your learners' progress as well as checking the short answers they provide to questions interspersed in the content.

At the end of each strand in the CAPS document, there is a section on assessment guidelines. There is a column entitled 'Check the learner's knowledge and that they can:' and there is a list. These items are included within the content for that strand and can be used for assessment.

The questions in the revision exercises at the end of each term can be used as formal assessment and you can use these questions, as well as your own, to make class tests and examinations.

At the end of the Teacher's Guide, there is an appendix with Assessment Rubrics. These rubrics are a guideline for assessment for the different tasks



which you would like to assess, either informally (to assess learners' progress) or formally (to record marks to contribute to the final year mark).

The various rubrics provided are:

- Assessment Rubric 1: Practical activity
- Assessment Rubric 2: Investigation
- Assessment Rubric 3: Graph
- Assessment Rubric 4: Table
- Assessment Rubric 5: Scientific drawing
- Assessment Rubric 6: Research assignment or project
- Assessment Rubric 7: Model
- Assessment Rubric 8: Poster
- Assessment Rubric 9: Oral presentation
- Assessment Rubric 10: Group work

Margin boxes

You may have already noticed some of the margin boxes in this Teacher's Guide overview so far. These boxes contain additional information and enrichment.

The **NEW WORDS** highlight not only the new words used, but also the key words for the chapter or section. The definitions for all these new words are listed in the glossary at the back of the strand.

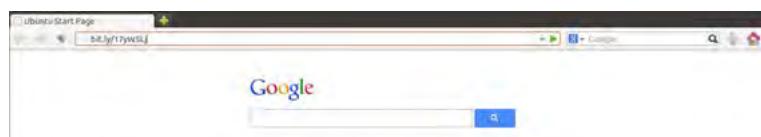
DID YOU KNOW has some fun, interesting facts relating to the content.

TAKE NOTE points out useful tips, with a special focus on language usage and the origins of words. This may be useful to second language learners.

The **VISIT** boxes contain links to interesting websites, videos relating to the content or simulations. This enrichment is also aimed to encourage learners to be curious about their subject in their own time by discovering more online. We feel it is important for learners to be aware that science is a rapidly advancing field and there are many exciting, innovative and useful discoveries being made all the time in science, mathematics and technology research.

To access the links in the VISIT boxes, you will see there is a bit.ly link. This is a shortened link that we created, as sometimes the website links to Youtube videos can be very long! You simply need to type this whole link into the address bar in your internet browser, either on your PC, tablet or mobile phone, and it will direct you to the website or video.

For example, in this Teacher's Guide overview, there is the link to a video about why open education matters. It is bit.ly/17yW5Lj Simply type this into your address bar as shown below and press enter.



This will either direct you to a website page, or to our website where you can watch the video online.

Discover more online at www.curious.org.za

Get involved

When we first embarked on this journey to create these books, our first step was to hold a workshop with volunteer teachers to get their perspective, suggestions and experience. Just turn to the front cover of this book to see how many people contributed in some way to these books! At Siyavula, we believe in openness and transparency and we would love your input in the next phase.

These books are not perfect and we will be continuously improving them. We would find your input and experience as a teacher crucial and highly beneficial in this process.

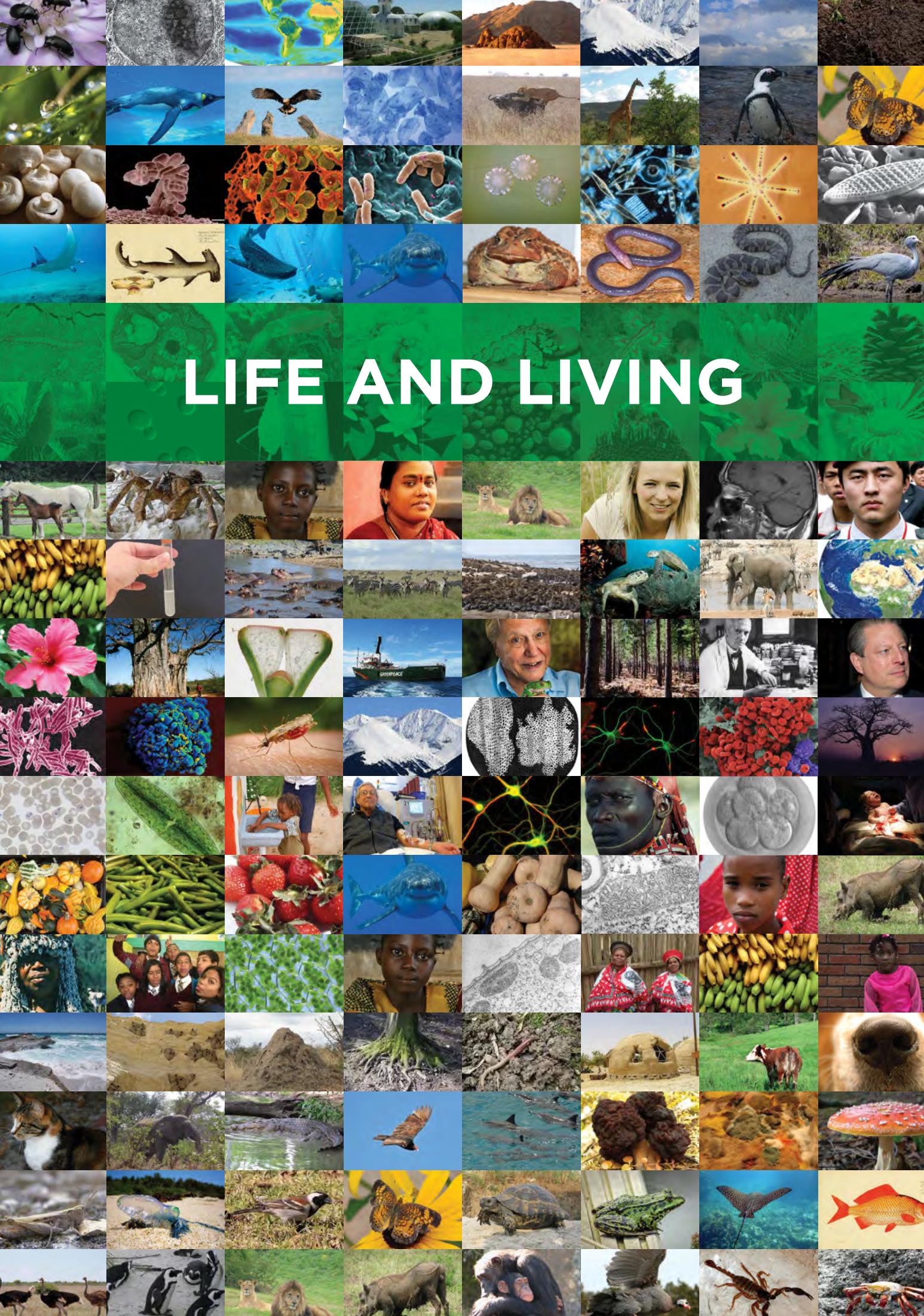
- Do you have any feedback about the books?
- Do you have suggestions?
- Would you like to share how you use these books in your classroom?
- Have you found any errors you would like to point out so we can fix them?
- Have you tried an activity and found a better way of doing it?
- What more would you like to see in these workbooks?

Get involved and let us know!

Find out more about our Siyavula Community at
projects.siyavula.com/community

And sign up by following this link bit.ly/15eiA6u. Specify Gr 7-9 Natural Sciences to stay informed about this process going forward in the future.





LIFE AND LIVING

Photosynthesis and respiration

TEACHER'S NOTE

Chapter overview

2 weeks

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

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

1.1 Photosynthesis (3.5 hours)

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

1.2 Respiration (2.5 hours)

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



KEY QUESTIONS:

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



Energy is needed to sustain life and without it nothing would be able to live on Earth. Our most important source of energy is the Sun. In this chapter we are going to investigate the processes involved in transferring the Sun's energy to our bodies to allow us to read this text! These two important processes are **photosynthesis** and **respiration**.

1.1 Photosynthesis

TEACHER'S NOTE

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

Energy sustains life

All life on Earth depends on energy to sustain the seven life processes.



ACTIVITY: The seven life processes

INSTRUCTIONS:

1. Do you remember what the seven life processes are? Do you remember using the letters from MRS GREN to help you remember these?
2. Write down the seven life processes below.

M _____

R _____

S _____

G _____

R _____

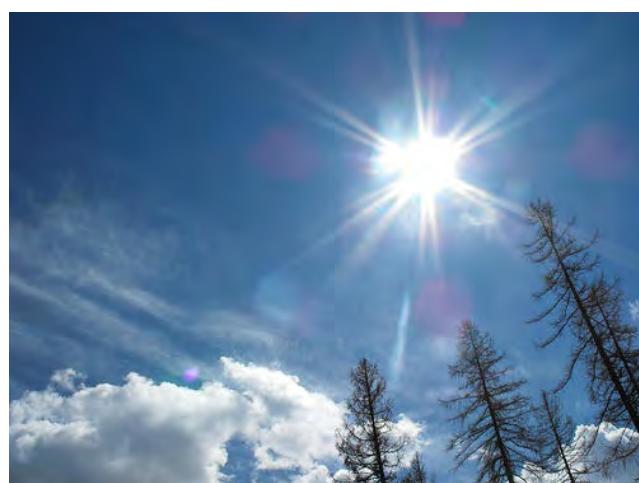
E _____

N _____

TEACHER'S NOTE

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

The form of energy that the Sun produces is called **radiant energy**. Although the Sun provides us with both light and warmth, plants only use the light energy from the Sun to photosynthesise.



The Sun provides us with energy in the form of light and heat.

Most organisms cannot directly use the energy from the sun to perform the seven life processes. For example, a reptile can lie in the Sun to warm up from the heat energy, but this does not provide the necessary energy for that animal to move, reproduce or excrete waste.

Except for a few sea slugs, plants are the only organisms on Earth that can absorb the Sun's radiant energy and convert it into food for themselves and for other living organisms.

Radiant energy to chemical potential energy

What is potential energy? Do you remember that we spoke about energy for movement (kinetic energy) and energy that is stored (potential energy) in Energy and Change in Gr. 6 and 7? What are some things that have kinetic energy and some that have potential energy? Remember to take down some notes in the margins of your workbook as you discuss things in class.

TEACHER'S NOTE

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

All living organisms can use energy in the form of **chemical potential energy** for the life processes. This is the energy that is stored in the food that organisms eat. Plants are able to capture the radiant energy from the Sun and transfer it to chemical potential (stored) energy for other organisms to use. They do this through the process of photosynthesis. All organisms release the stored potential energy from the food that they eat to support their life processes. This process is called **respiration**.

Photosynthesis takes place in small structures called **chloroplasts**, which are inside the cells of the leaves and stems of green plants. Inside the chloroplasts are green **pigments** called **chlorophyll**. This is what gives plants their green colour. Photosynthesis is the process in which chlorophyll molecules absorb the radiant energy from the sun and transfers it into chemical potential energy. The only function of chlorophyll is to trap the sunlight energy; chlorophyll is not produced or used up during photosynthesis.

VISIT

Find out why plants that photosynthesise are green.
bit.ly/18cAb2v

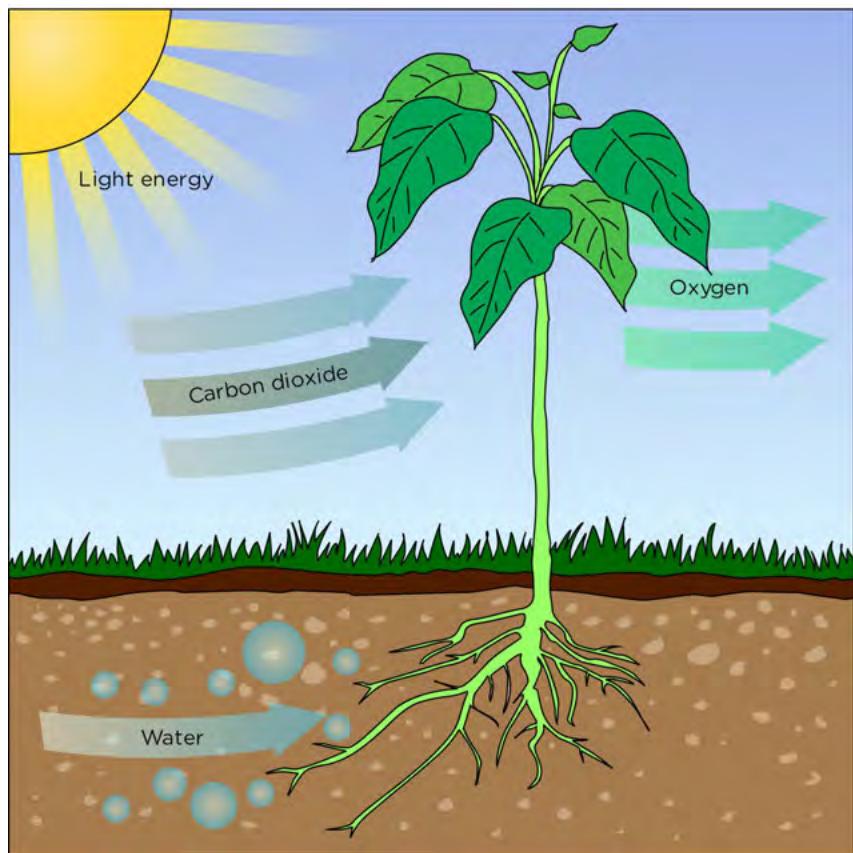


Elysia chlorotica, a sea slug, has evolved to absorb the chloroplasts from the green algae it eats and use them to photosynthesise! This animal can produce its own food and is green.

TAKE NOTE

Chloroplasts are a type of organelle found only in plant cells. A cell is the basic unit of all living things. We will learn more about the structure and functioning of cells next year in Gr. 9.

Photosynthesis has other requirements besides light energy from the Sun. What are these? Look at the following diagram which summarises the process of photosynthesis.



Plants use radiant energy from the Sun in a series of chemical reactions to change carbon dioxide from the air and water from the soil into **glucose**. The process releases oxygen.

ACTIVITY: Requirements and products of photosynthesis

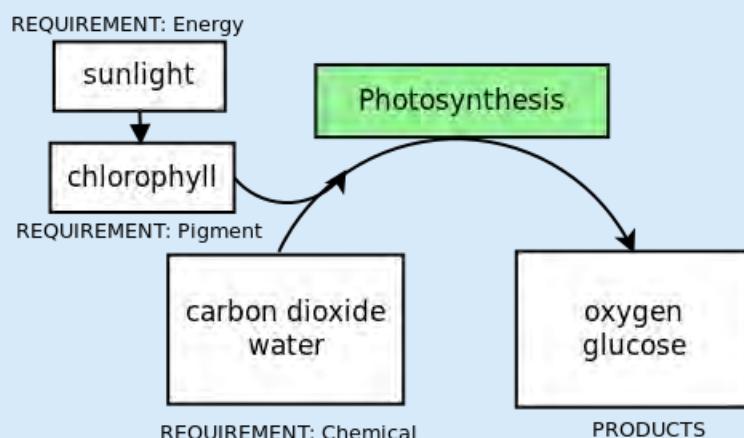


INSTRUCTIONS:

1. Summarise what you have learnt about photosynthesis in the diagram below.
2. Fill in the requirements of photosynthesis in the block on the left and fill in what type of energy is needed and the name of the pigment that absorbs the energy.
3. Fill in the products of photosynthesis in the block on the right.

TEACHER'S NOTE

The learner's diagram should look as follows:



The process of photosynthesis can be presented in the form of an equation:



What happens to the glucose that plants produce during photosynthesis?

Glucose storage and use

The glucose that a plant produces when it photosynthesises is the food for the plant. The plant can use this glucose directly, and release the energy during its own respiration or it can store the glucose or convert it into other chemical compounds.

Glucose is **soluble** in water. As we learnt in Matter and Materials in Gr. 6, this means that glucose can dissolve in water. This is useful to the plant as it means it can transport the glucose in water to where it is needed elsewhere in the plant. However, in order to store large amounts of glucose, plants need to convert it into compounds which are **insoluble** in water. Therefore the plant

TAKE NOTE

Plants use sugars (glucose) as a basic molecule from which to make hundreds of other compounds, such as proteins, oils, vitamins, colourful pigments in flowers, strong tasting chemicals (hot chilli plant), sweet tasting nectar and sweet smelling fragrances.

converts glucose into **starch**, which is insoluble in water. Why do you think the plant might need to store some glucose?

TEACHER'S NOTE

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

In addition to starch, plants also convert glucose into cellulose. Cellulose is used to support and strengthen plants. Animals do not have cellulose for support. Instead animals have something else to provide support and protect the body. Do you remember what this is?

TEACHER'S NOTE

A skeleton.

Glucose is also converted into other chemical compounds that enable processes in the plant such as reproduction and growth.

We have now learnt about how plants produce glucose and store it as starch, but how do we know for sure? As young scientists we also need to question whether this explanation of photosynthesis is accurate. Is there an investigation we can do to test for the presence of these compounds? Let's find out!

We have learnt that plants produce glucose during photosynthesis and store this in the form of starch. Therefore, to see if a plant photosynthesises, we can test to see if the plant produced starch.

Study the following properties of starch and glucose with your class. Think of possible tests that can be done to determine whether a plant has produced either starch or glucose. Record some of your discussion points.

TAKE NOTE

The **Visit** boxes in the margins contain links to interesting websites and videos. Simply type the link exactly as it is into the address bar in your browser.

TEACHER'S NOTE

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

- Glucose tastes sweet but starch does not taste sweet at all.

TEACHER'S NOTE

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

- Glucose will dissolve in water while starch will not dissolve in water.

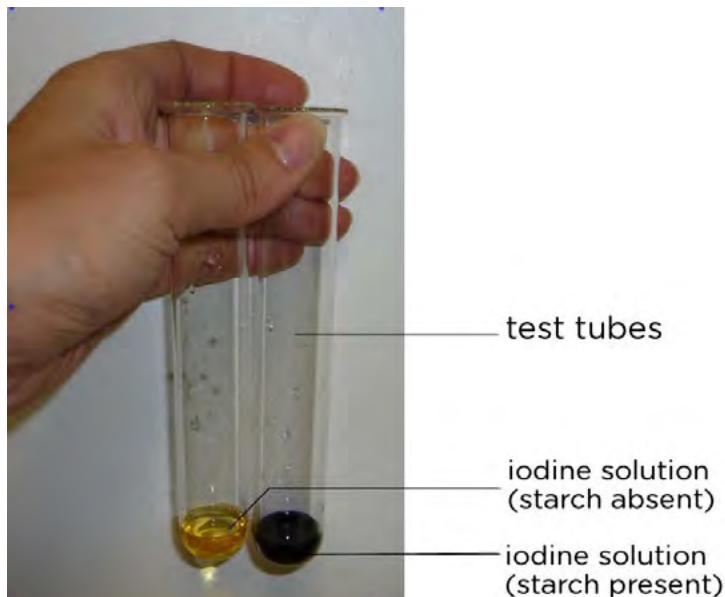
TEACHER'S NOTE

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

- Iodine changes from brownish-orange to dark blue-black when it comes into contact with starch. Have a look at the following photos which illustrate this.

TEACHER'S NOTE

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



The left tube contains only diluted iodine solution and the right tube contains diluted iodine solution with starch.

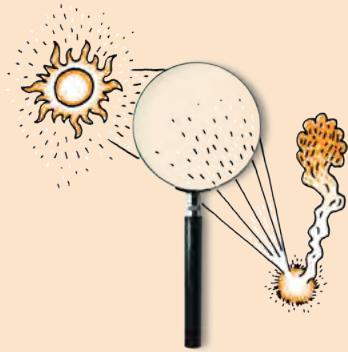
VISIT

A video on the starch test.
bit.ly/177Z3ay

TEACHER'S NOTE

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

Now that we know that plants produce glucose and change this into starch, we can find out if all leaves produce the same amount of starch through photosynthesis.



INVESTIGATION: Which leaves photosynthesise?

TEACHER'S NOTE

You will need variegated and normal leaves for this investigation. Variegated leaves have white patterns (areas lacking chlorophyll) on them. There are many examples of South African plants that have variegated leaves, such as some geraniums, African violets, ivy, etc. You can also take a walk around your school property and surrounds to see if you can find any variegated leaves. Get learners to look at the leaves and discuss the investigation first. They can also do this in groups. This investigation can be done over 2 lessons. You should place one set of pot plants in the cupboard the day before you want to do part 1 of the investigation. After you have done part 1, you can do part 2 in the following lesson. In part 2, learners will need to write up an experimental report. **If you do not have time to do both parts** of the investigation, a suggestion is to get your learners to read through Part 1, and then to conduct Part 2 where they have to write up their own report.

There are two parts to this investigation. First, we want to find out which leaves are able to photosynthesise. We will place some pot plants in the light for a day, and some other pot plants in a dark cupboard for a day, and then perform the investigation on the leaves of plants from both groups.

In the second part of the investigation, we will use what we have learnt to investigate which parts of variegated leaves photosynthesise.

Part 1: Leaves in light and dark

AIM:

1. What do you wish to establish by conducting this investigation?
Learner-dependent answer

TEACHER'S NOTE

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

HYPOTHESIS:

1. What do you think or predict will happen when you conduct this investigation?
Learner-dependent answer

TEACHER'S NOTE

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

MATERIALS AND APPARATUS:

- gloves
- a range of pot plants that can be easily moved around
- 100 ml beaker or glass jar in a saucepan with water
- bunsen burner, spirit lamp or a stove
- tweezers
- ethyl alcohol (or methylated spirits)
- glass petri dishes, white saucer or white tile
- stopwatch or timer
- glass pipette or dropper
- iodine solution

METHOD:

TEACHER'S NOTE

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

1. Work in groups of three or four.
2. Place half of the plants in the dark for at least 24-48 hours and the others in a well-lit area of the class that is exposed to lots of natural sunlight.
3. After 24 hours, pour 50 ml of the ethyl alcohol into the beaker and place it in the saucepan with water. Heat the saucepan over the bunsen burner or the stove. The water in the saucepan will distribute the heat evenly to warm the ethyl alcohol evenly.

TEACHER'S NOTE

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

4. Remove one healthy looking leaf from the pot plants that were in the well-lit area exposed to direct sunlight.
5. Using the tweezers, dip a leaf into the boiling water for 1-2 minutes. This helps to remove the waxy cuticle that covers the leaf and breaks down the cell walls.
6. After this, place the leaf into the beaker with the ethyl alcohol.

TEACHER'S NOTE

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

7. Leave the leaf in the alcohol until all the chlorophyll has been removed from the leaf and the alcohol turns green.
8. Place the leaf into warm water to soften it.
9. Remove the leaf from the warm water and place it on a white tile or a petri dish on top of a white surface.
10. Use the pipette or dropper to carefully drop 2 or 3 drops of iodine solution on the leaf in the petri dish and record your observations.

TEACHER'S NOTE

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

11. Repeat this process for two more leaves that were in the well-lit area.
12. Remove the plants that were in the dark for at least 24 hours. Use the test above to test whether there is starch present in the leaves from the plants that were kept in the dark.
13. Record your observations.

TEACHER'S NOTE

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

RESULTS AND OBSERVATIONS:

Keep a record of your observations. Draw a table to record and compare your results.

TEACHER'S NOTE

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

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

CONCLUSION:

1. What did you learn from doing this investigation?

Plants that were given sunlight were able to photosynthesise and therefore tested positive for starch (iodine solution turned blue-black). Those that did not receive radiant energy did not photosynthesise so they tested negative for starch presence (iodine solution remained yellow-brown). Therefore, light is necessary or required for photosynthesis to occur.

QUESTIONS:

1. Why were some plants placed in a well-lit area with direct sunlight and others in the dark?

This was done to allow some plants to photosynthesise and the others not. Thus those that were able to photosynthesise could produce starch and those that didn't only had small amounts of starch or no starch.

2. Explain what the results of the iodine test indicates.

If the iodine changes from brownish-orange to dark blue-black that indicates that the leaf or other part of the plant contains starch and must have photosynthesised. If the iodine solution does not change colour then the leaf or other part of the plant does not contain starch and did not photosynthesise.

Part 2 : Which parts of variegated leaves photosynthesise?

TEACHER'S NOTE

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

Have a look at the following photos of different plants. What do you notice about the leaves?



Ivy leaves.



Geranium leaves.

TEACHER'S NOTE

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

We call these leaves variegated as they have green and white sections. We want to find out which parts of these leaves photosynthesise in this part of the investigation.

INSTRUCTIONS:

1. You need to design this investigation yourself.
2. First decide what question you are trying to answer and the aim of your investigation.
3. Make a hypothesis for your investigation.
4. You then need to think back to part 1 and design the method for your investigation.
5. After conducting the investigation, you need to write up an experimental report of your findings.
6. In your report, you must have the following headings:
 - a) Aim
 - b) Hypothesis
 - c) Materials and apparatus
 - d) Method
 - e) Results
 - f) Discussion
 - g) Conclusion
7. In your results section you need to record your observations in a scientific way. You can do this using a table, diagrams or a combination of both. Think carefully about what information you need to record in order to come to conclusions at the end of your experiment.
8. In your discussion, you need to explain your results and what they mean. You also need to evaluate your investigation and explain if there were any unusual results and suggest ways that you could have improved your investigation for future researchers who might want to repeat what you have done.
9. Present your report on separate paper.

TEACHER'S NOTE

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

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

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

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

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

TEACHER'S NOTE

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

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

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



Leaves are not the only parts of plants that store starch. Starch is also stored in the stems, roots and fruit. Have you ever wondered why fruit becomes sweeter as it ripens? Think of an unripe green banana and a ripe yellow banana. Which one is sweeter? Let's find out why.



Ripe yellow bananas and unripe green bananas.



INVESTIGATION: Why do bananas become sweeter as they ripen?

TEACHER'S NOTE

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

In this investigation we will taste the bananas to determine if they have more glucose or more starch. We will also conduct a starch test on the ripe and unripe bananas to see which contain more starch.

AIM:

1. What do you wish to establish by conducting this investigation?
Learner-dependent answer

TEACHER'S NOTE

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

HYPOTHESIS:

1. What do you think or predict will happen when you conduct this investigation?
If the unripe banana does not taste so sweet compared to the very sweet tasting ripe banana then perhaps it contains more starch, and less glucose. The starch test might show that the unripe banana contains more starch.

MATERIALS AND APPARATUS:

- ripe and unripe bananas cut into discs
- petri dish or saucer
- iodine solution
- dropper

METHOD:

1. Work in groups of three or four. Take a piece of the ripe banana and a piece of the unripe banana and compare the tastes and textures of each. Record your observations in a table. Which banana do you think contains the most starch and the least glucose (a sugar) based on the taste test?
Learner-dependent answer

TEACHER'S NOTE

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

2. Use the iodine starch test identify which banana, the ripe or the unripe one, contains the most starch. Record your observations in the table.

TEACHER'S NOTE

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

3. Compare this test to the results from your taste and texture test to identify which banana contained the most starch.

OBSERVATIONS:

1. Draw a table to record your observations from the taste and iodine test for starch.

Learner-dependent answer

TEACHER'S NOTE

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

QUESTIONS:

1. Compare your observations of ripe and unripe bananas with those of the other learners in the class. Did you all make the same observations?

Learner-dependent answer.

TEACHER'S NOTE

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

- 
- What do you conclude from these results? Which method of testing is better to use and why do you say so?

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

- Explain what you think happens to the starch as the bananas ripen.

As the bananas ripen, the starch is converted into glucose.

Now that we have looked at how green plants produce their own food, let's find out how all living things release the energy stored in food in order to perform the life processes.

1.2 Respiration

TEACHER'S NOTE

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

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

An idea as introduction and/or conclusion to this section on Respiration is to let learners watch the YouTube video of a song about cell respiration:

³ bit.ly/1eupZUz. The initial explanation is simple and appropriate for this grade level but it might show some of the more inquisitive learners what actually happens during the 3 stages of respiration.

We have now seen how plants produce food during photosynthesis. The energy from this food needs to be used by plants and by all the animals who eat those plants. In fact, all organisms need to break down food in order to release its chemical potential energy for life processes. So how does this happen? Let's find out.

Energy from food

Our bodies need energy to move and do work. Where do we get our energy from? The energy is obtained from the food that we and all other organisms eat.

If you think back to the work you did on fuel and energy in previous grades in Energy and Change, you will remember that fuels, such as wood, coal, and oil, contain **chemical potential energy**. When this fuel is burned in the presence of oxygen, the chemical potential energy is transferred into light and heat energy. In the same way, the glucose from the food that you eat is combined with oxygen in a series of chemical reactions to release the energy. The glucose is broken down and the energy is released. This energy is then used to drive all the other processes in your body. This process is called **respiration**. We can define respiration in all living organisms as the process by which energy is released from glucose in a series of chemical reactions.

Respiration takes place in all organisms, even plants. However, plants do not need to eat any food as they make their own food during photosynthesis.

TEACHER'S NOTE

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

Products of respiration

Do you remember how we represented photosynthesis as an equation to show what goes in and what comes out? We can represent respiration as an equation in the same way as we did for photosynthesis.

We know what is required for respiration to take place in all organisms. List the two ingredients for respiration.

TEACHER'S NOTE

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

We also know that respiration releases energy. This energy is contained in the chemical bonds of ATP molecules. ATP is not energy itself, but instead it *stores* energy. The ATP molecules have chemical potential energy in their bonds. When the ATP molecules are broken down they release the energy in order for other processes to take place.

TAKE NOTE

We will learn more about chemical reactions next term in Matter and Materials. You will also learn more about respiration in later grades.

However, respiration does not only produce energy. It also produces water and carbon dioxide as by-products. We can write an equation for respiration as follows:



TEACHER'S NOTE

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

During photosynthesis in plants, oxygen is produced as a by-product. We call it a by-product as it is not the main product that is wanted from the process. In photosynthesis, the main product that is required from the process is glucose. What are the by-products in respiration?

TAKE NOTE

A by-product is also sometimes referred to as a waste product.

TEACHER'S NOTE

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

The carbon dioxide that is produced in the body of an organism during respiration needs to be removed. In humans, we do this by breathing out carbon dioxide-rich air. We will learn more about the whole respiratory system next year in Gr. 9, and how breathing, our blood circulation system and respiration all work together as one system within our bodies.

We can test for the products of respiration using our own breath. So how do we test that our breath contains carbon dioxide? It is a colourless gas, so we cannot see it directly.

There is a very well known test for detecting carbon dioxide using clear limewater. To test if a gas contains carbon dioxide, simply bubble the gas through **limewater**. If the clear limewater turns milky, then the gas contains carbon dioxide. Next term in Matter and Materials, we will look at this again and find out about the chemical reaction taking place in the test. For now, let's use this test to show that our breath contains carbon dioxide.

ACTIVITY: Does our breath contain carbon dioxide?

TEACHER'S NOTE

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

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

MATERIALS:

- small beakers (or test tubes)
- rubber tubes or drinking straws

TEACHER'S NOTE

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

- limewater
- 20 ml syringe (or larger if available)

TEACHER'S NOTE

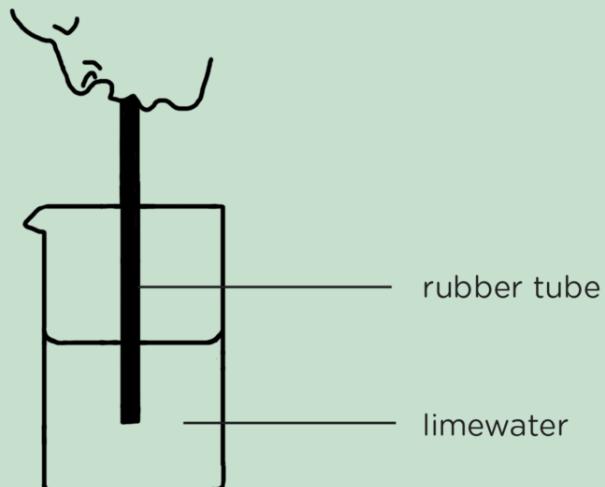
Pharmacies are generally quite helpful and will assist schools in purchasing low cost syringes. Technology teachers at your school might also have syringes for their syringe mechanics lessons. An alternative to a large syringe is to use a bicycle pump or balloon blower. **Safety warning:** remove the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

INSTRUCTIONS

1. Work in groups of three.
2. Mark one beaker AIR and the other BREATH.
3. Pour clear limewater into each beaker until they are half full.
4. Blow bubbles through the rubber tube into the beaker marked BREATH, as shown in the diagram. Do this for at least 1 minute. Notice what happens to the clear limewater.

VISIT

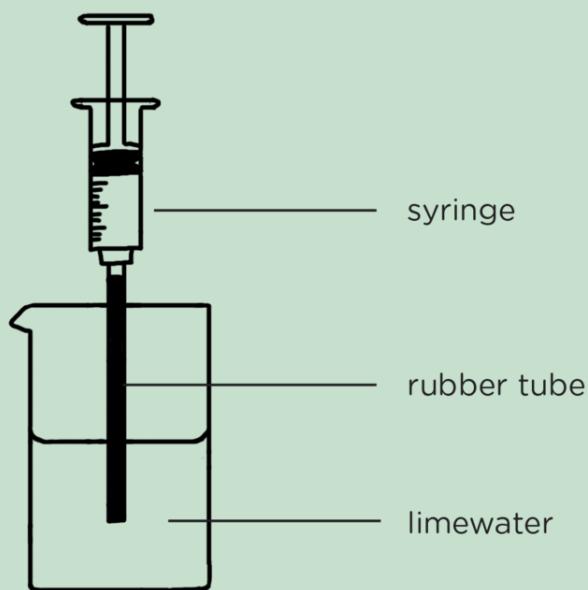
Watch a video of this activity. bit.ly/19cUVfc



5. Attach a rubber tube to the front of a syringe. Draw air into the syringe from the atmosphere.
6. Place this rubber tube into the beaker marked AIR and push out the air inside the syringe slowly and carefully into the limewater as shown in the diagram. Notice what happens to the clear limewater.

TAKE NOTE

Do not confuse breathing with respiration! Breathing is the act of inhaling and exhaling air into and out of the lungs. Respiration is the metabolic process that uses oxygen to release energy and releases carbon dioxide as a by-product.

**QUESTIONS**

1. Describe what you observed when you blew air from your lungs through the limewater. What does this mean?
The clear limewater turned cloudy white. This means our breath contains carbon dioxide from respiration.
2. Describe what you observed when you used the syringe to bubble air from the atmosphere through clear limewater.
The clear limewater did not change and remained clear. Some might notice a very slight change, which indicates that there is a small amount of carbon dioxide present in atmospheric air.

3. A very small percentage of atmospheric air is carbon dioxide gas (0.03). Why do you think you observed the result you did when you pushed air from the atmosphere through the limewater?

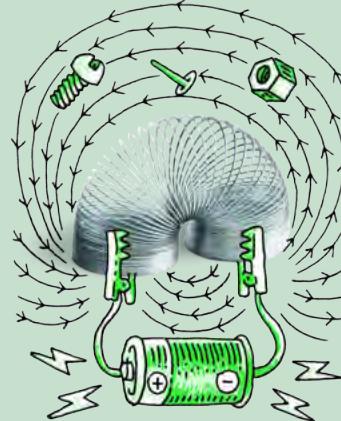
As air contains such a small percentage of carbon dioxide, there is not enough to cause a noticeable difference in the limewater. Discuss with your learners why they think that the limewater turned cloudy with your breath but not with the air, even though air does contain carbon dioxide. Point out that air from your lungs contains a much higher percentage of carbon dioxide from respiration and so this is able to turn the limewater cloudy in a shorter time than atmospheric air will.

4. Think about respiration.
- What are the requirements for respiration?
 - What are the products of respiration?
 - Glucose and oxygen.
 - Energy, carbon dioxide and water.

ACTIVITY: Requirements and products of respiration

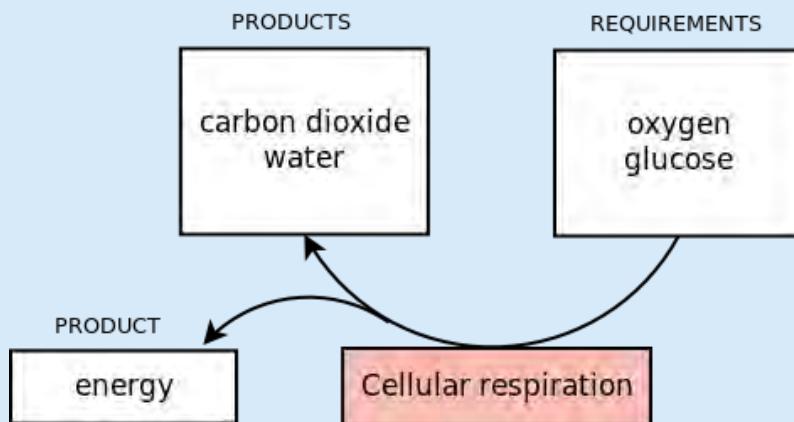
INSTRUCTIONS:

- Summarise what you have learnt about respiration in the summary diagram below.
- Fill in the requirements of respiration in the block on the right.
- Fill in the products of respiration in the block on the left.



TEACHER'S NOTE

This is what learners' diagrams should look like:





SUMMARY:

Key Concepts

- The need for energy drives the interactions and interdependence in an ecosystem.
- The Sun provides energy to the Earth in the form of radiant (light) energy and heat energy.
- Photosynthesis is the process whereby green plants use carbon dioxide from the air, water from the soil and radiant energy from the Sun in a series of chemical reactions to produce glucose (food) and oxygen.
- Plants are able to photosynthesise because they contain chlorophyll, a green pigment that can capture light energy from the Sun.
- Plants change the glucose that they produce into starch that can be stored more easily.
- Plants also produce cellulose fibres that give plants strength and support and are important to our digestive systems as roughage.
- The food that a plant produces is used by animals when they eat the plant and by other animals that eat them.
- This food contains chemical potential energy that needs to be released from the food.
- Respiration is the process in all living organisms by which energy is released from glucose in a series of chemical reactions.
- Respiration uses oxygen while carbon dioxide and water are given off as by-products.

Concept Map

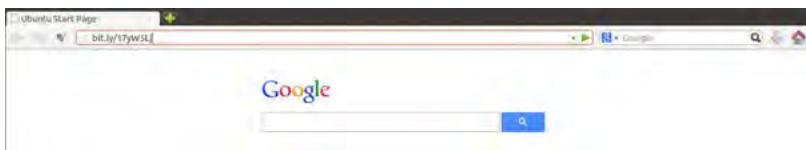
This year in Natural Sciences, we are going to learn more about how to make our own concept maps.

In the summary, we first have the "Key concepts" for this chapter. This is a written summary where the information from this chapter is summarised using words. We can also create a concept map of this chapter. This is a map of how all the concepts (ideas and topics) in this chapter fit together and are linked to each other. A concept map gives us a more visual way of summarizing information.

Different people like to learn and study in different ways; some people like to make written summaries, whilst others like to draw their own concept maps when studying and learning. Others like to make things even more visual, using pictures and diagrams to form their summaries. Figuring out the study method that works best for you, and developing these skills is very useful, especially for later in high school and after school!

Have a look at the concept map below for 'Photosynthesis and Respiration'. Do you see that there are some empty spaces? You need to complete the concept map by filling these in. To do this you need read the map from top to bottom and have a look at the concepts which come before. For example, read the concept map as follows, "Respiration takes place in all organisms. All organisms release energy from food, called". What type of energy does food contain? Remember, food is the fuel for our bodies. You also need to fill in the three things that plants use to photosynthesise. You need to look at what concepts link from these in order to know where to put each one. Finally, what does photosynthesis release as a by-product? You also need to fill this in.

Have you noticed the **VISIT** boxes in the margins which contain links? You simply need to type this whole link into the address bar in your internet browser, either on your PC, tablet or mobile phone, and press enter, like this:



It will direct you to our website where you can watch the video or visit the webpage online. **Be curious and discover more online at our website!**

TEACHER'S NOTE

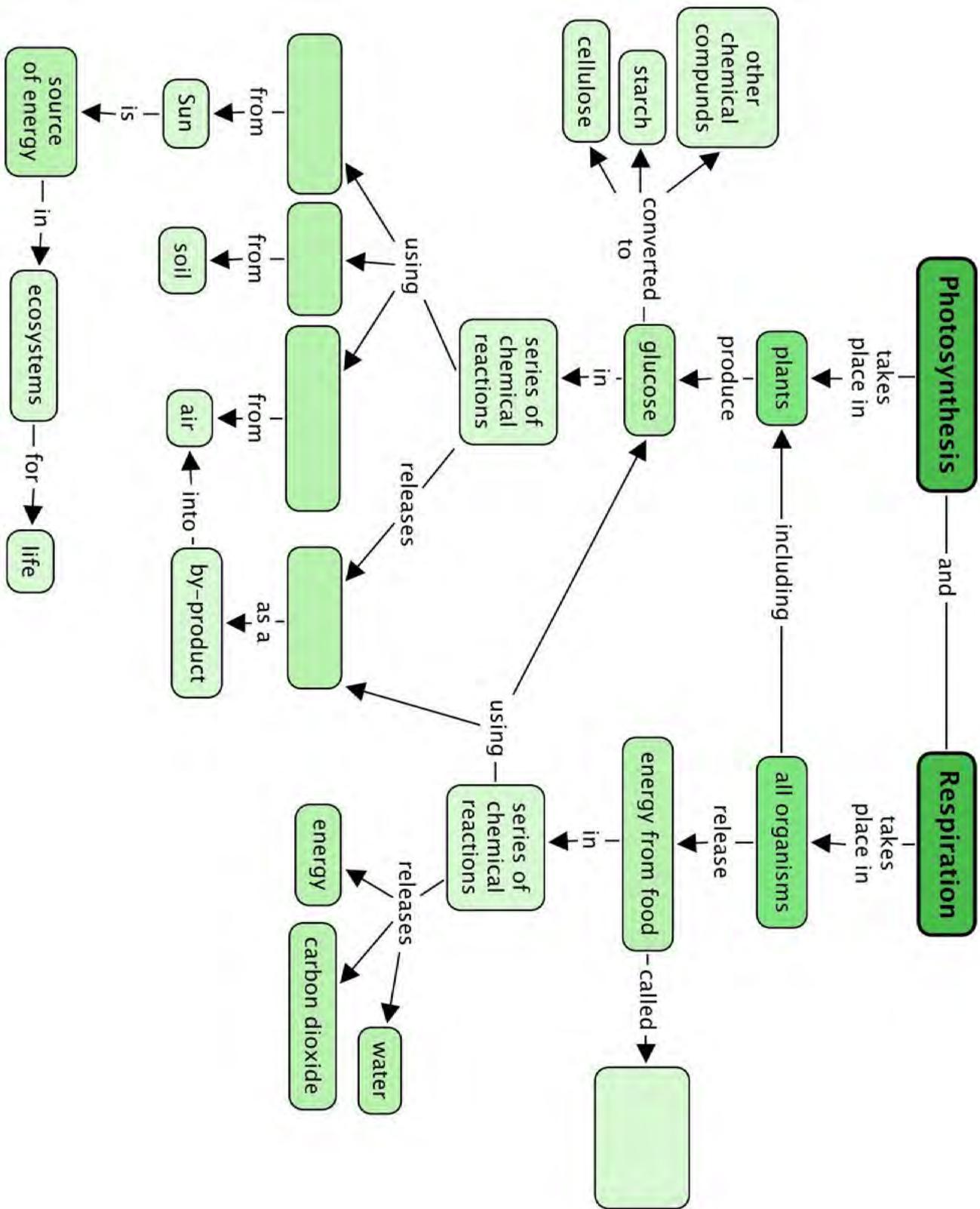
Throughout this year, we are going to develop the skill of designing and making **concept maps** in Natural Sciences. The "Key concepts" listed above is a summary written out in full sentences. A concept map provides another way of representing information (ideas and concepts) in a more visual way. The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

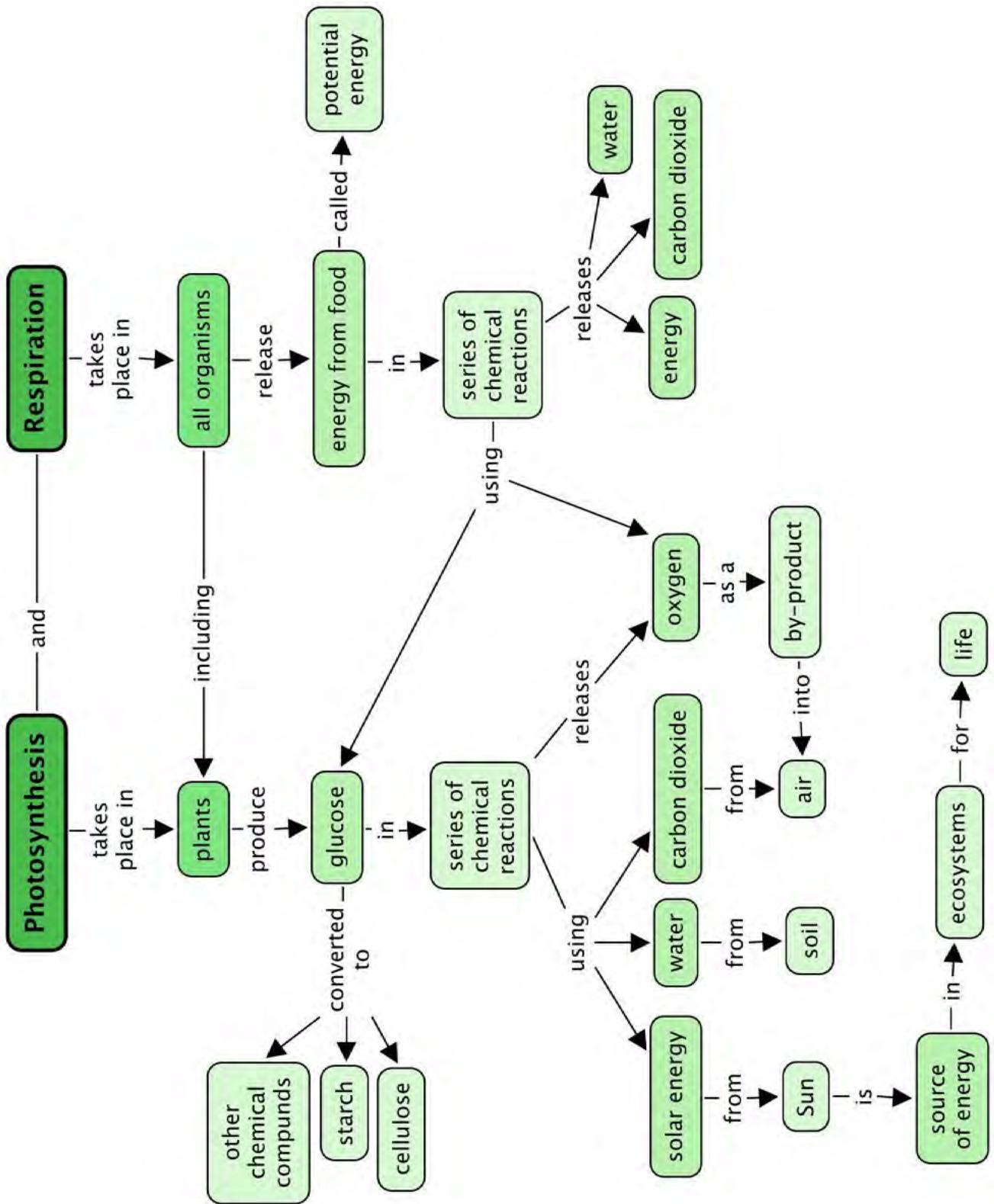
As this year progresses, learners will have to start filling in more parts of the concept maps themselves, and then hopefully draw their own ones by the end of the year. This teacher's guide contains the full version of each concept map. Encourage your learners to study the concept maps and make sense of them at the end of each chapter before doing the revision questions. Help your learners to understand and "read" the concept maps by constructing sentences from them. For example in this case you could read: "Respiration takes place in all organisms, releases energy from food".

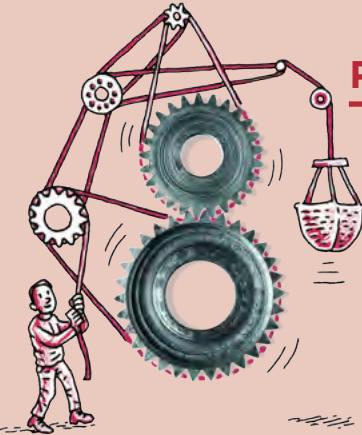
Learners need to learn how to learn! This is one skill which might help them later in their school career where they have a lot more information to ingest and learn and make sense of. Concept mapping is one tool for summarising information and understanding how different concepts link together. Real understanding and knowledge comes from grappling with the subject matter, and not just memorizing facts.

Below is the complete concept map with the answers filled in. Make sure your learners understand what a concept map is and that they have filled in the correct concepts into the empty spaces. Learners might battle to do this, especially to fill in "Potential energy" as the type of energy in food. Help them by reminding them of the two types of energy, namely kinetic energy and potential energy. You can ask them questions such as, "What do plants get from the Sun which is used for photosynthesis?" (Solar energy), "What do plants get from the soil that they use for photosynthesis?" (water), etc.

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







REVISION:

1. A Gr. 4 learner wanted to grow some beans and carefully planted them in a yoghurt tub and watered them. He was scared that his little brother would knock his tub over, so he hid the tub in his cupboard.
 - a) Explain what he would have noticed a few days after planting the beans. [2 marks]
 - b) Predict what would have happened after another few days with the beans hidden in his cupboard. [2 marks]
 - c) Explain why you predicted this outcome for his beans. [2 marks]
 - d) What should he have done to make his bean plants grow tall and strong? [2 marks]

a) Depending on what he planted the beans in, he might have noticed a root and first leaves forming.

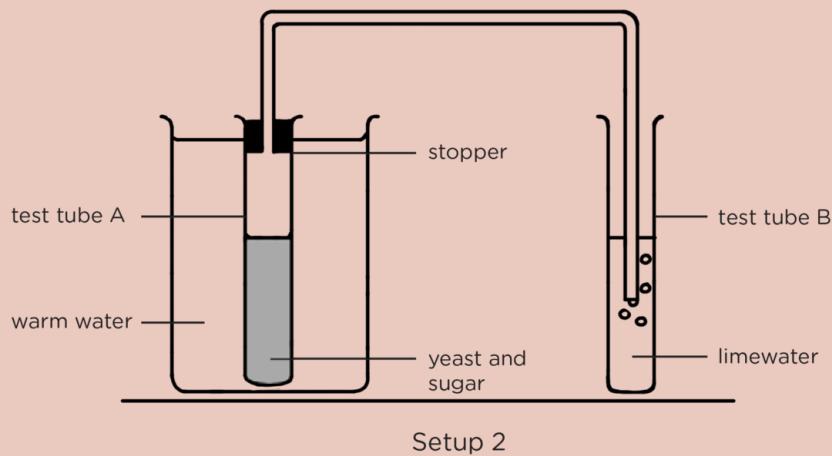
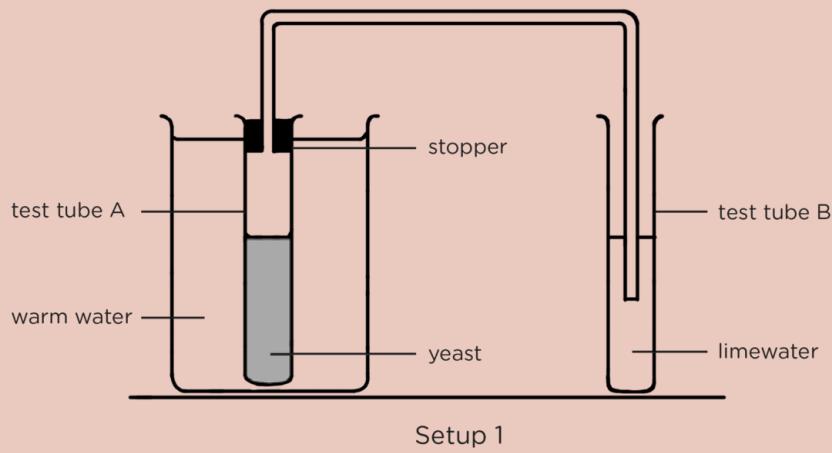
b) The young bean plants would have formed small leaves but the plants would slowly start to die.

c) The bean plants would die as the leaves would not have enough radiant energy to allow them to photosynthesise and produce glucose for the plants to use to grow and develop.

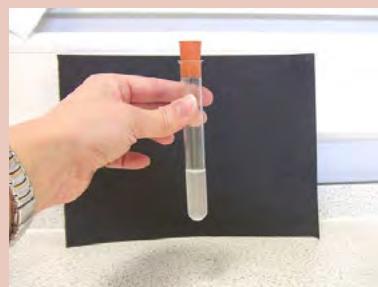
d) He should have put the plants in a place where they would get enough radiant energy (sunlight) to allow them to photosynthesise.
2. What are the requirements for photosynthesis to occur? [3 marks]
Carbon dioxide, sunlight and water.
3. A farmer is growing some tomatoes. He heard from his daughter that plants produce glucose during photosynthesis, so he decided to see for himself. However, when he tested the leaves, he did not find much glucose, but he did find a lot of starch present.
 - a) Why did the farmer see this result? [2 marks]
 - b) Describe the test that the farmer conducted to show that the leaf contained starch. [5 marks]

a) The plant converts the glucose to starch as it is easier to store. Therefore, the leaves will indicate a high starch content.

b) The chlorophyll must be removed by first dipping the leaf into boiling water for 1-2 minutes to remove the waxy top layer. Then the leaf must be placed in alcohol and this is heated over water to remove the chlorophyll. The leaf is then removed and dipped into hot water to soften it as the ethanol will make the leaf brittle. Iodine solution is dripped on it. Iodine changes from orange-brown to dark blue-black in the presence of starch and when it is dripped onto the leaf it changes to dark blue/black indicating that starch is present.
4. Do plants undergo photosynthesis and respiration all day and all night? Give reasons for your answer. [4 marks]
Plants only photosynthesise during the day, and not at night. This is because they need sunlight energy to photosynthesise. Plants respire all day and all night. All living organisms need to undergo respiration to release energy from chemical potential energy and perform the seven life processes.
5. A group of Gr. 7 learners wanted to show that carbon dioxide is used to make bread rise because the yeast and sugar that is added to the bread mix produces the carbon dioxide. They set up the following two experiments. The gas that they collected from each test tube was run through limewater.



- Why did they run the rubber tube from Test Tube A to Test Tube B? [3 marks]
- Explain why they added a stopper into the top of Test Tube A. [1 mark]
- The following photo shows one of the test tubes after the experiment. Which test tube do you think it is and from which set-up. Give reasons for your answer. [2 marks]

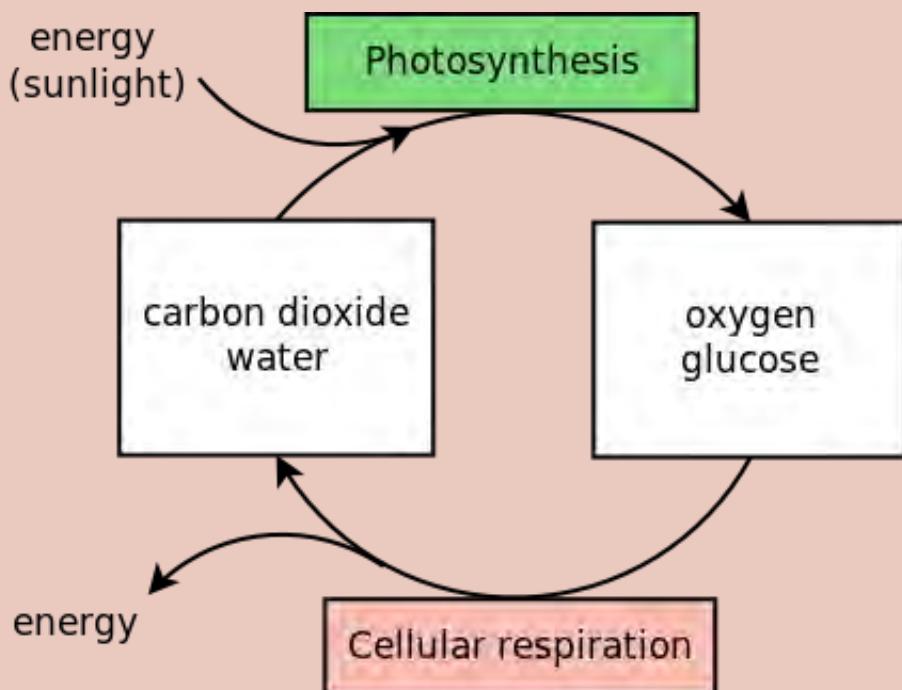


Which test tube is this?

- Why do you think the yeast solution in Setup 1 did not produce carbon dioxide. [2 marks]

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

6. Study the following diagram and fill in the missing information. [6 marks]



7. Draw a table in the following space to show the differences between the two processes, photosynthesis and respiration. Your table should highlight the differences in requirements, the differences in the products, which organisms the processes takes place in, and when. [8 marks]

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

Table of differences between photosynthesis and respiration

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

TEACHER'S NOTE

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

Total [44 marks]



Interactions and interdependence within the environment

TEACHER'S NOTE

Chapter overview

5 weeks

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

2.1 What is Ecology (0.5 hours)

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

2.2 Ecosystems (4 hours)

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

2.3 Feeding relationships (2 hours)

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

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

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

2.5 Balance in an ecosystem (2 hours)

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

2.6 Adaptations (2 hours)

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

2.7 Conservation of the Ecosystem (1.5 hours)

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



KEY QUESTIONS:



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

2.1 What is ecology?

TEACHER'S NOTE

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

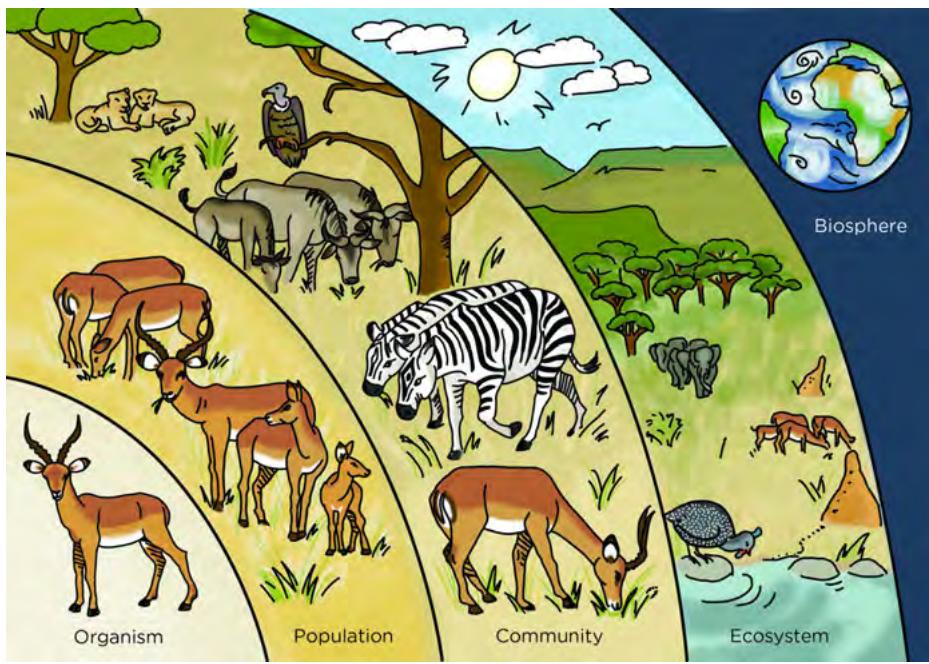
Every living organism on earth depends on and interacts with other living and non-living things to stay alive. Organisms depend on other organisms for food for example, and also depend on their environment for protection and a place to stay. The particular branch of Science that studies how organisms interact with other organisms and their environment is called **ecology**. Someone who studies these relationships and interactions is called an **ecologist**.

Ecological interactions

The ecological interactions that take place within a specific area are generally classified into four levels: **populations**, **communities**, **ecosystems** and the **biosphere**.

Individuals live together in **populations**. Different populations together make up a **community**. Communities together with the non-living things in their surroundings make up an **ecosystem**. All the ecosystems on Earth make up the **biosphere**.

Look at the following illustration which shows the levels of organisation.



TAKE NOTE

If you want to check the definitions of a **New word**, check the glossary at the back of this strand.

You may have heard of terms such as the biosphere and ecosystems in previous grades. What about populations and communities? You may have also heard about the population of people in South Africa, or when someone talks about your local community at home. What do we mean when we use these terms in ecology? Let's take a closer look.

Population

TEACHER'S NOTE

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

VISIT

A simulation of different real-time changes in Earth's human populations.
bit.ly/178rzXz

In the previous illustration, we can see that the individual impala make up a population in the game reserve. On a large scale, we can also say that the 50 million people in South Africa make up our country's population.

A population is a group of organisms of the same species that live in the same area at a specific point in time and they can interbreed with each other. When a scientist studies a population they might study how the population grows and the factors that affect how the population increases or decreases. They will also look at how the population interacts with the environment.

Community

In ecology, a community refers to all the populations of organisms that **interact** in a certain area. Community ecology is the study of how they interact. For

example, what feeding relationships occur in the area? What types of grasses do specific herbivores eat and what eats the herbivores? Turn back to the illustration of the wildlife in the game reserve. Which animals make up the community?

TEACHER'S NOTE

Lions, wildebeest, zebra, impala and vulture.



ACTIVITY: What is a population?

INSTRUCTIONS:

1. Look at the following examples of populations.
2. Answer the questions which follow.

TEACHER'S NOTE

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



A population of hippos in the St Lucia estuary (river mouth) in Kwa-Zulu Natal.



A population of zebra in Kruger National Park.



A population of seals on Seal Island in False Bay.



A population of penguins at Boulders Beach.

QUESTIONS:**TEACHER'S NOTE**

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

1. What do you notice about all the animals that make up a population?
All the animals are of the same species in a population. They are different ages, there are males and females.
2. In each of the photos, the populations of animals are found in a specific area. Do you think the zebra in Kruger National Park and the zebra in Hluhluwe-Umfholozi game reserve in Zululand are from the same population? Why do you say so?
No, they are not from the same population. Individuals in a population all live in a specific area and they can interact and breed with each other. They are not able to interbreed if they live in different areas.
3. How big is a population?
A population does not have a specific size. Rather, it is defined by the area that you are talking about and whether the individuals can interact.
4. Do you think the seals that lived on Seal Island 100 years ago are part of the same population as the seals that live there now in the photo? Why do you say so?
No, they are not from the same population. A population consists of organisms that live in the same space and at the same time. Individuals in a population interact with each other and are able to interbreed. Since the seals lived at different times, they cannot be part of the same population.
5. What do you think would happen to the population of hippos in the estuary at St Lucia if the river dried up? Explain your answer.
The number of hippos in the population would decrease. They might not necessarily all die, but the numbers would decline. The decline may be due to some individuals of the population migrating to other areas. The population would decrease because the environment cannot support the hippos anymore as there is not enough water in their habitat. (We will look more at balance in an ecosystem later in the chapter.)
6. A group of scientists is studying a population of zebra in the Kruger National Park. They notice that over the last 4 years, the population has grown quite rapidly. Why do you think this might be the case? What are some possible reasons for this? Discuss this with your class.
Some possible reasons include: there are perhaps fewer predators and so less of the zebra are being eaten. There might perhaps be an increase in the number of females that are born and so more are reproducing. There might be an increase in the amount of food available, perhaps other populations of herbivores have decreased or there might have been particularly rainy seasons so there is lots of food (green grass). Disease may have decreased so fewer animals are dying, or the amount of hunting or poaching by humans may have decreased.

TEACHER'S NOTE

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

TEACHER'S NOTE

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

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

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

TEACHER'S NOTE

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

Identify organisms in a community

INSTRUCTIONS:

1. Study the photo below.
2. Answer the questions that follow.



An underwater community.

QUESTIONS:

- Identify the different populations of organisms that make up this underwater community which is part of the ocean.

Different fish populations, turtles, seaweed, corals, sponges, plankton.

- Which other types of organisms would you expect to find in this community, but you cannot see in this photo?

Some other examples include: crustaceans such as crabs or crayfish, jellyfish, octopus, other fish species, perhaps a reef shark.

- How would describe the specific area that this community inhabits?

It is a coral reef.

- Identify some possible feeding relationships between the different populations of organisms in this community.

Some types of fish could eat other types of fish, the fish can eat the seaweed, the turtles eat the seaweed, the sponges filter the water for plankton.

Ecosystem

Turn back to the illustration of the wildlife in a game reserve. The different populations interact with each other to form a community. When we look at how the communities interact with the non-living things in their environment, then we are looking at ecology at the ecosystem level.

Think of the different populations of organisms making up a community in Kruger National Park, such as the zebra, elephant, lions, springbok, different trees and grasses. Now look at the photo of some of these populations at a watering hole. In this photo we are studying how the living things interact with the non-living things. For example, the zebra and springbok are drinking water, whilst the elephant is splashing mud over itself to cool down. This is an **ecosystem**.



An ecosystem in the game reserve consist of the living and non-living things interacting with each other.

Biosphere

All the ecosystems on Earth combined make up the biosphere. At the biosphere level, we can study how the living and non-living things interact on a much larger scale. This includes climate changes, how the Earth has changed over history and even how the movement of planet Earth affects different ecosystems, wind patterns as well as rock and soil formation.



All the ecosystems on Earth make up the biosphere.



ACTIVITY: Check your understanding

TEACHER'S NOTE

This can be done as a short revision task in class or as homework to check what learners understand so far, or you can ask learners the questions orally in class. Suggested answers have been given, but learners must be encouraged to use their own words.

Write your own definitions and explanations for the following terms.

1. Ecology:

The particular branch of science that studies how organisms interact with other organisms and their environment.

2. Interaction:

The process of interacting/influencing each other.

3. Organism:

An individual life form, either a plant, animal, fungus, protist or bacteria.

4. Population:

A group of organisms of the same species that live in the same area at a specific point in time and they can interbreed with each other.

5. Community:

All the populations of organisms that interact in a certain area.

6. Ecosystem:

The different living things interact with the non-living things in their environment to make up an ecosystem.

7. Biosphere:

All the ecosystems on Earth combined make up the biosphere.

VISIT

Interested in a career in Green Science? Discover the possibilities here!

bit.ly/1cMKvll

Let's now take a closer look at ecosystems.

2.2 Ecosystems

The living organisms on Earth live and interact in different ecosystems around the planet. Together all these ecosystems make up the Earth's biosphere. An ecosystem consists of the **abiotic** (non-living) environment and the **biotic** (living) organisms.

TEACHER'S NOTE

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

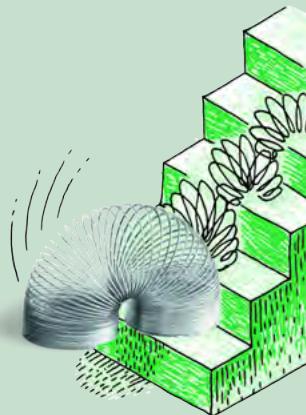
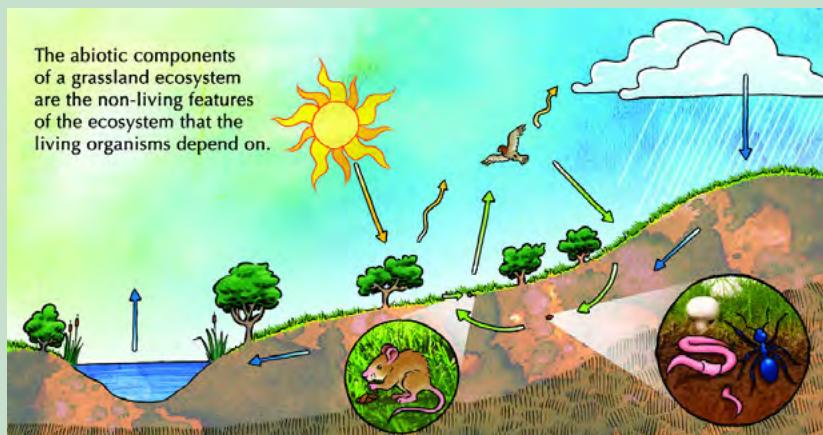
Biotic and abiotic components in an ecosystem

We have looked a lot at the living organisms in different ecosystems in the last section, but what are some of the abiotic things in ecosystems? And how do the biotic things interact with the abiotic environment in a system?

ACTIVITY: Abiotic components in a grassland ecosystem

INSTRUCTIONS:

1. Look at the following image of a grassland ecosystem.
2. Answer the questions that follow.



QUESTIONS:

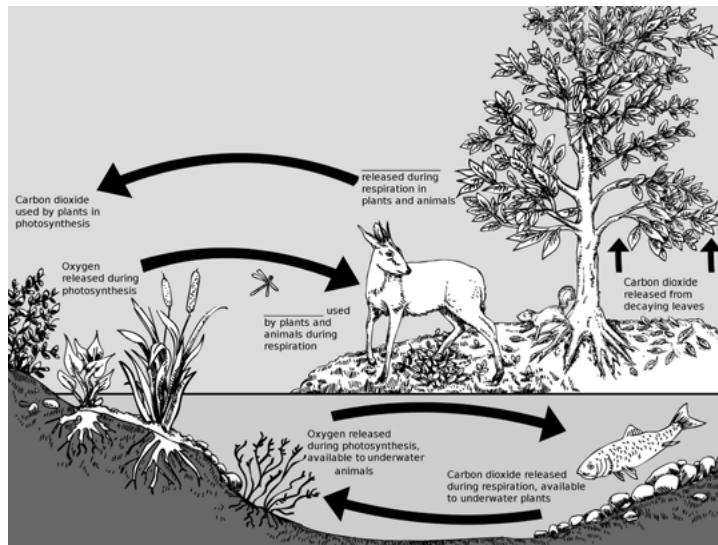
1. List some of the abiotic things in the grassland ecosystem shown in the image.
Soil, rocks, water, wind/air, sunlight/temperature, clouds.

2. For each of the animals, discuss how you think the organisms below are interacting with the abiotic environment.
- The eagle
 - The trees and grass
 - The mouse
 - The worm and insect
- a) The eagle uses the wind and air to soar and glide while hunting.
b) The trees and grass are rooted in the soil so that they do not blow over and they can get water and use sunlight and carbon dioxide to make food.
c) The mouse creates its home in the ground/dead stick/grass, it can store seeds and food in the soil and hide from predators.
d) The worm and insect live in the soil.*
3. In the picture, the blue arrows show the movement of water through the ecosystem. What do we call this movement of water?
The blue arrows describe the water cycle.
You can revise the water cycle here, namely: The water in the pond/dam evaporates as it changes from a liquid to a gas. The water vapour then condenses to form clouds as fine droplets of water. When the water droplets become big enough, they precipitate as rain. The water runs down the slopes and collects in the lower regions such as the pond.
4. Temperature is an abiotic factor in an ecosystem. What can affect the temperature in the grassland ecosystem?
The time of day will affect the temperature as this will affect how much heat energy the ecosystem receives from the Sun depending on the Earth's position. The time of year will also affect the temperature as the ecosystems distance from the sun changes. Weather conditions will also affect the temperature, for example if there are clouds, wind, or it is raining. The direction the area faces will also affect the temperature, for example if it is on a slope.
5. Another abiotic factor which affects ecosystems is the slope of the land. For example, is it flat or are there hills or mountains. How would you describe the land in the grassland ecosystem? How do you think this contour affects the ecosystem?
This grassland ecosystem has a sloped surface. There is a hill on the right hand side and the ground slopes downwards towards the pond. This shape and slope enables the water to run down when it rains and collect in the pond, thereby providing a collection of water for the ecosystem.

VISIT

Play a game to identify specific habitats on Earth.
bit.ly/1beFyQA

Apart from the recycling water, biotic and abiotic factors also interact to recycle carbon dioxide and oxygen in ecosystems. Photosynthesis in plants uses carbon dioxide to produce glucose. The plants and animals then break down the sugars and release carbon dioxide again during respiration. Photosynthesis releases oxygen, while plants and animals take it in for respiration. Look at the following illustration which shows how the gases are cycled through a pond ecosystem.



TAKE NOTE

You can find out lots more online by visiting the links provided in the **Visit** boxes. Be curious and discover the possibilities!

There are two labels missing, but lines have been provided for you to fill them in on the diagram. Discuss this with your class and write them in.

TEACHER'S NOTE

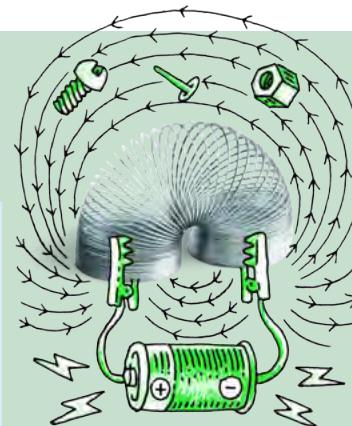
The arrow starting on the right above the buck should read '**Carbon dioxide** released during respiration in plants and animals.' The arrow ending on the right below the buck should read '**Oxygen** used by plants and animals during respiration.'

Now that we know a bit more about the different biotic and abiotic factors in an ecosystem and how they interact, let's study an ecosystem!

ACTIVITY: Studying an ecosystem

TEACHER'S NOTE

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



TEACHER'S NOTE

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

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

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

MATERIALS::

- 60 m long string
- pegs or stakes
- measuring tape (10 m long)
- old material for flags on pegs
- thermometer
- rulers
- trowel
- sieve
- insect nets
- large plastic ziploc bags
- marking pens
- forceps
- gloves
- hand lens
- clipboard, paper and pens or pencils
- camera (if possible)

INSTRUCTIONS:

1. Work in groups of five. Your teachers will help you to select a site to study.
2. Stake out a square measuring 10 m x 10 m. Use the 10 m measuring rope and knock the stakes or pegs into the ground to mark the corners of the square. Tie a flag to the stake to make it more visible. (You will use this square to study different things in the next few weeks so make sure that you choose an appropriate site that does not overlap with another group's site.)



An example of a square with four quadrants.

- Try to identify as many plants as possible. Use the following space to record your findings about the plants. You can even draw some illustrations.

TEACHER'S NOTE

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

- Use the net to capture a few small invertebrates. Try to identify them (ask for help if you need it), then release them unharmed. Use the following space to record your observations. You can use illustrations.

TEACHER'S NOTE

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

- Look for evidence of bigger animals. Are there any droppings, tracks, or birds in the trees? Record what you find.

TEACHER'S NOTE

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

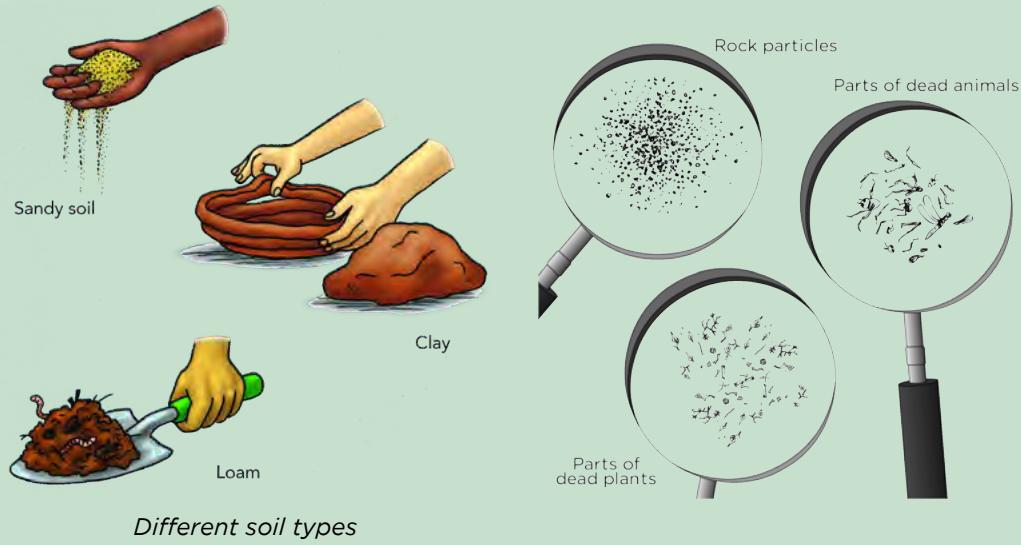
- Measure the temperature.

- Measure the air temperature in your square.
- Measure the temperature of the soil about 5 cm below the surface.

TEACHER'S NOTE

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

7. Take a soil sample by putting one scoop of soil into a plastic bag. Determine whether it is sand, loam or clay soil. Compare your sample with those of other groups. The following illustrations give an idea of the different types of soil.



TEACHER'S NOTE

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

Use the hand lens to see if you can find any plant or animal remains in the soil.

8. Use the following space to write about your observations and draw images. (Optional: Measure the rainfall and wind speed. Measure the rainfall over the next few weeks.)

TEACHER'S NOTE

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

VISIT

Build your own wind meter.

bit.ly/1cxI4FP

QUESTIONS:

1. Describe the different habitats in your ecosystem.
Learner-dependent answer. They may describe the habitats/ecosystem as aquatic, terrestrial, or even a pond, grass, forest, etc.
2. Explain how you think the abiotic factors of the ecosystem you studied affect the plants and animals in your ecosystem.
Learner-dependent answer. Learners should take note of the water resources in their square, the slope of the land, and the type of soil and how this affects the organisms.
3. What relationships did you notice between the plants and animals in the area you studied?
Learner-dependent answer. Learners should take note of any feeding relationships that may exist. We will be studying this in more detail next,

- but learners would have done this in previous grades.*
4. In the area that you studied, was there any evidence of human interference? For example, rubbish or a pathway? How did this impact on the living organisms and also the abiotic factors in your square? What suggestions can you make to prevent this kind of interference.
Learner-dependent answer. Perhaps there is litter which is blocking a stream, or that animals can eat and choke on. Perhaps there is a path that humans walk on, resulting in them trampling the plants so that nothing grows there. Learners could suggest putting some rubbish bins nearby, or perhaps mark off the area so that people have to walk around, etc.
5. Do you think that your presence while you made your observations had an influence on the animals or plants in the quadrant that you observed?
Learner-dependent answer. Learners may observe that insects or other small animals scurried away from them when they approached their quadrant. or perhaps insects were drawn to the stakes and rope that was used to demarcate their area.

TEACHER'S NOTE

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

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

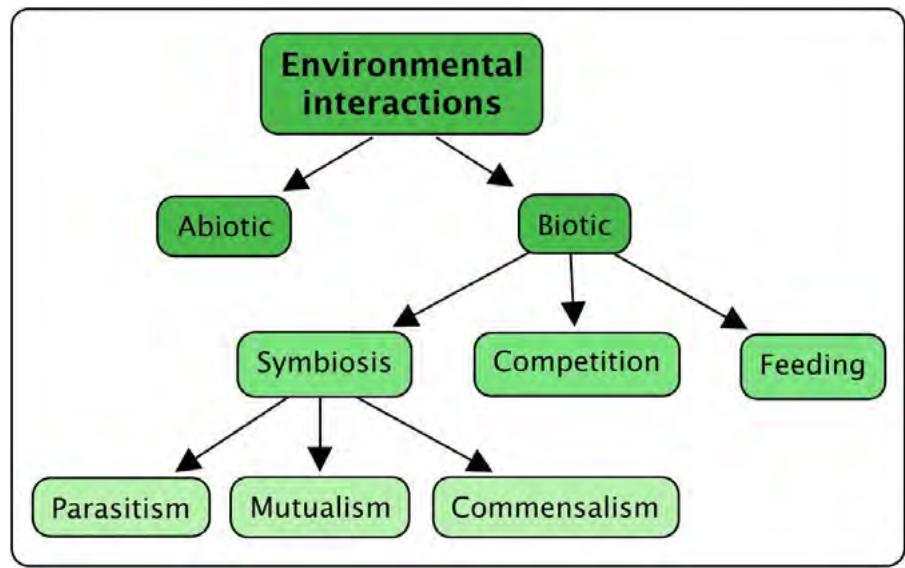
We studied relatively small ecosystems. How big can an ecosystem be? Does size in an ecosystem matter?

Ecosystem size

The size of a real ecosystem is not defined in terms of area, but rather by the interactions that occur inside it. It can be as small as a river bank or as large as the Kruger National Park.

Types of interactions

Within an ecosystem the species living in a particular area can interact in different ways with each other. We can classify the interactions between organisms as follows:



1. Competition

When two species in an ecosystem need to share a valuable and often limited resource, such as food or water, they are in competition with each other. The two different species compete with each other for the same resources, especially food.



Hyenas and vultures are both scavengers and compete for the same food.

2. Symbiosis

Symbiosis describes the way in which two different species living together in the same community, interact with each other over a long time period. This can occur in the form of parasitism, mutualism or commensalism.

a) Parasitism: Parasitism is when the one species benefits or gains something from the relationship and the other species is harmed in some way. The host may die in some interactions.



Ticks are parasites and feed off the blood of many animals, for example dogs, cows, buck and humans.

b) Mutualism: Mutualism occurs between any two species where both of the individuals benefit from the interaction. Both species gain something from the other, so we can say it is mutually beneficial.



Pollination is an example of mutualism as the bee gets food (nectar) from the flower and the flower is pollinated by the bee so that it can reproduce.

c) Commensalism: In some interactions between individuals from different species, the one species benefits, while the other one is unaffected by the relationship. Unlike parasitism, in commensalism the other species is not harmed or benefited in any way.



VISIT

A video of leaf cutter ants tending to their fungi farm
bit.ly/1cxI6xq

3. Feeding: Different species in an ecosystem are related and interact when one species can use the other species as a food source. For example, in predator-prey relationships, the one species (**predator**) will hunt another species (**prey**).



Lions and zebras have a predator-prey relationship.



ACTIVITY: Identify the type of interaction between organisms

TEACHER'S NOTE

This is an optional activity.

INSTRUCTIONS:

1. Study the photos and information in the following table.
2. Identify the interdependence in each case and give a reason for your choice.

	<i>Type of interaction</i>	<i>Explain this kind of interaction</i>
 <i>A hummingbird feeding.</i>	<i>Mutualism</i>	<i>The bird receives nectar from the flower and pollinates the flower at the same time.</i>
 <i>Plants on a forest floor.</i>	<i>Competition</i>	<i>The plants are competing for light, space and water.</i>
 <i>Flea bites on a human.</i>	<i>Parasitism</i>	<i>The fleas bite the human and feed, and the human is harmed in the process.</i>

	<i>Type of interaction</i>	<i>Explain this kind of interaction</i>
 <p>Clownfish in an anemone.</p>	Mutualism	<p>The sea anemone protects the clown fish from predators, the clown fish feeds on small invertebrates which might harm the anemone and the anemone also gets nutrients from the fish's fecal matter.</p> <p>Note: Discuss this with your class, especially if you do not live by the sea.</p>
 <p>An egret waiting for the rhino to disturb insects to eat.</p>	Commensalism	<p>The egret benefits as it waits for the rhino to disturb insects in the grass as it moves along feeding. the bird then catches the insects as they fly up. The rhino is not harmed and does not benefit from the relationship.</p>

Now that we know how organisms interact with each other, we will take a closer look at the feeding relationships between different organisms.

2.3 Feeding relationships

TEACHER'S NOTE

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

In the last section we saw how organisms from different species interact within an ecosystem. Let's now take a closer look at how organisms interact through their feeding relationships.

Feeding types

Living organisms need to feed to be able to perform the other life processes. Some organisms can produce their own food, such as plants, while other organisms cannot do this and need to feed on other organisms to obtain their energy.

We can therefore identify different feeding types in an ecosystem, based on how the organism obtains (gets) its food. There are **producers** and **consumers**.

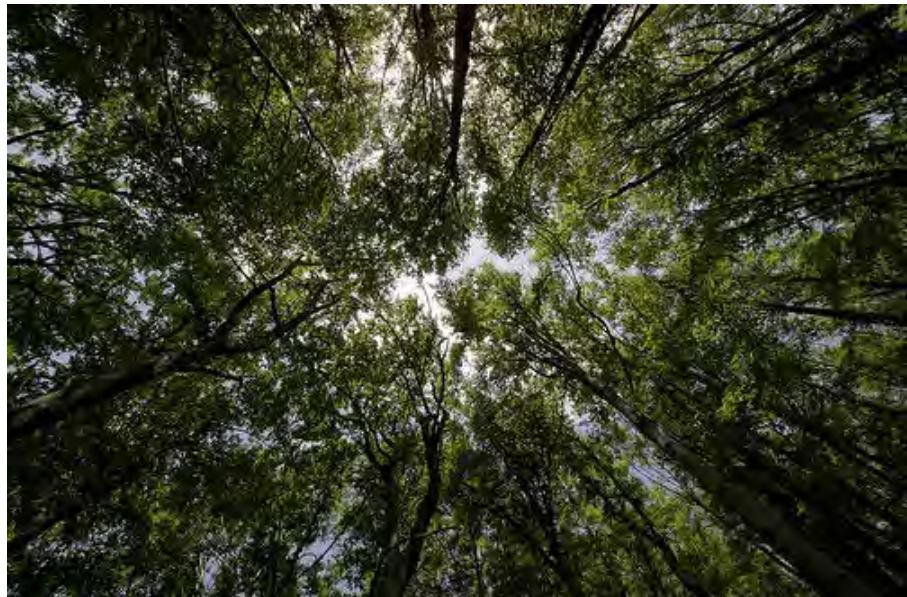
Producers

Producers are organisms that are able to produce their own organic food. They do not need to eat other organisms to do this. Producers are also called **autotrophs**. Which organisms have you come across that can make their own food?

Plants are producers because they make their own food during photosynthesis. What do plants need in order to photosynthesise?

TEACHER'S NOTE

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



TAKE NOTE

The term heterotroph comes from the Greek words *heteros* meaning 'different' and *trophe* meaning 'nourishing'. So heterotroph means 'different-feeding' or feeding on different things.

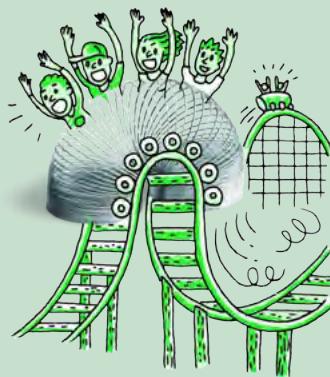
Consumers

Organisms which cannot produce their own food need to eat other organisms to get food. These organisms are called consumers. All animals are consumers as they cannot produce their own food. Consumers are also called **heterotrophs**.

There are many types of consumers and we can classify them into specific groups depending on the food that they consume. These are:

- **herbivores**
- **carnivores**
- **omnivores**
- **decomposers**

ACTIVITY: Different types of consumers



TEACHER'S NOTE

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

INSTRUCTIONS:

1. The following image shows a variety of different animals found in South Africa.
2. Study the illustration and then answer the questions that follow.



QUESTIONS:

1. What is a herbivore? Write a definition below and then give four examples of animals from the images which are herbivores.
A herbivore is an animal which feeds on plant material. Examples of herbivores are: elephant, duck, horse, buffalo, squirrel, grasshopper, rhino, zebra, cow, mouse, etc.
2. What is a carnivore? Write a definition below and then give four examples of animals from the images which are carnivores.

A carnivore is an animal which eats other animals (living or dead). Examples of carnivores are: lion, jackal, dolphin, crocodile, shark, leopard, mosquito, vulture, crab, seal, etc.

3. There are different types of carnivores. Some carnivores hunt other animals. They are called predators. The animals that they hunt are called prey. A lion is an example of a predator. Give three examples from the images of animals which are prey of the lion.
Buck, zebra, buffalo.
4. Other types of carnivores are called scavengers as they eat dead meat, for example a hyena. There are three other scavengers in the images. Identify them and write the names below.
Vulture, jackal, crab.
5. The following animals are also all carnivores. They all have a similar diet. Do you know what they all eat? Find out what these animals eat. Discuss this with your class.



A chameleon



A bat



A praying mantis



A swallow

6. Write down below what these animals all eat and what we call this type of carnivore.
These animals all eat insects and other small invertebrates. They are called insectivores.
7. What do we call animals that eat both plants and other animals? Give one example from the pictures.
An animal which eats both plants and other animals is an omnivore.
Examples are: pig, flamingo, mouse/rat.
8. What would you classify humans as?
Humans are omnivores.
9. The last group of animals that we can discuss from this image are the decomposers. Decomposers break down the remains of dead plants and animals. Give an example of a decomposer from the image.
An earthworm is a decomposer.

10. Refer to the study of an ecosystem in or near your school that you are busy with.
- List the producers in your ecosystem. Explain how you know they are producers.
 - List the herbivores that you found in your ecosystem. Explain how you know they are herbivores.
 - Did you find evidence of or find examples of carnivores in your ecosystem? List them below.
 - Study the soil again. Use the hand lens to see if there are any decomposers that you can see or see evidence of in your ecosystem. Describe any decomposers that you found below.
a) Learner-dependent answer.
b) Learner-dependent answer.
c) Learner-dependent answer.
d) Learner-dependent answer. *They might have seen earthworms or fungi.*

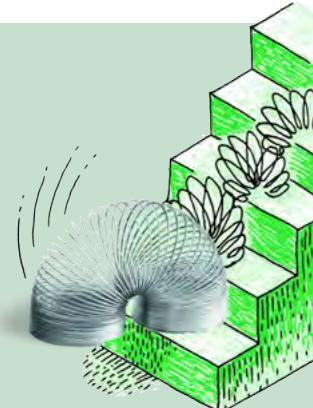
In the last activity, we looked at different consumers. The examples that we studied were all different types of animals. But what about the other kingdoms, such as fungi?

You might remember learning about fungi in previous grades. Fungi are not plants. Fungi cannot photosynthesise as they do not have chlorophyll. So where do fungi get their food from?

ACTIVITY: Different decomposers

INSTRUCTIONS:

- Look at the following photographs of different fungi.
- Answer the questions that follow.



VISIT

Play the food chain game!
bit.ly/13m4bWk

**QUESTIONS:**

1. What kingdom do the above organisms belong to?
They are mushrooms so they are part of the Fungi kingdom.
2. What do you notice about where these mushrooms are growing? What are they mostly growing on? Is it dead or alive?
The mushrooms are mostly growing on dead plant matter, such as dead tree logs and humus.
3. The mushrooms get their nutrients from what they are growing on. At the same time, they are breaking down this dead matter. What can we therefore call fungi?
We can call them decomposers.
4. When fungi, and other decomposers, break down dead material, they help to return nutrients to the soil. Write a few sentences where you explain why you think decomposers are important in an ecosystem and how they help an ecosystem to function.
Decomposers break down the matter in dead organisms to release the nutrients such as water and carbon, back into the ecosystem. These nutrients are therefore recycled and made available for other organisms to use. They also help to keep an ecosystem 'clean' as they make sure that dead and decaying material is not left lying around in an ecosystem for an extended period.

We now know that the different organisms in an ecosystem are related by how they feed. There are producers and consumers. We have seen that organisms from one species eat other organisms from another species. How can we link these feeding relationships together to describe how the energy is transferred in an ecosystem from the producers to the consumers?

2.4 Energy flow: Food chains and food webs

The flow of energy from the sun to different organisms in an ecosystem is very important as it supports all the life process of living organisms. In this section we will look more closely at the way in which energy flows from the sun to different organisms in order to support and sustain life on Earth.

Energy transfer

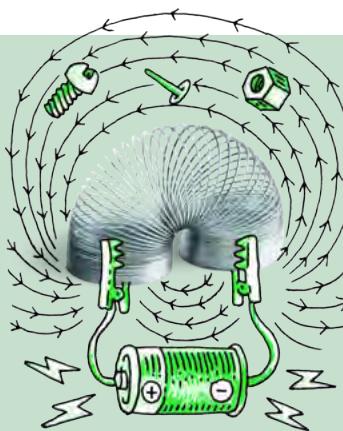
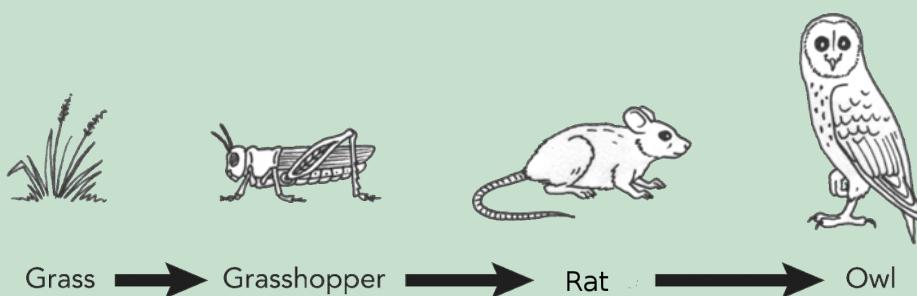
Energy is vital for organisms to carry out their life processes. All energy in **food webs** comes from the sun. Plants trap sunlight energy during photosynthesis

and convert it to chemical potential energy in food compounds, which are available to animals. Herbivores get energy directly from plants, but carnivores and omnivores eat animals for energy. This energy transfer is shown by **food chains**.

ACTIVITY: Energy transfer in an ecosystem

INSTRUCTIONS:

1. Study the following diagram which describes the feeding relationships between different organisms in an ecosystem.
2. Answer the questions which follow.



QUESTIONS:

1. What can we call this diagram?
It is called a food chain.
2. Which organism is the producer?
The grass.
3. Which organisms are the consumers?
Consumers are the grasshopper, the mouse and the owl.
4. Out of the consumers, identify the herbivore and the carnivores.
The grasshopper is the herbivore and the mouse and the owl are the carnivores.
5. The rat also actually eats seeds and other plants. Therefore, what do we call the rat? Give a reason for your answer.
The rat is an omnivore as it eats both plants and animals.
6. What do the arrows show us?
The arrows show the transfer of energy from one organism to the next.
7. Do you think it makes a difference which way the arrows are pointing? Explain your answer.
Yes, it does make a difference. The arrows show the direction in which the energy is transferred as one organism eats the other one, always from the producers to the consumers.

8. Use the following space to draw three more food chains. Use organisms from the ecosystem that you are studying at or near your school in at least two of the food chains you draw.

Learner-dependent answer. Learner's food chains must start with a green plant (producer), or part of a green plant, such as a fruit or wheat. Make sure they have used the arrows in the correct direction, and that they have three levels of consumers.

9. Where would you place decomposers in a food chain? Why do you say so?

Learner-dependent answer. They could say that decomposers would come at the end of the food chain as they break down the bodies of the dead organisms. Or they are often put at the side, with many arrows from all levels of the food chain as they break down all the dead organisms at every level.

Can you see how the above food chain describes how the energy is passed along from the producer to the consumers? But, there are three different consumers in this food chain. How can we distinguish between the different consumers?

- Animals that eat plants are **primary consumers**. (Primary means *first*.)
- Animals that eat primary consumers are called **secondary consumers**.
- Animals that eat the secondary consumers (mostly predators) are the **tertiary consumers**.

Identify the different levels of consumers in the food chain in the activity.

TEACHER'S NOTE

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

Each of these levels in the food chain is called a **trophic level**. The organism uses up to 90% of its food energy itself for its life processes. Only about 10% of the energy goes into new body cells and is available to the next animal when it gets eaten. This loss of energy at each trophic level can be shown by an **energy pyramid**. But, why do we show it in the shape of a pyramid? Let's find out.

VISIT

A video on energy pyramids
bit.ly/14nGOit

ACTIVITY: Studying energy pyramids

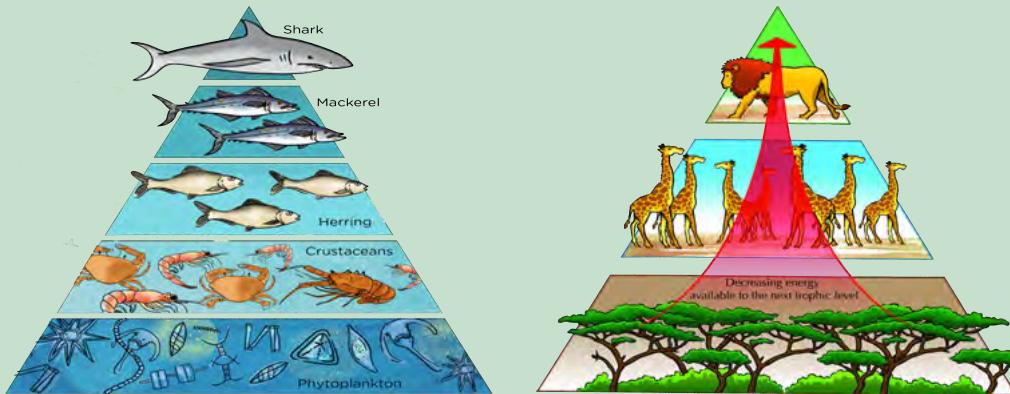
MATERIALS:

- cardboard
- scissors
- glue
- coloured pens and pencils



INSTRUCTIONS:

1. Have a look at the following energy pyramid for a marine and a savanna ecosystem. Pay careful attention to the number of organisms in each level.
2. Answer the questions that follow.
3. At the end, you can make your own energy pyramid.



QUESTIONS:

1. Which organisms are the producers in the marine ecosystem and in the savanna ecosystem?

The phytoplankton in the marine ecosystem and the trees in the savanna ecosystem.

2. Which organisms are the primary consumers in the marine ecosystem and in the savanna ecosystem?

The crustaceans in the marine ecosystem and the giraffe in the savanna ecosystem.

3. 90% of the energy is lost and only 10% is made available to the next trophic level. Why do you think this happens? Discuss this in your class and write your answer down below.

The organisms in each level use most of the energy (90%) to sustain their own life processes (such as breathing, moving, reproducing etc).

Therefore, only 10% is available to the next level which feeds on them.

Learners might need help with this question, so ask them leading questions such as, what do the organisms in each level need energy for?

4. Give possible reasons why you think there needs to be so many producers in these ecosystems.

Energy flow in an ecosystem is very inefficient and only 10% of the energy from a trophic level is passed to the next level. Therefore, to provide enough energy for the subsequent trophic levels, there needs to be many plants as primary producers.

5. How many trophic levels are there in each of the ecosystems?

There are 5 in the marine and 3 in the savanna ecosystem.

6. Compare the amount of producers with the amount of secondary consumers. Why does there seem to be such a large difference in numbers?

Since only 10% of the energy produced by the consumers is passed on to the next level, the primary consumers need to eat a large amount of producers to get enough energy to live. In the same way, each level needs to be supported by a larger population that it feeds on as only 10% of energy is passed on to each level.

7. Read the following quote and draw an energy pyramid with five trophic levels in the space provided:

"Three hundred fish are needed to support one man for a year. The trout, in turn, must consume 90 000 frogs, that must consume 27 million grasshoppers that live off 1000 tons of grass."

Learner-dependent answer

Now let's make our own energy pyramids. Follow the steps:

1. Use an A4 sheet of cardboard and cut out a square. Do this by folding one corner to the opposite side and cutting off the rectangle sticking out.



2. Next, fold the square in half the other way so that you have two folds diagonally across the square.



3. Cut along one fold to the centre.

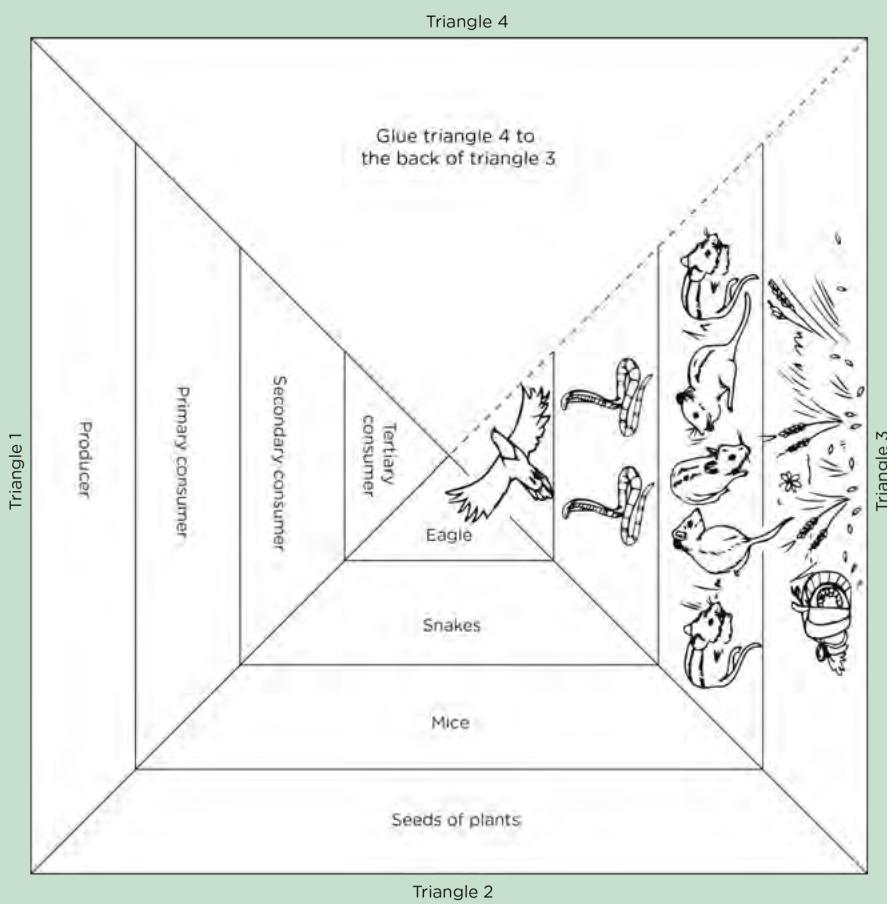


4. Fold the one of the triangle sides underneath the other one to make a pyramid.



5. Before gluing the two sides together, draw three lines to divide the sides into 4 layers.
6. Now you need to design your energy pyramid. Decide on the organisms that will go into each level. You will need producers, primary consumers, secondary consumers and a tertiary consumer.
7. In one of the triangles, draw images of each of the organisms in the different levels.
8. In another triangle write the names of the organisms.
9. In the last triangle, write whether the organism is the producer or which type of consumer.
10. Now glue the triangle together.

11. Have a look at the following example. You must come up with different organisms!



Food webs

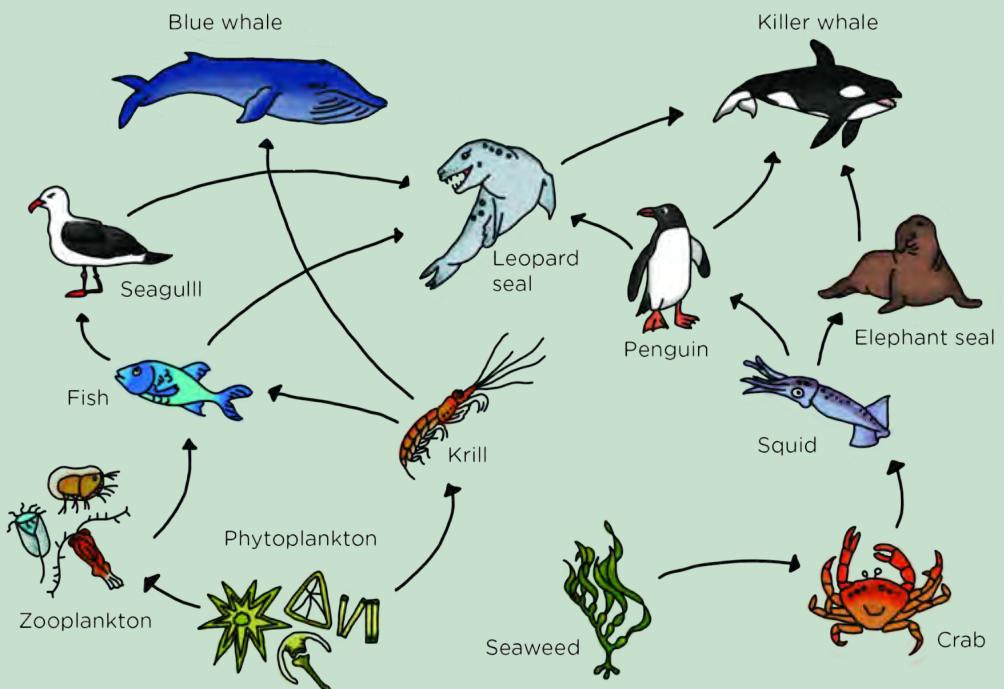
Consumers have different sources of food in an ecosystem and do not only rely on only one species for their food. If we put all the food chains within an ecosystem together, then we end up with many interconnected food chains. This is called a food web. A food web is very useful to show the many different feeding relationships between different species within an ecosystem.

ACTIVITY: Identifying food chains and food webs

INSTRUCTIONS:

1. Study the food web below.
2. Answer the questions that follow.





QUESTIONS:

- What sort of ecosystem does this food web describe?
A marine ecosystem.
- Use the following space to write down 4 different food chains from this food web.
*There are several answers. Some examples include:
phytoplankton krill fish penguin leopard seal
phytoplankton zooplankton fish sea gull leopard seal
phytoplankton krill blue whale
seaweed crab squid penguin leopard seal
seaweed crab squid elephant seal killer whale*
- What does a food web show?
It shows how the different food chains are connected.
- Name the producer in this food web.
Phytoplankton and seaweed
- List the herbivores in this food web.
Krill, zooplankton and crab
- Name two species in this food web that are top carnivores.
Killer whale and blue whale.

Refer to the ecosystem that you are currently studying. See if you can identify the food web that is applicable in your marked off ecosystem. Draw it below.

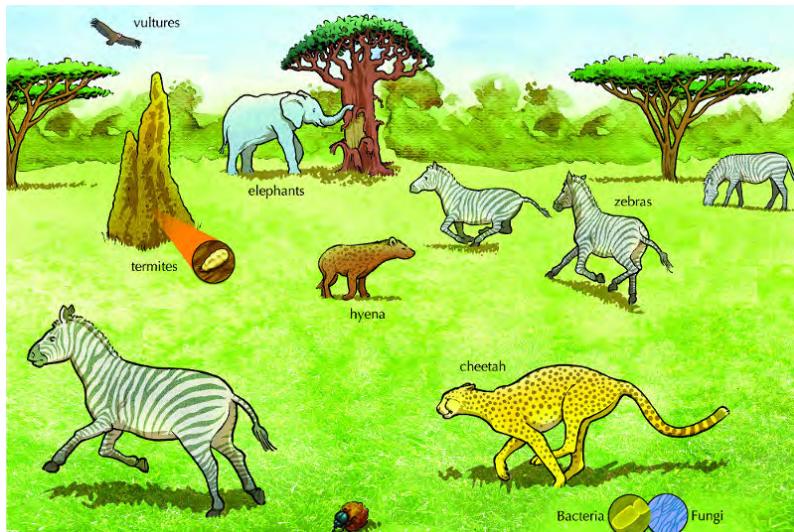
What do you think would happen to the marine ecosystem in the last activity if we removed the phytoplankton? This brings us to the next section.

2.5 Balance in an ecosystem

In this section will examine the balance between the different trophic levels in ecosystems, since all organisms in the ecosystem have to rely on the resources the area can supply. Any area can only support a **limited** number of animals. Look at the ecosystem below and decide which resources the organisms depend on. Remember to take some notes.

TEACHER'S NOTE

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



A balanced savanna ecosystem.

If all the grass and trees die, what would happen to the zebra and elephants? What would later happen to the cheetah and hyena? Why is this? The balance in an ecosystem refers to how many animals it can support for long periods. If the balance is upset, the whole system could fail.

TEACHER'S NOTE

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

VISIT

Try your hand at balancing a jungle ecosystem!
bit.ly/13IKVG5

One of the factors that we can look at within an ecosystem to see if it is balanced is the population growth of different species over time.

Population growth

Over time ecological populations interact and change within a community. All populations change over time and grow. The population growth of a species in the wild is kept in balance by a number of different factors.

Human intervention can sometimes cause serious damage to an animal population, such as the critically **endangered** Riverine Rabbit. There are fewer than 200 individuals left in South Africa. It only eats from a few plant types, so its **habitat** is restricted to where these plants are found, like small areas of the Karroo. During the day, it hides under bushes on the river banks, but many of its home areas have been invaded by humans or destroyed.

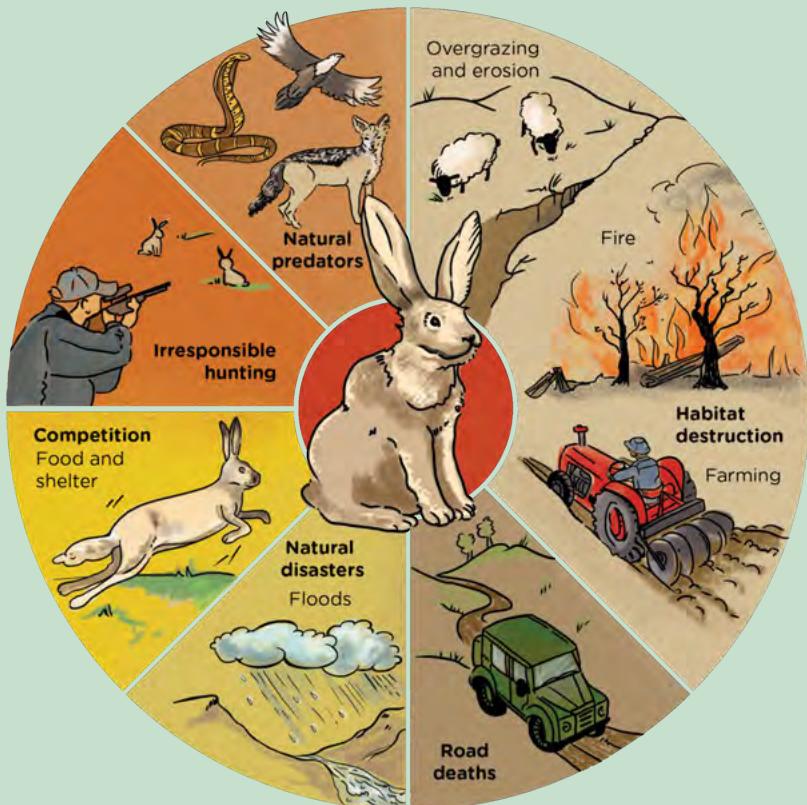
ACTIVITY: The critically endangered Riverine Rabbit

INSTRUCTIONS:

TEACHER'S NOTE

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

1. Study the diagram that shows the threats to the Riverine Rabbit.



VISIT

Learn more about the
Riverine Rabbit
bit.ly/178sJUW

1. Explain the different limiting factors on the population growth of the Riverine Rabbit using the information in the diagram.
 - *Habitat destruction is one of the main reasons, due to farming, fire and livestock (which may also cause erosion)*
 - *Other animal species compete for their food*
 - *Floods kill their young and destroy their habitat*
 - *Natural predators kill them*
 - *They are killed in the road and by 4x4 vehicles in river beds*
 - *Hunters accidentally kill them, thinking they eat crops*



The main goal of any species is to reproduce and ensure the survival of the species. Factors beyond the control of the species often influence this and limit the growth of the population, as with the Riverine Rabbit. These disruptions cause an imbalance in the ecosystem and can affect the organisms that live there as well as the ecosystem as a whole.

Factors that disrupt a balanced ecosystem

We can group these factors as:

1. natural factors; and
2. human factors.

We have already discussed this in some detail, but let's take a closer look.

Natural factors

Natural disasters like floods or hurricanes can cause severe disruptions to ecosystems, but the ecosystems recover eventually. If the change occurs over long periods, like climate change and global warming, the damage may not be reversible. For example, there are many different theories about why the dinosaurs became **extinct**. One of the main theories is a sudden change in climate. This sudden change, whether it was due to a meteor striking earth or not, disrupted the balance in the ecosystems. It was to such an extent that all the dinosaurs died out.

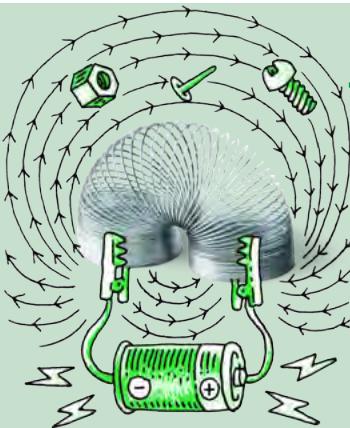
VISIT

A simulation of a meteor striking Earth (video).

bit.ly/110xV02



A sudden natural disaster, such as flooding, can disrupt an ecosystem.



ACTIVITY: Assessing the impacts of a natural disaster

In the 1980s a devastating drought and famine raged in Ethiopia and caused the death of 400 000 people. Many animals, plants and microorganisms also died and species that depend on water for their reproductive cycle, like amphibians, were particularly badly affected.



The dry landscape in Ethiopia.



People trying to collect water.

QUESTIONS:

1. What is a drought?
Drought is water shortage, when there is no rain for a long time.
2. What is a famine?
A famine is a scarcity of food when there is starvation.
3. How do you think a drought and famine in a particular area, such as in Ethiopia are linked?

- Drought makes plants die, so animals that eat them also die. This decreases food for humans, as crops and farm animals die as well.*
4. A famine is often accompanied by the spread of diseases amongst animals and humans. Why do you think this is so?
Hungry and malnourished animals and humans are too weak to fight off disease.
5. Do you think the effects of a drought and famine on an ecosystem are reversible or irreversible? Give a reason for your answer.
It is usually reversible, but ecosystems can take a very long time to recover from severe droughts.

TEACHER'S NOTE

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

Human factors

Many years ago, people like the San had little impact on their environment, as they lived in harmony with the land and only took what food they could carry. Modern man has, however, had a huge effect on nature. We clear land to build cities, roads and farms, we pollute the environment and produce waste and litter. Humans also poach endangered animals and over-harvest marine animals, causing lasting damage to ecosystems.

ACTIVITY: Poaching in Southern Africa

INSTRUCTIONS:

1. Read the following newspaper article.
2. Answer the questions that follow.

Hunting and bushmeat - the road to extinction

19 October 2012

Illegal hunting (poaching) of animals and the killing of wild animals for 'bush meat' in many parts of Southern Africa is of serious concern to environmentalists and is driving some species close to extinction. Poor communities often rely on small wild animals they can trap for food, but removing too many of the smaller animals could force the carnivores (like lions, leopards and wild dogs) that eat them to turn to domestic animals like sheep or cattle for food. For this reason, farmers may go out and shoot even more of them. The carnivores themselves sometimes get caught in the traps. Although hunting and finding bushmeat have been traditional ways of getting food for many generations, the current



'over-hunting' is causing concern. Dr Rene Czudec of FAO commented: "There is an urgent need to look for solutions to ensure the sustainable use of SA's wildlife, while still helping to develop poor communities"

VISIT

For more information on the bushmeat crisis
bit.ly/13m5JJ

QUESTIONS:

1. After reading this article, explain what you think bushmeat is.
Any meat obtained from wild animals that were trapped / snared/ poached, often illegally.
2. How did the hunting of the San differ from today's removal of bush meat?
The San only took what they needed, their traps were well set and their numbers were small. Today's people set traps badly, so the wrong animals are killed and then often not eaten. There are also a lot more people doing it now.
3. Why do you think there is a market for bushmeat (people who buy the bushmeat)?
Many people are poor and cannot afford to buy the more expensive meat in stores so rather buy much cheaper meat from illegal traders.
4. Some people from local communities that live on the edge of protected reserves, sneak into the reserves and illegally kill wildlife for food. Do you think this is justified? Discuss this with your class. What do you think some solutions to the problem could be?
Learner-dependent answer. Note: Encourage learners to express their opinion about this and have a debate in class. Some will feel it's wrong to exclude people from traditional food sources, others feel it's more important to protect the animals and find other ways of helping people. Ask for suggestions to solve the problem: quotas / education programmes / help people to grow food or keep animals etc.
5. What is poaching?
The illegal hunting of wild animals in areas for food or money.
6. Why do you think poaching causes an imbalance in an ecosystem?
When animals are poached, they are killed at a faster rate than their population can grow. They may become extinct.
7. In the article, wildlife is poached for the meat to be sold as food. What two other animals that are poached in southern African game reserves and why are they poached?
The rhino is poached for its horn, elephants are poached for their tusks.
8. Abalone (Perlemoen) are edible sea snails sold as a delicacy in Asia.
Although they are farmed, many are removed illegally by divers, causing a serious decrease in their numbers.



A perlemoen in its natural environment.



Perlemoen served as a delicacy.

How do you think the illegal poaching of perlemoen is affecting our marine ecosystems?

The natural predators of abalone have too little food so other species are eaten instead. This affects other populations too. Note: Local people who use Perlemoen as food for their families are also stopped from removing

them. Cape gangsters have taken over the illegal Perlemoen trade because of the huge amounts of money involved. It is illegal to buy or sell Perlemoen!

9. In the northern provinces in South Africa, Mopani worms are a traditional source of high protein seasonal food found in the area. But they have also become a favourite of tourists and visitors of the area. Each year, more and more are being eaten so that they are now hard to find. We say they are becoming locally extinct.



Describe the impact that this could have on the rest of the food chain or food web.

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

Another way in which humans have a huge impact on the environment and cause disruption to ecosystems is through pollution. There are many different types of pollution. Are you aware of the ways in which you are contributing to pollution?

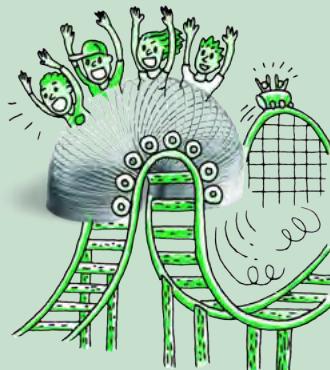
ACTIVITY: Assess your impact on the environment

QUESTIONS:

1. There are different types of pollution, as listed below. For each one, discuss it with your partner and write a short description of the pollution, where it can come from.
 - a) Water pollution.
 - b) Air pollution.
 - c) Land pollution and refills.

You can also start this first part of the activity as a class discussion. Ask learners what types of water resources are polluted and how. What pollutes the air? Where does our waste from our homes go? Below are some points for the discussion.

- **Land pollution:** *In spite of recycling, much rubbish still goes to landfill sites, where chemicals seep into soil water and poison food chains.*
- **Water pollution:** *Can be caused by car oil, people washing in rivers or*



using rivers as toilets. Some municipalities allow raw sewage into rivers / sea, others treat sewage first but still spill chemicals into rivers. Farmers spray crops to kill pests, but this also washes into rivers and damages ecosystems.

- **Air pollution:** Comes from chemicals burnt by factories, coal stoves, car exhausts, insecticide sprays and burning old tyres, etc.
2. Assess your own life. Where have you perhaps contributed to the types of pollution mentioned above?
Learner-dependent answer.
 3. Brainstorm ways in which you can reduce each of these types of pollution.
Learner-dependent answer.
 4. Study the following posters made by a Gr. 8 class.



What do you think they are trying to encourage us to do? What is the message of the posters?

This links to the last section on conservation of ecosystems. Note: Some answers include that the first poster is trying to convince us to think twice before throwing something away. We should rather recycle it or think of how it can be reused. We can also buy things with the minimum packaging and reduce the number of plastic bags we use. The second poster is playing on the words of having a 'plan B'. In this case however, we have no plan B for planet Earth - there is no second Earth or any other planet that we can live on. We only have this planet and we need to look after it.

2.6 Adaptations

TEACHER'S NOTE

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

- Adaptation is the change in structural, functional and behavioural characteristics of organisms in a species. Adaptation usually takes place over many generations.
- Adaptation, over time, allows a species to survive in response to changing conditions in the environment

- Species that are unable to adapt to changes within the environment die out (become extinct)

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

Organisms in ecosystems face competition, predation, parasitism and human influence, all of which could affect them negatively, forcing them to **adapt**, move away or die. It is well known that SA has undergone big climatic changes in the past. For example, the dry Karoo was once swampy and the Cango Caves in Oudtshoorn were once under water.



Rock formations inside the Cango Caves show that they were once under water.

What is adaptation?

When Southern Africa rose out of the sea millions of years ago, organisms that could not adapt to the new, drier **terrestrial environment** became extinct, but individuals that could adapt, survived and formed new populations. These adaptations could be changes in the organism's structure, function or behaviour over very long time periods. Only populations of organisms that happen to have suitable characteristics are able to survive in changing conditions within an environment. They are 'selected by nature' to survive. Those species that do not adapt will die out and become extinct.

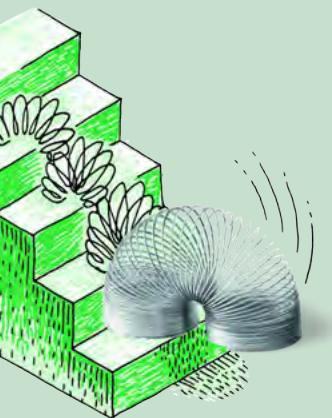
As we have said, adaptation in species can occur in three main ways:

1. Structural: the physical characteristics of a species such as having long legs and strong muscles.
2. Functional: a species may have special way of carrying out its life processes such as being able to produce eggs with a hard shell , so that the embryos can grow and hatch even if the climate changes.
3. Behavioural: the species can have special behaviours that are instinctive (which they know by **instinct**) or can be learned such as making safe nests for protecting their babies

These changes take place over a long time period within a species and must be passed on from generation to generation. Over time and over many generations, these adaptations in the individual organisms will allow the species to evolve and adapt to its changing environment. Let's have a look at some of the adaptations of plants and animals.

Adaptations in animals

Animals have different adaptations which have enabled different species to live and function in different areas. Let's look at some of the animals that live in our country and how they have adapted to live in their environments.



ACTIVITY: Distinguish between types of adaptations

INSTRUCTIONS:

1. We will work through different adaptations in South African animals that have enabled them to survive in the environment they live in.
2. In each of the examples, say whether you think it is a structural, functional or behavioural adaptation and give a reason for your choice.

QUESTIONS:

Record your work in the table below each set of animals.

1. **Aardvark:** It has a flexible, tubular tongue up to 30cm long as well as thick skin and short, powerful legs with strong claws for digging into termite mounds, its favourite food. These ants are then collected by the tongue - up to 50 000 in one night! It hides underground in daytime to escape heat and predators.



Two aardvarks in an enclosure.

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

2. **Desert beetles :**They have ridges on their backs for collecting mist in the Namib Desert at night. Long back legs tilt the body, so mist is collected, condenses and runs via channels and grooves into their mouths.



A desert beetle

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

3. **Gemsbok:** This striking antelope from the Kalahari Desert prefers grass and shrubs, but will dig for roots and tubers if it needs water. They save water by not sweating and sleep in the shade during the day. If they can not find shade, they turn the body's lightest side to the sun.



Gemsbok in the Kalahari

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

4. **Ostrich:** These are the biggest and heaviest birds, but they can't fly. To avoid predators, they fight with strong clawed toes or run away, up to 70km/hr! Ostriches swallow small stones to help digest any food they find. Male ostriches get red beaks in the mating season. The female lays eggs and she sits on them during the day, while the male incubates them at night - examine their colour differences to see why.



A female ostrich



A male ostrich

<p><i>How is the species adapted to life in its habitat?</i></p>	<p>Ostriches have a long toe and claw to fight predators and escape; eggs remain dormant until heat of breeding male and female's bodies starts their development. Male and female share nesting duties. Their bodies are specially camouflaged: male has black feathers to be camouflaged at night when it is on the nest; female has speckled dusty coloured feathers to be camouflaged during the day when she is on the nest.</p>
<p><i>What type(s) of adaptation is this?</i></p>	<p>Structural: strong toe and leg muscles help it to run fast; male beak turns red to signal female that it is ready to breed. Behavioural: male sits on nest at night and female on nest during day as they take turns to nest; ostriches eat pebbles to help digestion as they do not have teeth; female lays just enough eggs to cover with body</p>

5. **Stick and leaf insect:** These insects look like leaves or sticks to avoid predators - this is called **mimicry**. They feed on plant materials at night and move very slowly to avoid being seen. Female stick insects can reproduce without mating.



A stick insect

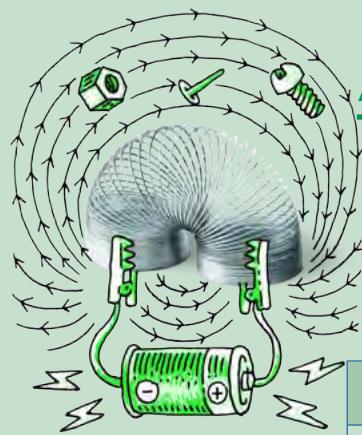
<i>How is it adapted to life in its habitat?</i>	<i>Body adapted to mimic leaf or stick; moves very slowly to seem like a branch or leaf moving; nocturnal to avoid being seen in daylight by predators; stick insects can reproduce without male insects</i>
<i>What type(s) of adaptation is this?</i>	Structural: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

VISIT

A video on wildebeest migration. bit.ly/1cf5E90

Other behavioural adaptations

Many species of animals display an interesting behavioural adaptation called **migration**. This occurs when an animal or a group of animals move between different areas at different times or periods.



ACTIVITY: Why do animals migrate?

INSTRUCTIONS:

1. Have a look at the following animals.
2. Think of reasons why they would want to **migrate** from their present habitat.

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

VISIT

Watch underwater footage of the amazing sardine run that occurs each year from May to July bit.ly/1chMUMX

Adaptations in plants

Several local plants are also adapted to their environment. The umbrella thorn in the African savannah can survive temperatures ranging from 50°C to below freezing. Its deep roots reach ground water easily and the small leaves prevent dehydration, while still being well exposed to light due to the umbrella shape of the tree. Why does it need light?

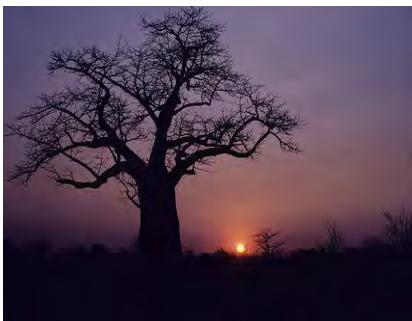


An umbrella thorn acacia.

TEACHER'S NOTE

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

The Baobab tree survives in dry areas, since it stores water in the thick trunk and spongy wood. The smooth bark reflects heat, making it cooler, but also helps protect the fruits from monkeys. How can it do this?



The sun setting behind a baobab tree.



This baobab is over 3000 years old! Take note of its width and the reflective bark.

TEACHER'S NOTE

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

The flowers smell like rotting meat to attract bats, flies and moths at night. Why do you think the baobab tree needs to attract these animals to its flowers?

TEACHER'S NOTE

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



A baobab flower which smells like rotting meat.

We are now going to look at some very unique plants, which are only found in South Africa.



ACTIVITY: Living stones

INSTRUCTIONS:

1. Study the following photographs. They show different types of plants. These plants actually look like pebbles. They are from the genus *Lithops* and they succulent plants, meaning they have parts that can store water.
2. Answer the questions which follow.



Lithops plants growing in dry rocky ground.



Different patterned *Lithops* plants.



A very camouflaged *Lithops* plant.
Can you see it?



A flowering *Lithops*.

QUESTIONS:

1. Why do you think these plants are commonly referred to as 'living stones' or 'pebble plants'?

This is because they are plants but they are camouflaged to look like stones or pebbles.

2. Why do you think the plants have such different patterns on their surfaces? How does this help them to survive in their environment?

The Lithops plants are camouflaged to look like stones and blend in with their rocky soil that they grow in. The patterns look like different rocks/pebbles. They are therefore not usually seen by herbivores which might eat them. This adaptation protects them from being eaten.

3. Lithops plants are classified as succulents. What does this mean? What type of environment are succulents adapted to live in?

Succulents are plants which are adapted to live in hot, arid environments and they have thickened, fleshy leaves and stems to store water.

4. Lithops leaves are fleshy and mainly underground, and the stem is short. Flowers grow between the leaves, which shrink to below ground level during drought. How does this help the plant survive?

The fact that the leaves are mostly underground helps the plant to conserve water because as little as possible is exposed to the hot environment so this reduces water loss. During drought, the leaves shrink even further underground to try to conserve water even more.

5. If the leaves are reddish-brown and mainly underground, where is the chlorophyll? Examine these dug-up stone plants.



The upper surfaces of Lithops plants.



The underneath surfaces of the Lithops plants.

Where is most of the green part of the plant located?.

Most of the leaf and hence the green chlorophyll is located on the underneath side of the plant underground.

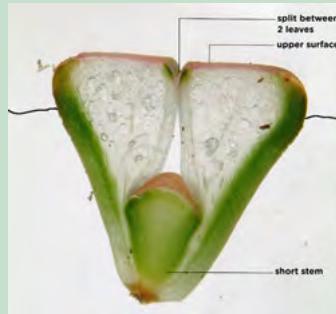
6. This is a thin section of a stone plant under a hand lens. Draw a diagram of it and label the top of the leaves, the split between the leaves and the stem. Indicate where the soil level would be. What is stored in the clear area of the leaves?



A cross section of a Lithops plant viewed under a microscope.

Learner-dependent answer

The labelled micrograph should look something like this:



7. The upper patterned surface acts as a window. Can you see the clear, fleshy middle parts of the leaves? Do you think light can travel through this? How does this allow the plant to photosynthesise?

The upper part of the leaves acts as window and lets light through. As the interior of the leaves is transparent, the sunlight can travel through to the bottom parts of the leaves which are underground and contain the chlorophyll in order to photosynthesise. This allows the plant to have a coloured, patterned upper surface to camouflage it from herbivores, but still allows that sunlight to travel through for photosynthesis.

2.7 Conservation of the ecosystem

Our country is one of the most naturally diverse in the world. This means that we have many different species and habitats and ecosystems here, more than most other places in the world.

Our country's natural beauty and diversity attract thousands of tourists each year, but it is under severe threat from poaching, pollution and other human influence. Ecosystems are able to naturally recycle materials like water, carbon dioxide and other gases and the remains of organisms, if they are left alone. But ecosystems cannot do this effectively if we interfere. These human interferences include:

- Habitat destruction like deforestation and burning
- Pollution causing global warming
- Alien invasive plants taking over ecosystems
- Hunting, poaching and other killing of wildlife

VISIT
Video on rhino poaching in South Africa. bit.ly/1euLd4R

These pressures have caused great loss in biodiversity. Some ecosystems are under strain and others have already collapsed. There are many reasons why it is important for humans to care about the environment. As we have learnt, everything in an ecosystem is connected. Therefore harming one component of the ecosystem will have a ripple effect that can damage all the other systems.

ACTIVITY: Finding solutions to environmental problems

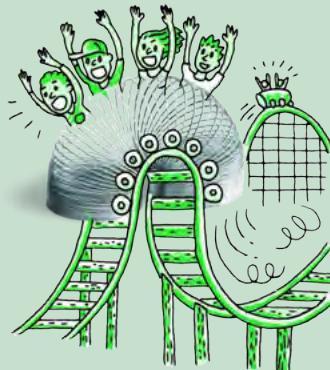
INSTRUCTIONS:

1. The following table is a list of environmental issues.
2. Do some research on air pollution, water pollution, landfills and climate change.

INSTRUCTIONS:

1. Write down the effect (consequence) of this issue on the ecosystem (or on humans). Write down a possible solution or a simple action that you can take to help.

There are many possible answers in this activity. Learners may be incredibly specific or they may prefer to answer generally. They can be creative with their suggestions. Below are some example answers, but learners may come up with many more.



Environmental Issue	Consequence	Action
<i>Inappropriate waste disposal: Air pollution</i>	<i>1) Harmful chemicals in the air cause a range of allergic and degenerative lung diseases as well as cardiovascular disease and many cancers. 2) Air pollution can also cause acid rain, which can destroy forests and poison lakes.</i>	<i>Support companies and products that use cleaner production methods. Do not use products known to cause pollution. Develop cleaner technologies.</i>
<i>Inappropriate waste disposal: Water pollution</i>	<i>Water pollution can be caused by factories or farms allowing their waste to run off into streams or water sources, or it can be caused by the accumulation of many people discarding their waste into rivers. This may cause the spread of disease or poison aquatic plants and animals.</i>	<i>Do not throw harmful chemicals down the drain or into rivers and streams. Support companies that dispose of their waste responsibly.</i>
<i>Inappropriate waste disposal: Landfills and littering</i>	<i>Litter builds up and can take many thousands of years to degrade. Due to inappropriate waste disposal, plastic is ending up in the oceans, and in many animals' habitats. Animals who mistake litter for food often end up choking and dying.</i>	<i>Reduce, reuse and recycle wherever possible. Do not throw litter onto the ground. Look after your belongings so that they last longer. Purchase responsibly - don't buy packaging that does not degrade (like polystyrene).</i>

Environmental Issue	Consequence	Action
Carbon emissions and climate change	<i>Excessive burning of fossil fuels is a type of air pollution that contributes to global warming and climate change. Climate change has an effect on habitats as animals and plants cannot adapt fast enough to the rapid changes in their habitats. This may result in many species going extinct.</i>	<i>Try to limit your use of electricity- switch off lights, put on more clothes instead of using a heater, turn off the geyser for some hours each day. Don't overfill the kettle. Use public transport. Share lifts and carpool. Don't drive excessively. Walk when you can. Use less plastic.</i>

Some people and organisations like Greenpeace, fight for environmental conservation. There may be groups in your local area that also promote environmental conservation - do not think that you can not make a difference if you are just one person!



The Greenpeace ship, Arctic Sunrise, which is used for environmental awareness campaigns and research.

ACTIVITY: Why should we care?

TEACHER'S NOTE

This is an optional, extension activity.

INSTRUCTIONS:

1. Divide the class into two teams. One group supports environmental conservation and the other believes we should use all earth's resources as we like.
2. Both groups must research their topics beforehand and gather relevant points.
3. The teacher can lead the debate and ensure it proceeds in an orderly way.

QUESTIONS:

- After the debate, write down 3 points about each viewpoint that you can remember.

Learner-dependent answer.

TEACHER'S NOTE

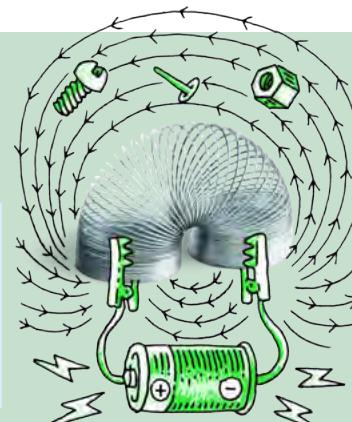
Below is some extra information on the types of individuals who are actively involved in conservation, if you wish to discuss this further with your learners:

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

VISIT

Learn about actions that you can take at home to help the environment. YOU can make a difference bit.ly/feulifN

There are all ordinary people who feel passionate about saving the only world we have. It takes the combined work of many concerned people to maintain healthy ecosystems - you can also make a difference!



ACTIVITY: Individuals who make a difference

TEACHER'S NOTE

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

INSTRUCTIONS:

- Below are some photos of various individuals who have contributed to environmental conservation and awareness in some way.
- Research what each individual has done.
- Then, chose one who you find most inspiring and write about them, identifying what is is you admire.
- You do not have to stick to the people who have been identified here. You

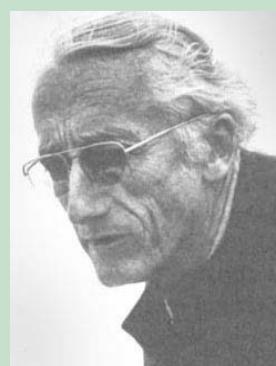
can write about someone else too who you have identified with.
5. Lastly, reflect on how you can make a difference in your own life and what you could do to conserve your own local environment. Write about this too.



Sir David Attenborough



Jane Goodall



Jacques Cousteau



Al Gore

VISIT

A short tribute film on
Wangari Mathai.
bit.ly/1lOzjAb

VISIT

Your photos can help
scientists to map where
mammals are in South Africa
and help guide their
conservation efforts
bit.ly/1lOzgEI

Some other people to research include:

- Wangari Mathai
- Lawrence Anthony
- Steve Irwin
- Diane Wilson
- Dian Fossey
- Ian Player



SUMMARY:

Key Concepts

Ecosystems

- Ecology is the study of interactions of organisms with one another and with the physical and chemical environment.
- The study of ecological interactions is conducted at four levels:
 - populations
 - communities



- ecosystems
- biosphere(s)
- All ecosystems combined make up the biosphere.
- An ecosystem consists of a community that includes all living organisms (biotic) such as plants and animals, together with the non-living (abiotic) environment and climatic conditions such as temperature, air and wind, water, interacting as a system.
- An ecosystem can refer to a specific area on Earth or the entire biosphere can be regarded as one large ecosystem.
- The survival of populations and species depends on whether enough individuals are suited to the environmental conditions at the time. As conditions do change over time only those better suited to the changed environment will be able to continue the species. And so over time species adapt.

Feeding relationships

- Plants are *producers*. They make their own food.
- Animals are *consumers*. They obtain food from plants either directly (such as herbivores) or indirectly (such as carnivores).
- *Herbivores* feed on plants.
- *Carnivores* feed on other animals (living or dead). This group includes:
 - *Predators* hunt other animals, their *prey*, for example lions and leopards.
 - *Scavengers* that eat dead animals, for example hyenas and vultures.
 - *Insectivores* that eat insects and other small invertebrates such as worms
- *Omnivores* feed on plants and animals. Humans are generally omnivores.
- *Decomposers* break down (decompose) the remains of dead plants and animals. They recycle important nutrients in the environment.

Energy flow: food chains and food webs

- Plants and some algae play a very important role in the ecosystem because they capture the radiant energy from the Sun and use it in the process of photosynthesis to produce glucose that the plant and other animals can use to gain energy.
- This energy is passed along a food chain from producers to consumers; decomposers are the last link in this transfer of energy. They release energy as heat to the environment.
- Each stage of a food chain is called a *trophic level*.
- Energy transfer and energy loss occur at each trophic level.
- Interlinked food chains together form food webs.

Balance in an ecosystem

- An ecosystem can only accommodate as many organisms as its resources (food, water and shelter) can carry.
- The balance can be disturbed by natural or human factors:
 - natural factors include extreme changes in patterns of weather and climate, such as floods, drought, extreme and sudden changes in temperature.
 - human factors include removing organisms from the ecosystem (such as poaching), human-induced pollution.
- These factors can contribute to an imbalance in an ecosystem, seriously impacting on its components and altering its nature.

Adaptations

- Adaptation is the change in the structural, functional or behavioural

characteristics of a species over many generations.

- Adaptation allows the species to survive as it adapts to changing conditions within the environment.
- Species and populations of organisms that are unable to adapt to changes in the environment will die out and become extinct.

Conservations of ecosystems

- People can work towards managing and sustaining natural ecosystems.
- Individuals can contribute to conservation in various ways such as appropriate waste disposal (including recycling and reusing).

Concept Map

This concept map shows how the concepts in this chapter on the 'Interactions and interdependence within the environment' link together. Complete the concept map by filling in the 2 levels which are missing for the study of ecology. Also, fill in the 4 types of consumers that you have learned about in this chapter.

Can you see how the arrows show the direction in which you must 'read' the concept map?

Interactions and interdependence within the environment

trophic levels

have defined in feeding relationships
link to form food webs

food webs

plants

are animals

producers consumers

include

humans

by - conserved

humans

make up
do not have
must be

biosphere

specific size

non-living things

whole planet

support organisms
to balanced

conserved

are
interact as system
are

living organisms

adapt
in order to
survive
are
biotic
abiotic

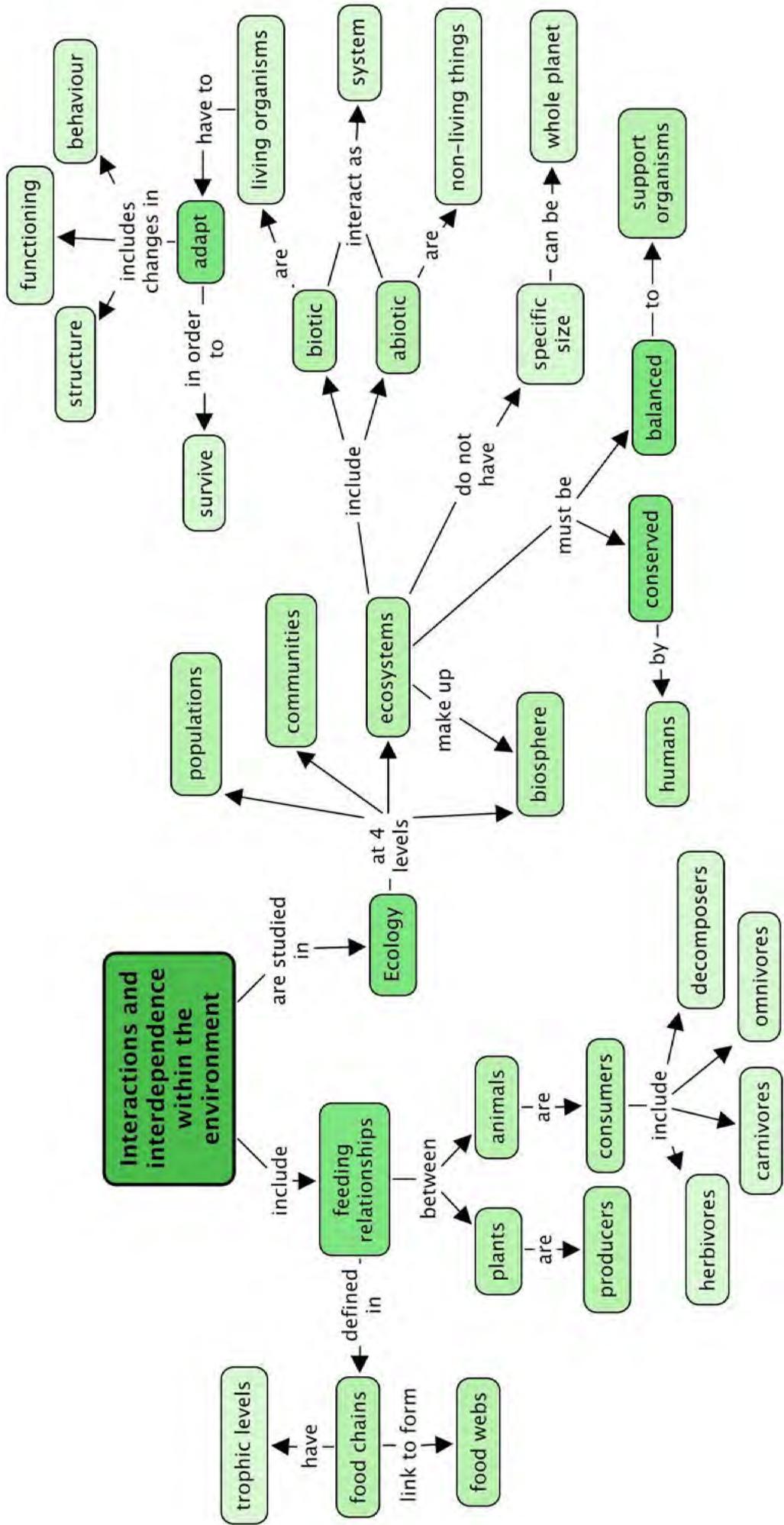
includes changes in behaviour
functioning
structure
in order to adapt
have to

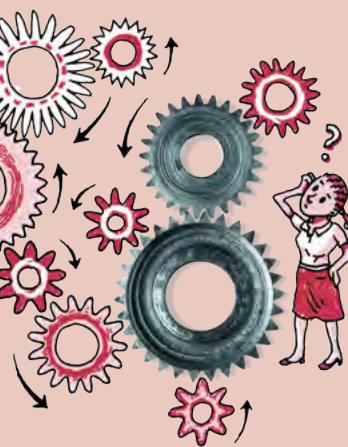
TEACHER'S NOTE

Teacher's version

Remember that concept maps are different to mind maps in that concept maps have a hierarchical structure and show how concepts link together using arrows and linking words. Whereas mindmaps generally contain a central topic and individual branches coming out which do not necessarily link together. Mindmaps can also be a useful way of summarizing information and studying, however, we are using concept maps as they help to show linkages, which is very important in science. Help your learners to 'read' the concept map by showing them that the arrows show the direction in which concepts progress and are linked to each other. Learners might battle to find the other 2 levels in which we study ecology - help them by reminding them of the 4 levels, namely; populations, communities, ecosystems and the biosphere.

Interactions and interdependence within the environment





REVISION:

- Match the columns in the following table to link the description to the term. Write your answers on the lines below. [9 marks]

1. Producer	A. Organisms that eat other organisms to obtain food
2. Carnivore	B. Feeds on plants and animals
3. Consumer	C. Organisms that make their own food.
4. Omnivore	D. Organisms that eat only plant material
5. Predator	E. A carnivore that eats dead animals
6. Decomposer	F. An organism which feeds on other animals (living or dead)
7. Insectivore	G. An organism that breaks down the remains of dead plants and animals
8. Scavenger	H. A carnivore that hunts other animals
9. Herbivore	I. A carnivore that eats mainly insects and other small invertebrates

1 - C

2 - F

3 - A

4 - B

5 - H

6 - G

7 - I

8 - E

9 - D

- Distinguish between abiotic and biotic factors in the environment. [4 marks]

Abiotic factors are the non-living elements in the environment that have never and will never live. This includes gases, rocks and soil, water, temperature and weather conditions. Biotic factors are those factors that have once lived or that are living today. This includes past and present plants and plant materials, animals and microorganisms.

- There are different levels of ecological organisation between an individual organism and the biosphere of the Earth. List and describe the levels in between the two mentioned here. [6 marks]

Population: *the individuals of the same species that live in the same space and time and breed with each other form a population.*

Community: *different populations of different species within the same area at the same time form a community.*

- Ecosystem:** all the communities within the larger area that interact with and are interdependent on each other and the abiotic factors within the area.
4. Discuss the different types of interaction that exists between species. [9 marks]

- *Competition: when organisms from different species compete for the same limited resource*
- *Feeding relationships: there are many different types of feeding relationships between different organisms in an ecosystem, such as herbivory, predation, scavenging.*
- *Symbiosis: when two (or more) organisms' actions have a positive, negative or neutral effect on other organisms from a different. The way in which they interact and the influence this has on the other species leads us to identify*
 - mutualism
 - parasitism
 - commensalism

5. Explain what the different trophic levels represent in an ecosystem and why we can represent the levels as a pyramid with the bottom layer being the largest. [8 marks]

Producers: are organisms / plants that are able to produce their own energy from sunlight, water and carbon dioxide and do not need to consume other organisms to get energy.

Primary Consumers: need to consume plants in order to get energy.

Secondary Consumers: need to consume primary consumers to get energy.

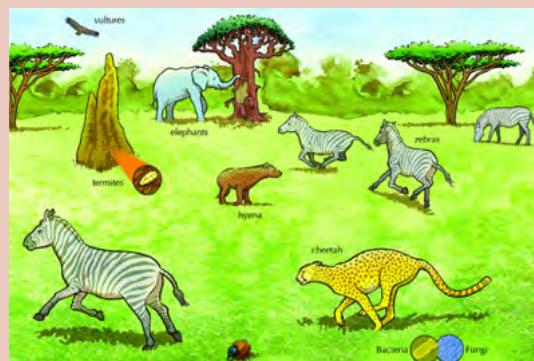
Tertiary Consumers: consumers secondary consumers to get energy.

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

6. Evaluate this statement: An insectivore is a carnivore.' [2 marks]

An insectivore eats insects and small invertebrates and is therefore a carnivore, as it eats other animals, thus the statement is correct because carnivores get their energy from eating other animals and not plants.

7. Identify the following in this food web. [7 marks]



- a) Producers:
 - b) Primary consumers:
 - c) Secondary consumers:
 - d) Scavengers:
 - e) Decomposers:
- a) trees, shrubs, grasses
 - b) zebra, elephant, termites
 - c) cheetah, hyena
 - d) vultures, hyenas
 - e) bacteria, fungi
8. There are more zebra than cheetah in this balanced ecosystem. Explain why this is so. [3 marks]

The zebra are primary consumers and use about 90% of the energy that they get from the grass, transferring about 10% to the cheetah to consume. There therefore needs to be more zebra than cheetah in order to make sure the cheetah are supported in terms of food supply, and also that they do not eat all the zebra so that the zebra population does not die out.

9. Describe the work of the producers in this ecosystem. [2 marks]

The producers capture the energy from the sunlight and convert it to chemical potential energy in the form of glucose through the process of photosynthesis. In this way they place energy into the ecosystem which animals cannot do.

10. Based on this picture, evaluate how active the decomposers are in this environment. [2 marks]

Learners should be able to identify the lack of dead animal carcasses and manure, which indicates that the decomposers are working efficiently.

11. What do you think would happen to this ecosystem if all the zebra got a disease and died? [2 marks]

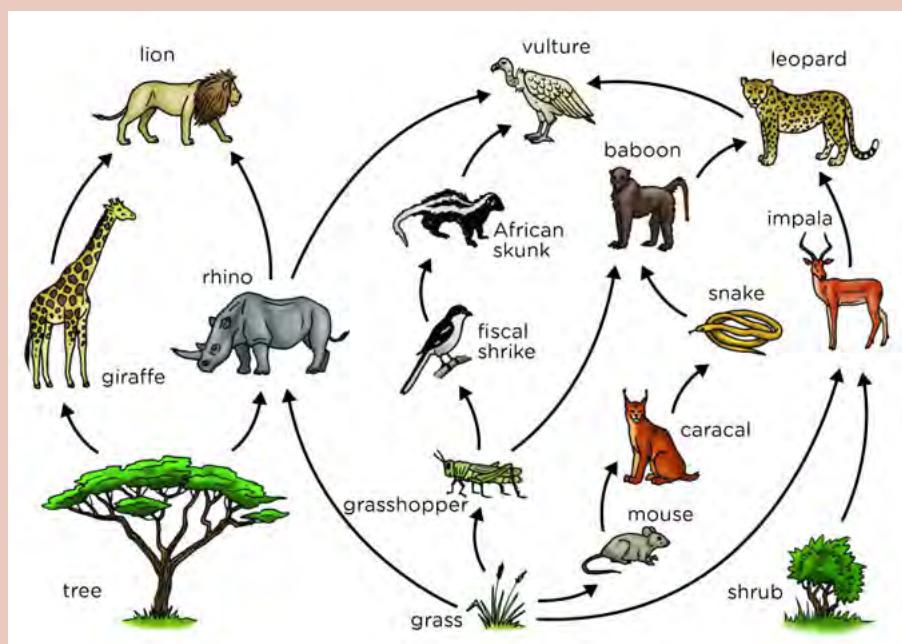
If all the zebra died, the ecosystem would become unbalanced. Firstly, the cheetah would not have a food source anymore and they would also in turn suffer and starve. The hyena would also have a depleted food source.

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

12. What do you think would happen to this ecosystem in the short term and in the long term if a big fire came through and burned most of the grass and some of the trees? [2 marks]

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

13. The following food web shows the feeding relationships between organisms in another savanna ecosystem.



Use this food web to write down three food chains. [6 marks]

There are multiple food chains here. Some examples are:

tree → →

tree → →

shrub → →

grass → → →

grass → → → →

14. Describe how the different organisms in the table below are adapted to live in their specific environments. [4 X 3 marks = 12 marks]

Organism	Adaptations
 <i>A leopard.</i>	<i>The leopard is camouflaged due its colouring and spots. This helps it to hide away from prey so that it can get as close as possible before chasing. The leopard is adapted to run fast over short periods in order to catch its prey. It has a light, streamlined body with strong legs. It has a tail for balance to turn sharp corners while chasing.</i>
 <i>A whale.</i>	<i>The whale is a mammal so it does not have gills, but it can hold its breath for a long time underwater so that it can dive down and also catch prey/filter feed. It has a blowhole on top of its head for breathing. The blubber keeps it warm as it insulates it and also provides energy when diving and swimming in very cold seas. It has a strong tail, streamlined body and its forelimbs are flippers for swimming.</i>
 <i>A Venus Flytrap.</i>	<i>This plant has adapted as it is carnivorous. It catches flies and has adapted to digest them. The red colouring inside the 'catchers' attracts the flies as it looks like meat. As soon as the flies land on the surface, the plant is triggered and the catchers clamp shut, catching the fly. The catchers are adapted with the spikes on the end to form a cage around the fly and keep it there while it is digested. The plant can also photosynthesise as it is green and contains chlorophyll</i>

Organism	Adaptations
 <p data-bbox="456 607 656 641"><i>A dung beetle.</i></p>	<p data-bbox="908 237 1345 726"><i>A dung beetle has adapted to its environment by using the dung from other big herbivores as a food source and to lay their eggs. They have adapted by being able to collect the dung and roll it into balls so they can transport it to where it is needed. This also creates a warm, safe chamber in which to lay their eggs, feed the young and protect them. The dung beetles have strong front legs so that they can do the rolling. Their back legs have fine control of the dung ball.</i></p>

15. Read this paragraph about the Quiver tree of the Kalahari and Namib desert.

The Quiver tree lives in the Namib and Kalahari deserts, where the heat and lack of water makes it extremely difficult for plants to grow and survive. It stores its water inside green succulent leaves and bloated branches. The San used to hollow out the branches and use them for their quivers, which is where the tree gets its name from. The branches are covered with a white powder that reflects the heat and the leaves have very few pores to minimise water loss through evaporation. During extremely harsh weather conditions, the tree can amputate (remove) its own branches and reduce the leaves to minimise water loss even further, then when the conditions improve, it sends out new shoots and grows a rich leafy top again.



How is this species adapted to life in its habitat? [4 marks]

The quiver tree has thick bloated branches and succulent leaves so that it can store water for the dry months. Its branches are covered in white powder to reflect heat away from plant which helps to reduce water loss. The leaves have few pores to also minimise loss of water. The tree can amputate leaves and branches if water is scarce.

16. A group of poachers recently made the following statement when they were arrested: "*Why is it so important to conserve the biodiversity and the environment? Surely there are enough wild animals and plants that it doesn't matter if some of them die and become extinct?*" Write 3 - 4 sentences to explain to them why we need to care about the biodiversity in our country. [6 marks]

Learners need to display the following:

- *recognition of the importance of valuing each species and their specific niche in their ecosystem*
- *recognition that each species fill a specific place in the food chain and if one is removed it affects all the other species in that food chain / web / pyramid.*
- *each organisms needs to be protected in order to preserve the entire ecosystem*
- *the importance of preserving our diversity to ecotourism and for future generations to enjoy (we have not INHERITED the earth from our parents, we are CUSTODIANS of the earth for our children!)*

Total [84 marks]



3 Microorganisms

TEACHER'S NOTE

Chapter overview

2 weeks

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

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

3.1 Types of microorganisms (2 hours)

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

3.2 Harmful microorganisms (2 hours)

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

3.3 Useful microorganisms (2 hours)

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



KEY QUESTIONS:

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

Microorganisms have been on Earth for billions of years and have adapted to live in extreme conditions. They are found in almost all areas of the Earth's biosphere and new microorganisms are still being discovered all the time. Some can be harmful, causing disease and illnesses, while others are useful to us and are a vital part of ecosystems. Let's take a closer look!

3.1 Types of microorganisms

Microorganisms are extremely small living organisms. People did not even know they existed until the invention of microscopes in the 1600s!

We say that we cannot see microorganisms with the 'naked eye' because they are too tiny to view without the aid of magnification. We have to view them under a microscope.

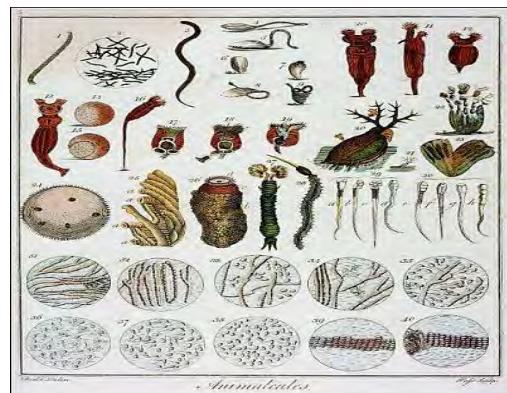


A basic light microscope.

Antonie van Leeuwenhoek designed and built his own microscopes. In 1674 he became the first person to see and describe microscopic organisms like **bacteria**, yeast and many other microorganisms.



Antonie van Leeuwenhoek is considered to be the first microbiologist.



Some of the microorganisms which van Leeuwenhoek observed and first described. He called them 'animalcules'.

TAKE NOTE

Someone who studies microorganisms is a *microbiologist*.

ACTIVITY: What does 'microscopic' mean?



TEACHER'S NOTE

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

MATERIALS:

- hand lens or magnifying glass
- newspaper print
- other small objects with detail

TEACHER'S NOTE

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

INSTRUCTIONS:

1. Your teachers will provide you with a range of different objects to view.
2. First observe the objects with your naked eye.
3. Then use the hand lens to view the objects again.
4. Take note of the differences in the detail you can observe.

QUESTIONS:

TEACHER'S NOTE

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

TAKE NOTE

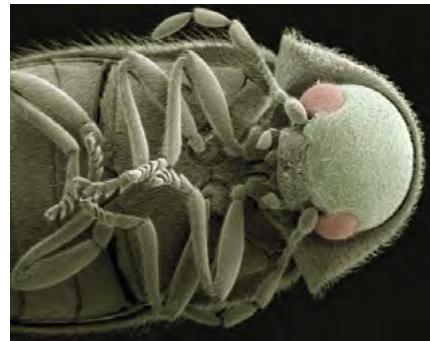
The prefix 'micro' comes from the Greek word *mikros* meaning small. How many words can you think of which contain the prefix *micro*? What do they all have in common?

1. What do we mean by the term 'naked eye'?
It means viewing something using only your eyes; with nothing in front of your eyes to help you view something.
2. Describe some of the differences when you viewed the objects using just your eyes and when you used a hand lens.
Learners should note that they were able to view more detail when viewing something using a hand lens and that things looked bigger.

3. The following images show different views of the same object. One image shows what we would see with our naked eye. We call this the **macroscopic** view. The other photo shows what we would see if we viewed the object under a microscope. This is called the **microscopic** view.

For each object, identify which is the microscopic view and which is the macroscopic view.

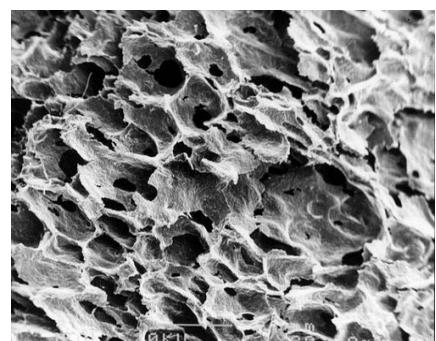
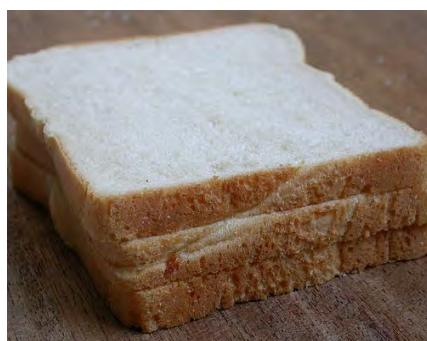
a) **Beetle**



Macroscopic

Microscopic

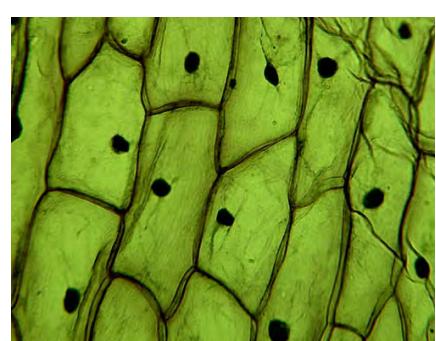
b) **White bread**



Macroscopic

Microscopic

c) **Onion skin**



Macroscopic

Microscopic

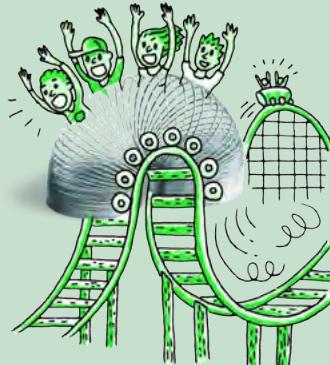
d) **Cotton**



In the last activity we saw that you can view objects under a microscope allowing you to see much more detail than if you just viewed them with your naked eyes. There are many organisms on Earth however, which we cannot see at all with our naked eye. We can only see them when we look under a microscope. These are **microorganisms**.

ACTIVITY: Classifying organisms

The living organisms on Earth can be grouped in many ways. You have learnt about classification before. Let's revise our classification system for all organisms on Earth.

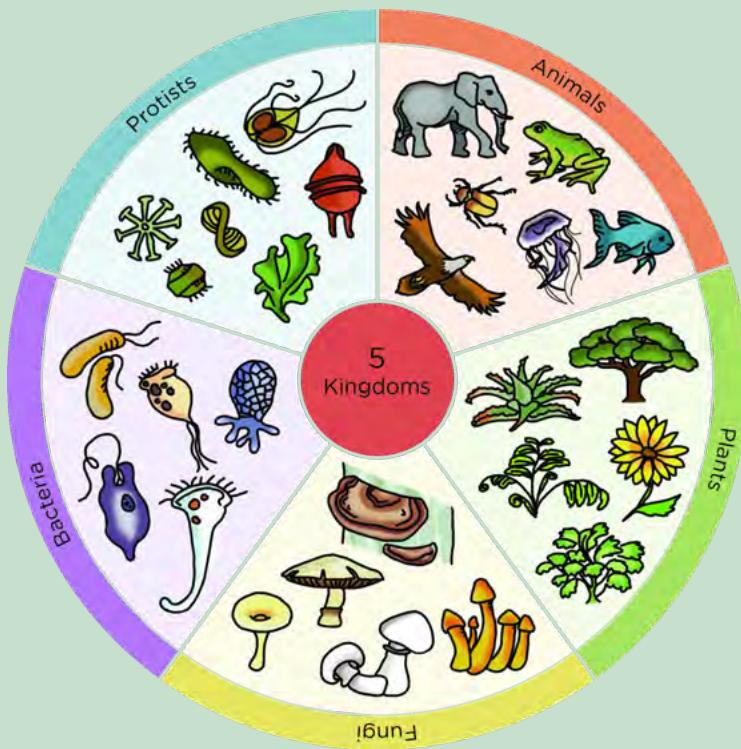


TEACHER'S NOTE

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

INSTRUCTIONS:

1. Study the following diagram showing how we classify organisms on Earth.
2. Answer the questions that follow.



QUESTIONS:

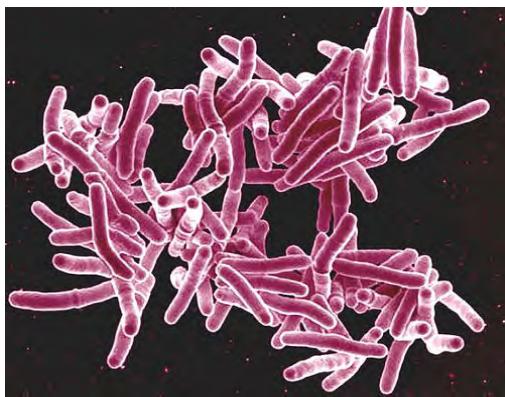
1. Do you see that the organisms in the diagram are divided into five groups? What do we call these five groups?
Kingdoms.
2. Which groups do you think contain organisms which can be classified as microorganisms?
Bacteria, Fungi and Protists.
3. Do you think microorganisms are living or non-living? Give a reason for your answer.
They are living. They perform all seven life processes (moving, respiring, sensing, growing, reproducing, excreting, feeding).

TEACHER'S NOTE

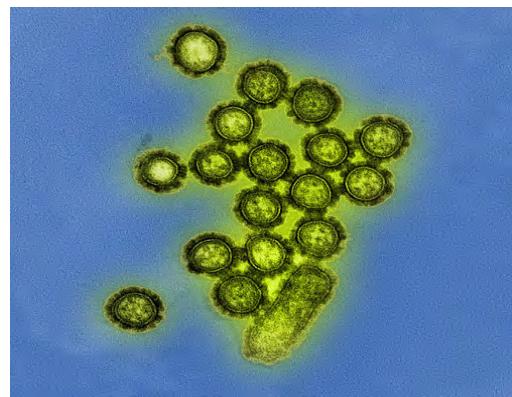
As discussed in this chapter, viruses are also microorganisms. There is much debate as to whether viruses are living or non-living. Viruses do not perform all seven life processes so they are not included in one of the five kingdoms.

Microorganisms include **viruses**, bacteria, **protists** and some types of **fungi** (although many fungi can be seen without the use of a microscope). Let's have a closer look at the different types of microorganisms, before looking at how they can impact our lives in a positive or negative way.

Bacteria are a large kingdom of microorganisms. Many bacteria are responsible for causing diseases in humans, however some are also useful as we will see later. Viruses are also tiny organisms, much smaller than bacteria even. They can **infect** all types of organisms, such as plants, animals and also bacteria. Viruses need to infect other organisms in order to replicate (reproduce).



Mycobacterium tuberculosis bacteria which cause Tuberculosis (TB) in people.



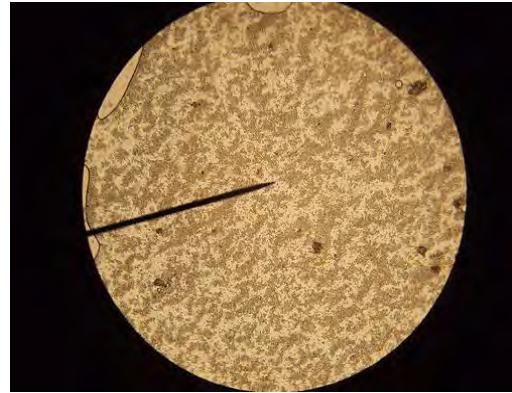
H1N1 influenza virus particles which cause flu symptoms in people.

TAKE NOTE

Bacterium is singular and bacteria is plural.



Not all fungi are microscopic, such as mushrooms.



Millions of yeast cells viewed under the microscope.

VISIT

Watch how yeast reproduce
bit.ly/lcfthiT

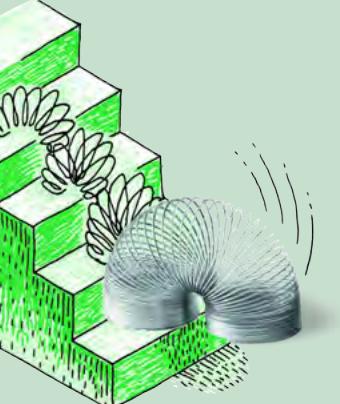
Protists are a very diverse group of microorganisms. The organisms in this kingdom do not fit easily into any of the other four kingdoms, namely animals, plants, fungi or bacteria. However, some protists are plant-like and others are animal-like. Most protists are microscopic and live in water. The only macroscopic members are the algae or seaweeds.



A protists living in freshwater.



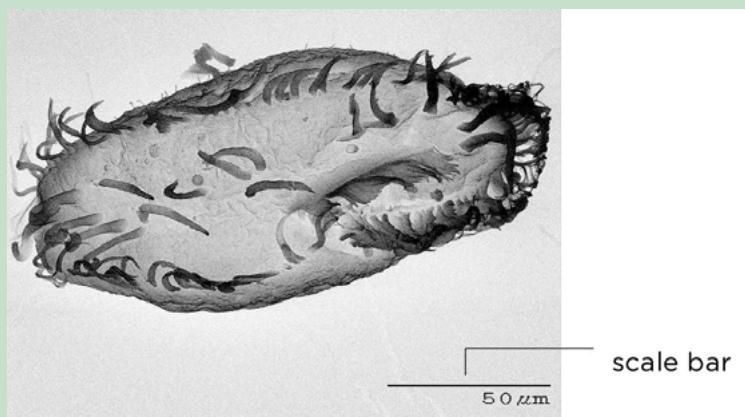
A protist found in the gut of many animals.



As you might have noticed from some of the microorganisms mentioned here, some of them can be harmful to humans and other organisms as they cause **diseases** and illnesses.

ACTIVITY: Calculating the size of an organism using a scale bar

How do you know the size of a microorganism? You will notice that many pictures of microorganisms have a **scale bar**. A scale bar is a very useful tool that allows us to calculate the actual size of objects. Follow the instructions below to figure out the length of this *Oxytricha trifallax* protist.



A micrograph of *Oxytricha trifallax*.

INSTRUCTIONS:

1. Measure the length of *Oxytricha trifallax* using your ruler. (Express your answer in mm.)

Learner-dependent answer.

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

2. Measure the length of the scale bar with your ruler. (Express your answer in mm.)

Learner-dependent answer

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

3. Divide the size of the object (in mm) by the size of the scale bar (in mm) and round off. Your answer will be a ratio and will not have units, since you divided mm by mm.

The answer should be approximately 3.

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

4. To find the actual size of the organisms, take your answer and multiply it by the number on the scale bar. The units on the scale bar are in μm and so your answer must be in μm . How big is *Oxytricha trifallax*?

The length of the organism is approximately 150 μm .

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

5. How many μm are there in a mm?

There are 1000 μm in 1 mm.

6. How many *Oxytricha trifallax* could lie end to end in 1 mm?

*Approximately 6.67 *Oxytricha trifallax* could lie end to end.*

Note: The answer is arrived at by dividing 1000 by the size of one *Oxytricha trifallax*. Teachers should accept answers between 6 and 8.

7. Using the same method you practised before, calculate the size of the following organisms:



a)

A Euglena

Approximately 110 μm

Note: Accept answers between 100 and 120 μm



b)

A fossilised diatom.

Approximately 57 μm (0.057 mm)

Note: Accept answers between 50-60 μm

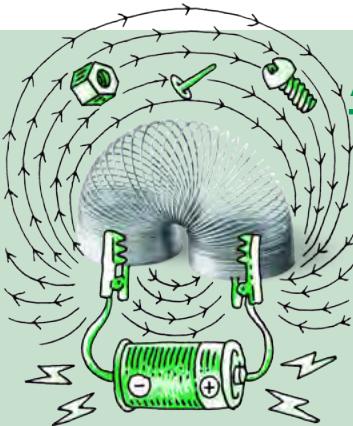
TAKE NOTE

Scientists know what size to make the scale bar because they know what magnification they are using on their microscopes. You will learn about magnification, field of view and how to create your own scale bar if you continue with Life Sciences in Gr. 10.

3.2 Harmful microorganisms

Some microorganisms cause diseases which may result in death.

Microorganisms that cause diseases are called **pathogens**. These pathogens infect other organisms and cause various signs and symptoms in the organism.



ACTIVITY: Where are pathogens found?

We can come into contact with various dangerous microorganisms each and every day. This activity will help you identify some common places where harmful pathogens are found.

INSTRUCTIONS:

1. Discuss the question asked in the title of this activity with your group or class.
2. Use the following photos in your discussion.



A handrail.



Public pay phones.



A basin and toilet.



An ATM keypad.



Rubbish.



Drains and pipes.

QUESTIONS:

1. What can you conclude about where disease-causing microorganisms are found?
Microorganisms that cause disease are found on many surfaces which come into contact with humans regularly, such as handrails, public keypads, etc. They are also found in places which are unclean. Learners should be able to see that disease-causing microorganisms are found almost everywhere.
2. How do you think diseases spread from one person to the next?
Learners need to come up with their own answers here based on the discussion about where pathogens are mostly found. They could conclude that they spread by humans coming into contact with surfaces and objects which have the pathogens on them.
3. Find out what it means to 'sterilise' an object, and write your own definition.
To sterilise something means to make something very clean so that any microorganisms on the surface of an object or in a fluid are removed or killed.

TAKE NOTE

These diseases are called **infectious** diseases as they can be passed from one organism to the next.

Transmission of infectious diseases

We can come into contact with various dangerous microorganisms each and every day, whether it is when you open the door handle of a toilet or use a trolley at the shopping centre. Pathogens can spread between humans and other organisms in many different ways, for example:

1. **In droplets from the air that we breathe:** When an infected person sneezes or coughs, the pathogen travels in the drops of spit or mucus to another person.
2. **In untreated and contaminated water:** The pathogen is **transmitted** in **contaminated** water, especially if it has been in contact with human sewage. These diseases are called waterborne diseases, such as cholera and typhoid, and cause diarrhoea.
3. **In contaminated food:** Sometimes people prepare food without washing and disinfecting their hands properly and the food can become contaminated.
4. **Through cuts or wounds:** Many pathogens enter our bodies via cuts or wounds. For example, tetanus bacteria live in the soil and when someone hurts themselves on a piece of rusty metal, this pathogen can infect the person.
5. **Through bites from animals:** Some pathogens can spread via bites from infected animals. For example, the rabies virus from infected animals and malaria is transmitted to humans through mosquitoes.



One of the best ways to prevent the spread of harmful pathogens is by washing your hands regularly with soap and warm water.

ACTIVITY: How easily do viruses spread?

TEACHER'S NOTE

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

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

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

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

We are going to have a look at how some viruses spread by acting it out.

MATERIALS:

- paper cups or beakers (one per learner)
- white vinegar (dilute)
- water
- dropper
- liquid indicator

TEACHER'S NOTE

If possible, use a universal indicator

INSTRUCTIONS:

1. Your teacher will divide your class into three groups: A, B and C.
2. Each group will be given specific instructions. You must obey the instruction that your teacher gives to your group for the activity.
3. After the activity, answer the questions.

TEACHER'S NOTE

Instructions for the activity:

1. Divide the class into three groups: A, B and C. Each group will be given different instructions to carry out.
2. Brief each of the groups in private as follows (the other groups must not be able to hear the instructions given):
 - a) **Group A:** Instruct them that no matter who offers to share their water with them, they must be very firm and polite but say "**No**". However, they should offer their water to people they want to give some to. They must NOT let anyone give them water.
 - b) **Group B:** Instruct them they can share their water with whoever they want and they can choose if they wish to receive water from other members of the class. They can say **yes or no**.
 - c) **Group C:** Instruct them that if anybody offers them water they should say "**Yes**". They must also try very hard to give a little of their water to as many people as they can. They must try to convince those that say no they should have some. (They are not allowed to give water if the person is definite about "no".)
 - d) **All groups should be encouraged to try to share a little water with as many people as they can but if someone is very firm about "no" they have to respect this.**
3. You (the teacher) must also take part in the activity. Your cup must have acidified water (vinegar) in it. Make sure you get as many pupils as possible to have some, or target pupils you know have strong persuasive skills.
4. Once everyone has their instructions and a cup of water, go outside or in an open space to perform the activity.
5. Allow everyone to sensibly walk round, mingling all groups, offering to share their water.
6. After about 10 minutes ask the groups to gather into their designated groups A, B or C again. Place the cups in groups (A, B, C) on a table keeping the groups separate.
7. Now carefully add a few drops of indicator to every person's cup.
8. Get your class to observe patterns in colour and discuss what each group's secret instructions were.
9. What you should find is all those in group A should turn green if you used universal indicator. (If someone was persuaded to share you may have the odd red cup, this is really useful because it shows even more clearly the power of NO). Group B will have a mix of red and green liquid in cups depending if they said yes to some or no to everybody. All of group C should be red, i.e. contaminated with acid.

QUESTIONS:

TEACHER'S NOTE

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

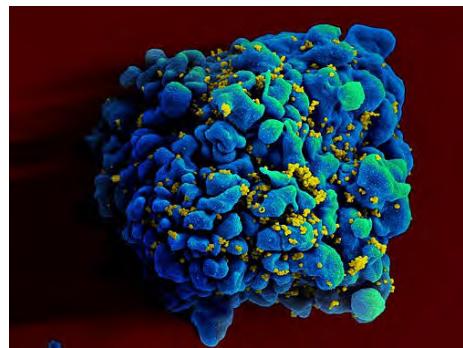
Point out that only one person had the disease to start with but now everyone who has red liquid in their cup has it. Encourage discussion about how even your best friend may have slept with someone else and thus could pass the disease on to you. Therefore the only safe way to prevent getting a STD is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

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

1. Which group had the most cups with red liquid? What does this mean?
Group C should have the most red cups. This means that they were contaminated. They did not say 'No'.
2. The activity that you just acted out can be used to describe the spread of one of the most devastating viruses in the world today, especially Southern Africa. Which virus is this?
The Human Immunodeficiency Virus (HIV).
Note: Learners must not say AIDS here. AIDS is not a virus- it is a syndrome that can result from infection with HIV.
3. How does this virus spread? What action did you do in the activity to represent this?
HIV spreads by sexual intercourse without protection or by coming into contact with an infected person's blood through an open wound. In the activity this was represented by mixing water with someone else.
Note: HIV can also be transmitted from mother to child during pregnancy.
4. How can you prevent the spread of this virus? Discuss this with your class.
The virus can be prevented from spreading by abstinence (saying "No") or by using male or female condoms.



The Human Immunodeficiency Virus (HIV) is one of the most devastating viruses in our world today. The HI virus causes Acquired Immunodeficiency Syndrome (AIDS) in humans. It is a condition where the **immune system** starts to fail and is ultimately life-threatening. HIV infects white blood cells in the human immune system.



White blood cell (stained blue) infected with tiny HIV viruses (stained yellow).

ACTIVITY: HIV Research

TEACHER'S NOTE

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

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



INSTRUCTIONS:

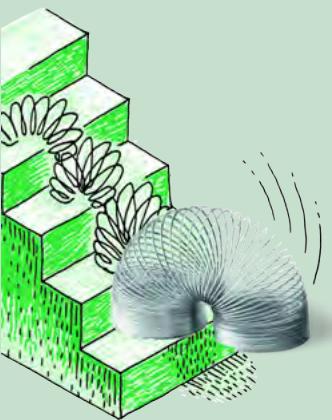
1. Below is a list of questions about HIV. You will be allocated a question to research.
2. Write your findings in the space provided and then you will report back to the class in a discussion.

QUESTIONS:

1. What organism causes HIV/AIDS?
2. What are the symptoms of the disease?
3. What are the dangers of having many sexual partners and unprotected sex?
4. How can the spread of the virus be prevented/minimised?
5. What is the current treatment for this condition?
6. How is mother-to-child infection prevented?
7. Why is pre- and post-natal treatment and monitoring important for pregnant mothers?

Write about what you found in the following space.

As we saw, the spread of HIV can be prevented by abstinence and having protected sex. HIV can also spread if one uses an infected needle, for example. This is why it is very important that doctors always use sterilised needles and equipment in their practise. Other diseases spread in different ways.

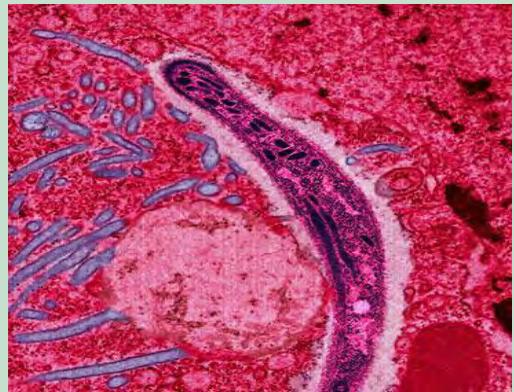


ACTIVITY: Preventing the spread of diseases

Malaria is a disease caused by a protist. The protist enters the human body via the bloodstream when an infected female Anopheles mosquito bites a person. The protist travels to the liver of the person and starts to reproduce. Malaria causes high fever and severe headaches, and can lead to a coma and death.



The Anopheles mosquito which spreads the protist that causes malaria in humans.



The protist (purple) that causes malaria is moving through the gut of the mosquito in this image.

QUESTIONS:

1. Find out how the spread of malaria can be prevented. Write about this in the space below and what you should do if you are travelling to an area where there is a high risk of malaria.

There are various ways to prevent malaria. Several different medicines are available which can be taken before going to a high-risk area, which prevents someone from contracting the disease. One way to prevent the spread is to also minimise the bites that you are likely to get by using mosquito repellents and sleeping underneath mosquito nets at night. Another method is to actually eradicate the infected mosquitoes, for example by spraying breeding grounds. You can also regularly empty out containers that could collect rain water and allow mosquitoes to breed.

2. Airborne diseases such as tuberculosis (TB) caused by a bacteria, and influenza (flu) caused by a virus, can spread very easily. How do these disease spread and how can we reduce the transmission of these diseases? *The symptoms of these diseases include coughing and sneezing. So, when an infected person coughs or speaks, they spray out drops which can carry the microorganisms and spread them to another person. The infected person could wipe their mouth or eyes and then wipe another surface, thus also spreading the disease. Ways to prevent the spread are to cover your mouth when coughing or sneezing, washing your hands, and there are also various vaccinations available to prevent one from getting these diseases.*

VISIT

Watch what happens inside you when a mosquito bites.

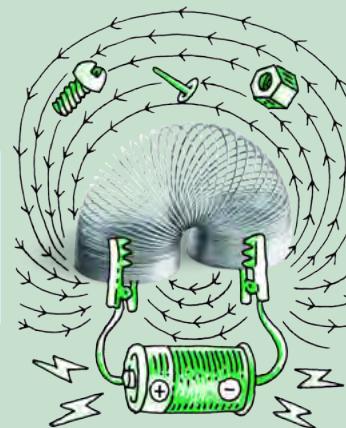
bit.ly/1IVNlzV

ACTIVITY: Typhoid Mary

TEACHER'S NOTE

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

Typhoid is a disease caused by a bacterial infection. Some people can have these bacteria inside their bodies without realising it, and without ever getting ill from it. They are called 'carriers'. This was the case with Mary Mallon or Typhoid Mary who was a carrier of the disease.



INSTRUCTIONS:

1. Research typhoid. Find out what causes the disease and what its symptoms are, and find out about treatment.

Learners should include: typhoid is generally spread through food and water that is contaminated with the faeces of an infected person, that contains Salmonella bacteria. It is a life-threatening illness that causes high fevers, weakness, stomach pains and headaches, and a loss of appetite; with a red rash in some patients. The only way to know for sure whether someone has typhoid is to test their blood or faeces for the bacteria Salmonella typhi. Typhoid is treated with antibiotics and there is a vaccine against it.

2. Share your research with the class.
3. Read Mary's story below and then answer the questions that follow.

Typhoid Mary

Mary Mallon emigrated from Ireland to America at the age of 15. When she arrived she became a servant, and soon discovered a talent for cooking. Since the cook in households earned a higher salary, she was happy to change from a simple servant to this role. She worked in 8 households from 1900-1907 as the cook, leaving a trail of 51 people seriously ill with typhoid, one of whom, a small girl, died of the disease.

When she was eventually identified as the cause of the many illnesses, authorities at first tried to persuade her to volunteer samples of her faeces, blood and urine to be tested. She refused, although she did admit that she seldom washed her hands when working with food. She didn't think it was necessary.

Eventually, after putting up a tremendous fight, she was taken with the help of 5 policemen, to the nearby hospital where the samples were removed. These proved that she was in fact infected with typhoid although she was not sick at all. The authorities sent her to a small island near the city where she was kept away from others for fear of infecting them too. Apart from a short 'parole period', she remained on this island, in full health, until her death.



Mary Mallon, also known as 'Typhoid Mary', was a carrier of typhoid without knowing it.

QUESTIONS:

1. Why do you think the newspaper article from more than 100 years ago shows Mary breaking skulls into a frying pan?
They were showing how each time she made a meal she was transmitting typhoid to the family and people who would eat the food, and could potentially die from the disease.
2. Explain how you think the disease was most probably spread from Mary to the people in the home where she worked? Tip: We know that handwashing was not a common practice at this time.
She might not have washed her hands after going to the toilet and might in this way have spread the disease to the food she was preparing. The people eating the food would then have contracted the illness.
3. Do you think Mary believed the accusations against her? What could have been her reasons for this?
Learner-dependent answer but could include: No, she did not show any symptoms so she probably thought that they were accusing her of something that was not true. Yes, she did because she saw so many people getting sick around her but she was afraid to admit it.
4. Imagine being Mary and refusing to give authorities samples of your faeces, urine and blood. Why would you not want to give these?
If she did not believe the accusations then she probably thought that they were on a witchhunt and wanted to make her look guilty, so she refused. If she thought that she was in fact making people sick she might have been really scared that the truth would come out and she would have caused all the people to be sick. Either way she knew that they would use the results to take action against her, banishing her to a quarantine colony.
5. Do you think authorities acted against Mary's basic human rights? Explain your answer.
Yes and no. Yes they could have taken more care in explaining the dangers and getting her to understand the problem of her 'carrier status' (she carried the disease without getting sick), and No, she was infecting many others and making them sick so they were right to protect these people. The authorities had to weigh up Mary's basic right to privacy against those of all the other people who could potentially be harmed by her.
6. If you were the doctor in charge of the investigation against Mary, how would you have acted in the same situation? Explain why you would have done this.
Learner-dependent answer.
Note: This question was included to allow learners to think how they would have managed the situation differently and requires them to think about the ethical issues of the case.
7. Discuss with your class possible alternative courses of action that we, as a society, can take when faced with such a dangerous microorganism that can potentially kill millions of people.
Learner-dependent answer.



As we have seen, many microorganisms can be harmful and cause dangerous diseases around the world.

ACTIVITY: Research an infectious disease

TEACHER'S NOTE

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



INSTRUCTIONS:

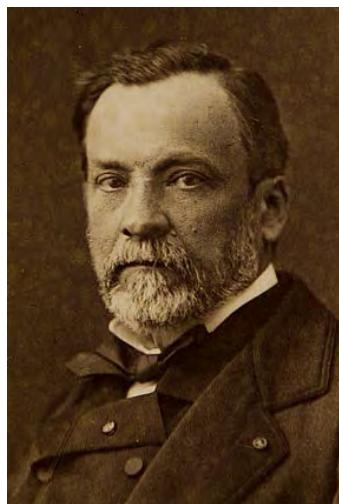
1. Your teacher will assign the following viruses, bacteria, protist or fungal diseases to different learners in the class.
2. Use sources from the library, the internet and interviews with healthcare professionals, to find out more about the diseases. Remember to list your sources in a bibliography.
3. Write a report, prepare a poster or oral depending on your teacher's instruction on the disease.
4. You must include information on:
 - a) The causes of the disease
 - b) Symptoms of the disease
At least 3-4 major symptoms.
 - c) Treatment of the disease
Tell learners that they do not need to know the exact names or dosages of medications.
 - d) How communities react to people with the disease

Diseases or illnesses caused by viruses	Diseases or illnesses caused by bacteria	Diseases from fungi and/or protist
chicken pox or shingles colds genital herpes infectious hepatitis influenza (flu) measles meningitis mumps pneumonia rabies rubella (German measles) smallpox yellow fever Marburg Virus Disease (MVD) Disease (MVD) poliomyelitis	anthrax bubonic plague cholera diphtheria some strains of dysentery gonorrhoea leprosy mastitis meningitis pneumonia syphilis tetanus tuberculosis typhoid fever whooping cough	malaria African sleeping sickness giardiasis amoebic dysentery diarrhoea candidiasis ringworm athlete's foot

TEACHER'S NOTE

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

Many scientists around the world are continually doing research to find and develop cures or vaccinations for infectious diseases, as well as ways to prevent the spread and transmission.



Louis Pasteur (1822 - 1895), a famous French microbiologist.

One of the most important scientists in medical microbiology was Louis Pasteur. He was a French chemist and microbiologist. He discovered a way to reduce death rate in many diseases and also created the first vaccines for rabies and anthrax.

Would you like to make a difference to the lives of people in the world? Perhaps you also want to contribute to the research going on to find cures for some of the devastating infectious diseases, such as HIV/AIDS? Or develop a vaccine against a certain strain of influenza? If so, find out what subjects you need to do in Gr. 10 and what and where you can study after school! Be curious and discover the possibilities!

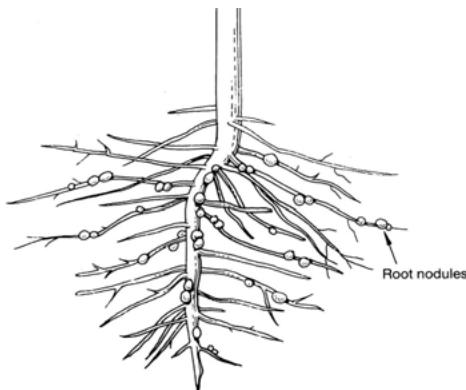
3.3 Useful microorganisms

In Chapter 2 we looked at the interactions and interdependence of organisms within an ecosystem. Do you remember discussing food chains and decomposers? What was the role of decomposers in the environment?

TEACHER'S NOTE

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

Many decomposers are microorganisms. These microorganisms play a very important role in ecosystems as they break down dead plant and animal matter. They help to return the nutrients to the soil so that they are recycled. Some bacteria remove **nitrogen** (N_2) from the air and convert it to nitrogen compounds that animals and plants can use. In plants such as **legumes**, the roots actually contain nodules with the bacteria inside of them.



Nitrogen-fixing bacteria form root nodules in some plants, such as legumes.

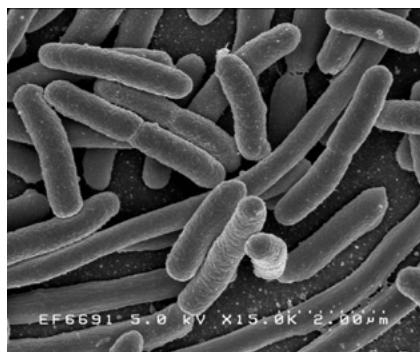


Can you see the white root nodules on these roots, which contain Rhizobia bacteria?

These nitrogen-fixing bacteria, called Rhizobia, cannot live independently and need a plant host. The bacteria get glucose from the plant and the plant benefits by getting the nitrogen compounds which the bacteria **fixed** from the soil. What is this kind of symbiotic relationship called?

TEACHER'S NOTE

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



Escherichia coli bacteria found in the gut of many warm-blooded animals.

We also have bacteria which live inside of us and help the functioning of our bodies! *Escherichia coli* is found in the lower intestine of many warm-blooded animals. They are part of the natural flora of the gut. They can actually help the animal by producing vitamin K₂ and also help prevent other harmful bacteria from growing in the gut.

VISIT

[Visit] An interesting article on a newly discovered species of microorganism that lives in symbiosis in the digestive tract of termites.
bit.ly/13m66dA

Humans have also found ways to use microorganisms to do things for us. This dates back throughout our history. Let's find out!

Microorganisms used by people

You might be surprised at how many of our day to day experiences are somehow due to microorganisms.

Have you ever seen the side of a yoghurt container which says it contains 'live cultures'? This refers to the bacteria inside the yoghurt. People use microorganisms for processing foods, such as when brewing beer, making wine, baking bread and pickling food. Microorganisms are also used in the **fermentation** process when producing dairy products, such as yoghurt and

cheese.

Yeast is one of the microorganisms humans have used for food-processing. The most common uses of yeast are in producing alcoholic beverages, such as beer and wine, and in baking, as yeast is used to make dough rise.

Yeast grows under specific conditions. As it grows it uses sugar for energy and converts it into carbon dioxide and alcohol. This process is called fermentation. We can measure the amount of carbon dioxide that is produced to see how well the process works.

What are the best conditions for this to take place? Is there an optimal amount of sugar and what about the best temperature? These are all questions which curious people have asked over time! Let's do an investigation to find out.

TAKE NOTE

We will look more at
fermentation next term in
Matter and Materials when
we do chemical reactions.



INVESTIGATION: Investigating the growth of yeast

You will conduct two separate investigations to determine the optimal conditions for yeast to grow.

- The first will measure what sugar concentrations are necessary for yeast to grow best. You will receive some guidance and help with this part.
- The second part will require that you set up your own investigation to determine at what temperature the yeast will grow best. You will be required to plan, conduct and collect data from the investigation on your own.

TEACHER'S NOTE

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

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

TEACHER'S NOTE

Before the investigation it might help learners to watch http://www.youtube.com/watch?v=PLG_bsJseCU or <http://bit.ly/1lOzWcR> to see what happens when yeast and sugar are mixed.

Part 1: Yeast growth in different sugar concentrations

AIM:

TEACHER'S NOTE

To determine the effect of different concentrations of sugar on the rate at which yeast grows.

INVESTIGATIVE QUESTION:

TEACHER'S NOTE

Which concentration of sugar is best for yeast growth?

HYPOTHESIS:

TEACHER'S NOTE

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

MATERIALS AND APPARATUS:

- 6 balloons
- 14 grams (2 packets) of dry yeast
- white sugar
- mass scale
- funnel
- 6 x 50 cm string
- 2 - 50 ml graduated cylinders
- 600 ml beaker
- overflow pan
- permanent markers
- ice packs

TAKE NOTE

There are different kinds of yeasts. The one we are using breaks down sugar in dough. Others break down wood and corn stalks and produce ethanol (alcohol) while another breaks down the sugar in fruits, nectar, molasses or sorghum.

METHOD:

1. Work in groups of four.
2. Use the permanent marker to label each balloon A, B, C, D, E and F.
3. Each balloon will need to be filled with 2 g of yeast and a different quantity of sugar. Balloon A will need to get 2 g of sugar, B will get 3 g of sugar, C will get 4 g of sugar and so on. (See the table below.) Use a plastic spoon or spatula to place the yeast and sugar into the balloon.
4. Use a funnel and pour 50 ml lukewarm tap water into each balloon.

5. One person should hold the balloon and funnel while the other pours in the water.
 6. As soon as the balloon has been filled, take a piece of string and tie off the balloon as close as possible to the level of the water without trapping any air.
 7. Knot the balloon's rubber neck to ensure that no air can get in or water can get out.
 8. Place each prepared balloon on ice to prevent the fermentation process from starting.
 9. Before you allow the fermentation process to start, you need to determine the starting mass and volume of each balloon.
10. **MASS:** Determine the mass of the tied balloon to the nearest 2 decimal places. Return it to the ice.
11. **VOLUME:** Use the water displacement method to determine the volume of the balloon.
- a) Place water in a large jug level with the top of the jug.
 - b) Completely submerge the balloon under the water in the jug: push the balloon and allow the water to flow over the sides into the overflow pan. You should stop when your fingers touch the water.
 - c) The water in the overflow plan is therefore the volume of water that the balloon displaced.
 - d) Carefully measure the water in the overflow pan. Record your measurements in the table below.
 - e) Return the balloon to the ice as soon as possible.
12. **PREPARE FOAM COOLER BOX:** You are going to place the balloons inside a foam cooler box with warm water in (the box should keep the water warm). Pour 40 °C water into the cooler box (as it normally cools down quite quickly).
13. **FERMENTATION INCUBATION:** You are now ready to start the process of incubating the yeast.
- a) Place each balloon into the warm water.
 - b) Record which balloons sink and which float.
 - c) Leave the balloons in the warm water for 20 - 30 minutes during which time the yeast will ferment the sugar.
 - d) Record the exact time that you used for incubation: _____ minutes.
14. **AFTER INCUBATION:** Use a paper towel to dry the balloons.
- a) Determine the volume of each balloon.
 - b) Determine the mass of each balloon.
- Tip: It is really important that you work fast and accurately at this point. Your team should really consider letting one pair determine the mass and the other the volume of each balloon.
15. Calculate what changes (if any) occurred during incubation to the mass and volume of each balloon.
 16. Hang your balloon on a clothesline or hanger in the class to dry.
 17. Clean up your work area and wash, dry and pack away all equipment that you used.

TEACHER'S NOTE

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

18. **THREE DAYS LATER:** remove your balloons from the clothes line / hanger. Record all observations that you can make - remember to use ALL your senses.
19. Use the same methods to determine the mass and volume of each balloon and record this on the table.
20. AFTER measuring the mass and volume of each balloon, carefully cut it open. Make careful notes to describe your observations of the contents of each balloon.
21. Use your table of measurements to draw a graph.

RESULTS AND OBSERVATIONS:

Complete the table with the correct information obtained from your work.

Balloon	Yeast (g)	Sugar (g)	Balloon mass before fermentation (g)	Balloon volume before fermentation (g)	Sink/Float	Balloon volume after fermentation (g)	Balloon mass after fermentation (g)
A	2	2					
B	2	3					
C	2	4					
D	2						
E	2						
F	2						

ANALYSIS:

Present the data you collected on a graph in the space below.

QUESTIONS:

1. Describe the changes that you observed happening in your balloons from the start to the end of the incubation period.

The answer would depend on the results from the investigation but learners should be able to say that the balloons filled up and became bigger (some more than others).

2. Were the changes the same in each balloon?

The answer would depend on the results from the investigation but they should be able to observe that the balloons with the small amount of sugar only increased a little bit but the ones with more sugar increased more in size.

3. Explain why you think these changes occurred differently in the contents of each of your balloons.
The answer would depend on the results from the investigation but learners should be able to say that the balloons with a greater concentration sugar were able to ferment more quickly or for a longer time than the ones with a smaller concentration of sugar.
4. How did you expect the balloons to react after 3 days?
Learner-dependent answer. Learners might indicate that they thought the balloons would just continue blowing up / increasing in size, or they may have hypothesised that once the sugar was used up the balloons would stay the same size (or even decrease).
5. Describe how each of the balloons actually looked after the 3 days.
The answer would depend on the results from the investigation but in most cases the balloons should have decreased in size.
6. Provide a possible explanation for your observations. Think for instance of what could possibly have been lost from the balloons.
The answer would depend on the results from the investigation but learners should be able to conclude that the sugar in the solution has all been used, so no new carbon dioxide was being made, and the carbon dioxide in the balloons slowly began to escape through the walls of the balloon.
7. At the start you added yeast, sugar granules and water. Describe how the contents of each of the balloons looked at the end of the investigation.
The answer would depend on the results from the investigation but learners should be able to describe the light brown fizzy contents that has a distinct sour smell and flavour.

CONCLUSION:

1. What did you learn from doing this investigation?

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

TEACHER'S NOTE

A simplified version of this investigation can also be done:

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

Part 2: Yeast growth at different temperatures

Conduct this investigation again, but this time you need to find out the best temperature for yeast growth. A suggestion is to use 10 ml of sugar for each of the balloons and 7 g of instant yeast (or 2 teaspoons of sugar and 1 teaspoon of yeast). Why do you need to add the same amount of yeast and sugar to all containers? You will need to change the temperature of the water however to

measure the optimum temperature for yeast to ferment.

Write an experimental report, using the headings of AIM, HYPOTHESIS, MATERIALS, METHOD, RESULTS AND OBSERVATIONS, DISCUSSION and CONCLUSION.

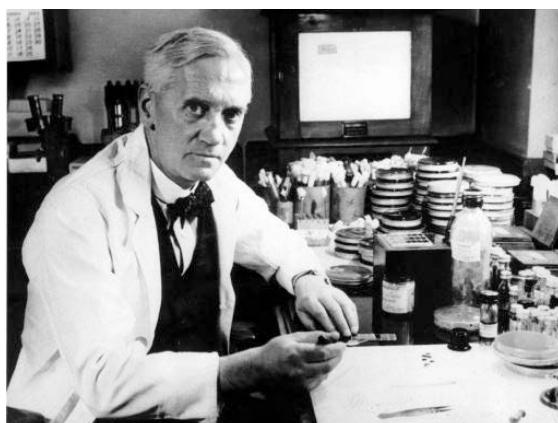
Remember to evaluate your results and discuss any difficulties you might have had or ways to improve your experimental design. In your discussion, you will also need to do some extra research about the applications of this process and include this information. Do not forget to reference your sources in a bibliography at the end.



Besides the use of microorganisms in food and food-making processes, there are also other processes for which we use microorganisms. Specific microorganisms are used in water treatment, like when treating sewage on a large scale.

In biotechnology research, microorganisms are being used to produce alternative, renewable energy, for example, biogas and biofuels.

Microorganisms are used in the development of various medicines, for example, **antibiotics**. Penicillin is a group of antibiotics which come from *Penicillium* fungi. The discovery of penicillin and its uses to treat certain bacterial infections happened by chance. This was due to the curiosity of a scientist, Alexander Fleming, and this led to the discovery of many more antibiotics.



Sir Alexander Fleming, who discovered penicillin in 1928.

VISIT

Learn more about biofuels from microorganisms.
bit.ly/16wTAKv

Microorganisms are also used in many fields of science and medical research. Scientists use yeast to learn more about many other types of organisms. The use of viruses is also currently being explored in many universities around the world to actually help with cures for various conditions, even cancer! The possibilities for discovery are endless!

VISIT

An article on how a virus could potentially help to cure melanomas, a type of cancer. bit.ly/13m6hWa



ACTIVITY: Careers as a natural scientist

TEACHER'S NOTE

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

INSTRUCTIONS:

1. Examine the list of careers below and select one career that interests you.

Agronomist	Farmer	Botanist	Zoologist	Food Scientist
Ecologist	Veterinarian	Microbiologist	Gameranger	Nature conservationist
Doctor	Nurse	Entomologist	Geneticist	Environmental Scientist

2. Do some research about the career you have selected.
3. Pretend it is 14 years in the future and you are about to attend your 10-year high school reunion!
4. Break into groups and have a discussion as 28-30 year-olds!
5. Use the questions below to guide your discussions.

QUESTIONS

VISIT

10 reasons to love science
(video). bit.ly/19dsvBP

1. What subjects did you take in Gr. 10?
2. *Learner-dependent answer*
Learner-dependent answer
3. Where do you live?
Learner-dependent answer
4. What does your "typical day" involve?
Learner-dependent answer
5. What is the best part of your job?
Learner-dependent answer
6. What is the worst part of your job?
Learner-dependent answer



SUMMARY:

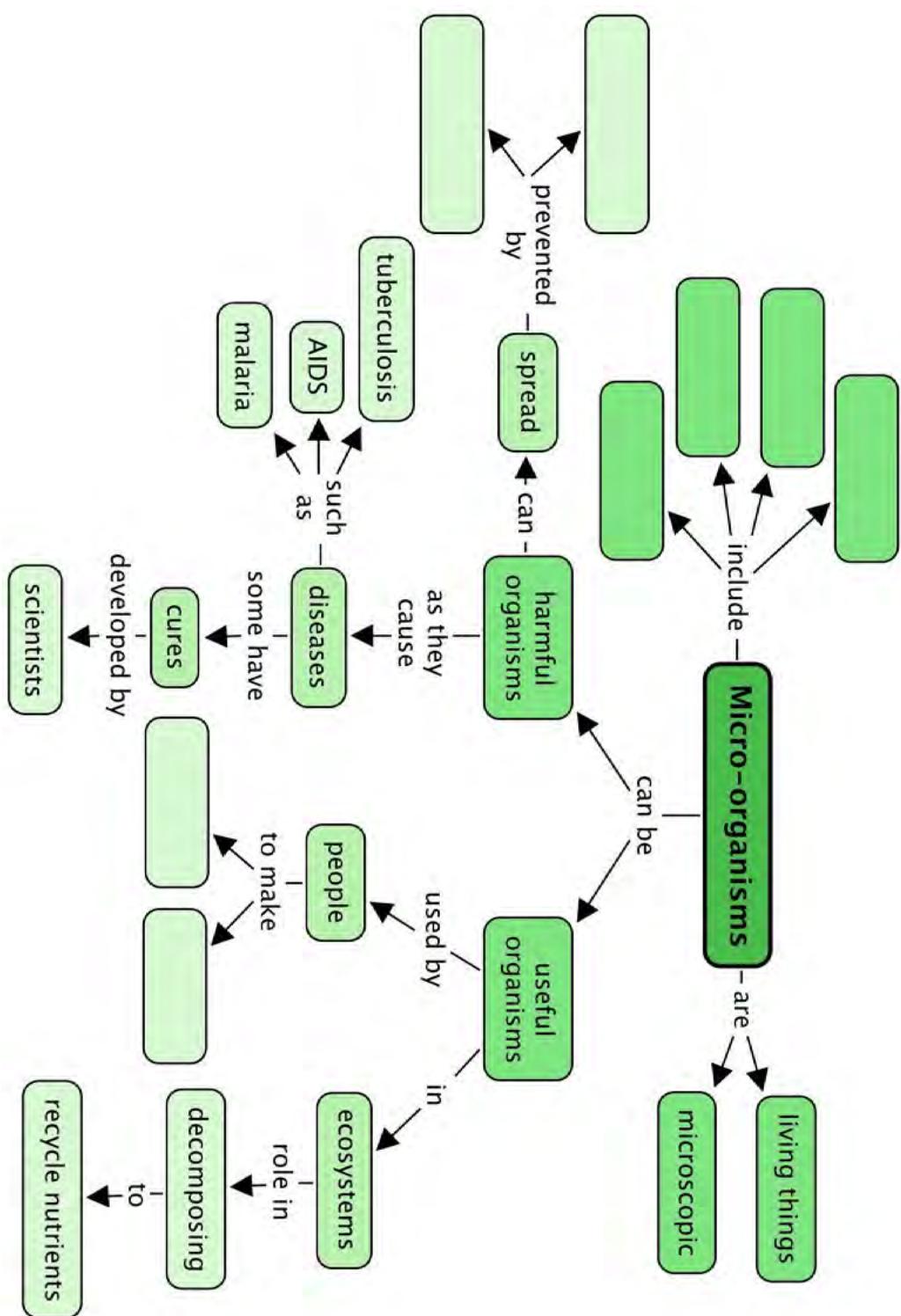
Key Concepts

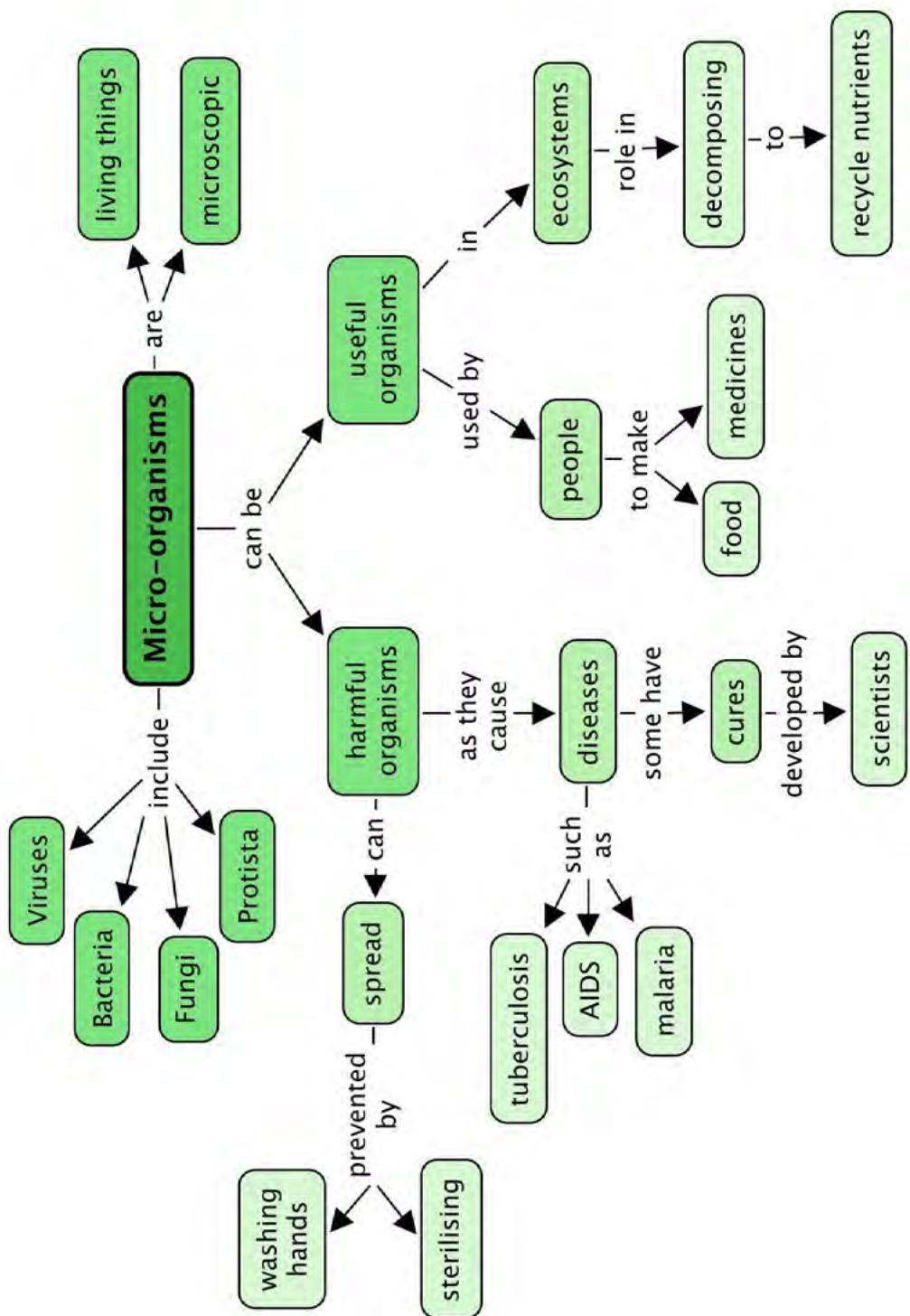
- Microorganisms are living things.
 - They are too small to see with the naked eye and can only be seen under a microscope.
 - There is a variety of microorganisms, including viruses, bacteria, protists and fungi.
 - Microorganisms can be harmful or useful.
-
- **Harmful microorganisms:**
 - Harmful microorganisms causes disease such as TB, HIV, malaria and food poisoning.
 - Disease-causing organisms are found almost everywhere - ATMs, handrails, toilets, etc.
 - Waterborne diseases such as cholera and dysentery cause diarrhoea resulting in many childhood deaths.
 - Effective methods of preventing the spread of diseases caused by microorganisms including washing hands and sterilising equipment and utensils.
 - Modern scientists such as Louis Pasteur play an important role in identifying and developing cures for some diseases.
-
- **Useful microorganisms:**
 - Some microorganisms play an essential role in ecosystems, such as decomposing dead plant and animal matter, thereby recycling nutrients in the soil.
 - Some microorganisms are used by people for making certain foods (like yoghurt and bread) and medicines (like penicillin)

Concept Map

This concept map shows all that we have learnt about Microorganisms in this chapter. What types of microorganisms are there? Fill these into the 4 spaces below. How can we prevent the spread of harmful microorganisms? Fill in 2 of these actions in the spaces provided. In this chapter we learnt about useful microorganisms - what are two products we make using microorganisms? Fill these in.









REVISION:

1. Explain in your own words why a microorganism is said to be 'microscopic'. [2 marks]
Microorganisms cannot be seen with the naked eye and they have to be viewed through a microscope.
2. Which groups of organisms are always microscopic? [3 marks]
Bacteria, viruses and protists.
3. Which kingdom contains organisms which can be microscopic or macroscopic? [1 mark]
Fungi.
4. Name 3 foods that are made using microorganisms. [3 marks]
Some examples are bread, yoghurt, cheese, wine and beer.
5. Draw a cartoon to show how someone in a shopping centre could possibly be contaminated by a virus or bacteria. [5 marks]
Learner-dependent answer.
Note: Learners should be able to show that the person might breathe in the virus/bacteria after someone has coughed without a hand or tissue in front of their mouths; touch another or touch an object where the bacteria is on; drink water that has not been sterilised; eat food that contains the virus / bacteria or have a mosquito or other insect bite the person.
6. More people seem to catch colds and the flu in winter than in summer. Explain a possible reason(s) for this. Hint: think of the different ways in which people behave in winter.) [2 marks]
People are indoors with windows and doors closed, and are more likely to huddle together, thus if someone sneezes it travels within the small confines of the room and fresh breezes do not come in from the windows and doors and blow the tiny droplets containing viruses away.
7. Describe how someone would typically contract a waterborne virus. [2 marks]
Either they would drink the water from a contaminated source without sterilising the water first, or they would eat fruit or vegetables that has been sprayed with this water and they might not wash it first before eating it and thus they get contaminated.
8. Why do you think certain diseases such as malaria, typhoid and cholera, are more serious and cause more deaths in third-world countries in Africa, especially in children, compared to first-world countries? [4 marks]
People in poverty cannot often get the medical help because they cannot afford to visit the doctor, live far away from clinics, have no transport or cannot travel fast enough to the hospitals to get their children treated in developing countries. The malaria in developing countries might be worsened by malnutrition and poor hygiene which might make the child too weak to survive. People living in developing countries might not be able to afford the preventative sprays that prevent the mosquitoes from biting them, and the soaps to wash away or kill bacteria. In poor communities, there is a huge lack in proper sanitation and sewage systems. This makes it much easier for disease-causing pathogens to travel in contaminated water and cause diarrhoea. Stagnant water areas are more common in third world countries which are ideal breeding grounds for mosquitoes.

9. List 3 important ways that we can prevent the spread of diseases. [3 marks]

You can wash your hands, sterilise or boil all utensils, don't leave food like meat and chicken out / in areas where bacteria can grow, take preventative measures such as using a condom during sex, having vaccinations.

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

10. Describe the optimal conditions necessary for yeast to grow. [2 marks]

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

Total [26 marks]



GLOSSARY

abiotic:	non-living; devoid of life
adapt:	to change, become adjusted to new conditions
antibiotic:	a compound, often produced by microorganisms, which kills or slows down the growth of bacteria
bacteria:	microscopic organisms, lacking a nucleus; they can inhabit many different environments (air, water, soil, the bodies of other organisms etc.)
biosphere:	the regions of the surface and atmosphere of the Earth where different organisms live
biotic:	relating to living organisms
camouflage:	an adaptation in which an animal can hide by blending in with its surroundings
carnivore:	an animal that feeds on other animals
chemical potential energy:	stored energy in the form of chemical compounds
chlorophyll:	a green pigment found in green plants (and certain bacteria) that absorbs radiant energy from the Sun to provide energy for photosynthesis
chloroplast:	a part inside the plant cell of green plants that contains chlorophyll, where photosynthesis occurs
community:	all the animals, plants or microorganisms that live together and interact in a certain area at a specific time
consumer:	an organism that cannot produce its own food and therefore has to eat other organisms; also called a heterotroph; e.g. all animals, fungi
contaminate:	unwanted or waste material enters a place where it does not belong e.g. sewage entering a river, bacteria entering a wound
decomposers:	organisms that decompose (break down) organic material, including the remains of dead plant and animal material; usually bacteria or fungi
disease:	an abnormal condition (or sickness) of an organism that interrupts the normal functioning; often includes pain, weakness and other symptoms
ecologist:	a scientist who studies the interactions of organisms with each other and with their environment
ecology:	the branch of biology that deals with the interactions of organisms with one another and with the physical and chemical environment
ecosystem:	a biological community of interacting organisms and their physical environment
endangered:	organisms that are seriously at risk of extinction
energy pyramid:	a triangular picture of a food chain with producers at the bottom and consumers higher up

extinct:	an organism that no longer exists; the death of an entire species
fermentation:	the chemical breakdown of a substance (by microorganisms such as bacteria or yeast) in the absence of oxygen, producing simpler compounds and energy
fever:	dangerously high body temperature
fixed (fix, fixation):	the process in nitrogen or carbon in their elemental forms are assimilated into biological molecules, eg nitrogen fixation by bacteria, carbon fixation during photosynthesis
food chain:	a series of organisms linked together to show which one eats what; arrows show the flow of energy through it
food web:	many food chains interlinked in an area form a food web, so organisms have many different food sources
fungi:	a kingdom of organisms which includes moulds, yeasts and mushrooms, that do not contain chlorophyll, produce spores to reproduce and feed on other matter
glucose:	a type of sugar, produced by plants during photosynthesis
habitat:	a particular type of environment in which an organism lives
herbivore:	an animal that eats only plants
hibernating:	an instinctive behaviour in which some animals spend time where conditions are not ideal (e.g. winter; periods of food scarcity) in an inactive (dormant) state
immune system:	the system that defends the body against infections, disease and foreign substances
infect:	a microorganism enters the body and multiplies, causing illness and damage to the organs
insectivore:	animals that feed on insects and other smaller invertebrates such as worms
insoluble:	substances that do not dissolve in a liquid
interact:	to have an effect on somebody/something else or on one another by being or working closely together
instinct:	a pattern of behaviour that requires no thinking and is biologically driven
legumes:	group of plants, including beans, lentils, peas and peanuts, that have edible seeds inside fruit that forms a pod
limewater:	a solution of calcium hydroxide in water which turns cloudy white in the presence of carbon dioxide
limit:	a restriction on the size or amount of something available or possible
migrate:	to move from one region or habitat to another according to the seasons

migration:	a seasonal movement of animals move from one place to another and back again
mimicry:	an adaptation in which one animal imitates (copies) another in appearance or behaviour
nitrogen:	an important element that forms part of proteins in all living organisms
nocturnal:	active at night
omnivore:	an animal that eats both plant and animal material
pathogen:	a microorganism that causes a disease
pigment:	is a molecule that absorb certain wavelengths of light and reflect others to produce colours
photosynthesis:	the process by which green plants and some bacteria use radiant energy from the Sun to turn carbon dioxide and water into glucose and oxygen
population:	a group of organisms from the same species that interbreed and live in the same place at the same time
population ecology:	the study of what contributes to the rise and fall of numbers of a species
predator:	an animal that naturally preys on other animals for food
primary consumer:	an organism that eats plant material
producer:	an organisms that is able to make its own food; for example, all green plants
protist:	member of a diverse group of microorganisms that are not viruses, bacteria or fungi; can be animal-like e.g. protozoa, plant-like e.g. algae or fungi-like e.g. slime moulds, water moulds
radiant energy:	energy contained in light rays or other forms of radiation
respiration:	the process by which energy is released from the glucose in food in a series of chemical reactions
secondary consumer:	an organisms that eats herbivores and primary consumers
soluble:	substances that are able to dissolve in a liquid
species:	a group of organisms classified by common attributes that can breed and produce fertile offspring
starch:	a substance which consists of many glucose molecules joined together; plants store glucose produced by photosynthesis in this complex form
terrestrial environment:	an environment on dry land
tertiary consumer:	an organism that eats secondary consumers; a carnivore at the highest level in a food chain that feeds on other carnivores
transmitted:	to cause something to be passed from one individual to another; eg. disease-causing microorganisms passed from one person to another
trophic level:	a feeding level in a food web, chain or pyramid; all organisms at the same trophic level get their energy in the same way

virus:

a small infectious agent that typically causes disease

Draw and discover the possibilities of what a slinky can be.







MATTER AND MATERIALS

TEACHER'S NOTE

Chapter overview

2 weeks

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

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

Play dough recipe

INGREDIENTS:

- 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 of the pan, remove the pan from the heat and allow the dough to cool enough to handle. Note: If the dough is still sticky, it simply needs to be cooked longer.
3. Turn the dough out onto a clean surface and knead vigorously until smooth. Divide the dough into balls for colouring.
4. Make a small depression in the centre of the ball, and pour a little food colouring into it. Work the colour through the dough, adding more if you wish to increase the intensity of the colour.

1.1 The building blocks of matter (1 hour)

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

1.2 Sub-atomic particles (1.5 hours)

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

1.3 Pure substances (3 hours)

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

1.4 Mixtures of elements and compounds (0.5 hours)

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



KEY QUESTIONS:

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

In this chapter, we will answer questions about the basic building block of matter, the **atom**.

1.1 The building blocks of matter

What is matter? The traditional definition says matter is anything that has mass and occupies volume (takes up space).

We could say that matter is 'stuff', but that would not be very specific. To understand matter in a scientific way, we need to imagine what it is made of.

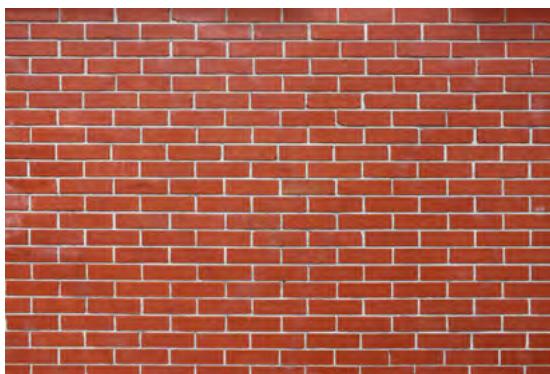
All the different types of matter that exist on Earth are made up of one or more chemical **elements**. You were introduced to some of the elements in Gr. 7 Matter and Materials. Before reading further, stop and see how much you can remember about the elements. Write down what you remember or say it out loud.

There are more than 100 known elements and scientists are still looking for more. We also learnt that each element has a unique name, chemical symbol and atomic number that represents it, along with a fixed place on the Periodic Table of elements.

The title of this section is 'The building blocks of matter'. For this reason, we will start our discovery by imagining a wall that has been built of bricks, like the one in the following picture. Can you see how the wall is made of many identical bricks?

TEACHER'S NOTE

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



A brick wall.

Similarly, we can think of most forms of matter as being made up of many, many small particles. These small particles are called **atoms**.

TAKE NOTE

Atomos is a Greek phrase which means 'not cut' or 'that which is indivisible'.

What are atoms?

The early Greek philosophers proposed that all matter is made up of incredibly small but discrete units (like the bricks in our wall example). Democritus (460 - 370 BC) was the first to call these units *atomos*. From this phrase came the term *atom* that we use today.



Democritus first used the term 'atomos' more than 2000 years ago to describe the smallest particle that matter is made of.

It took a very long time (more than 2000 years!) for the ideas of Democritus to be accepted by scientists. Why do you think it took so long? Discuss this in your class.

TEACHER'S NOTE

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

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

VISIT

Find out more about these microscopes which enable people to 'see' atoms

bit.ly/14AbIai

Can you imagine how difficult it must have been to convince those early scientists that matter consists of really, really small particles that no-one has ever seen?

How small are atoms really? Well, about 5 000 000 000 000 000 000 of them

VISIT

The world's smallest movie made with atoms
bit.ly/178tzB3 and how the scientists made it
bit.ly/13m5p3T

TAKE NOTE

You can find a larger version of the Periodic Table on the inside cover of your book for easy reference.

would fit inside the full stop at the end of this sentence. Of course different atoms have different sizes, so this is just an approximate number. Wait... atoms have different sizes? How does that work? In the next section, we will find out.

What are elements?

Democritus' ideas about matter were ignored and forgotten for more than 2000 years, until an Englishman by the name of John Dalton reintroduced them to the scientific world in 1803. Dalton made five claims about atoms that are still largely accepted as the truth today. Three of these claims, or **postulates** as they are more commonly called, tell us how to understand elements. We will get to the remaining two postulates later. Here is what Dalton taught us about elements:

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

This ties in with what we learnt about the elements in Gr. 7 Matter and Materials. Let us revise what we already know:

- The Periodic Table of elements was originally made to represent the patterns observed in the chemical properties of the elements.
- Each element has a fixed position on the Periodic Table.
- The elements are arranged in order of increasing atomic number.

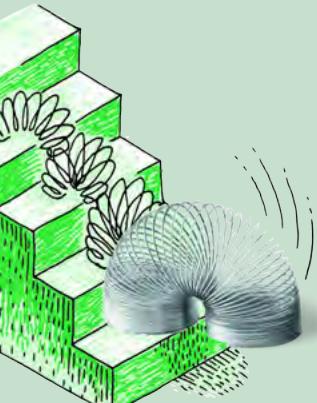
Periodic Table of the Elements																	18
1																	2
1 H	2																He
3 Li	4 Be																
5 Na	6 Mg	3	4	5	6	7	8	9	10	11	12						
7 K	8 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
11 Rb	12 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
15 Cs	16 Ba	57-71 La-Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89-103 Ac-Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Uup	115 Uuh	116 Uus	117 Uuo	
57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu			
89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr			

The elements are arranged in order of increasing atomic number.

ACTIVITY: A quick revision of the Periodic Table of Elements

TEACHER'S NOTE

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



QUESTIONS:

1. In your own words, explain what you think the Periodic Table is.
This is an open-ended question for learners to show what they understand at this point about the Periodic Table. They may write explanations such as:
 - The Periodic Table lists all the elements that we know about on earth.
 - The Periodic Table classifies all the elements on earth.
 - The Periodic Table gives us information about the elements, such as their names, symbols and atomic numbers.
 - We can see patterns in the Periodic Table in terms of chemical and physical properties.
2. Where do we find metals and where do we find non-metals on the Periodic Table?
Metals are found on the left and non-metals are found on the right.
3. What is the third class of elements called that we have learned about and where are they found.
These are the semi-metals and they are found in between the metals and non-metals in a jagged line.
4. Give the symbols of two examples of metals and two examples of non-metals.
Any of the metals on the left hand side of the table, such as Li, Na, K, Ca, Mg, etc. and any of the non-metals on the right hand side, such as C, N, O, Cl, I, He, S, etc.
5. Complete the following sentence: The elements are arranged in order of increasing _____.
atomic number.
6. What is the atomic number of hydrogen and what is the atomic number of carbon?
Hydrogen is 1 and Carbon is 6.
7. Complete the following table by supplying either the name or symbol for the elements listed, and whether it is a metal, non-metal, or semi-metal.

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

Are atoms really the smallest particles? Dalton thought so! He also postulated that:

4. Atoms can neither be created nor destroyed during chemical reactions .

Dalton was correct in saying that atoms cannot be created or destroyed in chemical reactions. Does that mean atoms are the smallest particles of matter? Not exactly. Scientists have since discovered that atoms themselves are made up of even smaller particles. We call these sub-atomic particles.

We will learn about the sub-atomic particles that make up atoms shortly, but

first we need to talk briefly about **scientific models**. Do you know what a model car is?

TEACHER'S NOTE

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



This is a photograph of a real car. It is about 2.5 m long.



This is a photograph of a model car. It is about 25 cm long.

Scientists use models to help them understand the real world and how it works.

Scientific models

Have you ever seen a geographical globe? The globe in the next picture is a model of the Earth. What do you think it can be used for? Do you think we could learn more from a globe than from a map of the Earth?

TEACHER'S NOTE

Get the learners to discuss this in class. Guide them towards the following ideas:

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

VISIT

Build an atom.
bit.ly/132PyMG



A globe of the world.



A map of the world.

Globes are the best representations we have of our planet; because they are three-dimensional. Can you think of some of the things we can learn about the Earth from a globe?

TEACHER'S NOTE

Here are some things to help learners think about:

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

Sometimes a model can be an idea or a set of ideas; a simplified representation of difficult concepts or phenomena. A scientific model is a set of ideas that tells a story about something in the world around us, in the same way that the globe tells us a story about Earth.

VISIT

Video about what an atom is: bit.ly/132PzAj

A model of the atom

Atoms cannot be seen with the naked eye, only with very powerful microscopes. However, scientists have a good idea of how they behave in different situations. Based on these ideas, they have developed a model of what the atom looks like, to help us understand atoms better.

The modern model of the atom teaches us that all atoms are made up of sub-atomic particles. Sub-atomic means 'smaller than the atom'. In the next section, we are going to learn more about these interesting little particles.

TEACHER'S NOTE

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

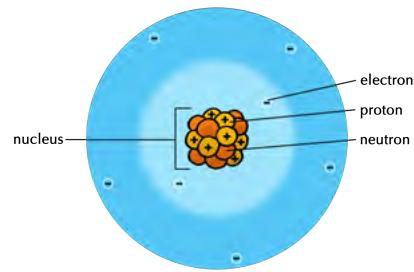
reinforce all the new information.

1.2 Sub-atomic particles

After many decades of studying atoms, scientists discovered that all atoms are made up of three different kinds of **sub-atomic particles**. They are called:

- electrons
- protons
- neutrons

The following picture of the atom shows how they all fit together. These three sub-atomic particles form the basis of our modern-day understanding of what atoms look like on the inside. Let's look at what is known about each particle in turn.



Neutrons, protons and electrons are sub-atomic particles that make up an atom.

TEACHER'S NOTE

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

¹ bit.ly/163XeMI and ² bit.ly/142RCzg .

Protons

The protons are deep inside the atom, in a zone called the **nucleus**. The protons are said to be positively charged. What does this mean?

To answer this question, think about the following phenomena that have been discovered by scientists:

- When two protons get near each other, they push each other away.
- When an electron gets near a proton, they attract each other.
- Two electrons will also push each other away.

What causes this? There must be some property of electrons and protons that make them apply these forces. Scientists use the word 'charge' to represent the property these particles have. We observe that:

- like charges repel (meaning the same charges push each other away)
- opposite charges attract

TEACHER'S NOTE

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

Neutrons

Neutrons are particles that are neither positively nor negatively charged. They are neutral. The neutrons together with protons form the tightly packed nucleus at the centre of the atom.

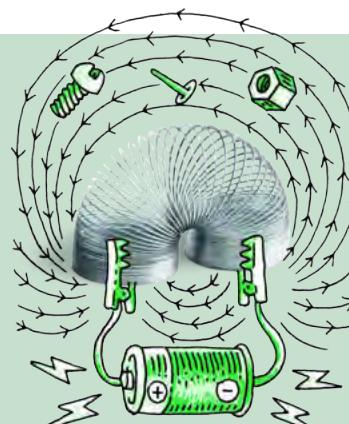
Electrons

Electrons are the smallest of the three sub-atomic particles. Electrons are about 2000 times smaller than protons and neutrons. The electrons move in a zone around the **atomic nucleus** at extremely high speeds, forming an electron cloud that is much larger than the nucleus. Have another look at the drawing which shows a model of the atom to see this. These three sub-atomic particles help us understand what atoms look like on the inside.

ACTIVITY: Make your own model of an atom

TEACHER'S NOTE

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



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

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

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

1. So, if we wanted to make a model of a Nitrogen atom, how many protons would we need?
7 protons
2. If we wanted to make a model of a sulfur atom, how many protons would we need?
16 protons

In most atoms of an element, the number of neutrons in the nucleus is the same as the number of protons. The number of electrons can change, but for now we are going to make models of neutral atoms. So, there must be the same number of electrons as protons.

TEACHER'S NOTE

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

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



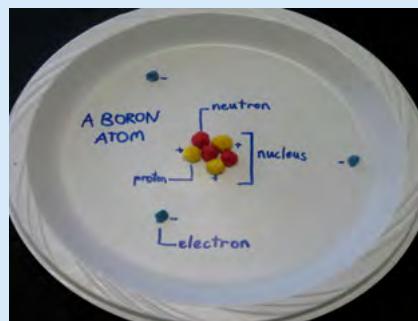
Start with a blank paper plate.



Add the protons and neutrons in the centre.



Add the electrons in the surrounding space.



Add in the labels.

MATERIALS :

- glue
- paper plate
- playdough, beads, dried lentils or peas, etc

INSTRUCTIONS:

1. After reading the information about atoms, your teacher will give you an

element of which you have to build a model. What is the name of your element?

Learner-dependent answer.

- What is the atomic number of your element?

Learner-dependent answer.

- How many protons will you need to make for your atom?

Learner-dependent answer. This must be the same as the atomic number.

- Now decide what objects you will use to create the subatomic particles in your model.

- Stick these onto the paper plate and provide labels.

Learners must label the element they are doing, as well as the electrons, protons, neutrons and the nucleus.

- After you have built your model, draw a model of your atom below.

Provide labels. These are both models of your atom!

TEACHER'S NOTE

Here is some general information on how to use simulations in the classroom:

³ bit.ly/14nA5RI . And this pdf contains more specific information for the

teacher about the 'Build an atom' simulation ⁴ bit.ly/142dSct

Can you remember learning about mixtures in Gr. 7? You may remember that a mixture consists of two or more substances mixed together. The next section is NOT about mixtures. It is about substances that are not mixed with anything and consists of only one type of matter throughout. Such substances are called **pure substances**. In this sense, 'pure' simply means: not mixed with any other substances.

VISIT

Build an atom with this simulation: bit.ly/14GFhHd

TEACHER'S NOTE

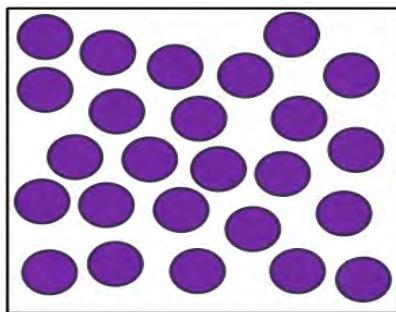
The 'Just how small is an atom?' video is a nice animation that attempts to put the size of an atom and its sub-atomic particles into perspective by comparing it to real life objects like fruit, houses and cars. It is fast-paced and uses many metaphors, so could potentially be confusing and too abstract.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

1.3 Pure substances

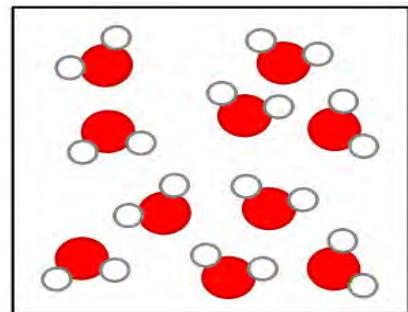
TEACHER'S NOTE

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

There are only two classes of pure substances, namely **elements** and **compounds**. To understand the difference between the two, look at the two diagrams below.



An element consists of atoms that are all the same kind.



A compound consists of two or more kinds of atoms in a fixed ratio.

VISIT

Just how small is an atom?
(video) bit.ly/18d6vT4

The diagram on the left represents an element. Can you see that all the atoms are of the same kind? An element is a material that is made up of atoms of only one kind.

Now look at the diagram on the right representing a compound. This diagram shows two important things about compounds:

- The compound consists of atoms, but there are more than one kind.
- The different atoms are combined in little clusters and the clusters are all exactly the same.

A compound is a material that is made up of two or more kinds of atoms that are chemically bonded together.

We are now going to explore each of these classes on their own and discuss some examples of each.

Elements

We have just learnt that an element is made up of atoms of the same kind. This means that if we had a piece of the metal copper, it would be made up entirely of copper atoms. Likewise, a piece of silver would be made up entirely of silver atoms. Copper and silver look different and have different properties, because they are made up of different atoms. Have a look at the following table which illustrates the sub-microscopic image of the atoms and also a piece of jewellery made from each of the different metals.

Copper	Silver
Sub-microscopic structure of copper	Sub-microscopic structure of silver
The element copper (Cu) consists of only copper atoms.	The element silver (Ag) consists of only silver atoms.
A necklace made of copper wire.	Earrings made of silver.

TAKE NOTE

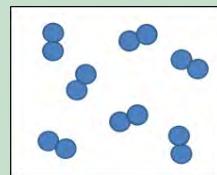
Here in these diagrams, the different coloured circles represent different **atoms**.



ACTIVITY: Studying representations of atoms and elements

QUESTIONS:

1. Why are the silver atoms bigger than the copper atoms in the previous diagrams? Hint: Find the two elements on the Periodic Table and compare their positions.
Silver lies below copper on the Periodic Table, which means the atoms of silver are bigger than those of copper.
2. Do you think the substance represented in the following diagram is an element? To help you answer the question, go through the questions below the diagram.



- a) First write down what you see in the picture.
Learners may say they see pairs of atoms stuck together.
- b) Are the clusters tightly packed or far apart?
They are relatively far apart.
- c) What does that mean? Do you think the substance is a solid, a liquid or a gas?
The substance is a gas.
- d) Do you think it is a mixture of substances or a pure substance? Why do you think so?
It is a pure substance because all the molecules look the same.
- e) Are the atoms all of the same kind?
Yes, they are.
- f) What class of substances is made up of only one kind of atom?
The elements.
- g) Is the substance an element? Why?
The substance is an element because it is made of only kind of atom.
Note: This actually represents the diatomic elements, such as oxygen (O_2), nitrogen (N_2), hydrogen (H_2), which exist as diatomic (two atoms) molecules at room temperature.
- h) Can elements be made up of molecules?
Yes, they can.

TEACHER'S NOTE

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

The clusters of atoms in the previous example are called molecules. **Molecule** is

a very important word in chemistry. A molecule is two or more atoms that have chemically bonded with each other.

The atoms in a molecule can be of the same kind (in which case it would be a molecule of an element), or they can be of different kinds (in which case it would be a molecule of a compound).

Not all elements have molecules. The metals on the left hand side and the middle part of the Periodic Table are solids at room temperature and so they exist as tightly packed arrays of atoms like the previous examples of silver and copper.

Many of the non-metals on the right hand side of the Periodic Table are gases at room temperature that exist as molecules made up of two atoms each. These are called **diatomic molecules**. The picture of the element that we discussed earlier shows what diatomic molecules look like. Oxygen (O_2), nitrogen (N_2), hydrogen (H_2), chlorine (Cl_2) and some other elements from the non-metals all form diatomic molecules.

Draw a picture of one of these diatomic molecules in the space below.

TEACHER'S NOTE

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

TAKE NOTE

Diatomic refers to a molecule made of two of the same atoms bonded together, as in oxygen (O_2). 'Di' means two. **Triatom**ic refers to a molecule made up of three of the same atoms bonded together, like ozone (O_3).

ACTIVITY: Atoms and molecules

TEACHER'S NOTE

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

Let's make sure we understand the difference between atoms and molecules.

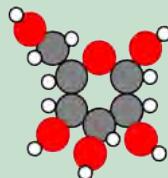
QUESTIONS:

1. Look at the following diagrams. Decide whether each represents an atom or a molecule. If it is a molecule, state how many atoms make up the molecule.



<i>Diagram</i>	<i>Atom or molecule?</i>
	<i>An atom</i>
	<i>A molecule of 2 atoms</i>
	<i>A molecule of 4 atoms</i>
	<i>An atom</i>
	<i>A molecule of 9 atoms</i>

2. Look at the following complex molecule.



- a) How many atoms make up this molecule?
24 atoms.
- b) How many different types of atoms make up this molecule?
3 different types of atoms make up this molecule.
- c) What holds the atoms together in this molecule?
There are chemical bonds between the atoms.

Now let's think about this: if compounds consist of two or more kinds of atoms, that would mean that compounds are made of two or more different elements that have combined.

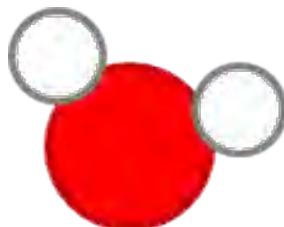
Compounds

TEACHER'S NOTE

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

There are at least 118 elements in our known universe. They can form compounds by bonding in millions of different combinations - far too many to discuss here! We will look at a few simple combinations of elements to illustrate the idea.

Since water is such an important compound for organisms living on Earth, we will use that as our first example. Scientists know that a water molecule is made up of one oxygen atom and two hydrogen atoms. If we could see them, all water molecules would look a little bit like this diagram of a water molecule.



A water molecule representation.

All water molecules are exactly the same. We say the atoms are bonded in a *fixed ratio*: two hydrogen atoms for every one oxygen atom. The atoms in the molecule are held together by a special force that we call a '**chemical bond**'.

TEACHER'S NOTE

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

Chemical formulae

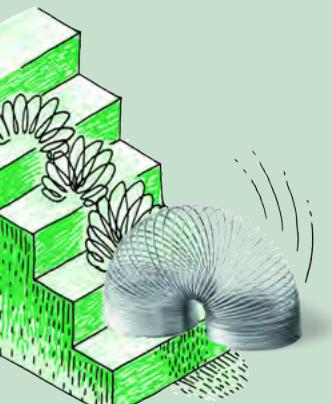
Can you remember that each element has its own unique chemical symbol? We can combine these symbols into a chemical formula for water. The **chemical formula** is another very important concept in chemistry.

The chemical formula for water is H_2O . It shows the ratio of hydrogen atoms (two) to oxygen atoms (one) in one molecule of water. What do you think the chemical formula CO_2 tells us?

TEACHER'S NOTE

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

- H_2 for hydrogen gas, meaning there are two hydrogen atoms bonded together. It is a diatomic molecule.
- NaCl for sodium chloride (table salt), meaning one sodium atom is bonded to one chlorine atom.

- 
- KMnO_4 is potassium permanganate. This could be slightly more challenging, but highlights that a molecule can consist of more than two different elements. Here one potassium, one manganese, one nitrogen and four oxygen atoms bonded together forming one molecule.

In the next activity we are going to practice writing and understanding chemical formulae. It is always a good idea to think about a new concept in many different ways. For this reason, we are also going to build models of the molecules we are writing formulae for.

ACTIVITY: Writing and understanding simple chemical formulae

MATERIALS:

- play dough or plasticine clay in different colours

INSTRUCTIONS:

1. In the following table, the names of some pure substances are given in the left-hand column. Fill in all the empty blocks in the table.
2. Build a model of one molecule of each of the compounds on the table. Your atoms should be roughly pea-sized. It may help you to build the model before drawing the molecule in the right-hand column. When you are done, show your teacher.

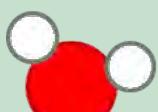
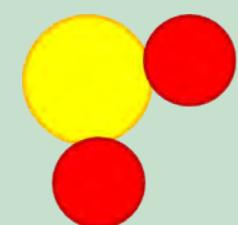
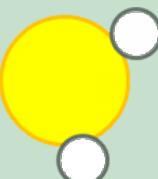
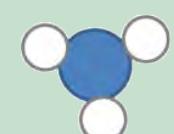
To help you do this, here are some guidelines:

- Each row in the table contains enough information that you can fill all the empty blocks.
- The first row has been filled in for you, so that you have an example:
 - Column 1 contains the name: water
 - Column 2 contains the formula: H_2O
 - Column 3: The formula of water (in column 2) contains all the information we need to fill in the block in the 'What is it made of?' column. When we read the formula H_2O , the subscript '2' tells us there are two H atoms. Since O does not have a subscript, it means there is only one O atom.
 - Column 4: The model of a water molecule must reflect that there is one O atom and two H atoms. How do we know that O must be in the middle? For now, it is enough to know that the atom that we have the least of, is usually in the middle.

TEACHER'S NOTE

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

The completed table should look as follows.

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

Name of substance	Chemical formula	What it is made of?	What would a molecule of this compound look like (if we could see it)?
Nitrogen gas	N_2	Two N atoms	
Chlorine gas	Cl_2	Two Cl atoms	
Hydrogen gas	H_2	Two H atoms	

QUESTIONS:

1. List all the substances from the table that are elements. Write their names and formulae.

Hydrogen, H_2

Oxygen, O_2

Chlorine, Cl_2

Nitrogen, N_2

2. List all the substances from the table that are compounds. Write their names and formulae.

Water, H_2O

Carbon dioxide, CO_2

Sulfur dioxide, SO_2

Sodium chloride, $NaCl$

Hydrogen sulfide, H_2S

Ammonia, NH_3

How did you know which of the substances in the table were compounds and not elements?

You probably looked to see which ones were made up of more than just one kind of atom. A compound is a material that consists of atoms of two or more different elements. The elements are not just physically mixed, but chemically bonded together at the atomic level.

Water (H_2O), carbon dioxide (CO_2) and salt or sodium chloride ($NaCl$) are examples of compounds, while oxygen gas (O_2), hydrogen gas (H_2) and nitrogen gas (N_2) are examples of elements.

The compound with the formula H_2O_2 also consists of hydrogen atoms and oxygen atoms. The formula tells us that one molecule of this substance is made

up of two atoms of hydrogen and two atoms of oxygen. Is H_2O_2 the same as water? What do you think?

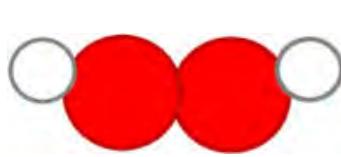
Do not confuse H_2O_2 with H_2O ! H_2O_2 is a compound called hydrogen peroxide. Hydrogen peroxide is similar to water in that it is a clear, colourless liquid at room temperature (25°C) though not as runny, but it is different in many ways. The following properties of hydrogen peroxide may convince you that it is not the same as water:

- Hydrogen peroxide has a boiling point of 150°C and it is a very effective bleach for clothes and hair.
- Concentrated hydrogen peroxide is so reactive that it is used as a component in rocket fuel!
- Hydrogen peroxide is extremely corrosive.
- We can drink water, but hydrogen peroxide is very hazardous and harmful.

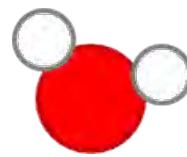
TAKE NOTE

Corrosive substances are substances that cause damage to metal or other materials through a chemical process. Think of rainwater causing rust that eats away at metal.

If this doesn't convince you, let us compare what the hydrogen peroxide molecule looks like next to water:



Hydrogen peroxide.



Water.

Even though they are made up of exactly the same elements, the two compounds are very different and should never be confused with one another.

The purpose of the comparison of hydrogen peroxide and water above was to show you that the atoms in a given compound are always combined in a fixed ratio. In all water molecules in the universe, there will always be one O atom and two H atoms bonded together.

This was the fifth of Dalton's postulates:

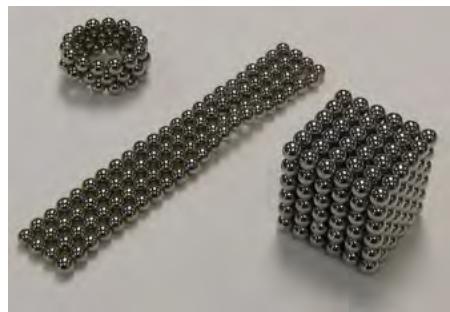
5. Atoms chemically combine in fixed ratios to form compounds.

How do atoms 'combine'? What makes them stick together to form molecules?

Chemical bonds

Look at the photo with the different arrangements of metal balls. These balls are magnetic and this allows you to make different patterns by sticking them together. What makes magnets stick together?

Magnets attract (or repel) each other because of a magnetic force between them (you will learn more about magnets in Gr. 9). When atoms combine, they do so because they also experience an attractive force. The force is slightly more complex than the force between magnets, but it works in the same way: The force holds atoms together as if they are stuck together with glue. The forces that hold atoms together are called **chemical bonds**.



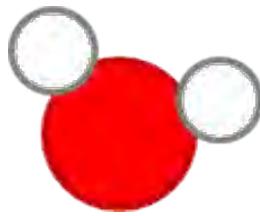
These balls are magnetic.

TEACHER'S NOTE

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

In the water molecule, chemical bonds between O and the two H atoms hold the whole molecule together.

How many chemical bonds in each water molecule? Look at the diagram on the right if you are not sure. The water molecule has two identical O-H bonds. What would happen if we had enough energy to break those bonds? What would we have if we separated water molecules into their atoms? Theoretically, we would have hydrogen and oxygen atoms.

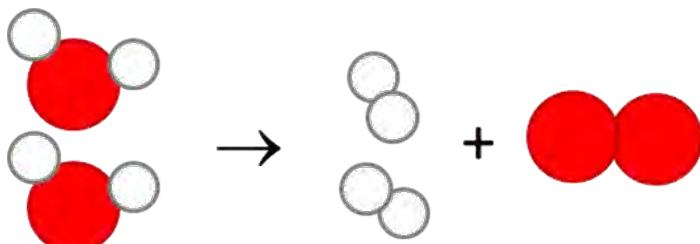


What actually happens is that the hydrogen atoms immediately combine to form H₂ and the oxygen atoms immediately combine to form O₂.

TEACHER'S NOTE

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

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



When atoms separate from each other and recombine into different combinations of atoms, we say a **chemical reaction** has occurred.

In the above chemical reaction, the water has decomposed (broken up) and recombined into smaller molecules. We say that water has undergone a **decomposition reaction** in the example above. Of course, not all chemical reactions are decomposition reactions. There are many different kinds of chemical reactions and we are going to investigate some examples in the next section.

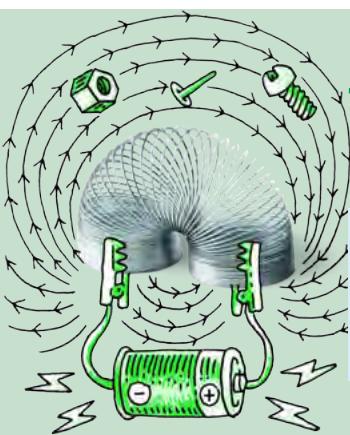
Chemical reactions

Two important events happen in all chemical reactions:

- chemical bonds break
- new chemical bonds form

This means that, in **all** chemical reactions, the atoms in the molecules rearrange themselves to form new molecules.

In the next activity, we are going to simulate the decomposition reaction of water using clay or play dough balls to represent the different atoms.



ACTIVITY: Imagining the decomposition of water at the scale of molecules

TEACHER'S NOTE

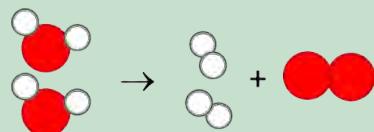
This is an optional extension. Learners will look more at chemical reactions later in the term.

MATERIALS:

- play dough or plasticine clay in two different colours

INSTRUCTIONS:

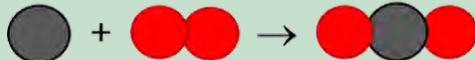
1. Build two water molecules from the clay or play dough. Look at the previous pictures to remind you what a water molecule looks like. You may use any colour clay to build yours.
2. Now break all the bonds holding the molecules together, separating them into individual atoms.
3. Answer the following questions:
 - a) How many hydrogen (H) atoms do you have?
Four H atoms.
 - b) How many oxygen (O) atoms do you have?
Two O atoms.
4. Combine the hydrogen and oxygen atoms into hydrogen molecules (H_2) and oxygen molecules (O_2).
5. Answer the following questions:
 - a) How many hydrogen molecules could you build from the H atoms?
Two hydrogen molecules (H_2) could be made from four H atoms.
 - b) How many oxygen molecules could you build from the O atoms?
One oxygen molecule (O_2) could be made from two O atoms.
6. Can you write a chemical equation for the reaction that you have just built with the clay models? Look at the diagram for inspiration:



TEACHER'S NOTE

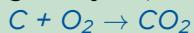
Chemical equations will be properly introduced in the final chapter of Gr. 8 Matter and Materials, but this may be a good place to start sensitising the learners to it. You could explain that when there is just one molecule of a certain kind (the O₂ in the above example) we do not write a number in front of it in the chemical reaction. Balancing equations is not a requirement at this stage.

7. Let us look at another example of a chemical reaction: the reaction when carbon (in coal) reacts with oxygen (in the air) to form carbon dioxide:



You can use the play dough balls to simulate this reaction.

- a) Try to write a chemical equation for the reaction when carbon and oxygen combine to form carbon dioxide. (Hint: Use the diagram to guide you.)



- b) How do the atoms in coal and oxygen rearrange to form carbon dioxide? Which bond breaks?

The bond between the two oxygen atoms breaks.

- c) What new bonds form?

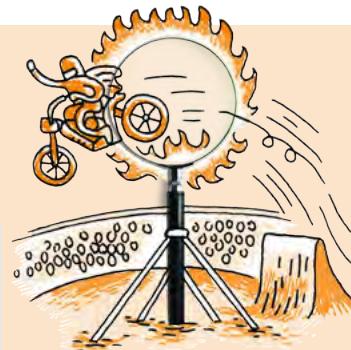
Two new carbon-oxygen bonds form when carbon dioxide is made.

Next, your teacher will demonstrate two chemical reactions to the class. Your job is to watch carefully and write down your observations, which is what you can see happening.

INVESTIGATION: The decomposition of copper chloride

TEACHER'S NOTE

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



AIM: To determine whether it is possible to decompose copper chloride using electrical energy.

MATERIALS AND APPARATUS:

- beaker
- cardboard disk large enough to cover the top of the beaker
- two graphite electrodes
- 2 bits of wire
- copper chloride solutions
- 9 volt battery

TEACHER'S NOTE

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

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

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

VISIT

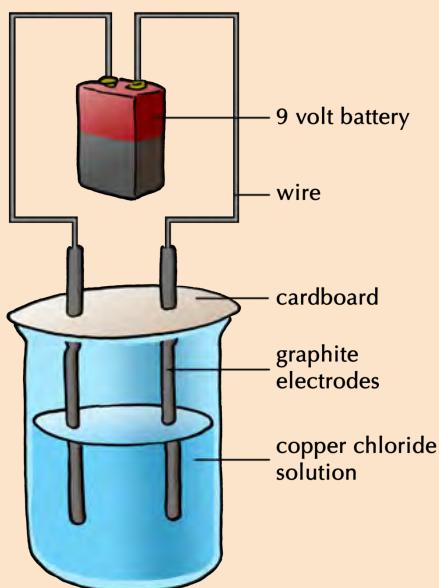
A video showing a similar reaction using copper sulfate. bit.ly/1I0ztaB

Make the following observations before starting:

1. What colour is the copper chloride solution?
Blue.
2. What colour are the graphite electrodes?
Dark grey or black.

METHOD:

1. Pour the copper chloride solution into the beaker.
2. Make two small holes in the cardboard disk and push the electrodes through the holes as shown on the following diagram.
3. Place the disk over the beaker, so that the greater part of each electrode is under the surface of the solution.
4. Connect the tops of the electrodes to the ends of the battery using the wire lengths. Have a look at the diagram of the experimental set-up.
5. Allow the reaction to proceed for a few minutes and observe what happens.
6. When the reaction has proceeded for approximately 10 minutes, the wires can be disconnected and the set-up disassembled.



The demonstration that your teacher sets up might look something like this.

TAKE NOTE

The electrode attached to the positive side of the battery is the positive electrode and called the **anode**. The electrode attached to the negative side of the battery is the negative electrode and called the **cathode**.

OBSERVATIONS:

- After the reaction had proceeded for a few minutes, what do you observe on the surface of the two electrodes?

The one electrode is covered in small bubbles, and the other is turning brown.

- At the end of the experiment, what colour was the copper chloride?

The solution is still blue.

TEACHER'S NOTE

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

- the copper ions are coming out of solution as they accept electrons and become solid copper which precipitates reddish-brown on the cathode. (Learners don't know about ions or electron sharing yet so they might guess that copper atoms/particles come out of solution and accumulate on the electrode.)
- chloride ions form chlorine gas, Cl_2 , at the anode. (Learners can observe that gas bubbles form on the other electrode and possibly infer that this is chloride coming out of solution as chlorine gas.)

Therefore, the concentration of the copper chloride solution is becoming weaker causing it to become slightly less blue.

- How did the appearance of the graphite electrodes change?

One electrode is still dark grey or black. The other electrode is covered in a reddish-brown layer.

TEACHER'S NOTE

You could point out that the electrode that remained gray-black was the one that had bubbles on earlier. Get some of the learners to smell this electrode. They may be able to smell 'bleach', which is the smell of chlorine gas, Cl_2 , forming. Ask learners to compare the colour of the layer with that of a copper coin. Could the deposit on the second electrode be copper? Yes, it is.

Learners do not need to understand what is happening in the solution on an ionic level. The emphasis here is on demonstrating that a compound can be broken down into elements. However, an explanation of the electrolysis of copper(II) chloride solution is provided here for background and if you would like to extend your learners knowledge :

- When the electrodes are attached to a power supply, the electrons move causing the electrode attached to the positive end of the battery to become positive. This is called the **anode**. The negatively charged chloride ions in solution are then attracted to the positive anode. The chloride ions give up their electrons and form chlorine gas, which is observed as bubbles.
- The electrode that is attached to the negative end of the battery becomes negative. It is called the **cathode**. At the cathode, the positively charged copper ions in solution are attracted to the negative electrode. At the cathode, the copper ions gain electrons forming copper metal which deposits on the cathode. This is the brown coating which is observed.

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

4. Summarise your experimental observations in the following table.

TEACHER'S NOTE

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

ANALYSIS AND DISCUSSION:

1. What gave the copper chloride solution its intense blue colour?
The copper chloride that was dissolved in it.
2. Do you think that some of the copper chloride may have changed into something else during the reaction? Explain why you think so.

The copper chloride solution became less blue. That tells us that some of the copper chloride turned into something else.

3. How would you explain the bubbles on the surface of the first electrode?

Do you have any idea what they might have been? Hint: what did the electrode smell like afterwards?

Bubbles mean that a gas formed on the surface of the electrode. It smelled like bleach. Chlorine gas also smells like bleach, so it is possible that the gas we saw forming at the electrode may have been chlorine gas.

Note: Chlorine is actually the active ingredient in bleach.

4. Do you know what the reddish-brown coating on the second electrode is?

Hint: Which metal has that same characteristic reddish-brown colour?

It is possible that the reddish-brown coating is copper.

5. How do we know that a chemical reaction has occurred?

The atoms in copper chloride were rearranged to make different materials: copper (Cu) and chlorine (Cl_2).

CONCLUSION:

1. Write a conclusion for the investigation. In your conclusion you should rewrite the aim of the investigation into a statement about the findings of your investigation.

Learner's conclusion should contain at least two of the following:

- *It is possible to decompose copper chloride solution using electrical energy.*
- *The compound copper chloride will decompose into copper metal (Cu) and chlorine gas (Cl_2).*



Do you think it would have been possible to separate the copper chloride into copper and chlorine by any of the physical separation methods that we learnt about in Gr. 7 Matter and Materials, such as sieving, filtering, evaporation, distillation or chromatography? Here is a hint: None of those methods are able to break the bonds between atoms in a substance.

The answer is no. Copper and chlorine are chemically bonded in copper chloride. We know this from its chemical formula: $CuCl_2$. Physical separation methods can only be used to separate **mixtures** into the substances they are made up of.

We have learnt about atoms, molecules, elements and compounds so far. These are sometimes confusing concepts because they describe things that are too small to see and sometimes difficult to imagine. In the next section we are going to return to the idea of mixtures and see how everything we have learnt so far can be placed into a scheme for classifying matter and materials.

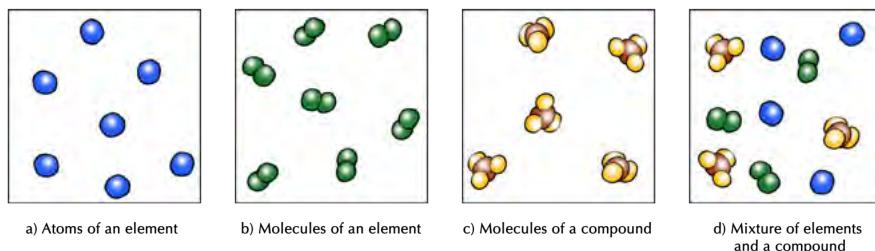
1.4 Mixtures of elements and compounds

In Gr. 7 Matter and Materials we learnt that a mixture is a combination of two or more materials. In this chapter we learnt about pure substances. Pure substances always consist of one type of matter throughout. That matter can be an element or a compound and we have learnt how to distinguish between them by looking at the different kinds of atoms they are made up of:

- elements are made up of just one kind of atom, and

- compounds are made up of more than one kind of atom, but always combined in a fixed ratio.

All material can be classified as either a pure substance (in other words, just one substance throughout), or a mixture of substances. Let's look at some diagrams to help us understand this **distinction** a little better.



Diagrams to show the difference between elements, compounds and mixtures.

The two diagrams on the left (a and b) summarise what we know about the particles in elements, namely that an element can consist of atoms or molecules, but that the atoms in a certain element are always of only one kind.

What special name do we give to the molecules of elements which consist of two atoms bonded together?

TEACHER'S NOTE

Diatomeric molecules.

Diagram (c) shows that the molecules of a compound consist of two or more different kinds of atoms, but in a given compound they will always be bonded in the same fixed ratio. Think of the example of water (H_2O) and hydrogen peroxide (H_2O_2) that we saw earlier.

Diagram (d) shows how elements and compounds are different from mixtures. Elements and compounds are both pure substances (they have the same kinds of particles throughout) whilst mixtures always have more than one kind of particle. We find mixtures of elements and compounds in many places in the natural world, such as in the air, sea water, in rocks, and in living organisms.

In the next activity, let's see if we can apply these principles to distinguish between different possibilities.

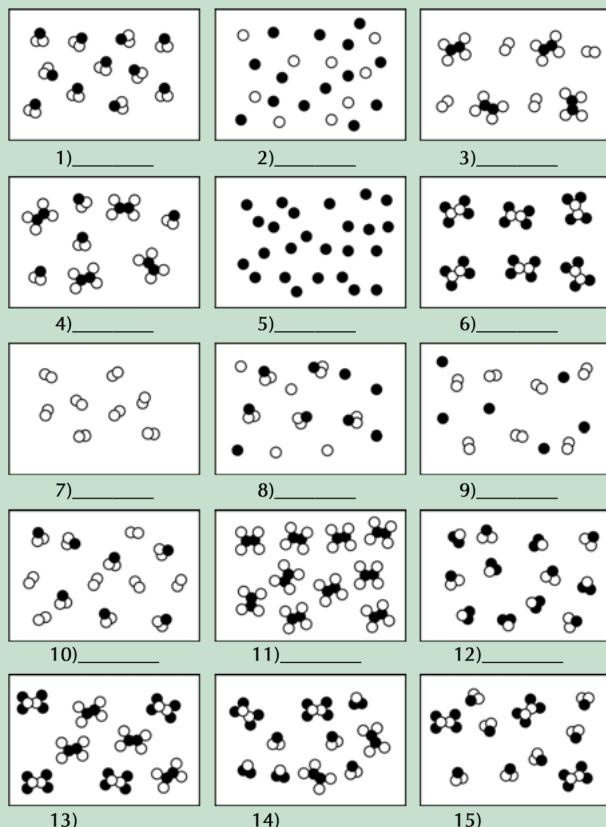
ACTIVITY: Distinguishing between elements, compounds and mixtures

INSTRUCTIONS:

1. Each of the 15 blocks contains a diagram representing atoms and molecules of matter.

2. You must classify the matter in each block using only the letters A to E to identify the categories:

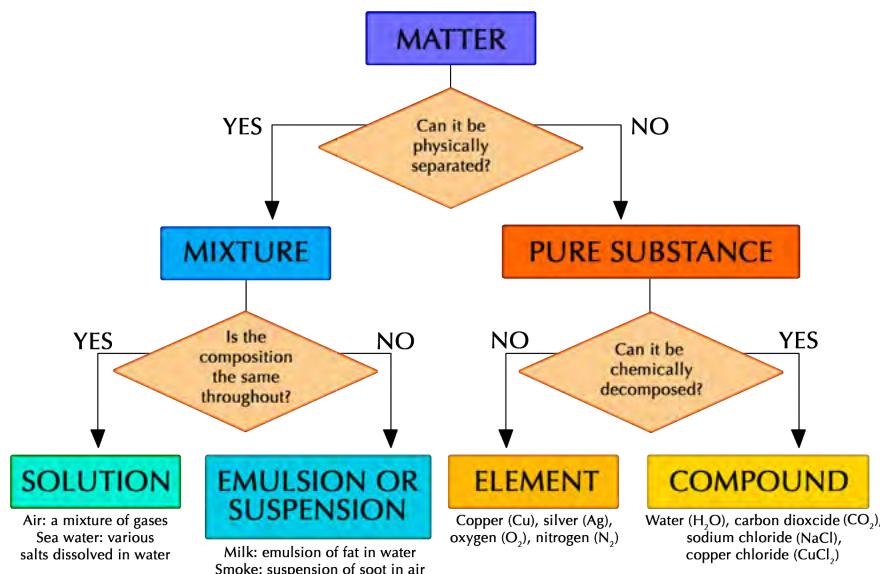
- A = element
- B = compound
- C = mixture of elements
- D = mixture of compounds
- E = mixture of elements and compounds



The classifications are as follows:

- a) B
- b) C
- c) E
- d) D
- e) A
- f) B
- g) A
- h) E
- i) C
- j) E
- k) B
- l) D
- m) D
- n) D
- o) D

You may find the following chart useful to help you understand how all these concepts fit together.



This flow diagram brings together all the different classes of matter we learnt about in this chapter. It puts them all into a scheme that helps us see how the different classes are related to each other.



SUMMARY:

Key Concepts

Atoms

- All matter is made up of tiny particles called atoms.
- The atoms of each element are unique and essentially identical to each other.
- All the known elements are listed on the Periodic Table.

Sub-atomic particles

- The three main sub-atomic particles that determine the structure of the atom are protons, neutrons and electrons.
- Protons are positively charged and are found in the nucleus, deep in the centre of the atom.
- Neutrons are similar to protons in size and mass, but they do not carry any charge (they are neutral). They are also found in the atomic nucleus.
- Electrons are negatively charged particles, much smaller than protons and neutrons. A cloud of fast-moving electrons surrounds the atomic nucleus.
- In a neutral atom, the number of protons always equals the number of electrons; hence the atom is neutral.

Pure substances

- All matter can be classified as mixtures of substances or pure substances.
- Pure substances can be further classified as elements or compounds.

Elements

- All the atoms in an element are of the same kind. That means that an element cannot be changed into other elements by any physical or



chemical process.

- Elements can be built up of individual atoms, or as bonded pairs of atoms called diatomic molecules.
- When elements combine, they form compounds.

Compounds

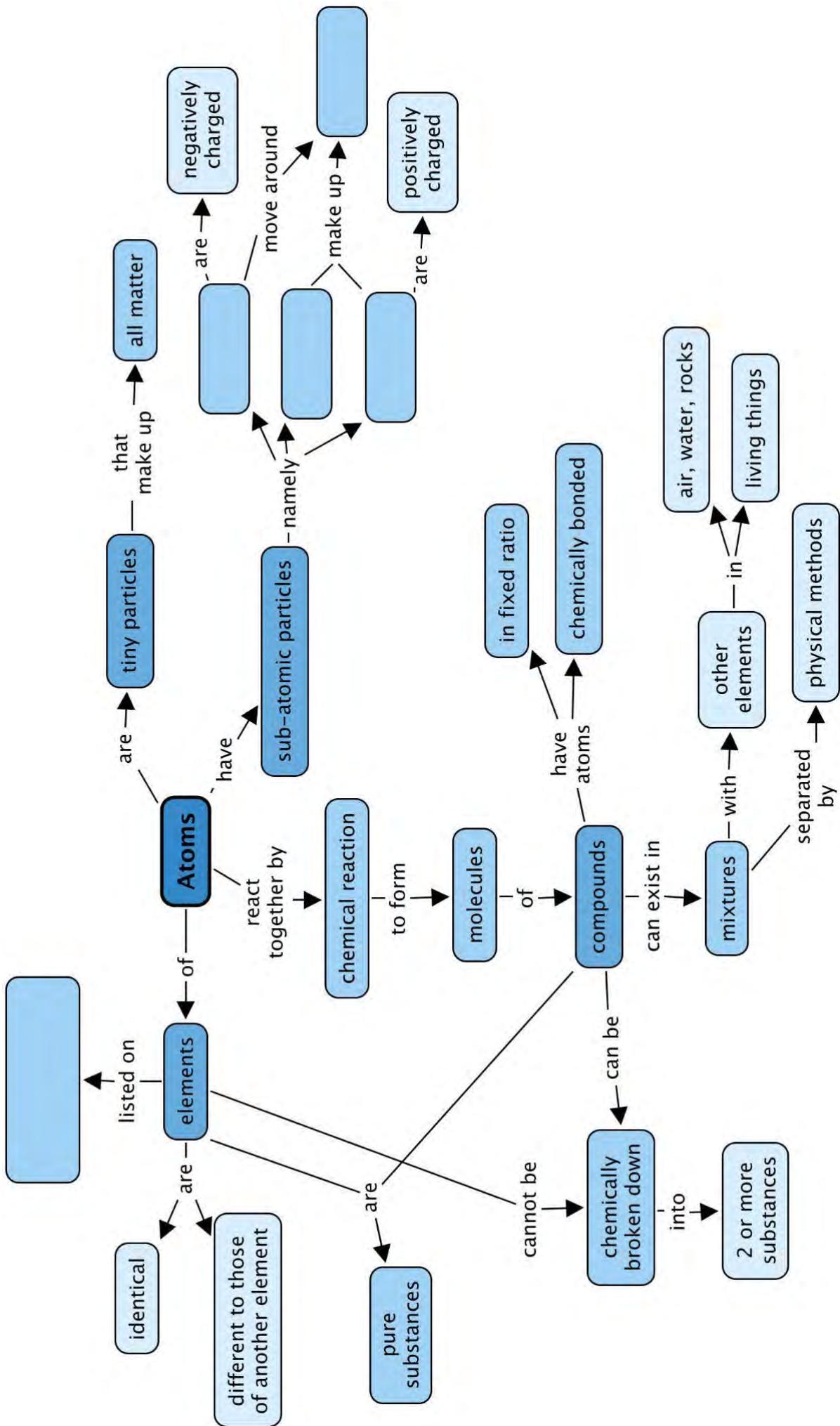
- In a compound, atoms of two or more different kinds are chemically bonded in some fixed ratio.
- The atoms that make up a molecule are held together by special attractions called chemical bonds.
- Compounds can be formed and broken down in chemical reactions.
- A chemical reaction in which a compound is broken down into simpler compounds and even elements, is called a decomposition reaction.
- Compounds cannot be separated by physical processes, but they can be separated into their elements (or simpler compounds) by chemical processes.

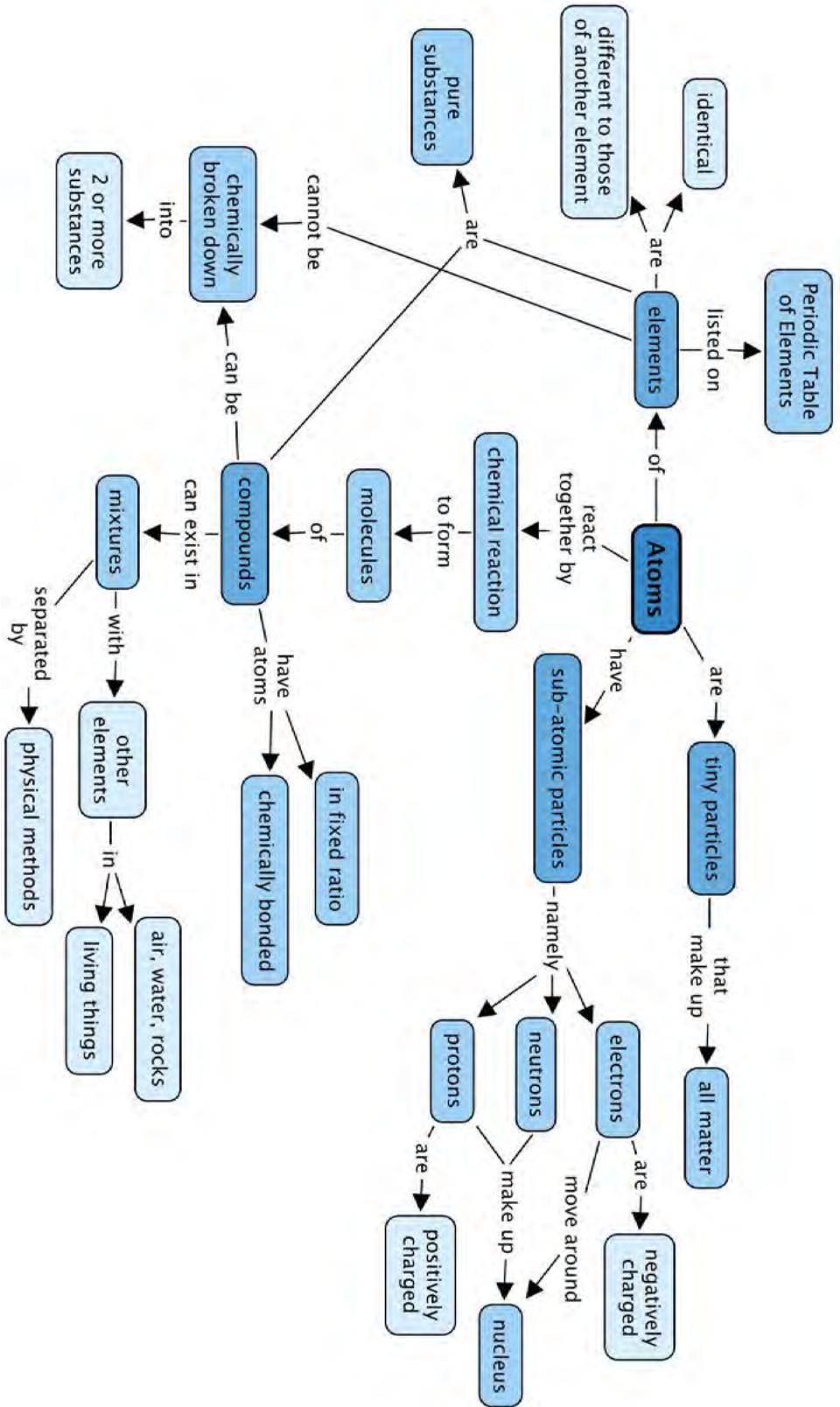
Mixtures

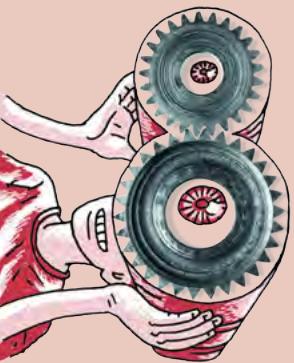
- Mixtures are combinations of two or more elements and/or compounds.
- The components in a mixture can be separated by physical separation methods, such as sieving, filtration, evaporation, distillation and chromatography.

Concept Map

The concept map summarizes all that we have learnt in this chapter about atoms, elements, compounds and mixtures. You need to complete the concept map by filling in the name of the table that lists all the elements, and the names of the three sub-atomic particles. You need to look at the concepts which come afterwards to determine which sub-atomic particle must be placed in which space.

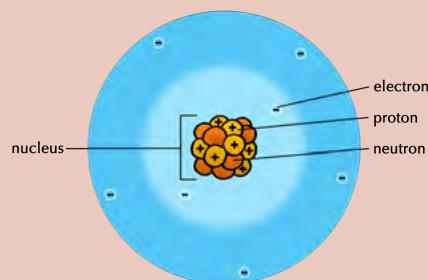






REVISION:

1. Name the three sub-atomic particles that atoms are made up of. [3 marks]
Protons, neutrons and electrons.
2. Draw a picture of the atom. Your picture must show all three different types of sub-atomic particles. [4 marks]



Learners' diagrams must show the protons and neutrons clustered in the centre of the atom, and be annotated separately (proton; neutron) as well as collectively (nucleus). The electrons should be annotated, placed outside the nucleus and the area represented by the 'electron cloud' should be large compared to that represented by the nucleus. The atom should not have a distinct boundary. At this stage, we have only looked at neutral atoms (and not ions) and so the number of electrons should equal the number of protons.

3. Read the following statements, and answer the questions that follow:
 - Some elements consist of molecules.
 - All compounds consist of molecules.
 - a) Do all elements consist of molecules? Explain your answer briefly. [2 marks]
 - b) Can you think of at least three examples of elements that do NOT consist of molecules? Write down their names and formulae. [6 marks]
 - c) Give examples of three elements that exist as molecules. Write down their names and formulae, and draw one molecule of each. [3 x 3 marks each = 9 marks]

a) Only SOME elements consist of molecules. Those which do not consist of molecules, consist of atoms.

b) Silver, Ag; Gold, Au; Iron, Fe

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

 - c) Oxygen, O_2



Hydrogen, H_2



Nitrogen, N_2



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

4. Give examples of three compounds. Write down their names and formulae, and draw one molecule of each. [3 x 3 marks each = 9 marks]

Water, H_2O



Carbon dioxide, CO_2



Ammonia, NH_3



Note: Any other valid examples are permissible, but the examples learners are most likely to come up with are the ones contained in this chapter. Once again, the colours are not important, but identical atoms such as the two O-atoms in CO_2 should have the same colour.

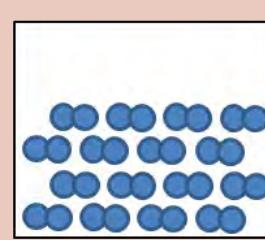
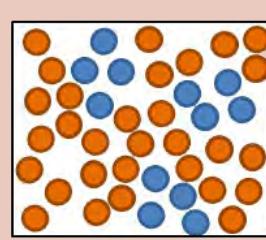
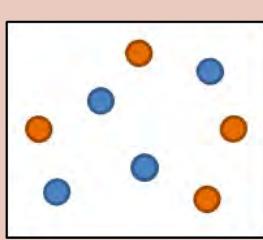
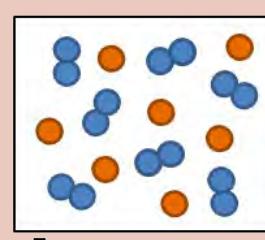
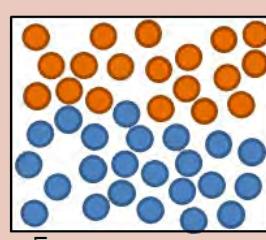
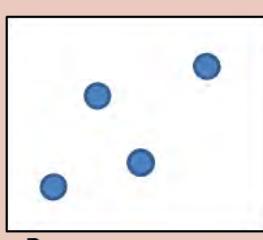
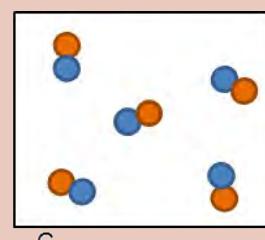
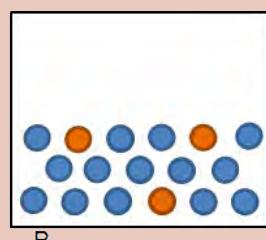
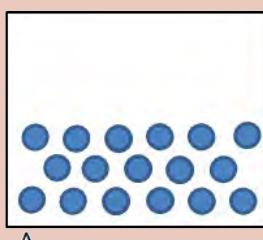
5. How are the molecules of an element different from the molecules of a compound? You may use drawings in your explanation. [4 marks]
The molecules of an element consist of one kind of atom, such as the molecules of N_2 , for instance. N_2 molecules are made up only of nitrogen (N) atoms.
Any suitable example is permissible.



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



6. Each of the nine blocks below (labelled A to I) contain some matter. You must answer the following questions using the diagrams in the blocks. Each question may have more than one answer! [7 marks]



- a) Which blocks represent the particles of an element?
b) Which block represents the particles of a compound?
c) Which block represents the particles of a mixture?
d) Which block represents the particles of a pure substance?
e) Which block represents diatomic molecules of an element?
- a) A, D and I
b) C
c) B, E, F, G and H
d) A, C, D and I
e) I

7. What is the difference between mixture and compounds in terms of how we can separate them? [2 marks]

Mixtures can be separated by physical means (such as sieving, filtering, distillation, etc), whereas compounds have to be separated by chemical means in a chemical reaction (such as electrolysis).

Total [44 marks]



Particle model of matter

TEACHER'S NOTE

Chapter overview

5 weeks

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

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

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

2.2 Solids, liquids and gases (3 hours)

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

2.3 Change of state (2 hours)

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

2.4 Density, mass and volume (1 hour)

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

2.5 Density and states of matter (1 hour)

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

2.6 Density of different materials (3 hours)

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

2.7 Expansion and contraction of materials (2 hours)

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

2.8 Pressure (2 hours)

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



KEY QUESTIONS:

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



Can you remember learning that matter can exist in three different states?
What are the three states called?

TEACHER'S NOTE

Solids, liquids and gases.

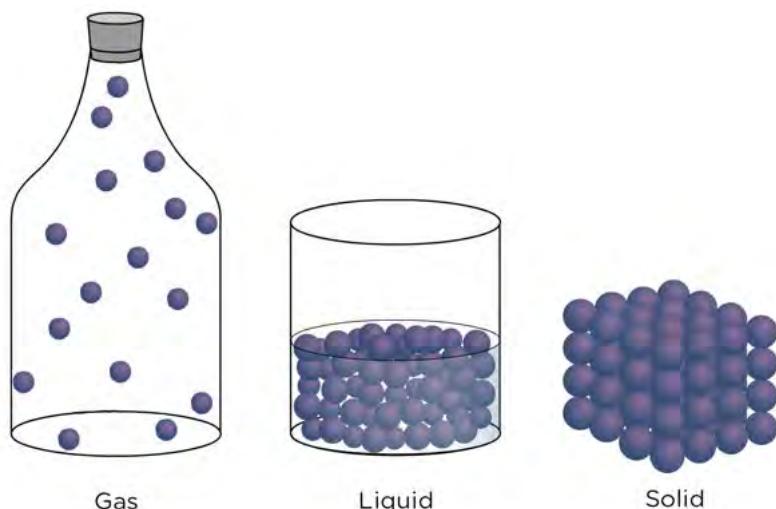
Can you remember the properties of the different states of matter? Discuss this in your class. Look at the following diagram of the states of matter to help you. Remember to take some notes as you discuss in class.

TEACHER'S NOTE

Get learners to discuss this briefly in small groups and draw a table on the board to summarise learners' ideas. Out of the class, three groups could be chosen randomly, and each group could say what they know about one of the states. Some of the properties that learners should already be familiar with are listed in the following table:

TEACHER'S NOTE

Gases	Liquids	Solids
<ul style="list-style-type: none">• Gases spread out and will escape if they are not in a closed container.• Gases can be compressed.• The particles are far apart and can move freely.	<ul style="list-style-type: none">• Liquids can flow to fill the container.• They cannot be compressed easily.• The particles are close together but they can move around.	<ul style="list-style-type: none">• Solids keep their shape.• They cannot be compressed.• The particles are closely packed and cannot move from their positions.

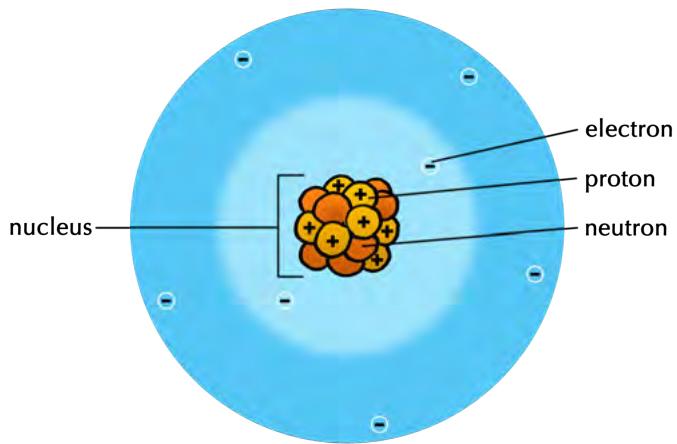


Each state of matter behaves differently and the particles in each state behave differently. This diagram compares the particles in a gas, a liquid and a solid.

In this chapter we are going to review what we know about solids, liquids and gases. We are going to learn about a scientific model that can be used to describe how the particles in all three states behave. This model is called the particle model of matter and it will help us understand much more about the properties of solids, liquids and gases. Let's get started!

2.1 What is the particle model of matter?

In the previous chapter we learnt that scientists use models when they want to describe things that are difficult to understand. We discussed a model of the atom that helped us to imagine what atoms look like.



This model of the atom shows us where the different sub-atomic particles can be found.
The sub-atomic particles shown here are the proton, neutron and electron.

Theories are similar to models. They explain scientific **phenomena** (things and events that can be described and explained in scientific terms) using pictures and words.

What does the particle model of matter teach us?

The particle model describes matter in a very specific way. It describes four important aspects of matter:

- All matter is made up of particles that are incredibly small - much too small to see with the naked eye. The particles can be atoms or combinations of atoms that are bonded.
- There are forces between the particles.
- The particles in matter are always moving. The more energy they have, the faster they move.

TEACHER'S NOTE

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

- The spaces between the particles in matter are empty. You might assume that the spaces between particles are filled with air, but this is not the case. They contain nothing at all.

TEACHER'S NOTE

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

TAKE NOTE

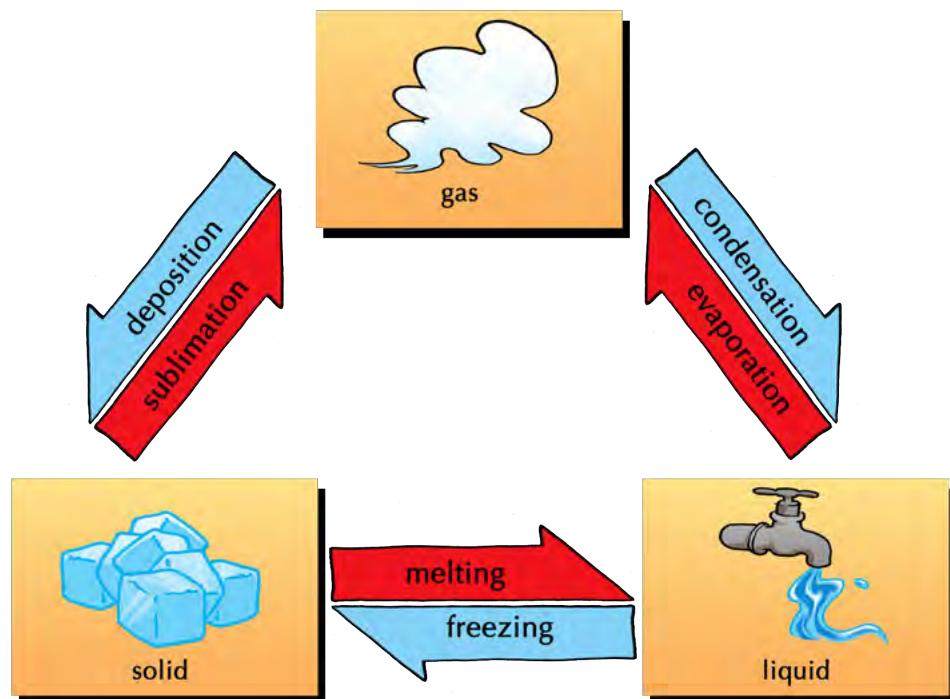
If you need to, turn back to chapter 1 to revise the terms atom, element, compound and molecule and how they relate.

Why is the particle model of matter so useful?

The particle model of matter is one of the most useful scientific models because it describes matter in all three states. Understanding how the particles of matter behave is vital if we hope to understand science!

The model also helps us to understand what happens to the particles when matter changes from one state to another.

The following diagram shows different changes of state, as well as which processes are the **reverse** of each other. Melting and freezing are the reverse processes of each other and so are evaporation (boiling) and condensation.



The change of states

ACTIVITY: Changes of state revision

INSTRUCTIONS:

1. Refer to the previous diagram.
2. Check that you remember some of the concepts you learnt about in previous grades by going through these quick questions.

QUESTIONS:

1. What is the name of the process when a solid turns into a liquid?
The process is called melting.
2. What is the reverse process to melting?
Freezing.
3. What can we do to make ice melt quickly?
We can put it in a warm spot, or heat it in some other way.
4. Explain the steps that a solid must go through to become a gas.
It must first melt to become a liquid and then evaporate to become a gas.
5. What is the reverse process of evaporation?
Condensation.
6. When we heat something, are we adding energy to it, or taking energy away?
Heating is adding energy.
7. How do you think the particles in a substance behave when we give them more energy?
They vibrate or move faster.



TEACHER'S NOTE

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

We will use the model to look at each of these changes more closely. But first, we will look at how the model describes each state of matter.

2.2 Solids, liquids and gases

We can use the particle model to help us understand the behaviour of each of the states of matter. We are going to look at each state in turn.

There is one very important thing to remember when we consider the different states of matter. For any matter, the individual particles of that matter are exactly the same in all three states, solid, liquid and gas. It is the *behaviour* of the particles that changes in each state.

The solid state

VISIT

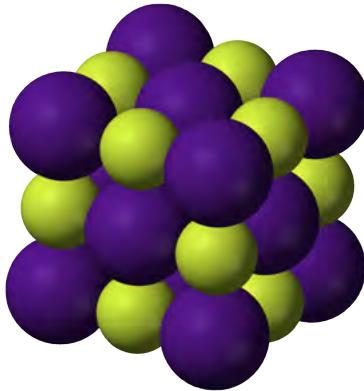
This video shows us the different ways that particles behave in the solid, liquid and gaseous states.
bit.ly/13mAd4o

Solids keep their shape and cannot be **compressed**. Let us see if the particle model can help us understand why solids behave in this way.

In a solid, the particles are packed close to each other in fixed positions. They are locked into place, and this explains why solids have a fixed shape. Look at the following images of sodium chloride (table salt). Do you remember the formula for sodium chloride?

TEACHER'S NOTE

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

Macroscopic view of sodium chloride	Submicroscopic view of sodium chloride
	
Table salt crystals are hard and have a fixed shape.	Can you see how the chloride atoms (purple) alternate with the sodium atoms (yellow) in a fixed arrangement?

Take a good look at the picture of the particles in a solid (table salt) above. You will see that they are packed in a **regular arrangement**. There are very small spaces between the particles in a solid.

Particles are held together by **forces of attraction**. In solids, these forces are strong enough to hold the particles firmly in position.

Does that mean the particles in a solid do not move at all? No. The particles in a solid move a little bit. They **vibrate** in their fixed positions. The more energy the particles have, the faster and more strongly they vibrate.

Do you see how we have used the particle model of matter to explain the properties of solids that we can **observe**? For example, the particles in solids

are closely packed and have strong forces between them explains why solids have a fixed shape and you cannot compress them.

The liquid state

An important characteristic of liquids is that they flow. They fill containers they are poured into. Liquids are also not very compressible. How can these properties be explained?

In the liquid state, particles do not have fixed positions. They move about freely, but they stay close together because the forces of attraction between them are quite strong, but not as strong as in solids.

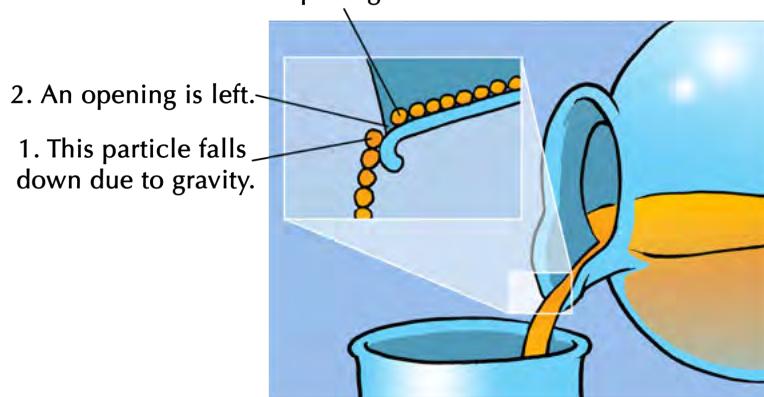
Have you noticed how a liquid always takes the shape of the container it is in? Within the liquid, the particles slip and slide past each other. This is why liquid flows. Their particles are free to move around, filling the spaces left by other particles. Look at the image of the juice being poured. Let's zoom in and have a look at what the particles are doing as the juice is poured.



Orange juice is a liquid, which can be poured.

The particles in a liquid have small spaces between them, but not as small as in solids. The particles in a liquid are loosely arranged which means they do not have a fixed shape like solids, but they rather take the shape of the container they are in.

3. The next particle can move into the opening leaving a new opening behind it.



The speed at which the particles move around inside the liquid depends on the energy of the particles. When we heat a liquid, we are giving the particles more energy and speeding them up.

In gases, the particles move at even greater speeds.

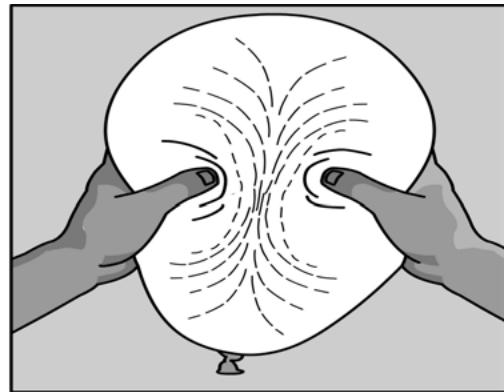
The gaseous state

Gases spread out quickly to fill all the space available to them. Think of when you blow up a balloon. The air that you blow into the balloon fills up the whole balloon. A gas will fill the entire space that is available to it. This is because the particles in a gas have no particular arrangement.

Gases do not have a fixed shape. Think about the balloon again: the gas fills the entire space inside the balloon. You can squeeze the balloon, changing the shape.



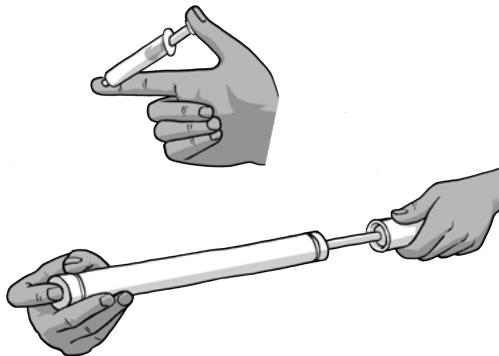
Gases fill the space available to them.



Gases do not have a fixed shape.

Gas particles move very fast, much faster than in solids and liquids. The particles in a gas possess a lot of energy.

Have you ever tried to compress the gas in a syringe or in a bicycle pump? Why do you think you can compress the gas?



TEACHER'S NOTE

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

In gases, the forces between particles are very weak. This explains why the particles in gases are not neatly arranged. They are not held together tightly and there are large spaces between them. These spaces are much larger than in the solid and liquid state.

Gases can be compressed, because their particles can be forced closer together. Look at the photo of a scuba diver underwater. Do you see the tank on his back? He uses this tank to breathe underwater. A scuba diver can stay underwater for almost an hour. How do you think he can get enough air to breathe for a whole hour from a small tank like that? Discuss this with your class.

TEACHER'S NOTE

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



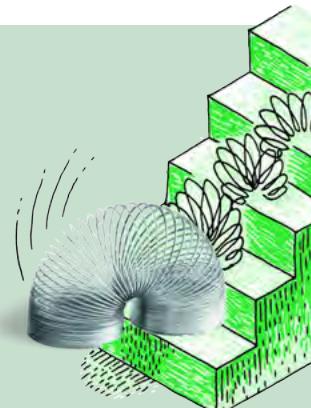
A scuba diver underwater with a tank of air.

ACTIVITY: Comparing solids, liquids and gases

Let's summarise what we have learnt about what the particle model of matter tells us about solids, liquids and gases.

INSTRUCTIONS:

1. Use the images of the different states to help you, and go back over the text in your workbook.



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

QUESTIONS:

TEACHER'S NOTE

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

1. Use the particle model of matter to explain why solids have a fixed shape, but gases fill the shape of the container they are in.
Solids have a fixed shape as their particles are arranged in a regular, fixed arrangement and they have strong forces holding them together, so the shape of the solid remains fixed. The particles in a gas do not have any particular arrangement and there are very, very weak forces between them. So, the particles in a gas can easily move around and fill the shape of the container they are in, meaning they have no fixed shape.
2. Use the particle model of matter to explain why you can compress a gas easily, but you cannot compress a liquid very easily.
The particles in a gas have very large spaces between them, so the particles can be 'squashed' closer together, meaning the gas can easily be compressed to take up a smaller volume. Liquids have very small spaces between the particles and so it is much harder to 'squash' them together, so they are not easily compressed.
3. Think of a bag of cake flour. You can pour the cake flour out of the bag and into a mixing bowl. Does this mean the flour is a liquid? Explain whether you think the cake flour (and all powders) are solids or liquids.
The cake flour is not a liquid, but a solid. Flour, and all powders, are solids made of very fine grains which are able to flow freely when the container is tilted or shaken. But these grains are solid.

VISIT

A video explaining the difference between the solid, liquid and gaseous states of matter. bit.ly/15frMav

TEACHER'S NOTE

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

Diffusion

Have you ever noticed how quickly smells travel? Perhaps you have walked past a rubbish bin, and smelled the garbage.



You can often smell garbage bins when you walk past them.



Has anyone ever set off a stink bomb near you?!

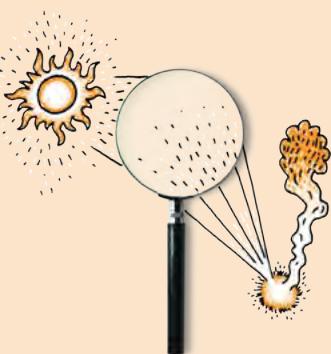
Have you ever smelled a stink bomb? When you smell these things, how do the 'stink bomb' or 'garbage' particles reach your nose?

TEACHER'S NOTE

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

Most smells travel fast, because their particles mix with air and get into our noses when we breathe. We say that the particles **diffuse** through the air.

In Gr. 7 we learnt about different kinds of mixtures. In the next investigation we are going to explore whether particles mix faster when they are in the liquid state or in the gas state. This is called the **rate of diffusion**. What would your prediction be?



INVESTIGATION: Comparing the diffusion of particles in a gas and in a liquid

INVESTIGATIVE QUESTIONS:

1. Do particles diffuse (mix) faster when they are in the liquid state or in the gaseous state? Which particles will mix more quickly: gases or liquids?
2. Do particles diffuse faster with or without mixing?

TEACHER'S NOTE

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

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

TAKE NOTE

When we talk about a **rate**, we are measuring how something changes in relation to another factor, such as time. Another example is speed measured in km/h - this is a rate of how distance in kilometres changes over a period of time (hours).

HYPOTHESIS:

What are your predictions? Do you expect liquids to mix more quickly than gases, or the other way around? Will stirring influence the speed at which gases mix? Write down your hypothesis below.

IDENTIFY VARIABLES:

This is not a **controlled experiment** as we are not measuring the rates of mixing of the liquids and gases under exactly the same conditions. We will make a simple comparison of the mixing rates, by seeing how long it takes each to mix under two different sets of conditions.

MATERIALS AND APPARATUS:

- large glass beaker or other large clear glass container
- dropper
- food colouring or ink
- tap water
- vanilla essence
- shallow dish or saucer

METHOD:

Part 1: How fast do liquids mix?

1. Fill a large, clear container with tap water and place it where everyone can see it.
2. Use a dropper to place one or two drops of the food colouring in the water.
3. Record the time at which the colouring is added to the water.
4. Look carefully at the two liquids mixing, and write your observations below. Allow the liquids to mix without any stirring.
5. Record the time when the liquids are fully mixed, in other words, when the colour is uniformly spread throughout the water.

TEACHER'S NOTE

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

Part 2: How fast do gases mix?

This experiment should be performed with the windows closed.

TEACHER'S NOTE

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

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

1. Pour some vanilla essence into the saucer.
2. Record the time when the vanilla essence is poured out.
3. Record the time when the first learner puts up his/her hand to indicate that they can smell the vanilla essence.
4. Record the time when roughly half of the learners in the class have their hands up to indicate that they can smell the vanilla essence.
5. Record the time when the learners at the back of the class first smell the vanilla essence.
6. If there is enough time during your next Natural Sciences lesson, repeat steps 1-5. You should do everything exactly the same, but this time, you should move your arms and try to 'wave' the air towards the back of the class.

TEACHER'S NOTE

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

RESULTS AND OBSERVATIONS:

- What did you observe in the container immediately after the liquids were mixed?

Learners should write down what they see. These are possible observations:

- It takes a long time for the two liquids to mix;*
- It looks as if the food colouring swirls around in the water.*
- At first, some parts of the water are more intensely coloured than others.*

- How long did it take for the liquids to be fully mixed, until the colour was uniformly spread throughout the water?

If the liquids are not fully mixed by the end of the lesson learners should note this as an observation.

- When the air was NOT mixed during the experiment:

- How long did it take until the first learners smelled the vanilla essence molecules?
- How long did it take until the last learners smelled the vanilla essence?

Learner/class dependent answers.

- When the air WAS mixed during the experiment:

- How long did it take until the first learners smelled the vanilla essence molecules?
- How long did it take until the last learners smelled the vanilla essence?

Learner/class dependent answers.

- Draw a table with your results for the vanilla essence experiment. You can choose your own column and row headings. Remember to give your table a heading.

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

Table to show the observations to smell vanilla essence with and without mixing the air.

Event	Time measured without mixing (minutes)	Time measured with mixing (minutes)
<i>The first learner smelled the vanilla</i>		
<i>Approximately half the class smelled the vanilla</i>		
<i>Learners at the back of the class smelled the vanilla.</i>		

ANALYSIS AND EVALUATION:

1. Did anything go wrong during the experiment?
Learner-dependent answer.
2. Can you think of anything that could have improved this experiment?
Learner-dependent answer.

CONCLUSIONS:

What are your conclusions? (What are your answers to the investigative questions?)

TEACHER'S NOTE

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

In this investigation we explored the rates at which particles diffuse. What do you think happens at the particle level when two substances mix?

TEACHER'S NOTE

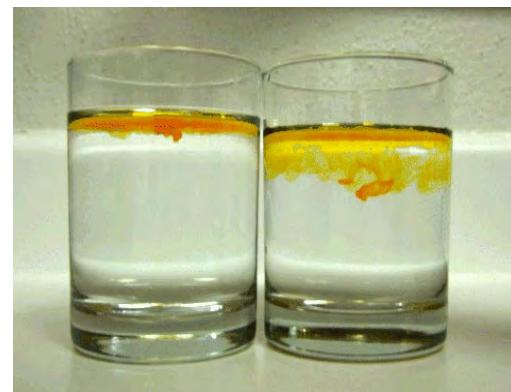
Get learners to discuss this briefly in small groups. Remind them of their observations when the food colouring was mixed with the water. Some ideas to mention are:

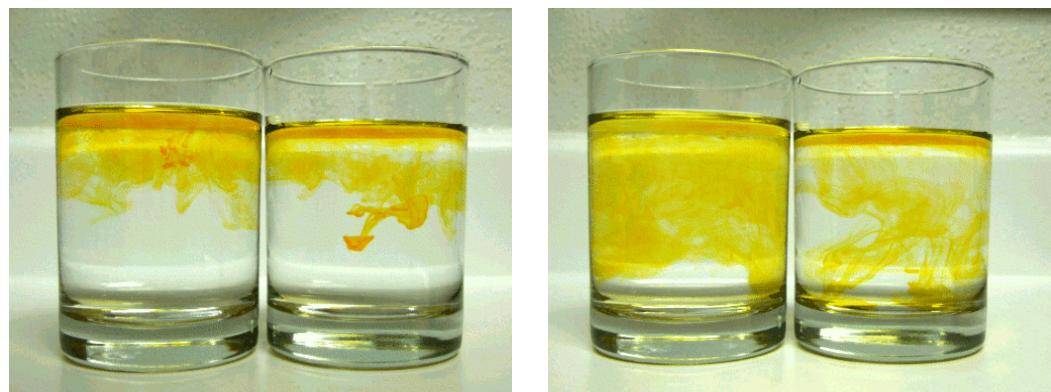
- When substances mix their particles intermingle.
- The process is not immediate but it takes time, because it means the particles have to travel from one point to another. (Ask learners if they think particles will travel in a straight line. What will happen if a gas particle collides with an air 'particle'?)

VISIT

An interesting video that explains what diffusion is and how it occurs.
bit.ly/13mAMvi

In the photos, we see a yellow liquid being added to a colourless one. Notice how the yellow liquid swirls and spreads out as the yellow particles mix with the colourless particles. Of course we cannot see the particles, but we can make a macroscopic observation (something we can see with the naked eye) of the process.



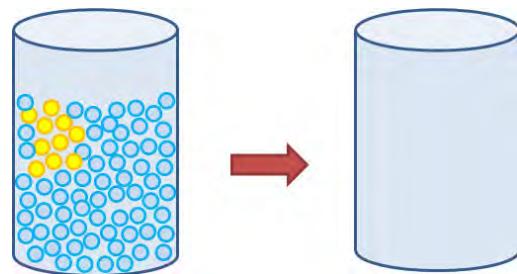


What will the mixture look like when the coloured particles are uniformly spread out amongst the water molecules?

TEACHER'S NOTE

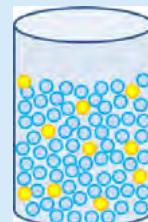
The mixture will have the same colour throughout. The last photo is almost like this, but not quite.

What will the mixing process look like on particle level? The following diagram represents one of the glasses pictured above, containing a colourless liquid (represented by the blue circles) to which a yellow liquid (represented by the yellow circles) is added. The glass on the left shows the particles in the mixture directly after the yellow liquid was added to the colourless liquid. The glass on the right is empty. You must draw the particles in the mixture after the yellow liquid has spread **uniformly** throughout the colourless liquid.



TEACHER'S NOTE

Here is what the final drawing should look like. Note that there should be 10 yellow particles in the final container. They should be spread more or less evenly amongst the colourless particles.



When you were watching the coloured liquid mix with the water in the last investigation, was it possible to predict the direction in which the colour would swirl? What made the two liquids mix?

TEACHER'S NOTE

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

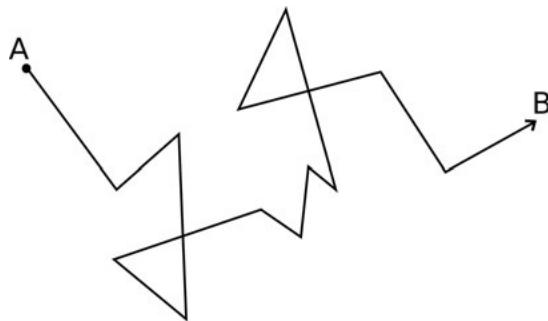
Random movement of particles

The particles in liquids and gases are constantly moving. Their movements are unpredictable: we say the particles move **randomly**. It is the random movement of the particles that allow liquid and gaseous substances to diffuse.

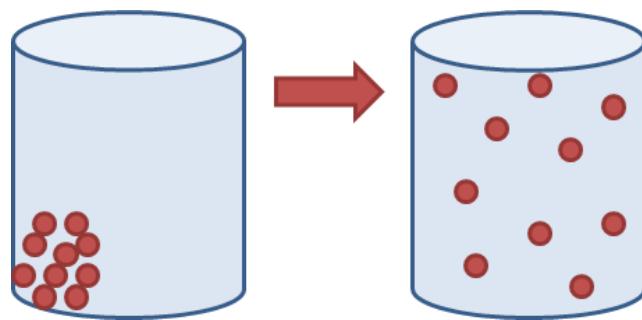
The following zigzag diagram explains what is meant by 'random' movement. When a gas particle travels from point A to point B, it will collide with many other gas particles along the way - up to eight billion collisions every second! Only a few of those collisions are shown in the diagram. Each time the particle collides, it will change direction. This means the actual distance travelled by the particle is much further than the direct distance between points A and B.

TEACHER'S NOTE

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



The process responsible for the mixing and spread of particles in a gas and liquid is called diffusion. We can define diffusion as the random movement of liquid or gas particles from a high concentration to a low concentration to spread evenly. The following diagram illustrates the idea in a very simple way: it shows the particles in a gas spreading out over time to fill all the space that is available to it.



In the diagram on the left some particles were placed into an empty container. At first they were close together (at high concentration), but over time they spread out to fill the entire container.

Factors that affect the rate at which particles diffuse

The speed at which particles diffuse depends on several factors, namely:

- The mass of the particles: lighter particles will diffuse faster, because on average they move faster.
- The state of the particles: the particles in a gas are always moving fast; we say their average speed is high. The particles in a liquid travel more slowly.
- The temperature of the particles: temperature is a measure of the kinetic energy of the particles. The higher the temperature, the more energy the particles have and the faster they will move and diffuse.
- The size of the spaces between particles: If there are large spaces between the particles of one substance, the particles of another substance can move into those spaces easily.

Particles diffuse because they are in **constant motion**. We found that gas particles diffused much more quickly than the liquid particles in the last investigation. Can we explain that result using the factors listed above?

TEACHER'S NOTE

You can do a practical demonstration of this in class with your learners. Get a group of learners to stand in the middle of an open space. First let them simulate the particles in a liquid, so they should be fairly close together, but still moving around. Then get other learners to move through the crowd of learners in the middle. Get a couple of learners to do this so everyone has a chance. Then get the learners in the middle to simulate the particles in a gas by spreading much further apart and moving around a lot more. They can also bump into each other. The other learners must now also move through the crowd, which should now be much easier and quicker for them to do.

Think of it in this way: imagine you are trying to move through a crowd of people. The closer they are together, the more often you are going to have to change direction to make it through the crowd and the longer it will take to get to your destination.



Imagine walking through this crowd of people. This is similar to diffusion through a liquid.

A particle in a liquid cannot travel very far before colliding with another particle, because the particles are so close together. That means the liquid particles are constantly colliding and are sent into a new direction with each collision. This means the rate of diffusion is much slower in liquids than in gases, because the particles of a gas are further apart and collide much less. Gas particles can travel further without being sent in a different direction by a collision. This is why gases diffuse more quickly.

The following table shows similar zigzag drawings as you saw before, but now you can see the difference between the random movement of a particle through a liquid and through a gas. It will take the particle much longer to travel from A to B in the liquid than in the gas.

Liquid	Gas
A zigzag path starting at point A and ending at point B. The path is highly irregular and wavy, representing the constant collisions of a particle with other particles in a liquid. The distance between A and B is relatively short compared to the gas path.	A zigzag path starting at point A and ending at point B. The path is much straighter and has larger, more distinct steps than the liquid path, representing the fewer collisions of a particle with other particles in a gas.

Now that we have a better idea of the behaviour of particles in the different states of matter, we are ready to look at how particles behave when matter changes its state.

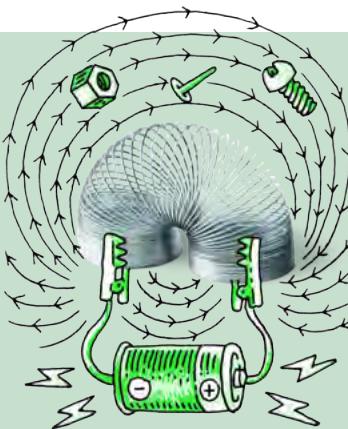
2.3 Changes of state

In science, a change of state refers to a change in physical state (e.g. when a liquid changes to a solid). What is this process called?

TEACHER'S NOTE

Freezing

It is always a good idea to learn new things in terms of what we already know. We are going to start this section with a crossword puzzle to revise what we already know about changes of state.



ACTIVITY: Changes of state

TEACHER'S NOTE

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

INSTRUCTIONS:

1. The crossword puzzle below can be completed by following the clues given below.
2. The 'Down' clues are for the vertical words in the puzzle and the 'Across' clues are for the horizontal words in the puzzle.
3. All the clues have to do with changes of state of materials, and the first letter of every word has been filled in to help you.

Here are the clues:

Down:

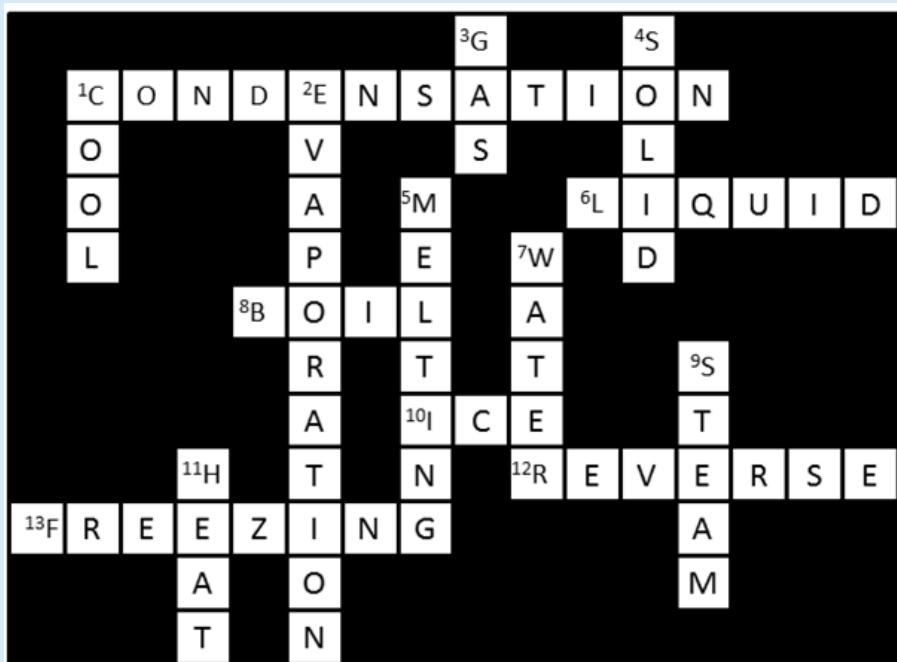
1. If we want to turn steam into water we have to _____ it. (4 letters)
2. The process of turning a liquid into a gas is called _____. (11 letters)
3. The particles of a _____ have large spaces between them. (3 letters)
4. The particles of a _____ are locked in position by strong forces. (5 letters)
5. A solid will change into the liquid state at its _____ point. (7 letters)
7. The liquid state of ice is called _____. (5 letters)
9. The gaseous state of ice is called _____. (5 letters)
11. If we want to turn water into steam we have to _____ it. (4 letters)

Across:

1. The process of turning a gas into a liquid is called _____. (12 letters)
 6. The particles of a _____ are close together but they can flow and slide over each other. (6 letters)
 8. The boiling point of a liquid is the temperature at which that liquid will start to _____. (4 letters)
 10. The solid state of water is called _____. (3 letters)
 12. Freezing and melting are the _____ of each other. (7 letters)
 13. _____ water turns it into ice. (8 letters)

TEACHER'S NOTE

Here is the completed crossword puzzle.



How can we change matter from one state to another?

TEACHER'S NOTE

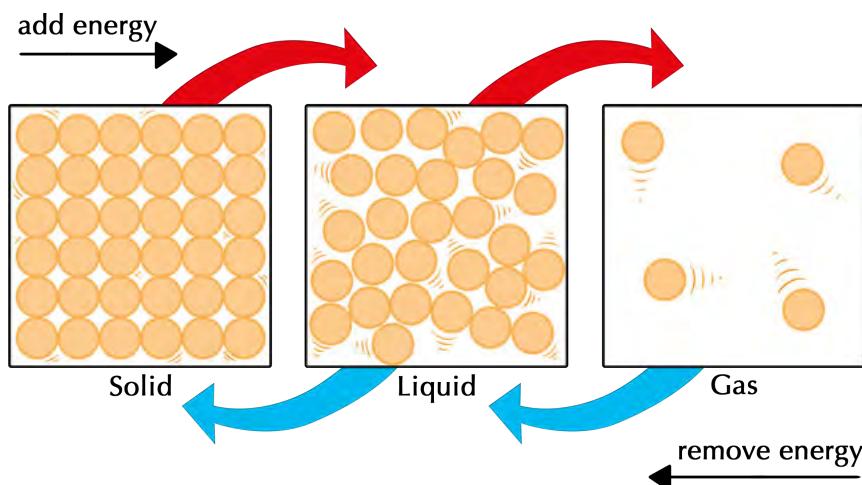
Get the learners to come up with some ideas in class. You should eventually guide them to realise that all changes of state involve changes in energy.

VISIT

Misconceptions about temperature (video).

Changes of state involve energy

For matter to change from one state to another, its particles must gain or lose energy. The following diagram shows us that to change the state of a substance, it must either be heated or cooled.



Melting and evaporation are processes that require heating; condensation and freezing are processes that require cooling.

TEACHER'S NOTE

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

First, let us look at what happens to particles when they are heated.

Melting and evaporation

TEACHER'S NOTE

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

When a solid is heated to reach its melting point, it will change into a liquid. This is a process that we are all familiar with, because we have seen how ice melts.



A melting ice cube.

For a solid to change into a liquid state, the particles in the solid need to be freed from their fixed positions in the solid state. How could that occur?

Imagine you are holding hands with a group of other learners. Everyone is jumping in place, much like a solid particle vibrating in a fixed position. The more **energetically** and randomly everyone jumps, the more difficult it will be for everyone to keep holding hands.

TEACHER'S NOTE

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

When a substance is heated, the particles are given more energy. By giving the vibrating particles in a solid more energy, their vibrations will become more and more **vigorous**, until the solid particles are able to shake themselves loose from their fixed positions. The forces between the particles are no longer able to hold them together tightly, and the solid **melts**.

What will happen if we add even more energy to the particles? The particles (which are now in the liquid state) will whizz around faster and faster as they heat up. Soon some of the particles near the surface will have enough energy to escape out of the liquid. Once they are free from the forces that hold them together in the liquid state, they enter the gas (or gaseous) state. The gaseous state is sometimes called the **vapour** phase, which forms when a liquid **evaporates**. This is why the gaseous state of water is sometimes called water vapour.



Clothes hanging outside.

The higher the temperature of the liquid, the faster it will evaporate. A puddle of water will evaporate much faster from the hot pavement than it would from a cool kitchen floor! Why do you think we hang washing outside in the sunshine to dry?

TEACHER'S NOTE

Discuss this with your class. They may simply answer that the sunshine dries the laundry faster, but ask them why they think this happens. It is because the heat from the Sun warms the molecules of the water that is in the wet clothing. When the water molecules are heated, the molecules gain enough energy to escape from their liquid state and the water evaporates. This evaporation will happen much faster outside, in the sunshine, than inside. Encourage them to take down notes as you discuss things in class.

Is there a difference between evaporation and boiling?

Evaporation takes place at all temperatures, while boiling occurs at a specific temperature, called the **boiling point**. When a liquid is heated to its boiling point, bubbles form in the liquid and rise up to the surface. When this happens, we say the liquid is boiling. Evaporation occurs only on the surface of the liquid, while boiling occurs throughout the entire liquid. Can you remember learning about boiling points in Gr. 7?



Boiling water.

What is the boiling point of water at sea level? Look carefully at the picture of the boiling water above. What do you think is inside the bubbles?

TEACHER'S NOTE

100°C

TEACHER'S NOTE

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

Next, we will look at the changes of state that can happen when we cool a substance.

Condensation and solidifying

When a gas changes to a liquid, the state change is called **condensation**. Condensation is the opposite of evaporation. Have you noticed the little droplets of water that form on the outside of a cold glass of water? They are formed by condensation.

When the temperature of a gas is lowered, it takes energy away from the gas particles. The movement of gas particles slows down as their energy decreases and they will start to experience attractive forces. These forces cause them to move closer to each other and they eventually return to the liquid state.



Water vapour in the air has condensed on the cold surface of this glass window.



Birds and animals in groups tend to huddle together when they get cold.

What do groups of people, animals, or birds do when they get cold? They huddle together! In the same way gas particles that are cooled down condense and come together to form water droplets.

What would happen if we cooled the liquid even more? By cooling the liquid, we would be removing energy from it. As the liquid particles lose energy, their movement slows down even more. As their movements become slower and slower, the attractive forces between them become stronger. The particles eventually 'lock' into position in the solid state. They can no longer move freely and are only able to vibrate in their fixed positions. We say the liquid has **solidified**.



INVESTIGATION:

What happens when we heat and then cool candle wax?

TEACHER'S NOTE

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

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

You can also use ice in this investigation.

AIM: What is your aim for this investigation?

TEACHER'S NOTE

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

HYPOTHESIS: What do you propose will happen in this investigation? This is your hypothesis.

TEACHER'S NOTE

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

MATERIALS AND APPARATUS:

- empty tin can or foil pie dish
- bunsen burner or spirit lamp
- tripod stand
- wire gauze
- candle wax
- matches

METHOD:

1. You need to write the method for this investigation. you will either plan this in a group, or your teacher might do the investigation as a demonstration. You must write down the steps for the investigation. They must be clear and allow someone else to repeat your investigation.
A possible method which learners might come up with, and which you can follow in class, is as follows: (The steps in a method must be numbered)

- Place a piece of candle wax in the tin/foil dish
 - Place the wire gauze on the tripod stand with the tin/foil dish in top of the gauze.
 - Place the bunsen burner/spirit lamp underneath the tripod stand.
 - Light the bunsen burner and allow the tin to heat up.
 - Observe the change in state at the candle wax heats up.
 - Turn off the bunsen burner and allow the wax to cool down again.
 - Record the change of state.
2. Draw a diagram of your setup for the investigation in the following space.
Remember to give your diagram a heading and to provide labels.

TEACHER'S NOTE

Learners must draw neat diagrams and label all the equipment used. The label lines must be parallel and drawn with a ruler.

RESULTS AND OBSERVATIONS:

1. What state of matter is the candle wax in at room temperature (at the start of the investigation)?
It is a solid at room temperature.
2. What happened when you heated the candle wax?
It melted.
3. What happened when you cooled the candle wax?
It solidified.
4. Would you say the melting point of candle wax is higher or lower than room temperature?
The melting point of wax is higher than room temperature as it is a solid at room temperature and needs to be heated in order to melt.

CONCLUSION:

Write a conclusion for this investigation. You must make reference to the particle model of matter in explaining the changes of state that occurred.

TEACHER'S NOTE

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



In the next activity we are going to have some fun with water balloons, but not in the usual way. We are going to blow up a balloon without blowing into it and we will make it rain inside the balloon! Sounds like magic? No, just science!



ACTIVITY: Hot water balloon

TEACHER'S NOTE

This is an optional activity. You need to be aware of the safety precautions and the fact that learners are working with hot, boiling materials.

For this activity you would need access to a microwave oven. If you do not have one at school or at home, learners could do this activity as a homework assignment if they have microwave ovens at home. An alternative would be to place the balloon in a pot with boiling water for a few minutes.

MATERIALS:

- large party balloon (plus spares)
- 2 teaspoons of tap water
- microwave oven
- oven gloves
- safety goggles
- large bowl of ice cold water



Let's have some fun with balloons!

INSTRUCTIONS:

1. Before you begin, put on your safety goggles.
2. Pour water into the balloon and squeeze out all the air before tying a knot in the neck of the balloon.
3. Place the balloon in the microwave oven and heat on full power until you see the balloon starting to expand. Only a few seconds of heating should be enough for the balloon to reach its full size (if you heat it for too long it might pop). What do you observe?

The balloon expands.

4. Remove the heated balloon with the oven glove. Shake it gently. If you are very quiet you will hear something happening inside the balloon. What does it sound like?
It sounds as if it is raining inside the balloon.
5. Place the balloon in the bowl of cold water. What do you observe?
The balloon shrinks.

QUESTIONS:

1. Did the balloon have any air inside it at the start of the experiment?
No, the balloon did not have any air inside it because all the air was squeezed out before we started to heat it.
2. What made the balloon expand?
The balloon expanded because the water inside evaporated, filling it with vapour (gas).
3. What is the name of the gas that made the balloon expand?
Water vapour or steam.
Note: Here is another opportunity to address the misconception that water decomposes into hydrogen and oxygen gas when it boils.
4. What did you hear inside the balloon when it started to cool down?
It sounded as if it was raining inside the balloon.
5. What caused the sound?
Water droplets falling inside the balloon.
6. Where did the water droplets inside the balloon come from?
The water vapour condensed inside the balloon to form droplets of liquid water.
7. What happened to the balloon when it was cooled down in the cold water?
It shrank back to its original size.
8. Which changes of state did the water undergo in this experiment?
Evaporation and condensation.

Next, we are going to look at three important properties of matter that are useful to scientists, namely density, mass and volume. These three properties are all related to each other.

2.4 Density, mass and volume

You have probably heard the terms **mass** and **volume** before in Natural Sciences and Mathematics. But what about **density**? Have you ever used this word before? Perhaps you have heard someone describe a cake as very dense? What does this mean?

This section introduces us to **physical quantities** that are important when we study science. Two of these quantities, namely mass and volume, are fundamental properties of matter. We are going to discuss them first, then we will introduce density. Density is another property of matter that is very closely related to the first two.

Mass tells us 'how much' matter we have



Look at the picture of a bag of rice. How much rice is in the bag? The mass of an object or a substance tells us how much matter it consists of. The greater the mass of an object, the more matter it contains.

TEACHER'S NOTE

1 kg of rice

VISIT

An interesting video on how to define a kilogram (by using the world's roundest object!) bit.ly/19e6zGs

Mass is measured in kilograms (kg). When we measure the mass of small objects or small amounts of matter we often measure in grams (g) or even milligrams (mg).

- One kilogram is the same as 1000 grams.
- One gram is the same as 1000 milligrams.

How many milligrams are in one kilogram?

TEACHER'S NOTE

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



Gold bars each with a mass of 250 g. How much is this in kg?

If one gold bar has twice the mass of another gold bar, then it contains twice as many gold atoms. The mass of an object stays the same, no matter where it is. Unless a piece of it is cut off, the same gold bar will have the same number of gold atoms whether it is in Gauteng, Bloemfontein, London, or the Moon. That means the mass will always remain constant.

TEACHER'S NOTE

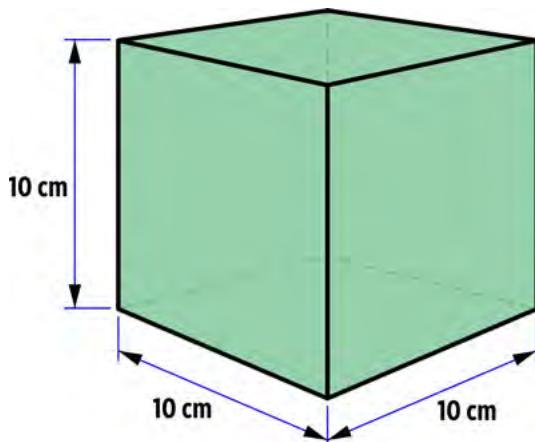
This is fundamentally different to weight, which is dependent on gravity, so the weight of an object will change when we are on Earth or on the Moon. Everyday language confuses the terms mass and weight, especially when talking about body 'weight'.

TEACHER'S NOTE

$250 \text{ g} = 0.25 \text{ kg}$.

Volume tells us 'how much space' matter takes up

The amount of space that an object occupies is called its volume. Volume is measured in litres and is calculated by multiplying the length, width and height of an object. A litre is the space inside a cube that is 10 cm wide, 10 cm long and 10 cm deep.



This cube has a volume of 1 litre.



A carton of milk and a bottle of juice.

TAKE NOTE

When calculating volume, $1 \text{ cm} \times 1 \text{ cm} \times 1 \text{ cm} = 1 \text{ cm}^3$. This is the same as 1 ml. That means that $10 \text{ cm} \times 10 \text{ cm} \times 10 \text{ cm} = 1000 \text{ cm}^3$ which equals 1000 ml or 1 litre.

What is the volume of milk in the carton and the volume of juice in the bottle in the following photo?

When we measure small volumes we use millilitres (ml) as the volume unit. 1000 millilitres is the same as one litre.

TEACHER'S NOTE

Milk is 1 litre and juice is 1.5 litres.

TAKE NOTE

We can also use symbols for density (D), mass (m) and volume (V), so the equation to calculate density can be written as $D = m/V$.

Density tells us how 'tightly packed' a material is

Density is a measure of how much mass of a material fits into a given volume. We say density is the ratio of mass to volume. We can write a mathematical relationship to show this ratio as follows:

$$\text{density} = \text{mass}/\text{volume}$$



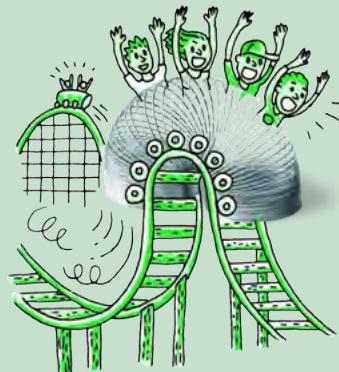
A dense piece of cake.

If we have two materials with the same volume, the material with a higher mass will be more dense. It will have a higher density. We can think of density as the 'lightness' or 'heaviness' of objects of the same size.

Think back to the slice of cake that we spoke about as being dense. This is how we can use the word density in everyday language. A piece of cake that is described as dense will feel heavy.

In the next activity we are going to compare different materials that have the same size (or volume), but different densities.

ACTIVITY: Which material is more dense?

**TEACHER'S NOTE**

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

MATERIALS:

A variety of objects that have the same size (volume) but different densities: sponge, polystyrene, wood, metal, brick or stone.

TEACHER'S NOTE

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

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

INSTRUCTIONS:

1. Handle all the different materials and compare their masses. You do not have to measure their masses on a scale. You can just feel how heavy they are in your hand.
2. Arrange them in order of increasing density. Do this activity as a group and discuss why some materials are more dense than others.
3. If you do have access to a triple beam balance, measure the masses of each of the objects.

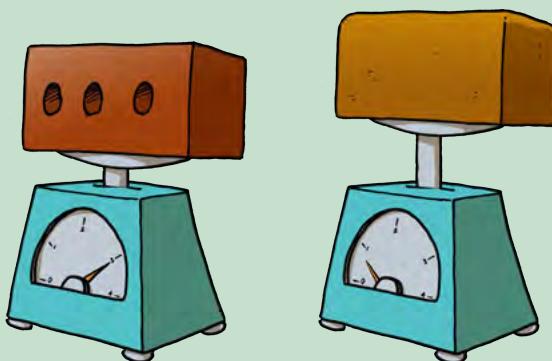
TEACHER'S NOTE

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

QUESTIONS:

TEACHER'S NOTE

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



1. Imagine a brick and a loaf of bread that are the same size. Would the brick or the bread have a greater volume?

If they are the same size, it means they have the same volume.

2. Which one, the brick or the bread, has more mass?

The brick has more mass.

3. Which one, the brick or the bread, would have the greater density? Explain your answer.

The brick would have the greater density. If we compare two objects of the same size, the one that is heavier (has more mass) has the greater density.

VISIT

Learn more about density
with this simulation
bit.ly/142lxv5

TEACHER'S NOTE

Here are some tips for teachers for the density simulation¹ bit.ly/1csJiSt

2.5 Density and states of matter

We have now learnt about the three states of matter and the properties of each. We know one of the ways in which solids, liquids and gases are different from each other has to do with the distances between the particles in each respective state. The particles in gases are much further apart than the particles in liquids or solids.

Does this mean the different states of matter have different densities? We will find out in the next activity.

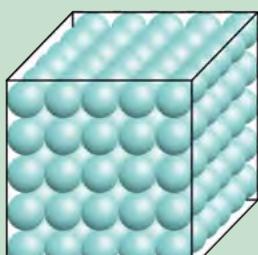
ACTIVITY: Which has the highest density: a solid, a liquid or a gas?

TEACHER'S NOTE

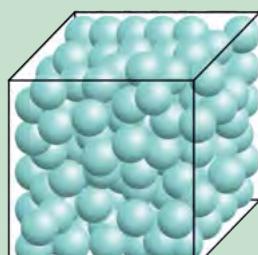
This activity is used to explain the general property that solids are more dense than liquids which are more dense than gases. It is mentioned that the boxes contain the 'same material', which is important. Water, is specifically not mentioned in this activity, as it is an exception which will be discussed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

INSTRUCTIONS:

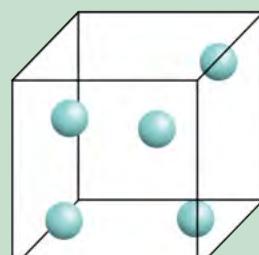
1. Compare the three identical containers below.
2. They all have the **same volume** and contain the **same material**
3. Container A contains a solid material, container B contains the liquid state of that material and container C the gaseous state of the same material.
4. Answer the questions that follow.



A.



B.



C.

QUESTIONS:

- Which container (A, B or C) contains the greatest number of particles?
Which container contains the smallest number of particles?
Container A contains the most particles and C the least.
Note: If learners are unsure, they can do a rough count or estimate of the number of particles in the containers. They must keep in mind that in reality, the number of particles would be impossible to count. It is important that they realise that the density of a gas is significantly lower than the densities of the other two phases.
- Which container (A, B or C) contains the material with the greatest mass?
Which container has the smallest mass? Why do you say so?
The container with the most particles would contain the greatest mass; therefore A contains the greatest mass and C the smallest.
- Which state has the highest density: solid (in container A), liquid (in container B) or gas (in container C)? Which state has the lowest density?
Why do you say so?
The solid has the highest density because it has the greatest mass. The gas has the lowest density because it has the smallest mass in the same volume.

We have just performed a conceptual activity (a 'thinking' activity) in which we compared the densities of the three states of the same material.

TEACHER'S NOTE

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

You could do the demonstration in the video yourself, in class. Do not tell the learners that the 'mystery liquid' is vegetable oil but rather let them try to identify it.

The high density of a solid material explains why it cannot be compressed. The particles in a solid are tightly packed and cannot be squeezed closer together into a smaller volume.

Liquids are also very dense. The density of a liquid is roughly the same as the density of the solid state of the same substance. This is because their particles are close together, even though they are not locked into fixed positions. Most liquids cannot be compressed into smaller volumes.

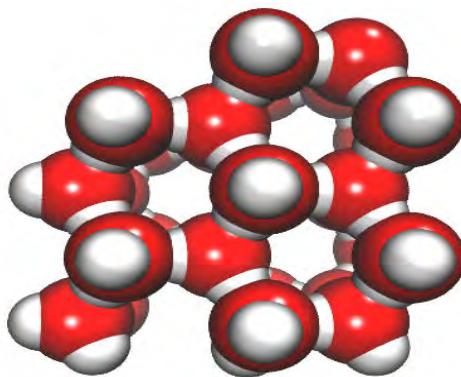
**VISIT**

Light ice, heavy water!
(video) bit.ly/1AyKxP

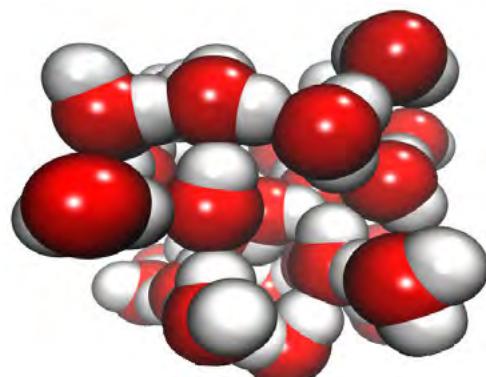
Ice blocks floating in a glass of water.

Liquids are slightly less dense than their solid states but water is an important exception. Have you ever wondered why your ice cubes float on top of the water in your glass?

The solid state of water (ice) is less dense than the liquid, because in ice the water molecules are packed in a unique way. The image below on the left shows that water molecules in ice are packed in such a way that there are open spaces between them. On the right, the same water molecules are shown in the liquid state.



Water molecules in the solid state (ice).



Water molecules in the liquid state.

Do you see how there are bigger spaces between the water molecules in a solid than in a liquid? This also helps to explain why icebergs are able to float in the sea.

Have you ever seen a frozen bottle of water with the ice pushed up out of the bottle? Why did the water push out of the bottle when it turned to ice?



A big floating iceberg in the Arctic.

TEACHER'S NOTE

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

Gases are not very dense at all because of the large spaces between the gas particles. That means they contain a small number of particles in a large volume. This is why gases can be compressed: their particles can be squeezed closer

together to fit into a smaller volume. Think back to the air that is compressed to fit inside a gas tank for a scuba diver.

In the activity 'Which has the highest density, a solid, a liquid or a gas?' we compared the densities of different states of the same material. This is an easy comparison because the particles in the different states are identical. By comparing the number of particles in the same volume of each state, we can determine the density of each state.

The densities of different materials are slightly more difficult to compare, because different materials consist of particles with differing masses.

2.6 Density of different materials

TEACHER'S NOTE

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

We are now going to do a practical activity (a 'doing' activity) to compare the densities of a solid, a liquid and a gas. It would be quite difficult to compare the three states of the same material, as the material would have to be at three different temperatures to be in three different states! For this reason we will compare three different materials: sand, water and air.

INVESTIGATION:

Comparing the densities of sand, flour, water and air



INVESTIGATIVE QUESTION:

Which material has the highest density: sand, flour, water or air?

TEACHER'S NOTE

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

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

HYPOTHESIS:

What do you predict: Which material has the highest density: sand, flour, water or air?

IDENTIFY VARIABLES:

1. Which variables must be kept constant to make this a fair test?
If a fixed volume (same size cup) of each material is used, then volume is the constant or fixed variable. The cups must all be made of the same material so that they have the same masses.
2. What is the independent variable? (what is it that you have control over to change in this investigation?)
The independent variable is the type of material.
3. What are the dependent variables? (Which variables will you be measuring?)
Mass is measured and used to calculate density.

MATERIALS AND APPARATUS:

- four identical cups (paper or plastic)
- sand
- flour
- tap water
- triple beam balance or scale

METHOD:

You will be designing this investigation yourself. If you are working in groups, you need to first discuss how you are going to conduct (carry out) this investigation. This is the planning. Write down your proposed method in your notebook or on scrap paper. Discuss this with your teacher. Remember to also think about how you are going to record your results. After you have conducted the investigation, write down your method on the lines provided here. Summarise each step in sequence and number the steps.

TEACHER'S NOTE

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

RESULTS AND OBSERVATIONS:

What were the results of your investigation? Summarise them below. You can draw a table. If you were able to measure the mass of each cup, show your calculations for the density of each material.

TEACHER'S NOTE

If learners were able to measure the masses of the cups containing different materials, then they must calculate the densities using the equation $D = m/V$.

An example of a calculation might look like this:

Mass of cup of flour = 150 g

Volume of cup = 250 mL

$$D = m/V$$

$$= 150/250$$

$$= 0,6 \text{ g/mL}$$

ANALYSIS AND EVALUATION:

1. Did anything go wrong during the experiment? If so, what?
Learner-dependent answer.
2. Can you think of anything that could have improved this experiment?
Learner-dependent answer.
3. What steps did you include to ensure fair testing?
Learner-dependent answer. They should include something about using the same cup for each measurement.

CONCLUSION:

What is your conclusion? (What is your answer to the investigative question?)

TEACHER'S NOTE

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



In the last investigation we saw that two solids, namely sand and flour have different densities as they are different materials. But what about liquids? Do all liquids have the same density or does the type of material of the liquid affect the density?

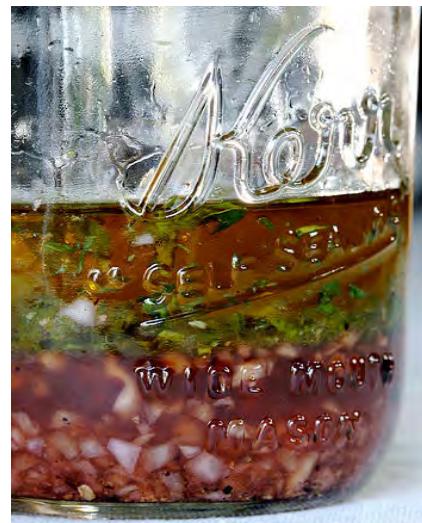
Have you ever noticed that oil floats on water?

VISIT

Create your own fluid simulation of oil and water.
bit.ly/15Ry2LR



Oil floats on water.



This homemade salad dressing contains oil that floats on top.

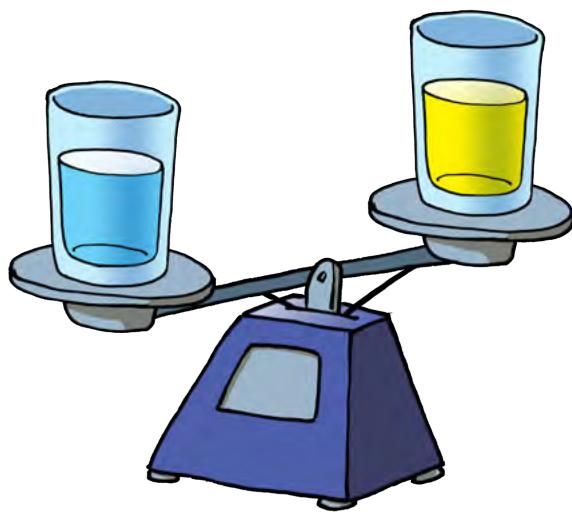
When you mix oil and water, as in the picture of the salad dressing the two materials will eventually separate because they do not mix well. They are **immiscible**. When they separate, the oil will always float on top. The two separate layers of water and oil are referred to as 'phases', the oil phase and the water phase.

TEACHER'S NOTE

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

Oil floats on water for two reasons:

- A cup of oil has less mass than a cup of water. The oil is less dense than water. This makes oil float on water, like a cork or an air-filled rubber duck floats on the surface of the water.



- Oil does not dissolve in water. The oil molecules **cluster** together and float on the surface. If a large amount of oil is poured into water, the oil will spread out and form a layer on the surface of the water. Oil that is spilled into the ocean or a lake spreads over a huge area. It poisons many animals, birds, fish and plants and is very expensive to clean up. That is why oil pollution has an extremely negative **impact** on our environment.



Oil pollution forms a thin layer on the surface of the sea water. The oil can spread out over a huge area as the layer is thin and it floats on top of the water.



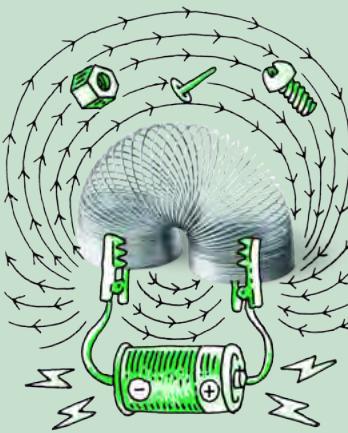
A sea bird trapped in the oil from a spill. The oil gets in between the bird's feathers, sticking them together and preventing the bird from flying.

When two substances are in the same container, but not mixed (like oil and water for instance), they will form two layers. In a certain sense, water and ice also form two 'layers'. Which layer will be on top: the one which is more dense or the one which is less dense?

TEACHER'S NOTE

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

In the next activity we look at how we can layer different liquids on top of each other depending on the densities!



ACTIVITY: Rainbow density column

TEACHER'S NOTE

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

MATERIALS:

- large glass vase or one litre glass measuring cylinder
- plastic cups
- honey
- golden syrup
- whole milk
- dish washing liquid
- water (can be coloured with food colouring, blue for example)
- vegetable oil
- rubbing alcohol (can be coloured with food colouring, red for example)
- a bolt
- a popcorn kernel
- a cherry tomato
- some plastic beads
- a ping pong ball/polystyrene ball

INSTRUCTIONS:

TEACHER'S NOTE

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

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

VISIT

A video showing how to make a rainbow density column. bit.ly/14oGnEu

1. Use the same amount of each liquid. The amount will be determined by the height of the vase or measuring cylinder. Pour equal volumes of each liquid into the cups.
2. If you have access to a scale, measure the mass of each cup with a different liquid. Arrange them in order from heaviest to lightest.
3. Start with the heaviest liquid (honey) and pour it into the container first. Be careful not to let any of it touch the sides of the container.
4. Next pour in the next heaviest until you have poured all the liquids into the container. If you have a pipette, use it to carefully layer the liquids.

- Stand the column on a desk and carefully drop in the bolt, popcorn kernel, cherry tomato and beads. Take note of where each object settles in the density column.
- Finally, drop the ping pong/polystyrene ball on top.

QUESTIONS:

1. Use the space provided to make a drawing of the density column that you made in class. Use coloured pencils if you have them. Label each layer. If you measured the mass of each liquid, write the mass in brackets after each label. Draw in the different objects to show where they dropped to in the density column.

- Which liquid is the most dense and which is the least dense? Explain your answer.

The honey is the most dense as it is at the bottom; the rubbing alcohol is the least dense as it floats on top of the other layers.

- Do you notice any relationship between the mass and density of the different liquids?

Yes, there is a relationship. In equal volumes of the liquids, the liquid that is the heaviest is the most dense.

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

- Arrange the objects from most dense to least dense. Explain how you did this.

Dependent on objects used. If the suggested ones are used, the order would be: bolt, popcorn kernel, cherry tomato, beads, ping pong ball. The most dense objects will be at the bottom and the least dense at the top.

- Why do you think the objects dropped to different levels in the liquid?

The objects drop to the different levels depending on their densities. The metal bolt is more dense than any of the liquids so it sinks to the bottom. The other objects will sink to the layer at which their density is equal to that of the liquid.

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

- Which objects are more dense than water? Which objects are less dense than water?

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



ACTIVITY: Some density calculations

TEACHER'S NOTE

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

INSTRUCTIONS:

1. Below is a table with some different substances and their densities. Use this information to do the following calculations.
2. Show how you worked out each answer and do not forget to include the units in your answer.

Material	density (g/mL)
water (liquid)	1
ice	0.917
glass	2.6
salt	2.2
chalk	2.36
coal	1.5
cork	0.25

QUESTIONS:

1. You have a 500g block of butter at home. You found out that its volume is 555mL. What is the density of the butter?
$$D = m/V$$
$$= 500/555$$
$$= 0.9 \text{ g/mL}$$
2. Which is more dense, salt or chalk?
Chalk is more dense.
3. You have a large glass marble and you want to find out what its volume is. You measure the mass and find it to be 50 g. What is its volume?
Density of glass = 2.6 g/mL.
$$D = m/V$$
$$V = m/D$$
$$= 50/2.6$$
$$= 19.2 \text{ mL}$$
4. You have a piece of coal and a piece of cork which are exactly the same size. They have the same volume of 100 mL. Which one will have the greater mass? Calculate the exact mass of each piece.

The coal will have the greater mass as it has a higher density.

Mass of coal:

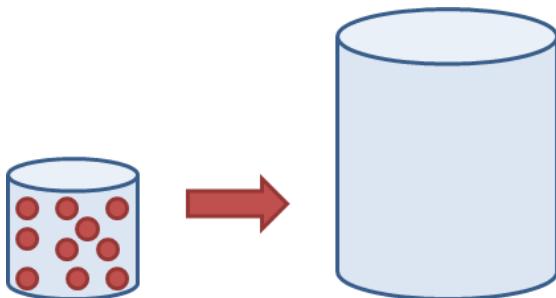
$$\begin{aligned}m &= DV \\&= 1.5 \times 100 \\&= 150 \text{ g}\end{aligned}$$

Mass of cork:

$$\begin{aligned}m &= DV \\&= 0.25 \times 100 \\&= 25 \text{ g.}\end{aligned}$$

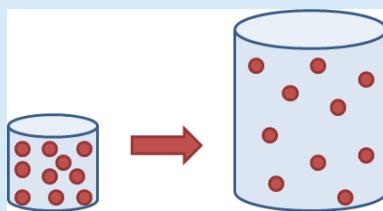
We have learnt that the density of a material depends on how tightly packed the particles inside the material are. The more tightly packed they are, the more dense we say they are.

The following diagram represents a container (on the left) that contains a small amount of gas. Imagine that all the gas from the small container is moved into the empty container on the right. Draw the gas particles in the container on the right.



TEACHER'S NOTE

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



A gas will expand to fill whatever space it is in. In the larger container we will still have the same number of gas particles, but now they are filling a much larger space.

If we take a certain amount of gas from one container and place it into another, larger container, the gas expands to fill the larger container. The same mass of gas is now in a larger volume, the gas now has a lower density.

Solids and liquids cannot behave in this way. Their densities will remain more or less constant no matter in which container they are placed. This is because their particles are relatively close together with strong forces between them. But what happens when we heat them? We have learnt that this is the same as giving them extra energy. How will heating them affect the packing of the particles and the density?

TEACHER'S NOTE

Get learners to discuss this question. They have learnt that particles move faster at higher temperatures. How would this affect the spaces between particles? Most solids and liquids tend to become less dense as they warm up. The learners do not need to come to any conclusions at this point. The question will, however, help to introduce the concepts of contraction and expansion.

In the next section we are going to look more closely at what happens to the particles inside materials when they expand. We are also going to look at the opposite of expansion, namely contraction.

2.7 Expansion and contraction of materials

Have you ever been inside a tin-roofed house? On a hot days, you often hear the metal roof panels groan and creak. Do you know why this happens?

Some materials become slightly larger when they are heated. We say they **expand**. Materials can also shrink slightly when they are cooled. We say they **contract**.



A house with a tin roof.

The metal roof panels expand and contract as the outside temperature changes. When this happens, the panels scrape against each other and against the nails that keep them in place. The scraping of metal against metal causes the creaky, groaning noises.

How is it possible for materials to contract and expand? Can you think of an explanation?

TEACHER'S NOTE

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

To understand this phenomenon, we will look at some examples of expansion. We will then try to explain expansion in terms of the particle model.

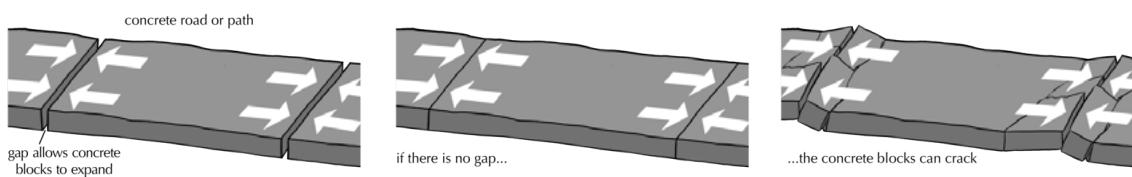
Some solids expand more than others. When we choose materials for a new job,

it is important to know how much they will expand. This way we can allow for expansion when the materials get hot.

In the following diagram, the picture on the left shows a concrete path or road surface. How have the engineers who built the road allowed for expansion?

TEACHER'S NOTE

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



Expansion can create forces strong enough to damage materials.

The picture above shows what could happen if no allowance is made for the expansion of the concrete blocks. The forces created by the expansion of the concrete are so strong that the road surface has cracked!



The expansion joint in a bridge.

This is a very important principle to remember when building bridges. When engineers design a bridge, they must allow for contraction and expansion of the materials used to build the bridge. Have a look at the following photo showing a close-up of the gap between the two road surfaces of a bridge. Can you see the interlocking 'teeth'? These allow the bridge to expand and contract while the teeth slide past each other.



ACTIVITY: How much longer?

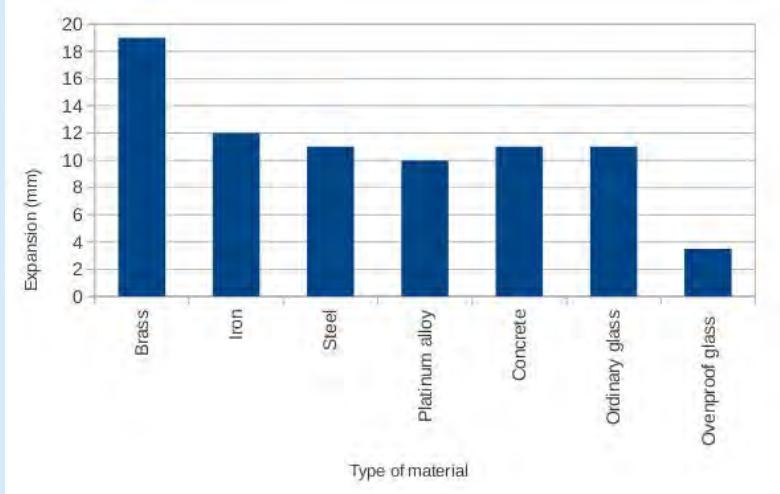
In this activity we will compare the expansion of different solid materials by drawing a graph. You will need the following information for your graph:

Material	How far a 100 metre length of the material will expand when the temperature increases by 10°C
Brass	19 mm
Iron	12 mm
Steel	11 mm
Platinum alloy	10 mm
Concrete	11 mm
Ordinary glass	11 mm
Ovenproof glass	3,5 mm

Draw a bar graph with 'Expansion' on the y-axis and 'Materials' as categories on the x-axis. Choose an appropriate title for your graph.

TEACHER'S NOTE

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



QUESTIONS:

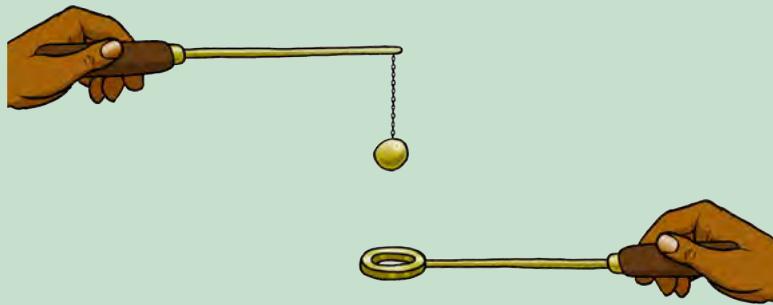
1. Which material expands the most upon heating?
Brass
2. Which material expands the least?
Ovenproof glass
3. Which solid would be the best material to **reinforce** concrete? (Hint: the reinforcing material should expand as much as the concrete, otherwise it will damage the concrete during expansion.)
Steel. It expands the same amount as concrete.
4. A man builds a house with large windows set in beautiful frames made of brass. The house is in a region where it gets very hot during summer. Imagine that the owner of the house has a problem: the windows of the house look beautiful in their shiny brass frames but they keep falling out during the summer months. As a scientist, how would you explain this and what would your advice to the owner of the house be? Should the frames be replaced? If so, with which material? What other solutions can you suggest?

From the graph and the data in the table, we can see that brass expands much more than ordinary glass. When the weather is really hot, the brass expands so much that the window glass does not fit properly anymore and falls out. You could advise the owner to try the following:

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

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

5. The following diagram shows a metal ball and ring apparatus. The ring and ball are both made of brass. At room temperature, the ball is just the right size to pass through the ring.



Do you think the ball will still fit through the ring when the ball has been heated?

The ball does not fit through the ring when the ball has been heated.

Note: This is a great way to demonstrate contraction and expansion if you have one of these at your school.

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

6. Do you think the brass ball will have more mass when it has expanded? Explain your answer.

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

- Note:** We know this because matter cannot be created (or destroyed).
7. What will happen to the brass ball when its temperature drops back to room temperature? Will it be larger than, smaller than, or the same size as before it was heated? Explain your answer.

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

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

Now that we have seen that materials can expand, how can we explain expansion of a material in terms of the behaviour of the particles in that material?

TEACHER'S NOTE

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

We have learnt that when matter is heated, the particles of that matter will move faster and push further apart from each other. What happens to the particles in matter when it is cooled?

TEACHER'S NOTE

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

When a substance cools (energy is removed), the particles in that substance will slow down and move closer together. That is why most materials contract when they are cooled.

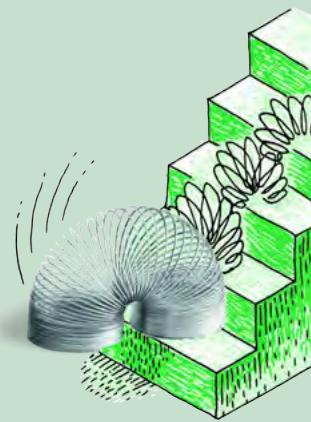
Expansion and contraction in a thermometer

Let's look at a thermometer to understand expansion and contraction.

ACTIVITY: How does a thermometer work?

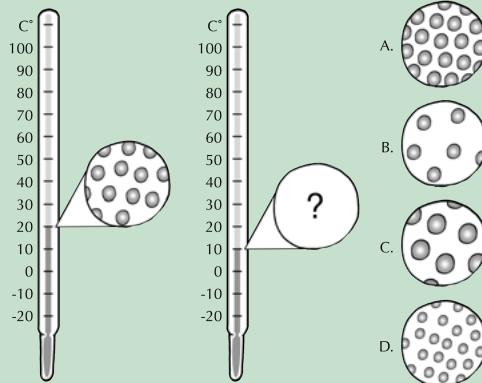
TEACHER'S NOTE

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



The common glass thermometer is called a bulb thermometer. All bulb thermometers have a fairly large bulb that is connected to a long, thin tube. The thermometer has a brightly coloured liquid on the inside. Some thermometers contain mercury as it expands and contracts quite a lot when heated or cooled.

Look carefully at the following set of diagrams. They represent the same thermometer at two different temperatures.



QUESTIONS:

1. The drawings represent the particles in the liquid inside a thermometer. What is the temperature measured on the thermometer on the left?
20°C
2. The drawing on the right is of the same thermometer, but slightly different. Can you tell the difference?
The temperature reading on the thermometer on the right is 10°C.
3. Which of the circles (A, B, C, or D) is the best representation of the liquid in the thermometer on the right? Why did you choose this one?
Circle A is the correct one. The lower temperature has made the liquid inside the thermometer contract, so the particles are closer together.

Note: This question provides an opportunity to identify learner misconceptions about expansion and contraction:

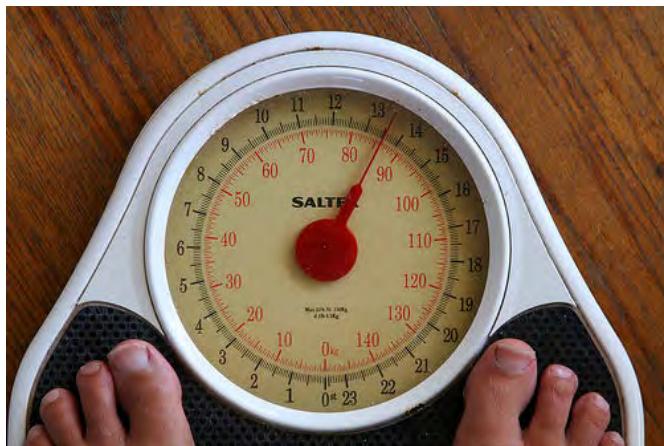
- Answer B is incorrect because the particles are further apart than in the diagram on the left. The learner may be confusing the two concepts expansion and contraction.
 - Answer C is incorrect because the particles in the diagram appear to have grown larger. This is not possible since particles cannot gain mass (matter cannot be created or destroyed), nor can they gain volume. Their mass and volume are fixed, and expansion means they move further apart; the spaces between them get bigger.
 - Answer D is incorrect because the particles in the diagram appear to have grown smaller. For the same reasons as just mentioned, this is a misconception. The spaces between particles get smaller when a material contracts.
4. Does a material have less mass when it has contracted? Explain.
No, the material cannot have less mass because it still has the same number of atoms as before and their mass is constant.
Note: This is a good time to remind learners that matter cannot be created or destroyed.
5. If the temperature was raised and the thermometer read 30°C, which circle would now best represent the particles in the liquid of the thermometer? Why?
Answer B would now represent the thermometer at a higher temperature of 30°C as the particles have gained more energy and therefore moving at greater speeds so they move further apart and the liquid expands.
6. How does the volume change when a material is heated? Why?
The volume of the material increases, because the particles move further apart. The material expands.
7. How does the density change when a material is heated? Why?
The mass does not change but the volume increases, therefore the density must decrease.
Note: It may help to refer back to the formula: density = mass/volume.

We have learnt that thinking about matter in terms of the particles inside it can help us to understand many interesting phenomena: the physical properties of the different states of matter, changes from one state of matter to another, density, and expansion and contraction.

How can we measure how much of a liquid or a solid we have? If we want to know how much of a material we have, we can measure its mass. What instrument do we use to measure mass?

TEACHER'S NOTE

A scale or a balance.



We can use a scale to measure the mass of a person or any other object.

TAKE NOTE

When a material is heated, its particles move further apart. When the material cools down, the particles move closer again. Heating and cooling cause the volume of the material to change.

Think back to the investigation comparing the densities of sand, water, flour and air. How did you measure the mass of the air in a cup?

TEACHER'S NOTE

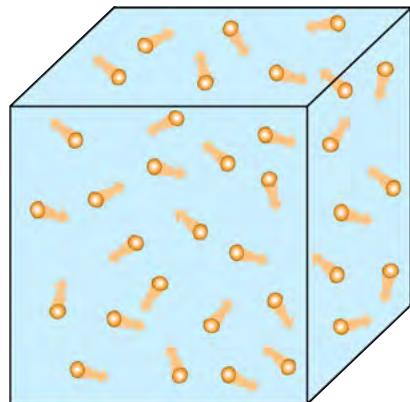
Most likely, the learners were unable to measure the mass of the air. If they managed to do so, it would probably have required quite a complicated process. They should be reminded that the air is not without mass, but that the mass of the air inside the cup is so small. (It is actually not possible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

We are now going to shift our focus to gases. Gases have much lower densities compared to solids and liquids. That means a large volume of gas will have a small mass. Small masses can be difficult to measure without a special, super-sensitive scale. Scientists have devised a different way of measuring how much of a gas they have.

2.8 Pressure

What is gas pressure?

We have learnt that gases contain millions of fast-moving particles. The following picture represents gas particles inside a container.



Gas particles in constant motion, inside a container. They collide with each other and with the inside of the container.

As the particles whizz around, they bump and bounce off each other. They also bump against the inside of the container. The force of the particles bumping against the sides of the container cause a phenomenon called gas pressure. The number of bumps (or collisions) will depend on the number of gas particles in the container. More particles inside the container means more collisions, and more collisions mean a higher pressure.

If we can measure the pressure of the gas, we will have an idea of how much gas is inside the container.

How can gas pressure be measured?

Have you ever seen anyone check the pressure in a car tyre? You may have seen them use a device like those in the photo below. It is called a tyre **pressure gauge** and it is specially designed to measure the air pressure inside a tyre.



A simple tyre pressure gauge.

The round end of the gauge should be pressed against the **air valve** of the tyre. This opens the valve and lets some of the air from the tyre escape into the gauge. The air particles bump against a disc inside the gauge. The force generated by many gas molecule collisions pushes out a bar at the back of the gauge. Can you see it in the picture? For this particular pressure gauge, the pressure inside the tyre is indicated by how far back the bar is pushed out of the back of the gauge. Note the numbers along the bar which allow us to measure the pressure.

VISIT

How to check tyre air pressure: bit.ly/1cxNqjr

Other, more complicated pressure gauges all work in a similar way.



Two more complicated types of tyre pressure gauges for measuring the air pressure inside car tyres. The right one is a digital gauge.



Measuring the pressure inside a tyre using a pressure gauge.

How could we increase or reduce the amount of gas in a container? In the next activity we are going to see if we can understand gas pressure in terms of the particle model of matter.



By blowing air into the balloon, the girl is forcing air particles into it.

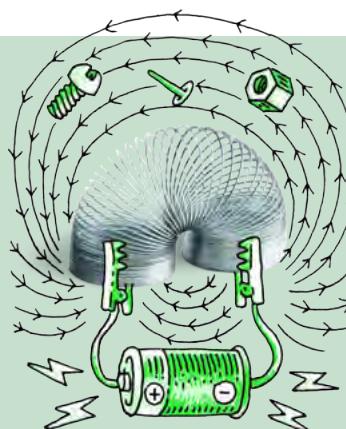
ACTIVITY: Understanding gas pressure

TEACHER'S NOTE

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

MATERIALS:

- brown paper bags (medium size)
- balloons
- empty plastic cold drink or water bottles (2-litre bottles are preferable)
- bicycle pump and tyre



INSTRUCTIONS:

1. This step requires a brown paper bag.
 - a) Blow up a brown paper bag until it is fully inflated.
 - b) Try blowing it up even more. See if you can make it pop by blowing into it.
 - c) Write two or three sentences to describe what it feels like to blow into the bag when it is 'empty', compared to when it is 'full' of air. Does it feel different? Is it more difficult to blow into the bag when it is already full?

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

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

2. This step requires a balloon.
 - a) Blow up the balloon until it is the size of an orange. Pinch it closed but do not tie a knot in the top.
 - b) Now blow up the balloon as large as you can.
 - c) Try blowing it up even more. See if you can make it pop by blowing into it.
 - d) Write two or three sentences to describe what it feels like to blow into the balloon when it is 'empty', compared to when it is 'full' of air. Does it feel different? Is it more difficult to blow into the balloon when it is already full?

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

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

- e) Tie a knot in the top of an inflated balloon. Leave the balloon in the classroom and examine it again after one week. Does it look the same as when you inflated it a week ago? Perhaps it looks a bit like this balloon in the following photo:



A deflated birthday balloon.

- f) Remember to write your observations below.

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

3. This step requires a balloon and an empty plastic bottle.
 - a) Stretch the balloon over the top of the bottle, with the balloon

hanging down into the bottle.

- b) Blow into the balloon. What do you observe? Can you blow up the balloon?
It is impossible to blow up the balloon.
- c) Now make a small hole in the bottom of the bottle. Blow into the balloon again. What do you observe now?
The balloon swells up and fills the inside of the bottle.

- 4. This step requires a bicycle tyre and pump.

- a) Use the pump to pump air into the tyre. Continue to pump until it becomes too difficult to pump any more air into the tyre.
- b) Write 1 or 2 sentences about your observations.

At first it is easy to pump air into the tyre but, the more you pump, the more difficult it becomes.

QUESTIONS:

Try to answer the following questions by explaining what is happening to the air particles in each case. Use the words 'particles', 'collisions' and 'pressure' in your answers.

- 1. What happens when you blow up a paper bag or a balloon, or when you pump air into a tyre?

Air particles are forced into the bag, balloon or tyre. The more you blow, the more particles are pushed into the bag, balloon or tyre. If there are more particles, there will be more collisions, and that means the pressure will be greater.

- 2. When you blow into a paper bag, why does the bag pop or start to leak air after a while?

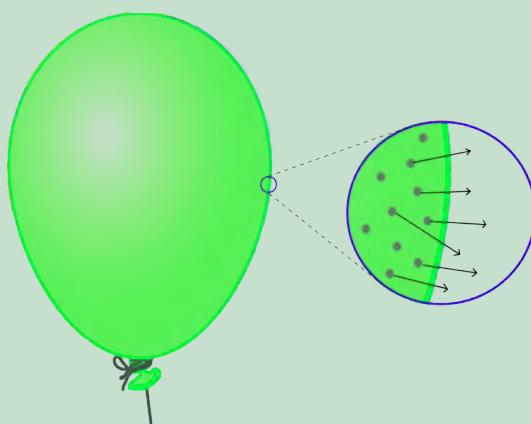
When the bag contains as many particles as it possibly can and we try to force even more particles into the bag, the force of the collisions of the particles against the inside of the bag becomes too much and the bag breaks.

- 3. When you blow into a balloon that is fully inflated, why does the balloon pop?

When the balloon contains as many particles as it possibly can, it will be stretched to its maximum size. If we try to force even more particles into the balloon, the force of the collisions of the particles against the inside of the balloon becomes too much and the balloon pops.

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

- 4. Why do you think the balloon became smaller when it was left for a week? The following diagram should provide a hint:



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

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

5. Explain why you think it was impossible to blow up the balloon inside the bottle? Why was it possible to blow up the balloon when there was a hole in the bottle?

The balloon does not inflate much because the bottle is already filled with air. There is no room for the balloon to expand inside the bottle. The air particles inside the bottle push back against the air particles inside the balloon. When the bottle has a hole in it, the air particles inside the bottle can be pushed out through the hole, as the balloon fills the space inside the bottle.

6. Why does it become more and more difficult to pump air into the bicycle tyre?

The more you pump, the more particles are pushed into the tyre. If there are more particles, there will be more collisions, and that means the pressure will be greater. The tyre will stretch to accommodate more air particles, but it will become more and more difficult (require more and more force) to stretch the tyre material.

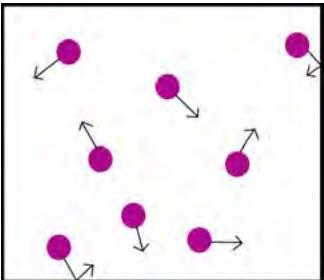
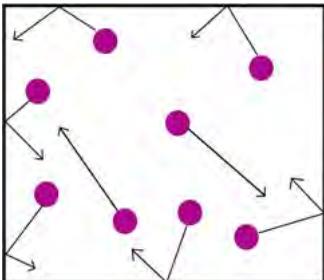
TEACHER'S NOTE

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

How does heating or cooling a gas change its pressure?

If the gas is heated, the particles will move faster as they gain more energy. That means they will collide with the inside of the container more often and with more force. This causes an increase in pressure.

If the gas is cooled, the particles will move more slowly, because they will have less energy. The gas pressure will decrease, because the particles will bounce against the inside of the container less frequently and with less force. Look at the following table which illustrates this.

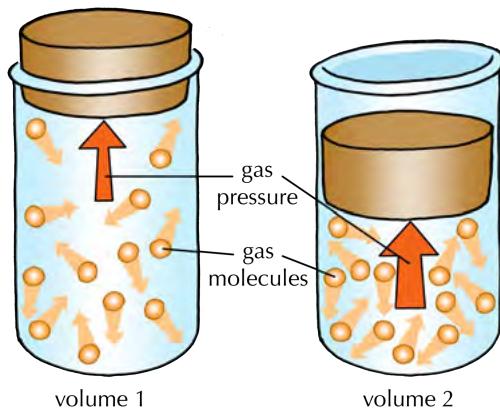
Cool gas	Hot gas
	

Fewer and less energetic collisions.

More and more energetic collisions.

How does changing the volume of a gas change its pressure?

When a gas is squeezed into a smaller volume, the particles have less space to move. This is shown in the diagram below. Have you noticed that when people are squashed into small spaces, they bump into things more often? In the same way, the gas particles will collide more often with each other and with the inside of the container if they have less space to move in. More collisions means increased pressure!



We have learnt that a gas will expand to fill all the available space. So, what will happen if we take a certain amount of gas out of one container and place it into another container that is twice as large?

TEACHER'S NOTE

The gas will expand, filling the larger container.

We still have the same number of gas particles, but now they are inside a much larger volume. There is twice as much space between the molecules as there was in the smaller container.

What has happened to the density of the gas? Has it increased, decreased or stayed the same?

TEACHER'S NOTE

The density has decreased because the volume increased.

In this chapter, we learnt how many different physical properties of matter can be better understood when we think in terms of the behaviour of the particles in the matter.



SUMMARY:

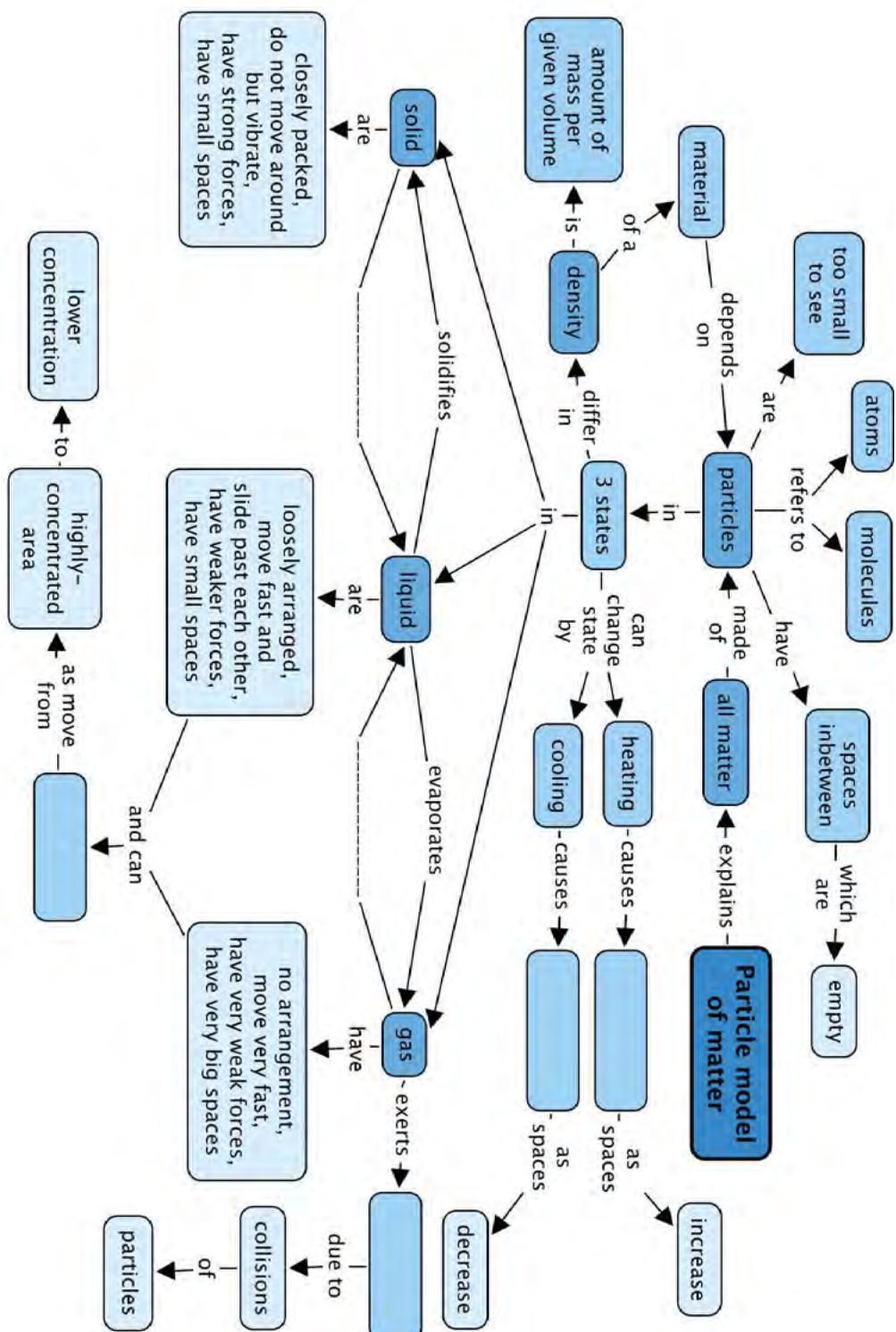
Key Concepts

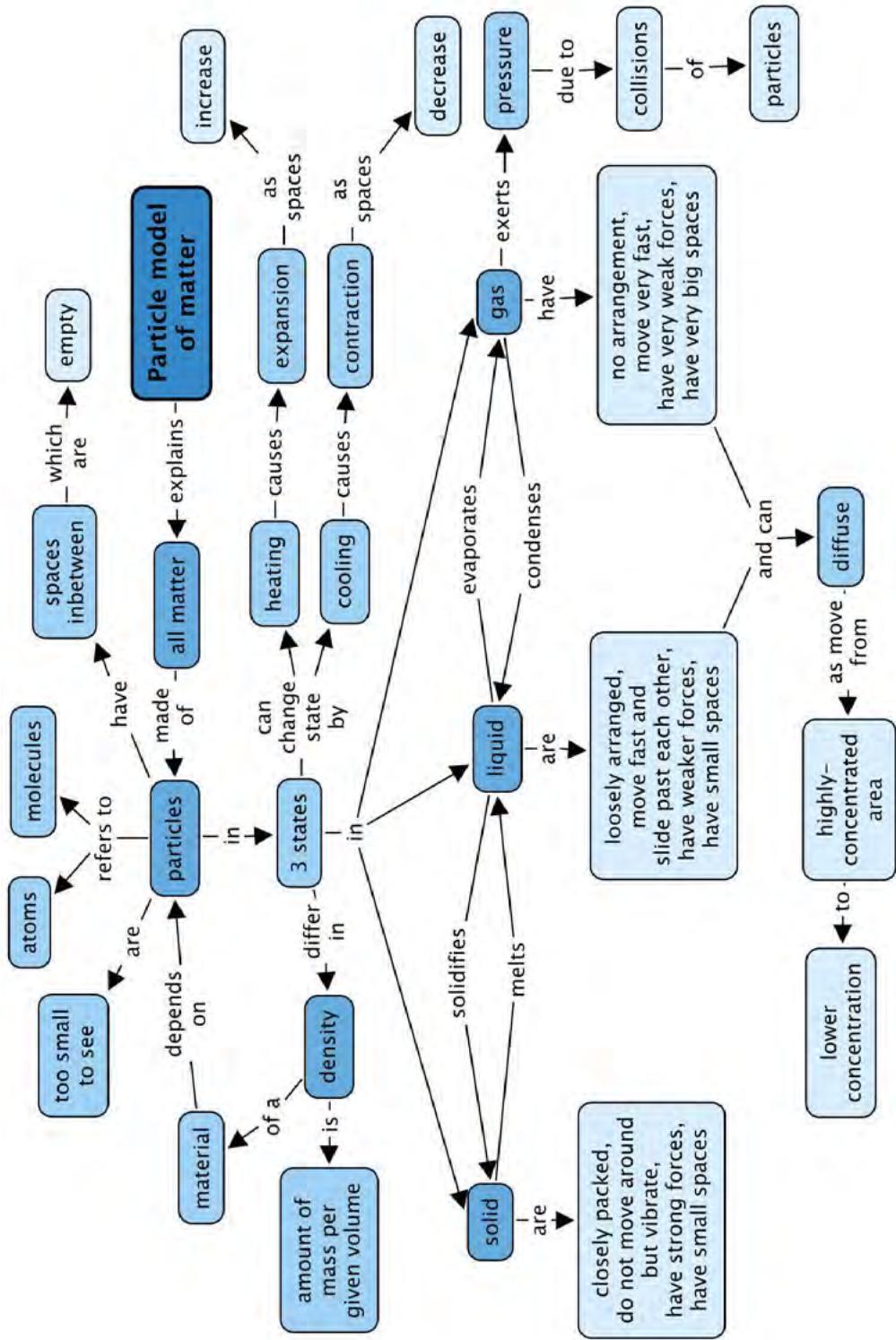
- 
- All matter can be described in terms of the particles it consists of, and how they are arranged. These extremely small particles are called atoms or molecules, depending on the type of material.
 - The theory that describes matter in terms of particles is called the particle model of matter. It helps us to understand the macroscopic properties of a material in terms of the behaviour of the particles in that material.
 - The particle model describes the particles in **solids** as follows:
 - They are closely and regularly packed and locked into position;
 - The only movement they are allowed is vibration;
 - They are held together by strong forces; and
 - The spaces between them are very small.
 - The particle model describes the particles in **liquids** as follows:
 - They are close together but not locked in position;
 - They are in constant motion and slide past each other;
 - They are held together by moderately strong forces; and
 - The spaces between them are very small (in most cases only slightly larger than the spaces between solid particles).
 - The particle model describes the particles in **gases** as follows:
 - They are in constant fast motion;
 - They are not arranged in any way but free to move;
 - The forces between them are weak; and
 - They are far apart with large empty spaces between them.
 - Since the particles of liquids and gases are in constant motion they are able to diffuse. Diffusion is a process in which particles spread out, through random movement from high to low concentration, until they are evenly distributed.
 - When two substances mix, their particles intermingle until their composition is uniform throughout. This is also called diffusion, and the process is much faster in gases than in liquids, because the particles in gases are further apart.
 - Changes of state are usually the result of heating or cooling:
 - When a solid is heated it will change to a liquid (in a process called melting) and, when heated further, the liquid will change to a gas (in a process called evaporation).
 - When a gas is cooled it will change to a liquid (in a process called condensation) and, when cooled even further, the liquid will change to a solid (in a process called freezing).

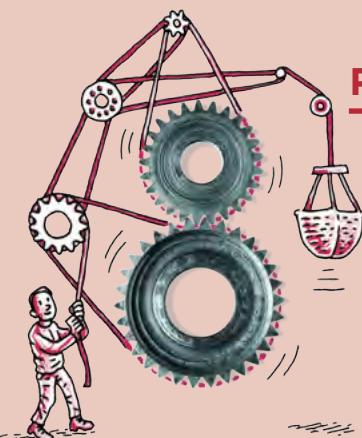
- The density of a material is a measure of its 'relative heaviness'. Denser materials have a greater mass in relation to their size; that is why they feel 'heavy'.
- The density of a material depends on two things:
 - the mass of the individual particles of that material - the larger the mass, the denser the material; and
 - the size of the spaces between the particles in the material - the larger the spaces, the less dense the material.
 - These explain how to calculate density, namely density = mass/volume
- Materials with a loose texture (like bread and sponge, for example) have empty spaces or holes inside them, which means they have less mass in relation to their volume. These materials tend to be less dense.
- Materials that are less dense always float on materials that are more dense.
- The particles of matter are constantly moving. In solids these movements are limited to vibrations, but in liquids and gases the particles have more freedom.
- Most materials will expand when they are heated and contract when they are cooled. This is because heating makes the particles move further apart and cooling makes them move closer together.
- When we want to know how much of a gas we have, we can measure its pressure.
- The 'pressure' of a gas is caused by the particles of the gas colliding with the inside of a container and with each other.
- More gas particles inside the container will mean more collisions against the sides, and therefore, more pressure.

Concept Map

Have a look at the concept map that shows how the many concepts relating to the particle model of matter fit together. There are 4 empty blocks which you need to fill in.







REVISION:

1. Write your own explanation of what you think the particle model of matter tells us. [2 marks]

Use this question to see what learners understand by the model. They should mention something such as: The particle model of matter is a scientific theory which is used to explain how all matter (solids, liquids and gases) are made up of particles and how they behave in the different states. Learners could also mention something about the size of the particles, and that there are empty spaces between the particles.

2. What is unusual about water in terms of the particle model of matter?

Explain why water is an exception. [2 marks]

Water is unusual in that the solid state is actually less dense than the liquid state and so ice floats on liquid water. This is because there are large spaces between the particles in the solid state, making the ice less dense.

3. Complete the following table with the terms and definitions of different changes of state. [4 marks]

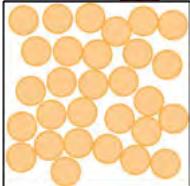
Change of state	Explanation
Melting	<i>When heat is added and a solid changes to a liquid</i>
Condensing	<i>When heat is removed and a gas changes state to a liquid</i>
Evaporating	<i>When heat is added and the particles at the surface of a liquid change to the gas state</i>
Solidifying	<i>When heat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

4. Explain what happens to the particles in a solid when heat is added to the solid and it changes to a liquid. [3 marks]

When heat is added, the particles start to vibrate faster and faster (as they gain kinetic energy), until they move fast enough to overcome the forces holding them together in fixed positions in the solid. The particles are then able to move and slide past each other as they are not held in an orderly arrangement anymore in the solid, and the solid becomes a liquid.

5. Complete the following sentence by writing it out in full again: During expansion, the spaces between the particles get _____, and during contraction, the spaces between the particles get _____. [2 marks]
During expansion, the spaces between the particles get bigger, and during contraction, the spaces between the particles get smaller.
6. How can a piece of metal get bigger (expand) and still have the same mass? Explain this in terms of the behaviour of the particles. [2 marks]
When the metal expands (because it is heated) the particles will move further apart. The piece of metal will get bigger, but it will still have the same number of particles and so it will still have the same mass. The density of the metal has decreased.
7. Why does oil float on top of water? [1 mark]
Oil is less dense than water so it floats on top of water.
8. Draw a picture to show the path of a perfume particle from a flower on one side of a room to your nose on the other. [2 marks]
Learner's picture should show random movement of the perfume particle, with many changes of direction.
9. Next time you are at the petrol station, look around for a warning sign that shows you should not light a match or use a cell phone. Why do you think it is dangerous to light a match or use a cell phone anywhere near a petrol station? [2 marks]
The petrol fumes around the petrol station are in the gas (or vapour) state. The particles in the gas can move freely and diffuse into the air around the pumps. If you light a match close to the pumps, the petrol gas can be ignited and this can cause a fire or explosion.
Note: Usually the underground fuel tanks are safeguarded against explosions and fires. Some people say that small sparks (caused by static charges) from cell phones can also cause ignition of the petrol fumes, but scientists generally do not agree.
10. If you fill a bicycle pump with air, and seal the end with your finger, the plunger can still be pushed in quite a way before the pressure forces air out of the pump. If the pump is filled with water instead of air, the plunger can hardly move. Why is this so? Try to use the words 'particles', 'spaces', and 'compress' in your explanation. [4 marks]
Air is a gas and water is a liquid. Gas particles have large spaces between them and that means they are easy to compress, or squeeze together. The spaces between liquid particles are so small that liquids cannot be compressed. That is why the plunger moves when there is air in the bicycle pump, but does not move much when the pump contains water.

11. The following table represents a summary of the entire chapter. You must complete it, using your own words and or diagrams. Some of the blocks in the table already contain information to help you form your own sentences. [18 marks]

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

Total [42 marks]



TEACHER'S NOTE

Chapter overview

1 week

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

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

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

Instructions for making clear limewater

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

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

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

3.2 Reactants and products (1.5 hours)

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



KEY QUESTIONS:

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



In the last chapter we looked at the particle model of matter and specifically at changes of state. Do you remember heating and cooling candle wax to observe it melt and then solidify. The wax first changed from a solid into a liquid and then back to a solid again. These are **physical** changes. The chemical properties of the substance does not change.

We are now going to look at what happens when we get **chemical** changes in substances. These take place during **chemical reactions**.

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

During a chemical reaction, one or more substances are changed into new substances. Do you know of any chemical reactions? Can you mention one or two examples?

TEACHER'S NOTE

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

How will we know when a chemical reaction is taking place? What are the signs?

TEACHER'S NOTE

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

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

We can tell if a chemical reaction has taken place when one or more of the following things happen:

- There has been a colour change inside the **reaction flask**.
- A gas has formed. Usually we know a gas has formed when we can see bubbles. This should not be confused with boiling, which only happens when a liquid is heated to its boiling point.
- A solid has formed. Usually we know that some solid material has formed when we can see a sludgy or cloudy deposit, or crystals forming.

TEACHER'S NOTE

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

All the signs listed above are visual, or recorded by sight. That means we can see them. Our other senses can also help us to say whether or not there was a chemical reaction:

- Sometimes chemical changes can be smelled, for instance when a new material, that has a strong smell, is formed.
- Other chemical changes can be felt, e.g. when the reaction produces heat.
- Some chemical changes can be heard, e.g. when an explosion takes place.

ACTIVITY: The difference between physical and chemical changes

TEACHER'S NOTE

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

INSTRUCTIONS:

1. Below is a table with some different chemical and physical changes listed.
2. You need to decide whether the change is physical or chemical and write the answer in the last column.

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

VISIT

Video on physical and chemical changes.
bit.ly/17Hes0x

Change	Is it a physical or chemical change?
Cutting up potatoes into cubes	Physical
Boiling water in a pot on the stove	Physical
Frying eggs in a pan	Chemical (the egg proteins undergo a chemical change and crosslink to form a network)
Whipping egg whites	Physical (air is forced into the liquid but no new substance is made)
Dissolving sugar in water	Physical (the sugar grains are dispersed within the water, but the individual sugar molecules are unchanged)
Burning gas in a gas cooker	Chemical (water vapour and carbon dioxide form)
Your ice cream melts in the sun	Physical
Milk turning sour	Chemical (lactic acid is produced)
An iron gate outside rusts	Chemical (iron oxide forms - this will be discussed in more detail in Gr. 9)

We will now put our checklist into practice by looking at a reaction safe enough to try at home. Have you ever wondered what a raw egg would look like without its shell? We are going to use a chemical reaction to strip away the shell of an egg, without breaking the egg!

ACTIVITY: Can we use a chemical reaction to see inside an egg?

MATERIALS:

- eggs
- a glass
- white vinegar





How can we make an egg look like this?

VISIT

Video on the naked egg experiment: bit.ly/16EhqUE

TEACHER'S NOTE

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

INSTRUCTIONS:

1. Carefully place the egg in the glass. Be careful not to crack the shell.
2. Cover the egg with vinegar. Wait a few minutes. Can you see anything happening on the surface of the eggshell?
 - a) Write your observations below.
 - b) What is this observation a sign of?
 - a) *The eggshell gradually becomes covered in bubbles.*
 - b) *The bubbles are a sign of a chemical reaction taking place.*

Note: *It may be necessary to top up the vinegar if the reaction starts to slow down. Remember to return to the activity at the end of the week, when the eggshell has dissolved completely.*

 3. Leave the egg in the vinegar for 4 - 5 days. You should complete the rest of the activity after this.

There is a foamy, brown layer floating on the vinegar.
 4. After 4 to 5 days, look at the egg in the vinegar and write down your observations.

The egg feels soft and wobbly. The shell disappeared because it has dissolved. In its place is a powdery coating.
 5. Carefully scoop the egg out of the vinegar with a large spoon. Touch the surface of the egg. Write your observations below. What has happened to the shell?

The egg has lost its shell and we can see the egg white and the yolk inside.
 6. Rub the powdery coating off the egg and place it in some clean water. What does it look like now?

The egg looks different. We also saw bubbles on the eggshell and afterwards there was a foamy, scummy layer floating on top of the vinegar.
 7. Draw and label pictures of what the contents of the glass looked like before and after the reaction took place.

The learners must draw pictures of the experiment at the beginning and at the end. The first picture should show an intact egg in a glass, covered with clear liquid vinegar. The second picture should show a transparent egg, with the white and the yolk clearly annotated, submerged in clear liquid vinegar with a brown layer floating on top.

QUESTIONS:

1. What signs did you see that told you a chemical reaction had taken place?

The egg looks different. We also saw bubbles on the eggshell and afterwards there was a foamy, scummy layer floating on top of the vinegar.
2. Write a short paragraph to explain what happened to the eggshell.

The learner's paragraph should contain at least the following ideas:
 - *The eggshell reacted with the vinegar and was 'eaten away'.*
 - *The eggshell dissolved in the vinegar.*
 - *The materials in the eggshell underwent a chemical change. They have changed into different materials.*

How is it possible to change one compound into another? What happens to the particles when compounds react? In the next section we are going to answer these questions.

3.2 Reactants and products

In Chapter 1 we learnt that compounds are formed by chemical reactions. Can you remember what a compound is? Write a definition here.

TEACHER'S NOTE

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

Write down the formulae of three different compounds.

TEACHER'S NOTE

Learner dependent answer. H_2O , CO_2 , NaCl , etc.

ACTIVITY: Analysing the eggshell experiment

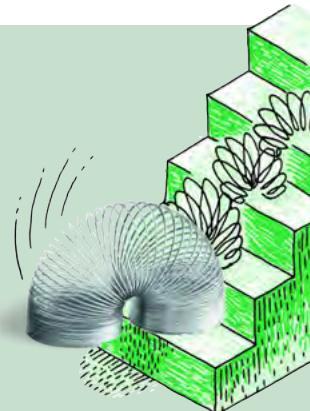
In the eggshell activity the calcium carbonate in the eggshell reacted with acetic acid and formed calcium acetate, carbon dioxide and water.

We can write this **chemical equation** as follows:



QUESTIONS:

1. There are two starting substances **before** this chemical reaction takes place. What are they?
The eggshell (calcium carbonate) and vinegar (acetic acid).
2. There are three substances present **after** the reaction. What are these?
They are calcium acetate, carbon dioxide and water.
3. What are the chemical formulae for the compounds water and carbon dioxide?
Water is H_2O and carbon dioxide is CO_2 .
4. We call the substances that are present before the chemical reaction has taken place, the **reactants**. What are the reactants of the eggshell experiment?
The eggshell (calcium carbonate) and vinegar (acetic acid).
5. What do you think happened to the reactants during the chemical reactions?
Use this to assess learner's understanding so far. They should mention that the reactants are used to make the products.



6. We call the substances that are produced during the chemical reaction, the **products**. What are the products of the eggshell experiment?
They are calcium acetate, carbon dioxide and water.
- 

During a chemical reaction, the reactants are used to make the products. The atoms in the reactants have been rearranged into new compounds (the products).

TEACHER'S NOTE

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

A chemical reaction is a rearrangement of atoms

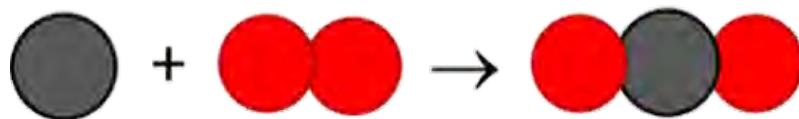
TEACHER'S NOTE

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

In order to change a compound into a different compound, we need to change the way in which the atoms in the compound are arranged. This is exactly what a chemical reaction is: a rearrangement of atoms to turn one or more compounds into new compounds.

Any time atoms separate from each other and recombine into different combinations of atoms, we say a chemical reaction has occurred.

We are going to use coloured circles to represent the atoms in the compounds which take place in chemical reactions. If you still have your beads or playdough from previously, you can also make these reactions yourself on your desk. Look at the following diagram.



We have carbon and oxygen on the left of the arrow reacting to make carbon dioxide on the right of the arrow.

To the left of the arrow, we have the 'before' situation. This side represents the substances we have before the reaction takes place. They are called the **reactants**.

To the right of the arrow we have the 'after' situation. This side represents the substances that we have after the reaction has taken place. They are called the **products**.

REACTANTS (before the reaction) → PRODUCTS (after the reaction)

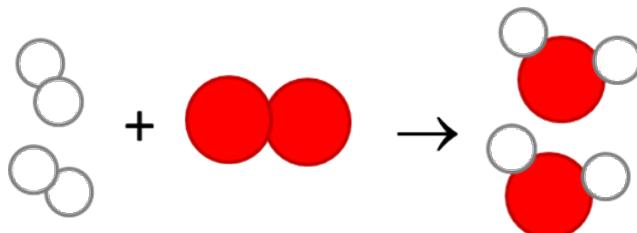
Do you see how the atoms have rearranged? This means a chemical reaction has taken place. Label the diagram with 'reactants' and 'product'.

The reaction between carbon and oxygen takes place when we burn coal. Coal is carbon and when it burns in oxygen gas, carbon dioxide is formed.



Burning coal.

The diagram below represents another chemical reaction. We have oxygen (red molecules) reacting with hydrogen (white molecule) to produce water.



What are the reactants in this reaction?

TEACHER'S NOTE

Oxygen and hydrogen.

What is the product in this reaction?

TEACHER'S NOTE

Water.

Why do you think hydrogen and oxygen are represented as two atoms joined together?

TEACHER'S NOTE

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

Do you remember when we spoke about **chemical bonds** between atoms in a molecule in Chapter 1? A chemical bond is a force which holds the atoms together. Therefore, during a chemical reaction, the bonds between atoms have to break so that the atoms can rearrange to form the products. New bonds form between the atoms in the product.

Next we will look at a chemical reaction that has been used by humankind for centuries.

Fermentation is a chemical reaction

Have you ever forgotten some milk or juice in a bottle, to find that it has 'gone off' a few days later? If you accidentally tasted it, it may have tasted sour and, in the case of the juice, a bit fizzy as well. Your senses may have warned you not to drink any more of it. Do you remember learning in Gr. 7 that our sense of taste protects us from food that has spoiled?

The sour taste of the milk or juice is caused by the products of **fermentation**. Which compounds have a sour taste?

TEACHER'S NOTE

Acids taste sour.

Fermentation does not only produce unwanted products. Yoghurt, buttermilk and cheese are all fermented milk products. In these examples, the fermentation process creates acids that give these foods a sour taste.



Different dairy products which are made using fermentation.



Two buckets of ginger beer fermenting.

VISIT

How fermentation works
bit.ly/14AHSzG

Fermentation is also the process by which a variety of fruits, vegetables and grains can be used to make alcohol. In many cultures the brewing of alcoholic drinks is part of their indigenous knowledge.

TEACHER'S NOTE

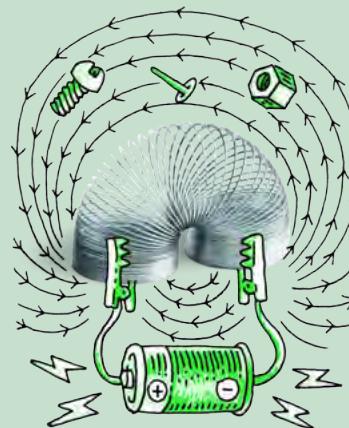
The video on how fermentation works (5:39) is short and fun. The first two minutes give a brief description. During the rest of the video, the presenter demonstrates how to make your own ginger beer.

ACTIVITY: Studying the fermentation reaction

The basic reaction in the fermentation process can be summarised as follows:



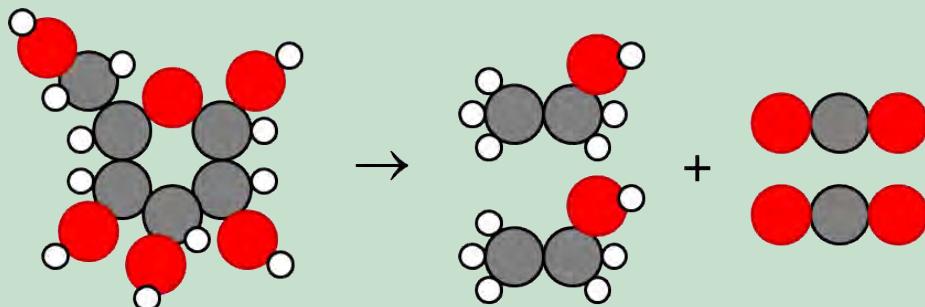
What are the reactants and products in this reaction?



TEACHER'S NOTE

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

We can draw pictures of the molecules to show how the atoms are rearranged during the reaction:



In the diagram above, the grey atoms are carbon (C), the red atoms are oxygen (O) and the small, white ones are hydrogen (H). Write in the names of the compounds in this reaction.

TEACHER'S NOTE

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

Glucose does not change into alcohol and carbon dioxide by itself! Microorganisms like yeast and bacteria actively ferment glucose.

TEACHER'S NOTE

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

In South Africa, a popular drink is ginger or pineapple beer! The fizzy bubbles in the ginger beer or pineapple beer are bubbles of carbon dioxide produced by the yeast during fermentation. Let's make some ginger beer!

TEACHER'S NOTE

This is an extension activity and can be performed if you have time in class. It may also be done as a **project**. We will also look at fermentation again in Matter and Materials next term. In fermentation, the glucose is incompletely broken down, so it yields less energy (in the form of ATP) than respiration. Fermentation is also anaerobic meaning it does not require oxygen, whereas respiration requires oxygen. Alcohol is produced during fermentation. However, **ginger beer is non-alcoholic**. Although it is called 'beer', it is not alcoholic because it is not fermented for long enough.

INSTRUCTIONS:

1. You need to research how to make traditional South African ginger beer.
2. Identify the different ingredients you will need.
3. Once you have done so, you can decide as a class about the best recipe you will use. You can then make ginger beer in class with your teacher.
4. Answer the questions that follow.

TEACHER'S NOTE

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

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

MATERIALS:

- 6 - 8 medium size lemons
 - grated rind of 2 lemons
 - 250 ml (1 cup) of freshly squeezed lemon juice (from about 6 lemons)
- 2 thumb-size pieces of fresh ginger
- 2 teaspoons of dried powder ginger
- 6 raisins
- 750 ml (3 cups) white sugar
- 5 litres of water
- 1 x 10 g sachet of instant (active dry) yeast
- grater
- lemon squeezer
- container or bucket
- wooden spoon
- large bottle
- several smaller bottles with lids
- balloons
- rubber bands

TEACHER'S NOTE

INSTRUCTIONS:

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

QUESTIONS:

1. What are the reactants in the reaction to make ginger beer?
The chemical reaction occurs between sugar and fermenting fruit and the yeast. So the reactants are the sugar and fruit (ginger and raisins).
2. What is the product in the reaction taking place in the ginger beer?
The product is carbon dioxide (and a very small amount of alcohol).
3. Why are there fizzy bubbles in the ginger beer?
It is the carbon dioxide gas that was trapped in the liquid.
4. Where do you think the gas came from?
It is a result of the chemical reaction between the yeast, the sugar and the fermenting fruit.
5. Another example of where we see a chemical reaction taking place is when we burn wood in a fire, either in our homes or to cook food. The wood burns and produces carbon dioxide gas and water vapour. What are the products and reactants in this reactions?
The reactants are the wood and oxygen, and the products are the carbon dioxide and water.

Chemical reactions can help us to detect certain substances

Some chemical reactions can produce results that are unique and even spectacular! Have you ever seen the volcano experiment? This experiment is shown in the video link in the visit box.

When ammonium dichromate burns in oxygen, the reaction produces bright orange sparks. The reaction forms nitrogen gas (N_2), water and a dark-green compound called chromium oxide as products. This reaction is unique. Only ammonium dichromate reacts with oxygen to form these particular products with these particular visual effects.



VISIT

A video showing the ammonium dichromate volcano bit.ly/13calrX

Ammonium dichromate before it is burned in oxygen.

Chromium oxide is the product.

When two substances react in a unique and characteristic way when they are mixed, one of them can be used to *detect* the other.



ACTIVITY: Some chemical reactions from Life and Living

TEACHER'S NOTE

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

1. Do you remember we used clear lime water to detect carbon dioxide in our breath in Chapter 1 in Life and Living? What colour did the clear lime water turn when we blew bubbles through it? *It turned a milky white colour.*
2. Limewater is a solution of calcium hydroxide in water. A reaction occurs between the lime water and the carbon dioxide to produce a white substance in the water called calcium carbonate. What are the reactants and products in this reaction?
The reactants are limewater (calcium hydroxide) and carbon dioxide and the products are calcium carbonate and water.



3. We say that we used the colour change of the lime water to detect the carbon dioxide in our breath. Carbon dioxide is the by-product of the chemical reaction that takes place during respiration in all organisms. Write a word equation for respiration.
- glucose + oxygen → energy + carbon dioxide + water**
4. In Life and Living we spoke about the ingredients of respiration as we had not yet learned the terms reactant and product. What are the reactants and what are the products in respiration?
- The reactants are glucose and oxygen. The products are energy, carbon dioxide and water.*
5. What are the reactants and products in photosynthesis?
- The reactants are carbon dioxide and water, the products are glucose and oxygen.*



We have also learnt that chemical reactions are simply rearrangements of atoms in molecules, to make different molecules. That is what many chemists do for a living! They find ways of rearranging atoms in order to make new compounds.

Careers in chemistry

TEACHER'S NOTE

This section is not for assessment purposes, and you may be inclined to leave it out. However, we strongly encourage you to give your learners the opportunity to discover the applications of what they are learning in class in the world around them, even if it is 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!



Marie Curie (1867 - 1934) was a famous chemist and physicist, honoured specifically for her research on radioactivity. She was the first woman to win a Nobel Prize, the only woman to win in two fields and the only person yet to win a Nobel Prize in multiple sciences!

Natural sciences is all about discovery! We want to show you how the things you study in class are useful in the real world. This subject is much too big for us to learn everything about it in school. There are many different careers based in science that you can choose. Be curious about the world around you and explore it with your growing science knowledge!

TAKE NOTE

Next year you will choose the subjects that you will be studying until Grade 12. Will you choose Physical Sciences, Life Sciences and Mathematics? Before you decide which subjects to take, explore what you can do with each of them after school.

Let's find out a bit more about the possibilities of fields related to what we have been studying in Matter and Materials.

There are many, many applications and uses of chemistry, and many different careers make use of chemistry in some way. Let's find out.

TEACHER'S NOTE

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

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

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

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

Invite a chemist/engineer: Do you know someone who is a chemist or a chemical engineer? Perhaps you live near a university? If you do, you could invite a chemist or engineer to come to your school and talk to your class about the work that chemists do. Alternatively, you could visit the chemist or engineer at their workplace and ask them to show you around. You could get your learners to prepare a few questions beforehand: you could ask them about their work, their training and what they think are the qualities needed if one wanted to become a chemist. Just remember to make an appointment first! This activity could be turned into a small group project. Learners could be required to write a short report on the information they have gathered. It is not for assessment purposes.

ACTIVITY: Careers in chemistry

INSTRUCTIONS:

1. Below is a list of different careers that all use chemistry in some way. Have a look through the list and then select the five careers you find most interesting.
2. Do an internet search to find out what each career is.
3. Write a one line description of this career.



- If there is a career that really interests you, draw a smiley face next to it and be sure to do some extra reading around the topic and where chemistry might take you! Find out what level of chemistry you will need for this particular career.
- There are many other careers besides the ones listed here which use chemistry in some way, so if you know of something else which is not listed here and it interests you, follow your curiosity and discover the possibilities!

Some careers involving chemistry:

- Agricultural chemistry
- Biochemistry
- Biotechnology
- Chemical education/teaching
- Chemistry researcher
- Environmental chemistry
- Forensic science
- Food science/technology
- Geneticist
- Geochemistry
- Materials science
- Medicine and medicinal chemistry
- Oil and petroleum industry
- Organic chemistry
- Oceanography
- Patent law
- Pharmaceuticals
- Space exploration
- Zoology

VISIT

A useful site to find out more about some chemistry-related careers.
bit.ly/16Ei2tf

VISIT

Science is awesome!
bit.ly/19IME8C
bit.ly/14AlmFZ

Your descriptions of the careers you are interested in:



SUMMARY:

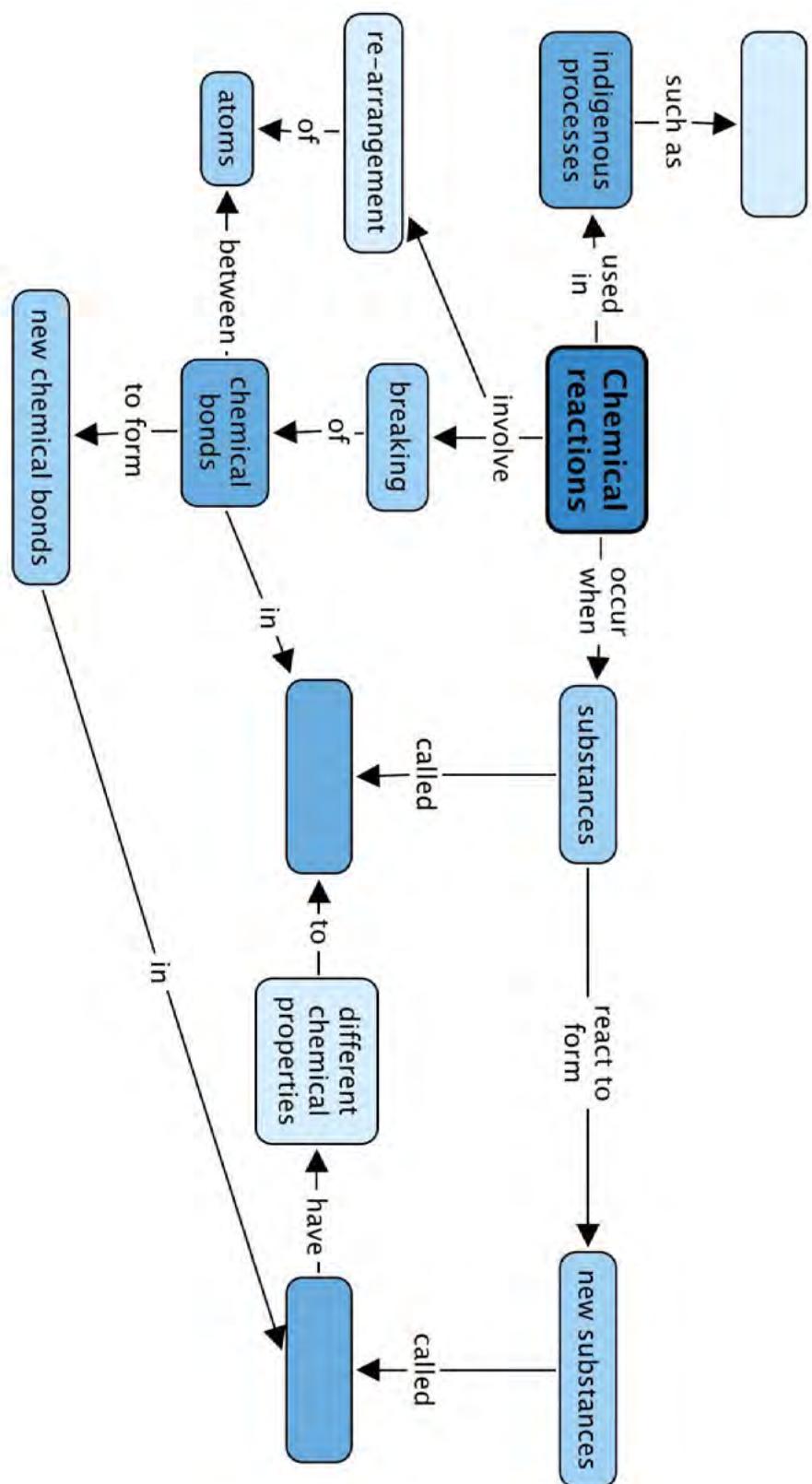
Key Concepts

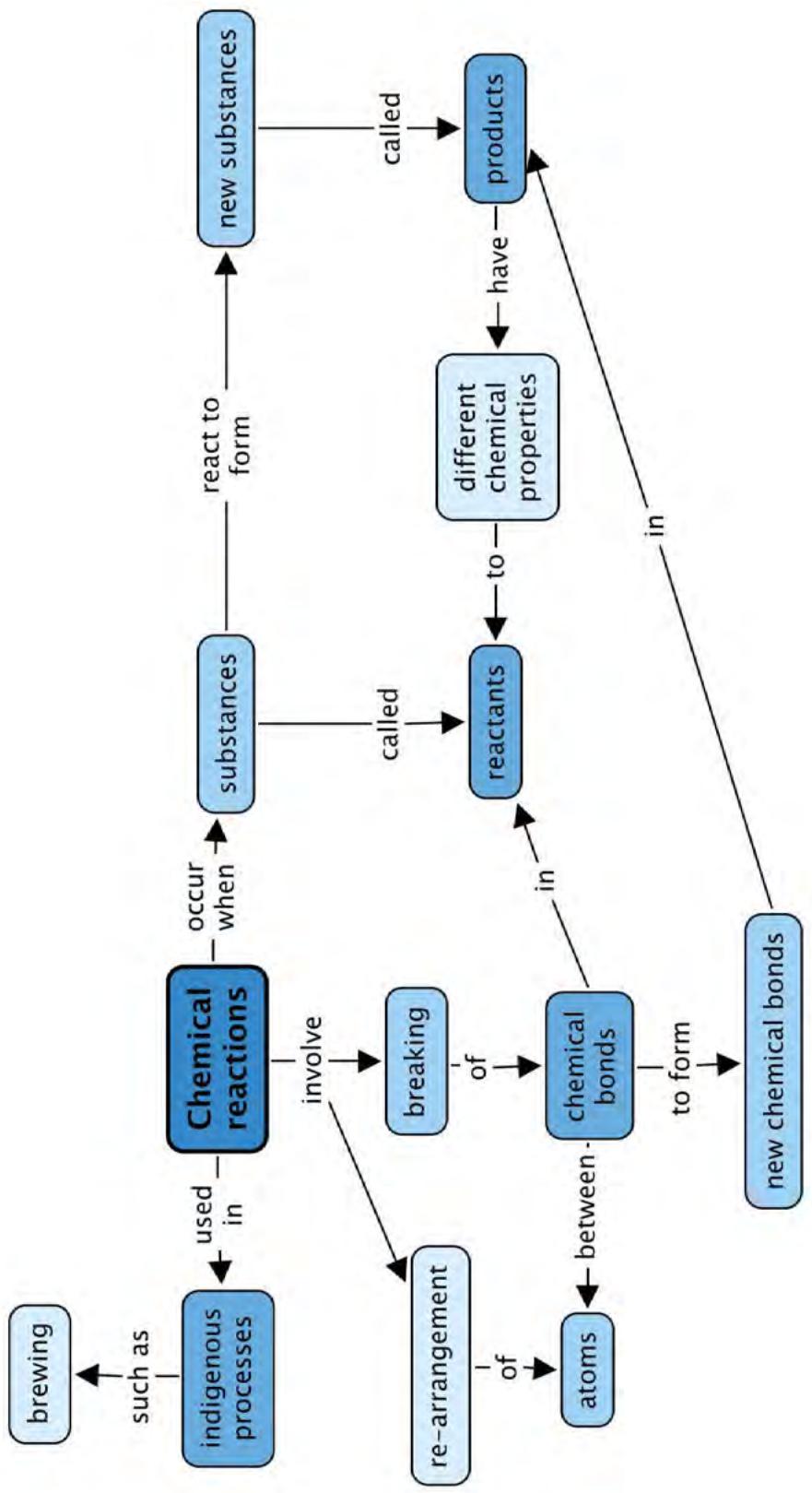
- During chemical reactions, materials are changed into new materials with new chemical and physical properties.
- The materials we start with are called reactants and the new materials that form are called products.
- During chemical reactions, atoms are rearranged. This requires that chemical bonds in the reactants are broken and that new bonds are formed, resulting in product formation.
- Fermentation in brewing is an example of a chemical reaction that is also part of indigenous knowledge.

Concept Map

Fill in the blanks in the concept map for the Chemical Reactions chapter on the next page.









REVISION:

- Suppose you mix some chemicals in a beaker. How will you know if a reaction has taken place? Write a paragraph describing each of the signals that would indicate a reaction has taken place and what each signal tells you about that reaction. [6 marks]

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

We know a chemical reaction has taken place when one or more of the following occurs:

- There has been a colour change inside the reaction flask.*
- A gas has formed. Usually we know a gas has formed when we can see bubbles.*
- A solid has formed. Usually we know that some solid material has formed when we can see a sludgy or cloudy deposit, or crystals forming.*

Non-visual signs that help us to say whether or not there was a chemical reaction include:

- Sometimes chemical changes can be smelled, for instance when a new material is formed that has a strong smell.*
- Other chemical changes can be felt, for instance when the reaction causes heat to be released.*
- Some chemical changes can be heard, for instance when an explosion takes place.*

- Write your own definition for what a reactant is. [1 mark]

Learners should mention that the reactants are those substances that are present before a chemical reaction has taken place. They react to form the products.

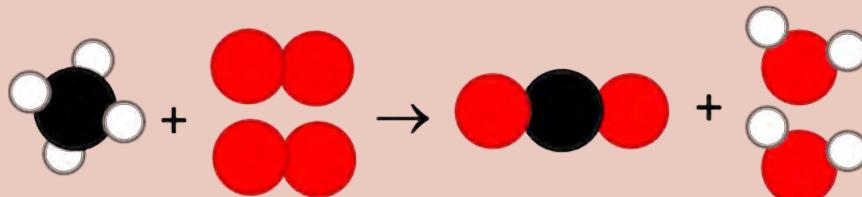
- Write your own definition for what a product is. [1 mark]

Learners should mention that the products are the substances that form during a chemical reaction. They are present at the end of a chemical reaction.

- Explain what happens to the bonds between atoms in the reactants and products in a chemical reaction. [2 marks]

Chemical bonds break between atoms in the reactants and new bonds form between atoms in the products.

- Methane gas (CH_4) is a natural fuel gas that burns in oxygen gas to produce carbon dioxide and water. The reaction can be represented by the following diagram:



Key:

Carbon atoms (C): black

Oxygen atoms (O): red

Hydrogen atoms (H): white

- a) Use the diagram and the 'key' below it to write formulae for each of the substances in the reaction. [4 marks]

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

- b) What are the reactants of the above reaction? [2 marks]

Methane (CH_4) and oxygen (O_2)

- c) What are the products of the above reaction? [2 marks]

Water (H_2O) and carbon dioxide (CO_2)

- d) Write the names of the reactants and products under the colourful picture representations of each of the molecules. [2 marks]

The equation should read as follows: methane + oxygen → carbon dioxide + water.

6. Ammonia (NH_3) is produced from hydrogen gas and nitrogen gas.

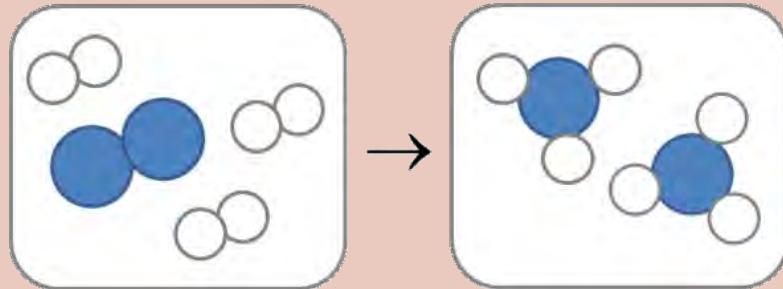
- a) Draw one molecule of each of the substances in the reaction in the following table. [3 marks]

The colours shown here are just a suggestion; what is important is that atoms of the same type should be the same size and colour, and the relative sizes of the atoms should reflect the fact that an H atom is smaller than an N atom.

Name of compound	Diagram of one molecule of the compound
Hydrogen gas, H_2	
Nitrogen gas, N_2	
Ammonia, NH_3	

- b) Use the template below to draw diagrams representing the particles before and after the reaction. Your diagram should also show how many of each type of particle take part in the reaction. [4 marks: 2 marks each for 'before' (left) and 'after' (right) sketch]

An example of what learners should produce.



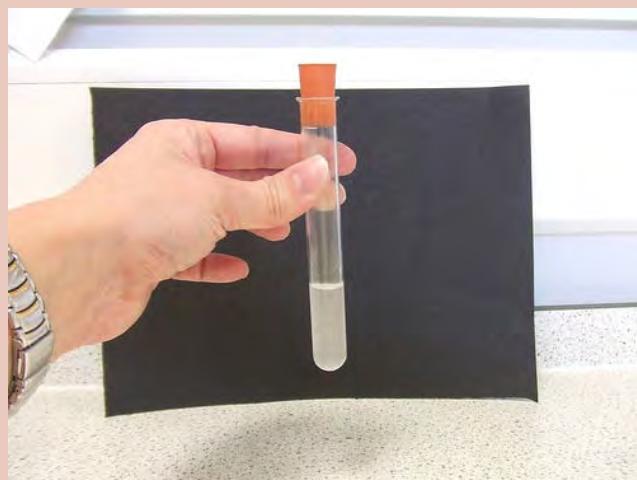
- c) What are the reactants of the above reaction? [2 marks]

Hydrogen and nitrogen.

- d) What is the product of the above reaction? [1 mark]

Ammonia.

7. Look at the following photo which shows a test tube with milky limewater. What gas must have been bubbled through it to make it turn milky? [1 mark]



Limewater that has turned milky in a test tube.

Carbon dioxide.

8. What are the reactants in this chemical reaction? [1 mark]

Limewater (calcium hydroxide) and carbon dioxide.

Total [32 marks]



GLOSSARY

air valve:	a device that works as a gateway to allow air to flow in only one direction (either into or out of something)
atomic nucleus:	a tightly packed cluster of protons and neutrons at the centre of the atom
atoms:	the fundamental particles that all matter is made up of
boiling:	occurs <i>within a liquid</i> when it is heated to its boiling point and particles escape as bubbles of gas from the liquid
chemical bond:	a special force that holds the atoms in a molecule together
chemical equation:	a way of representing a chemical reaction in terms of the chemical formulae of the reactants and products
chemical formula:	a combination of element symbols that shows the types and number of atoms in one molecule of a certain compound
chemical reaction:	a process in which chemical bonds are broken and new ones are formed between atoms; atoms in the starting compounds, called reactants, are rearranged to form new compounds, called products
chemical reaction:	an event during which the atoms in molecules are rearranged to form new molecules
cluster:	(verb) to come together and form a tight group
coefficients:	the numbers in front of the atom and molecule formulae in the chemical equation; they represent the ratio of the numbers of individual molecules that take part in the chemical reaction
collide:	(noun: collision) to bump or crash into something
compound:	a pure substance in which atoms of two or more different chemical elements are bonded in some fixed ratio
compress:	(adjective: <i>compressible</i>) to squeeze the particles of a material closer together
condensation:	when energy is removed and a gas changes state to a liquid
constant motion:	something that is in constant motion never stops moving
contract:	the physical size of an object gets smaller
controlled experiment:	an experiment in which the variables are controlled so that the results can be compared to those obtained in another experiment
decomposition reaction:	a chemical reaction in which a given molecule is broken up and recombined into smaller molecules
density:	the mass of a substance in a given space (volume)

diffuse:	(noun: diffusion) the movement of particles so that they end up spread out randomly and uniformly in a given space
disordered:	untidy; without regular arrangement
distinction:	the separation of things into different groups according to features or characteristics
electrons:	the smallest of the three types of sub-atomic particles; they are negatively charged and are located outside the atomic nucleus
element:	a pure substance made up only of atoms of the same kind
energetic:	full of energy
evaporation:	when energy is added and the particles <i>at the surface</i> of a liquid change state to a gas
expand:	the physical size of an object gets bigger
fermentation:	a chemical reaction that occurs in the presence of yeast and/or bacteria, during which a sugar is converted to an alcohol or an acid
forces of attraction:	forces that particles experience which draw them closer to each other
immiscible:	incapable of mixing or blending
impact:	(noun) effect
mass:	a measure of the amount of matter in an object or material
melting point:	the temperature beyond which a particular material changes from the solid to the liquid state (melts)
melting:	when energy is added and a solid changes state to a liquid
mixture:	a combination of two or more pure substances mixed together
molecule:	two or more atoms that have chemically bonded with each other; the atoms in a molecule can be of the same kind (in which case it would be a molecule of an element), or they can be of different kinds (in which case it would be a molecule of a compound)
neutrons:	a type of sub-atomic particle similar to protons in mass and size, but neutral (without charge); neutrons together with protons make up the atomic nucleus
observation:	an observation is something we can see, hear, taste, smell or feel
phenomenon:	(plural: phenomena) an event or occurrence that we can observe with our senses
physical quantity:	something that can be measured or estimated
postulate:	a claim that can be supported by experimental evidence
pressure gauge:	an instrument used to measure the gas pressure inside something
product:	a substance that forms during the reaction; it will be present after the reaction has taken place

protons:	a type of sub-atomic particle that is positively charged and occurs inside the atomic nucleus along with neutrons
pure substance:	matter that consists of the same material throughout; two classes exist, namely elements and compounds
random:	unpredictable
rate:	how fast or slow an event (e.g. diffusion) occurs
reactant:	a substance that is present before the reaction takes place; it is a starting material of the reaction
reaction flask or reaction vessel:	the container in which the reaction has taken place; small scale chemical reactions done in a laboratory are usually performed in glass beakers or flasks
regular arrangement:	an arrangement of particles in a neatly packed, consistent and repetitive pattern
reinforce:	to make stronger, usually by the addition of another material or other form of support
reverse:	in this chapter reverse means 'opposite', as in: melting and freezing are <i>reverse</i> processes (the opposite of each other)
scientific model:	a set of ideas that represents a concept, object, or process in nature to help us understand it
scientific theory:	an explanation of scientific phenomena or aspects of the natural world, supported and confirmed by facts obtained through observation and experimentation
solidifying:	(freezing) when energy is removed and a liquid changes state to a solid
sub-atomic particle:	a particle that is smaller than the atom and occurs inside the atom
transformation:	change; to transform is to change from one form into another
uniform:	the same throughout
vapour:	the gaseous state of a substance that is normally liquid or solid at room temperature, such as water that has evaporated into the air
vibrate:	to move rapidly back and forth
vigorous:	strong and forceful
volume:	a measure of the amount of space occupied by a three-dimensional object or material

Here is your chance to discover the possibilities. What else can this beaker be?



The assessment guidelines for Gr 7-9 Natural Sciences are outlined in CAPS on page 85. Provided here are various rubrics as a guideline for assessment for the different tasks which you would like to assess, either **informally** (to assess learners' progress) or **formally** (to record marks to contribute to the final year mark). These rubrics can be photocopied and used for each learner.

The various rubrics provided are:

- **Assessment Rubric 1: Practical activity**
 - To be used for any practical task where learners are required to follow instructions to complete the task.
- **Assessment Rubric 2: Investigation**
 - To be used for an investigation, especially where learners have to write their own experimental report or design the investigation themselves.
- **Assessment Rubric 3: Graph**
 - To be used for any graph or translation task you would like to assess, either on its own or within another activity.
- **Assessment Rubric 4: Table**
 - To be used when learners have to draw their own table and you would like to assess it.
- **Assessment Rubric 5: Scientific drawing**
 - To be used when learners have to do a drawing, particularly in Life and Living.
- **Assessment Rubric 6: Research assignment or project**
 - To be used when learners have to do a research assignment or project, either outside of class or in class time, and either individually or in groups.
- **Assessment Rubric 7: Model**
 - To be used when learners have to design and build their own scientific models.
- **Assessment Rubric 8: Poster**
 - To be used when learners have to make a poster, either individually or in a group.
- **Assessment Rubric 9: Oral presentation**
 - To be used when learners have to give an oral presentation to the class on a selected topic.
- **Assessment Rubric 10: Group work**
 - To be used to assess any work where learners are required to complete the task as a group. This rubric is designed to assess the group as a whole.

A.1 Assessment Rubric 1: Practical activity

Name:

Date:

Task:

Assessment criteria	0	1	2	Comments
Following instructions	Unable to follow instructions	Instructions followed with guidance	Able to work independently	
Observing safety precautions	Unable to observe safety precautions	Sometimes does not follow safety precautions	Able to follow safety precautions completely	
Ability to work tidily	Cannot work tidily	Can work tidily		
Cleans up afterwards	Does so once reminded	Does so without reminding		
Organisation	Disorganised	Fairly organised	Organised and efficient	
Use of apparatus, equipment and materials	Always used incorrectly and materials wasted	Sometimes used correctly and aware of material usage	Apparatus and materials used correctly and efficiently	
Results or final product	No result or final product	Partially correct results or product	Results or product correct	
Answers to questions based on activity	No answers provided or most are incorrect	Can answer questions and at least 60% are correct	Can answer application and questions correctly	
			Total	/15

A.2 Assessment Rubric 2: Investigation

Name:

Date:

Task:

Assessment criteria	0	1	2	3	Comments
Aim	Not stated or incorrect	Not clearly stated	Clearly stated		
Hypothesis or prediction	Not able to hypothesise	Able to hypothesise, but not clearly	Clearly hypothesises		
Materials and apparatus	Not listed or incorrect	Partially correct	Correct		
Method	None	Confused, not in order or incorrect	Partially correct	Clearly and correctly stated	
Results and observations (recorded either as a graph, table or observations)	No results recorded or incorrectly recorded	Partially correctly recorded	accurately recorded but not in the most appropriate or specified way	Correctly and accurately recorded in the most appropriate or specified way	
Analysis or discussion	No understanding of the investigation	Some understanding of the investigation	Understands the investigation	Insightful understanding of the investigation	
Evaluation	No attempt	Partially correct	Correct, but superficial	Critical evaluation with suggestions	
Neatness of report	Untidy	Tidy			
Logical presentation of report	Not logical	Some of report is logically presented	Report is logically presented		
				Total	/25

A.3 Assessment Rubric 3: Graph

Name:

Date:

Task:

Assessment criteria	0	1	2	Comments
Correct type of graph	Not correct	Correct		
Appropriate heading, describing both variables	Not present	Present, but incomplete	Complete	
Independent variable on x-axis	Not present or incorrect	Present		
Dependent variable on y-axis	Not present or incorrect	Present		
Appropriate scale on x-axis	Incorrect	Correct		
Appropriate scale on y-axis	Incorrect	Correct		
Appropriate heading for x-axis	Not present or incorrect	Correct		
Appropriate heading for y-axis	Not present or incorrect	Correct		
Units for independent variable on x-axis	Not present or incorrect	Correct		
Units for dependent variable on y-axis	Not present or incorrect	Correct		
Plotting points	All incorrect	Mostly or partially correct	All correct	
Neatness	Untidy	Tidy		
Graph size	Too small	Large		
			Total	/15

A.4 Assessment Rubric 4: Table

Name:

Date:

Task:

Assessment criteria	0	1	2	Comments
Appropriate heading, describing both variables	Not present	Present, but incomplete	Complete	
Appropriate column headings	Not present or incorrect	Mostly correct	Correct and descriptive	
Appropriate row headings	Not present or incorrect	At least half correct	All correct	
Units in headings and not in body of table	None present	Present but in the body	Present and in the headings	
Layout of table	No horizontal or vertical lines	Some lines drawn	All vertical and horizontal lines drawn	
Data entered in table	Not correct	Partially correct	All correct	
			Total	/12

A.5 Assessment Rubric 5: Scientific drawing

Name:

Date:

Task:

Assessment criteria	0	1	2	Comments
Appropriate, descriptive heading	Not present	Present, but incomplete	Complete	
Appropriate size of drawing (sufficiently large on page)	Incorrect (too small)	Correct		
Accuracy of drawing (correct shape and proportion of parts)	Incorrect	Somewhat correct	Correct	
Structures or parts placed correctly in relation to each other	Mostly incorrect	Mostly correct, but some misplaced	All correct	
Diagram lines are neat, straight and done with a sharp pencil	Not clear or neat or blunt pencil	Clear and neat		
Label lines do not cross over each other	Incorrect	Correct	All correct	
Parts are labelled	Mostly incorrect	Mostly correct with some missing or incorrectly labelled	All correct and labelled	
			Total	/12

A.6 Assessment Rubric 6: Research assignment or Project

Name:

Date:

Task:

Assessment criteria	0	1	2	Comments
Group work (if applicable)	Conflict between members or some did not participate	Some conflict and some members did not always participate	Worked efficiently as a group	
Project layout	No clear or logical organisation	Some parts are clear and logical, while others are not	Clear and logical layout and organisation	
Accuracy	Many errors in content	A few errors in content	Content is accurate	
Resources used (material or media)	No resources used	Some or limited resources used	A range of resources used	
Standard	Poor standard	Satisfactory	Of a high standard	
Use of time	Did not work efficiently and ran out of time	Worked fairly efficiently	Worked efficiently and finished in time	
			Total	/12

A.7 Assessment Rubric 7: Model

Name:

Date:

Task:

Assessment criteria	0	1	2	Comments
Scientifically accurate	Model inaccurate or incomplete	Mostly accurate, but with some parts missing or incorrect	Accurate, complete and correct.	
Size and scale	Too big or too small, parts not in proportion to each other	Correct size, but some parts too big or too small	Correct size and proportional scale	
Use of colour or contrast	Dull, with little use of contrast	Somewhat colourful	Creative and good use of colour and contrast	
Use of materials	Inappropriate use or only expensive materials used	Satisfactory use of appropriate materials and recyclables where possible	Excellent use of materials and recyclables where appropriate	
Use of a key or explanation	Not present	Present but incomplete or vague	Clear and accurate	
			Total	/10

A.8 Assessment Rubric 8: Poster

Name:

Date:

Task:

Assessment criteria	0	1	2	Comments
Title	Absent	Present, but not sufficiently descriptive	Complete title	
Main points	Not relevant	Some points relevant	All points relevant	
Accuracy of facts	Many incorrect	Mostly correct, but some errors	All correct	
Language and spelling	Many errors	Some errors	No errors	
Organisation and layout	Disorganised and no logic	Organisation partially clear and logical	Excellent, logical layout	
Use of colour	No colour or only one colour	Some use of colour	Effective colour	
Size of text	Text very small	Some text too small	Text appropriate size	
Use of diagrams and pictures	Absent or irrelevant	Present but sometimes irrelevant	Present, relevant and appealing	
Accuracy of diagrams or pictures	Inaccurate	Mostly accurate	Completely accurate	
Impact of poster	Does not make an impact	Makes somewhat of an impact	Eye catching and makes a lasting impact	
Creativeness	Nothing new or original	Some signs of creativity and independent thought	Original and very creative	
			Total	/22

A.9 Assessment Rubric 9: Oral presentation

Name:

Date:

Task:

Assessment criteria	0	1	2	3	Comments
Introducing the topic	Did not do	Present, but with no clear links to content	Present, and links to content being covered	Interesting and catching introduction	
Speed of presentation	Too fast or too slow	Started off too fast or too slow but reaches optimal pace	Good speed throughout		
Pitch and clearness of voice	Too soft or unclear	Started off unclear or too soft, but improved	Speaks clearly and optimal pitch throughout		
Capturing audience's attention and originality	Did not make an impact or no attempt to capture interest	Interesting at times	Sustained interest and stimulating	Sustained interest and stimulating throughout with originality	
Organisation of content during presentation	Illogical or unclear	Clear and mostly logical	Clear and logical throughout		
Factual content	Many errors in content	Some errors in content	All correct		
Concluding remarks	No conclusion or not appropriate	Made a satisfactory conclusion	Insightful/ thought-provoking conclusion		
Answers to educator and class's questions	Was not able to answer questions or gave incorrect answers	Was able to answer recall questions only	Was able to answer recall and application questions		
			Total		/18

A.10 Assessment Rubric 10: Group work

Name:

Date:

Task:

Assessment criteria	0	1	2	3	Comments
Member participation	Very few members participated or one or two members did most of work	Only some members participated	In the beginning only some members participated but then full participation	Full participation throughout	
Discipline within the group	Lack of discipline	Some members disciplined	Most members disciplined	All members disciplined	
Group motivation	Unmotivated or lack focus	Some members motivated, but others lack focus	Most members motivated and focused	All members motivated and focused	
Respect for each other	Show disrespect to each other	Some members showed disrespect	All members are respectful		
Conflict within the group	Considerable conflict and disagreements which were unresolved	Some conflict which was either resolved or unresolved	No conflict or any issues were resolved maturely		
Time management	Disorganised and unable to stick to time frames	Mostly able to work within the given time	Effective use of time to complete the task		
			Total		/15

Image Attribution

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17	http://www.flickr.com/photos/mark233/6338069992/	72
18	http://www.flickr.com/photos/66770481@N02/6741179033/	72
19	http://www.flickr.com/photos/dkeats/8040036825/	73
20	http://www.flickr.com/photos/mickers/7896129722/	74
21	http://www.flickr.com/photos/42244964@N03/4325982802/	76
22	http://www.flickr.com/photos/chimothy27/3642531568/	76
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25	http://www.flickr.com/photos/usace_kcd/5846530366/	88
26	http://www.flickr.com/photos/ctsnow/95573879/	88
27	http://www.flickr.com/photos/oxfameastafrica/5933226731/	88
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77	http://commons.wikimedia.org/wiki/File:Kind_of_Volkswagen_Beetle.jpg	164
78	http://www.flickr.com/photos/puuikibeach/8589310784/	164
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89	http://www.flickr.com/photos/yortw/5470226807/in/photostream/	240
90	http://www.flickr.com/photos/jackson3/3894097289/	240
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95	http://www.flickr.com/photos/29233640@N07/5714502617/	255
96	http://commons.wikimedia.org/wiki/File:Girl_inflating_a_red_balloon.jpg	255
97	http://www.flickr.com/photos/robbophotos/2095823996/	256
98	http://www.flickr.com/photos/gemsling/2687069763/	272
99	http://www.flickr.com/photos/cote/66570391/	275
100	http://www.flickr.com/photos/nikonvscanon/4231775258/	276
101	http://www.flickr.com/photos/tessawatson/379270115/	288